February 26, 2010

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Indiana Department of Environmental Management
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RE: Comments of the Indiana Coal Council on IDEM's 2010 Draft List of Impaired Waters and Consolidated Assessment and Methodology

INTRODUCTION

The Indiana Coal Council ("ICC") submits the following comments on the Indiana Department of Environmental Management's ("IDEM's") 2010 Draft List of Impaired Waters and Consolidated Assessment and Methodology (collectively the "303(d) list" or "2010 Draft List"). The ICC is a trade association representing Indiana's coal producers, coal reserve holders, and other business entities related to the coal industry. The association was formed to foster, promote, and defend the interests of our members, who will be affected by 2010 Draft List of Impaired Waters.

The biannual development of the 303(d) list is one of IDEM's three primary responsibilities in the protection of state waters. Prior to the preparation of the 303(d) list, IDEM must develop water quality criteria to protect the designated uses of Indiana surface waters. Those numeric criteria are the metrics against which IDEM must prepare its 303(d) list. Only after that list is developed and approved by the U.S. Environmental Protection Agency ("EPA") may IDEM proceed with its final task of developing total maximum daily loads ("TMDLs") for those impaired waters in order to achieve compliance with state water quality standards. As discussed herein, the 2010 Draft List reflects IDEM's utter failure to properly complete any of these tasks and exposes the agency's repeated efforts to deny the public its rightful opportunity to meaningfully participate in the decision-making process. IDEM's actions are arbitrary and capricious and an abuse of discretion and, as such, are contrary to its obligations under the federal Clean Water Act and Indiana law.

The proposed 303(d) list suffers from fatal technical and legal flaws and must be revised. For the first time, IDEM has determined that Indiana waters are impaired as a result of aluminum and iron. These impairment determinations were based on informally derived aluminum and iron water quality values[1] that have not been properly vetted by the public. Now that IDEM is applying these derived values to state water bodies, it is clear that the aluminum and iron limits are not based in sound science and are fraught with technical errors. Legal problems also abound with the draft 303(d) list. Indeed, what has emerged is an apparently systematic attempt by IDEM at every turn to circumvent any meaningful opportunity for the public to review and comment on this agency action. First, IDEM has made it impossible for the public to ascertain what IDEM has proposed to do by inconsistently and incorrectly using important legal terminology throughout its draft 303(d) list. Second, effective public participation has been thwarted by the Indiana Water Control Board's ("Water Board's") ongoing failure to formally promulgate methodologies to guide IDEM's impairment determinations, in violation of the Board's clear statutory mandate. Third, IDEM has chosen to sidestep state rulemaking procedures, and their inherent due process protections, and informally derive aluminum and iron water quality values. These values undoubtedly are "rules" under Indiana law when applied in 303(d) listing process and thus must be formally promulgated by the Water Board. As developed, there has been no opportunity for the public to comment. Finally, IDEM's disregard for proper legal procedure and due process protections is further evidenced by the agency's reliance on a draft TMDL for the Busseron Creek Watershed ("Draft Busseron Creek TMDL") to classify 52 water bodies as "Category 4A" waters even though IDEM had no authority to develop the TMDL, and the draft TMDL, itself, was developed in violation of federal Clean Water Act requirements, has not received final state approval, and has yet to be submitted to EPA.

In light of these technical and legal deficiencies, the draft 303(d) list as currently proposed must be deemed invalid. Before IDEM may proceed with its 2010 impairment determinations, the Water Board must formally promulgate regulations that detail the 303(d) listing methodologies for IDEM to follow. The aluminum and iron water quality values also must be revised and formally adopted pursuant to Indiana's formal rulemaking procedures. In particular, the Water Board cannot adopt a single set of criteria for these metals but instead must develop and promulgate equations and/or values tables that are consistent with accepted science and take into consideration stream-specific conditions. Until these revisions are made, IDEM cannot identify aluminum or iron impairments in its draft 303(d) list. IDEM must also revise its document to address the various other technical errors, discussed below. In addition, due to the volume and complexity of information that required review in order to prepare informed public comments, a second hearing should be held before the Water Board following the end of this public

[1] It is unclear to the ICC what water quality "values" IDEM is using to make its aluminum and iron impairment determinations. As discussed further in Section I of the Legal Analysis, below, IDEM inconsistently and imprecisely refers to these values as "Tier I/Tier II" criteria and "site-specific criteria developed pursuant to Method

comment period to provide the regulated community a meaningful opportunity to discuss this proposed 303(d) list. Finally, the Draft Busseron Creek TMDL must be reexamined after the finalization of the 303(d) list to realign IDEM's decision-making process with that contemplated by the federal Clean Water Act.

TECHNICAL ANALYSIS

I. No Technical Basis Exists for the Aluminum Water Quality Criterion

The draft 303(d) list marks the first time that IDEM has used an aluminum water quality value as a basis for impairment determinations. IDEM acknowledges in the 2010 Draft List that its previous 303(d) list for 2008 did not identify any aluminum impairments. By contrast, IDEM now proposes to list 117 waters as impaired for aluminum. *2010 Draft List*, IDEM, p.17 (Nov. 2, 2009). These proposed impairments, however, are not based on formally promulgated water quality criteria because the state regulations do not specify numeric water quality criteria for aluminum. *See* 327 Ind. Admin. Code 2-1-6. Instead, the aluminum impairments are based on a value of 174 µg/L, which IDEM developed in 2005 without the benefit of formal public review. *See* Email from Syed Ghiasuddin, IDEM Office of Water Quality, to Bruno Pigott *et al.* (March 24, 2005); *see also* Section III of the Legal Analysis portion of these comments for further discussion of the problems with the derived water quality values. This water quality value is not based on best available data, was improperly derived, does not account for background aluminum concentrations or otherwise reflect risks to human health and the environment, and is fundamentally unreasonable. Accordingly, this aluminum value cannot be used for IDEM's 2010 303(d) impairment assessments.

A. IDEM Relied on Invalid EPA Data

IDEM's aluminum value (174 µg/L) is based on the data used by EPA to calculate a similar criterion for cold (salmonid) waters (87 µg/L). Email from Syed Ghiasuddin, IDEM Office of Water Quality, to Bruno Pigott *et al.* (March 24, 2005); *see also Ambient Aquatic Life Water Quality Criteria for Aluminum*, 440/5-86-008, U.S. EPA (1988). However, this federally-calculated chronic criterion was based on invalid toxicity data and represents a very limited data set that does not have the necessary scientific or statistical rigor. Accordingly, this federal criterion cannot be the basis for IDEM's aluminum standard, nor can it be used for the state's 303(d) impairment determinations.

1 (327 IAC 2-1-8.3)." Accordingly, ICC refers to these numbers generically as "values" in its comments and reserves the right to supplement these public comments once IDEM's actual basis for these values is clarified.

EPA's chronic criterion for aluminum is based on data from only two tests – the striped bass test (Buckler et al., 1987) and brook trout test (Cleveland et al., 1986) – which the agency, itself, deemed inappropriate in its 1988 decision document, listing them in Table 6 as "unused data." *Ambient Aquatic Life Water Quality Criteria for Aluminum.* According to EPA, the Buckler and Cleveland studies were unsuitable because they used dilution water with a pH less than 6.5 and the control mortality was too high. *Id.* The Buckler and Cleveland studies also were contrary to EPA's own guidance that advises that chronic fish data used for chronic aquatic water quality criteria calculations should be based on tests that cover sensitive life stages of that species for an appropriate test duration. *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*, PB85-227049, U.S. EPA (1985), *available at* www.epa.gov/waterscience/criteria/library/85guidelines.pdf. For example, when conducting a partial life-cycle test, the test should begin "with immature juveniles at least two months prior to active gonad development, continue through maturation and reproduction, and end not less than 24 days after the hatching of the next generation." *Id.* at 38. EPA disregarded this guidance in developing its chronic criterion for aluminum and instead relied upon a striped bass test that lasted for only seven days and used a 160-day age fish. *Ambient Aquatic Life Water Quality Criteria for Aluminum.* EPA also improperly used the lower chronic limit of the striped bass test, which is in contravention of the agency's guidance that advises chronic values to be based on the geometric mean of the upper and lower chronic limits. *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*, p.38.

Despite these fatal problems, EPA opted to develop its chronic criterion for aluminum based on that very limited data set, casting aside its established derivation methodologies. Curiously, EPA disregarded a chronic criterion (748 μg/L), which was based on the agency's larger, acceptable data set (found in Table 2 for chronic criteria) and was derived with appropriate calculations and statistical analysis. Indeed, others in the scientific community have recognized the scientific and statistical deficiencies with EPA's aluminum criterion, including GEI Consultants who questioned the derivation of EPA's aluminum chronic criterion in conducting a 2009 review of the Agency's standard-setting methodologies in furtherance of proposed aluminum criteria for the State of Colorado. *Ambient Water Quality Standards for Aluminum – Review and Update*, GEI Consultants, p. 6 (Oct. 2009) (Attachment 1).

B. IDEM Failed to Consider the Effects of pH and Hardness on Aluminum Toxicity

IDEM's reliance on EPA's chronic aquatic criterion for aluminum is also technically flawed because the state agency has failed to take into consideration the constraints on that federal value. The 87 μg/L chronic criterion is based on tests conducted in water with a pH between 6.5 and 6.6 and a hardness less than 10 mg/L. *National Recommended Water Quality Criteria*, U.S. EPA, *available at* www.epa.gov/waterscience/criteria/wqctable/. These conditions are significant because, according to EPA, "aluminum is substantially less toxic at higher pH and hardness values." *Id.* (citing *Aluminum Water-Effect Ratio for the 3M Plant Effluent Discharge, Middleway, West Virginia* (May 1994)). IDEM, too, has acknowledged in the context of its aluminum water quality value that pH may affect aluminum toxicity in fish. *See* Email from Syed Ghiasuddin, IDEM Office of Water Quality, to Bruno Pigott *et al.* (March 24, 2005). Nevertheless, IDEM did not consider the effects of pH or hardness when deriving its aluminum value. In the absence of this important evaluation, the aluminum value must be deemed invalid and thus inappropriate for the 303(d) impairment determination process.

Since IDEM's development of the aluminum value in 2005, additional aluminum toxicity data of acceptable EPA quality have been collected, and have confirmed a scientifically significant relationship between pH and hardness and aluminum toxicity. The effect of pH and hardness on aluminum toxicity is of sufficient significance and magnitude that IDEM's continued disregard of these conditions calls into question the scientific basis of IDEM's aluminum criteria. IDEM's failure to consider the effects of pH and hardness is in contrast to the necessary, stream-specific, risk-based approach taken by numerous other regulatory agencies, including, based on our limited survey, states such as Colorado, Utah, and Wyoming. For example, the Colorado Department of Public Health and the Environment ("CDPHE") only applies its chronic criterion of 87 μg/L to waters that have a pH less than 7 and a hardness less than 50 mg/L. 5 Colo. Code Regs. § 1002-31.16, Table 1. If a water body does not meet those conditions, then the CDPHE uses the acute aquatic criterion value of 750 μg/L. *Id.*

The CDPHE's approach to developing aluminum water quality criteria properly acknowledges that, because aluminum toxicity is inextricably linked to stream-specific conditions, a single set of criteria for all waters is inappropriate and lacks scientific justification. CDPHE's approach represents a step in the right direction, but still falls short of the full risk-based methodologies that must be applied here. As demonstrated by GEI Consultants, Inc., who were retained by the Colorado Mining Association in October 2009 to review the most recent aluminum toxicity data, a statistically significant relationship exists between hardness and aluminum and, therefore, aluminum criteria in Colorado must be derived and applied stream segment by stream segment using the following equations:

- Acute Al Criterion = e(1.3695 [ln (hardness)] + 1.8308)
- Chronic Al Criterion = e(1.3695 [ln (hardness)] + 0.9161)

GEI Consultants has recommended that, to be conservative, the calculation be capped at 250 mg/L hardness and be applied to waters with a hardness value that exceeds 250 mg/L. *Ambient Water Quality Standards for Aluminum – Review and Update*, p. 21 (Attachment 1).

Similar to Colorado, the States of Utah and Wyoming consider pH and hardness when applying its aluminum water quality criteria. Both states follow the same approach as the CDPHE, limiting their application of the chronic criterion (87 µg/L) to waters with a pH less than 7 and a hardness less than 50 mg/L; in all other instances, the acute criterion must be applied. *See* Utah Admin. Code r. 317-2-14, Table 2.14.2; *see also* Wyo. Code R. § 020-080-001, App. B. These state examples make it clear that IDEM should not have automatically presumed that EPA's aluminum criterion (87 µg/L) is valid for any and all stream segments. The derivation is absolutely a stream-specific, risk-based analysis, and must consider highly correlative toxicity factors such as pH and hardness in developing appropriate aluminum criteria. IDEM's single-criteria approach has no support in science and has been consistently rejected by other states.

C. IDEM Improperly Derived and Applied the Total Aluminum Criterion

The 117 aluminum impairments identified in the draft 303(d) list are based on a water quality value for *total* aluminum. *2010 Draft List*, p. 29. Remarkably, IDEM relies on a total aluminum number even though its own regulations state that it should use a *dissolved* metal number to set and measure compliance with state water quality standards because it "more closely approximates the bioavailable fraction of metal in the water column than does total recoverable metal." 327 Ind. Admin. Code 2-1-8.1(b). It is well established that measuring the total form of a metal overestimates the risk to aquatic life because it accounts for the amount in suspended sediments, which is generally not in a form available to aquatic life. This distinction between total and dissolved metals is especially important when determining impairments of water bodies predominantly impacted by agriculture, which results in increased erosion and suspended sediment in streams. Total recoverable metal numbers are appropriate only under limited circumstances when a more conservative approach is necessary. *Id.* It is clear that such a conservative approach is inappropriate for aluminum, as it is well established that measurements of total aluminum contain the particulate form that is not bioavailable. Moreover, as noted by GEI Consultants in arguing for the use of dissolved criteria in Colorado, laboratory water quality data represent the dissolved fraction of aluminum, even if the data are measured as total aluminum, since there are no particulates present in a laboratory setting. *Ambient Water Quality Standards for Aluminum – Review and Update* (Attachment 1). Not suprisingly, IDEM has failed to sufficiently explain why it has disregarded its own regulations and common scientific knowledge and developed a value in the form of total recoverable aluminum instead of dissolved. Since no technical basis exists, IDEM's use of a total aluminum value is misplaced and inappropriate.

Likewise, IDEM has inconsistently applied the aluminum value to state waters. Although the 2010 Draft List characterizes the aluminum value as total rather than dissolved, IDEM's memorandum outlining the derivation of the aluminum value does not specify whether the 174 µg/L value is in the form of total or dissolved recoverable metal. *See* Email from Syed Ghiasuddin, IDEM Office of Water Quality, to Bruno Pigott *et al.* (March 24, 2005). Despite this silence, IDEM applied the value as a *dissolved* aluminum value in a 2007 National Pollutant Discharge Elimination System ("NPDES") permit for Alcoa – Warrick (NPDES Permit #0001155). IDEM's application of the aluminum value thus cannot be based on sound science, because total and dissolved aluminum criteria are not interchangeable. A criteria conversion factor must be used. 327 Ind. Admin. Code 2-1-8.1(b). Furthermore, since total and dissolved aluminum criteria are not equivalent, it is impossible that IDEM's application of the aluminum value as dissolved in the 2006 NPDES permit and as total in the 303(d) list are both appropriately linked to the protection of designated uses. This inconsistency makes a mockery of state and federal water law, which contemplates an interrelationship between numeric water quality criteria and designated uses. Such careless application of the aluminum value further supports the need for comprehensive revisions to the draft 303(d) list.

IDEM's application of its aluminum value as both total and dissolved can be contrasted with the more consistent and scientifically sound approaches taken by other regulatory agencies, including the West Virginia Department of Environmental Protection, the Montana Department of Environmental Quality, and the Wyoming Department of Environmental Quality. All three states recognize the dissolved fraction of aluminum to be the bioavailable toxic for and equivalent to existing toxicity data. In West Virginia, the 750 µg/L value is applied as the acute and chronic criteria (dissolved) for warm waters and the 87 µg/L value is applied as the acute and chronic criteria (dissolved) for trout waters. W. Va. Code R. § 47-2, App. E. Similarly, in Montana and Wyoming, the acute aluminum criteria (750 µg/L) and chronic aluminum criteria (87 µg/L) are both applied as dissolved. Wyo. Code R. § 020-080-001, App. B; Mont. Admin. R. 17.30.619 (incorporating by reference Dept. Circular DEQ-7). These state examples call into further question the reasonableness and scientific basis of IDEM's total aluminum water quality value.

D. The Aluminum Criterion is Inappropriately Low and Unreasonable

IDEM's application of flawed and outdated science has resulted in the establishment of an aluminum water quality value that is unjustifiably more stringent than other states' limits, fails to account for highly relevant site-specific toxicity factors, and is unachievable, even in pristine, unimpaired waters.

As stated above, IDEM's aluminum value departs from the standards adopted in other states. Moreover, IDEM's own sampling data indicate that the numeric water quality value for aluminum cannot be met in any Indiana water body. Nearly 60 percent of IDEM sampling sites with total aluminum data showed at least one exceedance of the total aluminum target. *See* Attachment 2. The fact that well over half of the aluminum sampling sites in the state waters cannot meet the standard suggests that the value is fundamentally flawed. This analysis was conducted on an individual sampling site basis, and does not encompass whole stream segments. The percentage of stream segments showing exceedances may be even higher, as many times a stream segment will contain multiple sampling sites. The net effect would be that virtually every water body sampled by IDEM for aluminum would show an exceedance of the aluminum value. This data clearly indicate that the water quality value was improperly derived and is not an accurate measure of stream impairments.

This conclusion is supported by empirical data collected by Peabody Energy Company following the publishing of the Draft Busseron Creek TMDL. In that draft TMDL document, IDEM attributed elevated aluminum concentrations primarily to abandoned and active mining operations. *Busseron Creek Watershed TMDL Development*, IDEM (June 5, 2008). However, chemical analyses of water samples collected in historically undisturbed headwater areas of the Busseron Creek watershed demonstrate that none of the four headwater sampling sites met the 174 μg/L value. *See* Attachment 3. In addition, IDEM data indicate that the Blue River, which has been designated as an "Indiana Outstanding River" and an "Exceptional Use Water" has a maximum aluminum concentration of 789 μg/L, which significantly exceeds the state's aluminum water quality value. *See* Email from Charles M. Bell, IDEM Office of Water Quality, to Kerry Mierau, ENVIRON International Corp. (Jan. 15, 2010); *see also Indiana Register Natural Resources Commission Informational Bulletin #4*, May 30, 2007. If one of the most "pristine" waters in the state cannot meet the aluminum value, then it is difficult to imagine that many, if any, water bodies, including those downstream of these particular areas, will be able to meet this limit. Total aluminum concentrations in the Ohio River and Wabash River for 2003 to 2004 further demonstrates the unfeasibility of this aluminum value:

Newburgh Max (µg/L)	Newburgh Min (µg/L)	Cannelton Max (µg/L)	Cannelton Min (µg/L)
11,600	547	5,470	540

ORSANCO (2003-2004). These concentrations are significantly higher than the 174µg/L value and further question the practicality of the derived value.

Clearly, IDEM misunderstands the source of aluminum in state waters and the concentrations at which impairment occurs. Rather than coming from discrete point sources, the aluminum concentrations in many Indiana water bodies are most likely the result of widespread suspended sediments unassociated with any industrial or other regulated activities. *See* Attachment 4. Interestingly, the Alcoa-Lafayette NPDES permit (#0001210) issued by IDEM acknowledges that total suspended solids can impact total aluminum concentrations, and the agency consequently does not require compliance with aluminum limits in storm events that cause an increase in total suspended solids:

> However, during precipitation events that exceed the hydraulic capacity of the storage units and Natural Media Filtration (NMF) system, defined by when the MH-12 Level 4 switch is activated, aluminum [and total suspended solids] monitoring results for the corresponding composite sample must be reported, and will count toward the required monitoring frequency, but will not be used to assess compliance with the discharge limits for Outfall 001.

Agriculture is also a prime culprit, and it will be difficult to find water bodies in agricultural areas of the state that fall within the proposed aluminum limit. In addition, since aluminum is one of the most common metals in the earth's crust, concentrations of this metal will be present in ambient water naturally as a result of contact with soil. As presented in the 2006 draft ATSDR "Toxicology Profile for Aluminum":

> Aluminum is the most abundant metal and the third most abundant element in the earth's crust, comprising about 8.8% by weight (88 g/kg). Mean aluminum concentrations in cultivated and uncultivated soil samples collected during a number of field studies were 33 g/kg (range 7–>100 g/kg) for subsurface soils in the eastern United States. Concentrations of various elements in 541 streambed-sediment samples collected from 20 study areas in the conterminous United States (1992–1996) were analyzed as part of the National Water-Quality Assessment Program of the U.S. Geological Survey. Aluminum was present in all samples; concentrations ranged from 1.4 to 14% by weight (14–140 g/kg), with a median of 6.4% by weight.

None of this site-specific information is currently reflected in the state's water quality value for aluminum. That oversight, combined with IDEM's reliance on flawed EPA data, its failure to consider other site-specific conditions including pH and hardness, and the agency's improper derivation and application of the aluminum value as total recoverable metal have resulted in an inappropriately low, unreasonable water quality value that will result in exceedances in nearly all sampled streams. This value must be revised and presented as an equation or values table that reflect stream-specific conditions.

II. No Technical Basis Exists for the Iron Water Quality Criterion

As with aluminum, there is no specific numeric criterion for iron in the state water quality regulations, and IDEM has derived a chronic value without the benefit of public comment. *See* Memorandum from Syed Ghiasuddin, IDEM Office of Water Quality, to C.J. Song, IDEM Office of Water Quality (June 10, 1997); *see also* Section III of the Legal Analysis portion of these comments for further discussion of the problems with the derived water quality values. This, too, marks the first time that IDEM has used an iron water quality value as a basis for impairment determinations. Whereas the previous 303(d) list did not identify any waters impaired for iron, 21 water segments have now been listed. *2010 Draft List*, p. 17. These impairment determinations lack a sound technical basis and must be revised because the water quality value for iron was incorrectly applied and based on inappropriate data.

A. IDEM Improperly Applied the Total Iron Criterion as Dissolved

IDEM continues its haphazard application of water quality criteria with the application of the water quality value for iron (2,495 μg/L). This value was derived in the form of *total* recoverable metal, yet is being applied by IDEM as *dissolved* in the 303(d) listing process. *See* Memorandum from Syed Ghiasuddin, IDEM Office of Water Quality, to C.J. Song, IDEM Office of Water Quality (June 10, 1997); *see also 2010 Draft List*, p. 29. While state regulations permit IDEM to convert a total criterion into a dissolved criterion, the agency must use the appropriate conversion factor. 327 Ind. Admin. Code 2-1-8.1(b). The 2010 Draft List does not specify a conversion factor and IDEM cannot assume a conversion factor of 1.0. *See 2010 Draft List*, p. 29. Readily available ORSANCO data on the Ohio River and IDEM data on Lake Michigan and Fall Creek indicate that the geomean of the total to dissolved ratios and respective conversion factors for iron are:

Location	Total:Dissolved Ratio	Conversion Factor
Ohio River	38	0.027
Fall Creek	85	0.012
Lake Michigan	18	0.056

Therefore, the conversion factors for converting total iron data into dissolved iron data is significantly less than 1.0 and ranges from 0.012 to 0.056. *See* Attachment 5. The correct conversion factors must be used to properly apply the iron water quality value as dissolved. Application of the iron water quality value as total recoverable metal would be inappropriate because, as with total aluminum, total iron is highly correlative with suspended solids. *See* Attachment 6.

B. IDEM Relied on Inappropriate Data

The water quality value for iron (2,495 µg/L) derived by IDEM in 1997 was incorrectly based on combined ferrous and ferric iron toxicity data. The toxicity of iron depends on whether it is in the form of divalent iron ("iron (II)" or "ferrous iron") or trivalent iron ("iron (III)" or "ferric iron"). The former is significantly more toxic than the latter. Indeed, both federal and state regulations for Great Lakes waters recognize that different oxidation states have differing potentials for aquatic toxicity and advise that different species of metals be considered separately in criteria development. *See* 40 C.F.R. 132, App. A(I)(A)(2) ("[e]ach oxidation state of a metal and each different non-ionizable covalently bonded organometallic compound should usually be considered a separate material"); *see also* 327 Ind. Admin. Code 2-1.5-11. The species of iron, in turn, depends on the pH of the water. Ferrous iron, the readily available bioavailable form, is only present in low pH (<4.0) environments, whereas more neutral waters commonly support ferric iron. Waters that also contain appreciable amounts of dissolved oxygen at pH values between 6 and 9 will be dominated by ferric hydroxide. In neutral pH waters, the bioavailable ferrous form rapidly oxidizes to the non-bioavailable and insoluble ferric form. *See* Attachment 7; *see also* J.D. Hem, *Study and Interpretation of the Chemical Characteristics of Natural* Water, 3d Ed., U.S. Geological Survey (1985). Although ferrous iron is significantly more toxic than ferric iron, the ferric iron form is more commonly found in Indiana waters where the pH ranges between 6 and 9. Since the pH-iron relationship determines which form of iron is predominant in the water, water quality criteria must be derived to account for the predominant form of iron present at the ambient pH. This likely cannot be accomplished with a single set of criteria and IDEM instead must develop equations and/or values tables that appropriately take into account these stream-specific considerations.

IDEM's development of the iron value is further flawed because the agency used a 48-hour Daphnia test result, which was fed during testing, to calculate an ACR of 2.2. Use of an acute test that was fed is generally not accepted by EPA unless it is determined that the food did not affect the toxicity of the test material. *Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*, p. 27. Since metals have a tendency to bind to particulate matter, introducing food particles to the test water can affect exposure concentrations. IDEM states that "it was assumed that feeding of Daphnids during the test did not affect the acute toxicity of iron." Memorandum from Syed Ghiasuddin, IDEM Office of Water Quality, to C.J. Song, IDEM Office of Water Quality, p. 2

(June 10, 1997). However, the study authors (Biesinger and Christensen 1972) did not determine if such an effect occurred. This further invalidates the iron value used by IDEM to develop its 303(d) impairment determinations.

III. Additional Technical Deficiencies with 303(d) List

In addition to the data and methodology-related issues previously discussed in Sections I and II, above, the 303(d) list suffers from a variety of other technical errors that must be addressed:

- IDEM has identified 44 water segments as impaired for sulfates, but has not included a specific water quality criterion for sulfates in the 303(d) list document. *See 2010 Draft List*, p. 17, 29. It is the ICC's understanding that IDEM is currently completing a statewide reassessment of sulfates and has replaced its previous water quality criterion of 250 mg/L with a calculated criterion. Since water segments have been identified as impaired for sulfates on the 2010 303(d) list, this criterion and the methodology used to derive that number must be included in the 303(d) list document.

- IDEM has identified three water segments as impaired for manganese, but has not included a specific water quality criterion for manganese in the 303(d) list document. *See 2010 Draft List*, p. 29, 97. The Draft Busseron Creek TMDL includes the following information regarding manganese criteria:

  $$\text{AAC } (\mu g/L) = (e^{(0.8784[\ln(\text{hardness})]+2.992)})$$
  $$\text{CAC } (\mu g/L) = (e^{(0.8784[\ln(\text{hardness})]+2.226)})$$

  According to IDEM, these acute and chronic aquatic criteria for manganese were obtained from IDEM's NPDES program. Email from J. Arthur, IDEM, to Kerry Mierau, ENVIRON International Corp. (Dec. 14, 2009) (providing IDEM's Busseron Creek TMDL Assessment Notes). These numeric criteria and the methodology used must be included in the 303(d) list document.

- IDEM identified five water segments as impaired for Oil and Grease, but has not included a specific water quality criterion for Oil and Grease in the 303(d) list document. *See 2010 Draft List*, p. 17, 29.

- Table 11 in the 303(d) list document must be revised to reflect the hardness-based formula used to calculate the water quality criteria as presented in 327 Ind. Admin. Code 2. This revision will clarify the statement: "sample result reported as total mean (µg/L) is multiplied by Conversion Factor" and avoid the interpretation that the criterion is the product of instream sample results multiplied by a conversion factor. If impairments decisions are made by comparing dissolved criteria to sample results expressed as total metal, then the quoted text can be added as a footnote to Table 11.

- IDEM is incorrect in using EPA's criterion for methylmercury (0.3 mg/kg) as the state water quality criterion for total mercury in fish tissue. *See 2010 Draft List*, p. 40. IDEM bases this decision on the proposition that nearly 100 percent of mercury in fish tissue is methylmercury. *Id.* However, this hypothesis is only true for top predator fish, since the percentage of methylmercury in fish tissue depends on the trophic status of the fish (with higher-status fish typically having higher percentages of methylmercury). Focusing only on top predator fish would likely significantly limit IDEM's data pool. For example, fish sampling data performed by the U.S. Geological Survey in September 2007 in the Busseron Creek Watershed identified only 5.1 percent of captured fish as high trophic fish (*e.g.*, largemouth bass and grass pickerel). These species were both found to be limited in their spatial distribution and each contribute a minor component to the fish assemblage within the watershed. Moreover, the EPA methylmercury criterion is an integrated average value and thus assumes that people eat different amounts of fish at different trophic levels. Accordingly, IDEM's application of the federal methylmercury criterion as a total mercury water quality criterion is erroneous.

- According to the Busseron Creek Assessment Notes compiled and provided by IDEM, the following assessment units were not impaired for sulfates:

Assessment Unit ID	Assessment Unit Name
INB11G7_01	Busseron Creek
INB11G8_T1036	Busseron Creek
INB11GA_01	Busseron Creek
INB11GD_01	Busseron Creek
INB11GD_02	Busseron Creek
INB1136_T1033	Sulphur Creek - Unnamed Tributary 2 Basin
INB11G4_T1003	Sulphur Creek (Headwaters)
INB11G4_T1004	Sulphur Creek
INB11G4_T1005	Sulphur Creek
INB11G5_T1034	Big Branch Tributary - Gilmour
INB11G6_02	Big Branch
INB11G6_03	Mud Creek

INB11G6_04	Mud Creek
INB11G9_00	Buttermilk Creek
INB11G9_01	Buttermilk Creek
INB11G9_02	Buttermilk Creek
INB11G9_03	Buttermilk Creek
INB11GA_03	Robbins Branch

Email from J. Arthur, IDEM, to Kerry Mierau, ENVIRON International Corp. (Dec. 14, 2009) (providing IDEM's Busseron TMDL Assessment Notes). Accordingly, these impairments must be removed from the 2010 Draft List.

- According to the Busseron Creek Assessment Notes compiled and provided by IDEM, Assessment Unit INB11GA_03 (Robbins Branch) has IBI scores of 36, but is listed as impaired for impaired biotic communities ("IBC"). According to IDEM's listing methodology, segments with IBI scores of 36 or greater are deemed to be fully supporting the designated use. *2010 Draft List*, p. 45-46. Thus, segment INB11GA_03 should not be listed as impaired for IBC in the 303(d) list document.

- The current 303(d) list document inconsistently classifies the following water segments:

Assessment Unit ID	Assessment Unit Name
INB11GA_00	Busseron Creek – Robbins Creek
INB11GD_00	Busseron Creek – Tanyard Branch
INB11G9_00	Buttermilk Creek

These segments are listed in the 303(d) list document, Attachment 2 as "retired as a result of resegmentation," as well as in Attachment 11 as impaired waters. Since these waters have been resegmented, they must be removed from Attachment 11. Additionally, segment INB11GD_00 is listed both in Attachment 7, indicating that it has been delisted due to new information, and in Attachment 11 for sulfate. If this segment has been delisted, then it must be removed from Attachment 11 for sulfate.

- According to the updated Busseron Creek Assessment Notes compiled and provided by IDEM, the following assessment units have been determined to no longer be impaired for certain parameters:

Assessment Unit ID	Assessment Unit Name	2010 Draft Impairment
INB11G4_T1003	Sulphur Creek (Headwaters)	Cu, Ni, DO, Sulfates
INB11G4_T1004	Sulphur Creek	Cu, Ni ,DO, Sulfates
INB11G4_T1005	Sulphur Creek	Cu, Ni, Zn, DO, IBC, pH, Sulfates

INB11G5_T1034	Big Branch Tributary - Gilmour	Sulfates
INB11G6_02	Big Branch	pH, Zn, Sulfates
INB11G6_03	Mud Creek	pH, Zn, Sulfates
INB11G6_04	Mud Creek	Sulfates
INB11G7_01	Busseron Creek	Sulfates
INB11G8_T1036	Busseron Creek	Sulfates
INB11GA_01	Busseron Creek	Sulfates
INB11GD_01	Busseron Creek	Sulfates
INB11GD_02	Busseron Creek	Sulfates
INB11G9_01	Buttermilk Creek	Sulfates
INB11G9_02	Buttermilk Creek	Sulfates
INB11G9_03	Buttermilk Creek	Sulfates
INB11GA_03	Robbins Branch	Sulfates

Thus, these assessment units and impairments must be removed from the Category 5 list.

LEGAL ANALYSIS

In addition to the troubling technical deficiencies discussed above, the Draft 2010 List suffers significant legal shortcomings. As discussed below, IDEM has paid no attention to proper legal terminology, carelessly using incorrect terms throughout the Draft 2010 List and thereby making it impossible for the public to understand what IDEM is proposing to do. IDEM also has been making its 303(d) impairment determinations in the absence of statutorily-required regulatory methodologies and consequently in violation of the Indiana General Assembly's mandate. Finally, IDEM has expressed an absolute disregard for state and federal law, ignoring state administrative procedures and federal Clean Water Act requirements and their inherent due process protections. IDEM's intentional and improper actions have allowed the agency the luxury of unilaterally developing water quality values, 303(d) lists, and TMDLs without the constraints of meaningful public participation on the agency decision-making process. This purposeful circumvention of agency legal process cannot stand.

I. IDEM's use of Terminology is Inconsistent, Misleading, and Incorrect

IDEM's seemingly deliberate effort to prevent effective public comment is particularly evident in its imprecise classification of aluminum and iron derived water quality values. Throughout the 2010 Draft List document, IDEM inconsistently refers to these values as "Tier I/Tier II" criteria and "site-specific criteria developed pursuant to Method 1 (327 IAC 2-1-8.3)." *Compare 2010 Draft List*, p. 29 *with 2010 Draft List*, p. 30. Those regulatory terms are not interchangeable and make it impossible for the public to understand what water quality values IDEM has truly developed. In addition, Section 8.3 of the Indiana Water Quality Standards regulations does not address site-specific criteria, but instead provides the methodology for determining chronic aquatic criteria for downstate waters. *See* 327 Ind. Admin. Code 2-1-8.3. Instead, it is Section 8.9 of the regulations that allows for site-specific modifications to water quality criteria. 327 Ind. Admin. Code 2-1-8.9. It is doubtful, however, that IDEM meant to cite Section 8.9, since that regulatory provision requires compliance with specific due process steps that do not appear to have been undertaken with respect to the development of the aluminum and iron values. *See* 327 Ind. Admin. Code 2-1-8.9 (requiring notice and comment, public hearing, and publishing on the IDEM website in connection with a site-specific criterion). IDEM's recurring reference to "site-specific criteria" is also dubious because, by definition, such criteria are only allowed on a case-by-case basis in response to an application for specific criteria modifications. 327 Ind. Admin. Code 2-1-8.9(b). It is nonsensical to suggest that the aluminum or iron water quality values can legally constitute "site-specific criteria" when they have been applied to *all* stream segments reviewed for the 2010 303(d) listing, resulting in a total of 138 impairment determinations. The notion that IDEM is attempting to develop site-specific criteria becomes even more absurd recognizing that IDEM intends to apply these values to more stream segments in the future as it continues to rotate through water management basins.

IDEM's strategically sloppy drafting is also seen with its incorrect use of "Tier I" and "Tier II" terminology. In the "Consolidated Assessment and Methodology" section of the 2010 Draft List, IDEM attempts to "simplify" its discussion of water quality criteria by referring to total aluminum and dissolved iron water quality values, among other constituents, as "Tier I" criteria, which is a regulatory term reserved for waters located within the Great Lakes Basin. *See 2010 Draft List*, p. 28-29. This simplification is entirely inappropriate for downstate water quality criteria, including aluminum and iron, because the term "Tier I" wrongly suggests that the criteria were based on complete, valid, peer-reviewed data sets. *See* 327 Ind. Admin. Code 2-1.5-11, 2-1.5-12. Downstate water quality criteria have not gone through the same scientific or statistical rigor as Tier I/Tier II values and thus IDEM cannot use the Tier I/Tier II terminology when discussing downstate water quality criteria.

Since IDEM has failed to develop its 2010 Draft List with sufficient particularity, the 303(d) impairment determinations and 305(b) water assessment must be deemed arbitrary and capricious and an abuse of agency discretion. In addition, the ICC reserves the right to supplement these public comments once IDEM's actual basis for these values is clarified, since the ICC can only speculate at this point as to what regulatory procedures apply to the development of the derived water quality values.

II. Indiana Water Pollution Control Board's Failure to Develop 303(d) Listing Methodology Regulations Violates State Law

Meaningful public participation and appropriate scientific rigor to support agency action have also been thwarted by the Water Board's ongoing failure to formally promulgate regulations to guide IDEM's identification of impaired state waters and development of 303(d) lists. *See* Ind. Code § 13-18-2-2(b) (providing that the Water Board "*shall* adopt a rule that establishes the methodology to be used in identifying waters as impaired and specifies the methodology and criteria for including and removing waters from the list of impaired waters") (emphasis added). This non-discretionary obligation has been in the Indiana Code since 2000, yet the Water Board has failed to act and IDEM has instead been acting pursuant to internal policy documents that are not publicly available and have not been subject to public review and comment. In fact, the ICC is not aware of any actions taken by IDEM since 2000 to pursue the required rule development. This perhaps should come as no surprise since the absence of a rule affords the agency the unfettered discretion to proceed with its impairment determinations unimpeded by process and procedures aimed at the protection of the rights of the regulated community.

While the Indiana Code does not specify a deadline for this rulemaking, implied with an agency's power to act is the obligation that the agency act within a reasonable amount of time. *See State Bd. of Tax Comm'rs v. L.H. Caride Corp.*, 702 N.E.2d 706, 707 (Ind. 1998) (holding that "[w]hatever a reasonable time means, it is surely not five years"). Certainly the Water Board's failure to develop 303(d) list regulations within 10 years is unreasonable and contrary to state law. *See MHC Surgical Ctr. Assoc., Inc. v. State Office of Medicaid Policy & Planning*, 699 N.E.2d 306, 309 (Ind. Ct. App. 1998) (holding that the agency failed to act within a reasonable time when it did not respond to plaintiffs' request for Medicaid services reimbursement filed four years prior); *see also Indiana State Highway Comm'n v. Zehner*, 366 N.E.2d 697, 698 (Ind. 1977) (requiring the agency to make an expeditious determination whether to pay a landowner's claim after three years had passed since the submittal of the claim). The Water Board's disregard for its non-discretionary duty and the ultimate absence of formal methodologies represent fundamental legal shortcomings of Indiana's impaired waters program. In the absence of adopted regulations and because of the Water Board's unreasonable delay, the 2010 Draft List must be invalidated.

III. IDEM's Widespread Application of Derived Water Quality Criteria Violates State Administrative Procedures

IDEM's intentional manipulation of the public's participation in its decision-making process is further evidenced by the agency's use of *derived* water quality values for aluminum and iron in the draft 303(d) list and Draft Busseron Creek TMDL. As discussed, Indiana water quality standards do not specify numeric criteria for these metals and IDEM calculated acute and chronic aquatic values for aluminum and iron in 2005 and 1997, respectively. These water quality values were developed outside of the state rulemaking process and were never subject to the rigors of public notice and comment. Indeed, that may explain why both water quality values are fraught with technical errors, as detailed above.

While state regulations may allow IDEM to derive water quality criteria without initiating a rulemaking in the event that state water quality standards do not identify a specific value, that authority is limited to discrete situations such as the development of individual permit limits. *See* 327 Ind. Admin. Code 2-1-6(a)(1)(E), (a)(2)(C). Indeed, IDEM recognizes the limit on its authority in the 2010 Draft List document. *2010 Draft List*, p. 29 (noting that the state methods for deriving water quality criteria are used by IDEM's NPDES Program "typically at the *request of permittees* in order to help develop *appropriate permit limits*") (emphasis added). Applying derived water quality criteria on such a large scale as the 303(d) list and Draft Busseron Creek TMDL is a serious abuse of IDEM's limited regulatory authority and runs afoul of Indiana law. When used to make 138 impairment determinations throughout the state and develop TMDLs for an entire watershed, derived water quality criteria categorically meet the state statutory definition of a "rule" and thus must be promulgated by the Water Board before IDEM may use them as metrics for state water quality. Moreover, derived water quality criteria cannot be deemed a lawful numeric translation of Indiana narrative water quality criteria because the narrative criteria, themselves, are unlawfully vague and the derived values cannot constitute an administrative interpretation.

A. Derived Water Quality Criteria Applied by IDEM are Rules that must be Adopted through Formal Rulemaking

The derived water quality values for aluminum and iron meet the definition of a "rule" under Indiana law when applied in such a comprehensive manner as the 303(d) listing and TMDL development processes. These values consequently must be promulgated pursuant to formal state rulemaking procedures. Indiana law defines a "rule" as the "whole or any part of an agency statement of general applicability that: (1) has or is designed to have the effect of law; and (2) implements, interprets, or prescribes: (A) law or policy; or (B) the organization, procedure or practice requirements of an agency." Ind. Code § 4-22-2-3(b). Derived water quality criteria used in the 303(d) listing process satisfy each element of this statutory definition – they are generally applicable, designed to have the effect of law, prescribe policy, and implement and interpret law – and thus constitute rules that must be formally promulgated. *See, e.g., Blinzinger v. Americana Healthcare Corp.*, 466 N.E.2d 1371, 1375 (Ind. Ct. App. 1984) (observing that rules, in contrast to an adjudication, "embrace[ ] an element of generality, operating upon a class of individuals or situations").

IDEM's proposed widespread application of these derived aluminum and iron water quality values exemplifies the expansive applicability of these values. These values were not developed for a specific permit or even a small subset of individual dischargers. Instead, IDEM has applied these derived water quality values in the broadest sense possible, using them to develop the state-wide 303(d) list and the watershed-wide Draft Busseron Creek TMDL. These derived values in turn will be incorporated into individual NPDES permits across the state. As a result, there is no discernible distinction between IDEM's application of these derived water quality values and the Water Board's formally promulgated numeric water quality criteria. Indeed, IDEM acknowledges in the 2010 Draft List that these values are "valid for use in *all* IDEM regulatory processes." *2010 Draft List*, p. 29 (emphasis added).

In addition to being "generally applicable" within the meaning of the Indiana Code, these derived water quality values undoubtedly have the "effect of law." As mentioned, these values are being used to determine water body impairments and prepare the state- and federally-approved 303(d) list, develop TMDLs, and establish legally-enforceable NPDES permit limits. Exceedance of these derived water quality values thus carries with it the same legal implications as other water quality standard violations.

Finally, these derived values "prescribe policy" and "implement and interpret law." Similar to formally-adopted numeric water quality criteria, these derived values indicate the "minimum surface water quality conditions" that all state waters must meet in order to protect the waters' designated uses. *See* 327 Ind. Admin. Code 2-1-6(a), 2-1-3. Since they are used by IDEM to develop the state's 303(d) list, TMDLs, and individual NPDES permit limits, these derived values also convey the agency's position on what constitutes an impaired water body. Likewise, these derived values are used to implement state and federal law, including Section 13-18-2-3 of the Indiana Code and Section 303(d) of the federal Clean Water Act, which require IDEM to prepare a list of impaired waters. *See* Ind. Code § 13-18-2-3; 33 U.S.C. § 1313(d).

Because the derived water quality values for aluminum and iron meet the statutory definition of a "rule" in this broad application, they must be formally promulgated by the Water Board, which is delegated exclusive rulemaking power for water quality matters. *See* Ind. Code § 13-18-3-1. In the absence of a formal rulemaking, IDEM's derived water quality criteria must be deemed invalid for such widespread application. *See Blinzinger*, 466 N.E.2d at 1375 (holding that the Indiana Department of Public Works' Medicaid freeze directive was "in the nature of a rule, and because it was not promulgated in compliance with statutory requirements, it is *void and without effect*") (emphasis added). To hold otherwise flouts the General Assembly's specific delegation of rulemaking authority and does away with the full range of due process safeguards built into Indiana's rulemaking process, including two 30-day public comment periods, IDEM's duty to evaluate and respond to comments, and a formal rulemaking hearing before the Water Board.[2] *See* Ind. Code §§ 13-14-9-2, 13-14-8-3, 4-22-2-23, 4-22-2-24, 4-22-2-27, 4-22-2-28. Developing water quality criteria outside of the formal rulemaking process also hinders the exchange of information that is critical to developing well-informed, scientifically sound, reasonable regulations that are based on the best available data and a thorough economic analysis that balances water quality priorities against economic impacts. *See* Ind. Code §§ 4-22-2-27 (requiring IDEM to fully consider all public comments), 13-14-9-4.2 (requiring IDEM to provide the Water Board with a fiscal impact statement of the proposed rule), 4-22-2-28 (requiring the Indiana Economic Development Corporation to review proposed rules and determine if alternatives exist). Furthermore, these procedures are a cornerstone of Indiana's regulatory process and place necessary limits on unelected administrative officials' decision-making. Therefore, until the aluminum and iron derived water quality values are promulgated through the formal rulemaking process, they cannot be used for the 303(d) listing process or the development of TMDLs. IDEM must revise its draft 303(d) list and Draft Busseron Creek TMDL accordingly.

B. Derived Water Quality Criteria Cannot be Applied as a Numeric Translation of Narrative Water Quality Criteria

In what appears to be an effort to validate its derived water quality values, IDEM asserts in the draft 303(d) list that these derived values are the "numeric translation" of already-promulgated narrative water quality criteria. *See 2010 Draft List*, p. 29. This explanation, however, is insufficient to cure the legal deficiencies associated with the fact that these values have not been formally adopted. The reason IDEM must "translate" the narrative criteria is because these provisions, standing alone, are vague and thus cannot be applied in any meaningful way. Neither IDEM nor a regulated discharger can review a narrative criterion and determine whether a particular water body is in compliance. These narrative water

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[2] IDEM and the Water Board have avoided many mandatory due process requirements, including the following: Twenty-eight days prior to the adoption of a rule, IDEM must publish a notice of intent to adopt a rule including the intent and scope of the proposed rule in the Indiana Register. *See* Ind. Code § 4-22-2-23(b). The full text of the proposed rule must be published in the Indiana Register and notice of a public hearing must be provided. Ind. Code § 4-22-2-24. A statement regarding the availability of any supporting material for the proposed rule must also be included. Ind. Code § 4-22-2-24(d). After publication of the proposed rule and notice of public hearing, IDEM must hold a hearing on the proposed rule. Ind. Code § 4-22-2-26. All comments received at the public hearing must receive full consideration from IDEM. Ind. Code § 4-22-2-27. The Water Board may not adopt a rule until it has conducted at least two 30-day comment periods. Ind. Code § 13-14-9-2. IDEM must provide the Water Board with a fiscal impact statement of the proposed rule prepared by the office of management and budget. Ind. Code § 13-14-9-4.2. The Indiana Economic Development Corporation ("IEDC") must review proposed rules to determine if alternatives exist to reduce the regulatory burden, and IDEM must respond to any comments the IEDC makes before the proposed rule can be adopted. *See* Ind. Code § 4-22-2-28. The final rule must be adopted within one year from the date that the notice of intent is published in the Indiana Register. Ind. Code § 4-22-2-25. After a rule is adopted, the agency must submit the rule to the attorney general and then the governor for approval. Ind. Code §§ 4-22-2-31, 4-22-2-33.

quality criteria are consequently unlawful, as Indiana law requires regulations to be stated with "sufficient precision" to ensure that members of the public, including the regulated community, understand what conduct is proscribed. *See Yater v. Hancock County Bd. of Health*, 677 N.E.2d 526, 530 (Ind. Ct. App. 1997). The ascertainable standards doctrine, as recognized by Indiana courts, prohibits agencies from promulgating a regulation that is so vague or "indefinite that persons of common intelligence must . . . guess at its meaning and differ as to its application." *Ind. State Ethics Comm'n v. Nelson*, 656 N.E.2d 1172, 1176 (Ind. Ct. App. 1995); *see also Sterling Mgmt.-Orchard Ridge Apartments v. State Bd. Of Tax Comm'rs*, 730 N.E.2d 828, 836-37 (Ind. Tax Ct. 2000). IDEM's narrative water quality criteria do not satisfy that test.

Deriving numeric criteria outside of the formal rulemaking process to "translate" the narrative criteria into concrete numeric limits does not resolve the illegality inherent in the narrative provisions. To do so would essentially replace narrative criteria with numeric criteria, which IDEM consistently insists it is unauthorized to do. According to IDEM, the agency cannot modify an existing water quality criterion without first undergoing a rulemaking. *See, e.g,* Development of Amendments to 327 Ind. Admin. Code 2-1-6 Concerning Sulfate Criterion in Waters of the State, LSA Document #07-185 ("The only option for revising a water quality standard contained in Title 327 is through rulemaking"). Accordingly, the numeric criteria used to "translate" the narrative water quality criteria must be formally promulgated.

Finally, the derived water quality criteria cannot be applied as a numeric translation of narrative water quality standards because these derived values impose new duties and thus do not constitute a lawful regulatory interpretation. Criteria that courts consider in determining whether an agency action is an interpretation that does not need to go through the formal rulemaking process include whether the agency action: (1) "presently imposes a binding obligation or norm on a regulated firm or individual;" (2) "genuinely leaves the agency and its decisionmakers free to exercise discretion;" (3) "establish[es] a binding norm;" and (4) imposes new and more stringent duties upon regulated entities. *See U.S. v. Zimmer Paper Prod., Inc.*, 20 Envtl. L. Rep. 20,556, 20,557-58 (S.D. Ind. 1989). Courts also consider whether the particular agency action is of the type that would benefit from the public comment process. *See Hoctor v. U.S. Dept. of Agric.*, 82 F.3d 165 (7th Cir. 1996). Based on these criteria, it is clear that IDEM's derived water quality values do not constitute administrative interpretations. Application of these derived values eliminates agency discretion in assessing water quality. While IDEM has nearly unfettered discretion in evaluating water quality based on narrative standards, a translation into a specific numeric value leaves IDEM with no decision-making flexibility. In addition, the derived water quality values are a necessary and essential part of the TMDL development process, which imposes binding discharge limits on regulated entities (as incorporated into individual NPDES permits). The derived water quality values thus constitute an agency action that must be developed through a formal rulemaking.

IV. The 303(d) List Compounds the Legal Problems Identified in the Draft Busseron Creek TMDL

IDEM's disregard for proper legal procedure is further evidenced by its premature development of and reliance on the Draft Busseron Creek TMDL. The proposed 303(d) list comes on the heels of that TMDL development process. As the ICC discussed in a previous memorandum submitted to IDEM on October 3, 2008, the Draft Busseron Creek TMDL includes limits for aluminum and iron, even though the constituents were not previously identified as impairments for those water segments during IDEM's 303(d) listing process that preceded the draft TMDL. *See* Attachment 8. The ICC challenged this agency action on legal and technical grounds, correctly arguing that the Draft Busseron Creek TMDL was inconsistent with the Clean Water Act and applicable regulations. Specifically, IDEM improperly circumvented the 303(d) listing process and consequently failed to provide the public with its vital opportunity to review and comment on the water quality criteria and, in turn, the basis for any impairment determinations. While IDEM did not revise the Draft Busseron Creek TMDL in any meaningful way in response to the ICC's comments, the Indiana General Assembly subsequently recognized the legal deficiencies of this process. Legislation has been adopted to ensure that the public is afforded a real and legitimate opportunity to comment on these fundamental water quality determinations before being subjected to enforceable regulations. *See* Ind. Code § 13-18-2(d), (e) (requiring IDEM to initiate a new public comment period before developing a TMDL for an impairment not previously included on the state's 303(d) list).

Despite the ICC's previous comments on the draft TMDL and the state legislative response, IDEM's draft 303(d) list exacerbates the legal problems identified with the Draft Busseron Creek TMDL. The proposed 303(d) list is based on five categories of water bodies, which EPA encourages states to use to facilitate the 303(d) listing process and help monitor progress in developing TMDLs for listed waters. *See Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act*, § V, EPA (2005); *see also 2010 Draft List*, p. 2. For purposes of these comments, the relevant categories include "Category 5," which covers water bodies that are not meeting water quality standards and will require a TMDL. These waters comprise the 303(d) list, which informs IDEM's TMDL development priorities. Waters that have been identified as impaired and have a TMDL in place are classified as "Category 4A" waters. Finally, waters for which there is insufficient data to determine water quality status are placed in "Category 2 or 3."

Indiana Coal Council Comments on IDEM's 2010 Draft 303(d) List

As part of IDEM's 303(d) listing process, the agency proposes to move 52 water body segments that fall within the Busseron Creek watershed from Category 2 or 3 directly into Category 4A. Fifteen of these water segments are allegedly impaired by aluminum or iron. These water segments thus have never been included on the 303(d) list as Category 5 waters for these particular impairments. These waters also have not been subject to public and federal review regarding the identified impairments. IDEM's proposal is based solely on the Draft Busseron Creek TMDL, which was prematurely developed, has not received final state approval, and has yet to be submitted to EPA. IDEM's proposal to simultaneously classify these 52 water segments as Category 4 and issue the Draft Busseron Creek TMDL thus sabotages the clear process established by the Clean Water Act and presents the impairment determinations as a fait accompli.

This abuse of agency authority cannot stand. The Clean Water Act establishes a clear process that must occur in sequence, which state water quality managers must follow when addressing their impaired waters. These steps are vital to realizing the objective of the Clean Water Act to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a). These steps also form the foundation of the Clean Water Act's water quality-based approach to pollution control, which "emphasizes the overall quality of water within a water body and provides a mechanism through which the amount of pollution entering a water body is controlled based on the intrinsic conditions of that body of water and the standards set to protect it." *Water Quality Handbook*, Chpt. 7, EPA, (2007).

The statutory and regulatory provisions make clear that IDEM's impairment determination must precede TMDL development. This decision-making sequence is especially critical for the alleged aluminum and iron impairments since no numeric water quality criteria exist in the state regulations and the limits have been calculated by IDEM outside of the formal rulemaking process. In particular, Section 303(d)(1)(A) of the Clean Water Act requires each state to identify those water bodies not meeting the state's water quality standards, identify the constituents responsible for those impairments, and prioritize that list based on the severity of pollution and the particular water body's designated uses. 33 U.S.C. 1313(d)(1)(A). Moreover, Section 303(d)(1)(C) of the Act provides that each state must establish TMDLs at a level *necessary* to implement *applicable* water quality standards (*i.e.*, those which are not being met by the listed water body). 33 U.S.C. § 1313(d)(1)(C). EPA's regulations, in turn, require each state to develop TMDLs for *all constituents* preventing attainment of water quality standards *as identified* in the 303(d) list. 40 C.F.R. 130.7(c)(ii). This statutory and regulatory language thus emphasizes the connection envisioned by Congress and EPA between state water quality standards, the 303(d) list, and TMDL parameters. Ultimately, it is the 303(d) list and the applicable state water quality criteria for listed impairments that determine the content of a TMDL. IDEM, however, has disregarded that approach for the 52 Busseron Creek water segments, instead identifying those impairments outside of the 303(d) listing process in violation of the Clean Water Act.

Built into this legally-required sequence of events are required opportunities for the public and EPA to review and provide comments on the impairments proposed in a state's 303(d) list before the state proceeds with the development of a TMDL. Prior to issuing its 303(d) list as final, the state must first make the list available for public comment. 40 C.F.R. 130.7(a); *see also* Ind. Code § 13-18-2-3(a) (requiring a 90-day public comment period on IDEM's proposed 303(d) list). Then, once the 303(d) list is final, the state must submit it to EPA for its review and affirmative approval. 40 C.F.R. 130.7(d); Ind. Code § 13-18-2-3(a). IDEM has inexplicably and unlawfully sidestepped this valuable public involvement and federal agency review. Specifically, by moving 52 Busseron Creek water segments from Category 2 or 3 to Category 4A based on determinations made outside of the 303(d) listing process, IDEM has skipped the rigorous public review of the water quality criteria and the agency's impairment determinations. IDEM also has skirted EPA's review and approval of the same. Moreover, IDEM is in violation of the new state statutory provision, which requires the agency to initiate a new public comment period before developing a TMDL for an impairment not previously included on the state's 303(d) list. *See* Ind. Code §§ 13-18-2-3(d), (e).

The public comments currently being solicited by IDEM on its proposed 303(d) list and the public comments solicited last year on the Draft Busseron Creek TMDL cannot cure these fundamental procedural deficiencies. First, since the Category 4A determination and supposed issuance of the Draft Busseron Creek TMDL are occurring in close succession, if not simultaneously, the identified impairments for the 52 water segments within the Busseron Creek watershed are effectively already determined and not truly amenable to change. Second, although the ICC's comments on last year's draft TMDL addressed the newly-identified impairments, the ICC also recognized that the TMDL development process was not well-suited to assess underlying impairments. The impairments are to be established during the 303(d) listing process and should be able to be taken as a given at the TMDL stage. Third, and most importantly, courts have consistently held that an opportunity for public participation after-the-fact rarely satisfies an agency's notice and comment obligations. *See, e.g., Air Transport Ass'n v. Dep't of Transp.*, 900 F.2d 369 (D.C. Cir. 1990). Notice and comment must precede agency decision-making to ensure not only that the agency benefits from the expertise and input of commenting parties, but also that the agency maintains a flexible and open-minded attitude towards its own decisions. *Nat'l Tour Brokers Ass'n v. Interstate Commerce Comm'n*, 591 F.2d 896, 902 (D.C. Cir. 1978). Courts have found that agencies are not likely to be receptive to suggested changes once they put their credibility on the line in the form of formal rules. *Id.*; *see also Air Transp. Ass'n*, 900 F. 2d at 379. Indeed, that is the primary concern here where IDEM will have to redraft significant portions of its Draft Busseron Creek TMDL if it seriously considers our technical comments on the underlying impairments. In addition, if post hoc public comments could cure this deficiency, then an agency could "negate at will the Congressional [and EPA] decision that notice and an opportunity for comment must precede promulgation." *Sharon Steel Corp. v. EPA*, 591 F.2d 377, 381 (3d Cir. 1979).

CONCLUSION

Based on the significant technical and legal deficiencies detailed above, it is clear that the proposed 303(d) list is arbitrary and capricious, represents an abuse of agency discretion, and is otherwise contrary to federal and state law. IDEM's impairment determinations and proposed 303(d) list are based on internal policy documents that are not publicly available and have not be subject to public review and comment. The public's role in this process has been further diminished in IDEM's 303(d) listing effort where the agency appears to have gone to great lengths to obfuscate its decision-making by incorrectly and imprecisely using key legal terms throughout the 2010 Draft List document. However, one thing is clear: IDEM has proposed to use water quality values that bear no rational relationship to the protection of designated uses, do not appropriately consider stream conditions including pH, hardness, toxicity, and naturally-occurring background concentrations, and, when applied, result in exceedances throughout the state, including in otherwise healthy water bodies. Of course, it is not surprising that these water quality values are unachievable on a state-wide basis, since they were informally derived outside of the formal rulemaking process in plain violation of Indiana law.

The 2010 Draft List, as proposed, must therefore be invalidated. Before IDEM may proceed with its 2010 impairment determinations anew, the Water Board must fulfill its non-discretionary obligation to promulgate regulations that detail the 303(d) listing methodologies for IDEM to follow. IDEM must also revise the aluminum and iron water quality values consistent with state and federal law and acceptable scientific methodologies for the Water Board to adopt in a formal rulemaking. Only then may IDEM proceed with its aluminum and iron impairment assessments. In revising the 303(d) list, an additional hearing before the Water Board should also be held. IDEM first presented the 303(d) list to the Water Board in December 2009, more than two months before the end of the public comment period. Given the volume and complexity of information that members of the regulated community have had to review to develop informed public comments, a second hearing should be held following the end of the public comment period to ensure that all information is provided for the Water Board's review. Indeed, a second hearing would be consistent with IDEM's decision to extend the public comment period by a month.

Moreover, holding a Water Board hearing before the expiration of the public comment period is premature and contrary to Indiana law, which outlines a three step process that IDEM must follow in finalizing its list of impaired waters. This process begins with publishing the list in the Indiana Register, is then followed by making the list available for public comment, and then the process concludes with a presentation of the list to the Water Board. Ind. Code § 13-18-2-3(a). Finally, the Draft Busseron Creek TMDL must be revised after the finalization of the 303(d) list to realign IDEM's decision-making process with that contemplated by the Clean Water Act. That is the only way to ensure that important and highly relevant technical issues are properly considered and used to inform the limits imposed by the TMDL. If IDEM proceeds as proposed, then the agency will be denying the public and EPA their obligatory right to meaningfully participate in the process – an extraordinary overreaching of authority by IDEM in violation of state and federal law.

1

ATTACHMENT 1

GEI Consultants

Geotechnical
Water Resources
Environmental and
Ecological Services

Ambient Water Quality Standards for Aluminum – Review and Update

Submitted to:
Colorado Mining Association
Denver, Colorado 80202

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October 2009

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1.0 Introduction

At the request of the Colorado Mining Association, GEI Consultants, Inc (GEI), Ecological Division, has evaluated the technical basis for current water quality standards for aluminum (Al) for the protection of aquatic life, based on the United States Environmental Protection Agency (USEPA) criteria derivation and recalculation procedures (Stephan et al. 1985, USEPA 1994). This analysis was initiated using the existing criteria document and national Al toxicity databases (USEPA 1988), which are the basis for current Colorado surface water quality standards.

The purpose of this analysis was to revise and update acute and chronic Al standards using the USEPA criteria derivation methods. This report is based primarily on an overall evaluation of the USEPA recalculation procedure for Arid West effluent-dependent waters (AWWQRP 2006), which included an analysis of potential updates to Al standards. The first step of any USEPA recalculation procedure is a technical review of the most up-to-date USEPA ambient water quality criteria (AWQC) document to determine if 1) suitable and correct data were included in national toxicity databases and 2) USEPA criteria development methods were followed for deriving standards. USEPA Guidelines for Deriving Numerical Water Quality for the Protection of Aquatic Organisms and their Uses (Stephan et al. 1985), hereafter referred to as 1985 Guidelines, provide details on the acceptable data and criteria derivation methods, including minimum data requirements for the toxicity database, often referred to as the "eight-family rule" (Stephan et al. 1985). The next step is an update of national toxicity databases, with an emphasis on literature available since the most recently published databases. Following the compilation of literature and development of the revised database, each acute and chronic standard is recalculated using methods described in the 1985 Guidelines.

The USEPA established national aquatic life criteria for Al in a 1988 report entitled *Ambient Water Quality Criteria for Aluminum* (USEPA 1988), hereafter referred to as the 1988 Aluminum Document. This document established a working toxicity database with recommended AWQC to protect freshwater organisms. This report and its accompanying recommended AWQC for Al are now 21 years old. Since publication of this report, information on the environmental significance of freshwater organism Al exposure and available toxicity studies has increased, allowing an update to these AWQC.

2.0 Background

Aluminum is the most abundant metal and the third most abundant element in the earth's crust. As such, it is commonly found in waterways as a result of natural runoff, erosion of clay-based soils, and other geologic sources. Acid rain deposition has dramatically increased the amount of Al appearing in many biological systems, increasing exposure of soluble Al to aquatic species. Other anthropogenic sources include wastewater effluent (from pharmaceuticals, cooking practices, water supplies, and aluminum-sulfate (alum) flocking of drinking water supplies or phosphorus removal in effluent, burning of coal and hydrocarbons, and suspension of fine dusts during agricultural practices (AWWQRP 2006).

Aluminum water solubility is a function of pH. In the neutral pH range, the thermodynamic stability of Al hydroxide, or gibbsite ($Al(OH)_3$), controls solubility with little monomeric Al^{3+} in solution (Gensemer and Playle 1999). Monomeric Al^{3+} becomes more available relative to gibbsite at pH < 4.7 and pH > 9. At circumneutral pH range, total Al is usually much greater than monomeric species (Gensemer and Playle 1999). Al solubility is also dependent on organic compounds in solution. At circumneutral pH ranges, dissolved organic matter, and especially weak organic acids (e.g., fulvic, citric, and humic acids), can increase Al solubility while decreasing aquatic organism toxicity. This is an important transport mechanism in Al cycling (Schlesinger 1997).

These complex speciation and complexation kinetics raise issues of how to measure Al in natural water and/or toxicity test media. Filtration and ion exchange resins are used to separate monomeric dissolved Al from particulate and polymeric forms (Van Benschoten and Edzwald 1990). Rapid speciation of Al in test solutions can be a potential problem when determining solid and dissolved species. Analytical and technical issues when characterizing dissolved from total Al in complex solutions are limited using kinetic modeling. Many authors use theoretical calculations such as REDEQL (Morel and Morgan 1972) and later replaced by MINEQL (Environmental Research Software, Hallowell, ME) that model speciation in relation to water quality parameters and total Al measurements (Lamb and Bailey 1981, Cleveland et al 1989, and Lacroix et al. 1993). Given these physical and methodological issues, USEPA originally recommended that the toxicity values for Al be regarded as total Al (USEPA 1988). However, for calculation of standards from hardness-based equations, a total recoverable Al standards basis would be over-conservative, because it would likely include Al bound in minerals, clays, and other solids fractions that are not toxic and are not likely to become toxic under natural conditions.

The 1988 Aluminum Document recommends Al criteria should be implemented on the basis of "acid-soluble" Al. While the existing Colorado standards *values* are consistent with those in the 1988 Aluminum Document (USEPA 1988), the Colorado standards are expressed on a total-recoverable Al basis. According to USEPA criteria, the acid-soluble basis is "the Al that passes through a 0.45μm membrane filter after the sample has been acidified to a pH between1.5 and 2.0 with nitric acid" (USEPA 1988). Expressing the Al standards on this basis would seem to have both toxicological and practical advantages because it captures a more complete fraction of potentially toxic Al species (when compared to only the dissolved fraction). However, there does not appear to be a current USEPA-approved methodology for the acid-soluble approach.

While a "dissolved Al" methodology might not be the absolute best approach for the revised hardness-based equations presented in this report, the characteristics of Al allow for the use of a dissolved method to reliably measure potential Al toxicity. Colloidal Al is able to pass through a 0.45 μm filter and would be included in "dissolved" measurements when it is not actually "dissolved" (as cited in Hem 1985). In fact, it is likely those colloidal particles are actually included in current dissolved data and may represent much of the fraction USEPA believes would be captured by the acid-soluble methodology recommended in the 1988 Aluminum Document. As such, we believe the dissolved Al approach is appropriate for the proposed standards updates below. Furthermore, studies reporting results in both total and dissolved aluminum in the aluminum toxicity database. Half of the data for the top four most sensitive species, on which the criteria calculations are based, are reported as dissolved concentrations.

The speciation and/or complexation of Al is highly dependent on ambient water quality characteristics and ultimately determine the mechanism of toxicity. Wilkinson and Campbell (1993) demonstrated the difficulty of determining Al speciation in complex solutions – such as natural waters with abundant Dissolved Organic Carbon (DOC) and silicic acid – when determining mechanisms of toxicity in fish. The primary target of Al toxicity in fish is damage to respiratory organs, such as gills (Lacroix et al. 1993). The chemical conditions at the gill surface are thought to modify Al speciation and sorption. Water passing over the gills can become more basic due to neutralization of acidic water by NH_3. This can lead to precipitation and polymerization of Al, resulting in Al deposition on the gill surface. Accumulation of Al on the gill surface epithelium and/or mucous layer has been shown to enhance rates of sloughing and hyperplasia of lamellae (Leivestad 1982). The ionoregulatory versus respiratory effects of Al on fish are pH-dependent, with the former predominating at relatively acidic pH (Gensemer and Playle 1999). Additionally, concentration of calcium in the water was shown to decrease toxic effects to fish (Muniz and Leivestad 1980). Calcium reduces Al toxicity by competing with monomeric Al binding to negatively charged fish gills and by keeping tight junctions between epithelial cells intact (Gensemer and Playle 1999).

The number of toxicity tests addressing Al toxicity in aquatic invertebrates is considerably less when compared to fish, but, in general, results indicate invertebrates are less sensitive than fish (Sparling and Lowe 1996). Mechanisms of toxicity are confounded by H+ toxicity when testing at low pH, but published evidence supports ionoregulatory effects of Al exposure. Different H+ exchange mechanisms in different invertebrates can have different impacts on their pH-dependent Al toxicity (Gensemer and Playle 1999). Havens (1990) identified significant accumulation of particulate Al on ionoregulatory and respiratory surfaces in cladocerans. Additionally, increased membrane permeability with subsequent ion loss has been reported in acid sensitive invertebrate species (Locke 1991). In mayflies, Al accumulation on respiratory surfaces reduced oxygen consumption due to physical blockage of gill chambers (Rockwood et al. 1990).

From our understanding of Al toxicity, we can identify two distinctly different mechanisms of toxicity. The first mechanism is a physical suffocation or irritation caused by particulate Al exposure, or from precipitation in the gill microenvironment (Gensemer and Playle 1999), leading to hypoxia-related toxic effects that often become manifest during acute exposure scenarios. The second mechanism is driven by dissolved monomeric Al species that disrupt ionic regulation, an effect expected with a chronic exposure regimen (although acute effects could also be observed at acidic pH). Given Al speciation and behavior in complex solutions, the mechanism responsible for toxicity will probably be dependent on pH and calcium concentration of a given solution. Therefore, understanding Al speciation chemistry and its influence on the mechanisms of toxicity to fish and invertebrates are important to interpreting the toxicological studies which form the basis of ambient water quality standards development (AWWQRP 2006).

3.0 Phase I – Technical Review of 1988 Aluminum Document

Phase I of the evaluation of the 1988 Aluminum Document consists of a thorough investigation of the data used to calculate the most recent Al standards. This document was critically reviewed for relevance of the toxicological data and adherence to USEPA methodology (Stephan et al. 1985).

3.1 Existing Acute Standards for Aluminum

The 1988 Aluminum Document (USEPA 1988) presents acute data for 14 genera, including seven species of invertebrates and seven species of fish. These 14 species in 11 families satisfy the "eight-family rule" as specified in the 1985 Guidelines. The 1988 Aluminum Document reports a calculated final acute value (FAV) of 1,496 µg/L with a criterion maximum concentration (CMC) = FAV/2 or 750 µg/L (after rounding to two significant digits).

When reviewing the reported values used in the USEPA criteria development, an apparent discrepancy regarding the species mean acute value (SMAV) for *Girardia* (= *Dugesia*) *tigrina* (AWWQRP 2006) was discovered. The authors of the toxicity test data for this species reported that the greatest Al exposure concentration for this species was 16,600 µg/L (Brooke 1985) with the ambient acute value of >16,600 µg/L, since no significant mortality was observed. However, the 1988 Aluminum Document reports >23,000 µg/L for the same species and reference. The implications of this discrepancy could be significant and would result in a *Girardia* genus mean acute value (GMAV) rank change from 6th most sensitive to 4th most sensitive. Charles Stephan, USEPA, (personal communication to David Moon, December 13, 2004) has since noted that no *G. tigrina* died at 16,600 µg/L in that study, so it was reasonable to assume that the "true" LC_{50} was potentially two times the concentration that caused a low level of acute mortality (i.e., 32,000 µg/L) – with the "real" value somewhere in between. As such, the geometric mean of 16,600 µg/L and 32,000 µg/L was then reported in the criteria document as the acute value (i.e., >23,000) for *Girardia* to account for the undefined test value.

Since the 1988 Aluminum Document was published, new data became available suggesting the undefined value (>16,600 µg/L) may actually be more appropriate. Calevro et al. (1998) tested Al toxicity in a related flatworm (*G. etrusca*) and reported that this species showed lethality, abnormal mucus production, and decreased regeneration at concentrations near 16,000 µg/L. Therefore, in this re-analysis, the existing >23,000 value is replaced with Brooke's original reported value of >16,600 µg/L for *G. tigrina*.

3.2 Existing Chronic Standards for Aluminum

The 1988 Aluminum Document presents chronic data for three genera of freshwater organisms, including two species of invertebrates and one fish species. These three species do not satisfy the "eight-family rule" as specified in the 1985 Guidelines. The chronic database assemblage did, however, satisfy the minimal requirements for calculation of an acute-to-chronic ratio (ACR) in that one of the invertebrates is an acutely sensitive species.

After calculation of three valid ACRs for the three species, it was evident that the most acutely sensitive species had lower ACRs. Given this relationship, a final ACR (FACR) was calculated using acutely sensitive *Ceriodaphnia dubia*, which resulted in a FACR that was less than 2, which then defaults to 2 according to USEPA guidance (Stephan et al. 1985). A FACR of 2 thus resulted in a chronic criterion of 750 µg/L, equal to the acute criterion, since in both cases the FAV was divided by 2.

However, USEPA did not use this calculated chronic value. Additional data on Al toxicity for *Salvelinus fontinalis* and *Morone saxatilis* (Cleveland et al. manuscript and Buckler et al. manuscript) were used by the USEPA to modify the final chronic value (FCV) to protect these two species (USEPA 1988). Interestingly, these two studies were deemed inappropriate for the Al chronic database (i.e., they are included in Table 5-6, "Other Data on Effects of Aluminum on Aquatic Organisms"), but were still used to reduce the FCV from approximately 750 to 87 µg/L.

Therefore, the 1988 Aluminum Document recommended a Criteria Chronic Concentration (CCC) of 87 µg/L at which no *M. saxatilis* died after a seven-day exposure (Buckler et al. manuscript). In the same toxicity test, 174.4 µg/L killed 58 percent of the fish. Criteria derivation methods would typically calculate the chronic value as the geometric mean of these two numbers, or 122 µg/L. However, the 87 µg/L chronic criterion was recommended and is the current value used in Colorado.

4.0 Phase II – Update to the National Aluminum Database

A comprehensive literature review was recently conducted of Al aquatic toxicity related documents used and not used in the 1988 Aluminum Document (AWWQRP 2006). This included a review of documents published since the 1988 Aluminum Document, as well as those published prior to 1988 that were not used in criterion derivation. Available Al documents were obtained and reviewed for relevance of toxicological data and adherence to USEPA criteria development methodology (Stephen et al. 1985).

A pH range of 6.5 to 9.0 was established as a limit for data used in the update of the Al toxicity databases because the USEPA has established this as an acceptable range for pH in ambient freshwater (USEPA 1976). This circumneutral pH gradient was the same range used to derive current criteria in the 1988 Aluminum Document. From the discussion on Al speciation above, we would thus expect that toxic effects of Al in test media of circumneutral pH could be attributed to exposure to monomeric Al species. Additionally, reported total Al measurements should be substantially greater than dissolved measurements owing to the poor solubility of Al under these pH conditions.

Approximately 120 papers were reviewed, including documents cited in the 1988 Aluminum Document. We also reviewed three specific papers (Baker and Schofield 1982, Dwyer et al. 1995, and Dwyer et al. 2005) later recommended in 2007 following a preliminary review of the AWWQRP (2006) analysis of the Santa Ana River, CA, Al case study by Luis A. Cruz (Ecological Risk Assessment Branch, Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, DC – personal communication). Those three additional papers yielded no useable data for the updated Al database.

Much of the research into Al toxicity in aquatic organisms has been concerned with toxicity of Al in acidic solutions – specifically in research investigating effects of acid rain – with considerably fewer studies addressing toxic effects at circumneutral pH. Published reports that tested aquatic organism toxicity at circumneutral pH solutions often did so as part of tests over a wider range of acidic pH values. For example, a common experimental design in published Al toxicity studies was limiting the number of treatments and replicates at higher pH values to focus on lower pH values where Al is soluble and hence, more toxic. This experimental design resulted in very few data points with usable LC_{50}s or EC_{50}s (based on a narrow dose response within the applicable pH range of 6.5-9.0). In addition, given that most available research was conducted to test toxicity over a pH range using a constant Al exposure concentration, rather than over an Al concentration gradient, reportable end points for Al were often "greater than" values. Such undefined values were added to the toxicity database judiciously, if they could be corroborated by additional sources of published evidence, and after careful consideration of the author's qualitative effect descriptions. This aided in developing an updated Al toxicity database that did not ignore potentially important toxicity data.

4.1 New Aluminum Acute Toxicity Data

Following review of the available studies, 35 acute data points from 13 studies (Table 1) were deemed suitable for addition to the revised and updated acute toxicity database. Of the 13 studies added to the database, three were published prior to the 1988 Aluminum Document. One of these studies published prior to the 1988 Aluminum Document were not cited in either Table 1, "Acute Toxicity of Aluminum to Aquatic Animals," or Table 6, "Other Data on Effects of Aluminum on Aquatic Organisms" in the 1988 Aluminum Document and apparently represent data that were unknown to the USEPA at that time.

Of the 13 studies examined and accepted for database revision, two studies provided new data for two species that are within the top four most sensitive genera in the revised database (*Asellus aquaticus* and *Tubifex tubifex*). Martin and Holdich (1986) performed acute toxicity tests with *A. aquaticus* to a variety of heavy metals, including Al. Static renewal test exposures were conducted in soft water (hardness 50 mg/L $CaCO_3$) at a pH of 6.75. Khangarot (1991) performed acute toxicity tests with *T. tubifex* to 32 metals, including Al. Renewal test exposures were conducted in hard water (hardness 245 mg/L $CaCO_3$) at a pH of 7.6. Reported results included 96-hr LC_{50}s for both tests.

In addition to the single *Ceriodaphnia dubia* (McCauley et al. 1986) data point presented in the 1988 Aluminum Document, two more acceptable acute values are available from McCauley et al. (1986). While an LC_{50} value of 1,900 µg/L (test pH = 7.42) from this study was included in the 1988 Aluminum Document, McCauley et al. (1986) also provided two additional LC_{50} values of 1,500 µg/L (test pH = 7.86) and 2,560 µg/L (test pH = 8.13). These data were added to the updated acute database (Table 1).

While studies reporting data for the rainbow trout (*Oncorhynchus mykiss*) and smallmouth bass (*Micropterus dolomieu*) were found, data from these studies were determined to be unusable (Thomsen et al. 1988, Kane and Rabeni 1987, respectively). In the Thomsen et al. (1988) study, hardness data were not provided; instead, only calcium water quality data were provided. In addition, there is some uncertainty regarding the actual duration of the study. In the Kane and Rabeni (1987) study, the highest effect level observed was 20%, which is considerably far away from an LC_{50}. Due to the uncertainty in the accuracy of this value, and the fact that *Micropterus* would fall in the lowest four GMAV values and thus be an extremely important driver in the standards calculations, this questionable data point was not used.

Table 1: Summary of acute Al data that were deemed acceptable for standards derivation and added to the updated Al acute database.

Species	Method	Hardness (mg/L $CaCO_3$)	pH	LC_{50} (µg/L)	Reference
Ictalurus punctatus	F, M	23.1	6.5	>400	Palmer et al. 1988
Ictalurus punctatus	F, M	23.1	7.5	>400	Palmer et al. 1988
Oncorhynchus mykiss	F, M	25	7.6	<8,000	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	45	7.6	<8,000	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	85	7.6	<8,000	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	125	7.6	<8,000	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	23.2	8.25	6,170	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	35	8.25	6,170	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	83.6	8.29	7,670	Gundersen et al. 1994
Oncorhynchus mykiss	F, M	115.8	8.29	6,930	Gundersen et al. 1994
Pimephales promelas	F, M	21.6	6.5	>400	Palmer et al. 1989
Pimephales promelas	F, M	21.6	7.5	>400	Palmer et al. 1989
Pimephales promelas	F, M	21.6	6.5	>400	Palmer et al. 1989
Pimephales promelas	F, M	21.6	7.5	>400	Palmer et al. 1989
Pimephales promelas	F, M	23.1	6.5	>400	Palmer et al. 1988
Pimephales promelas	F, M	23.1	7.5	>400	Palmer et al. 1988
Pimephales promelas	S, M	26	7.8	1,160	ENSR 1992b
Pimephales promelas	S, M	46	7.6	8,180	ENSR 1992b
Pimephales promelas	S, M	96	8.1	20,300	ENSR 1992b
Pimephales promelas	S, M	194	8.1	44,800	ENSR 1992b
Crangonyx pseudogracilis	S, U	50	6.75	9,190	Martin and Holdich 1986
Asellus aquaticus	S, U	50	6.75	4,370	Martin and Holdich 1986
Gammarus pulex	S, U	--	6.9	>2,698	Storey et al. 1992
Ceriodaphnia dubia	S, M	26	7.5	720	ENSR 1992a
Ceriodaphnia dubia	S, M	46	7.6	1,880	ENSR 1992a
Ceriodaphnia dubia	S, M	96	7.8	2,450	ENSR 1992a
Ceriodaphnia dubia	S, M	194	8.1	>99,600	ENSR 1992a
Ceriodaphnia dubia	S, M	98.5	7.6	2,880	Soucek et al. 2001
Ceriodaphnia dubia	S, M	50	7.86	1,500	McCauley et al. 1986
Ceriodaphnia dubia	S, M	50	8.13	2,560	McCauley et al. 1986
Ceriodaphnia sp.	S, M	47.4	7.36	2,300	Call 1984
Cyclops viridis	S, U	--	6.9	>2,698	Storey et al. 1992
Salmo salar	S, M	6.8	6.5	599	Hamilton and Haines 1995
Tubifex tubifex	R, U	245	7.6	50,230	Khangarot 1991
Hybognathus amarus	S, M	140	8.1	>59,100	Buhl 2002

NOTES:
S = static renewal test exposures
F = flow-through test exposure
R = renewal test exposure
M = test media aluminum concentration was measured
U = test media aluminum concentration was not measured

In addition to the acute test results, water quality parameters in toxicity tests were also added to the updated Al database. Test solution pH and hardness values were needed to determine inclusion of data within the specified circumneutral pH range and to investigate a possible relationship to general water quality parameters, such as hardness. Most of the added studies reported hardness values of test media or reported calcium and magnesium concentrations that were used to calculate water hardness.

Of the 35 new acute data points, two provided insufficient information on water quality parameters to determine test media hardness. Unfortunately, each was for a unique species (*Cyclops viridis* and *Gammarus pulex*) found in the updated database that subsequently had to be removed during FAV derivation (see discussion below).

4.2 New Aluminum Chronic Toxicity Data

Following review of the available studies, 11 new chronic data points from nine studies (Table 2) were added to the revised chronic database. Of the nine studies added to the database, seven were published prior to the 1988 Aluminum Document. Three studies published prior to the 1988 Aluminum Document were not cited in either Table 1 ("Chronic Toxicity of Aluminum to Aquatic Animals") or Table 6 ("Other Data on Effects of Aluminum on Aquatic Organisms") of the 1988 Aluminum Document and apparently represent data that were unknown to the USEPA at the time. Four publications that were found in Table 6 ("Other Data") in the 1988 Aluminum Document were re-reviewed and deemed appropriate for use in updating the chronic database, as described below.

Table 2: Summary of chronic Al data that were deemed acceptable for standards derivation and added to the updated Al chronic database.

Species	Hardness (mg/L $CaCO_3$)	pH	NOEC- LOEC (µg/L)	Chronic Value (µg/L)	Reference
Ceriodaphnia dubia	50	7.75	1,100-2,400	1,624	McCauley et al. 1986
Ceriodaphnia dubia	47.4	7.55	6,250-12,100	8,696.26	Call 1984
Daphnia magna	45.3	7.74	--	320[a]	Biesinger and Christenson 1972
Daphnia magna	45.3	7.74	--	1,400[b]	Biesinger and Christenson 1972
Tanytarsus dissimilis	17.43	6.8	10,000-80,000	28,284	Lamb and Bailey 1981
Salvelinus fontinalis	12.5	7.2	>303.9	>303.9	Cleveland et al. 1991
Salvelinus fontinalis	7.5	6.5	169-350	243.21	Cleveland manuscript
Salvelinus fontinalis	12.5	6.5	57-88	70.82	Cleveland manuscript
Salvelinus fontinalis	7.5	6.5	88-169	122	Cleveland et al. 1989
Salvelinus fontinalis	0.567	7.81	0-300	<300	Hunn et al. 1987
Micropterus dolomieu	12.8	7.3	0-250	<250	Kane and Rabeni 1987

NOTES:
[a]EC_{16} for reduced reproduction
[b]21 day LC_{50}
NOEC = no observable effect concentration
LOEC = lowest observable effect concentration

Biesinger and Christensen (1972) performed acute and chronic Al toxicity tests with *Daphnia magna*. Acute toxicity results were included in the USEPA acute database; yet, no explanation was given as to why chronic data from this same study were not included in the chronic database. We reviewed methods used for the chronic toxicity tests and could not find a reason to exclude these data. Therefore, two chronic values from this study were added to the database. Data from this publication were also deemed suitable for inclusion in the FACR derivation, described later.

In a 55-day Al exposure study, Lamb and Bailey (1981) tested acute and chronic toxicity in *Tanytarsus dissimilis*. The authors reported high variability in mortality rates among treatments and provided little information on statistical significance of mortality among treatments. Fortunately, a figure showing the cumulative percent mortality was provided and analyzed with information in the text to derive a chronic value of 10,000 μg/L, representing the treatment level that produced 37 percent mortality.

The Cleveland manuscript, used to lower the 1988 Aluminum Document chronic criterion, contained additional data for *Salvelinus fontinalis* that were not reported in the USEPA chronic databases. These additional chronic values were incorporated into the revised chronic database (AWWQRP 2006). *S. fontinalis* were exposed to Al in soft water with a pH of 6.5, the lowest pH in the acceptable circumneutral range. The chronic value was determined for a statistical difference in two chronic endpoints: length (growth) and mortality. The growth value was more sensitive than mortality (243 μg/L) and resulted in a chronic value of 70 μg/L in soft water.

Hunn et al. (1987) investigated influence of pH and Al on early life stages of developing *S. fontinalis*. Only two treatments, the control and 283 μg/L, were used in a 60-day larvae toxicity test using flow through exposure with very soft water. The authors reported a statistical decrease in growth ($p<0.001$) between treatment and control using a least squares deviation linear model with interaction terms representing treatment effects. Since a geometric mean could not be determined, a chronic value of <283 μg/L was added to the revised chronic database.

Five additional studies with appropriate toxicity tests were found that were not listed in the 1988 Aluminum Document. Three of these publications were published after the 1988 Aluminum Document. Cleveland et al. (1991) performed a 56-day Al exposure for *S. fontinalis* to examine effects on bioaccumulation, growth, and mortality. The authors reported 1 percent mortality in the 7.2 pH treatment at the end of the exposure period at a measured mean Al concentration of 303.88 μg/L, which resulted in an undefined chronic value of >303.88 μg/L. Although test duration was four days short of the recommended 60 days for a chronic test with this species, we decided that test methods and duration were acceptable and suitable for use. Cleveland et al. (1989) reported another chronic value for *S. fontinalis*. The authors used similar methods as in prior toxicity tests with this species and Al. After a 60-day exposure at a mean pH of 6.5, statistical differences in growth were observed. The result of this partial life cycle test, that started exposures with embryos, was the lowest chronic value added to the chronic database.

The remaining three studies entered into the updated chronic database were published prior to 1988, but were not cited in the 1988 Aluminum Document. McCauley et al. (1986) performed acute and chronic toxicity tests using *C. dubia* with different pH exposure media. The 1988 document used only one of the chronic values from a test with a pH of 7.15, but did not report the second test that was conducted at a pH of 7.61. The chronic value that was added to the updated database was from this second test. Extensive acute data were provided by Call (1984) from the University of Wisconsin Center for Lake Superior Environmental Studies laboratory, with addition of a chronic toxicity test using *Ceriodaphnia* sp. After an eight-day Al exposure, statistical differences in survival and reproduction were observed in the 12,100 µg/L treatment (lowest-observed-effect concentration [LOEC]). The updated chronic database value was derived by taking the geometric mean of this treatment concentration and the next lowest treatment of 4,900 µg/L (no-observed-effect concentration [NOEC]). Kane and Rabeni (1987) performed a 30-day partial life cycle toxicity test using *Micropterus dolomieu*. Although the authors did not find any statistical differences in growth between control and the 250 µg/L treatment, they did note that the fish embryos showed overt signs of Al toxicity, which included scoliosis and lordosis. Therefore, an undefined value of >250 µg/L was added to the database.

4.3 Potential Relationships Between Aluminum Toxicity and Water Quality Parameters

An inverse Al toxicity and hardness relationship (within the pH range of 6.5 to 9.0) was identified during the literature review and subsequent database update that was not reported in the 1988 Aluminum Document. To evaluate the relationship between acute toxicity of aluminum and hardness, guidelines from the USEPA (Stephan et al. 1985) and the example calculations provided in the 2001 USEPA cadmium criteria document (USEPA 2001) were followed. USEPA (2001) explicitly states that species acute values should only be used for pooled-hardness slope derivation if data are available for a range of hardnesses such that the highest hardness value is at least three times the lowest and the highest is at least 100 mg/L higher than the lowest.

Pooled-hardness slopes can be derived following guidance by Stephan et al. (1985). First, toxicity and hardness (or other appropriate water quality characteristics) data are normalized (by dividing the toxicity value and the hardness value for a study by the geometric mean toxicity and hardness values of all studies for that species). These normalized values are then log-transformed. Next, a least squares regression of log-transformed normalized acute values on normalized hardness values is performed to obtain the acute hardness slope for that species. This is done for all species and the regression lines are compared (either by visually looking at slopes and intercepts or mathematically with covariance analysis). If they are considered similar enough, data for all species are pooled and the regression is run again to develop the "pooled-hardness" slope used in the final equation.

Appropriate acute values with relevant test media hardness measurements were regressed within and among three species: *Ceriodaphnia dubia*, *Pimephales promelas*, and *D. magna*. These species were chosen because respective hardness treatments fell within a wide range of values and each had many acute endpoints to regress (Stephen et al. 1985). Regression analysis for each species (excluding *D. magna*) resulted in a statistically significant positive relationship between effect measurement and test media hardness (two-sided test, to test that slope term equals zero, both p-values < 0.02). Discussion of data used or not used in this analysis is provided below.

D. magna was used in this evaluation, even though only two data points are available. Stephan et al. (1985) states that it is acceptable to use only two data points if "the two points cover a broad enough range of the water quality characteristic." The two hardness values used in the hardness regression analysis, 220 and 45.3 mg/L, cover a significant range. In addition, a clear relationship was observed between these hardness values and associated LC_{50} values; at a hardness of 220 mg/L the *D. magna* LC_{50} was 38,200 μg/L, and at hardness of 45.3 mg/L the LC_{50} was 3,900 μg/L (Kimball, manuscript; Biesinger and Christensen 1972).

C. dubia data were included in the hardness regression analysis because while the hardness values for the seven usable data points for this species technically do not have a wide enough range, the overall database does represent a sufficient hardness range. While an additional data point is available which would broaden the hardness range, it was reported as a "greater than" value, and thus cannot be used in hardness slope derivation (ENSR 1992a). Thus, the hardness values for usable *C. dubia* data ranged from 26-98.5 mg/L $CaCO_2$ (Soucek et al. 2001).

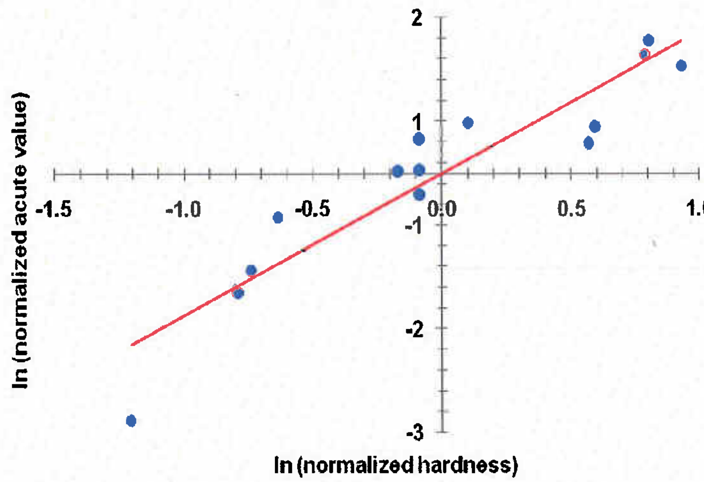
The Al database contains three data points for *I. punctatus*. However, all three of these values are "greater than" values (i.e., not definitive), and thus are not appropriate for use in regression analyses.

A water hardness versus Al toxicity equation was derived with this subset of data, which included values for *C. dubia*, *P. promelas*, and *D. magna*, that minimized the residual standard error ($r^2 = 0.87$) and resulted in a pooled slope of 1.3695 (Table 3). Figure 1 is a plot of the acute values versus the hardness values used to derive this Al hardness slope.

Table 3: Derivation of acute Al hardness slope.

Species	N	Species Mean Acute Slope	R^2
Ceriodaphnia dubia	7	0.8699	0.73
Daphnia magna	2	1.4439	--
Pimephales promelas	5	1.5298	0.90
Pooled Hardness Slope =		**1.3695**	**0.87**

Figure 1:
Scatter plot of Al toxicity and water hardness values used to derive the Al hardness slope.



The Al toxicity data in both acute and chronic databases were subsequently normalized to hardness 50 mg/L $CaCO_3$ concentration using this slope, using USEPA criteria derivation methods (Stephan et al. 1985). The acute water quality standard equation was thus developed to incorporate the protective effect of hardness, which is likely a proxy for calcium, as discussed earlier.

Additional water quality parameters such as pH also affect aquatic organism Al toxicity. The pH of a solution is a major driver of Al speciation. Over the range of USEPA acceptable circumneutral pH values, we could expect that the fraction of monomeric Al in solution will change, most notably at lower (approximately 6.5) and higher pH values (approximately 9). Freeman and Everhart (1971) demonstrated an increase of Al toxicity in rainbow trout from a pH of 7 to 9 using the same concentration and experimental methods. They reported that test organisms showed immediate shock and heavy mortalities within the first 48 hours at a test solution pH of 9.0, effectively terminating the 45-day test after 113 hours. Although there was an apparent pH relationship within the USEPA range, we could not develop a significant toxicity relationship with pH. Attempts to develop such an equation were hindered by limited studies conducted for any species at an acceptable range of pH values (6.5-9.0). In fact, the greatest pH value in the database is 8.29, at which no increased toxicity was apparent. Available data points at lower pH values approximately 6.5 for some taxa indicate that increased toxicity occurs at the lower end of the USEPA recommended range. This trend provided qualitative evidence of a water quality toxicity relationship in some organisms. However, this relationship is not significant within, or consistent between, an acceptable sample of organisms in the updated database.

Preliminary review of published reports that tested aquatic organism toxicity over a wider range of acidic pH values did indicate a strong relationship between measured Al toxicity and pH, with more acidic waters having greater Al toxicity. However, this relationship reached an asymptote at approximately pH = 6, again with no observable pH versus Al toxicity relationship found in the required pH range of 6.5-9.0. As such, no pH factor is included in this update to Al standards.

5.0 Phase III – Recalculation of Acute and Chronic Standards for Aluminum

Data discovered and screened during phase II of this project were used to update and revise the Al acute and chronic database. The revised database was then used to derive potentially updated acute and chronic standards for Al to protect freshwater aquatic organisms.

5.1 Updated Acute Database

Not all of the new acute data added to the database contained enough water quality information to use in derivation of the recommended updated Al standards. Effects data without reported hardness water quality parameters of test water were not used to generate a revised FAV since data values could not be normalized to a hardness of 50 mg/L. In addition, data from Palmer et al. (1988 and 1989) were not included in the final updated acute toxicity database because all LC_{50} values from this study were undefined (i.e., reported as >400 µg/L). When compared to other appropriate values in the database for both *P. promelas* and *I. punctatus*, these undefined values are considerably lower. Thus, while the Palmer et al. data are consistent with data used from other studies (i.e., the other values are indeed "greater than 400 µg/L"), the Palmer et al. >400 µg/L values are irrelevant in the context of other reported LC_{50} values for these organisms, which are up to 100 times higher than 400 µg/L. The undefined *Oncorhynchus mykiss* data from Gundersen et al. (1994) were also not included in the final acute database for the same reason.

Table 4 summarizes the final list of data and ranked GMAV values used for calculation of the recommended updated acute Al water quality standard.

Table 4: Proposed final Al acute database, with species mean acute values (SMAV), normalized to hardness = 50 mg/L, and ranked by genus mean acute value (GMAV).

Rank	Species	Common Name	Method	SMAV (µg/L)	GMAV (µg/L)
17	*Tanytarsus dissimilis*	Midge	S, U	338,321	338,321
16	*Lepomis cyanellus*	Green sunfish	S, M	53,794	53,794
15	*Perca flavescens*	Yellow perch	S, M	53,578	53,578
14	*Ictalurus punctatus*	Channel catfish	S, M	51,534	51,534
13	*Physa* sp.	Snail	S, M	32,922	32,922
12	*Acroneuria* sp.	Stonefly	S, M	24,315	24,315
11	*Gammarus pseudolimnaeus*	Amphipod	S, M	23,669	23,669
10	*Dugesia tigrina*	Flatworm	S, M	17,859	17,859
9	*Hybognathus amarus*	Minnow	S, M	14,428	14,428
8	*Salmo salar*	Atlantic salmon	S, M	9,205	9,205
7	*Crangonyx pseudogracilis*	Amphipod	S, U	9,190	9,190
6	*Oncorhynchus mykiss*	Rainbow trout	F, M	7,547	7,547
	Oncorhynchus tshawytscha	Chinook salmon	S, M	88,495*	
5	*Pimephales promelas*	Fathead minnow	S, M	5,869	5,869
4	*Tubifex tubifex*	Worm	S, U	5,698	5,698
3	*Daphnia magna*	Cladoceran	S, U	4,735	4,735
2	*Asellus aquaticus*	Isopod	S, U	4,370	4,370
1	*Ceriodaphnia dubia*	Cladoceran	S, M	2,164	2,604
	Ceriodaphnia sp.	Cladoceran	S, M	3,134	

NOTES:
S = static renewal test exposure; M = test media aluminum concentration was measured
F = flow-through test exposure; U = test media aluminum concentration was not measured
* = Value not used in calculation of GMAV because acute value considerably higher than others in the genus

The updated acute database contains values for 17 genera, increased from 14 genera in the existing criteria document, including 11 species of invertebrates and eight species of fish. These 19 species in 14 families satisfy the "eight-family rule" as specified in the 1985 Guidelines. Addition of new species data and normalization of acute values changed the sensitivity ranking of three of the four most sensitive genera when compared to the 1988 Aluminum Document. The rank of the most sensitive genus (*Ceriodaphnia*) in the updated database is unchanged and its reported acute value changed very little after hardness correction. The 1988 Aluminum Document database ranked the genus *Salvelinus* as second. This value was based on one study in which hardness was not measured (Decker and Menendez 1974). Since the effect endpoint could not be normalized for hardness, this value was not included in the updated database. As a result, *Asellus* replaced *Salvelinus* as the second ranked genus in the updated database. The normalized value for *Asellus* was very similar to that reported for *Salvelinus*, so this deletion and addition process was not particularly influential in updating the FAV. The updated 3rd and 4th ranked genera, *Daphnia* and *Tubifex*, replaced *Oncorhynchus* and *Gammarus* of the 1988 Aluminum Document. These updated values were lower with a range closer to the first two genera, resulting in reduced variability between the four most sensitive genera.

5.2 Updated Chronic Database

The revised and updated Al chronic toxicity database presents data for six genera of freshwater organisms, including three species of invertebrates and three species of fish (Table 5). These six species found in five families do not satisfy the "eight-family rule" as specified in the 1985 Guidelines. The chronic database assemblage does, however, satisfy the minimal requirements for calculation of a FACR.

Table 5: Proposed final Al chronic values (SMCV), with hardness normalized (50 µg/L), and ranked by genus mean chronic values (GMCV).

Rank	Species	Common Name	SMCV (µg/L)	GMCV (µg/L)
6	*Tanytarsus dissimilis*	Midge	68,021	68,021
5	*Ceriodaphnia dubia*	Cladoceran	4,165	4,165
4	*Pimephales promelas*	Fathead minnow	957	957
3	*Micropterus dolomieu*	Smallmouth bass	777	777
2	*Salvelinus fontinalis*	Brook trout	624*	624*
1	*Daphnia magna*	Cladoceran	274	274

*GMCV was calculated without the undefined chronic value reported by Hunn et al. (1987).

The revised FACR was derived from three species mean ACRs (SMACRs), using the revised and updated chronic toxicity databases. Each ACR was determined from paired acute and chronic values within the same study using similar dilution water (Table 6). The respective SMACRs used to derive the FACR were 0.96 (*C. dubia*), 10.65 (*P. promelas*), and 12.19 (*D. magna*). Including only the Biesinger and Christensen (1972) data in the *D. magna* SMACR calculation (tested at hardness = 45.3) resulted in a substantially lower SMACR for this species than was reported in the 1988 Aluminum Document (12.19 versus 51.47, which was calculated from data from the Kimball manuscript). These data resolved the previous problem noted in the 1988 Aluminum Document associated with taking a geometric mean from a wide range of results.

In general, the inclusion of more available chronic data resulted in a better sample of ACRs, in which values ranged roughly within a factor of 10 from one another. Because the USEPA was lacking data to legitimately generate a FACR using multiple SMACRs, the FACR was set to the lowest organism then defaulted to 2.0. The updated database allows a multiple SMACR approach as an improvement over the EPA's FACR estimate. The revised FCV derived from the revised FACR is expected to be protective of every organism in the chronic database, when corrected for hardness.

Table 6: Updated Al final acute-chronic ratio (FACR).

Species	Hardness ($CaCO_3$ mg/L)	Chronic Value (µg/L)	Acute Value (µg/L)	ACR	SMACR
Daphnia magna	45.3	320[a]	3,900	12.1875	12.1875
Pimephales promelas	220	3,288	35,000	10.6448	10.6448
Ceriodaphnia dubia	50	1,908	1,900	0.9958	
Ceriodaphnia dubia	50	1,624	1,500	0.9236	0.9590
					FACR = 4.9923

NOTES:
[a]16% decrease in reproduction
SMACR = species mean acute-chronic ratio

5.3 Updated Aluminum Standards Derivation

An updated final acute value (FAV) was derived from the four most sensitive genera in the updated and revised, hardness-normalized acute toxicity database (*Ceriodaphnia, Asellus, Daphnia*, and *Tubifex*), the total number of genera in the updated acute database, and newly derived acute toxicity hardness slope (Table 7). The resulting FAV (2,648 µg/L) is greater than the 1988 FAV of 1,496 µg/L (which was not hardness-modified in the 1988 Aluminum Document), and was used to derive the hardness modified Al standards equation.

Since the revised chronic database did not satisfy the "eight-family rule," the FACR was used to derive a FCV for Al from the acute database. Following the 1985 Guidelines, the acute hardness toxicity relationship was assumed to be similar for chronic toxicity. Therefore, a chronic Al criterion equation was also calculated using this pooled acute-hardness slope (Table 7). Use of the acute-hardness slope in the chronic equation should be applied cautiously given the limited chronic toxicity data, which do not strongly support this assumption. However, the lack of support may be an artifact of difficulties associated with conducting chronic toxicity tests with a poorly soluble compound, rather than a true lack of a hardness relationship.

Table 7: Recalculation of the final acute values for Al using the revised hardness adjusted (50 mg/L $CaCO_3$) acute database.

Rank	Genus	GMAV (µg/L)	ln GMAV	(ln GMAV)^2	P = R/(N+1)	√P
4	*Tubifex*	5,698	8.6479	74.7863	0.2222	0.4714
3	*Daphnia*	4,735	8.4627	71.6178	0.1667	0.4082
2	*Asellus*	4,370	8.3825	70.2666	0.1111	0.3333
1	*Ceriodaphnia*	2,604	7.8650	61.8577	0.0556	0.2357
		Sum	33.3581	278.5284	0.5556	1.4487

NOTES:
N = 17 genera, R = sensitivity rank in database, P = rank / (N+1)

Calculations:

Acute Criterion

$$S^2 = \frac{\Sigma (\ln GMAV)^2 - (\Sigma \ln GMAV)^2/4}{\Sigma P - (\Sigma\sqrt{P})^2/4} = \frac{278.5284 - (33.3581)^2/4}{0.5556 - (1.4487)^2/4} = 10.9238 \qquad S = 3.3051$$

$L = [\Sigma \ln GMAV - S(\Sigma\sqrt{P})]/4 = [33.3581 - 3.3051\ (1.4487)]/4 = 7.1425$

$A = S\ (\sqrt{0.05}) + L = (3.3051)(0.2236) + 7.1425 = 7.8816$

Final Acute Value = FAV = e^{A} = 2,647.9903 µg/L

CMC = ½ FAV = 1,323.9952 µg/L

Pooled Slope = 1.3695

ln (Criterion Maximum Intercept) = ln CMC - [pooled slope × ln (standardized hardness level)]
= ln (1,323.9952) - [1.3695 × ln (50)]
= 1.8308

Acute Aluminum Criterion = $e^{(1.3695 [\ln (\text{hardness})] + 1.8308)}$

Chronic Criterion

Chronic Slope = 1.3695

Final Acute-Chronic ratio (FACR) = 4.9923 (recalculated)

Final Chronic Value (FCV) = FAV / ACR = 2,647.9903 ÷ 4.9923 = 530.4149 µg/L

ln (Final Chronic Intercept) = ln FCV - [chronic slope × ln(standardized hardness level)]
= ln (530.4149) - [1.3695 × ln (50)]
= 0.9161

Chronic Aluminum Criterion = $e^{(1.3695 [\ln (\text{hardness})] + 0.9161}$

This review and update to the 1988 Aluminum Criteria Document resulted in new standards using hardness-based equations, similar to other metals standards. We recommend use of these updated standards as the appropriate Al standards for Colorado, with values calculated as µg/L dissolved Al.

$$\text{Recommended Acute Al Criterion} = e^{(1.3695\ [\ln\ (\text{hardness})]\ +\ 1.8308)}$$

$$\text{Recommended Chronic Al Criterion} = e^{(1.3695\ [\ln\ (\text{hardness})]\ +\ 0.9161)}$$

Updated and revised Al standards based on these equations are presented across a wide range of hardness levels (Table 8). It is important to understand the boundaries of the reported equation. Since the equation models hardness values that ranged from 1 mg to 245 mg of $CaCO_3$/L, estimations made outside of this range should be treated with caution. While convention for metals is to use up to a 400 mg/L hardness cap for calculating criteria [40CFR131.6(c)(4)(i)], a conservative approach in this case is to apply the values calculated at hardness of 250 mg/L to higher hardnesses.

Table 8: Updated and revised acute and chronic Al criterion value across selected hardness values.

Aluminum Equations	Mean Hardness (mg/L as $CaCO_3$)						
	25	50	75	100	150	200	250
Updated/Revised Aluminum Standards							
Acute= $e^{(1.3695\ [\ln\ (\text{hardness})]+1.8308)}$	512	1,324	2,307	3,421	5,961	8,839	11,999
Chronic= $e^{(1.3695\ [\ln\ (\text{hardness})]+0.9161)}$	205	530	924	1,370	2,388	3,541	4,807

NOTE: All values are as µg Dissolved Aluminum/L.

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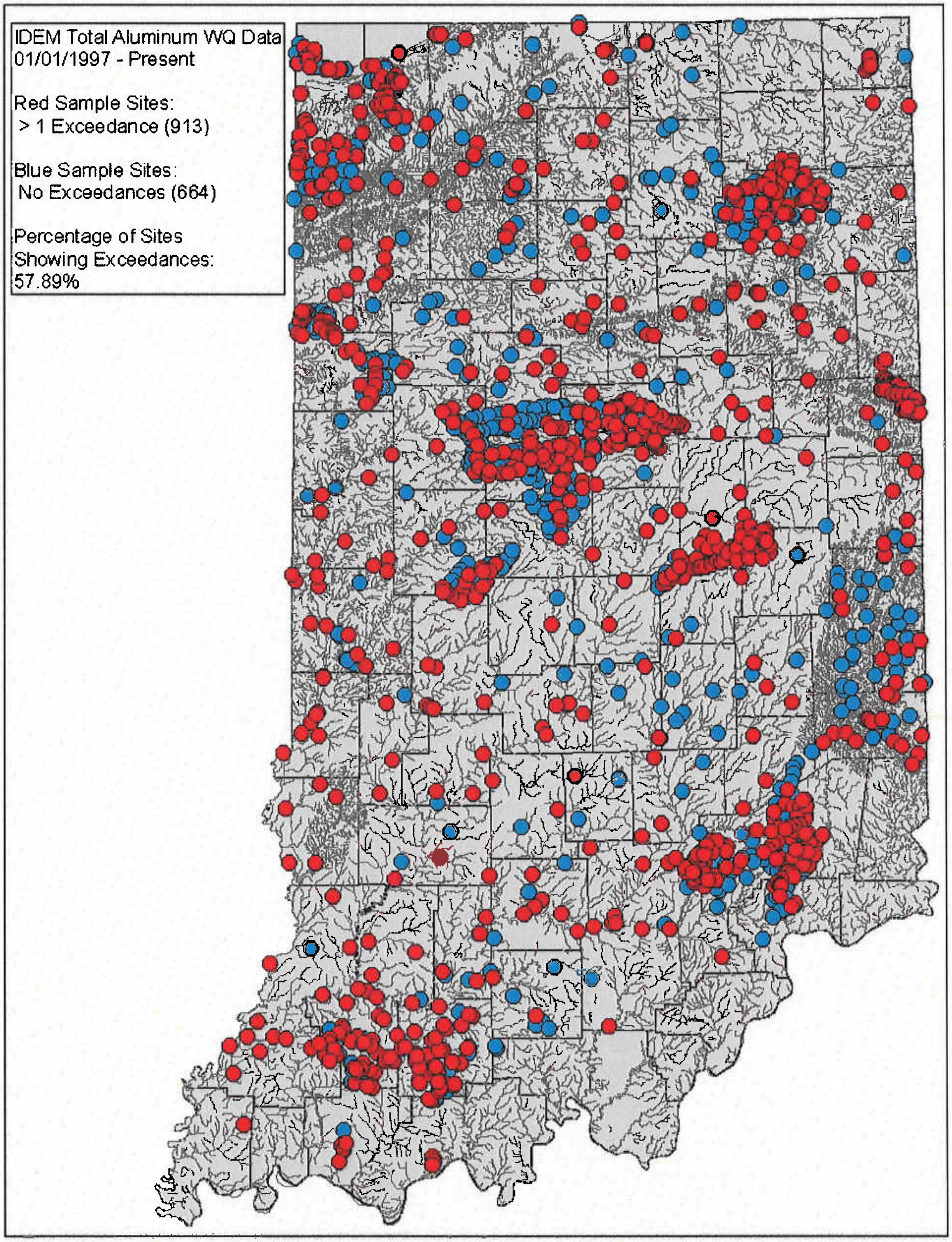
2

ATTACHMENT 2

Widespread Consequences – The following analysis was conducted on data obtained from the IDEM AIMS water quality database. The inclusion of the total aluminum target values in the 2010 303(d) list will have a profound impact on the assessment of Indiana waters. The following map was developed by comparing individual sample results from the AIMS water quality database to the target values for total aluminum. Sampling sites that showed at least one exceedance were mapped in red. Sampling sites with no exceedances were mapped in blue. As can be seen, a large percentage of sampling sites have exceeded target values for total aluminum.

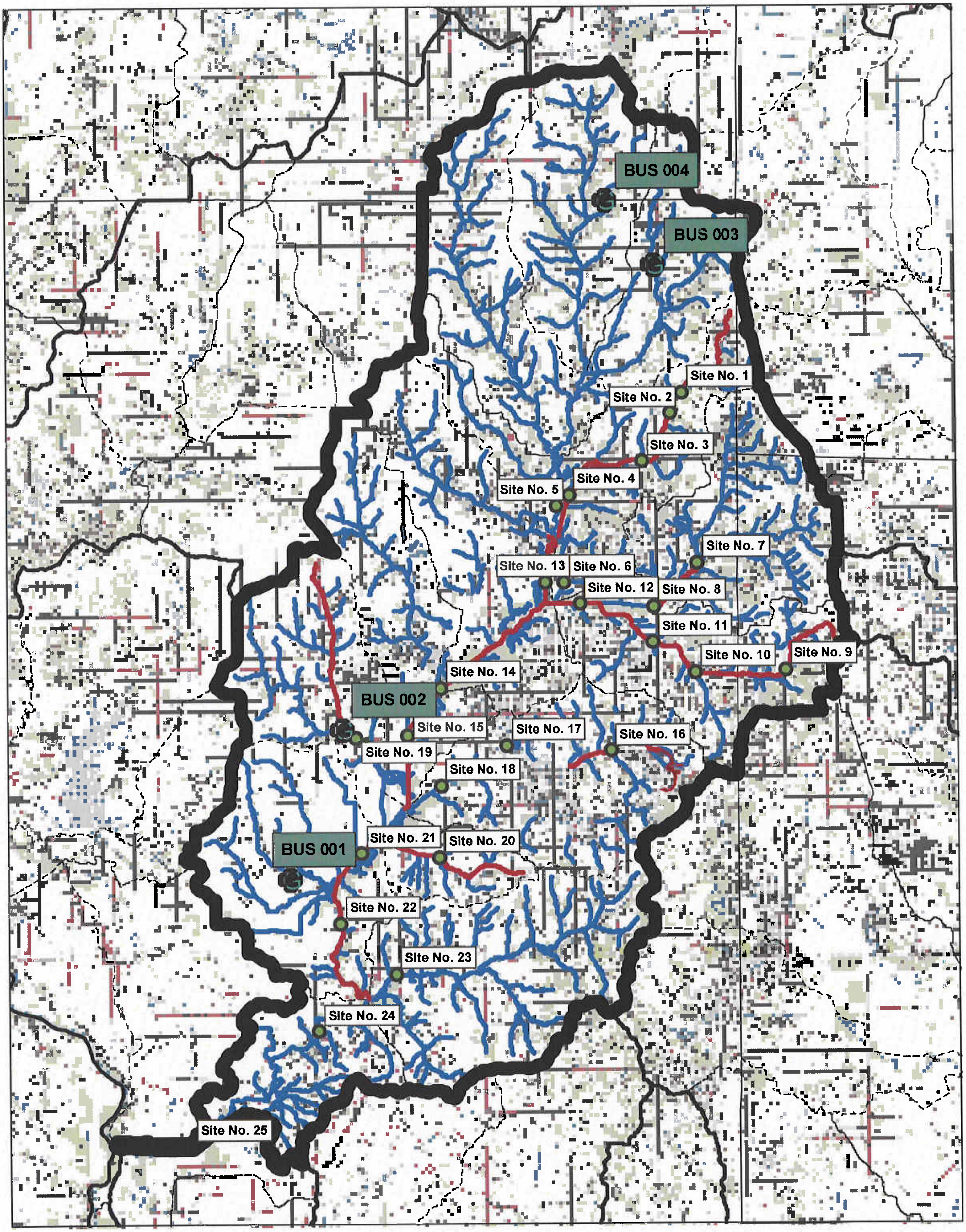
This map shows the number of IDEM sampling sites that have shown at least one exceedance of the **total aluminum** target value. All historical data within the AIMS database was used for this comparison.



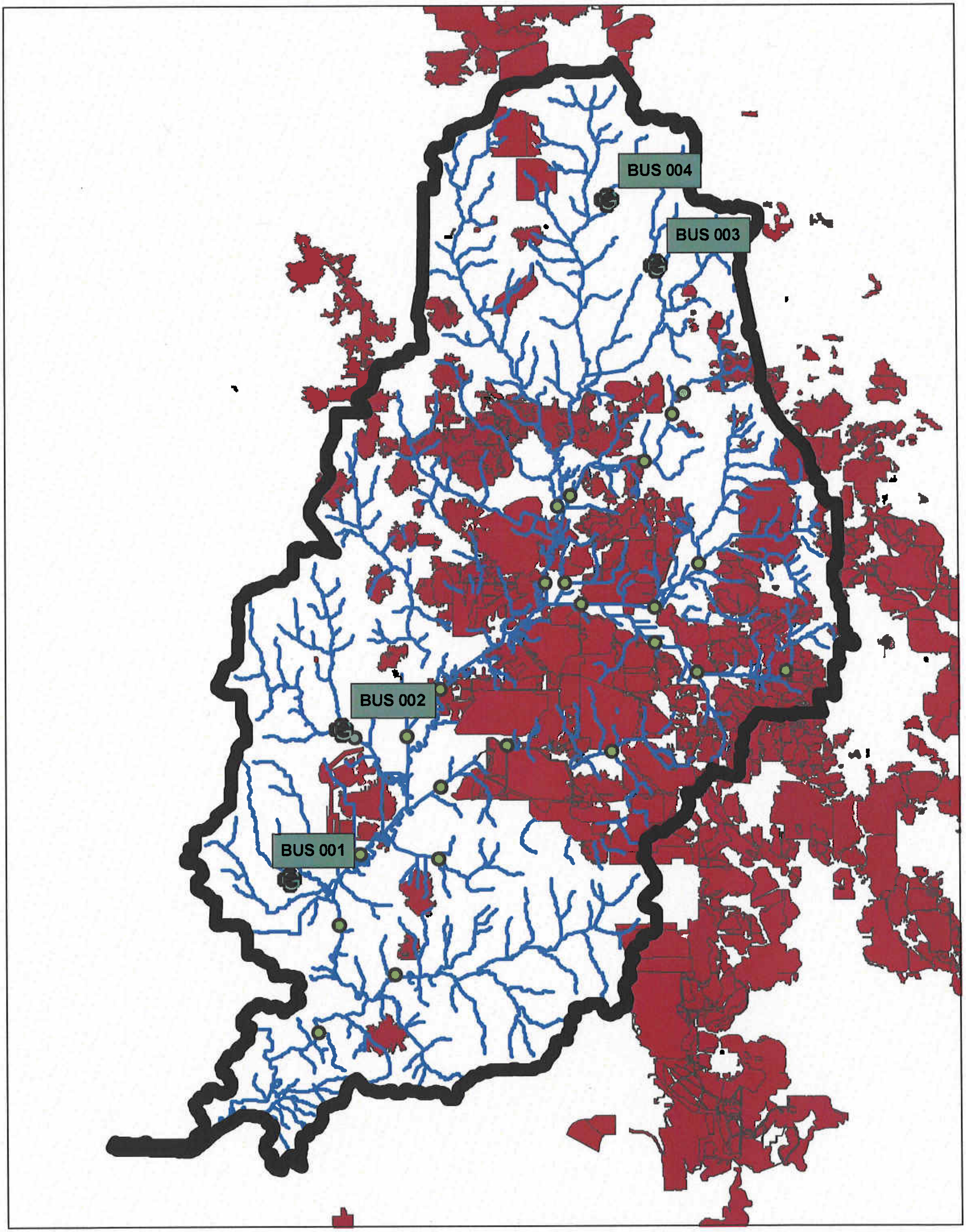
3

ATTACHMENT 3

This map shows locations of Peabody sampling locations in headwaters of Busseron Creek watershed.


BUS 004
BUS 003
Site No. 1
Site No. 2
Site No. 3
Site No. 4
Site No. 5
Site No. 7
Site No. 13
Site No. 6
Site No. 12
Site No. 8
Site No. 11
Site No. 10
Site No. 9
Site No. 14
BUS 002
Site No. 15
Site No. 17
Site No. 16
Site No. 19
Site No. 18
BUS 001
Site No. 21
Site No. 20
Site No. 22
Site No. 23
Site No. 24
Site No. 25

This map shows these locations of Peabody sampling locations in headwaters of Busseron Creek watershed in relation to the underground and surface coal mining in the area. The four sampling points are located upstream from mining areas.


BUS 004
BUS 003
BUS 002
BUS 001

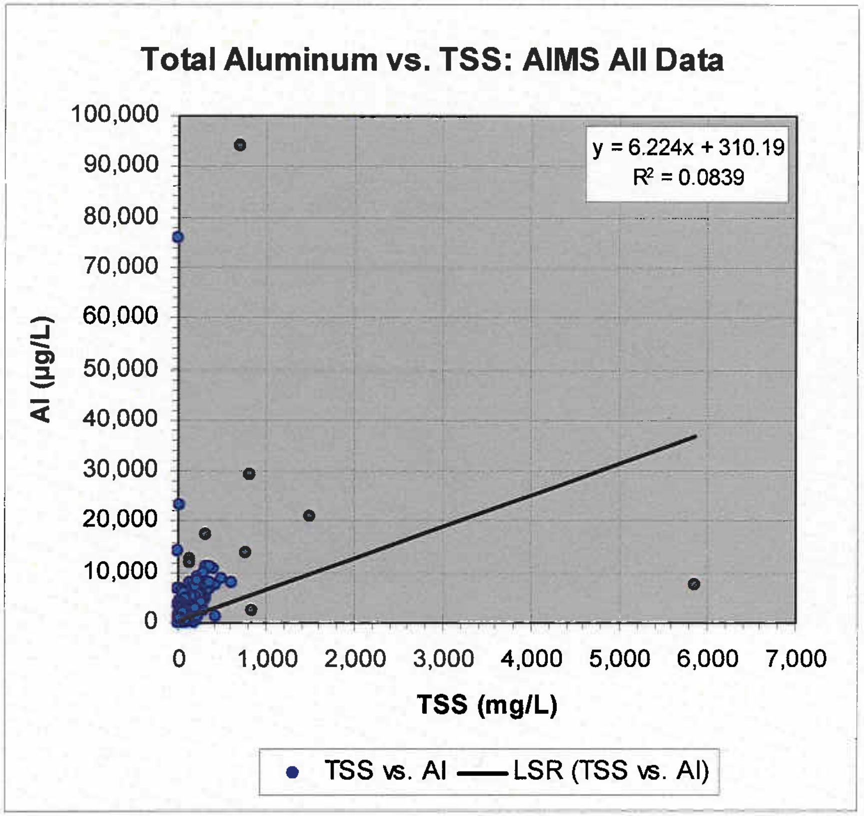
Sampling Location	Sample Date	Aluminum, Total		Aluminum, Dissolved		Total Suspended Solids		Total Dissolved Solids		Laboratory
		[µg/L]		[µg/L]		[mg/L]		[mg/L]		
1630 BUS 001	6/19/2008		**545**		25		10		360	Environmental Certification Lab, Inc.
1630 BUS 002	6/19/2008		**1281**		10		22		238	Environmental Certification Lab, Inc.
1630 BUS 003	6/19/2008		**688**	<	4	<	4		330	Environmental Certification Lab, Inc.
1630 BUS 004	6/19/2008		**912**		42		14		345	Environmental Certification Lab, Inc.
1630 BUS 001	6/19/2008		**900**	<	100		12		282	SGS
1630 BUS 002	6/19/2008		**1500**		100		22		197	SGS
1630 BUS 003	6/19/2008		**300**	<	100		3		280	SGS

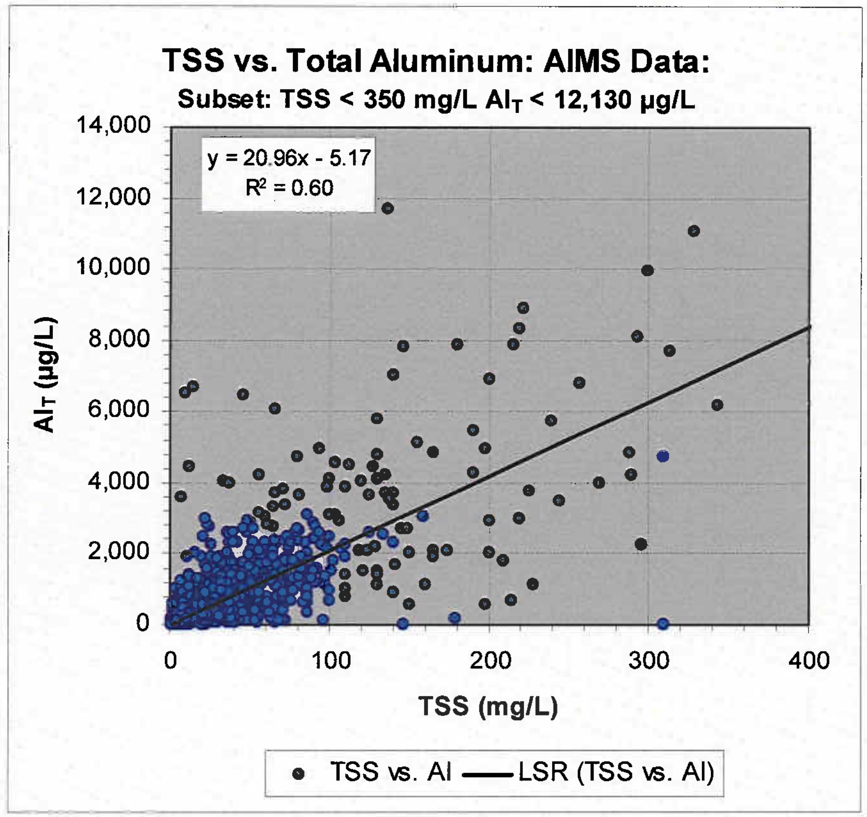
This table shows the results of sampling conducted by Peabody Energy in the headwater areas of Busseron Creek watershed. The locations are shown in the map on the previous page. The samples were run by two different laboratories to evaluate QA/QC. All results for total aluminum exceed the TMDL "target" of 174 µg/L.

4

ATTACHMENT 4

Correlation with TSS – The concentration of metals in total form is highly correlated with suspended sediment. The following graphs were created from **total aluminum** data within the AIMS database. The graph on the left shows all data from the AIMS database (4,432 samples). This graph shows a low correlation due to a few extreme data points that skew the regression calculation. When the extreme values are removed from the dataset, the data shows a much higher correlation. The graph on the right represents the dataset after removing TSS concentrations greater than 350 mg/L and total aluminum concentrations greater than 12,130 µg/L, reducing the total number of samples to 4,414 samples. The correlation between TSS and total aluminum is easily seen (correlation coefficient: 0.60). The extreme values that were removed were based on values that have a probability of occurring less than 0.01% based on the individual datasets.





5

ATTACHMENT 5

TOTAL VS DISSOLVED IRON - ORSANCO DATA

Site Name	Date	Fe, Total ug/L	Fe, Diss ug/L	Total to Diss Ratio	Diss to Total Conversion Factor
Cannelton	20-Nov-02	1160	<100	12	
Cannelton	14-Jan-03	1100	<100	11	
Cannelton	11-Mar-03	4180	<100	42	
Cannelton	14-May-03	8880	<100	89	
Cannelton	15-Jul-03	3490	<100	35	
Cannelton	23-Sep-03	1800	<100	18	
Cannelton	24-Nov-03	3040	<50	61	
Cannelton	14-Jan-04	4480	<50	90	
Cannelton	09-Mar-04	3920	<50	78	
Cannelton	25-May-04	2375	<50	48	
Cannelton	07-Jul-04	475	<50	9	
Newburgh	20-Nov-02	1460	<100	15	
Newburgh	14-Jan-03	3100	<100	31	
Newburgh	11-Mar-03	2580	<100	26	
Newburgh	14-May-03	10000	<100	100	
Newburgh	15-Jul-03	4890	<100	49	
Newburgh	23-Sep-03	3090	<100	31	
Newburgh	24-Nov-03	11740	<50	235	
Newburgh	28-Jan-04	1720	<50	34	
Newburgh	09-Mar-04	4640	<50	93	
Newburgh	25-May-04	2435	<50	49	
Newburgh	07-Jul-04	587	<50	12	
Geomean				38	**0.027**

Note:
1. Variable TSS Waters

TOTAL VS DISSOLVED IRON - IDEM DATA

1998 Fall Creek
Sample Locations: Sites 1 thru 5

Fe, Total mg/L	Fe, Diss mg/L	Total to Diss Ratio	Diss to Total Conversion Factor
0.61	<0.003	203	
0.83	<0.003	277	
0.25	0.01	25	
0.09	<0.003	30	
0.11	<0.003	37	
0.331	<0.003	110	
1	0.05	20	
0.76	<0.003	253	
0.17	<0.003	57	
0.16	<0.003	53	
0.45	<0.003	150	
0.92	<0.003	307	
0.4	<0.003	133	
0.11	<0.003	37	
0.23	0.01	23	
0.12	<0.003	40	
1.2	<0.003	400	
0.54	<0.003	180	
0.23	<0.003	77	
0.36	<0.003	120	
Geomean		85	**0.012**

Note:
Trace Metals Pilot Project 1998Fall Creek Watershed Study ReportFederal Grant CP 985282-01
Prepared By Betty Ratcliff & Dr. Syed GhiasUddin Environmental Toxicology & Chemistry Section
Assessment Branch/OWM/IDEMNovember 1999IDEM/32/01/3221/1999

TOTAL VS DISSOLVED IRON - IDEM DATA

IDEM Fixed Station DATA - From GCR TMDL documents

Sample Site Description	SampleDate	LSite	Fe, Total ug/L	Fe, Diss ug/L	Total to Diss Ratio	Diss to Total Conversion Factor
Raw Water, E Chicago Waterworks	2/3/1998	LMG020-0008	390	<10	39	
Raw Water, E Chicago Waterworks	6/2/1998	LMG020-0008	100	<10	10	
Raw Water, E Chicago Waterworks	7/27/1998	LMG020-0008	62	<10	6	
Raw Water, Hammond Waterworks	4/27/1998	LMG020-0010	610	<10	61	
Raw Water, Hammond Waterworks	6/29/1998	LMG020-0010	47	<10	5	
Raw Water, Hammond Waterworks	8/31/1998	LMG020-0010	20	<10	2	
Raw Water, Hammond Waterworks	10/26/1998	LMG020-0010	99	<10	10	
Raw Water, Hammond Waterworks	9/28/1998	LMG020-0010	37	<10	4	
Raw Water, Hammond Waterworks	11/16/1998	LMG020-0010	97	<10	10	
Raw Water, Hammond Waterworks	12/14/1998	LMG020-0010	63	<10	6	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	3/4/1998	LMG020-0009	430	<10	43	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	4/1/1998	LMG020-0009	390	<10	39	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	2/4/1998	LMG020-0013	200	<10	20	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	3/4/1998	LMG020-0013	95	<10	10	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	4/28/1998	LMG020-0013	150	<10	15	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	6/3/1998	LMG020-0013	160	<10	16	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	6/30/1998	LMG020-0013	20	<10	2	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	10/27/1998	LMG020-0013	42	<10	4	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	9/29/1998	LMG020-0013	32	<10	3	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	11/17/1998	LMG020-0013	100	<10	10	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	12/15/1998	LMG020-0013	76	<10	8	
Raw Water, Whiting Waterworks	2/3/1998	LMG020-0006	120	<10	12	
Raw Water, Whiting Waterworks	3/3/1998	LMG020-0006	160	<10	16	
Raw Water, Whiting Waterworks	3/31/1998	LMG020-0006	700	<10	70	
Raw Water, Whiting Waterworks	4/27/1998	LMG020-0006	630	<10	63	
Raw Water, Whiting Waterworks	6/2/1998	LMG020-0006	83	<10	8	
Raw Water, Whiting Waterworks	6/29/1998	LMG020-0006	100	<10	10	
Raw Water, Whiting Waterworks	7/27/1998	LMG020-0006	150	<10	15	
Raw Water, Whiting Waterworks	8/31/1998	LMG020-0006	21	<10	2	
Raw Water, Whiting Waterworks	10/26/1998	LMG020-0006	79	<10	8	
Raw Water, Whiting Waterworks	9/28/1998	LMG020-0006	120	<10	12	
Raw Water, Whiting Waterworks	11/16/1998	LMG020-0006	310	<10	31	
Raw Water, Whiting Waterworks	12/14/1998	LMG020-0006	1400	<10	140	
Raw Water, E Chicago Waterworks	4/27/1999	LMG020-0008	260	<8	33	
Raw Water, E Chicago Waterworks	5/25/1999	LMG020-0008	110	<8	14	

TOTAL VS DISSOLVED IRON - IDEM DATA

IDEM Fixed Station DATA - From GCR TMDL documents

Sample Site Description	SampleDate	LSite	Fe, Total ug/L	Fe, Diss ug/L	Total to Diss Ratio	Diss to Total Conversion Factor
Raw Water, E Chicago Waterworks	7/28/1999	LMG020-0008	84	<8	11	
Raw Water, E Chicago Waterworks	8/26/1999	LMG020-0008	580	<8	73	
Raw Water, E Chicago Waterworks	9/28/1999	LMG020-0008	280	<8	35	
Raw Water, E Chicago Waterworks	10/27/1999	LMG020-0008	300	<8	38	
Raw Water, E Chicago Waterworks	11/23/1999	LMG020-0008	100	<8	13	
Raw Water, E Chicago Waterworks	12/14/1999	LMG020-0008	840	<8	105	
Raw Water, Hammond Waterworks	3/23/1999	LMG020-0010	430	<8	54	
Raw Water, Hammond Waterworks	4/27/1999	LMG020-0010	320	<8	40	
Raw Water, Hammond Waterworks	5/25/1999	LMG020-0010	110	<50	2	
Raw Water, Hammond Waterworks	7/27/1999	LMG020-0010	41	<8	5	
Raw Water, Hammond Waterworks	8/25/1999	LMG020-0010	90	<8	11	
Raw Water, Hammond Waterworks	9/28/1999	LMG020-0010	180	<8	23	
Raw Water, Hammond Waterworks	10/27/1999	LMG020-0010	190	<8	24	
Raw Water, Hammond Waterworks	11/23/1999	LMG020-0010	110	<8	14	
Raw Water, Hammond Waterworks	12/14/1999	LMG020-0010	950	<8	119	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	4/27/1999	LMG020-0009	310	<8	39	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	5/25/1999	LMG020-0009	130	<8	16	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	7/27/1999	LMG020-0009	23	<8	3	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	8/26/1999	LMG020-0009	64	<8	8	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	9/29/1999	LMG020-0009	1600	<8	200	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	10/28/1999	LMG020-0009	150	<8	19	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	11/23/1999	LMG020-0009	48	<8	6	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	12/14/1999	LMG020-0009	500	<8	63	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	1/26/1999	LMG020-0013	190	<8	24	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	3/24/1999	LMG020-0013	330	<8	41	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	4/28/1999	LMG020-0013	130	<8	16	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	5/25/1999	LMG020-0013	120	<8	15	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	7/28/1999	LMG020-0013	28	<8	4	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	8/18/1999	LMG020-0013	89	<8	11	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	9/29/1999	LMG020-0013	240	<8	30	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	10/19/1999	LMG020-0013	160	<8	20	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	11/30/1999	LMG020-0013	230	<8	29	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	12/15/1999	LMG020-0013	170	<8	21	
Raw Water, Whiting Waterworks	1/25/1999	LMG020-0006	360	<8	45	
Raw Water, Whiting Waterworks	2/22/1999	LMG020-0006	530	<8	66	
Raw Water, Whiting Waterworks	3/23/1999	LMG020-0006	480	<8	60	

TOTAL VS DISSOLVED IRON - IDEM DATA

IDEM Fixed Station DATA - From GCR TMDL documents

Sample Site Description	SampleDate	LSite	Fe, Total ug/L	Fe, Diss ug/L	Total to Diss Ratio	Diss to Total Conversion Factor
Raw Water, Whiting Waterworks	4/27/1999	LMG020-0006	370	<8	46	
Raw Water, Whiting Waterworks	5/25/1999	LMG020-0006	380	<50	8	
Raw Water, Whiting Waterworks	8/25/1999	LMG020-0006	76	<8	10	
Raw Water, Whiting Waterworks	9/28/1999	LMG020-0006	180	<8	23	
Raw Water, Whiting Waterworks	10/27/1999	LMG020-0006	390	<8	49	
Raw Water, Whiting Waterworks	11/23/1999	LMG020-0006	77	<8	10	
Raw Water, Whiting Waterworks	12/14/1999	LMG020-0006	690	<8	86	
Raw Water, E Chicago Waterworks	1/27/2000	LMG020-0008	530	<8	66	
Raw Water, E Chicago Waterworks	2/29/2000	LMG020-0008	37	<8	5	
Raw Water, E Chicago Waterworks	3/29/2000	LMG020-0008	390	<8	49	
Raw Water, E Chicago Waterworks	4/27/2000	LMG020-0008	570	<8	71	
Raw Water, E Chicago Waterworks	5/31/2000	LMG020-0008	110	<8	14	
Raw Water, E Chicago Waterworks	7/25/2000	LMG020-0008	120	<8	15	
Raw Water, E Chicago Waterworks	9/27/2000	LMG020-0008	130	<8	16	
Raw Water, E Chicago Waterworks	10/31/2000	LMG020-0008	110	<8	14	
Raw Water, E Chicago Waterworks	11/29/2000	LMG020-0008	78	<8	10	
Raw Water, E Chicago Waterworks	12/19/2000	LMG020-0008	640	<8	80	
Raw Water, Hammond Waterworks	1/26/2000	LMG020-0010	450	<8	56	
Raw Water, Hammond Waterworks	2/28/2000	LMG020-0010	61	<8	8	
Raw Water, Hammond Waterworks	3/28/2000	LMG020-0010	140	<8	18	
Raw Water, Hammond Waterworks	4/26/2000	LMG020-0010	470	<8	59	
Raw Water, Hammond Waterworks	5/30/2000	LMG020-0010	110	<8	14	
Raw Water, Hammond Waterworks	7/25/2000	LMG020-0010	20	<8	3	
Raw Water, Hammond Waterworks	9/27/2000	LMG020-0010	73	<8	9	
Raw Water, Hammond Waterworks	10/30/2000	LMG020-0010	81	<8	10	
Raw Water, Hammond Waterworks	11/28/2000	LMG020-0010	150	<8	19	
Raw Water, Hammond Waterworks	12/19/2000	LMG020-0010	460	<8	58	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	1/26/2000	LMG020-0009	850	<8	106	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	3/29/2000	LMG020-0009	440	<8	55	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	4/27/2000	LMG020-0009	450	<8	56	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	5/31/2000	LMG020-0009	25	<8	3	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	7/26/2000	LMG020-0009	48	<8	6	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	9/28/2000	LMG020-0009	450	<8	56	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	10/31/2000	LMG020-0009	76	8.3	9	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	11/29/2000	LMG020-0009	55	<8	7	
Water, Northwest Indiana Water Company (Gary), Borman Pk Treatment	12/13/2000	LMG020-0009	850	<8	106	

TOTAL VS DISSOLVED IRON - IDEM DATA

IDEM Fixed Station DATA - From GCR TMDL documents

Sample Site Description	SampleDate	LSite	Fe, Total ug/L	Fe, Diss ug/L	Total to Diss Ratio	Diss to Total Conversion Factor
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	1/25/2000	LMG020-0013	200	<8	25	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	2/15/2000	LMG020-0013	190	<8	24	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	3/29/2000	LMG020-0013	130	<8	16	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	4/24/2000	LMG020-0013	470	<8	59	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	5/24/2000	LMG020-0013	67	<8	8	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	7/18/2000	LMG020-0013	130	<8	16	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	9/20/2000	LMG020-0013	49	<8	6	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	10/23/2000	LMG020-0013	38	<8	5	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	11/21/2000	LMG020-0013	200	<8	25	
w Water, Northwest Indiana Water Company, Ogden Dunes Treatment Pl	12/13/2000	LMG020-0013	310	<8	39	
Raw Water, Whiting Waterworks	1/26/2000	LMG020-0006	290	<8	36	
Raw Water, Whiting Waterworks	2/28/2000	LMG020-0006	25	<8	3	
Raw Water, Whiting Waterworks	3/29/2000	LMG020-0006	180	<8	23	
Raw Water, Whiting Waterworks	4/26/2000	LMG020-0006	600	<8	75	
Raw Water, Whiting Waterworks	5/30/2000	LMG020-0006	68	<8	9	
Raw Water, Whiting Waterworks	7/25/2000	LMG020-0006	48	<8	6	
Raw Water, Whiting Waterworks	8/30/2000	LMG020-0006	70	<8	9	
Raw Water, Whiting Waterworks	9/27/2000	LMG020-0006	120	<8	15	
Raw Water, Whiting Waterworks	10/30/2000	LMG020-0006	150	<8	19	
Raw Water, Whiting Waterworks	11/28/2000	LMG020-0006	96	<8	12	
Raw Water, Whiting Waterworks	12/19/2000	LMG020-0006	490	<8	61	
Geomean					18	**0.056**

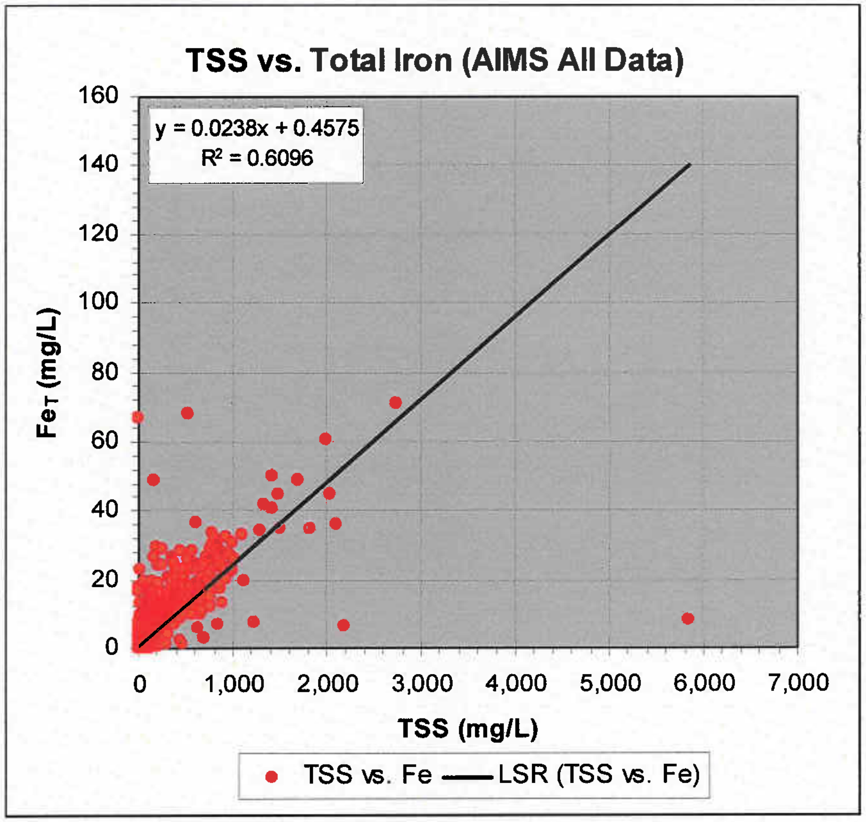
Note:
1. Low TSS waters

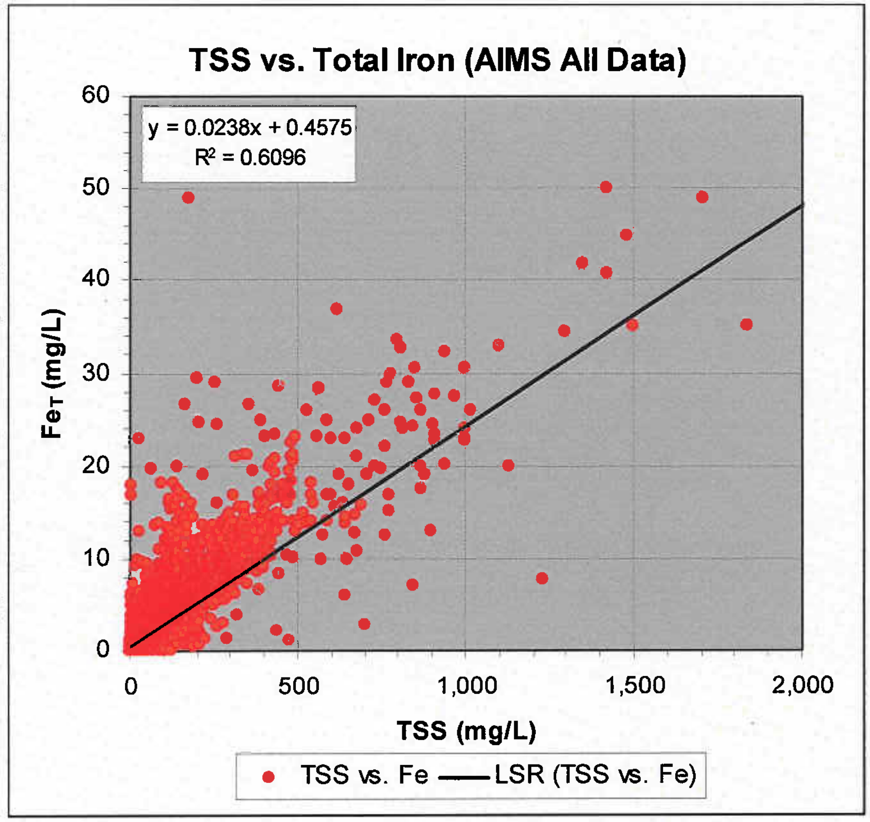
ATTACHMENT 6

6

ATTACHMENT 6

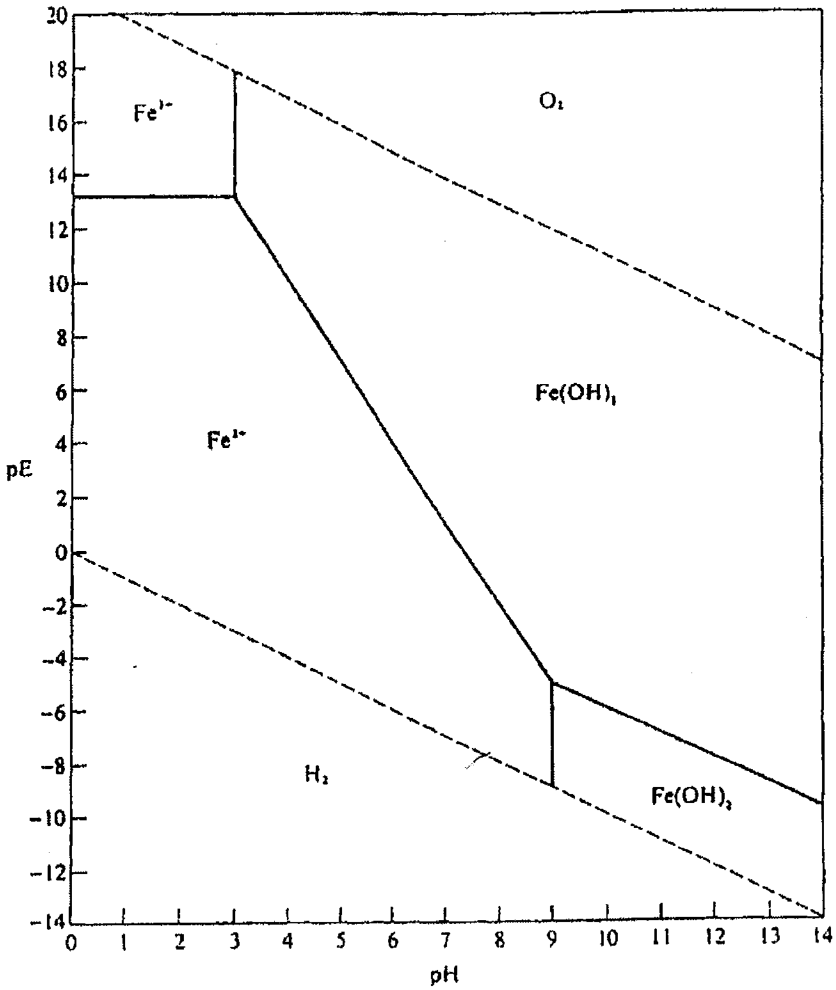
Correlation with TSS – The concentration of metals in total form is highly correlated with suspended sediment. The following graphs were created from **total iron** data within the AIMS database. The graph on the left shows all data from the AIMS database (28,333 samples). This graph shows a high correlation (correlation coefficient: 0.61). The graph on the right represents the same dataset, but the axes have been rescaled to focus on typical TSS and total iron concentrations.





7

ATTACHMENT 7



*The maximum soluble iron concentration 1.00×10^{-5} M

ENVIRON	SIMPLIFIED pE-pH DIAGRAM FOR IRON IN WATER*	Figure 1

Drafter: APR | Date: 04/12/07 | Contract Number: [illegible] | Approved: | Revised:

slow oxidation from Fe^{2+} to Fe^{3+}

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ATTACHMENT 8

BAKER & MCKENZIE

Memorandum

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Date	September 29, 2008
To	Nat Noland, Indiana Coal Council, Inc.
From	John W. Watson
Re	Due Process Issues in IDEM's proposed Busseron Creek TMDL

BACKGROUND

The Indiana Department of Environmental Management ("IDEM") has proposed total daily maximum loads ("TMDLs") for the Busseron Creek Watershed. Under the federal Clean Water Act, the clear objective of total daily maximum loads ("TMDLs") is to establish stream loadings to address "impairments" that have been identified and prioritized for a particular waterbody. The TMDLs proposed by IDEM include limits for a series of impairments, including impaired biotic communities, total iron, total aluminum, total manganese, total phosphorous, dissolved oxygen, pH, and total suspended solids. None of these constituents were identified as causes of impairment pursuant to section 303(d) of the federal Clean Water Act for the particular water body segments with which they are now linked. As discussed in a separate set of comments prepared by the Indiana Coal Council, IDEM's inclusion of these unlisted impairments lacks a sound technical basis. By proposing limits for unlisted impairments, IDEM's TMDL development also lacks legal basis and constitutes a fundamental violation of the Clean Water Act. Specifically, IDEM has circumvented the 303(d) listing process and has failed to provide the public with its vital opportunity to review and comment on the unlisted impairments. Furthermore, IDEM's proposed TMDLs would, in effect, amend federal law without proper approval from the U.S. Environmental Protection Agency ("EPA"). Given the absence of any technical basis for the

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proposed TMDLs and IDEM's utter disregard for the Clean Water Act's clear TMDL decision-making process, the TMDLs for the unlisted impairments must be stricken.

ANALYSIS

A. <u>No Basis Exists for the TMDLs because IDEM Circumvented the Clean Water Act Process.</u>

IDEM's proposed TMDLs seek to regulate a host of constituents that have not resulted in identified impairments to the Busseron Creek Watershed. As explained more fully in the technical comments submitted by the Indiana Coal Council, there is no scientific basis for the proposed TMDLs that concern unlisted impairments. Furthermore, because IDEM has circumvented the decision-making obligations that are fundamental to the TMDL process, its proposed TMDLs lack any legal basis, as well. IDEM consequently has exceeded its designated authority in this process and the resulting TMDLs are inconsistent with and a fundamental violation of the Clean Water Act.

Any attempt to propose impairments at this point in the process represents an unauthorized evasion of federal Clean Water Act requirements. Section 303(d) of the Act obligates states to identify those waterbodies that are not meeting the state's water quality standards, identify the constituents responsible for those impairments, prioritize those impaired waters, and then promulgate TMDLs for the identified constituents. 33 U.S.C. § 1313(d). The Clean Water Act thus establishes a clear process that must occur in sequence, which state water quality managers must follow in addressing their impaired waters. These steps are vital to realizing the objective of the Clean Water Act to "restore and maintain the chemical, physical and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a). These steps also form the foundation of the Clean Water Act's water quality-based approach

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to pollution control, which "emphasizes the overall quality of water within a water body and provides a mechanism through which the amount of pollution entering a water body is controlled based on the intrinsic conditions of that body of water and the standards set to protect it." *Water Quality Handbook*, U.S. Environmental Protection Agency, Chpt. 7, available at http://www.epa.gov/waterscience/standards/handbook/ (2007). IDEM has disregarded this sequence and has developed TMDLs for the Busseron Creek Watershed that are entirely unsubstantiated.

The proposed Busseron Creek TMDLs include parameters for impaired biotic communities, total iron, total aluminum, total manganese, total phosphorous, dissolved oxygen, pH, and total suspended solids. *Busseron Creek Watershed TMDL Development, Revised Public Review Draft*, Indiana Department of Environmental Management (Sept. 3, 2008). None of these constituents were identified as causes of impairment on Indiana's 303(d) list for the particular water body segments with which they are now linked. Indeed, IDEM admits that the report includes new constituents, noting in the draft TMDL Report that the agency has "re-assess[ed] the causes of impairment appearing on the 2006 Section 303(d) list" and hence "the pollutants for which TMDLs were developed differ from the pollutants appearing on the 2006 Section 303(d) list." *Id.* at v.

However, IDEM cannot simply explain away this issue in a few introductory sentences. IDEM lacks any authority to conduct this reassessment or develop TMDLs based on unlisted impairments. Section 303(d)(1)(A) of the Clean Water Act requires each state to first identify its impaired waters and then prioritize that list based on the severity of pollution and the particular waterbody's designated uses. 33 U.S.C. § 1313(d)(1)(A). Only after that

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deliberative process may IDEM develop TMDLs for those identified water segments. The Busseron Creek TMDL process stands in direct opposition to those procedural requirements and has resulted in overreaching TMDLs.

Section 303(d)(1)(C) of the Clean Water Act further provides that each state must establish TMDLs at a level *necessary* to implement *applicable* water quality standards (*i.e.*, those which are not being met by the listed waterbody). 33 U.S.C. § 1313(d)(1)(C). The federal regulations, in turn, provide that each state must establish TMDLs for *all constituents* preventing attainment of water quality standards *as identified* in the 303(d) list. 40 C.F.R. 130.7(c)(ii). This statutory and regulatory language reinforces that states are to prepare their TMDLs in response to those impairments identified on the 303(d) list. This language further emphasizes the link envisioned by Congress and EPA between TMDL parameters and water quality standards. The content of TMDLs is tied to those particular water quality standards for which a waterbody is impaired. In addition, the content is limited by those standards. Neither the Clean Water Act nor its implementing regulations authorize a state to promulgate TMDLs for constituents that have not been identified as an impairment on the 303(d) listing for the waterbody. To do so renders the 303(d) list meaningless.

The sequential process established by the Clean Water Act and the relationship between 303(d) lists and TMDLs have also been emphasized in EPA's publicly-available water quality guidance to state water quality managers on the development of TMDLs. EPA has stated that "[the Clean Water Act's water quality-based] approach *begins* with the determination of waters not meeting (or not expected to meet) water quality standards . . . . An overall plan to manage excess pollutants in each waterbody can *then* be developed."

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Guidance for Water-Quality Based Decisions: The TMDL Process, U.S. Environmental Protection Agency, Chpt. 2, available at http://www.epa.gov/OWOW/tmdl/decisions/ (1991) (emphasis added). "*Once* the identification and priority ranking of water quality-limited waters are completed, states are to develop TMDLs at a level necessary to achieve the applicable State water quality standards." *Id.* at Chpt. 1 (emphasis added). Furthermore, EPA has observed that the Clean Water Act's water-quality based approach to pollution control consists of "stages" and the stage is to make different water quality decisions at each stage. *Water Quality Handbook*, Chpt. 7. According to EPA's *Water Quality Handbook*, states are to identify impaired waters at stage 2 and prioritize those waterbodies at stage 3. *Id.* It is not until stage 4 that a state begins developing TMDLs for those impaired waterbodies. *Id.* Several of EPA's guidance documents provide flow charts, which graphically illustrate this sequence of events for dealing with water pollution. The 303(d) listing effort always precedes the TMDL development process in these flow charts. *Id.* at Chpt. 7; *Guidance for Water-Quality Based Decisions: The TMDL Process*, Chpt. 2. IDEM has entirely disregarded this procedural sequence mandated for state regulation of water quality.

B. <u>The TMDLs were Developed in Violation of the Clean Water Act because IDEM failed to Provide Adequate Public Comment.</u>

In addition to lacking any technical or legal basis, the proposed TMDLs make a mockery of the Clean Water Act's notice and comment requirements and thus constitute a clear violation of the Act. By identifying impairments at the TMDL stage rather than the 303(d) listing stage, IDEM has denied the public and EPA their required right to review and comment on these impairments. This post hoc identification violates both the federal and

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state public comment requirements. As discussed, IDEM recognizes that it has overstepped its authority with its proposed TMDLs, but tries to characterize its actions as merely a "reassessment." However, IDEM lacks any authority to unilaterally reassess or add constituents to its 303(d) list; to do so represents a blatant disregard for Clean Water Act process and no amount of wordsmithing can change that. Moreover, the public comments currently being solicited by IDEM on the proposed TMDLs and the subsequent EPA review cannot cure this fundamental procedural deficiency.

First, as previously discussed, the purpose of the TMDL process is to develop specific limits for each impaired waterbody. The time for identifying impairments has since passed; impairments are to be established during the 303(d) listing process and should now be taken as a given. Second, and more importantly, courts have consistently held that an opportunity for public participation after-the-fact rarely satisfies an agency's notice and comment obligations. *See, e.g., Air Transport Ass'n v. Dep't of Transp.*, 900 F.2d 369 (D.C. Cir. 1990). Notice and comment must precede agency decision-making to ensure not only that the agency benefits from the expertise and input of commenting parties, but also that the agency maintains a flexible and open-minded attitude towards its own decisions. *Nat'l Tour Brokers Ass'n v. Interstate Commerce Comm'n*, 591 F.2d 896, 902 (D.C. Cir. 1978). Courts have found that an agency is not likely to be receptive to suggested changes once it puts its credibility on the line in the form of final rules. *Id.; see also Air Transp. Ass'n*, 900 F.2d at 379. In addition, if post hoc public comments could cure this deficiency, then an agency could "negate at will the Congressional [and EPA] decision that notice and an opportunity for comment must precede promulgation." *Sharon Steel Corp. v. EPA*, 597 F.2d 377, 381

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(3d Cir. 1979). Finally, the approach taken by IDEM in identifying the unlisted impairments and developing the corresponding TMDLs arguably amounts to a constructive amendment of its 303(d) list while evading the public comment and EPA review procedures clearly set out in the federal and state requirements. *See Safe Air for Everyone v. EPA*, 488 F.3d 1088, 1098 (9th Cir. 2007) (emphasizing that "if [agencies were] permitted to adopt . . . interpretations [without providing an opportunity for notice and comment], agencies could constructively amend their regulations while evading their duty to engage in notice and comment") (quoting *Exportal Ltda. v. U.S.*, 902 F.2d 45, 50-51 (D.C. Cir. 1990)).

The critical role of public participation in the 303(d) listing and TMDL processes is underscored by the criticisms now being provided by the Indiana Coal Council regarding the identification of these unlisted impairments to the Busseron Creek Watershed. The Council has prepared a memorandum on the technical flaws in IDEM's determination that these constituents amount to impairments. The 303(d) listing step is supposed to precede the development of TMDLs so that the appropriate technical considerations on impairments can be made *before* TMDLs are established. The Clean Water Act and EPA's water quality regulations mandate this sequence, and public input at each step in the process, to ensure that technical issues are addressed at the appropriate stage. Clearly, IDEM's proposed TMDLs have suffered from a lack of public participation due to IDEM's failure to provide for public comment on the unlisted impairments at the stage when impairments for the Busseron Creek Watershed should have been identified, specifically, at the stage prior to TMDL development.

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C. **By Proposing a TMDL For an Impairment Not Identified in the 303(d) Listing For the Busseron Creek Watershed, IDEM Effectively Amended Federal Law Without EPA Approval.**

Finally, it must be noted that section 303(d) lists, while developed by the states and incorporated into state law, are ultimately a creature of federal law because they must be reviewed and approved by EPA before a state may incorporate them into their water quality regulatory scheme. *Ala. Dep't of Envtl. Mgmt. v. Legal Envtl. Assistance Found.*, 922 So. 2d 101, 112 (Ala. Civ. App. 2005); *see also* 40 C.F.R. § 130.10(b)(2). By adding unlisted impairments at the TMDL stage, IDEM not only has circumvented a fundamental obligation to submit its complete 303(d) list to EPA for review and comment, the state agency also has overstepped its authority, effectively amending federal law without EPA authorization. Since a section 303(d) list becomes federal law upon EPA approval, it cannot be revised without going through the federally-mandated process of EPA review and approval. *Cf. Safe Air for Everyone*, 488 F.3d at 1096-97 (noting that a State Implementation Plan becomes federal law once EPA approves it and cannot be changed unless and until EPA approves any change). IDEM has failed to put its 303(d) list through the statutorily-required rigors of EPA review.

CONCLUSION

Accordingly, for the reasons detailed above, the proposed TMDLs for the unlisted impairments must be deemed invalid. There exists no technical or legal bases for these proposed TMDLs. IDEM has entirely disregarded the Clean Water Act's fundamental decision-making process and denied the public and EPA their obligatory right to participate in that process. IDEM consequently has exceeded its authority in developing its TMDLs and

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developed parameters that are entirely inconsistent with and in violation of the Clean Water Act.

ENVIRON

MEMORANDUM

Date: September 30, 2008

To: Nat Nolan, Indiana Coal Council, Inc.
From: Robin Garibay, ENVIRON International Corp.
Re: Technical Issues of Concern for IDEM's proposed Busseron Creek TMDL

TECHNICAL COMMENTS

The September 3, 2008 draft "Busseron Creek Watershed TMDL Development" (TMDL draft) contains numerous data gaps that contribute to a presentation of a TMDL that does not allow certainty in targets, or if targets are achieved, if the watershed quality would be restored. One of the major gaps in data and information is the support for the presumed relationship of the fish Index of Biotic Integrity (IBI) scores to water quality versus other key components such as water quantity and habitat. The interpretation presented in the TMDL draft is that the fish IBI scores are related to only iron and aluminum concentrations.

ICC suggests that this interpretation is not supported by:
(1) the data presented in the report,
(2) data available on the concentrations of aluminum and iron in Indiana waters, and
(3) data readily available on the aquatic toxicity of aluminum and iron.

ICC believes that attributing low fish IBI scores to iron and aluminum and ignoring habitat and hydraulics and their role in fish community diversity, fish richness, and fish abundance leads to an unsupported assertion that a reduction in iron and aluminum will result in improved fish IBI scores.

ICC also would suggest that IDEM designed a flawed study to assess the water quality of the Busseron Creek watershed and identify key issues associated with the impairments and potential sources. Additionally, IDEM did not use the best available science to determine the maximum load and identify the process and methods to achieve the dramatic and substantial reductions needed to achieve the TMDL draft targets.

Aluminum and Iron Water Quality Data versus Fish IBI Scores

There is no concurrent aluminum or iron data with the reported fish IBIs (USGS study); therefore there is no specific data to relate the fish IBI scores to the levels of aluminum and iron. In the TMDL draft, aluminum and iron data are presented from IDEM and IDNR for some, but not all of the sites USGS surveyed. The revised draft TMDL document identifies that the form of the aluminum and iron under consideration is total. It is important to note that in regards to metals associated with biological impairment it is the dissolved form of the metal that is commonly accepted as the bio-available form that impacts biological organisms. Total concentrations often include particulate and unavailable bound forms of the metal that typically have minimal impact on chemical toxicity to fish and other organisms.

In the presentation of the data, ICC believes that a geometric mean is the best summary statistic to present the central tendency of a database. However, the median and means of the database are also presented.

Interestingly, there were not data for all the sites particularly those with fair and good IBI scores and only one poor IBI score.

ICC would recommend that IDEM provide the type of summary ICC has generated from the USGS data, IDEM data, and IDNR data to allow all stakeholders understand the concerns about water quality in Busseron Creek and also understand the limitations of the data and information.

Table 1. Summary of Aluminum Data Compared to Fish IBI Scores

Station #	Fish IBI Score (1)	(2)	Parameter	First Sample Date	Last Sample Date	Total Samples	Geo-mean (ug/L)	Median (ug/L)	Mean (ug/L)
2	12	vp	Aluminum, Total	8/22/2006	12/12/2006	11	5,667	6,750	6,857
5	20	vp	Aluminum, Total	9/19/2006	9/19/2006	[redacted]	3,692	3,705	3,705
8	14	vp	Aluminum	7/27/2006	4/23/2008	6	301	359	476
9	12	vp	Aluminum, Total	8/22/2006	12/12/2006	8	359	247	1,151
11	16	vp	Aluminum, Total	8/22/2006	12/12/2006	9	946	1,277	2,697
11	16	vp	Aluminum	7/27/2006	4/23/2008	6	214	100	487
12	18	vp	Aluminum, Total	7/27/2006	4/23/2008	5	1,098	868	17,836
16	28	p	Aluminum, Total	4/13/2004	1/23/2007	8	409	372	491
2	12	vp	Aluminum, Dissolved	8/22/2006	12/12/2006	11	2,356	4,660	4,000
5	20	vp	Aluminum, Dissolved	9/19/2006	9/19/2006	[redacted]	47	47	47
9	12	vp	Aluminum, Dissolved	8/22/2006	12/12/2006	9	84	76	90
11	16	vp	Aluminum, Dissolved	8/22/2006	12/12/2006	10	415	67	6,110

Table 2. Summary of Iron Data Compared to Fish IBI Scores

Station #	Fish IBI Score (1)	(2)	Parameter	First Sample Date	Last Sample Date	Total Samples	Geomean (ug/L)	Median (ug/L)	Mean (ug/L)
2	12	vp	Iron, Total	8/22/2006	12/12/2006	11	4,294	4,440	8,107
5	20	vp	Iron, Total	9/19/2006	9/19/2006	[redacted]	3,109	3,115	3,115
8	14	vp	Iron	7/27/2006	4/23/2008	6	1,055	668	7,212
9	12	vp	Iron, Total	8/22/2006	12/12/2006	8	875	698	1,189
11	16	vp	Iron, Total	8/22/2006	12/12/2006	9	1,664	3,220	7,131
11	16	vp	Iron	7/27/2006	4/23/2008	6	2,582	4,305	18,297
12	18	vp	Iron, Total	7/27/2006	4/23/2008	5	5,427	3,590	18,156
16	28	p	Iron, Total	4/13/2004	1/23/2007	12	548	560	783
2	12	vp	Iron, Dissolved	8/22/2006	12/12/2006	11	517	573	920
5	20	vp	Iron, Dissolved	9/19/2006	9/19/2006	[redacted]	108	108	108
9	12	vp	Iron, Dissolved	8/22/2006	12/12/2006	9	159	175	170
11	16	vp	Iron, Dissolved	8/22/2006	12/12/2006	10	961	1,460	2,260
12	18	vp	Iron, Dissolved	7/27/06	1/23/07	2	4,444	4,545	4,550

(1) Field Work occurred Sept 17 through Sept 19, 2007
(2) vp = very poor; p= poor
(3) Source of data uncertain – found in spreadsheets supplied to ICC by IDEM, but not specific to IDEM or IDNR
[redacted]

The presence of a relationship between iron and aluminum and fish IBI scores forms the basis of eliminating biological impairment due to fish IBI scores in the draft TMDL. A quick review of the summary data in Table 1 indicates there is no relationship between aluminum concentration and IBI score or iron concentration and IBI scores, regardless of whether the form of metal is total or dissolved. Thus, a reduction in iron and aluminum would not be projected to improve fish IBI scores. For example, an IBI score of 12 is associated with a geometric mean range of 5,667 to 359 ug/L total aluminum, and a range of 2,356 to 84 ug/L for dissolved aluminum from the same sites. These concentration data almost span the full range of aluminum data presented. A similar pattern indicating no relationship between IBI score and metals concentration is shown for the summary data for iron in Table 2.

Observations from the summary data are as follows:

- Use of one result to characterize a site (Station 5) is highly problematic, particularly given the role of total suspended solids and flow on concentrations of aluminum and iron.
- The total aluminum (summarized 3 different ways to observe central tendency of data) concentrations for Stations 8, 9, 10, 11 are not distinctly different than the concentrations for the only site that is scored "poor" (Station 16).
- The total iron (summarized 3 different ways to observe central tendency of data) concentrations for Stations 8 and 9 are not distinctly different than the concentrations for the only site that is scored "poor" (Station 16).
- The dissolved aluminum data for Station 2 is greater than expected given the pH is greater than 6, based on the USGS field data. Given the dissolved aluminum varied from Non-Detect to 7,430 ug/L, field or lab contamination or ineffective field filtration could be indicated. It would have been extremely useful, given the relationship of aluminum solubility and iron solubility to pH for field pH to have been generated concurrent with sample collection.
- The dissolved aluminum data for Station 11, as compared to the two data sources for total aluminum data, appear aberrant. It is not technically possible to have greater levels of dissolved aluminum compared to total aluminum. Again, field or lab contamination or ineffective field filtration or sample bottle mis-labeling could be indicated.
- The dissolved iron data for Station 12 (only two samples) is highly questionable and the ICC will advise against using this dataset as valid and representative.

Given that Stations 8 and 9 levels (very poor) are similar to Station 16 (poor), the 'historic' data (both IDEM and IDNR) presented in the report does not support that aluminum and iron are the related to the fish IBI scores. If there was a definitive relationship of only these two variables to fish IBI scores, then the projection would be that Stations 8 and 9 would score as poor (IBI = 28), not very poor (IBI = 12 and 14). The data presented implicate that other factors such as habitat, hydrologic patterns, land use influences, and other water quality constituents may be significant contributors in forming the fish community structure. These other factors appear to have not been considered in the draft TMDL.

IDEM should have performed some statistical evaluation to determine whether there was a relationship or even a concordance between aluminum and / or iron data and the fish IBI scores. Of course for IDEM to have conducted this type of invaluable assessment, IDEM should have collected concurrent aluminum and iron water quality data during the USGS study and analyzed aluminum and iron at those sites where fish IBI scores spanned a wider range to include sites that included good, fair, and poor rating.

There is no data or information that provides convincing evidence that there is a relationship between aluminum and fish IBI scores or iron and fish IBI scores.

<u>Aluminum and Iron Busseron Creek Water Quality Data versus other Indiana Water Quality Data</u>

The TMDL draft does not compare the aluminum and iron concentrations monitored in the Busseron Creek watershed to other results that are available to the public. IDEM should have conducted this exercise since iron and aluminum are elements commonly found in soil and minerals. Weathering of earth minerals and stormwater run-off containing suspended solids should contain total aluminum and total iron.

By way of example, the increase in soil-related suspended solids should result in an increase in total aluminum. As presented in the 2006 draft ATSDR "Toxicology Profile for Aluminum":

> Aluminum is the most abundant metal and the third most abundant element in the earth's crust, comprising about 8.8% by weight (88 g/kg). Mean aluminum concentrations in cultivated and uncultivated soil samples collected during a number of field studies were 33 g/kg (range 7–>100 g/kg) for subsurface soils in the eastern United States. Concentrations of various elements in 541 streambed-sediment samples collected from 20 study areas in the conterminous United States (1992–1996) were analyzed as part of the National Water-Quality Assessment Program of the U.S. Geological Survey. Aluminum was present in all samples; concentrations ranged from 1.4 to 14% by weight (14–140 g/kg), with a median of 6.4% by weight.

A little soil-related suspended solid can significantly impact the total aluminum concentration, e.g., 5 mg of soil-related TSS could contribute 0.165 mg of total aluminum to the water column.

Table 3. Comparison of Total Aluminum Concentrations (in ug/L) for Indiana Waters

Location	Maximum	75th Percentile	Minimum	Geomean	Coefficient Of Variation	n
Busseron Creek Watershed	19,700	7,450	20	1,200	1.18	69
Terre Haute, Wabash River	10,700	2,925	329	1,418	1.1	39
Newburgh, Ohio River	11,600	3,452	547	2,201	1.05	10
Cannelton, Ohio River	5,470	2,698	540	1,814	0.65	10

The Wabash River data was generated by IP Terre Haute between April and November 2002 using an IDEM approved Sampling and Analysis Program. It was submitted to IDEM in 2003 as part of a NPDES Permit activity. The Ohio River data is from ORSANCO and was generated between January 2003 and July 2004.

As the sample sizes are different, a statistical comparison cannot be made but an observation would be that Terre Haute, Newburgh and the Busseron Creek geometric mean of results are similar. In addition the Coefficient of Variation (CV), an indicator of variability and distribution of data, are not that different. It should be noted that based on review of ORSANCO, Kentucky, and Indiana reports, the Ohio River shows no fish impairment even though aluminum is greater than the target presented in the TMDL draft. In addition, the Wabash River segment incorporating Terre Haute is not considered biologically impaired based on fish IBI, nor listed as having "impaired biotic communities".

Similar to aluminum, total iron is supposed to be present in ambient waters and will vary as suspended solids vary. IDEM has acknowledged this fact in NPDES permitting for stormwater dominated dischargers (e.g., AEP Tanners Creek, 2004 and ALCOA Warrick, 2005-2006). In a special study on Fall Creek conducted by IDEM reported mean results for total iron between 150 ug/L to 990 ug/L (Trace Metals Pilot Project 1998 Fall Creek Watershed Study Report). Once again, IDEM should have placed the Busseron Creek iron data in context to other Indiana waters.

Using the ORSANCO Ohio River data referenced for total aluminum, total iron data can be compared.

Table 4. Comparison of Total Iron Concentrations (in ug/L) for Indiana Waters

Location	Maximum	75th Percentile	Minimum	Geomean	Coefficient Of Variation	n
Busseron Creek Watershed	35,900	4,880	110	2,644	1.42	69
Newburgh, Ohio River	11,740	4,828	587	3,318	0.81	10

Cannelton, Ohio River	8,880	4,115	475	2,623	0.70	10

As expected, the range of iron is greater (CV) in the Busseron Creek watershed that may be attributed to land use activities as there are mines that are being reclaimed. However, the geometric mean between the Busseron Creek watershed results and the Ohio River do not appear to be different. Once again, it should be noted that the Ohio River is not reported as biologically impaired based on iron concentrations that are equivalent to Busseron Creek or based on fish IBI scores, nor has ORSANCO indicated a concern with fish diversity, abundance, and richness.

The comparison of just a few Indiana waterbodies, that would also have variable suspended solids similar to Busseron Creek waters, to the results from Busseron Creek do not indicate that the total aluminum and total iron levels are dramatically different and at levels that would presume to be the only cause of very poor and poor fish IBI scores.

Aquatic Toxicity Data for Aluminum and Iron

The TMDL draft claims that the target values shown in Table 5 are aquatic life criteria; they are not. The iron and aluminum values are not even non-rule policy guidance values as they have not been presented to the Indiana WPCB for approval. In addition, whenever IDEM has recently attempted to use these out-dated aquatic life values for development of NPDES Permit discharge limits, they have been challenged and IDEM has revised or withdrawn applying these values. Finally, given the ramifications of establishing a TMDL for iron and aluminum, common elements of minerals and soils, IDEM should have attempted to update these values by updating the toxicity databases and updating their data validation of all toxicity data.

Aluminum. Despite the reference to the IDEM 2005 update, IDEM has not updated their toxicity database for aluminum to recent studies, even in 2005. In addition, IDEM did not reference that there was a July 2005 detailed response (from ALCOA to IDEM) requesting further technical clarification of the March 2005 update; these technical clarifications have yet to be made. One of the issues that IDEM seems to be struggling with is that 40 CFR 132 Appendix F and their own regulations (327 IAC 2-1.5-11) for inside the Great Lakes Basin provide very specific guidance on the validation toxicity data prior to use of developing criteria. These regulations expand the 1985 USPEA guidance on data validation. IDEM, in applying these test acceptability criteria to their databases for aluminum, have declined to develop a Tier II aquatic life value or Tier I aquatic life criteria. This is a similar position to other Great Lakes states.

Comprehensive evaluations of the data on the toxicity of aluminum have recently been conducted by the states of New Mexico and West Virginia and the province of British Columbia. In proposed rulemaking for West Virginia, there is documentation that provides an updated toxicity database as well as an evaluation of the validity of historic, as well as recent, aluminum toxicity studies. USEPA approved (January 2006) West Virginia's use of 750 ug/L dissolved aluminum as an applicable chronic aquatic criteria for non-trout waters.

Using an expanded valid aquatic toxicity database for aluminum, ICC provides the following comparison built from Table 1:

Table 5. Comparison of Mean Aluminum Measurements to Published Literature Toxicity Values

Station #	Fish IBI Score (1)	(2)	Parameter	Geo-mean (ug/L)	IDEM 2005 memo - Chronic	Published Data- ChV **Fish (3)**	Most Sensitive Spp.-Invertebrates, ChV	Published Data - LC50 **Fish (4)**
2	12	vp	Aluminum, Total	5,667		7,350	1,908	35,000 to >59,100
5	20	vp	Aluminum, Total	3,692		7,350	1,908	35,000 to >59,100
8	14	vp	Aluminum	301		7,350	1,908	35,000 to >59,100
9	12	vp	Aluminum, Total	359		7,350	1,908	35,000 to >59,100
11	16	vp	Aluminum, Total	946		7,350	1,908	35,000 to >59,100
11	16	vp	Aluminum	214		7,350	1,908	35,000 to >59,100
12	18	vp	Aluminum, Total	1,098		7,350	1,908	35,000 to >59,100
16	28	p	Aluminum, Total	409		7,350	1,908	35,000 to >59,100
2	12	vp	Aluminum, Dissolved	2,356	174			>1,300
5	20	vp	Aluminum, Dissolved	47	174			>1,300
9	12	vp	Aluminum, Dissolved	84	174			>1,300
11	16	vp	Aluminum, Dissolved	415	174			>1,300

1. Field Work occurred Sept 17 through Sept 19, 2007
2. vp = very poor; p= poor
3. Validated studies, for warmwater 'occur at the site' species. ChV = Chronic Value based on most sensitive species.
4. Validated studies, range for warmwater 'occur at the site' species. LC50 = Lethal Concentration to 50% test organisms, therefore acute response.

Observations from the presentation of the chronic values (reflecting sublethal responses like reproduction and growth) and acute values (reflecting mortality):

- Based on updated toxicity studies as well as the IDEM March 2005 document, the most sensitive species to aluminum, whether as total or dissolved, are aquatic invertebrates and not vertebrates such as fish. The toxicity data indicate that a reduction in aluminum from the concentrations measured in Busseron Creek would not be expected to improve fish IBI scores.
- The IDEM Chronic Aquatic Life concentration is based on the intent of deriving a 4-day average concentration to protect 95 percent of the species 95 percent of the time [not to be exceeded once every 3 years]. It is not indicative of the tolerance level of a chemical to specific species that occur at a site, it is not indicative of 'cause and effect'.
- The chronic value for total aluminum would not indicate that fish would be impacted by the total aluminum geometric means for the Busseron Creek Stations, even though fish IBI are very poor and one is poor. Use of a chronic value (geometric mean of the LOEC and NOEC concentration for the most sensitive sublethal endpoint) for a specific species allows for a better framework to discern 'cause and effect'.
- The LC50 range for total aluminum would not indicate that total aluminum geometric means for the Busseron Creek Stations are causing fish mortality.
- The toxicity data for dissolved aluminum would not indicate that dissolved aluminum geometric means for the Busseron Creek Stations are causing fish mortality.
- Using the technically flawed 2005 IDEM aquatic life chronic concentration, which is presented in the form of dissolved aluminum, the geometric mean of dissolved aluminum for Stations 5 and 9 are well below this value. As mentioned earlier, the dissolved data for Stations 2 and 11 appear to contain questionable results. Specific to Station 11, of the 10 results, nine (9) are well below 174 ug/L.
- It would have been extremely useful, given the relationship of aluminum solubility and bioavailability of aluminum to pH for field pH to have been generated concurrent with sample collection.

Iron. The IDEM memorandum issued in 1997 was not based on a complete reference list of studies on the aquatic toxicity of iron, in addition the studies that were presented did not undergo data validation and assessment of acceptability, and finally IDEM mixed the toxicity results for iron(+2), ferrous and iron(+3), ferric in developing a database for iron. It is commonly accepted that the species of iron most toxic to aquatic life is ferrous iron, not ferric.

IDEM has received significant comments from discharges when IDEM attempted to implement the technically flawed 1997 memorandum on iron into NPDES permits (e.g., ALCOA Warrick, ALCOA Lafayette, USS Gary, AEP Tanners Creek) and IDEM did not move forward with limits or conditions using this 1997 memorandum. In addition, IDEM, for inside the Great Lakes, as required by Indiana regulations about species and form of metal and data validity, has not presented a Tier II aquatic life value. This is a similar position as other Great Lakes states.

The ICC is confounded by the level of confidence the TMDL draft places on this antiquated 1997 memorandum. According to the logic of the TMDL draft, the Ohio River should have impaired fish communities based on the IDEM 1997 iron aquatic life value of 2,495 ug/L.

There are at least two references that have more completely evaluated the studies on iron toxicity: "Water Quality Criteria Development for Iron – Technical Report", December 2004 EPRI, Palo Alto, CA and "Ambient Water Quality Guidelines for Iron", February 2008, MOE, Province of British Columbia. Using the updated and validated data from these documents, ICC presents a comparison iron built from Table 2 (and continuing IDEM's approach of not distinguishing between ferrous and ferric as analytically IDEM did not measure the different species):

Table 6. Comparison of Mean Iron Measurements to Published Literature Toxicity Values

Station #	Fish IBI Score (1)	(2)	Parameter	Geomean (ug/L)	IDEM 1997 memo - Chronic	Published Data-ChV **Fish (3)**	Most Sensitive Spp.-Invertebrates, ChV	Published Data - LC50 **Fish (4)**
2	12	vp	Iron, Total	4,294	2,495		1,740	
5	20	vp	Iron, Total	3,109	2,495		1,740	
8	14	vp	Iron	1,055	2,495		1,740	
9	12	vp	Iron, Total	875	2,495		1,740	
11	16	vp	Iron, Total	1,664	2,495		1,740	
11	16	vp	Iron	2,582	2,495		1,740	
12	18	vp	Iron, Total	5,427	2,495		1,740	
16	28	p	Iron, Total	548	2,495		1,740	
2	12	vp	Iron, Dissolved	517	2,495	693 to > 10,230		2,086 - 105,500
5	20	vp	Iron, Dissolved	108	2,495	693 to > 10,230		2,086 - 105,500
9	12	vp	Iron, Dissolved	159	2,495	693 to > 10,230		2,086 - 105,500
11	16	vp	Iron, Dissolved	961	2,495	693 to > 10,230		2,086 - 105,500

1. Field Work occurred Sept 17 through Sept 19, 2007
2. vp = very poor; p= poor
3. Validated studies, for warmwater 'occur at the site' species. ChV = Chronic Value based on most sensitive species.
4. Validated studies, range for warmwater 'occur at the site' species. LC50 = Lethal Concentration to 50% test organisms, therefore acute response.

Observations from the presentation of the chronic values (reflecting sublethal responses like reproduction and growth) and acute values (reflecting mortality):

- The pH during the fish collection for the above stations was between pH 6.9 to 8.4. The Dissolved Oxygen was between 4.5 mg/L to 10.9 mg/L. Based on these pH and DO readings, it is logical to project that the predominant form of iron present would be ferric or iron(+3).

- Based on updated toxicity studies as well as the IDEM 1997 document, the most sensitive species to iron, whether as total (mainly ferric) or dissolved (mainly ferrous), are aquatic invertebrates not vertebrates such as fish. The toxicity data indicate that a reduction in iron from the concentrations measured in Busseron Creek would not be expected to improve fish IBI scores.
- The IDEM Chronic Aquatic Life concentration is based on the intent of deriving a 4-day average concentration to protect 95 percent of the species 95 percent of the time [not to be exceeded once every 3 years]. It is not indicative of the tolerance level of a chemical to specific species that occur at a site, it is not indicative of 'cause and effect'.
- The chronic value for dissolved iron would not indicate that fish would be impacted by the dissolved iron geometric means for the Busseron Creek Stations, even though fish IBI are very poor and one is poor. Use of a chronic value (geometric mean of the LOEC and NOEC concentration for the most sensitive sublethal endpoint) for a specific species allows for a better framework to discern 'cause and effect'.
- The LC50 range for dissolved iron would not indicate that dissolved iron geometric means for the Busseron Creek Stations are causing fish mortality.
- It would be have been extremely useful, given the relationship of iron speciation and iron aquatic toxicity to pH, DO, and redox potential, if field pH, DO, and redox were generated concurrent with sample collection.

Based on use of updated published aquatic toxicity data for aluminum and iron, use of the chronic value (ChV) for species that occur in Busseron Creek, and comparing the appropriate forms (dissolved or total), there is no indication that aluminum, either as total or dissolved (barring Stations 2 and 11 aberrant data), or iron are the chemicals causing the low fish IBI scores.

IDEM, before finalizing the TMDL for Busseron Creek, must:

- Update the toxicity databases for aluminum and iron;
- Update the process for validating data from aquatic toxicity references;
- Clarify if the aquatic toxicity databases address total or dissolved aluminum, the relationship to pH, iron(+2) or iron(+3);
- Given the lack of complete species databases and the concern with fish IBI, use ChV for the species that occur in the Busseron Creek watershed and not use FCV or CAC; and
- If IDEM continue to focus on fish IBI score as the biological metric to indicate biological impairment, then IDEM must make a concerted effort to evaluate other factors that commonly influence fish IBI scores (includes water quality constituents, riparian and instream habitat, land use practices, and hydrologic patterns).

In general, it would be beneficial to being able to focus on appropriate components potentially impacting the Busseron Creek watershed if IDEM designed their programs to generate data concurrently. For example, if the fish population is of most concern, then collect data on water quantity (velocities, flow), habitat, and for the chemicals of concern, those parameters that allow assessment of bioavailability (e.g., pH, DO, redox, DOC, in addition to hardness and cations/anions).

Other issues of concern with the draft TMDL involve expressions of the Waste Load Allocations (WLA) values of 0 (zero). Revisions of the draft TMDL incorporate language that implies a WLA of zero

> "...does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments."

IDEM must include additional explanation and technical discussion on the methodology of how the TMDL will be modified as needed to account for any allocation changes. At a minimum, a discussion of "as needed" should be included along with a description of what steps will be taken to determine the revised WLA.

The use of a surrogate watershed for determination of the hydrologic condition of the Busseron Creek Watershed for TMDL modeling purposes without ground truth calibration within the Busseron Creek Watershed continues to be of concern. IDEM has presented statements that the U.S. Geological Survey's (USGS) National Water Information System (NWIS) database was checked and determined that both gauges 03342100 and 03342500 have sufficient flow. In addition, the flow record from these gauges can therefore be used to approximate flows at the various monitoring sites in the Busseron Creek watershed using an area-weighted approach (i.e., flows at the individual monitoring sites are assumed proportionate to flows at the gauge and adjusted to account for drainage area). They continue to state: "The relative error for the load duration analysis will be evaluated by comparing the predicted flows to the available (limited) observed flows. A target error of less than 10 percent is the proposed tolerance limit." In a response to questions regarding calibration of the model to actual Busseron Creek flows and determination of relative error, IDEM states "No additional flow data was found for this watershed, therefore it was unnecessary to calculate relative error. The QAPP contained language that gave the option to calculate relative error if and only if additional data was found." More detailed explanation should be provided in the draft TMDL of how a lack of additional flow data (i.e., spot checking flow status at various locations in the watershed to see if it matches the surrogate model for site-specific calibration purposes) negates the need to estimate relative error for the load duration analysis. The load duration analysis is crucial to the determination of WLA, the load allocation, and the overall TMDL plan. While a lack of flow data may prevent the ability to calculate relative error, it does not eliminate the potential for relative error to exist.