Hi Katie,

At the meeting of the Wild Rice Task Force on October 11, 2018, you informed folks present that the next meeting of the Task Force would review the sulfate standard and the question of listing wild rice waters.

I understand that the Task Force has already received copies of the Administrative Law Judge Report and the peer-reviewed articles authored by Dr. John Pastor et al. in 2017 and by Sophie LaFond Hudson in 2018. I've attached Dr. Pastor's expert opinion in the wild rice sulfate standard rulemaking proceeding, which is a cogent explanation of the science supporting retention of the existing 10 ppm standard, including Ms. LaFond Hudson's research as well as Dr. Pastor's research. This expert review would help members of the Task Force understand the scientific basis for retaining the wild rice sulfate standard.

You informed the Task Force and members of the public that the Task Force would also review the issue of listing wild rice waters. The Administrative Law Judge Report addressed this issue as follows (footnote omitted):

¶ 287. The Administrative Law Judge concludes that the MPCA's proposed list of wild rice waters at Minn. R. 7050.0471, subps. 3 through 9 is defective because it fails to include all waters previously identified by the MDNR and federally recognized Indian tribes as waters where wild rice was an existing use since November 28, 1975. The MPCA's approach, in using a "weight-of-evidence" standard to identify waters such as those with "lush stands of wild rice" that would meet its criteria for "the beneficial use as a wild rice water" violates federal law, which prohibits removing an existing use for wildlife unless more stringent criteria are applied. Because Minn. R. 7050.0471 violates federal law, it fails to meet the requirements of Minn. R. 1400.2100.D and is defective.

¶ 288. The MPCA could cure the defect at Minn. R. 7050.0471 by amending the listed waters to include all waters previously identified by the MDNR and federally recognized Indian tribes as waters where wild rice was an existing use since November 28, 1975. The Administrative Law Judge concludes that adding the wild rice waters as described in this paragraph would not constitute modification that makes the rule substantially different than the rule as originally proposed based on the standards set forth at Minn. Stat. § 14.05, subd. 2.

I believe it would be helpful for the Task Force to also review WaterLegacy's comments on this matter, which are attached. The section discussion listing of wild rice waters begins on page 30 of the comments. Exhibit 52 and Exhibit 52A to these comments, also attached, are spreadsheets showing waters that the Department of Natural Resources identified as wild rice waters that were excluded from the Minnesota Pollution Control Agency (MPCA) list of proposed identified wild rice waters.

Finally, I'm not sure if the Task Force has already received copies of the April 2018 Order of the Chief Administrative Law Judge rejecting the MPCA's request for review and modification of the January 2018 decision. The Order of the Chief Judge concluded with respect to the proposed listing of wild rice waters (p. 12):

The Administrative Law Judge disapproved the proposed list, concluding that the MPCA's approach excluded hundreds of water bodies previously on lists from the DNR and other sources, including the 1854 Treaty Authority's 2016 and 2017 lists of wild rice waters.[57] The Administrative Law Judge determined that these exclusions violated the federal prohibition against removing a designated use if such a use is an existing use.[58] She also expressed concerns with the reasonableness of the Agency's exclusion of waters without any explicit standards or discussion.[59]

In its Resubmissions, the Agency argued that it compiled its list in consultation with the DNR and tribes, but insisted that it alone can determine what constitutes an "existing use" in Minnesota for purposes of the federal Clean Water Act (CWA).[60] Citing Minn. Stat. §§ 115.03, subd. 1(b) and 115.44, the MPCA argues that it is the only state agency with legal authority to classify waters of the state and assign designated uses.[61]

The Agency's authority is not as clear as it asserts. Minn. Stat. §§ 115.03, subd. 1(b) and 115.44 address the Agency's authority to classify waters, not specifically to determine existing uses for purposes of the CWA. While federal law provides that "the state" may determine existing uses, it does not specify which agency within a state has that unique authority.[62]

Even if the MPCA can establish that its authority trumps that of the DNR or any other state agency, it cannot establish that it is the sole decider of what constitutes an existing use for purposes of federal law. The CWA specifically authorizes certain Indian tribes to make designations as well. The Fond du Lac Band and the Grand Portage Band of Lake Superior Chippewa are both authorized to do so based on approved agreements with the federal government regarding water quality standards.[63] Both Bands agreed that, in rejecting the DNR's report and the 1854 Treaty Authority's list, the MPCA was removing waters that the Bands had already designated as having wild rice as an existing use under federal law.[64]

The April 2018 Order of the Chief Administrative Law Judge is attached with this email. There may be other documents from the record, such as comments from the Bands or the 1854 Treaty Authority, that would also be helpful for the Task Force and staff to review.

Please feel free to share this email and the attached documents with the Task Force members and other staff. We'd appreciate knowing whether these documents have been distributed.

Thank you,
Paula

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WATERLEGACY

OAH 80-9003-34519
Revisor R-4324

In the Matter of the Proposed Rules of the Pollution Control Agency Amending the Sulfate Water Quality Standard Applicable to Wild Rice and Identification of Wild Rice Rivers, Minnesota Rules parts 7050.0130, 7050.0220, 7050.0224, 7050.0470, 7050.0471, 7053.0135, 7053.0205 and 7053.0406

CHIEF ADMINISTRATIVE LAW JUDGE'S ORDER ON REVIEW OF RULES UNDER MINN. STAT. § 14.16, SUBD. 2, AND MINN. R. 1400.2240, SUBP. 5.

Background

The Minnesota Pollution Control Agency (MPCA or Agency) proposes to amend the state's existing rules governing Minnesota's water quality standard to protect wild rice from excess sulfate. The current standard limits sulfate to 10 milligrams per liter in waters used for the production of wild rice as well as in wild rice waters that do not contain cultivated wild rice.[1] The proposed rule amendments identify approximately 1,300 bodies of water in Minnesota as "wild rice waters" designated as subject to the new sulfate standard.[2]

The new standard is set forth in proposed rule at Minn. R. 7050.0224, subd. 5(B).[3] The proposed standard establishes an equation used to calculate the sulfate limit for each MPCA-designated body of water. The equation factors site-specific information and establishes a unique sulfate limit based upon the concentration of iron, organic carbon, and sulfide in the sediment of each designated body of water.[4]

When sulfate in water interacts with iron and organic carbon in sediment, sulfide can form, which the MPCA has determined is toxic to wild rice.[5] Key features of the proposed rules include limits on the amount of sulfide in the sediment of designated waters, and sampling and analytical methods to determine the amount of sulfide, carbon and iron present in the saturated sediment.[6]

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[1] *See, e.g.,* Minn. R. 7050.0224, subps. 1 and 2 and Minn. R. 7050.0220, subps. 1, 3a, 4a,5a, and 6a (2017).
[2] MPCA Resubmission at 8 and Attachment 8, at 58 – 116.
[3] In the July 24, 2017 version of the proposed rules, the methods for calculating sulfate limits were found in part 7050.0224, subp. 5(B)(1). In the revised draft dated March 16, 2108, the requirements appear in part 7050.0224, subp. 5(B).
[4] *See* MPCA's Resubmission, Attachment 1, at 1, and Attachment 8, at 54-55.
[5] Report of the Administrative Law Judge, OAH Docket No. 80-9003-34519, at 1, 5 (January 9, 2018) (Report of the Administrative Law Judge).
[6] *See generally,* MPCA Resubmission, Attachment 8.

Procedural Posture

The Minnesota Pollution Control Agency commenced this rulemaking process on October 26, 2015 with its publication of a Request for Comments in the *State Register*.[7] With necessary approval, the Agency published its initial Notice of Hearing on August 21, 2017[8] and announced a series of hearings scheduled in October and November, 2017.[9] Over 350 individuals attended the six public hearings.[10] Members of the public submitted approximately 4,500 written comments on the proposed rule amendments.[11]

In a report dated January 9, 2018, Administrative Law Judge LauraSue Schlatter disapproved many of the proposed revisions to Minn. R. 7050.0220, 7050.0224 and 7050.0471. The matter then came before the Chief Administrative Law Judge pursuant to Minn. Stat. § 14.15, subd. 3 (2016), and Minn. R. 1400.2240, subp. 4 (2017). These authorities require that the Chief Administrative Law Judge review an Administrative Law Judge's disapproval of an Agency's proposed rule.

In a Report dated January 11, 2018, the Chief Administrative Law Judge concurred with the disapproval determinations of the Administrative Law Judge.[12] As a result:

1. The following proposed rules were disapproved:

    a. Proposed Minn. R. 7050.0220, subps. 3a, 4a, 5a, 6a
    b. Proposed Minn. R. 7050.0224, subp. 2
    c. Proposed Minn. R. 7050.0224, subp. 5, A
    d. Proposed Minn. R. 7050.0224, subp. 5, B (1)
    e. Proposed Minn. R. 7050.0224, subp. 5, C
    f. Proposed Minn. R. 7050.0224, subp. 6
    g. Proposed Minn. R. 7050.0471, subps. 3 through 9

2. The following modifications to rules as originally proposed were also disapproved:

    a. Proposed changes to Minn. R. 7050.0224, subp. 5, B (1)
    b. Proposed changed to Minn. R. 7050.0224, subps. 5, E, F
    c. Proposed changes to Minn. R. 7050.0224, subp. 5, B (2)

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[7] *Id.* at 9, Finding 17.
[8] A second Notice of Hearing was published in September 2017 after the Agency scheduled a hearing to be held at the Fond du Lac Tribal Community College.
[9] *Id.* at 9, Finding 20.
[10] *Id.* at 2-3.
[11] *Id.* at 4.
[12] Report of the Chief Administrative Law Judge, OAH Docket No. 80-9003-34519, at 1, 5 (January 11, 2018) (Report of the Chief Administrative Law Judge).

The Report of the Chief Administrative Law Judge specifically instructed the MPCA on the statutory procedure for the Agency to follow in the event it decided not to correct the defects identified in the proposed rules, as follows:

> If the Department elects not to correct the defects associated with the repeal of the existing rules and the defects associated with the proposed rules, the Department must submit the proposed rules to the Legislative Coordinating Commission and the House of Representatives and Senate policy committees with primary jurisdiction over state governmental operations, for review under Minn. Stat. § 14.15, subd. 4 (2016).[13]

Effective on April 2, 2018, the MPCA requested that the Chief Administrative Law Judge review additional submissions in the matter, including the following:

a) March 28, 2018, Letter Response to the Report of the Chief Administrative Law Judge dated January 11, 2018 (Response), with the following attachments:

- Attachment 1: March 5, 2018 Letter from Christopher Korleski, Environmental Protection Agency, Region V, to Shannon Lotthammer, Assistant Commissioner, MPCA (EPA 2018 Letter);

- Attachment 2: November 5, 2015 Letter from Tinka G. Hyde, Environmental Protection Agency, Region V, to Rebecca Flood, MPCA (EPA 2015 Letter);

- Attachment 3: EPA's Review of Revisions to Minnesota's Water Quality Standards: Human Health Standards Methods (Nov. 5, 2015);

- Attachment 4: November 22, 2017 Letter from Christopher Korleski, Environmental Protection Agency, Region V, to LauraSue Schlatter, Administrative Law Judge with enclosed comments on Minnesota's "Proposed Rules Relating to Wild Rice Sulfate Standard and Wild Rice Water" (EPA 2017 Comments);

- Attachment 5: Sampling and Analytical Method for Wild Rice Methods (March 2018);

- Attachment 6: Technical Discussion of Proposed Equation Related Changes to the Rule;

- Attachment 7: List of Proposed Rule Changes;

[13] Report of the Chief Administrative Law Judge at 2.

- Attachment 8: Revisor's March 16, 2018, version of Proposed Rule incorporating changes as proposed in March 28, 2018 filing (Revisor's AR4324);

- Attachment 9: January 19, 1999 Memorandum from Marvin E. Hora, Manager, Environmental Research and Reporting, Environmental Outcomes Division to the Minnesota Pollution Control Agency Board Water Quality Committee regarding Proposed Revisions of Minn. Rules ch. 7050;

- Attachment 10: Statement of Need and Reasonableness "In the Matter of the Proposed Revisions to the Rules Governing the Classification and Standards for Waters of the State, Minnesota Rules Chapter 7050" page 54 (April 27, 1993) and attached draft rule page;

b) Draft Order Adopting Rules (filed April 2, 2018); and

c) Revisor's July 24, 2017, version of Proposed Rules (Revisor's RD4324A).

The MPCA's request for review was made pursuant to Minn. Stat. § 14.16, subd. 2 (2016) and Minn. R. 1400.2240, subp. 5 (2017).

Legal Analysis

Rulemaking is a statutory process governed by the provisions of the Minnesota Administrative Procedure Act (Act), Minn. Stat. Ch. 14. The Office of Administrative Hearings is statutorily required to review rulemaking matters in accordance with the dictates of that Act.[14]

Relevant to the current proceeding, Minn. Stat. § 14.14, subdivision 2 (2016), provides as follows:

> **At the public hearing** the agency shall make an affirmative presentation of facts establishing the need for and reasonableness of the proposed rule and fulfilling any relevant substantive or procedural requirements imposed on the agency by law or rule. The agency may, in addition to its affirmative presentation, rely upon facts presented by others on the record during the rule proceeding to support the rule adopted.[15]

In this case, the Administrative Law Judge determined that the MPCA failed to meet this and other requirements of the Act and therefore disapproved the proposed rule.[16] As required by law, the disapproval was reviewed by the Chief Administrative Law

[14] Minn. Stat. §§14.05 and 14.08 (2016).
[15] Emphasis added.
[16] Report of the Administrative Law Judge at 5-6.

Judge and, in a January 11, 2018 Report, the MPCA was advised regarding how to correct the determined defects.

Building upon the statutory directive that an agency meet all requirements of the Act relevant to rulemaking, Minn. Stat. § 14.15, subd. 4, provides as follows:

> If the chief administrative law judge determines that the need for or reasonableness of the rule has not been established pursuant to section 14.14, subdivision 2, and if the agency does not elect to follow the suggested actions of the chief administrative law judge to correct that defect, then the agency shall submit the proposed rule to the Legislative Coordinating Commission and to the house of representatives and senate policy committees with primary jurisdiction over state governmental operations for advice and comment. The agency may not adopt the rule until it has received and considered the advice of the commission and committees. However, the agency is not required to wait for advice for more than 60 days after the commission and committees have received the agency's submission.

The MPCA has not complied with the law in this regard. In its Resubmissions, it has not followed the Chief Administrative Law Judge's directives regarding how to correct the defects in the proposed rule, nor has it submitted the disapproved rule to the identified legislative bodies for advice. Instead, the MPCA has, in effect, requested reconsideration of the rule's disapproval and seeks an order allowing adoption of the proposed rule, in modified form.

The Chief Administrative Law Judge declines to grant the MPCA its requested relief. While it is clear that the Agency has made significant efforts to reexamine the proposed rule and make clarifications and revisions where deemed appropriate, it is just as clear that the Agency has not followed the provided directives for curing all identified defects, nor identified other record-based and public-vetted solutions to achieve the same ends consistent with the spirit and the letter of the Minnesota Administrative Procedure Act.[17] Neither has the Agency availed itself of the only other statutory alternative: seeking legislative advice as required by the law.

The Chief Administrative Law Judge is cognizant of the fact that the Agency is dedicated to protecting the quality of the waters in the state and so has invested significant human, temporal and financial resources in this effort. Mindful that the protection of Minnesota's wild rice waters will remain an important policy and regulatory goal for and in the state, the Chief Administrative Law Judge has set forth below additional information that may prove useful to the Agency as it continues to address this issue on behalf of all Minnesotans.

[17] Minn. Stat. 14.001 (2016).

Substantive Review of Agency Resubmissions

The Agency submitted three categories of information to the Chief Administrative Law Judge in support of its request for review. The bulk of the submissions constitute legal argument intended to serve as a basis for reversal of various findings of rule disapproval contained in both the Administrative Law Judge's Report and the Chief Administrative Law Judge's Report.[18] In addition, the submissions include proposed modifications to portions of the disapproved rule. Last, the filings encompass other proposed rule changes not recommended by the Administrative Law Judge.[19] The MPCA's filings are silent on many of the disapproved rule parts notwithstanding the fact that the Administrative Law Judge specified various legal grounds for their disapproval.

Below, the Chief Administrative Law Judge has summarily addressed each of the major issues raised in the MPCA's Resubmissions.

I. Equation-Based Standard

A. Numeric Expression of the Standard

The MPCA argues that the Administrative Law Judge found the proposed equation-based standard to be *per se* invalid, and argues that the existence of other approved rules which rely on mathematical equations proves the Administrative Law Judge's determination to be incorrect.[20] In fact, it is the MPCA that is incorrect. The Administrative Law Judge did not disapprove the proposed standard based on the fact that it contained an equation, but instead determined that the Agency had met its statutory burden to show the equation-based standard to be necessary and reasonable.[21] The Administrative Law Judge went on to find that the proposed implementation of the equation-based standard requires measurement of 1,300 identified waters, a feat that will require approximately ten years to accomplish, and until that is completed no one can know exactly what standard applies and must be met in each identified body of water.[22] Given these facts, the Administrative Law Judge determined that the proposed rule was insufficiently specific to be approved[23] and that it was not "rationally related to the Agency's objective" of "protect[ing] wild rice from the impact of sulfate, so that wild rice can continue to be used as a food source by humans and wildlife."[24] Pursuant to Minn. R. 1400.2100.B., a rule cannot lawfully be approved if it does not rationally relate to the

[18] The Report of the Chief Administrative Law Judge concurred in all respects with the findings and conclusions contained in the Report of the Administrative Law Judge. For the convenience of the reader, further references to the issued Reports will cite only to the Report of the Administrative Law Judge.
[19] MPCA Resubmission at 1.
[20] MPCA Resubmission at 1-4.
[21] Report of the Administrative Law Judge at 60-61, Findings 251, 256, 257.
[22] *Id.* at 61, Finding 258 and at 55-59, Findings 234-249.
[23] *Id.* at 58, Finding 247. *See also Minnesota Chamber of Commerce v. Minnesota Pollution Control Agency*, 469 N.W.2d 100, 107 (Minn. Ct. App. 1991) ("A rule, like a statute, is void for vagueness if it fails to give a person of ordinary intelligence a reasonable opportunity to know what is prohibited or fails to provide sufficient standards for enforcement") (citing *Grayned v. City of Rockford,* 408 U.S. 104, 108-09 (1972)).
[24] Report of the Administrative Law Judge at 58, Finding 246.

Agency's objectives. Having reached this conclusion, the Administrative Law Judge disapproved the proposed rule.

In its Resubmissions the Agency reverts to its argument that:

> "[e]ffluent limit review is case-specific and includes evaluating information such as pollution concentrations in the receiving water and the discharge . . . and how many sources contribute to the receiving water. … Until that information is reviewed and the effluent limit is established, no permittee can know if or to what extent they will have to treat their wastewater discharge for the given pollutant, even if the standard that the effluent limit is protecting is a single numeric value."[25]

In essence, the Agency ignores the Administrative Law Judge's rational relationship analysis and continues to insist that the proposed equation-based rule should be approved based upon the fact that it is necessary and reasonable. Unfortunately, the Administrative Procedure Act does not provide for approval based on that factor alone; all other requirements of statute and rule must also be met in order for rule approval to be lawfully granted.[26]

Even while continuing to argue that the proposed equation-based standard is legally sufficient and should be approved, the MPCA's Resubmissions include several key clarifications and revisions to the equation and required analysis. Three major revisions, and the Chief Administrative Law Judge's responses to each, are addressed below.

(1) Removal of Second Lake

The MPCA revised the proposed equation through the removal of one of four identified outliers in the dataset upon which it had relied in originally promulgating the formulaic equation. This proposed change was made as a result of the Agency's apparent post-January 2018 recognition, grounded in "new information" published in a 2017 study which the Agency relied upon at the rulemaking hearings,[27] which established that "the equation would potentially be made inaccurate if the concentrations [of sulfate compared between groundwater and surface water] were significantly different."[28] A significant difference in the concentrations suggests that upwelling groundwater rather than downward-moving sediment from overlying surface water could be responsible for the "observed false positives in the MPCA data set (false positives are waterbodies for which the equation predicts that sulfide should exceed 120 micrograms per liter, but the sulfide is less than 120)."[29] Having found the concentrations to be materially different in four water bodies, but only having data documenting the fact of upwelling groundwater in one of the four (Second Creek), the Agency proposes removal of this one outlier water body

[25] *Id*. at 4.
[26] Minn. Stat. § 14.05 (2016).
[27] *See* Hearing Exhibit L.2, Ng et al., 2017.
[28] MPCA Resubmissions, Attachment 6 at 1.
[29] *Id.*

from the data set. The result of this removal is a resulting in a change in the mathematical terms included in the equation.[30]

The Agency's newly-submitted revision, based on the exclusion of one outlier in the data set, is based on information available at the time of hearings. This indicates that the Agency's discernment of the proper criteria for inclusion/non-inclusion in the proposed equation-based standard continues to evolve. While this is laudatory, it supports the view expressed at hearing that the proposed standard is too much a continuing work-in-progress to be adopted as an enforceable rule.

By law, a rule is defined as an "agency statement of general applicability and future effect, including amendments, suspensions, and repeals of rules, adopted to implement or make specific the law enforced or administered by that agency or to govern its organization or procedure."[31] It is not difficult to understand how the public questions whether a standard that is unknowable until sufficiently sampled and calculated over a period of ten years, which consists of an equation with mathematical terms that continue to evolve even before adoption, can constitute a rule by which their actions can be regulated.

(2) Inserted Caps

In the proposed revised standard, the MPCA sets minimum and maximum sulfate limits separate and apart from the site-specific limits derived from the equation calculation in proposed rule Minn. R. 7050.0224, subd. 5(B). Functioning as boundaries on the standard, the Agency proposes that the minimum numeric expression of the sulfate standard would be 0.5 milligrams per liter and the maximum numeric expression of the standard would be 335 milligrams per liter.[32]

The insertion of capped boundaries appears to be a prudent and reasonable change to the proposed standard. The Chief Administrative Law Judge notes, however, that the public has had no opportunity to comment regarding whether these specific, proposed caps are the appropriate ones for inclusion in the proposed rule.

(3) Choosing Between Competing Values

The Administrative Law Judge disapproved the proposed rule, in part, based upon the fact that the Agency allowed for any person to measure and propose the standard for an identified water body but had provided no written, transparent process or criteria for doing so. Neither had the Agency identified what process it would rely upon when required to choose among differing, submitted numeric standards.[33]

In its Resubmissions, the Agency clarified that any person, including persons who are not MPCA staff, are allowed to calculate the allowable amount of sulfate for a

[30] *Id.*; Part 7050.0224, subp. 5, Item B.
[31] Minn. Stat. § 14.02, subd. 4 (2016).
[32] MPCA Resubmissions, Attachment 8 at 55.
[33] Report of the Administrative Law Judge at 74, Findings 308-310.

particular body of water by undertaking collection and calculation processes in compliance with the Agency's publication titled *Sampling and Analytical Methods for Wild Rice Waters*.[34] This required technical methodology is incorporated by reference at proposed Minn. R. 7050.0224, subd. 5 (E).

In an apparent attempt to address the issue of choosing between competing and differently valued samples, the Agency's Resubmissions provide as follows:

> All data collected in a wild rice water would be used to set the numeric expression of the standard for that wild rice water. If MPCA has already collected and analyzed 15 (or more) values, then the next 15 (or more) values would be added to the calculation. Moving to a percentile approach will provide greater stability in the numeric expression of the standard – as more data is collected, the numeric expression will converge on the "true" value. This will reduce the likelihood of major changes in the calculated expression of the standard.[35]

The Chief Administrative Law Judge finds this statement to be an insufficient response to the stated concern. First, the statement is not contained in the language of the proposed rule; it is included only in correspondence filed with the Chief Administrative Law Judge as part of the Agency's Resubmissions. This will not become part of any published rule available for future reference or review, and will not have the force and effect of law. Second, the described process does not address the Agency's planned response when less than 15 samples are submitted. For example, assume that Measurer A samples, calculates and submits a proposed standard of .1X for an identified water and Measurer B samples, calculates and submits a proposed standard of 100X for the same body. While the Resubmissions imply that the Agency would average the two submissions into its existing 15 or more samples, that process is not explicitly stated.

In addition, the Agency's Resubmissions clearly indicate that "as more data is collected" the standard for any specified water body will continue to change.[36] In essence, then, the public will be unable to rely upon even the Agency's publication of any specified standard. As an example, consider a situation wherein a water body is sufficiently sampled and the standard calculated to be Y, a value with the Agency publishes on its website and is relied upon by the public. An hour after publication, a different measurer gathers, calculates and submits 15 additional samples to the Agency, which promptly "add[s] them to the calculation" so as to allows the standard to "converge on the 'true' value."[37] As a result, the enforceable standard is immediately changed, and the public would have no knowledge of the change absent continual monitoring of the Agency's website. In essence, the proposed standard becomes not a measuring stick, but a slide

[34] MPCA Resubmission at 4 ("the proposed wild rice rule requires sampling from specific water bodies in order to generate data needed to plug into the equation before a numeric expression can be developed and provides notice of how that data should be gathered and the numeric expression to be determined"). Part 7050.0224, subp. 5, item E.
[35] *Id*., Attachment 6 at 10.
[36] *Id.*
[37] *Id.*

rule. It is difficult to conclude that such a process could ever "give a person of ordinary intelligence a reasonable opportunity to know what is prohibited or … provide sufficient standards for enforcement."[38] Failing to do so, the proposed rule cannot withstand legal scrutiny.

Overall, it is possible that the Agency's submitted clarifications and revisions noted above may represent improvements in the proposed rule. Even so, the fact remains that none of these refinements were made available for public comment or discussion, at hearing or otherwise.

B. Repeal of existing 10 mg/L standard

In her Report disapproving the rule, the Administrative Law Judge noted the public's significant concern that increases in sulfate could lead to increases in methyl mercury, which bio-accumulates in fish and has long-term serious health effects on humans.[39] The MPCA agreed that "enhanced production of methylmercury is a significant concern,"[40] but insisted that this issue was outside the scope of this rulemaking process.[41]

In its Resubmissions, the Agency clarified that it would continue to rely on the state's existing eutrophication standards and mercury standards to ensure that all applicable water standards are met.[42] The Agency admitted that this fact was "so fundamental" to its work that it "escaped mention" in its written response to the public's comments on this issue.[43] If the Agency resubmits this rule in the future, it should include evidence in the record to support its allegations regarding its ability to ensure that all applicable water standards are met.

C. Downstream Waters: Tribes

Both the Fond du Lac Band and the Grand Portage Band of Lake Superior Chippewa have in place wild rice water quality standards that limit sulfate to 10 milligrams/liter. These standards are federally approved and not alterable by the state.[44] The Administrative Law Judge expressed a concern that loosening the sulfate standard for the state's designated waters could degrade the quality of the Bands' wild rice waters.[45]

In its Resubmissions, the Agency recognized the possibility that completing the calculation in proposed Minn. R. 7050.0224, subd. 5(B), might result in numeric expressions of the sulfate standard that are greater than 10 milligrams per liter. In such

[38] *Minnesota Chamber of Commerce v. Minnesota Pollution Control Agency*, 469 N.W.2d 100, 107 (Minn. Ct. App. 1991).
[39] Report of the Administrative Law Judge at 51-52, Findings 219-221.
[40] *Id.* at 52, Finding 220.
[41] *Id.* at 52, Finding 221.
[42] MPCA Resubmission at 5.
[43] *Id.* at 6.
[44] Minn. R. 7050.0155; Report of the Administrative Law Judge at 52, n. 326, citing Hearing Ex. 1020.
[45] Report of the Administrative Law Judge at 52-53, Findings 223-225.

cases, the Agency asserts that it would use other regulatory controls to ensure that waters flowing downstream into areas still governed by the current 10 milligram per liter standard continue to meet applicable water quality standards.[46] If this rule is resubmitted for approval, the Agency should include in the record sufficient evidence to support this assertion.

II. Proposed List of Waters

Federal law delegates to states the authority to establish designated uses of waters and to establish water quality criteria to protect those designated uses in bodies of water.[47] States are prohibited from removing a designated use, if such a use is an "existing use," unless a use with more stringent criteria is added.[48] An existing use is one "actually attained in the water body on or after November 28, 1975, whether or not it is included in the water quality standards."[49]

In the proposed rule, the Agency identified a list of approximately 1,300 waters at Minn. R. 7050.0471. The MPCA based its list upon, among other sources, a comprehensive, reviewed list compiled by the Minnesota Department of Natural Resources (DNR) in a 2008 Report to the Legislature.[50] The MPCA recognized that the DNR's list "is widely considered the most comprehensive source of information regarding where rice may be found in Minnesota" and so extensively reviewed the DNR list when making its designations.[51] In compliance with its legislative directive, the MPCA also consulted with the various Tribes when compiling its list.[52]

In making its determinations as to which water bodies would be included in the list, the MPCA did not explicitly apply the standards it intends to use in future rulemakings to determine whether a water body should be added to the list of wild rice waters.[53] Instead, the Agency used a "weight of evidence" standard to identify waters that met its criteria for "beneficial use as a wild rice water."[54] The rulemaking record does not identify each water considered and rejected for inclusion on the list, nor does it reveal on what basis the Agency rejected any proposed water from inclusion on the list.[55] The MPCA

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[46] MPCA Resubmission, at 6 ("Protection of downstream waters is required by 40 CFR 131.10(b). The MPCA already complies with this requirement and there is now a state rule that expressly requires such compliance, Minn. R. 7050.0155…. [To protect these waters, MPCA will] 'facilitate consistent and efficient implementation and coordination of water quality-related management actions' such as permits.").
[47] 40 C.F.R. § 131.3.
[48] 40 C.F.R. § 131.11(h)(1).
[49] 40 C.F.R. § 131.3(e); *See* Report of the Administrative Law Judge at 65, 68, Findings 269, 283.
[50] Report of the Administrative Law Judge at 63-64, Findings 263, 265.
[51] *Id.* at 64, Finding 265.
[52] *Id.* at 62, Finding 261.
[53] *Id.* at 67, Finding 279.
[54] *Id.* at 67, Finding 278.
[55] *Id.* at 67, Finding 279. According to its Resubmissions, the Agency recently asked the federal Environmental Protection Agency (EPA) how uses are designated and whether an existing use can be a designated use. The EPA responded in a March 5, 2018 letter to the Agency (March 28 letter, Att. 1, at 5-8). The only discussion of "existing use" is a clarification of the regulatory definition at 40 CFR 131.3 (e) ("those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.") The EPA explains "that existing uses are known to be 'actually

acknowledged that it may not have included in the proposed list all waters where the wild rice use has existed since Nov. 28, 1975.[56]

The Administrative Law Judge disapproved the proposed list, concluding that the MPCA's approach excluded hundreds of water bodies previously on lists from the DNR and other sources, including the 1854 Treaty Authority's 2016 and 2017 lists of wild rice waters.[57] The Administrative Law Judge determined that these exclusions violated the federal prohibition against removing a designated use if such a use is an existing use.[58] She also expressed concerns with the reasonableness of the Agency's exclusion of waters without any explicit standards or discussion.[59]

In its Resubmissions, the Agency argued that it compiled its list in consultation with the DNR and tribes, but insisted that it alone can determine what constitutes an "existing use" in Minnesota for purposes of the federal Clean Water Act (CWA).[60] Citing Minn. Stat. §§ 115.03, subd. 1(b) and 115.44, the MPCA argues that it is the only state agency with legal authority to classify waters of the state and assign designated uses.[61]

The Agency's authority is not as clear as it asserts. Minn. Stat. §§ 115.03, subd. 1(b) and 115.44 address the Agency's authority to classify waters, not specifically to determine existing uses for purposes of the CWA. While federal law provides that "the state" may determine existing uses, it does not specify which agency within a state has that unique authority.[62]

Even if the MPCA can establish that its authority trumps that of the DNR or any other state agency, it cannot establish that it is the sole decider of what constitutes an existing use for purposes of federal law. The CWA specifically authorizes certain Indian tribes to make designations as well. The Fond du Lac Band and the Grand Portage Band of Lake Superior Chippewa are both authorized to do so based on approved agreements with the federal government regarding water quality standards.[63] Both Bands agreed that, in rejecting the DNR's report and the 1854 Treaty Authority's list, the MPCA was removing waters that the Bands had already designated as having wild rice as an existing use under federal law.[64]

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attained' when theh use has actually occurred *and* the water quality necessary to support the use has been attained. EPA recognizes, however, that all necessary data may not be available to determine whether the use actually occurred or the water quality to support the use has been attained. When determining an existing use, the EPA provides substantial flexibility to states and authorized tribes to evaluate the strength of the available data . . . ." *See* MPCA Resubmissions, Attachment 1 at 8, citing 80 Fed. Reg. 51027.

[56] Report of the Administrative Law Judge at 67, Findings 280-282.

[57] *Id.* at 65, Finding 269.

[58] *Id.* at 69, Finding 287.

[59] *Id.* at 68, Finding 283.

[60] MPCA Resubmissions at 8-10.

[61] *Id.* at 9.

[62] The Chief Administrative Law Judge notes that the MPCA is designated as the "agency responsible for providing section 401 certifications for nationwide permits: under the CWA. Minn. Stat. 115.03, subd. 4a (2016).

[63] MPCA Resubmissions at 9, n 44.

[64] Report of the Administrative Law Judge at 65, Finding 269, n 395.

III. **Narrative criteria**: Minn. R. 7050.0224, subp. 6

In Part 7050.0224, subp. 6,[65] the MPCA leaves in place an existing (but slightly re-worded) narrative standard for protecting certain wild rice waters. The Administrative Law Judge disapproved this standard because it applies only to some, and not all, wild rice waters.[66] The record reveals no showing of need and/or reasonableness for distinguishing between application of the narrative standard to some waters and the numeric standard to others.[67]

In its resubmissions, the Agency clarified that establishing a sulfate limit standard for certain bodies of water designated in the proposed rule does not remove protections under the federal Clean Water Act for other bodies of water not designated in the proposed rule.[68] The Agency argued that federal law allows a narrative standard to be applied to a set of identified waters that are not the same set to which a numeric standard applies.[69]

Without more, this argument is not convincing. While federal law clearly allows for different regulatory standards for subgroups of waters, Minnesota's rulemaking statute requires an explanation for differentiating between similarly situated groups in these circumstances. The missing explanation relates to whether the differentiation is necessary and reasonable, a foundational criteria for approval of any proposed rule.

IV. Unaddressed Technical Errors[70]

The Chief Administrative Law Judge's review of the Agency's resubmissions has revealed the following instances wherein the Agency has failed to address technical errors identified as additional bases for disapproval.

A. Part 7050.0220, subp. 5a.[71]

According to a review of the 2017 rule language published at the Revisor of Statutes website, the existing rule language highlighted below continues to be missing from the proposed rule amendment.

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[65] *See* Lines 9.13 - 9.18 in 7/24/17 version and lines 56.18 - 56.23 in 3/16/18 version.
[66] Report of the Administrative Law Judge at 69, Finding 287b.
[67] Report of the Administrative Law Judge at 69-70.
[68] MPCA Resubmissions at 7 ("[H]aving different standards for different reaches is not inherently unprotective of downstream waters. As required by federal law, the MPCA has met, and will continue to meet requirements to ensure that downstream standards are protected in the permitting process. The MPCA submits that ... with respect to the proposed rule, as with all its rules, it has and is obligated to implement its rules so as to be protective of downstream uses.").
[69] *Id.*, Attachment 1 at 8-9. The EPA cited to 40 CFR 131.10(c), which provides that "States may adopt sub-categories of a use and set the appropriate criteria to reflect varying needs of such sub-categories of uses, for instance, to differentiate between cold water and warm water fisheries." The MPCA offers no explanation for distinguishing between the categories of wild rice waters.
[70] MPCA Resubmissions, Proposed Order at 7, comment 28.
[71] *See* Lines 4.19-4.24 of 7/24/17 version and lines 38.21-39.3 of 3/16/18 version.

Subp. 5a.

Cool and warm water aquatic life and habitat and associated use classes.

Water quality standards applicable to use classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, or 3C; 4A and 4B; and 5 surface waters. See parts 7050.0223, subpart 5; 7050.0224, subpart 4; and 7050.0225, subpart 2, for class 3D, 4C, and 5 standards applicable to wetlands, respectively. The water quality standards in part 7050.0222, subpart 4, that apply to class 2B also apply to classes 2Be, 2Bg, and 2Bm. In addition to the water quality standards in part 7050.0222, subpart 4, the biological criteria defined in part 7050.0222, subpart 4d, apply to classes 2Be, 2Bg, and 2Bm.

B. Part 7050.0470, subps. 1 through 9.[72]

Based on the 2017 rule language available for review on the Revisor of Statutes website, the Agency is proposing to amend an outdated version of subparts 1-9. Subpart 1 is given as an example, below. The highlighted language is the language on the Revisor's website and noted as "published electronically on November 20, 2017." The language without highlighting is the language the Agency now presents as the current language, with proposed amendments indicated.

Subpart 1.

Lake Superior basin.

The water use classifications for the listed waters in the in the Lake Superior basin are as identified in items A to D. See parts 7050.0425 ~~and~~, 7050.0430, and 7050.0471 for the classifications of waters not listed. Thus, it appears that the Agency proposes to amend an out-of-date version of the rule. This applies to all 9 subparts of part 7050.0470.

Lake Superior basin.

The water-use classifications for the stream reaches within each of the major watersheds in the Lake Superior basin listed in item A are found in tables entitled "Beneficial Use Designations for Stream Reaches" published on the Web site of the Minnesota Pollution Control Agency at www.pca.state.mn.us/regulations/minnesota-rulemaking. The tables are incorporated by reference and are not subject to frequent change. The date after each watershed listed in item A is the publication date of the applicable table. The water-use classifications for the other listed waters in the Lake Superior basin are as identified in items B to D. See parts 7050.0425 and 7050.0430 for the classifications of waters not listed. Designated use information for water bodies can also be accessed through the agency's

[72] *See* Lines 9.21-11.13 of 7/24/17 version and lines 57.3-58.17 of 3/16/18 version.

Environmental Data Access (http://www.pca.state.mn.us/quick-links/eda-surface-water-data).

V. Approved Rule Modifications

In Attachment 7 of its Resubmissions, the Agency provides a list of 22 proposed rule changes for consideration by the Chief Administrative Law Judge. Upon review, the Chief Administrative Law Judges finds as follows:

- Proposed Rule Changes 1 – 4: Already approved in the Report of the Administrative Law Judge

- Proposed Rule Changes 5 – 8: Relate to the proposed equation-based standard and not approved for the reasons specified in the Report of the Administrative Law Judge and this Order.

- Proposed Rule Changes 9 – 11: Already approved in the Report of the Administrative Law Judge

- Proposed Rule Changes 12 – 13: Approved as related to Proposed Rule Change 11

- Proposed Rule Changes 14 – 16: Approved as minor clarifications

- Proposed Rule Changes 17 – 21: Already approved in the Report of the Administrative Law Judge

- Proposed Rule Change 22: Not approved for the reasons set forth in the Report of the Administrative Law Judge and this Order.

Based upon a review of the rulemaking docket, the Report of the Administrative Law Judge, the Report of the Chief Administrative Law Judge and the Agency's Resubmissions, the Chief Administrative Law Judge issues the following:

ORDER

1. The proposed rules, dated July 27, 2017, as modified by the Agency's Resubmissions, remain disapproved for the reasons set forth in the Report of the Administrative Law Judge, as modified and or clarified by the provisions of this Order.

2. Pursuant to Minn. Stat. 14.15, subd. 4, if the Agency elects not to correct the identified defects as identified in the Report of the Chief Administrative Law Judge, the Agency shall submit the proposed rule to the Legislative Coordinating Commission

and to the legislative policy committees with primary jurisdiction over state governmental operations for advice and comment. The Agency may not adopt the rule until it has either: received and considered the advice of the commission and committees; or 60 days have passed following the Agency's submission of the rule to the commission and committees.

Dated: April 12, 2018

TAMMY L. PUST
Chief Administrative Law Judge

	A	B	C	D	E	F	G	H	I	J	K
1	**MPCA Wild Rice Waters database (July 19, 2016)**									**Received by Advisory Committee dated Jan. 25, 2017**	
2	Column L "STATUS_LIST" codes :										
3	"DL" = Draft List										
4	"II" = Insufficient Information										
5	"7050" = wild rice water currently in Minn. R. 7050.0470										
6									MNDNR2008		STATUS
7	OBJECTID	Line_Number	COUNTYNAME	NAME	MPCA_WID	ALT_SITE_ID	WB_Type	ACRES	ESTACRE	REFERENCE_SOURCE	_LIST
8	1317	1	Aitkin	Ball Bluff	01-0046-00		Lake	178		MDNR 2013	II
9	1318	2	Aitkin	Bear	01-0064-00		Lake	127	1	MDNR 2008	II
10	1319	3	Aitkin	Boot	01-0055-00		Lake	77		MDNR 2013	II
11	1320	4	Aitkin	Cartie	01-0189-00		Lake	27		MDNR 2013	II
12	1321	5	Aitkin	Cedar	01-0065-00		Lake	260		MDNR 2013	II
13	1322	6	Aitkin	Clear	01-0093-00		Lake	590		MDNR 2013	II
14	1323	7	Aitkin	Dam	01-0096-00		Lake	633		MDNR 2013	II
15	1324	8	Aitkin	Diamond	01-0171-00		Lake	80		MDNR 2013	II
16	1325	9	Aitkin	Douglas	01-0009-00		Lake	75		MDNR 2013	II
17	1326	10	Aitkin	Glacier	01-0042-00		Lake	139		MDNR 2013	II
18	1327	11	Aitkin	Hammal	01-0161-00		Lake	376	1	MDNR 2008	II
19	1328	12	Aitkin	Hay	01-0059-00		Lake	133	1	MDNR 2008	II
20	1329	13	Aitkin	Horseshoe	01-0154-00		Lake	53		MDNR 2013	II
21	1330	14	Aitkin	Jenkins	01-0100-00		Lake	127	1	MDNR 2008	II
22	1333	17	Aitkin	Kingsley Pothole	01-0138-00		Lake	33		MDNR 2013	II
23	1334	18	Aitkin	Little Prairie	01-0016-00		Lake	78	1	MDNR 2008	II
24	1337	21	Aitkin	Long	01-0089-00		Lake	433		MDNR 2013	II
25	1336	20	Aitkin	Long	01-0101-00		Lake	33		MDNR 2013	II
26	1338	22	Aitkin	McKinney	01-0199-00		Lake	52		MDNR 2008	II
27	1339	23	Aitkin	Moulton	01-0212-00		Lake	282	1	MDNR 2008	II
28	1341	25	Aitkin	Mud	01-0035-00		Lake	65		MDNR 2013	II
29	1340	24	Aitkin	Mud (Grayling WMA)	01-0029-00		Lake	400	1	MDNR 2008	II
30	1343	27	Aitkin	Round	01-0023-00		Lake	571		MDNR 2013	II
31	1342	26	Aitkin	Round	01-0070-00		Lake	188		MDNR 2013	II
32	1344	28	Aitkin	Round	01-0137-00		Lake	634	1	MDNR 2008	II
33	1345	29	Aitkin	Round	01-0204-00		Lake	736		MDNR 2013	II
34	1346	30	Aitkin	Section 25	01-0127-00		Lake	48		MDNR 2013	II
35	1347	31	Aitkin	Sixteen	01-0124-00		Lake	18	1	MDNR 2008	II
36	1348	32	Aitkin	Spectacle	01-0156-00		Lake	107	1	MDNR 2008	II
37	1349	33	Aitkin	Studhorse	01-0110-00		Lake	63		MDNR 2013	II
38	1351	35	Aitkin	Sugar	01-0084-00		Lake	23	1	MDNR 2008	II
39	1350	34	Aitkin	Sugar	01-0087-00		Lake	416	1	MDNR 2008	II
40	1352	36	Aitkin	Thornton	01-0174-00		Lake	186		MDNR 2013	II
41	1353	37	Aitkin	Turner	01-0074-00		Lake	63		MDNR 2013	II
42	1357	41	Aitkin	Unnamed	01-0020-00		Lake	19	1	MDNR 2008	II
43	1358	42	Aitkin	Unnamed	01-0262-00		Lake	14	1	MDNR 2008	II
44	1359	43	Aitkin	Unnamed	01-0314-00		Lake	16		MDNR 2013	II
45	1354	38	Aitkin	Unnamed	01-0372-00		Lake	22		MDNR 2013	II
46	1360	44	Aitkin	Unnamed	01-0450-00		Lake	5		MDNR 2013	II
47	1355	39	Aitkin	Unnamed (Rice)	01-0419-00		Lake	16	1	MDNR 2008	II
48	1356	40	Aitkin	Unnamed (Twin Lakes)	01-0413-00		Lake	10		MDNR 2013	II
49	1361	45	Aitkin	Vanduse	01-0058-00		Lake	233		MDNR 2013	II
50	1362	46	Aitkin	Wilkins	01-0102-00		Lake	366		MDNR 2013	II
51	1363	47	Aitkin	Wolf	01-0019-00		Lake	168		MDNR 2008	II
52	1364	48	Anoka	Boot	02-0028-00		Lake	130		MDNR 2013	II
53	2331		Anoka	Carlos Avery - Pool 16		W9001016	Lake	67		MDNR 2008	II
54	2332		Anoka	Carlos Avery - Pool 17		W9001017	Lake	185		MDNR 2008	II
55	2333		Anoka	Carlos Avery - Pool 23		W9001023	Lake	1600		MDNR 2008	II
56	1365	49	Anoka	Carlos Avery WMA Pool 15	DNR	W9001015		365	1	MDNR 2008	II
57	1366	50	Anoka	Carlos Avery WMA Pool 6	02-0029-00	W9001006		200	1	MDNR 2008	II
58	1367	51	Anoka	Deer	02-0059-00		Lake	376		MDNR 2013	II
59	1368	52	Anoka	East Twin	02-0020-00		Lake	171	1	MDNR 2008	II
60	1369	53	Anoka	Fish	02-0065-00		Lake	332		MDNR 2013	II
61	1371	55	Anoka	Grass	02-0092-00		Lake	12		MDNR 2008	II
62	1370	54	Anoka	Grass	02-0113-00		Lake	36		MDNR 2008	II
63	1372	56	Anoka	Rice	02-0008-00		Lake	371		MDNR 2008	II
64	1373	57	Anoka	Rice	02-0043-00		Lake	64	1	MDNR 2008	II
65	1374	58	Anoka	Rice Creek	07010206-5802r1		Stream			MDNR 2008	II
66	1375	59	Anoka	Rondeau	02-0015-00		Lake	552		MDNR 2008	II
67	1376	60	Anoka	Rum River	07010207-5502r2		Stream			MDNR 2008	II
68	1381	65	Anoka	Unnamed	02-0029-00		Lake	1037		MDNR 2013	II
69	1380	64	Anoka	Unnamed	02-0030-00		Lake	235		MDNR 2013	II
70	1379	63	Anoka	Unnamed	02-0031-00		Lake	635		MDNR 2013	II
71	1377	61	Anoka	Unnamed	02-0101-00		Lake	148		MDNR 2013	II
72	1378	62	Anoka	Unnamed	02-0505-00		Lake	1732		MDNR 2013	II
73	1382	66	Anoka	West Twin	02-0033-00		Lake	18		MDNR 2008	II
74	2334		Becker	Albertson	03-0266-00		Lake	73		MDNR 2008	II
75	1383	67	Becker	Alvin	03-0184-00		Lake	20		MDNR 2013	II
76	2335		Becker	Axberg	03-0660-00		Lake	47		MDNR 2008	II
77	1384	68	Becker	Bad Medicine	03-0085-00		Lake	782		MDNR 2013	II
78	1386	70	Becker	Bass	03-0127-00		Lake	142		MDNR 2013	II
79	1385	69	Becker	Bass	03-0332-00		Lake	138		MDNR 2013	II
80	2336		Becker	Bass	03-0480-00		Lake	28		MDNR 2008	II
81	2337		Becker	Bean	03-0411-00		Lake	19		MDNR 2008	II
82	1387	71	Becker	Besseau (Bijou)	03-0638-00		Lake	229		MDNR 2013	II
83	1388	72	Becker	Big Cormorant	03-0576-00		Lake	3380		MDNR 2013	II
84	1389	73	Becker	Campbell	03-0419-00		Lake	547		MDNR 2013	II
85	1390	74	Becker	Cotton	03-0286-00		Lake	1916		MDNR 2013	II
86	1391	75	Becker	Dahlberg	03-0577-00		Lake	77		MDNR 2008	II
87	1393	77	Becker	Detroit	03-0381-00		Lake	3089		MDNR 2013	II
88	1394	78	Becker	Dumbbell	03-0124-00		Lake	149		MDNR 2013	II
89	1395	79	Becker	Elbow	03-0065-00		Lake	65		MDNR 2013	II
90	1396	80	Becker	Eunice	03-0503-00		Lake	370		MDNR 2013	II
91	1397	81	Becker	Floyd	03-0387-00		Lake	1212		MDNR 2013	II
92	1398	82	Becker	Halverson	03-0412-00		Lake	18		MDNR 2008	II
93	1399	83	Becker	Hanson	03-0177-00		Lake	35		MDNR 2013	II
94	1400	84	Becker	Hernando DeSoto	03-0032-00		Lake	180		MDNR 2013	II
95	1401	85	Becker	Hungry	03-0166-00		Lake	245		MDNR 2013	II
96	1402	86	Becker	Island	03-0153-00		Lake	1209		MDNR 2013	II

	A	B	C	D	E	F	G	H	I	J	K
97	1403	87	Becker	Jones	03-0123-00		Lake	36		MDNR 2013	II
98	1404	88	Becker	Juggler	03-0136-00		Lake	434		MDNR 2013	II
99	1405	89	Becker	Leif	03-0575-00		Lake	519		MDNR 2013	II
100	1406	90	Becker	Little Bass	03-0337-00		Lake	87		MDNR 2013	II
101	1407	91	Becker	Little Long	03-0009-00		Lake	14		MDNR 2013	II
102	1408	92	Becker	Little Mud	03-0188-00		Lake	63		MDNR 2013	II
103	1409	93	Becker	Little Sugar Bush	03-0313-00		Lake	222		MDNR 2013	II
104	1410	94	Becker	Loon	03-0489-00		Lake	236		MDNR 2013	II
105	2338		Becker	Lyman WPA		03IMP003	Lake			MDNR 2008	II
106	1411	95	Becker	Maud	03-0500-00		Lake	540		MDNR 2013	II
107	1412	96	Becker	Meadow	03-0371-00		Lake	66		MDNR 2013	II
108	1413	97	Becker	Melissa	03-0475-00		Lake	1827		MDNR 2013	II
109	1415	99	Becker	Mud	03-0016-00		Lake	86		MDNR 2008	II
110	1416	100	Becker	Mud	03-0187-00		Lake	144		MDNR 2013	II
111	1417	101	Becker	Net	03-0334-00		Lake	243		MDNR 2013	II
112	1418	102	Becker	Pearl	03-0486-00		Lake	268		MDNR 2008	II
113	1419	103	Becker	Pine	03-0200-00		Lake	540		MDNR 2013	II
114	1420	104	Becker	Rice	03-0173-00		Lake	37		MDNR 2008	II
115	1421	105	Becker	Rice	03-0285-00		Lake	51		MDNR 2008	II
116	1422	106	Becker	Sallie	03-0359-00		Lake	1287		MDNR 2013	II
117	1423	107	Becker	Sand	03-0659-00		Lake	199		MDNR 2013	II
118	1424	108	Becker	Senical	03-0365-00		Lake	122		MDNR 2013	II
119	1426	110	Becker	Strawberry	03-0323-00		Lake	1607		MDNR 2013	II
120	1431	115	Becker	Unnamed	03-0087-00		Lake	23		MDNR 2008	II
121	1429	113	Becker	Unnamed	03-0140-00		Lake	43		MDNR 2008	II
122	1430	114	Becker	Unnamed	03-0175-00		Lake	25		MDNR 2013	II
123	1433	117	Becker	Unnamed	03-0598-00		Lake	36		MDNR 2008	II
124	1434	118	Becker	Unnamed	03-0599-00		Lake	34		MDNR 2008	II
125	1432	116	Becker	Unnamed	03-0600-00		Lake	59		MDNR 2008	II
126	1427	111	Becker	Unnamed	DNR	being assign*		6		MDNR 2013	II
127	1428	112	Becker	Unnamed	DNR	W0127601		20		MDNR 2013	II
128	1435	119	Becker	Unnamed (Little Round)	03-0008-00		Lake	12		MDNR 2013	II
129	1436	120	Becker	Upper Cormorant	03-0588-00		Lake	963		MDNR 2013	II
130	1437	121	Becker	Waboose	03-0213-00		Lake	249		MDNR 2013	II
131	1438	122	Becker	Wahbegon	03-0082-00		Lake	121		MDNR 2013	II
132	1439	123	Beltrami	Alice	04-0151-00		Lake	96		MDNR 2013	II
133	1440	124	Beltrami	Balm	04-0329-00		Lake	512		MDNR 2013	II
134	1441	125	Beltrami	Barr	04-0327-00		Lake	28		MDNR 2013	II
135	1442	126	Beltrami	Bass	04-0191-00		Lake	56		MDNR 2013	II
136	1443	127	Beltrami	Baumgartner	04-0021-00		Lake	27		MDNR 2013	II
137	1444	128	Beltrami	Beltrami	04-0135-00		Lake	701		MDNR 2013	II
138	1445	129	Beltrami	Bemidji	04-0130-02	4013000		6920		MDNR 2013	II
139	1446	130	Beltrami	Benjamin	04-0033-00		Lake	36		MDNR 2013	II
140	1447	131	Beltrami	Borden	04-0027-00		Lake	30		MDNR 2013	II
141	1448	132	Beltrami	Bullhead	04-0002-00		Lake	35		MDNR 2013	II
142	1449	133	Beltrami	Carla	04-0058-00		Lake	25		MDNR 2013	II
143	1450	134	Beltrami	Carter	04-0056-00		Lake	30		MDNR 2013	II
144	1451	135	Beltrami	Chinaman	04-0017-00		Lake	72		MDNR 2013	II
145	1452	136	Beltrami	Crandall	04-0070-00		Lake	74		MDNR 2013	II
146	1453	137	Beltrami	Deer	04-0230-00		Lake	287		MDNR 2013	II
147	1454	138	Beltrami	Dellwater	04-0331-00		Lake	147		MDNR 2013	II
148	1455	139	Beltrami	Dutchman	04-0067-00		Lake	171		MDNR 2008	II
149	1456	140	Beltrami	Erick	04-0229-00		Lake	75		MDNR 2013	II
150	1457	141	Beltrami	Fagen	04-0060-00		Lake	35		MDNR 2013	II
151	1458	142	Beltrami	Flora	04-0051-00		Lake	178		MDNR 2013	II
152	1459	143	Beltrami	Fox	04-0162-00		Lake	148		MDNR 2013	II
153	1460	144	Beltrami	Funk	04-0073-00		Lake	140		MDNR 2013	II
154	1461	145	Beltrami	Gilstad	04-0024-00		Lake	256		MDNR 2013	II
155	1462	146	Beltrami	Gimmer	04-0020-00		Lake	77		MDNR 2013	II
156	1463	147	Beltrami	Grant	04-0217-00		Lake	200		MDNR 2013	II
157	1464	148	Beltrami	Grass	04-0216-00		Lake	233		MDNR 2008	II
158	1465	149	Beltrami	Grenn	040-241-00		Lake	70		MDNR 2013	II
159	1466	150	Beltrami	Holland (Little Rice Pond)	04-0023-00		Lake	22		MDNR 2008	II
160	1467	151	Beltrami	Island	04-0265-00		Lake	368		MDNR 2013	II
161	1468	152	Beltrami	Jessie	04-0052-00		Lake	50		MDNR 2013	II
162	1469	153	Beltrami	Julia	04-0166-00		Lake	492		MDNR 2013	II
163	1470	154	Beltrami	Lindgren	04-0153-00		Lake	84		MDNR 2013	II
164	1471	155	Beltrami	Little Gilstad	04-0016-00		Lake	40		MDNR 2013	II
165	1472	156	Beltrami	Little Rabideau	04-0359-00		Lake	25		MDNR 2013	II
166	1473	157	Beltrami	Little Rice	04-0170-00		Lake	72		MDNR 2008	II
167	1474	158	Beltrami	Lower Red	04-0035-02		Lake	2E+05		MDNR 2008	II
168	1475	159	Beltrami	Manomin Creek	07010101-5404r1		Stream			MDNR 2008	II
169	1476	160	Beltrami	Meadow	04-0050-00		Lake	118		MDNR 2013	II
170	1477	161	Beltrami	Muskrat	04-0054-00		Lake	37		MDNR 2013	II
171	1478	162	Beltrami	Muskrat	04-0240-00		Lake	106		MDNR 2013	II
172	1479	163	Beltrami	Nelson	04-0057-00		Lake	29		MDNR 2013	II
173	1480	164	Beltrami	Ose	04-0089-00		Lake	68		MDNR 2013	II
174	1481	165	Beltrami	Peterson	04-0119-00		Lake	78		MDNR 2013	II
175	1482	166	Beltrami	Peterson	04-0177-00		Lake	66		MDNR 2013	II
176	1483	167	Beltrami	Peterson	04-0235-00		Lake	305		MDNR 2013	II
177	1484	168	Beltrami	Polly Wog	04-0168-00		Lake	35		MDNR 2013	II
178	1485	169	Beltrami	Preston	04-0009-00		Lake	10		MDNR 2013	II
179	1486	170	Beltrami	Rice	04-0250-00		Lake	124		MDNR 2008	II
180	1487	171	Beltrami	Roadside	04-0075-00		Lake	46		MDNR 2013	II
181	1488	172	Beltrami	School	04-0114-00		Lake	74		MDNR 2013	II
182	1489	173	Beltrami	Stump	04-0130-01		Lake	323		MDNR 2013	II
183	1490	174	Beltrami	Swenson	04-0085-00		Lake	394		MDNR 2013	II
184	1491	175	Beltrami	Ten Mile	04-0267-00		Lake	98		MDNR 2013	II
185	1496	180	Beltrami	Unnamed	04-0080-00		Lake	130		MDNR 2013	II
186	1494	178	Beltrami	Unnamed	04-0090-00		Lake	27		MDNR 2013	II
187	1495	179	Beltrami	Unnamed	04-0103-00		Lake	43		MDNR 2013	II
188	1497	181	Beltrami	Unnamed	04-0117-00		Lake	48		MDNR 2013	II
189	1500	184	Beltrami	Unnamed	04-0131-00		Lake	45		MDNR 2013	II
190	1499	183	Beltrami	Unnamed	04-0146-00		Lake	34		MDNR 2013	II
191	1502	186	Beltrami	Unnamed	04-0202-00		Lake	18		MDNR 2013	II
192	1501	185	Beltrami	Unnamed	04-0220-00		Lake	28		MDNR 2013	II
193	1503	187	Beltrami	Unnamed	04-0232-00		Lake	32		MDNR 2013	II

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194	1498	182	Beltrami	Unnamed	04-0370-00		Lake	223		MDNR 2013	II
195	1504	188	Beltrami	Unnamed (Addition)	04-0144-00		Lake	12		MDNR 2013	II
196	1505	189	Beltrami	Unnamed (Great Lake Pond)	04-0203-00		Lake	44		MDNR 2013	II
197	1506	190	Beltrami	Unnamed (Horseshoe)	04-0301-00		Lake	24		MDNR 2013	II
198	1507	191	Beltrami	Unnamed (Kinn)	04-0100-00		Lake	32		MDNR 2013	II
199	1508	192	Beltrami	Unnamed (Moose)	04-0112-00		Lake	58		MDNR 2013	II
200	1509	193	Beltrami	Unnamed (Parkers)	04-0106-00		Lake	48		MDNR 2013	II
201	1492	176	Beltrami	Unnamed (Twin Pothole Nor	04-0010-00		Lake	9		MDNR 2013	II
202	1493	177	Beltrami	Unnamed (Twin Pothole Sou	DNR	not assigned		7		MDNR 2013	II
203	1510	194	Beltrami	Upper Lindgren	04-0179-00		Lake	56		MDNR 2013	II
204	1511	195	Beltrami	Upper Red	04-0035-01	4003500		1E+05		MDNR 2008	II
205	1512	196	Beltrami	Whitefish	04-0300-00		Lake	122		MDNR 2013	II
206	1513	197	Beltrami	Wolf	04-0079-00		Lake	1206		MDNR 2013	II
207	1514	198	Benton	Pularskis	05-0009-00		Lake	138		MDNR 2013	II
208	1515	199	Big Stone	Big Stone	06-0152-00		Lake	6028		MDNR 2013	II
209	1516	200	Big Stone	Long Tom	06-0029-00		Lake	110		MDNR 2013	II
210	1517	201	Big Stone	Marsh	06-0001-00		Lake	6100		MDNR 2013	II
211	1518	202	Big Stone	North Rothwell	06-0147-00		Lake	228		MDNR 2013	II
212	1519	203	Blue Earth	Rice	07-0059-00		Lake	255		MDNR 2008	II
213	1520	204	Blue Earth	Rice Creek	07020011-5307r1		Stream			MDNR 2008	II
214	2340		Brown	Altematt	08-0054-00		Lake			MDNR 2008	II
215	1521	205	Brown	Gilman (Rice)	08-0035-00		Lake	164		MDNR 2008	II
216	1522	206	Carlton	Eagle	09-0057-00		Lake	410		MDNR 2013	II
217	1523	207	Carlton	Merwin	09-0058-00		Lake	51		MDNR 2013	II
218	1524	208	Carlton	Railroad	09-0174-00		Lake	7		MDNR 2013	II
219	1525	209	Carlton	Venoah	09-0009-00		Lake	82		MDNR 2013	II
220	1526	210	Carver	Rice	10-0078-00		Lake	244		MDNR 2008	II
221	1527	211	Carver	Rice Marsh	10-0001-00		Lake	77		MDNR 2008	II
222	1528	212	Cass	Ada	11-0250-00		Lake	1092		MDNR 2013	II
223	1529	213	Cass	Barnum	11-0281-00		Lake	139		MDNR 2013	II
224	1530	214	Cass	Bass	11-0474-00		Lake	264		MDNR 2013	II
225	1531	215	Cass	Big Deep	11-0277-00		Lake	532		MDNR 2013	II
226	1532	216	Cass	Blackwater	11-0274-00		Lake	761		MDNR 2013	II
227	1533	217	Cass	Bluebill	11-0397-00		Lake	51	1	MDNR 2008	II
228	1534	218	Cass	Cedar	11-0289-00		Lake	121		MDNR 2013	II
229	1535	219	Cass	Crow Wing River	07010106-7211r3		Stream			MDNR 2008	II
230	1536	220	Cass	Dade	11-0214-00		Lake	103		MDNR 2013	II
231	1537	221	Cass	Donkey (Little Mule)	11-0280-00		Lake	54		MDNR 2008	II
232	1538	222	Cass	Dry Sand	11-0514-00		Lake	191		MDNR 2013	II
233	1539	223	Cass	Fucat	11-0641-00		Lake	10		MDNR 2013	II
234	1540	224	Cass	Gijik	11-0185-00		Lake	118	1	MDNR 2008	II
235	1541	225	Cass	Grass	11-0090-00		Lake	16		MDNR 2008	II
236	1542	226	Cass	Grass	11-0315-00		Lake	113		MDNR 2008	II
237	1543	227	Cass	Hardy	11-0209-00		Lake	108		MDNR 2013	II
238	1544	228	Cass	Hole-In-Bog	11-0197-00		Lake	76		MDNR 2008	II
239	1545	229	Cass	Horseshoe	11-0284-00		Lake	142		MDNR 2013	II
240	1546	230	Cass	Horseshoe	11-0358-00		Lake	245		MDNR 2013	II
241	1547	231	Cass	Hovde	11-0394-00		Lake	115		MDNR 2013	II
242	1548	232	Cass	Island	11-0257-00		Lake	173		MDNR 2013	II
243	1549	233	Cass	Iverson	11-0194-00		Lake	80		MDNR 2013	II
244	1550	234	Cass	Johnson	11-0363-00		Lake	92		MDNR 2013	II
245	1552	236	Cass	Life Raft	11-0406-00		Lake	45		MDNR 2013	II
246	1553	237	Cass	Little Boy	11-0369-00		Lake	71		MDNR 2008	II
247	1554	238	Cass	Little Long	11-0323-00		Lake	33	1	MDNR 2013	II
248	1555	239	Cass	Little Moss	11-0489-00		Lake	93		MDNR 2013	II
249	1556	240	Cass	Little Reservoir	11-0002-00		Lake	14		MDNR 2013	II
250	1557	241	Cass	Little Thunder	11-0009-00		Lake	264		MDNR 2013	II
251	1558	242	Cass	Little Twin	11-0487-00		Lake	114		MDNR 2013	II
252	1560	244	Cass	Long	11-0023-00		Lake	112		MDNR 2013	II
253	1559	243	Cass	Long	11-0258-00		Lake	229		MDNR 2013	II
254	1561	245	Cass	Long	11-0480-00		Lake	218		MDNR 2013	II
255	1562	246	Cass	Loon	11-0226-00		Lake	220		MDNR 2013	II
256	1563	247	Cass	Lower Sucker	11-0313-00		Lake	598		MDNR 2013	II
257	1564	248	Cass	Mad Dog	11-0193-00		Lake	27		MDNR 2008	II
258	1565	249	Cass	Mile	11-0207-00		Lake	76		MDNR 2013	II
259	1566	250	Cass	Ox Yoke	11-0355-00		Lake	199		MDNR 2013	II
260	1567	251	Cass	Pickerel	11-0352-00		Lake	66		MDNR 2008	II
261	1568	252	Cass	Pine	11-0292-00		Lake	256		MDNR 2013	II
262	1569	253	Cass	Portage	11-0490-00		Lake	352		MDNR 2013	II
263	1570	254	Cass	Reservoir	11-0003-00		Lake	60		MDNR 2013	II
264	1571	255	Cass	Rice	11-0138-00		Lake	55	1	MDNR 2008	II
265	1572	256	Cass	Sanborn	11-0361-00		Lake	224		MDNR 2013	II
266	1573	257	Cass	Sand	11-0275-00		Lake	36		MDNR 2013	II
267	1574	258	Cass	Sand	11-0279-00		Lake	144		MDNR 2013	II
268	1575	259	Cass	Silver	11-0202-00		Lake	104		MDNR 2013	II
269	1576	260	Cass	Spider	11-0221-00		Lake	21		MDNR 2013	II
270	1577	261	Cass	Steamboat	11-0504-00		Lake	1761		MDNR 2013	II
271	1578	262	Cass	Stephens	11-0213-00		Lake	104	1	MDNR 2008	II
272	1579	263	Cass	Stony	11-0371-00		Lake	523		MDNR 2013	II
273	1580	264	Cass	Swamp	11-0483-00		Lake	592		MDNR 2013	II
274	1581	265	Cass	Ten	11-0467-00		Lake	28		MDNR 2013	II
275	1582	266	Cass	Ten Mile	11-0413-00		Lake	4640		MDNR 2013	II
276	1583	267	Cass	Third River Flowage	11-0147-00	11014701		2260		MDNR 2013	II
277	1584	268	Cass	Thirty-Six	11-0173-00		Lake	49	1	MDNR 2008	II
278	1585	269	Cass	Three Island	11-0177-00		Lake	168		MDNR 2013	II
279	1586	270	Cass	Tobique	11-0132-00		Lake	24		MDNR 2013	II
280	1587	271	Cass	Trillium	11-0270-00		Lake	149		MDNR 2013	II
281	1588	272	Cass	Twin	11-0484-00		Lake	168		MDNR2008	II
282	1590	274	Cass	Unnamed	11-0714-00		Lake	19		MDNR 2013	II
283	1591	275	Cass	Unnamed	11-0776-00		Lake	18		MDNR 2013	II
284	1592	276	Cass	Unnamed	11-0862-00		Lake	10		MDNR 2013	II
285	1594	278	Cass	Unnamed (Egg)	11-0975-00		Lake	15		MDNR 2013	II
286	1593	277	Cass	Unnamed (Greenhill)	11-0786-00		Lake	12		MDNR 2013	II
287	1595	279	Cass	Unnamed (MPL)	11-0777-00		Lake	40		MDNR 2008	II
288	1589	273	Cass	Unnamed (Rice Swamp)	11-0698-00		Lake	11		MDNR 2008	II
289	1596	280	Cass	Unnamed (Rice)	11-0615-00		Lake	11		MDNR 2008	II
290	1597	281	Cass	Upper Loon	11-0225-00		Lake	114		MDNR 2008	II

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291	1598	282	Cass	Upper Milton	11-0081-00		Lake	27		MDNR 2013	II
292	1599	283	Cass	Vermillion	11-0029-00		Lake	408		MDNR 2013	II
293	1600	284	Cass	Vermillion River	07010106-50	11r1	Stream			MDNR 2013	II
294	1601	285	Cass	Webb	11-0311-00		Lake	619		MDNR 2013	II
295	1602	286	Cass	Welch	11-0493-00		Lake	191		MDNR 2013	II
296	1603	287	Cass	White Oak	11-0016-00		Lake	68	1	MDNR 2008	II
297	1604	288	Cass	Widow	11-0273-00		Lake	197		MDNR 2008	II
298	1605	289	Chisago	Comfort	13-0053-00		Lake	220		MDNR 2013	II
299	1606	290	Chisago	Fish	13-0068-00		Lake	323		MDNR 2013	II
300	1607	291	Chisago	Goose	13-0083-00		Lake	710		MDNR 2008	II
301	1608	292	Chisago	Green	13-0041-00		Lake	1830		MDNR 2013	II
302	1609	293	Chisago	Horseshoe	13-0073-00		Lake	226		MDNR 2013	II
303	1610	294	Chisago	North Center	13-0032-01	13003200		760		MDNR 2013	II
304	1611	295	Chisago	Rush	13-0069-01	13006900		3170		MDNR 2008	II
305	1612	296	Chisago	South Center	13-0027-00		Lake	913		MDNR 2013	II
306	1613	297	Chisago	South Lindstrom	13-0028-00		Lake	664		MDNR 2013	II
307	1614	298	Chisago	Sunrise	13-0031-00		Lake	810		MDNR 2013	II
308	1615	299	Clay	Hartke	14-0336-00		Lake	18		MDNR 2013	II
309	1616	300	Clay	Tilde	14-0004-00		Lake	256		MDNR 2013	II
310	2341		Clearwater	Berg	15-0025-00		Lake	50		MDNR 2008	II
311	1617	301	Clearwater	Duncan	15-0024-00		Lake	18		MDNR 2008	II
312	1618	302	Clearwater	Floating Moss	15-0483-00		Lake	3		MDNR 2013	II
313	1619	303	Clearwater	Haggerty	15-0002-00		Lake	149		MDNR 2013	II
314	1620	304	Clearwater	Kibbee / Shuckhart	15-0114-00		Lake	61		MDNR 2013	II
315	1621	305	Clearwater	Lindberg	15-0144-00		Lake	92		MDNR 2013	II
316	2342		Clearwater	Lower Red	15-0202-00		Lake			MDNR 2008	II
317	1622	306	Clearwater	Peterson	15-0083-00		Lake	114		MDNR 2013	II
318	1623	307	Clearwater	Rockstad	15-0075-00		Lake	128		MDNR 2013	II
319	1624	308	Clearwater	Tamarack	15-0056-00		Lake	21		MDNR 2008	II
320	1625	309	Clearwater	Tamarack	15-0136-00		Lake	115		MDNR 2008	II
321	1626	310	Clearwater	Unnamed	15-0049-00		Lake	26		MDNR 2013	II
322	1627	311	Clearwater	Unnamed (Little Pine)	15-0293-00		Lake	32		MDNR 2013	II
323	1628	312	Clearwater	West Four-Legged	15-0028-01		Lake	129		MDNR 2013	II
324	1629	313	Clearwater	Whipple	15-0014-00		Lake	30		MDNR 2013	II
325	1630	314	Cook	Alder	16-0114-00		Lake	342		MDNR 2013	II
326	1631	315	Cook	Barker	16-0358-00		Lake	166		MDNR 2013	II
327	1632	316	Cook	Bearskin	16-0228-00		Lake	522		MDNR 2013	II
328	1633	317	Cook	Chester	16-0033-00		Lake	50		MDNR 2013	II
329	1634	318	Cook	Deer Yard	16-0253-00		Lake	358		MDNR 2013	II
330	1635	319	Cook	East Bearskin	16-0146-00		Lake	643		MDNR 2013	II
331	1636	320	Cook	Flour	16-0147-00		Lake	352		MDNR 2013	II
332	1637	321	Cook	Gordon	16-0569-00		Lake	167		MDNR 2013	II
333	1638	322	Cook	Holly	16-0366-00		Lake	78		MDNR 2013	II
334	1639	323	Cook	Knight	16-0807-00		Lake	99		MDNR 2013	II
335	1640	324	Cook	Little Iron	16-0355-00		Lake	121		MDNR 2013	II
336	1641	325	Cook	Loon	16-0448-00		Lake	1197		MDNR 2013	II
337	1642	326	Cook	Mistletoe	16-0368-00		Lake	151		MDNR 2013	II
338	1643	327	Cook	Moose	16-0043-00		Lake	452		MDNR 2013	II
339	1911	595	Cook	Moose	16-0043-00		Lake	452		MDNR 2013	II
340	1644	328	Cook	North	16-0331-00		Lake	549		MDNR 2013	II
341	1645	329	Cook	Pike	16-0252-00		Lake	850		MDNR 2013	II
342	1646	330	Cook	Star	16-0405-00		Lake	120		MDNR 2013	II
343	1647	331	Cook	Strobus	16-0370-00		Lake	11		MDNR 2013	II
344	1648	332	Cook	Tait	16-0384-00		Lake	386		MDNR 2013	II
345	1649	333	Cook	Tucker	16-0417-00		Lake	168		MDNR 2013	II
346	1650	334	Cook	Vern	16-0409-00		Lake	230		MDNR 2013	II
347	1651	335	Cook	Wampus	16-0196-00		Lake	33		MDNR 2013	II
348	1652	336	Crow Wing	Bass	18-0229-00		Lake	114	1	MDNR 2008	II
349	1653	337	Crow Wing	Bassett	18-0026-00		Lake	32		MDNR 2013	II
350	1654	338	Crow Wing	Big Trout	18-0315-00		Lake	1486		MDNR 2013	II
351	1655	339	Crow Wing	Black Bear	18-0140-00		Lake	235		MDNR 2013	II
352	1656	340	Crow Wing	Bonnie	18-0259-00		Lake	83		MDNR 2013	II
353	1657	341	Crow Wing	Butterfield	18-0231-00		Lake	225	1	MDNR 2008	II
354	1658	342	Crow Wing	Carlson	18-0395-00		Lake	45	1	MDNR 2008	II
355	1659	343	Crow Wing	Clearwater	18-0038-00		Lake	917		MDNR 2013	II
356	1660	344	Crow Wing	Coffee	18-0039-00		Lake	24		MDNR 2013	II
357	1661	345	Crow Wing	Cole	18-0127-00		Lake	114	1	MDNR 2008	II
358	1662	346	Crow Wing	Cross Lake Reservoir	18-0312-00		Lake	1884		MDNR 2013	II
359	1663	347	Crow Wing	Eastham	18-0202-00		Lake	68		MDNR 2013	II
360	1664	348	Crow Wing	Gladstone	18-0338-00		Lake	457		MDNR 2013	II
361	1665	349	Crow Wing	Grass	18-0362-00		Lake	45	1	MDNR 2008	II
362	1666	350	Crow Wing	Grave	18-0110-00		Lake	177		MDNR 2013	II
363	1667	351	Crow Wing	Green	18-0233-00		Lake	14	1	MDNR 2008	II
364	1668	352	Crow Wing	Hubert	18-0375-00		Lake	1344		MDNR 2013	II
365	1669	353	Crow Wing	Jack Pine	18-0023-00		Lake	149		MDNR 2013	II
366	1670	354	Crow Wing	Little Pelican	18-0351-00		Lake	402		MDNR 2013	II
367	1671	355	Crow Wing	Little Rabbit	18-0139-00		Lake	153		MDNR 2013	II
368	1672	356	Crow Wing	Loon / Ward	18-0111-00		Lake	54		MDNR 2013	II
369	1673	357	Crow Wing	Lower Cullen	18-0403-00		Lake	469		MDNR 2013	II
370	1674	358	Crow Wing	Lower Hay	18-0378-00		Lake	720		MDNR 2013	II
371	1675	359	Crow Wing	Mahnomen	18-0126-00		Lake	238	1	MDNR2008	II
372	1676	360	Crow Wing	Mayo	18-0408-00		Lake	148		MDNR 2013	II
373	1677	361	Crow Wing	Nokay	18-0104-00		Lake	782		MDNR 2013	II
374	1678	362	Crow Wing	Olander	18-0091-00		Lake	89		MDNR 2013	II
375	1679	363	Crow Wing	Pointon	18-0105-00		Lake	193		MDNR 2013	II
376	1680	364	Crow Wing	Rabbit	18-0093-01	18009300		840		MDNR 2013	II
377	1681	365	Crow Wing	Reno	18-0067-00		Lake	181		MDNR 2013	II
378	1682	366	Crow Wing	Rush-Hen (Rush)	18-0311-00		Lake	782		MDNR 2013	II
379	1683	367	Crow Wing	Rushmeyer	18-0082-00		Lake	43		MDNR 2013	II
380	1684	368	Crow Wing	Ruth	18-0212-00		Lake	623		MDNR 2013	II
381	1685	369	Crow Wing	Star	18-0359-00		Lake	153		MDNR 2013	II
382	1686	370	Crow Wing	Thompson	18-0172-00		Lake	20		MDNR 2013	II
383	1687	371	Crow Wing	Twin (East Twin)	18-0148-02		Lake	25		MDNR 2013	II
384	1694	378	Crow Wing	Unnamed	18-0055-00		Lake	70	1	MDNR 2008	II
385	1693	377	Crow Wing	Unnamed	18-0154-00		Lake	57		MDNR 2013	II
386	1690	374	Crow Wing	Unnamed	18-0201-00		Lake	16	1	MDNR 2008	II
387	1689	373	Crow Wing	Unnamed	18-0422-00		Lake	20		MDNR 2013	II

	A	B	C	D	E	F	G	H	I	J	K
388	1691	375	Crow Wing	Unnamed	18-0424-00		Lake	16		MDNR 2013	II
389	1688	372	Crow Wing	Unnamed	18-0504-00		Lake	28		MDNR 2013	II
390	1695	379	Crow Wing	Unnamed (Island)	18-0382-00		Lake	139		MDNR 2013	II
391	1692	376	Crow Wing	Unnamed (Little Whale)	18-0510-00		Lake	36		MDNR 2013	II
392	1696	380	Crow Wing	Upper South Long	18-0096-00		Lake	793		MDNR 2013	II
393	2343		Dakota	Blackhawk	19-0059-00		Lake			MDNR 2008	II
394	1697	381	Dakota	Chub	19-0020-00		Lake	301	1	MDNR 2008	II
395	653	594	Douglas	Anka Lake	21-0353-00		Lake	208		UofM/MPCA 2013, MDNR 2013	II
396	1698	382	Douglas	Brophy	21-0102-00		Lake	281		MDNR 2013	II
397	1699	383	Douglas	Freeborn	21-0162-00		Lake	250		MDNR 2013	II
398	1700	384	Douglas	Hidden	21-0058-00		Lake	17		MDNR 2013	II
399	1701	385	Douglas	Indian	21-0136-00		Lake	83		MDNR 2013	II
400	1702	386	Douglas	Little Chippewa	21-0212-00		Lake	282		MDNR 2013	II
401	1703	387	Douglas	Long	21-0343-00		Lake	205		MDNR 2013	II
402	1704	388	Douglas	Mary	21-0092-00		Lake	2559		MDNR 2013	II
403	1705	389	Douglas	Mina	21-0108-00		Lake	447		MDNR 2013	II
404	1706	390	Douglas	Mud	21-0236-00		Lake	50		MDNR 2008	II
405	1707	391	Douglas	Stowe	21-0264-00		Lake	533		MDNR 2013	II
406	1708	392	Douglas	Unnamed	21-0075-00		Lake	32		MDNR 2013	II
407	2344		Faribault	Minnesota	22-0033-00		Lake	1915		MDNR 2008	II
408	1710	394	Faribault	Rice	22-0007-00		Lake	266		MDNR 2008	II
409	1709	393	Faribault	Rice	22-0075-00		Lake	976		MDNR 2008	II
410	1711	395	Fillmore	Rice	07040008-58	23r1				MDNR 2008	II
411	1712	396	Freeborn	Bear	24-0028-00		Lake	1560		MDNR 2008	II
412	1713	397	Freeborn	Lower Twin	24-0027-00		Lake	480		MDNR 2013	II
413	2345		Goodhue	Cannon River		25r2	Stream			MDNR 2008	II
414	1714	398	Goodhue	Rice Bottoms	07040002-50	25r1				MDNR 2008	II
415	1715	399	Grant	Elk	26-0040-00		Lake	171		MDNR 2013	II
416	1716	400	Grant	Pelican	26-0002-00		Lake	3680		MDNR 2013	II
417	1718	402	Hennepin	Grass	27-0080-00		Lake	326		MDNR 2008	II
418	1717	401	Hennepin	Grass	27-0135-00		Lake	7		MDNR 2008	II
419	1719	403	Hennepin	Little Long	27-0179-00		Lake	117		MDNR 2013	II
420	1721	405	Hennepin	Rice	27-0116-00		Lake	353		MDNR 2008	II
421	1720	404	Hennepin	Rice	27-0132-00		Lake	294		MDNR 2008	II
422	1722	406	Hubbard	Beauty	29-0292-00		Lake	54		MDNR 2013	II
423	1724	408	Hubbard	Big Sand	29-0185-00		Lake	1738		MDNR 2013	II
424	1725	409	Hubbard	Eleventh Crow Wing	29-0036-00		Lake	752		MDNR2008	II
425	1726	410	Hubbard	Emma	29-0186-00		Lake	85		MDNR 2013	II
426	1727	411	Hubbard	Evergreen	29-0227-00		Lake	206		MDNR 2013	II
427	1728	412	Hubbard	Frontenac	29-0241-00		Lake	224		MDNR 2013	II
428	1729	413	Hubbard	Halverson	29-0220-00		Lake	19		MDNR 2013	II
429	1731	415	Hubbard	Hinds	29-0249-00		Lake	310		MDNR 2013	II
430	1732	416	Hubbard	Holland-Lucy	29-0095-00		Lake	44		MDNR 2008	II
431	1733	417	Hubbard	Island	29-0088-00		Lake	235		MDNR 2013	II
432	1734	418	Hubbard	Little Rice	29-0183-00		Lake	27	1	MDNR 2008	II
433	1735	419	Hubbard	Little Stony	29-0080-00		Lake	55		MDNR 2008	II
434	1736	420	Hubbard	Loon	29-0020-00		Lake	112		MDNR 2008	II
435	1737	421	Hubbard	Many Arm	29-0257-00		Lake	71		MDNR 2013	II
436	1738	422	Hubbard	Midge	29-0066-00		Lake	588		MDNR 2013	II
437	1739	423	Hubbard	Oelschlager Slough	29-0006-00		Lake	328		MDNR 2008	II
438	1740	424	Hubbard	Paine	29-0217-00		Lake	258		MDNR 2008	II
439	1741	425	Hubbard	Pine	29-0197-00		Lake	46		MDNR 2013	II
440	1743	427	Hubbard	Spider	29-0117-00		Lake	593		MDNR 2008	II
441	1745	429	Hubbard	Sunday	29-0144-00		Lake	62		MDNR 2008	II
442	1747	431	Hubbard	Tripp	29-0005-00		Lake	155	1	MDNR 2008	II
443	1748	432	Hubbard	Twenty	29-0231-00		Lake	88		MDNR 2013	II
444	1749	433	Hubbard	Twin	29-0293-00		Lake	7		MDNR 2008	II
445	1756	440	Hubbard	Unnamed	29-0019-00		Lake	15		MDNR 2008	II
446	1750	434	Hubbard	Unnamed	29-0021-00		Lake	16		MDNR 2008	II
447	1754	438	Hubbard	Unnamed	29-0057-00		Lake	54		MDNR 2013	II
448	1759	443	Hubbard	Unnamed	29-0084-00		Lake	87		MDNR 2008	II
449	1755	439	Hubbard	Unnamed	29-0114-00		Lake	24		MDNR 2008	II
450	1751	435	Hubbard	Unnamed	29-0115-00		Lake	16		MDNR 2008	II
451	1752	436	Hubbard	Unnamed	29-0118-00		Lake	21		MDNR 2008	II
452	1757	441	Hubbard	Unnamed	29-0158-00		Lake	60		MDNR 2008	II
453	1753	437	Hubbard	Unnamed	29-0179-00		Lake	16		MDNR 2008	II
454	1758	442	Hubbard	Unnamed	29-0263-00		Lake	20		MDNR 2008	II
455	1760	444	Hubbard	Unnamed	29-0608-00		Lake	9		MDNR 2013	II
456	1761	445	Hubbard	Unnamed (Boubora)	29-0082-00		Lake	48	1	MDNR 2008	II
457	1762	446	Hubbard	Unnamed (Thirteen)	29-0079-00		Lake	38		MDNR 2008	II
458	1763	447	Hubbard	Unnamed (Waboose #1)	29-0099-00		Lake	26		MDNR 2008	II
459	1764	448	Hubbard	Upper Bass	29-0034-00		Lake	30		MDNR 2008	II
460	1766	450	Hubbard	Waboose	29-0098-00		Lake	158		MDNR 2013	II
461	1767	451	Isanti	Athens WMA	30-0026-00		Lake	101		MDNR 2013	II
462	1768	452	Isanti	Elizabeth	30-0083-00		Lake	323		MDNR 2008	II
463	1769	453	Isanti	Grass	30-0017-00		Lake	51		MDNR 2008	II
464	1770	454	Isanti	Grass	30-0142-00		Lake	33		MDNR 2008	II
465	1771	455	Isanti	Krans	30-0020-00		Lake	47		MDNR 2013	II
466	1772	456	Isanti	Krone	30-0140-00		Lake	142		MDNR 2008	II
467	1773	457	Isanti	Linderman	30-0023-00		Lake	70		MDNR 2013	II
468	2346		Isanti	Lindgren	30-01444-00		Lake	75		MDNR 2008	II
469	1774	458	Isanti	Little Stanchfield	30-0044-00		Lake	155		MDNR 2008	II
470	1775	459	Isanti	Marget	30-0070-00		Lake	188		MDNR 2013	II
471	1776	460	Isanti	Matson	30-0141-00		Lake	89		MDNR 2013	II
472	1777	461	Isanti	Mimi's Pool	DNR	W0098001		5		MDNR 2013	II
473	1779	463	Isanti	Mud	30-0065-00		Lake	300		MDNR 2008	II
474	1780	464	Isanti	Mud	30-0106-00		Lake	81		MDNR 2008	II
475	1778	462	Isanti	Mud	30-0117-00		Lake	99		MDNR 2008	II
476	1781	465	Isanti	North Stanchfield	30-0143-00		Lake	153		MDNR 2008	II
477	1782	466	Isanti	Olson Impoundment	30-0094-00		Lake	24		MDNR 2013	II
478	1783	467	Isanti	Rice	30-0018-00		Lake	42		MDNR 2008	II
479	1784	468	Isanti	Section	30-0060-00		Lake	130		MDNR 2008	II
480	1785	469	Isanti	South Stanchfield	30-0138-00		Lake	433		MDNR 2008	II
481	1787	471	Isanti	Twin	30-0004-00		Lake	59		MDNR 2013	II
482	1786	470	Isanti	Twin	30-0046-00		Lake	31		MDNR 2013	II
483	1788	472	Isanti	Typo	30-0009-00		Lake	273		MDNR 2008	II
484	1789	473	Isanti	Unnamed	30-0063-00		Lake	55		MDNR 2013	II

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485	1790	474	Isanti	Unnamed	30-0116-00		Lake	36		MDNR 2013	II
486	1791	475	Itasca	Batson	31-0704-00		Lake	107		MDNR 2013	II
487	1792	476	Itasca	Bear	31-0157-00		Lake	328		MDNR 2013	II
488	1793	477	Itasca	Bello	31-0726-00		Lake	492		MDNR 2013	II
489	1794	478	Itasca	Big Calf	31-0884-00		Lake	24		MDNR 2013	II
490	1795	479	Itasca	Bluewater	31-0395-00		Lake	356		MDNR 2013	II
491	1796	480	Itasca	Buck	31-0340-00		Lake	18		MDNR 2013	II
492	1797	481	Itasca	Burrows	31-0413-00		Lake	322		MDNR 2013	II
493	2347		Itasca	Clubhouse	31-0540-00		Lake			MDNR 2008	II
494	1798	482	Itasca	Coleman	31-0943-00		Lake	57		MDNR 2013	II
495	2348		Itasca	Cophenhagen	31-0539-00		Lake			MDNR 2008	II
496	1799	483	Itasca	Cottonwood	31-0594-00		Lake	109		MDNR 2013	II
497	1800	484	Itasca	Crooked	31-0193-00		Lake	423		MDNR 2013	II
498	1801	485	Itasca	Day	31-0637-00		Lake	46		MDNR 2013	II
499	1802	486	Itasca	Dead Horse	31-0622-00		Lake	96		MDNR 2013	II
500	1803	487	Itasca	Dry Creek	31-0869-00		Lake	98		MDNR 2013	II
501	1804	488	Itasca	Dunbar	31-0904-00		Lake	273		MDNR 2013	II
502	1805	489	Itasca	East	31-0798-00		Lake	92		MDNR 2013	II
503	1806	490	Itasca	Fawn	31-0609-00		Lake	174		MDNR 2013	II
504	1807	491	Itasca	Forest	31-0663-00		Lake	29		MDNR 2013	II
505	1808	492	Itasca	Grass	31-0144-00		Lake	40		MDNR 2008	II
506	1809	493	Itasca	Grass	31-0527-00		Lake	19		MDNR 2008	II
507	1810	494	Itasca	Grave	31-0624-00		Lake	538		MDNR 2013	II
508	1811	495	Itasca	Hartley	31-0154-00		Lake	271		MDNR 2013	II
509	1812	496	Itasca	Irene	31-0878-00		Lake	10	1	MDNR 2008	II
510	1813	497	Itasca	Irma	31-0634-00		Lake	337		MDNR 2008	II
511	1814	498	Itasca	Jay Gould	31-0565-00		Lake	455		MDNR 2013	II
512	1815	499	Itasca	Jessie	31-0786-00		Lake	1782		MDNR 2013	II
513	1816	500	Itasca	Kenogama	31-0928-00		Lake	580		MDNR 2013	II
514	1817	501	Itasca	Lammon Aid	31-0096-00		Lake	64		MDNR 2013	II
515	1818	502	Itasca	Larson	31-0317-00		Lake	190		MDNR 2013	II
516	1819	503	Itasca	Lauchoh	31-0692-00		Lake	50		MDNR 2013	II
517	1820	504	Itasca	Little Bowstring	31-0758-00		Lake	314		MDNR 2013	II
518	1821	505	Itasca	Little Cowhorn	31-0198-00		Lake	157		MDNR 2013	II
519	1822	506	Itasca	Little Dixon	31-0936-00		Lake	31		MDNR 2013	II
520	1823	507	Itasca	Little Sand	31-0853-00		Lake	222		MDNR 2013	II
521	1824	508	Itasca	Little Trout	31-0394-00		Lake	78		MDNR 2013	II
522	1825	509	Itasca	Logging Slough (Stevens)	31-0708-00		Lake	232		MDNR 2008	II
523	1827	511	Itasca	Long	31-0266-01	31026600		238		MDNR 2013	II
524	1826	510	Itasca	Long	31-0570-00		Lake	117		MDNR 2013	II
525	1828	512	Itasca	Lost	31-0289-00		Lake	89		MDNR 2008	II
526	1829	513	Itasca	Moose (Rice)	31-0121-00		Lake	108		MDNR 2008	II
527	1831	515	Itasca	No-ta-she-bun (Willow)	31-0775-00		Lake	232		MDNR 2013	II
528	1830	514	Itasca	North Twin	31-0190-00		Lake	250		MDNR 20013	II
529	1832	516	Itasca	Pothole	31-0991-00		Lake	8		MDNR 2008	II
530	1833	517	Itasca	Reed	31-0074-00		Lake	72		MDNR 2013	II
531	1834	518	Itasca	Rice	31-0942-00		Lake	39		MDNR 2008	II
532	1835	519	Itasca	Rice (Round)	31-0777-00		Lake	363		MDNR 2008	II
533	1836	520	Itasca	Shoal	31-0534-00		Lake	661		MDNR 2013	II
534	1837	521	Itasca	Smith	31-0547-00		Lake	39		MDNR 2013	II
535	1838	522	Itasca	South Ackerman	31-0795-00		Lake	22		MDNR 2013	II
536	1839	523	Itasca	Sugar	31-0926-00		Lake	1585		MDNR 2013	II
537	1840	524	Itasca	Third Sucker	31-0122-00		Lake	34		MDNR 2013	II
538	1841	525	Itasca	Trout	31-0216-00		Lake	1953		MDNR 2013	II
539	1842	526	Itasca	Trout	31-0410-00		Lake	1792		MDNR 2013	II
540	1843	527	Itasca	Unnamed	31-0094-00		Lake	30		MDNR 2013	II
541	1844	528	Itasca	Unnamed	31-1223-00		Lake	65		MDNR 2013	II
542	1845	529	Itasca	Unnamed (Dishpan)	31-1210-00		Lake	106		MDNR 2013	II
543	1846	530	Itasca	Unnamed (Hecemovich) (Sha	31-0229-00		Lake	14		MDNR 2013	II
544	1847	531	Itasca	Unnamed (Pinnett)	31-0337-00		Lake	18		MDNR 2013	II
545	1848	532	Itasca	Unnamed (Wildlife Marsh)	31-1209-00		Lake	70		MDNR 2013	II
546	1849	533	Itasca	Wabana	31-0392-00		Lake	2146		MDNR 2013	II
547	1850	534	Itasca	Wagner	31-0912-00		Lake	63		MDNR 2013	II
548	1851	535	Itasca	Wilson	31-0320-00		Lake	84		MDNR 2013	II
549	1852	536	Kanabec	Devils	33-0033-00		Lake	121		MDNR 2013	II
550	1853	537	Kanabec	Eleven	33-0001-00		Lake	320		MDNR 2013	II
551	1854	538	Kanabec	Fish	33-0036-00		Lake	440		MDNR 2013	II
552	1855	539	Kanabec	Grass	33-0013-00		Lake	24		MDNR 2008	II
553	1856	540	Kanabec	Kent	33-0035-00		Lake	34		MDNR 2008	II
554	1857	541	Kanabec	Knife	33-0028-00		Lake	1259		MDNR 2008	II
555	1858	542	Kanabec	Pennington	33-0030-00		Lake	132		MDNR 2013	II
556	2349		Kanabec	Pomroy	33-0009-00		Lake	267		MDNR 2008	II
557	1859	543	Kanabec	Rice	33-0011-00		Lake	172		MDNR 2008	II
558	1861	545	Kanabec	Rice (Erickson)	33-0031-00		Lake	39		MDNR 2008	II
559	1862	546	Kanabec	Twin or East	33-0019-00		Lake	27		MDNR 2008	II
560	1863	547	Kanabec	Unnamed	33-0029-00		Lake	21		MDNR 2008	II
561	1865	549	Kanabec	Unnamed (Jones)	33-0012-00		Lake	11		MDNR 2008	II
562	1866	550	Kanabec	Unnamed (Twin)	33-0014-00		Lake	30		MDNR 2008	II
563	1864	548	Kanabec	Unnamed (WL Imp Pool 1)	33-0072-00		Lake	31	1	MDNR 2008	II
564	1867	551	Kanabec	White Lily	33-0008-00		Lake	32		MDNR 2013	II
565	1868	552	Kandiyohi	Andrew	34-0206-00		Lake	781		MDNR 2013	II
566	2351		Kandiyohi	Bear	34-0148-00		Lake	128		MDNR 2008	II
567	1869	553	Kandiyohi	Brenner	34-0339-00		Lake	81		MDNR 2013	II
568	1870	554	Kandiyohi	Calhoun	34-0062-00		Lake	1396		MDNR 2013	II
569	1871	555	Kandiyohi	Crook	34-0357-00		Lake	82		MDNR 2013	II
570	1872	556	Kandiyohi	Deer	34-0344-00		Lake	115		MDNR 2013	II
571	1873	557	Kandiyohi	Diamond	34-0044-00		Lake	1697		MDNR 2013	II
572	1874	558	Kandiyohi	East Solomon	34-0246-00		Lake	601		MDNR 2013	II
573	1875	559	Kandiyohi	Eight	34-0146-00		Lake	89		MDNR 2008	II
574	1876	560	Kandiyohi	Elizabeth	34-0022-02	34002200		1153		MDNR 2013	II
575	1877	561	Kandiyohi	Elkhorn	34-0119-00		Lake	79		MDNR 2013	II
576	1878	562	Kandiyohi	Foot	34-0181-00		Lake	544		MDNR 2013	II
577	1879	563	Kandiyohi	Games	34-0224-00		Lake	557		MDNR 2013	II
578	1880	564	Kandiyohi	Green	34-0079-00		Lake	5821		MDNR 2013	II
579	1881	565	Kandiyohi	Lillian	34-0072-00		Lake	1608		MDNR 2013	II
580	1882	566	Kandiyohi	Nest	34-0154-00		Lake	1019		MDNR 2013	II
581	1883	567	Kandiyohi	Norway	34-0251-00		Lake	2496		MDNR 2013	II

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582	1884	568	Kandiyohi	Ringo	34-0172-00		Lake	774		MDNR 2013	II
583	1885	569	Kandiyohi	Unnamed	34-0150-01	34015000		19		MDNR 2013	II
584	1887	571	Kandiyohi	Unnamed	34-0236-00		Lake	117		MDNR 2008	II
585	1886	570	Kandiyohi	Unnamed	34-0391-00		Lake	16		MDNR 2013	II
586	1888	572	Kandiyohi	Wakanda Lake	34-0169-00		Lake	1792		MDNR 2013	II
587	1889	573	Koochiching	Battle	36-0024-00		Lake	268		MDNR 2013	II
588	1890	574	Koochiching	Moose	36-0008-00		Lake	50		MDNR 2013	II
589	1891	575	Koochiching	Seretha	36-0009-00		Lake	58		MDNR 2013	II
590	1892	576	Lac Qui Parle	Lac Qui Parle	37-0046-00		Lake	8400		MDNR 2013	II
591	1893	577	Lake	Bill	38-0085-00		Lake	51		MDNR 2013	II
592	1894	578	Lake	Bunny	38-0293-00		Lake	41		MDNR 2013	II
593	1895	579	Lake	Cedar	38-0810-00		Lake	472		MDNR 2013	II
594	1896	580	Lake	Cook	38-0004-00		Lake	89		MDNR 2013	II
595	1897	581	Lake	Denley	38-0773-00		Lake	45		MDNR 2013	II
596	1898	582	Lake	Diana	38-0459-00		Lake	49		MDNR 2013	II
597	1899	583	Lake	Dragon	38-0552-00		Lake	85		MDNR 2013	II
598	1900	584	Lake	East Chub	38-0674-00		Lake	98		MDNR 2013	II
599	1901	585	Lake	Folly	38-0265-00		Lake	16		MDNR 2013	II
600	1902	586	Lake	Fourth McDougal	38-0657-00		Lake	14		MDNR 2013	II
601	2295		Lake	Good	38-0726-00		Lake	175		MPCA Bio2015	II
602	1903	587	Lake	Hide (Bearskin)	38-0553-00		Lake	22		MDNR 2013	II
603	1904	588	Lake	Homestead	38-0269-00		Lake	50		MDNR 2013	II
604	1905	589	Lake	Island River	DNR	H-1-92-21-15	Stream			MDNR 2013	II
605	1906	590	Lake	Jack	38-0441-00		Lake	51		MDNR 2013	II
606	1907	591	Lake	Jouppi	38-0909-00		Lake	7		MDNR 2013	II
607	1908	592	Lake	Katherine	38-0538-00		Lake	77		MDNR 2013	II
608	1909	593	Lake	Micmac	38-0233-00		Lake	121		MDNR 2013	II
609	1910	594	Lake	Mitawan	38-0561-00		Lake	202		MDNR 2013	II
610	1912	596	Lake	Newfound	38-0619-00		Lake	652		MDNR 2013	II
611	1913	597	Lake	Pose	38-0455-00		Lake	76		MDNR 2013	II
612	1914	598	Lake	Redskin	38-0440-00		Lake	43		MDNR 2013	II
613	1915	599	Lake	Sapphire	38-0446-00		Lake	42		MDNR 2013	II
614	1916	600	Lake	Section 29	38-0292-00		Lake	97		MDNR 2013	II
615	2350		Lake	Sells	33-0018-00		Lake	64		MDNR 2008	II
616	1917	601	Lake	Slate (Spider)	38-0666-00		Lake	354		MDNR 2013	II
617	1918	602	Lake	Square	38-0074-00		Lake	127		MDNR 2013	II
618	1919	603	Lake	Sullivan	38-0755-00		Lake	45		MDNR 2013	II
619	1920	604	Lake	Swamp	38-0285-00		Lake	33		MDNR 2013	II
620	1921	605	Lake	Tommy	38-0425-00		Lake	8		MDNR 2013	II
621	1922	606	Lake	Unnamed (Two Fifty Four)	38-0254-00		Lake	12		MDNR 2013	II
622	1923	607	Lake	Wager	38-0458-00		Lake	10		MDNR 2013	II
623	1924	608	Lake	Wanless	38-0049-00		Lake	78		MDNR 2013	II
624	1925	609	Lake	Watonwan	38-0079-00		Lake	58		MDNR 2013	II
625	1926	610	Lake	West Chub	38-0675-00		Lake	124		MDNR 2013	II
626	1927	611	Lake	Wilson	38-0047-00		Lake	666		MDNR 2013	II
627	1928	612	Le Sueur	Fish	40-0051-00		Lake	84		MDNR 2013	II
628	1929	613	Le Sueur	Rice	40-0016-00		Lake	182		MDNR 2008	II
629	1931	615	Le Sueur	Rice	40-0037-00		Lake	21		MDNR 2008	II
630	1930	614	Le Sueur	Rice	40-0114-00		Lake	11		MDNR 2008	II
631	1932	616	LeSueur	Rice	DNR	40wtld1				MDNR 2008	II
632	1933	617	Lincoln	Hawksnest	41-0045-00		Lake	270		MDNR 2013	II
633	1934	618	Lincoln	Oak	41-0062-00		Lake	107		MDNR 2013	II
634	1935	619	Lincoln	Perch	41-0067-00		Lake	206		MDNR 2013	II
635	1936	620	Lincoln	Steep Bank	41-0082-00		Lake	208		MDNR 2013	II
636	1937	621	Lincoln	Unnamed (Bohemian)	41-0109-00		Lake	111		MDNR 2013	II
637	1938	622	Mahnomen	Bass	44-0006-00		Lake	700		MDNR 2013	II
638	1939	623	Mahnomen	Grass	44-0047-00		Lake	22		MDNR 2008	II
639	1940	624	Mahnomen	Little Vanose	44-0169-00		Lake	149		MDNR 2013	II
640	1941	625	Mahnomen	Peabody	DNR	44-wetld1				MDNR 2008	II
641	1942	626	Mahnomen	Rice	44-0024-00		Lake	120		MDNR 2008	II
642	1943	627	Mahnomen	Sargent	44-0108-00		Lake	174		MDNR 2008	II
643	1944	628	Mahnomen	Snetsinger	44-0121-00		Lake	213		MDNR 2013	II
644	1945	629	Mahnomen	Tulaby	44-0003-00		Lake	849		MDNR 2013	II
645	1946	630	Mahnomen	Wakefield	44-0122-00		Lake	149		MDNR 2013	II
646	1947	631	McLeod	Coon	43-0020-00		Lake	118		MDNR 2013	II
647	1948	632	McLeod	Grass	43-0013-00		Lake	62		MDNR 2008	II
648	1949	633	McLeod	Rice	43-0042-00		Lake	60		MDNR 2008	II
649	1950	634	Meeker	Darwin	47-0076-00		Lake	200		MDNR 2013	II
650	1951	635	Meeker	Francis	47-0002-00		Lake	1172		MDNR 2013	II
651	1952	636	Meeker	Jennie	47-0015-00		Lake	1089		MDNR 2013	II
652	1953	637	Meeker	Rice	47-0087-00		Lake	69		MDNR 2008	II
653	1954	638	Meeker	Ripley	47-0134-00	47013400		1060		MDNR 2013	II
654	1955	639	Meeker	Spring	47-0032-00		Lake	202		MDNR 2013	II
655	1956	640	Meeker	Stella	47-0068-00		Lake	626		MDNR 2013	II
656	1957	641	Meeker	Thoen (Grass)	47-0154-00		Lake	216		MDNR 2008	II
657	1958	642	Meeker	Washington	47-0046-00		Lake	2524		MDNR 2013	II
658	1961	645	Mille Lacs	Bass	48-0016-00		Lake	12		MDNR 2013	II
659	1959	643	Mille Lacs	Bass	48-0017-00		Lake	14		MDNR 2013	II
660	1960	644	Mille Lacs	Bass	48-0018-00		Lake	22		MDNR 2013	II
661	1962	646	Mille Lacs	Cranberry	48-0007-00		Lake	240		MDNR 2013	II
662	1964	648	Mille Lacs	Mikkelson Pool	48-0035-00	W9004001				MDNR 2008	II
663	1966	650	Mille Lacs	Rice	48-0010-00		Lake	512		MDNR 2008	II
664	1967	651	Mille Lacs	Section 3 Pool	48-0043-00	W9004005				MDNR 2008	II
665	1968	652	Mille Lacs	Unnamed	48-0047-00		Lake	25		MDNR 2013	II
666	1969	653	Mille Lacs	West Fork Groundhouse Rive	07030004-53	48IMP002	Stream	50		MDNR 2008	II
667	1970	654	Mille Lacs	Wildlife Impoundment	48-0047-00		Lake			MDNR 2008	II
668	2352		Morrison	Bernhart	49-0135-00		Lake	39		MDNR 2008	II
669	1971	655	Morrison	Cedar	49-0140-00		Lake	250		MDNR 2013	II
670	1972	656	Morrison	Crookneck	49-0133-00		Lake	200		MDNR 2008	II
671	1973	657	Morrison	Green Prairie Fish	49-0035-00		Lake	193		MDNR 2013	II
672	1974	658	Morrison	Little Elk WMA	07010104-52	W0069101				MDNR 2013	II
673	1975	659	Morrison	Longs	49-0104-00		Lake	60		MDNR 2008	II
674	1976	660	Morrison	Madaline	49-0101-00		Lake	50		MDNR 2008	II
675	1978	662	Morrison	Mud	49-0018-00		Lake	29		MDNR 2008	II
676	1977	661	Morrison	Mud	49-0095-00		Lake	105		MDNR 2008	II
677	1979	663	Morrison	Pierz	49-0024-00		Lake	186		MDNR 2013	II
678	1980	664	Morrison	Pine	49-0081-00		Lake	197		MDNR 2013	II

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679	1981	665	Morrison	Skunk	49-0007-00		Lake	32		MDNR 2008	II
680	1982	666	Morrison	Stanchfield	49-0118-00		Lake	145		MDNR 2013	II
681	1983	667	Morrison	Sylvan	49-0036-00		Lake	260		MDNR 2013	II
682	1984	668	Nicollet	Rice	52-0033-00		Lake	118		MDNR 2008	II
683	1985	669	Nicollet	Swan	52-0034-00		Lake	9346		MDNR 2013	II
684	1986	670	Otter Tail	Bear	56-0069-00		Lake	217		MDNR 2013	II
685	1987	671	Otter Tail	Beers	56-0724-00		Lake	255		MDNR 2013	II
686	2353		Otter Tail	Berger	56-1149-00		Lake	190		MDNR 2008	II
687	1988	672	Otter Tail	Brown	56-0315-00		Lake	164		MDNR 2013	II
688	1989	673	Otter Tail	Clear	56-0559-00		Lake	378		MDNR 2013	II
689	1990	674	Otter Tail	Davies	56-0311-00		Lake	69		MDNR 2008	II
690	1991	675	Otter Tail	Duck	56-0483-00		Lake	96		MDNR 2013	II
691	1993	677	Otter Tail	East Annalaide	56-0001-00		Lake	97		MDNR 2013	II
692	1994	678	Otter Tail	Elbow	56-0306-00		Lake	193		MDNR 2013	II
693	1995	679	Otter Tail	Ellingson	56-0178-00		Lake	158		MDNR 2013	II
694	1996	680	Otter Tail	Fladmark	56-0727-00		Lake	55		MDNR 2013	II
695	1999	683	Otter Tail	Grass	56-0717-00		Lake	72		MDNR 2008	II
696	2000	684	Otter Tail	Grass	56-0723-00		Lake	37		MDNR 2008	II
697	2001	685	Otter Tail	Gray	56-0353-00		Lake	92		MDNR 2013	II
698	2002	686	Otter Tail	Leek (Trowbridge)	56-0532-00		Lake	640		MDNR 2013	II
699	2003	687	Otter Tail	Little McDonald	56-0328-00		Lake	1506		MDNR 2008	II
700	2008	692	Otter Tail	Mud	56-0132-00		Lake	155		MDNR 2008	II
701	2007	691	Otter Tail	Mud	56-0484-00		Lake	585		MDNR 2013	II
702	2005	689	Otter Tail	Mud	56-1148-00		Lake	134		MDNR 2008	II
703	2009	693	Otter Tail	Mud (Amor)	56-0381-00		Lake	231		MDNR 2008	II
704	2010	694	Otter Tail	Mud (McGowan)	56-0215-00		Lake	138		MDNR 2008	II
705	2011	695	Otter Tail	Murphy	56-0229-00		Lake	358		MDNR 2013	II
706	2012	696	Otter Tail	Nitche	56-0126-00		Lake	72		MDNR 2013	II
707	2014	698	Otter Tail	North Rice	56-0349-00		Lake	103		MDNR 2008	II
708	2015	699	Otter Tail	Orwell	56-0945-00		Lake	396		MDNR 2013	II
709	2016	700	Otter Tail	Paul	56-0335-00		Lake	334		MDNR 2013	II
710	2017	701	Otter Tail	Peterson	56-0471-00		Lake	141		MDNR 2008	II
711	2018	702	Otter Tail	Portage	56-0140-00		Lake	289		MDNR 2013	II
712	2019	703	Otter Tail	Rankle	56-0935-00		Lake	57		MDNR 2008	II
713	2020	704	Otter Tail	Reed	56-0876-00		Lake	155		MDNR 2008	II
714	2021	705	Otter Tail	Rice	56-0006-00		Lake	6		MDNR 2008	II
715	2022	706	Otter Tail	Rice	56-0702-00		Lake	26		MDNR 2008	II
716	2023	707	Otter Tail	Rose	56-0620-00		Lake	107		MDNR 2013	II
717	2024	708	Otter Tail	Rusch	56-1641-00		Lake	100		MDNR 2013	II
718	2025	709	Otter Tail	Sharp	56-0482-00		Lake	160		MDNR 2008	II
719	2026	710	Otter Tail	Snow	56-0110-00		Lake	72		MDNR 2013	II
720	2028	712	Otter Tail	South Rice	56-0352-00		Lake	121		MDNR 2008	II
721	2029	713	Otter Tail	Sybil	56-0387-00		Lake	654		MDNR 2013	II
722	2032	716	Otter Tail	Ten Mile	56-0613-00		Lake	1445		MDNR 2013	II
723	2033	717	Otter Tail	Unnamed	56-0094-00		Lake	23		MDNR 2013	II
724	2039	723	Otter Tail	Unnamed	56-0101-00		Lake	14		MDNR 2013	II
725	2041	725	Otter Tail	Unnamed	56-0143-00		Lake	31		MDNR 2013	II
726	2038	722	Otter Tail	Unnamed	56-0198-00		Lake	69		MDNR 2008	II
727	2035	719	Otter Tail	Unnamed	56-0284-00		Lake	83		MDNR 2008	II
728	2037	721	Otter Tail	Unnamed	56-1031-00		Lake	35		MDNR 2013	II
729	2044	728	Otter Tail	Unnamed	56-1259-00		Lake	12		MDNR 2008	II
730	2042	726	Otter Tail	Unnamed	56-1273-00		Lake	126		MDNR 2008	II
731	2034	718	Otter Tail	Unnamed	56-1517-00		Lake	23		MDNR 2008	II
732	2045	729	Otter Tail	Unnamed	56-1550-00		Lake	14		MDNR 2008	II
733	2043	727	Otter Tail	Unnamed	56-1578-00		Lake	29		MDNR 2008	II
734	2040	724	Otter Tail	Unnamed (Beaver Pond Lake	56-1126-00		Lake	28		MDNR 2013	II
735	2046	730	Otter Tail	Unnamed (Nycklemoe)	56-1083-00		Lake	198		MDNR 2008	II
736	2047	731	Otter Tail	Unnamed (Olson)	56-0436-00		Lake	42		MDNR 2013	II
737	2048	732	Otter Tail	West Silent	56-0519-00		Lake	340		MDNR 2013	II
738	2050	734	Otter Tail	Zorns	56-0497-00		Lake	49		MDNR 2013	II
739	2051	735	Pennington	Red Lake River Reservoir	57-0051-00		Lake	75		MDNR 2013	II
740	2296		Pine	Big Pine	58-0138-00		Lake	399		MDNR 2008	II
741	2052	736	Pine	Close	58-0071-00		Lake	34		MDNR 2013	II
742	2054	738	Pine	Grace	58-0029-00		Lake	78		MDNR 2013	II
743	2055	739	Pine	Grass	58-0125-00		Lake	84		MDNR 2008	II
744	2056	740	Pine	Greigs	58-0013-00		Lake	58		MDNR 2013	II
745	2057	741	Pine	Little Mud	58-0106-00		Lake	19		MDNR 2013	II
746	2058	742	Pine	Little Tamarack	58-0028-00		Lake	58		MDNR 2013	II
747	2060	744	Pine	Oak	58-0048-00		Lake	444		MDNR 2013	II
748	2061	745	Pine	Olive	58-0044-00		Lake	12		MDNR 2013	II
749	2297		Pine	Passenger	58-0076-00		Lake	75		MDNR 2008	II
750	2298		Pine	Rush	58-0078-00		Lake	88		MDNR 2008	II
751	2062	746	Pine	Sand	58-0081-00		Lake	575		MDNR 2013	II
752	2063	747	Pine	Sturgeon	58-0067-00		Lake	1456		MDNR 2013	II
753	2064	748	Pine	Unnamed	58-0170-00		Lake	70		MDNR 2013	II
754	2065	749	Polk	Union	60-0217-00		Lake	910		MDNR 2013	II
755	2066	750	Polk	Unnamed (Leo)	60-0220-00		Lake	34		MDNR 2013	II
756	2067	751	Polk	Unnamed (Tamarack)	60-0247-00		Lake	92		MDNR 2013	II
757	2068	752	Pope	East Johanna (Rocky Mounta	61-0002-00		Lake	98		MDNR 2013	II
758	2069	753	Pope	Emily	61-0180-00		Lake	2164		MDNR 2013	II
759	2070	754	Pope	Gilchrist	61-0072-00		Lake	330		MDNR 2013	II
760	2071	755	Pope	Rice	61-0069-00		Lake	191		MDNR 2008	II
761	2073	757	Pope	Unnamed	61-0007-00		Lake	32		MDNR 2013	II
762	2072	756	Pope	Unnamed	61-0091-00		Lake	47		MDNR 2013	II
763	2074	758	Pope	Unnamed	61-0287-00		Lake	195		MDNR 2013	II
764	2076	760	Ramsey	Grass	62-0074-00		Lake	139		MDNR 2008	II
765	2077	761	Redwood	Rice Creek	DNR	64r1	Stream			MDNR 2008	II
766	2078	762	Renville	Preston	65-0002-00		Lake	678		MDNR 2013	II
767	2079	763	Rice	Dudley	66-0014-00		Lake	83		MDNR 2008	II
768	2081	765	Rice	Kelly	66-0015-00		Lake	62		MDNR 2008	II
769	2082	766	Rice	Pooles	66-0046-00		Lake	182		MDNR 2008	II
770	2083	767	Rice	Rice	66-0048-00		Lake	331		MDNR 2008	II
771	2084	768	Rice	Unnamed	66-0103-00		Lake	26		MDNR 2008	II
772	2085	769	Roseau	Hayes	68-0004-00		Lake	187		MDNR 2013	II
773	2086	770	Roseau	Marvin	68-0002-00		Lake	199		MDNR 2013	II
774	2087	771	Roseau	Roseau River WMA Pool 1-W	68-0005-00	68000502		1016		MDNR 2013	II
775	2354		Scott	Artic	70-0085-00		Lake			MDNR 2008	II

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776	2088	772	Scott	Rice	70-0001-00		Lake	55		MDNR 2008	II
777	2089	773	Scott	Rice	70-0060-00		Lake	27		MDNR 2008	II
778	2090	774	Sherburne	Ann	71-0069-00		Lake	226		MDNR 2013	II
779	2091	775	Sherburne	Birch	71-0057-00		Lake	149		MDNR 2013	II
780	2301		Sherburne	Clitty	71-0116-00		Lake	56		MDNR 2008	II
781	2092	776	Sherburne	Elk	71-0141-00		Lake	352		MDNR 2013	II
782	2093	777	Sherburne	Fremont	71-0016-00		Lake	466		MDNR 2008	II
783	2094	778	Sherburne	Kliever Marsh	71-0003-00		Lake	37		MDNR 2008	II
784	2096	780	Sherburne	Lundberg Slough	71-0109-00		Lake	50		MDNR 2008	II
785	2097	781	Sherburne	Mitchell	71-0081-00		Lake	156		MDNR 2013	II
786	2098	782	Sherburne	Pool 31	71-0187-00	71IMP011	Lake			MDNR 2008	II
787	2099	783	Sherburne	Rice	71-0015-00		Lake	11		MDNR 2008	II
788	2100	784	Sherburne	Rice	71-0078-00		Lake	505		MDNR 2008	II
789	2101	785	Sherburne	Rice Creek	07010203-5	71-river1	Stream			MDNR 2008	II
790	2102	786	Sherburne	Rush	71-0147-00		Lake	161		MDNR 2013	II
791	2103	787	Sherburne	Sand Prairie WMA	DNR	W0152601				MDNR 2013	II
792	2104	788	Sherburne	Sandy	71-0040-00		Lake	70		MDNR 2013	II
793	2302		Sherburne	Unnamed	71-0025-00		Lake	31		MDNR 2008	II
794	2105	789	Sherburne	Upper Roadside	71-0375-00	71IMP005				MDNR 2008	II
795	2106	790	Sibley	Titlow	72-0042-00		Lake	924		MDNR 2008	II
796	2107	791	St. Louis	Ash	69-0864-00		Lake	678		MDNR 2013	II
797	2108	792	St. Louis	Astrid	69-0589-00		Lake	114		MDNR 2013	II
798	2109	793	St. Louis	Auto	69-0731-00		Lake	100		MDNR 2013	II
799	2110	794	St. Louis	Ban	69-0742-00		Lake	396		MDNR 2013	II
800	2111	795	St. Louis	Barrs	69-0132-00		Lake	134		MDNR 2013	II
801	2112	796	St. Louis	Bear Island	69-0115-00		Lake	2667		MDNR 2013	II
802	2113	797	St. Louis	Beast	69-0837-00		Lake	96		MDNR 2013	II
803	2114	798	St. Louis	Black Duck	69-0842-00		Lake	1264		MDNR 2013	II
804	2115	799	St. Louis	Blackwood	69-0850-00		Lake	25		MDNR 2013	II
805	2116	800	St. Louis	Bog	69-0811-00		Lake	30		MDNR 2013	II
806	2117	801	St. Louis	Central	69-0637-00		Lake	75		MDNR 2013	II
807	2355		St. Louis	Cloquet River		69r5	Stream			MDNR 2008	II
808	2118	802	St. Louis	Dark	69-0790-00		Lake	244		MDNR 2013	II
809	2119	803	St. Louis	Elbow	69-0744-00		Lake	1528		MDNR 2013	II
810	2120	804	St. Louis	Elephant	69-0810-00		Lake	782		MDNR 2013	II
811	2121	805	St. Louis	Ely	69-0660-00		Lake	827		MDNR 2013	II
812	2122	806	St. Louis	Fishing	69-0270-00		Lake	17		MDNR 2013	II
813	2123	807	St. Louis	Gansey	69-0913-00		Lake	74		MDNR 2008	II
814	2124	808	St. Louis	Goldmine Slough Section - V	09030002-53	R001-46G				MDNR 2013	II
815	2125	809	St. Louis	Golf Course Pond (Upper Tw	69-1345-00		Lake	1		MDNR 2013	II
816	2126	810	St. Louis	Headquarters	69-0766-00		Lake	65		MDNR 2013	II
817	2127	811	St. Louis	Horseshoe	69-0232-00		Lake	96		MDNR 2013	II
818	2128	812	St. Louis	James	69-0734-00		Lake	19		MDNR 2013	II
819	2129	813	St. Louis	Kangas	69-0057-00		Lake	35		MDNR 2013	II
820	2130	814	St. Louis	Kelly	69-0901-00		Lake	21		MDNR 2013	II
821	2131	815	St. Louis	Leora	69-0521-00		Lake	276		MDNR 2013	II
822	1183	1164	St. Louis	Little Mesaba Lake	69-0436-00		Lake	207		2008, 1854 List	II
823	2132	816	St. Louis	Little Rice	69-0180-00		Lake	161		MDNR 2008	II
824	2133	817	St. Louis	Locator	69-0936-00		Lake	140		MDNR 2013	II
825	2135	819	St. Louis	Long	69-0495-00		Lake	366		MDNR 2013	II
826	2134	818	St. Louis	Long	69-0653-00		Lake	157		MDNR 2013	II
827	2136	820	St. Louis	Long	69-0765-00		Lake	472		MDNR 2013	II
828	2137	821	St. Louis	Longyear	69-0857-00		Lake	188		MDNR 2013	II
829	2138	822	St. Louis	Marion	69-0755-00		Lake	174		MDNR 2013	II
830	2139	823	St. Louis	Meadow	69-0165-00		Lake	21		MDNR 2013	II
831	2140	824	St. Louis	Moose	69-0806-00		Lake	942		MDNR 2013	II
832	2141	825	St. Louis	Mukooda	69-0684-00		Lake	748		MDNR 2013	II
833	2142	826	St. Louis	Murphy	69-0646-00		Lake	356		MDNR 2013	II
834	2143	827	St. Louis	North Twin	69-0419-00		Lake	67		MDNR 2013	II
835	2144	828	St. Louis	Pat Zakovec Impoundment	69-1463-00		Lake	72		MDNR 2013	II
836	2145	829	St. Louis	Pleasant	69-0655-00		Lake	360		MDNR 2013	II
837	2146	830	St. Louis	Rat	69-0922-00		Lake	73		MDNR 2008	II
838	2147	831	St. Louis	Rice River	09030005-5	69-river9	Stream			MDNR 2008	II
839	2148	832	St. Louis	Sabin	69-0434-01		Lake			1854 List	II
840	2149	833	St. Louis	Sand	69-0736-00		Lake	792		MDNR 2013	II
841	2150	834	St. Louis	Sand Point	69-0617-00		Lake	4848		MDNR 2008	II
842	2151	835	St. Louis	Schelins	69-0624-00		Lake	164		MDNR 2013	II
843	2356		St. Louis	Sioux River		69r9	Stream			MDNR 2008	II
844	2152	836	St. Louis	South Bog	69-0807-00		Lake	20		MDNR 2013	II
845	2153	837	St. Louis	St. Mary's	69-0651-00		Lake	249		MDNR 2013	II
846	2154	838	St. Louis	Stone	69-0027-00		Lake	228		MDNR 2013	II
847	2155	839	St. Louis	Swan	69-0863-00		Lake	85		MDNR 2013	II
848	2156	840	St. Louis	Thirty-Six	69-0854-00		Lake	110		MDNR 2013	II
849	2157	841	St. Louis	Trettel Pool	DNR	W0889002		30		MDNR 2008	II
850	2158	842	St. Louis	Trout	69-0498-00		Lake	9237		MDNR 2013	II
851	2159	843	St. Louis	Twin	69-0505-00		Lake	25		MDNR 2008	II
852	2160	844	St. Louis	Unnamed	69-0640-00		Lake	10		MDNR 2008	II
853	2161	845	St. Louis	Vermilion Falls Section - Verr	09030002-53	R001-46V				MDNR 2013	II
854	2162	846	St. Louis	White	69-0030-00		Lake	134		MDNR 2013	II
855	2163	847	St. Louis	White Iron	69-0004-00		Lake	3429		MDNR 2013	II
856	2164	848	St. Louis	Whiteface Reservoir	69-0375-00		Lake	4980		MDNR 2013	II
857	2165	849	St. Louis	Whitewater	69-0376-00		Lake	599		MDNR 2013	II
858	2166	850	St. Louis	Wolf	69-0161-00		Lake	301		MDNR 2013	II
859	2167	851	Stearns	Achman	73-0125-00		Lake	49		MDNR 2013	II
860	2299		Stearns	Anna	73-0126-00		Lake	133		MDNR 2008	II
861	2168	852	Stearns	Big	73-0159-00		Lake	446		MDNR 2013	II
862	2300		Stearns	Big Rice	73-0168-00		Lake	282		MDNR 2008	II
863	2169	853	Stearns	Big Spunk	73-0117-00		Lake	410		MDNR 2013	II
864	2170	854	Stearns	Cedar	73-0255-00		Lake	243		MDNR 2013	II
865	2171	855	Stearns	Cedar Island	73-0133-00		Lake	995		MDNR 2013	II
866	2173	857	Stearns	Fifth	73-0180-00		Lake	76		MDNR 2008	II
867	2175	859	Stearns	Grass	73-0294-00		Lake	157		MDNR 2008	II
868	2176	860	Stearns	Gravel	73-0204-00		Lake	55		MDNR 2008	II
869	2177	861	Stearns	Great Northern	73-0083-00		Lake	113		MDNR 2013	II
870	2179	863	Stearns	Henry	73-0160-00		Lake	62		MDNR 2008	II
871	2178	862	Stearns	Henry	73-0237-00		Lake	191		MDNR 2008	II
872	2180	864	Stearns	Island	73-0104-00		Lake	118		MDNR 2013	II

	A	B	C	D	E	F	G	H	I	J	K
873	2181	865	Stearns	Koronis (Mud)	73-0200-01		Lake	156		MDNR 2013	II
874	2182	866	Stearns	Laura	73-0020-00		Lake	147		MDNR 2013	II
875	2183	867	Stearns	Linneman	73-0127-00		Lake	108		MDNR 2008	II
876	2186	870	Stearns	Long	73-0105-00		Lake	31		MDNR 2013	II
877	2185	869	Stearns	Long	73-0139-00		Lake	478		MDNR 2013	II
878	2188	872	Stearns	Marie	73-0014-00		Lake	145		MDNR 2013	II
879	2190	874	Stearns	Mud	73-0161-00		Lake	55		MDNR 2008	II
880	2191	875	Stearns	North Brown's	73-0147-00		Lake	312		MDNR 2013	II
881	2192	876	Stearns	Otter	73-0015-00		Lake	125		MDNR 2013	II
882	2193	877	Stearns	Pearl	73-0037-00		Lake	755		MDNR 2013	II
883	2194	878	Stearns	Pelican	73-0118-00		Lake	344		MDNR 2013	II
884	2195	879	Stearns	Rice	73-0196-00		Lake	1568		MDNR 2008	II
885	2196	880	Stearns	Sagatagan	73-0092-00		Lake	170		MDNR 2008	II
886	2197	881	Stearns	Schultz Slough	73-0201-00		Lake	29		MDNR 2008	II
887	2198	882	Stearns	Swamp	73-0069-00		Lake	40		MDNR 2013	II
888	2199	883	Stearns	Unnamed	73-0017-00		Lake	47		MDNR 2013	II
889	2200	884	Stearns	Zumwalde	73-0089-00		Lake	111		MDNR 2013	II
890	2201	885	Todd	Big Birch	77-0084-00		Lake	2025		MDNR 2013	II
891	2202	886	Todd	Coal	77-0046-00		Lake	178		MDNR 2013	II
892	2203	887	Todd	Fairy	77-0154-00		Lake	303		MDNR 2013	II
893	2204	888	Todd	Hayden	77-0080-00		Lake	253		MDNR 2008	II
894	2205	889	Todd	Jacobson	77-0143-00		Lake	40		MDNR 2008	II
895	2206	890	Todd	Lady	77-0032-00		Lake	207		MDNR 2013	II
896	2207	891	Todd	Lawrence	77-0083-00		Lake	172		MDNR 2008	II
897	2208	892	Todd	Lily	77-0358-00		Lake	56		MDNR 2013	II
898	2209	893	Todd	Little Fishtrap	77-0074-00		Lake	51		MDNR 2008	II
899	2210	894	Todd	Little Pine	77-0134-00		Lake	16		MDNR 2008	II
900	2211	895	Todd	Little Pine (Little Rice)	77-0042-00		Lake	71		MDNR 2008	II
901	2212	896	Todd	Little Rice	77-0054-00		Lake	71		MDNR 2008	II
902	2213	897	Todd	Little Swan	77-0034-00		Lake	178		MDNR 2013	II
903	2215	899	Todd	Long	77-0149-00		Lake	215		MDNR 2013	II
904	2214	898	Todd	Long	77-0357-00		Lake	98		MDNR 2013	II
905	2216	900	Todd	Mill	77-0050-00		Lake	166		MDNR 2013	II
906	2217	901	Todd	Mud	77-0070-00		Lake	219		MDNR 2008	II
907	2218	902	Todd	North Twin	77-0158-00		Lake	71		MDNR 2013	II
908	2219	903	Todd	Peat	77-0055-00		Lake	28		MDNR 2013	II
909	2220	904	Todd	Pendergast	77-0207-00		Lake	93		MDNR 2008	II
910	2221	905	Todd	Pine Island	77-0077-00		Lake	156		MDNR 2008	II
911	2222	906	Todd	Rice	77-0235-00		Lake	28		MDNR 2008	II
912	2357		Todd	Sheets	77-0122-00		Lake	100		MDNR 2008	II
913	2223	907	Todd	Spier	77-0148-00		Lake	53		MDNR 2013	II
914	2224	908	Todd	Stones	77-0081-00		Lake	63		MDNR 2008	II
915	2225	909	Todd	Thunder	77-0066-00		Lake	215		MDNR 2008	II
916	2226	910	Todd	Tucker	77-0139-00		Lake	43		MDNR 2008	II
917	2229	913	Todd	Unnamed	77-0140-00		Lake	61		MDNR 2008	II
918	2227	911	Todd	Unnamed	77-0197-00		Lake	53		MDNR 2008	II
919	2358		Todd	Unnamed	77-0202-00		Lake	70		MDNR 2008	II
920	2228	912	Todd	Unnamed	77-0259-00		Lake	50		MDNR 2013	II
921	2230	914	Todd	William	77-0180-00		Lake	131		MDNR 2013	II
922	2231	915	Wabasha	McCarthy	79-0006-00		Lake	57		MDNR 2013	II
923	2232	916	Wabasha	Unnamed	79-0012-00		Lake	8		MDNR 2008	II
924	2233	917	Wadena	Jim Cook	80-00027-02	80002700		238		MDNR 2008	II
925	2234	918	Wadena	Rice	80-0024-00		Lake	8		MDNR 2008	II
926	2235	919	Waseca	Goose	81-0016-00		Lake	370		MDNR 2013	II
927	2237	921	Waseca	Rice	81-0022-00		Lake	214		MDNR 2008	II
928	2236	920	Waseca	Rice	81-0088-00		Lake	75		MDNR 2008	II
929	2305		Wright	Albion	86-0212-00		Lake	238		MDNR 2008	II
930	2306		Wright	Beaver Dam	86-0296-00		Lake	253		MDNR 2008	II
931	2307		Wright	Butler	86-0198-00		Lake	131		MDNR 2008	II
932	2308		Wright	Butternut	86-0253-00		Lake	203		MDNR 2008	II
933	2309		Wright	Carrigan	86-0097-00		Lake	162		MDNR 2008	II
934	2238	922	Wright	Fish	86-0183-00		Lake	104		MDNR 2013	II
935	2310		Wright	Gilchrist	86-0064-00		Lake	388		MDNR 2008	II
936	2311		Wright	Gonz	86-0019-00		Lake	152		MDNR 2008	II
937	2239	923	Wright	Grass	86-0243-00		Lake	92		MDNR 2008	II
938	2240	924	Wright	Grass	86-0257-00		Lake	2		MDNR 2008	II
939	2312		Wright	Henshaw	86-0213-00		Lake	277		MDNR 2008	II
940	2313		Wright	Long	86-0194-00		Lake	255		MDNR 2008	II
941	2241	925	Wright	Long	86-0246-00		Lake	85		MDNR 2013	II
942	2242	926	Wright	Louisa	86-0282-00		Lake	183		MDNR 2008	II
943	2243	927	Wright	Malardi	86-0112-00		Lake	149		MDNR 2008	II
944	2314		Wright	Mallard Pass	86-0185-00		Lake	51		MDNR 2008	II
945	2315		Wright	Maple	86-0197-00		Lake	82		MDNR 2008	II
946	2316		Wright	Maple Unit	86-0157-00		Lake	177		MDNR 2008	II
947	2317		Wright	Mary	86-0049-00		Lake	331		MDNR 2008	II
948	2244	928	Wright	Millstone	86-0152-00		Lake	221		MDNR 2008	II
949	2318		Wright	Mink	86-0229-00		Lake	304		MDNR 2008	II
950	2319		Wright	Mud	86-0026-00		Lake	128		MDNR 2008	II
951	2320		Wright	Mud	86-0219-00		Lake	66		MDNR 2008	II
952	2321		Wright	Pelican	86-0031-00		Lake	2793		MDNR 2008	II
953	2322		Wright	Pools	86-0102-00		Lake	166		MDNR 2008	II
954	2245	929	Wright	Rice	86-0002-00		Lake	57		MDNR 2008	II
955	2246	930	Wright	Rice	86-0032-00		Lake	246		MDNR 2008	II
956	2247	931	Wright	Rice	86-0164-00		Lake	93		MDNR 2008	II
957	2248	932	Wright	Rock	86-0182-00		Lake	181		MDNR 2013	II
958	2323		Wright	School	86-0025-00		Lake	76		MDNR 2008	II
959	2324		Wright	School Section	86-0180-00		Lake	266		MDNR 2008	II
960	2325		Wright	Shakopee	86-0255-00		Lake	206		MDNR 2008	II
961	2249	933	Wright	Smith	86-0250-00		Lake	330		MDNR 2008	II
962	2326		Wright	Spring	86-0200-00		Lake	63		MDNR 2008	II
963	2327		Wright	Taylor	86-0204-00		Lake	78		MDNR 2008	II
964	2251	935	Wright	Unnamed	86-0244-00		Lake	78		MDNR 2013	II
965	2250	934	Wright	Unnamed	86-0258-00		Lake	18		MDNR 2008	II
966	2252	936	Wright	West Lake Sylvia	86-0279-00		Lake	1027		MDNR 2013	II
967	2328		Wright	White	86-0214-00		Lake	145		MDNR 2008	II
968	2329		Wright	Willima	86-0209-00		Lake	246		MDNR 2008	II
969	1	1	Aitkin	Aitkin Lake	01-0040-00		Lake	850	298	2007, 2008, 2010	DL

	A	B	C	D	E	F	G	H	I	J	K
970	2	2	Aitkin	Anderson Lake	01-0031-00		Lake	97	30	2008	DL
971	3	3	Aitkin	Big Sandy Lake	01-0062-00		Lake	9380	94	2007, 2008, MDNR APM, 2010	DL
972	4	4	Aitkin	Birch Lake	01-0206-00		Lake	449	5	2008	DL
973	5	5	Aitkin	Blind Lake	01-0188-00		Lake	323	39	2007, 2008, MDNR APM	DL
974	6	6	Aitkin	Brown Lake	01-0078-00		Lake	97	34	2008	DL
975	7	7	Aitkin	Camp Lake	01-0098-00		Lake	127	30	2008	DL
976	8	8	Aitkin	Cedar Lake	01-0209-00		Lake	1778		MDNR APM, MDNR 2013	DL
977	9	9	Aitkin	Clear Lake	01-0106-00		Lake	123	20	2008	DL
978	10	10	Aitkin	Cornish Lake	01-0427-00		Lake	600	30	2008, MDNR 2013	DL
979	11	11	Aitkin	Davis Lake	01-0071-01		Lake	76	30	2007, 2008	DL
980	12	12	Aitkin	Deer Lake	01-0086-00		Lake	47	3	2008	DL
981	13	13	Aitkin	Elm Island Lake	01-0123-00		Lake	656	30	2007, 2008, MDNR APM, 2010	DL
982	14	14	Aitkin	Farm Island	01-0159-00		Lake	2025	20	2007, 2008, MDNR APM	DL
983	15	15	Aitkin	Fleming Lake	01-0105-00		Lake	326	1	2008, MDNR APM	DL
984	16	16	Aitkin	Flowage Lake	01-0061-00		Lake	720	432	2007, 2008, UofM/MPCA 2013, 2010	DL
985	17	17	Aitkin	Gun Lake	01-0099-00		Lake	735	60	2008, MDNR APM, 2010	DL
986	18	18	Aitkin	Hanging Kettle Lake	01-0170-00		Lake	320		MDNR APM, MDNR 2013	DL
987	19	19	Aitkin	Hickory Lake	01-0179-00		Lake	183	10	2008, MDNR APM	DL
988	20	20	Aitkin	Horseshoe Lake	01-0034-00		Lake	252		MDNR APM, MDNR 2013	DL
989	21	21	Aitkin	Jewett State WMA - Impoun	01-0383-00		Lake	180	30	2008	DL
990	22	22	Aitkin	Johnson Lake	01-0131-00		Lake	27	6	2008	DL
991	23	23	Aitkin	Killroy Lake	01-0238-00		Lake	23	4	2008	DL
992	24	24	Aitkin	Kimberly State.WMA - Lower	01-0411-00		Lake	300	30	2008	DL
993	25	25	Aitkin	Kimberly State.WMA - Upper	01-0410-00		Lake	900	76	2008	DL
994	26	26	Aitkin	Krilwitz Lake	01-0283-00		Lake	30	6	2008	DL
995	27	27	Aitkin	Lily Lake	01-0088-00		Lake	50	2	2008	DL
996	28	28	Aitkin	Little Hill River WMA - Impou	01-0433-00		Lake	135	18	2008	DL
997	29	29	Aitkin	Little McKinney Lake	01-0197-00		Lake	26	6	2008	DL
998	30	30	Aitkin	Little Pine Lake	01-0176-00		Lake	126	1	2008, MDNR APM	DL
999	31	31	Aitkin	Little Red Horse Lake	01-0052-00		Lake	32	3	2007, 2008	DL
1000	32	32	Aitkin	Little Willow R. WMA - Uppe	01-0420-00	W0642001	Stream	50	20	2008	DL
1001	1335	19	Aitkin	Little Willow River WMA Poo	01-0332-00	W0642002	Stream	140	50	MDNR 2008	DL
1002	33	33	Aitkin	Mallard Lake	01-0149-00		Lake	354	320	2007, 2008, 2010	DL
1003	34	34	Aitkin	Mandy Lake	01-0068-00		Lake	107	27	2008	DL
1004	35	35	Aitkin	Minnewawa Lake	01-0033-00		Lake	2451	130	2007, 2008, 2010	DL
1005	36	36	Aitkin	Monson Lake	01-0126-00		Lake	48	25	2008	DL
1006	37	37	Aitkin	Moose Lake	01-0140-00		Lake	148	117	2007, 2008, 2010	DL
1007	39	39	Aitkin	Moose River	07010103-52	01r4	Stream			2008	DL
1008	38	38	Aitkin	Moose River Pool	01-0358-00		Lake	900	89	2008, 2010	DL
1009	40	40	Aitkin	Moose Willow WMA - Willov	01-0431-00		Lake	300	50	2008, 2010	DL
1010	41	41	Aitkin	Mud Lake	01-0194-00		Lake	135	68	2008, 2010	DL
1011	42	42	Aitkin	Nelson Lake	01-0010-00		Lake	71	1	2008, 1854 List	DL
1012	43	43	Aitkin	Newstrom Lake	01-0097-00		Lake	97	76	2007, 2008, 2010	DL
1013	44	44	Aitkin	Pine Lake	01-0001-00		Lake	391	4	2008	DL
1014	45	45	Aitkin	Portage Lake	01-0069-00		Lake	387	5	2008	DL
1015	46	46	Aitkin	Prairie River	07010103-51	01r6	Stream			2007, 2008, 2010, 1854 List	DL
1016	47	47	Aitkin	Rat House Lake	01-0053-00		Lake	122	100	2007, 2008, 2010	DL
1017	48	48	Aitkin	Rat Lake	01-0077-00		Lake	442	45	2007, 2008, MDNR APM, 2010	DL
1018	49	49	Aitkin	Red Lake	01-0107-00		Lake	97	4	2007, 2008, MDNR APM, 2010	DL
1019	50	50	Aitkin	Rice Lake	01-0005-00		Lake	83	50	2007, 2008, 2010	DL
1020	51	51	Aitkin	Rice Lake	01-0067-00		Lake	3635	1700	2008, 2010	DL
1021	52	52	Aitkin	Rice River	07010104-50	01r1	Stream			2008	DL
1022	53	53	Aitkin	Ripple Lake	01-0146-00		Lake	676	50	MDNR APM, 2010	DL
1023	54	54	Aitkin	Ripple River	07010104-66	01r3	Stream			2007, 2008, 2010	DL
1024	55	55	Aitkin	Rock Lake	01-0072-00		Lake	366	50	2008, 2010, MDNR 2013	DL
1025	56	56	Aitkin	Salo Marsh State WMA Imp.	01-0415-00		Lake	690	76	2008, 2010	DL
1026	57	57	Aitkin	Sanders Lake	01-0076-00		Lake	55	36	2008	DL
1027	58	58	Aitkin	Sandy River	07010103-50	01r2	Stream			2008	DL
1028	59	59	Aitkin	Sandy River Lake	01-0060-00		Lake	368	200	2007, MDNR APM, 2010	DL
1029	60	60	Aitkin	Savanna Lake	01-0014-00		Lake	86	1	2007, 2008	DL
1030	61	61	Aitkin	Savanna River	07010103-51	01r5	Stream			2007, 2008	DL
1031	62	62	Aitkin	Section Ten Lake	01-0115-00		Lake	440	52	2007, 2008, 2010	DL
1032	63	63	Aitkin	Section Twelve Lake	01-0120-00		Lake	167	1	2007, 2008, 2010	DL
1033	64	64	Aitkin	Shovel Lake	01-0200-00		Lake	230	207	2007, 2008, 2010	DL
1034	65	65	Aitkin	Sisabagamah Lake	01-0129-00		Lake	386	39	2008	DL
1035	66	66	Aitkin	Sitas Lake	01-0134-00	1013400	Lake	59	5	2008	DL
1036	67	67	Aitkin	Sjodin Lake	01-0316-00		Lake	43	28	2007, 2008, 2010	DL
1037	68	68	Aitkin	Spirit Lake	01-0178-00		Lake	523	26	2007, 2008	DL
1038	69	69	Aitkin	Split Rock Lake	01-0002-00		Lake	27	1	1854 List	DL
1039	70	70	Aitkin	Spruce Lake	01-0151-00		Lake	80	80	2008, 2010	DL
1040	71	71	Aitkin	Steamboat Lake	01-0071-02		Lake	59	15	2008	DL
1041	72	72	Aitkin	Stony Lake	01-0017-00		Lake	52	5	2008	DL
1042	73	73	Aitkin	Swamp Lake	01-0092-00		Lake	270	1	2008, MDNR APM	DL
1043	74	74	Aitkin	Tamarack River	07010103-52	01r7	Stream			2008	DL
1044	75	75	Aitkin	Twenty Lake	01-0085-00		Lake	153	119	2007, 2008, 2010	DL
1045	76	76	Aitkin	Unnamed - Little Willow Rive	01-0332-00		Lake	140	50	2008, 2010	DL
1046	77	77	Aitkin	Unnamed (Round Lake Potho	01-0285-00		Lake	15	12	2008	DL
1047	78	78	Aitkin	Upper Blind Lake	01-0331-00		Lake	14	3	2008	DL
1048	79	79	Aitkin	Washburn Lake	01-0111-00		Lake	73	4	2008	DL
1049	80	80	Aitkin	Waukenabo Lake	01-0136-00		Lake	819	49	2008, MDNR APM, 2010	DL
1050	81	81	Aitkin	West Lake	01-0287-00		Lake	51	20	2007, 2008	DL
1051	82	82	Aitkin	White Elk Lake	01-0148-00		Lake	780	350	2007, 2008, 2010	DL
1052	83	83	Anoka	Amelia Lake	02-0014-00		Lake	178		MDNR APM	DL
1053	2330		Anoka	Carlos Avery - Pool 9 (2)		W9001011	Lake	71	30	MDNR 2008	DL
1054	84	84	Anoka	Carlos Avery WMA - Pool 1	DNR	W9001001		180	15	2008	DL
1055	85	85	Anoka	Carlos Avery WMA - Pool 13	DNR	W9001013		586	2	2008	DL
1056	86	86	Anoka	Carlos Avery WMA - Pool 14	DNR	W9001014		749	15	2008	DL
1057	87	87	Anoka	Carlos Avery WMA - Pool 2	DNR	W9001002		683	20	2008	DL
1058	88	88	Anoka	Carlos Avery WMA - Pool 22	DNR	W9001022		141	10	2008	DL
1059	89	89	Anoka	Carlos Avery WMA - Pool 24	DNR	W9001024		35	2	2008	DL
1060	90	90	Anoka	Carlos Avery WMA - Pool 26	DNR	W9001026		200	5	2008	DL
1061	91	91	Anoka	Carlos Avery WMA - Pool 3	DNR	W9001003		186	120	2008, 2010	DL
1062	92	92	Anoka	Carlos Avery WMA - Pool 5	DNR	W9001005		52	25	2008	DL
1063	93	93	Anoka	Carlos Avery WMA - Pool 7	DNR	W9001007		240	3	2008	DL
1064	94	94	Anoka	Carlos Avery WMA - Pool 9	DNR	W9001009		269	120	2008, 2010, UofM/MPCA 2013	DL
1065	95	95	Anoka	Hickey Lake	02-0096-00		Lake	41	0	2007, 2008, 2010	DL
1066	96	96	Anoka	Little Coon Lake	02-0032-00		Lake	486	10	2008	DL

	A	B	C	D	E	F	G	H	I	J	K
1067	97	97	Anoka	Pickerel Lake	02-0130-00		Lake	303	25	2008	DL
1068	98	98	Anoka	Swan Lake	02-0098-00		Lake	273	33	2008	DL
1069	99	99	Anoka	Trott Brook	07010207-68	13UM044	Stream			MPCA_BioMon	DL
1070	100	100	Anoka	Unnamed Lake	02-0101-00		Lake	148	80	MDNR 2013	DL
1071	101	101	Becker	Abners Lake	03-0039-00		Lake	100	80	2008, 2010	DL
1072	102	102	Becker	Acorn Lake	03-0258-00		Lake	144		MCBS2011, MDNR 2013	DL
1073	103	103	Becker	Aspinwall Lake	03-0104-00		Lake	178	18	2008	DL
1074	104	104	Becker	Balsam Lake	03-0292-00		Lake	148	10	2008	DL
1075	105	105	Becker	Bass Lake	03-0088-00		Lake	208	10	2008, MDNR APM	DL
1076	106	106	Becker	Big Basswood Lake	03-0096-00		Lake	586	304	2007, 2008, 2010, MCBS 2011	DL
1077	107	107	Becker	Big Elbow Lake	03-0159-00		Lake	1002		MDNR APM	DL
1078	108	108	Becker	Big Floyd Lake	03-0387-00		Lake	1212		MDNR APM	DL
1079	109	109	Becker	Big Rat Lake	03-0246-00		Lake	1102	110	2008, 2010	DL
1080	110	110	Becker	Big Rush Lake	03-0103-00		Lake	1128	20	2008	DL
1081	111	111	Becker	Big Sugarbush Lake	03-0304-00		Lake	668		MDNR APM, MDNR 2013	DL
1082	112	112	Becker	Blackbird Lake	03-0197-00		Lake	284	42	2007, 2008, 2010	DL
1083	113	113	Becker	Blueberry Lake	03-0007-00		Lake	160	2	2008	DL
1084	114	114	Becker	Booth Lake	03-0198-00		Lake	48	43	2008, 2010	DL
1085	115	115	Becker	Buffalo Lake	03-0350-00		Lake	444	89	2007, 2008, MDNR APM, 2010	DL
1086	116	116	Becker	Buffalo River	09020106-59	03river	Stream			2007	DL
1087	117	117	Becker	Bullhead Lake	03-0312-00		Lake	39	6	2008	DL
1088	118	118	Becker	Bush Lake	03-0212-00		Lake	110	40	2008, 2010	DL
1089	119	119	Becker	Cabin Lake	03-0346-00		Lake	38		2007, 2008, 2010	DL
1090	120	120	Becker	Camp Seven Lake	03-0151-00		Lake	78	8	2008	DL
1091	121	121	Becker	Carman Lake	03-0209-00		Lake	217	30	2007, 2008, 2010	DL
1092	122	122	Becker	Chippewa Lake	03-0196-00		Lake	960	288	2007, 2008, 2010	DL
1093	1392	76	Becker	Dead	03-0160-00		Lake	296		MDNR 2008	DL
1094	123	123	Becker	Dinner Lake	03-0044-00		Lake	53	11	2007, 2008	DL
1095	124	124	Becker	Eagen Lake	03-0318-00		Lake	85		2007, 2008	DL
1096	125	125	Becker	Equay Lake	03-0219-00		Lake	73	7	2008	DL
1097	126	126	Becker	Flat Lake	03-0242-00		Lake	1970	197	2007, 2008, 2010	DL
1098	127	127	Becker	Gull Creek	09020108-56	03r2	Stream			2007, 2008	DL
1099	128	128	Becker	Gyles Lake	03-0066-00		Lake	42	16	2008, MDNR APM	DL
1100	129	129	Becker	Height Of Land Lake	03-0195-00		Lake	3943	197	2007, 2008, UofM/MPCA 2013, MCBS 2011, MD	DL
1101	130	130	Becker	Hubbel Pond Lake	03-0240-00		Lake	561	168	2007, 2008, 2010	DL
1102	131	131	Becker	Ida Lake	03-0582-00		Lake			MDNR APM	DL
1103	132	132	Becker	Indian Creek (I.C. Impoundm	03-0786-00	03r4	Stream			2007, 2008	DL
1104	133	133	Becker	Johnson Lake	03-0199-00		Lake	181	40	2008	DL
1105	134	134	Becker	Johnson Lake	03-0374-01		Lake			MDNR APM	DL
1106	135	135	Becker	Kane Lake	03-0042-00		Lake	28		MCBS 2011, MDNR 2013	DL
1107	136	136	Becker	Kneebone Lake	03-0090-00		Lake	149	15	2008	DL
1108	137	137	Becker	Knutson Lake	03-0004-00		Lake	54		MCBS 2011, MDNR 2013	DL
1109	138	138	Becker	Little Basswood Lake	03-0092-00		Lake	105	31	2007, 2008, 2010	DL
1110	139	139	Becker	Little Dinner Lake	03-0045-00		Lake	12	5	2008	DL
1111	140	140	Becker	Little Flat Lake	03-0217-00		Lake	235	211	2008, 2010, UofM/MPCA 2013	DL
1112	141	141	Becker	Little Floyd Lake	03-0386-00		Lake	231		MDNR APM, MDNR 2013	DL
1113	142	142	Becker	Little Mud Lake	03-0022-00		Lake	25	6	2008	DL
1114	143	143	Becker	Little Rice Lake	03-0239-00		Lake	110	21	2008	DL
1115	144	144	Becker	Little Round Lake	03-0302-00		Lake	565	0	2007, 2008, 2010, UofM/MPCA 2013, hydropon	DL
1116	145	145	Becker	Little Toad Lake	03-0189-00		Lake	434		MDNR APM, MDNR 2013	DL
1117	146	146	Becker	Long Lake	03-0383-00		Lake			MDNR APM	DL
1118	147	147	Becker	Lower Egg Lake	03-0210-00		Lake	171	75	2007, 2008, 2010	DL
1119	148	148	Becker	Many Point Lake	03-0158-00		Lake	1588		MCBS 2011, MDNR 2013	DL
1120	149	149	Becker	Mary Yellowhead Lake	03-0243-00		Lake	68	7	2008	DL
1121	1414	98	Becker	Mud	03-0120-00		Lake	170		MDNR 2008	DL
1122	150	150	Becker	Mud Lake	03-0023-00		Lake	85	42	2008, 2010	DL
1123	151	151	Becker	Mud Lake	03-0067-00		Lake	88	83	2008, 2010	DL
1124	152	152	Becker	Ottertail River	09020103-53	03r1	Stream			2007, 2008	DL
1125	154	154	Becker	Rice Lake	03-0201-00		Lake	245	245	2008, 2010, MCBS 2011, MDNR APM	DL
1126	153	153	Becker	Rice Lake	03-0291-00		Lake	245	196	2007, 2008, 2010	DL
1127	155	155	Becker	Rock Lake	03-0293-00		Lake	1198	240	2007, 2008, MDNR APM, 2010	DL
1128	156	156	Becker	Round Lake	03-0155-00		Lake	1094	0	2007, 2008, MDNR APM, MCBS 2011	DL
1129	157	157	Becker	Saint Patrick Lake	03-0277-00		Lake	78	78	MDNR 2013	DL
1130	158	158	Becker	Schultz Lake	03-0278-00		Lake	103	82	2008, 2010	DL
1131	159	159	Becker	Shell Lake	03-0102-00		Lake	3147	169	2007, 2008, MDNR APM, MCBS 2011, 2010	DL
1132	1425	109	Becker	Shipman	03-0005-00		Lake	71		MDNR 2008	DL
1133	160	160	Becker	Sieverson / Sivertson Lake	03-0108-00		Lake	79	1	MDNR 2013, MCBS 2011	DL
1134	161	161	Becker	Spindler Lake	03-0214-00		Lake	185	125	2008	DL
1135	162	162	Becker	St. Clair Lake	03-0430-00		Lake	192		MCBS 2011,MDNR 2013	DL
1136	163	163	Becker	Tamarack Lake	03-0388-00		Lake			MDNR APM	DL
1137	164	164	Becker	Tamarack North Lake	03-0241-02		Lake	1442		2008, 2010, MCBS 2011, MDNR 2013	DL
1138	2339		Becker	Tamarack NWR - Ogemash Pool		03IMP002	Lake	71	20	MDNR 2008	DL
1139	165	165	Becker	Tamarack South Lake	03-0241-01		Lake			2008, 2010, MCBS 2011	DL
1140	166	166	Becker	Tea Cracker Lake	03-0157-00		Lake	122	30	2008	DL
1141	167	167	Becker	Toad Lake	03-0107-00		Lake	1816		MDNR APM, MDNR 2013	DL
1142	168	168	Becker	Town Lake	03-0264-00		Lake	117	35	2008	DL
1143	169	169	Becker	Trieglaff Lake	03-0263-00		Lake	111	56	2008, 2010	DL
1144	170	170	Becker	Twin Island Lake	03-0033-00		Lake	71	5	2007,	DL
1145	171	171	Becker	Two Inlets Lake	03-0017-00		Lake	643	40	2007, 2008, MDNR APM, 2010	DL
1146	172	172	Becker	Unnamed - Big Slough Lake	03-0185-00		Lake	33	33	MDNR 2013	DL
1147	173	173	Becker	Unnamed - Davis Lake	03-0268-00		Lake	19	1	MDNR 2013 Hubbel Pond WMA	DL
1148	174	174	Becker	Unnamed - Myrel's Pond	DNR	03_imp_002		40	30	MDNR 2013 Hubbel Pond WMA	DL
1149	175	175	Becker	Unnamed - Osprey Pond				42	42	MDNR 2013 Hubbel Pond WMA	DL
1150	176	176	Becker	Unnamed - Trout Pond	DNR	03_imp_003		20	20	MDNR 2013	DL
1151	177	177	Becker	Unnamed (Indian Creek imp	03-0786-00		Lake	13		2007, 2008, 2010	DL
1152	178	178	Becker	Unnamed Lake	03-0434-00		Lake	21	17	2008	DL
1153	179	179	Becker	Unnamed Lake	03-0716-00		Lake	25	12	2008	DL
1154	180	180	Becker	Unnamed Lake	03-0776-00		Lake	20	10	2008	DL
1155	181	181	Becker	Unnamed Lake	03-1093-00		Lake	72	7	2008	DL
1156	182	182	Becker	Upper Egg Lake	03-0206-00		Lake	493	24	2007, 2008, 2010	DL
1157	183	183	Becker	White Earth Lake	03-0328-00		Lake	2074		MDNR APM, MDNR 2013	DL
1158	184	184	Becker	Winter Lake	03-0216-00		Lake	117	43	2008, 2010	DL
1159	185	185	Becker	Wolf Lake	03-0101-00		Lake	1453	10	2007, 2008	DL
1160	186	186	Beltrami	Andrusia Lake	04-0038-00		Lake	1448		MCBS2011, MDNR 2013	DL
1161	187	187	Beltrami	Big Lake	04-0049-00		Lake	3565	250	2008, 2010	DL
1162	188	188	Beltrami	Big Rice Lake	04-0031-00		Lake	642	96	2007, 2008, 2010	DL
1163	189	189	Beltrami	Blackduck Lake	04-0069-00		Lake			MDNR APM	DL

	A	B	C	D	E	F	G	H	I	J	K
1164	190	190	Beltrami	Blackduck River	09020302-51	14RD122	Stream			MPCA_BioMon	DL
1165	191	191	Beltrami	Bootleg Lake	04-0211-00		Lake	308	185	2007, 2008, 2010	DL
1166	192	192	Beltrami	Buck Lake	04-0042-00		Lake			MDNR APM	DL
1167	193	193	Beltrami	Burns Lake	04-0001-00		Lake	131	105	2008, 2010	DL
1168	194	194	Beltrami	Campbell Lake	04-0196-00		Lake	462	23	2008, MCBS 2011	DL
1169	195	195	Beltrami	Carr Lake	04-0141-00		Lake	51	8	2007, 2008	DL
1170	196	196	Beltrami	Cass Lake	04-0030-00		Lake	15958	10	2008	DL
1171	197	197	Beltrami	Clearwater Lake	04-0343-00		Lake	1039		MDNR APM, MDNR2008	DL
1172	198	198	Beltrami	Cranberry Lake	04-0123-00		Lake	77	46	2007, 2008, 2010	DL
1173	199	199	Beltrami	Depressional Wetland	04-0460-00	09Belt143	Wetland			MPCA_BioMon	DL
1174	200	200	Beltrami	Erickson NW Lake	04-0068-01		Lake			2008, 2010	DL
1175	201	201	Beltrami	Erickson SE Lake	04-0068-02		Lake			2008, 2010	DL
1176	202	202	Beltrami	George Lake	04-0175-00		Lake	89	18	2008	DL
1177	203	203	Beltrami	Gourd Lake	04-0253-00		Lake			UofM/MPCA 2013	DL
1178	204	204	Beltrami	Grant Creek	07010101-54	04r1	Stream			2007, 2008	DL
1179	205	205	Beltrami	Gull Lake	04-0064-00		Lake	170	34	2008	DL
1180	206	206	Beltrami	Gull Lake	04-0120-00		Lake			UofM/MPCA 2013	DL
1181	207	207	Beltrami	Heart Lake	04-0271-00		Lake	10		2007, 2008	DL
1182	208	208	Beltrami	Irving Lake	04-0140-00		Lake	644	97	2008, 2010	DL
1183	209	209	Beltrami	Kitchi Lake	04-0007-00		Lake	1850	185	MDNR APM, 2010	DL
1184	210	210	Beltrami	Little Mississippi River	07010101-51	13UM122	Stream			MPCA_BioMon	DL
1185	211	211	Beltrami	Little Puposky Lake	04-0197-00		Lake	158	95	2008, 2010	DL
1186	212	212	Beltrami	Little Rice Lake	04-0015-00		Lake	123	60	2008, 2010	DL
1187	213	213	Beltrami	Little Turtle Lake	04-0155-00		Lake	464	23	2008	DL
1188	214	214	Beltrami	Long Lake	04-0227-00		Lake	706		MDNR APM, MDNR 2013	DL
1189	215	215	Beltrami	Manomin Lake	04-0286-00		Lake	288	144	2007, 2008, 2010	DL
1190	216	216	Beltrami	Marquette Lake	04-0142-00		Lake	578		2008, MDNR APM	DL
1191	217	217	Beltrami	Medicine Lake	04-0122-00		Lake	458	69	2008, 2010	DL
1192	218	218	Beltrami	Mississippi River	07010101-75	04r2	Stream			2007, 2008, MPCA_BioMon	DL
1193	219	219	Beltrami	Moose Lake	04-0011-00		Lake	617	96	2008, 2010	DL
1194	220	220	Beltrami	Moose Lake	04-0342-00		Lake	133		2007, 2008, MCBS 2011	DL
1195	221	221	Beltrami	Movil Lake	04-0152-00		Lake			MDNR APM, MDNR 2013	DL
1196	222	222	Beltrami	Norman Lake	04-0029-00		Lake	61	8	2008	DL
1197	223	223	Beltrami	North Turtle River	07010101-57	13UM131	Stream			MPCA_BioMon	DL
1198	224	224	Beltrami	Pimushe Lake	04-0032-00		Lake	1350	135	2007, 2008, 2010, MCBS 2011	DL
1199	225	225	Beltrami	Puposky Lake	04-0198-00		Lake	2120	236	2008, 2010	DL
1200	226	226	Beltrami	Rabideau Lake	04-0034-00		Lake	723	217	2007, 2008, MDNR APM, MCBS 2011, 2010	DL
1201	227	227	Beltrami	Rice Lake	04-0121-00		Lake	36		2008, MCBS 2011	DL
1202	228	228	Beltrami	Rice Lake	04-0174-00		Lake	55		2008, MCBS 2011	DL
1203	229	229	Beltrami	Rice Pond	04-0059-00		Lake	247	123	2008, 2010	DL
1204	230	230	Beltrami	Tamarac River	09020302-50	14RD139	Stream			MPCA_BioMon	DL
1205	231	231	Beltrami	Three Island Lake	04-0134-00		Lake	836	125	2007, 2008, 2010	DL
1206	232	232	Beltrami	Turtle Lake	04-0159-00		Lake	1584		MDNR APM, MCBS 2011, MDNR 2013	DL
1207	233	233	Beltrami	Turtle River	07010101-51	13UM153	Stream			MPCA_BioMon	DL
1208	234	234	Beltrami	Turtle River Lake	04-0111-00		Lake	1664		2007, 2008, MDNR APM, 2010	DL
1209	235	235	Beltrami	Whitefish Lake	04-0309-00		Lake	126		2007, 2008	DL
1210	236	236	Buffalo, WI	Mississippi Pool 5 / Spring	07040003-62	S007-660				UofM/MPCA 2013	DL
1211	237	237	Buffalo, WI - Wa	Mississippi Pool 5 / Spring	07040003-62	S007-690	Stream			2008, UofM/MPCA2013	DL
1212	238	238	Carlton	Bang Lake	09-0046-00		Lake	58	1	2008, 1854 List	DL
1213	239	239	Carlton	Bob Lake	09-0026-00		Lake	78	1	2008, 1854 List	DL
1214	240	240	Carlton	Cedar Lake	09-0031-00		Lake	62	10	2008, 1854 List	DL
1215	241	241	Carlton	Cross Lake	09-0062-00		Lake	110	6	2008, 1854 List	DL
1216	242	242	Carlton	Dead Fish Lake	09-0051-00		Lake	153	115	2007, 2008, UofM/MPCA 2013, 1854 List, 2010	DL
1217	243	243	Carlton	Flower Lake	09-0064-00		Lake	14	10	2008, 1854 List	DL
1218	244	244	Carlton	Hardwood Lake	09-0030-00		Lake	100	25	2008, 1854 List	DL
1219	245	245	Carlton	Hay Lake	09-0010-00		Lake	103	1	2007, 2008, MDNR APM, 1854 List, 2010	DL
1220	246	246	Carlton	Island Lower Lake	09-0060-02		Lake			2007, 2008, 1854 List, 2010	DL
1221	247	247	Carlton	Island Upper Lake	09-0060-01		Lake			2007, 2008, 1854 List, 2010	DL
1222	248	248	Carlton	Jaskari Lake	09-0050-00		Lake	74	74	2008, 1854 List, 2010	DL
1223	249	249	Carlton	Kettle Lake	09-0049-00		Lake	611	415	2007, 2008, 1854 List, 2010	DL
1224	250	250	Carlton	Kettle Lake	09-0074-00		Lake	22		1854 List, MDNR 2013	DL
1225	251	251	Carlton	Kettle River	07030003-51	KR	Stream			1854 List	DL
1226	252	252	Carlton	Little Kettle Lake	09-0077-00		Lake	18		1854 List, MDNR 2013, 2010	DL
1227	253	253	Carlton	Long Lake	09-0066-00		Lake	17	4	2008, 1854 List, 2010	DL
1228	254	254	Carlton	Miller Lake	09-0053-00		Lake	156	156	2008, 1854 List, 2010	DL
1229	255	255	Carlton	Moose (Little) Lake	09-0043-00		Lake	133		2008, 1854 List	DL
1230	256	256	Carlton	Moose Horn River	07030003-53	MHR	Stream			2007, 1854 List, 2010	DL
1231	257	257	Carlton	Moosehead Lake	09-0041-00		Lake	279		2008, 1854 List	DL
1232	258	258	Carlton	Perch Lake	09-0036-00		Lake	796	597	2008, 1854 List, 2010	DL
1233	259	259	Carlton	Rice Portage Lake	09-0037-00		Lake	832	120	2007, 2008, 1854 List, 2010	DL
1234	260	260	Carlton	Sawyer WMA (Sawyer P)	09-0145-00		Lake	21		1854 List, MDNR 2013	DL
1235	261	261	Carlton	Sawyer WMA, Sterly Pool	DNR	W0854002		29	2	2008, 1854 List	DL
1236	262	262	Carlton	Tamarack Lake	09-0067-00		Lake	228	11	2008, 1854 List, 2010	DL
1237	263	263	Carlton	Tamarack River	07010103-52	09r1	Stream			1854 List, in MDNR 2008 as 09r1, 2010	DL
1238	264	264	Carlton	unnamed (FDL1)	09-0178-00		Lake			1854 List, MDNR 2013	DL
1239	265	265	Carlton	unnamed (SWTorchlight)	09-0027-00		Lake	15		1854 List, MDNR 2013	DL
1240	266	266	Carlton	Walli Lake	09-0071-00		Lake	12		1854 List, MDNR 2013	DL
1241	267	267	Carlton	Wild Rice Lake	09-0023-00		Lake	54	36	2008, 1854 List, MCBS 2011, 2010	DL
1242	268	268	Carlton	Woodbury Lake	09-0063-00		Lake	59	10	2008, 1854 List	DL
1243	269	269	Cass	Baby Lake	11-0283-00		Lake	736	7	2008	DL
1244	270	270	Cass	Bergkeller Lake	11-0447-00		Lake	120	5	2008	DL
1245	271	271	Cass	Beuber Lake	11-0353-00		Lake	135	15	2007, 2008, MCBS 2011, 2010	DL
1246	272	272	Cass	Big Birch Lake	11-0017-00		Lake	255	45	2008, 2010	DL
1247	273	273	Cass	Big Boy Lake	11-0144-00		Lake			MDNR APM	DL
1248	274	274	Cass	Big Portage Lake	11-0308-00		Lake	956	30	2008, MDNR APM, MCBS 2011	DL
1249	275	275	Cass	Big Rice Lake	11-0073-00		Lake	2717	1411	2007, 2008, MCBS 2011, 2010	DL
1250	276	276	Cass	Big Sand Lake	11-0077-00		Lake	752	10	2008, MCBS 2011	DL
1251	277	277	Cass	Big Vermillion Lake	11-0029-00		Lake			MDNR APM	DL
1252	278	278	Cass	Birch Lake	11-0412-00		Lake	1262	1	2008, MDNR APM	DL
1253	2304		Cass	Bowen	11-0350-00		Lake	182		MDNR 2008	DL
1254	279	279	Cass	Boy Lake	11-0143-00		Lake	5544	340	2007, 2008, MDNR APM	DL
1255	280	280	Cass	Boy River	07010102-51	11r2	Stream			2007, 2008	DL
1256	281	281	Cass	Boy River	07010102-52	00UM012	Stream			2008, MPCA_BioMon	DL
1257	282	282	Cass	Brockway Lake	11-0366-00		Lake	182	55	2007, 2008, MCBS 2011	DL
1258	283	283	Cass	Bullhead Lake	11-0184-00		Lake	88		2008, Aquatic veg map/lake depth map 1993	DL
1259	284	284	Cass	Cat Lake	11-0509-00		Lake	108	5	2008	DL
1260	287	287	Cass	Cedar Lake	11-0082-00		Lake	20		MCBS2011, MDNR 2013	DL

	A	B	C	D	E	F	G	H	I	J	K
1261	285	285	Cass	Cedar Lake	11-0444-00		Lake	17	4	2008	DL
1262	286	286	Cass	Cedar Lake	11-0481-00		Lake	34	3	2008	DL
1263	288	288	Cass	Child Lake	11-0263-00		Lake	295	12	2008, MDNR APM, MCBS2011	DL
1264	289	289	Cass	Chub Lake	11-0517-00		Lake	57	51	2008, 2010	DL
1265	290	290	Cass	Ding Pot Lake	11-0565-00		Lake	29	29	2008	DL
1266	291	291	Cass	Drumbeater Lake	11-0145-00		Lake	376	5	2008, 2010	DL
1267	292	292	Cass	Esterday Lake	11-0511-00		Lake	43	3	2008	DL
1268	293	293	Cass	Farnham Lake	11-0513-00		Lake	142	71	2007, 2008	DL
1269	294	294	Cass	Five Point Lake	11-0351-00		Lake	265	13	2008, MDNR APM	DL
1270	295	295	Cass	Flaherty Lake	11-0492-00		Lake	24		MCBS 2011, MDNR 2013	DL
1271	296	296	Cass	George Lake	11-0101-00		Lake	720	262	2007, 2008, MCBS 2011	DL
1272	297	297	Cass	Girl Lake	11-0174-00		Lake	384		MDNR APM, MDNR 2013	DL
1273	298	298	Cass	Goose Lake	11-0096-00		Lake	844	844	2007, 2008, MCBS 2011	DL
1274	299	299	Cass	Gull Lake	11-0305-00		Lake	9541	15	2008, MDNR APM	DL
1275	300	300	Cass	Gull River	07010106-50	11r1	Stream	219	110	2007, 2008	DL
1276	301	301	Cass	Hardy Lake	11-0332-00		Lake	89	2	2008	DL
1277	302	302	Cass	Hattie Lake	11-0232-00		Lake	592	40	2008, MDNR APM, 2010	DL
1278	303	303	Cass	Hay Lake	11-0199-00		Lake	364	36	2008	DL
1279	304	304	Cass	Hunter Lake	11-0170-00		Lake	189	2	2008	DL
1280	305	305	Cass	Inguadona Lake	11-0120-00		Lake	935	19	2007, 2008, MCBS 2011	DL
1281	306	306	Cass	Island Lake	11-0102-00		Lake	390	10	2008, 2010	DL
1282	307	307	Cass	Island Lake	11-0360-00		Lake	117	30	2007, 2008, MCBS 2011	DL
1283	308	308	Cass	Jack Lake	11-0400-00		Lake	145		MCBS 2011, 2010	DL
1284	309	309	Cass	Kelly Lake	11-0428-00		Lake	50	10	2008	DL
1285	1551	235	Cass	Kerr	11-0268-00		Lake	81	1	MDNR 2008	DL
1286	310	310	Cass	Kid Lake	11-0262-00		Lake	167	3	2008	DL
1287	311	311	Cass	Laura Lake	11-0104-00		Lake	1424	854	2007, 2008, MCBS 2011	DL
1288	312	312	Cass	Leech Lake	11-0203-00		Lake	1E+05	4000	2007, 2008, 2010	DL
1289	313	313	Cass	Lind (Lindsey) Lake	11-0367-00		Lake	462	95	2007, 2008	DL
1290	314	314	Cass	Little Birch Lake	11-0018-00		Lake	25	25	2008, MCBS 2011	DL
1291	315	315	Cass	Little Boy Lake	11-0167-00		Lake	1396	10	2008	DL
1292	316	316	Cass	Little Hattie Lake (Unnamed)	11-0232-01		Lake	55		MCBS2011,MDNR 2013	DL
1293	317	317	Cass	Little Swift Lake	11-0131-00		Lake	62	16	2008	DL
1294	318	318	Cass	Little Vermillion Lake	11-0030-00		Lake	138	15	2008	DL
1295	319	319	Cass	Little Woman Lake	11-0265-00		Lake			2008, MCBS2011	DL
1296	320	320	Cass	Lizotte Lake	11-0231-00		Lake	75	50	2008	DL
1297	321	321	Cass	Lomish Lake	11-0136-00		Lake	282	197	2008, MCBS 2011, 2010	DL
1298	322	322	Cass	Long Lake	11-0142-00		Lake	926		MDNR APM, MDNR 2013	DL
1299	323	323	Cass	Lower Hand Lake	11-0251-00		Lake	122	50	2008, 2010	DL
1300	324	324	Cass	Lower Milton Lake	11-0080-00		Lake	80	5	2008	DL
1301	325	325	Cass	Lower Trelipe Lake	11-0129-00		Lake	618	20	2007, 2008, MDNR APM	DL
1302	326	326	Cass	Margaret Lake	11-0222-00		Lake	230	3	2008, MDNR APM	DL
1303	327	327	Cass	McCarthey Lake	11-0168-00		Lake	194	78	2008	DL
1304	328	328	Cass	McKeown Lake	11-0261-00		Lake	171	3	2008	DL
1305	329	329	Cass	Middle Sucker Lake	11-0317-00		Lake	290		MCBS 2011, MDNR 2013	DL
1306	330	330	Cass	Moon Lake	11-0078-00		Lake	58	5	2008	DL
1307	331	331	Cass	Moose Lake	11-0424-00		Lake	92	1	2007, 2008, 2010	DL
1308	333	333	Cass	Mud Lake	11-0100-00		Lake	1440	1300	2007, 2008, MCBS 2011, 2010	DL
1309	332	332	Cass	Mud Lake	11-0309-00		Lake	18	18	2008	DL
1310	334	334	Cass	Norway Brook	07010105-67	11000000	Stream			MDNR APM	DL
1311	376	335	Cass	Norway Lake	11-0307-00		Lake	498	10	2007, 2008, MDNR APM, MCBS 2011	DL
1312	377	336	Cass	Nushka Lake	11-0137-00		Lake	78		2008	DL
1313	378	337	Cass	Ododikossi Lake	11-0074-00		Lake	20	10	2008	DL
1314	379	338	Cass	Oxbow Lake	11-0075-00		Lake	172	4	2008	DL
1315	380	339	Cass	Peterson Lake	11-0154-00		Lake	139	3	2008	DL
1316	381	340	Cass	Pick Lake	11-0267-00		Lake	36	1	MCBS 2011, 2008	DL
1317	382	341	Cass	Pillager Lake	11-0320-00		Lake	213	10	2008	DL
1318	383	342	Cass	Pine Mountain Lake	11-0411-00		Lake	1657	40	2008, 2010	DL
1319	384	343	Cass	Pine River	07010105-67	11river_1	Stream			2007	DL
1320	385	344	Cass	Pleasant Lake	11-0383-00		Lake	997		UofM/MPCA 2013, MDNR 2013	DL
1321	386	345	Cass	Portage Creek	07010102-54	12UM100	Stream			MPCA_BioMon	DL
1322	388	347	Cass	Portage Lake	11-0134-00		Lake	154	10	MDNR 2013	DL
1323	389	348	Cass	Portage Lake	11-0204-00		Lake	1381		MDNR APM, MDNR 2013	DL
1324	387	346	Cass	Portage Lake	11-0476-00		Lake	277		2007, 2008, 2010	DL
1325	390	349	Cass	Potshot Lake	11-0149-00		Lake	28	14	2008	DL
1326	391	350	Cass	Rabbit Lake	11-0135-00		Lake	32	10	MDNR 2013	DL
1327	392	351	Cass	Rainy Lake	11-0356-00		Lake	132		MDNR APM	DL
1328	393	352	Cass	Rat Lake	11-0285-00		Lake	104		2008, Aquatic Veg map/lake depth map	DL
1329	394	353	Cass	Ray Lake	11-0220-00		Lake	183	37	2008	DL
1330	395	354	Cass	Rice (Carrol's) Lake	11-0227-00		Lake	46	46	2008, 2010	DL
1331	396	355	Cass	Rice (Pillager) Lake	11-0321-00		Lake	232	100	2007, 2008	DL
1332	397	356	Cass	Rice Lake	11-0162-00		Lake	342	137	2008	DL
1333	398	357	Cass	Rice Lake	11-0402-00		Lake	188	5	2008	DL
1334	399	358	Cass	Rice Pad	11-0720-00		Lake	14	4	2008	DL
1335	400	359	Cass	Rock Lake	11-0324-00		Lake	249	10	2008, MDNR APM	DL
1336	401	360	Cass	Sailor Lake	11-0019-00		Lake	42	10	2008	DL
1337	402	361	Cass	Schafer Lake	11-0004-00		Lake	44	2	2008	DL
1338	403	362	Cass	Scribner Lake	11-0441-00		Lake	93	5	2008	DL
1339	404	363	Cass	Six Mile Lake	11-0146-00		Lake	1288	70	2008	DL
1340	405	364	Cass	Skunk Lake	11-0027-00		Lake	145	30	2008	DL
1341	406	365	Cass	Spring Lake	11-0022-00		Lake	86	12	2008	DL
1342	407	366	Cass	Steamboat Bay	11-0491-00		Lake	146		2007	DL
1343	408	367	Cass	Steamboat River	07010102-50	11river_2	Stream			2007	DL
1344	409	368	Cass	Swift Lake	11-0133-00		Lake	359	51	MDNR APM, MCBS, 2008 2011, 2010	DL
1345	410	369	Cass	Sylvan Lake	11-0304-00		Lake	882		MDNR APM, MDNR 2013	DL
1346	411	370	Cass	Tamarack Lake	11-0189-00		Lake	63	6	2008	DL
1347	412	371	Cass	Tamarack Lake	11-0347-00		Lake	46	4	2008	DL
1348	413	372	Cass	Thiebault Lake	11-0020-00		Lake	37	5	2008	DL
1349	414	373	Cass	Third Guide Lake	11-0001-00		Lake	44	14	2008	DL
1350	415	374	Cass	Thunder Lake	11-0062-00		Lake	1316	2	2008	DL
1351	416	375	Cass	Twin (East Twin) Lake	11-0123-00		Lake	297	50	2008, MCBS 2011, 2010	DL
1352	417	376	Cass	Unnamed (Pistol Lake Rice B	11-0738-00		Lake	22	20	2008	DL
1353	429	388	Cass	Unnamed Lake	11-0777-00		Lake	40		2008, multi-year MDNR WR observations	DL
1354	418	377	Cass	Unnamed Lake	11-0780-00		Lake	10	4	2008	DL
1355	419	378	Cass	Upper Gull Lake	11-0218-00		Lake	345	2	2008, MDNR APM	DL
1356	420	379	Cass	Upper Hand Lake	11-0242-00		Lake	316	20	2008	DL
1357	421	380	Cass	Upper Trelipe Lake	11-0105-00		Lake	422		MDNR APM, MDNR 2013	DL

	A	B	C	D	E	F	G	H	I	J	K
1358	422	381	Cass	Wabedo Lake	11-0171-00		Lake	1272	5	2008, MCBS 2011	DL
1359	423	382	Cass	Wabegon Lake	11-0403-00		Lake	42	4	2008	DL
1360	424	383	Cass	Washburn Lake	11-0059-00		Lake	1768	60	2008, MDNR APM	DL
1361	425	384	Cass	Wax Lake	11-0124-00		Lake	95	10	2008	DL
1362	426	385	Cass	West Twin Lake	11-0125-00		Lake	200	11	2008	DL
1363	427	386	Cass	Winnibigoshish Lake	11-0147-00		Lake	69821	1000	2007, 2008, 2010	DL
1364	428	387	Cass	Woman Lake	11-0201-00		Lake	5360	54	2007, 2008, MDNR APM, 2010	DL
1365	430	389	Chisago	Carlos Avery WMA - Mud	13-0059-02		Lake	400	15	MDNR 2013	DL
1366	431	390	Chisago	Carlos Avery WMA - North S	13-0059-03		Lake	875	80	MDNR 2013	DL
1367	432	391	Chisago	Carlos Avery WMA - Peterso	13-0060-00		Lake	50	12	MDNR 2013	DL
1368	433	392	Chisago	Carlos Avery WMA - South S	13-0059-01		Lake	1480	80	MDNR 2013	DL
1369	434	393	Clay	Cromwell Lake	14-0103-00		Lake	27		2007, 2008, UofM/MPCA sampled	DL
1370	435	394	Clearwater	Anderson Lake	15-0074-00		Lake	53	3	2008	DL
1371	436	395	Clearwater	Bagley Lake	15-0040-00		Lake	106		2007, 2008	DL
1372	437	396	Clearwater	Clearwater	09020305-51	S004-204				UofM/MPCA 2013	DL
1373	438	397	Clearwater	Clearwater River	09020305-51	15r1	Stream			2007, 2008, 2010, UofM/MPCA 2013	DL
1374	439	398	Clearwater	Elk Lake	15-0010-00		Lake	305		2008, UofM/MPCA 2013	DL
1375	440	399	Clearwater	Falk Lake	15-0038-00		Lake	71		MCBS 2011, MDNR 2013	DL
1376	441	400	Clearwater	First Lake	15-0139-00		Lake	60	3	2008	DL
1377	442	401	Clearwater	Gill Lake	15-0019-00		Lake	380	38	2008	DL
1378	443	402	Clearwater	Itasca Lake	15-0016-00		Lake	1065		2008, UofM/MPCA 2013	DL
1379	444	403	Clearwater	Lomond Lake	15-0081-00		Lake	108	5	2008	DL
1380	445	404	Clearwater	Lower Rice	09020108-51	S006-985	Stream			UofM/MPCA 2013	DL
1381	446	405	Clearwater	Lower Rice	09020108-51	S007-164				UofM/MPCA 2013	DL
1382	447	406	Clearwater	Lower Rice Lake	15-0130-00		Lake	2375	1568	2007, 2008, 2010	DL
1383	448	407	Clearwater	Mallard Lake	15-0018-00		Lake	123	25	2008	DL
1384	449	408	Clearwater	Minerva Lake	15-0079-00		Lake	239	36	2007, 2008, MCBS 2011, 2010	DL
1385	450	409	Clearwater	Minnow Lake	15-0137-00		Lake	107		MDNR APM, MDNR 2013	DL
1386	451	410	Clearwater	Mississippi River	07010101-92	15r3	Stream			2007, 2008	DL
1387	452	411	Clearwater	Moose Lake	04-0342-00	4034200				2008 ArcMap, MCBS 2011	DL
1388	453	412	Clearwater	Mud Lake	15-0061-00		Lake	294	103	2007, 2008, 2010	DL
1389	454	413	Clearwater	Pine Lake	15-0149-00		Lake	1465	220	2008, UofM/MPCA 2013, 2010	DL
1390	456	415	Clearwater	Second Lake	15-0091-00		Lake			UofM/MPCA 2013	DL
1391	455	414	Clearwater	Second Lake	15-0140-00		Lake	68	7	2008, MCBS 2011	DL
1392	457	416	Clearwater	Spike Lake	15-0035-00		Lake	89		MCBS 2011, MDNR 2013	DL
1393	458	417	Clearwater	Sucker Lake	15-0020-00		Lake	90	14	2007, 2008, MCBS 2011, 2010	DL
1394	459	418	Clearwater	Third Lake	15-0141-00		Lake	38	2	2008	DL
1395	460	419	Clearwater	Unnamed (Rice Bed)	15-0021-00		Lake	150	45	2008, 2010	DL
1396	461	420	Clearwater	Upper Rice Lake	15-0059-00		Lake	1860	1116	2007, 2008, MCBS 2011, 2010	DL
1397	462	421	Clearwater	Walker Brook Lake	15-0060-00		Lake	94		MCBS 2011, MDNR 2013	DL
1398	463	422	Clearwater	Wild Rice River	09020108-51	15r2	Stream			2008	DL
1399	464	423	Cook	Baker Lake	16-0486-00		Lake	22		1854 List, MDNR 2013	DL
1400	465	424	Cook	Bigsby Lake	16-0344-00		Lake	89	1	2008, 1854 List	DL
1401	484	425	Cook	Bower Trout Lake	16-0175-00		Lake	136		1854 List	DL
1402	485	426	Cook	Brule River	04010101-50	BR	Stream			1854 List	DL
1403	488	429	Cook	Cuffs Lake	16-0006-00		Lake	16		2008, 1854 List	DL
1404	489	430	Cook	Dick Lake	16-0157-00		Lake	141		1854 List	DL
1405	490	431	Cook	East Pipe Lake	16-0386-00		Lake	136		1854 List, MDNR 2013	DL
1406	491	432	Cook	Elbow Lake	16-0096-00		Lake	415	124	2007, 2008, 1854 List	DL
1407	492	433	Cook	Fente Lake	16-0741-00		Lake	35		2008, 1854 List	DL
1408	494	435	Cook	Grassy Lake	16-0390-00		Lake	22		1854 List	DL
1409	495	436	Cook	Gust Lake	16-0380-00		Lake	159	1	1854 List	DL
1410	496	437	Cook	Iron Lake	16-0328-00		Lake	125		2007, 2008, 1854 List	DL
1411	497	438	Cook	Jack Lake	16-0521-00		Lake	127	12	2008, 1854 List	DL
1412	498	439	Cook	John Lake	16-0035-00		Lake	101		2008, 1854 List, MDNR 2013	DL
1413	499	440	Cook	Kelly Lake	16-0476-00		Lake	188	56	1854 List	DL
1414	500	441	Cook	Kelso Lake	16-0706-00		Lake	97	2	MDNR 2013	DL
1415	501	442	Cook	Little John Lake	16-0026-00		Lake	39		1854 List, MDNR 2013	DL
1416	502	443	Cook	Mark Lake	16-0250-00		Lake	126		2007, 2008, 2010, 1854 List	DL
1417	503	444	Cook	Marsh Lake	16-0048-00		Lake	18		1854 List, MDNR 2013	DL
1418	505	446	Cook	Merganser Lake	16-0107-00		Lake			1854 List	DL
1419	507	448	Cook	Mt. Maud Wetland	PCA - SN	16-wetland2				2008, 1854 List	DL
1420	508	449	Cook	North Fowl Lake	16-0036-00		Lake	297		2008, 1854 List	DL
1421	510	451	Cook	Otter Lake	16-0032-00		Lake	76		1854 List, MDNR 2013	DL
1422	511	452	Cook	Peterson Lake	16-0478-00		Lake	104	1	2008, 1854 List	DL
1423	512	453	Cook	Phoebe Lake	16-0808-00		Lake	758	1	2008, 1854 List	DL
1424	513	454	Cook	Pigeon River	04010101-50	PR	Stream			1854 List T. 64, R. 4 - 5 E	DL
1425	514	455	Cook	Prout Lake	16-0013-00		Lake	18		2008, 1854 List	DL
1426	515	456	Cook	Rib Lake	16-0544-00		Lake	94		2008, 1854 List	DL
1427	517	458	Cook	Richey Lake	16-0643-00		Lake	114		2008, 1854 List	DL
1428	518	459	Cook	Royal Lake	16-0025-00		Lake	22		1854 List	DL
1429	519	460	Cook	Royal River	04010101-07	16r1	Stream			2008, 1854 List	DL
1430	520	461	Cook	South Fowl Lake	16-0034-00		Lake	508		2008, 1854 List	DL
1431	521	462	Cook	Swamp Lake	16-0009-00		Lake			2008, 1854 List	DL
1432	522	463	Cook	Swamp Lake	16-0256-00		Lake			1854 List	DL
1433	523	464	Cook	Swamp River	04010101-54	16r2	Stream			2008, 1854 List	DL
1434	525	466	Cook	Teal Lake	16-0003-00		Lake	73	1	2008, 1854 List	DL
1435	526	467	Cook	Temperance River	04010101-61	16r3				2008, 1854 List	DL
1436	527	468	Cook	Toohey Lake	16-0645-00		Lake	369		2008, 1854 List	DL
1437	528	469	Cook	Turtle Lake	16-0251-00		Lake	61		2007, 2008, 1854 List	DL
1438	529	470	Cook	Two Island Lake	16-0156-00		Lake	858		1854 List	DL
1439	530	471	Cook	unnamed (Grd Portage)	04010101-75	URGP				1854 List	DL
1440	531	472	Cook	Unnamed Lake	16-0416-00		Lake	14	14	2008, 1854 List	DL
1441	532	473	Cook	Vern River	04010101-89	VR	Stream			1854 List T. 63, R. 3W, MDNR 2013	DL
1442	534	475	Cook	Wonder Lake	16-0664-00		Lake	76	5	MDNR 2013	DL
1443	535	476	Crow Wing	Arrowhead Lake	18-0366-00		Lake	285	40	2008	DL
1444	536	477	Crow Wing	Bass Lake	18-0011-00		Lake	65	13	2008	DL
1445	537	478	Crow Wing	Bay Lake	18-0034-00		Lake	2435	1	MDNR APM	DL
1446	538	479	Crow Wing	Big Bird Lake	18-0285-00		Lake	205	10	2008	DL
1447	539	480	Crow Wing	Birchdale Lake	18-0175-00		Lake	80	40	2008, MDNR APM	DL
1448	540	481	Crow Wing	Borden Lake	18-0020-00		Lake	1038	31	2008	DL
1449	541	482	Crow Wing	Buffalo Lake	18-0152-00		Lake	36	18	2008	DL
1450	542	483	Crow Wing	Bulldog Lake	18-0014-00		Lake	151	5	2008, MDNR APM	DL
1451	543	484	Crow Wing	Camp Lake	18-0018-00		Lake	537	22	2007, 2008, MDNR APM	DL
1452	544	485	Crow Wing	Caraway Lake	18-0179-00		Lake	40	32	2008	DL
1453	545	486	Crow Wing	Clark Lake	18-0374-00		Lake	309	3	2008, MDNR APM	DL
1454	546	487	Crow Wing	Clough Creek Lake	18-0414-00		Lake	274		MDNR APM	DL

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1455	547	488	Crow Wing	Crow Wing Lake	18-0155-00		Lake	378		2007, 2008	DL
1456	549	490	Crow Wing	Dahler Lake	18-0204-00		Lake	277	28	2007, 2008	DL
1457	550	491	Crow Wing	Deadmans Lake	18-0188-00		Lake	28	5	2008	DL
1458	551	492	Crow Wing	Deer Lake	18-0182-00		Lake	78	30	2008	DL
1459	552	493	Crow Wing	Dog Lake	18-0107-00		Lake	71	71	2008	DL
1460	554	495	Crow Wing	Duck Lake	18-0178-00		Lake	310	175	UofM/MPCA 2013	DL
1461	553	494	Crow Wing	Duck Lake	18-0314-00		Lake	160	3	2007, 2008	DL
1462	555	496	Crow Wing	Eagle Lake	18-0296-00		Lake	356	1	2008, MDNR APM	DL
1463	556	497	Crow Wing	Edward Lake	18-0556-00		Lake			MDNR APM	DL
1464	557	498	Crow Wing	Emily Lake	18-0203-00		Lake	675	2	2008	DL
1465	558	499	Crow Wing	Erskine Lake	18-0009-00		Lake	186	7	2008	DL
1466	559	500	Crow Wing	Faupel Lake	18-0237-00		Lake	42	25	2008	DL
1467	560	501	Crow Wing	Flanders Lake	18-0247-00		Lake	181	20	2008	DL
1468	561	502	Crow Wing	Garden Lake	18-0329-00		Lake	262	100	2007, 2008	DL
1469	562	503	Crow Wing	Gilbert Lake	18-0320-00		Lake	391	7	2008, MCBS 2011, MDNR APM	DL
1470	563	504	Crow Wing	Goodrich Lake	18-0226-00		Lake	382	5	2008	DL
1471	564	505	Crow Wing	Google Lake	18-0223-00		Lake	107	11	2007, 2008	DL
1472	565	506	Crow Wing	Grass Lake	18-0230-00		Lake	78	4	2008	DL
1473	566	507	Crow Wing	Greer Lake	18-0287-00		Lake	384	20	2008	DL
1474	567	508	Crow Wing	Half Moon Lake	18-0238-00		Lake	70	14	2007, 2008	DL
1475	568	509	Crow Wing	Happy Lake	18-0101-00		Lake	51	36	2008	DL
1476	570	511	Crow Wing	Hay Lake	18-0120-00		Lake	44		MDNR APM, 2010	DL
1477	569	510	Crow Wing	Hay Lake	18-0444-00		Lake	46	29	2008	DL
1478	571	512	Crow Wing	Hole- in-the-Day Lake	18-0401-00		Lake	217	90	2008	DL
1479	572	513	Crow Wing	Holt Lake	18-0029-00		Lake	164	10	2007, 2008	DL
1480	573	514	Crow Wing	Horseshoe Lake	18-0317-00		Lake	33	13	2008	DL
1481	574	515	Crow Wing	Island Lake	18-0052-00		Lake	37	18	2008	DL
1482	575	516	Crow Wing	Island Lake	18-0383-00		Lake	85	2	2008	DL
1483	576	517	Crow Wing	Jail Lake	18-0415-00		Lake	190	2	2008	DL
1484	577	518	Crow Wing	Johnson Lake	18-0328-00		Lake	129	25	2008	DL
1485	578	519	Crow Wing	Lily Pad Lake	18-0275-00		Lake	47	30	2008	DL
1486	579	520	Crow Wing	Little Pine Lake	18-0176-00		Lake	135	30	2007, 2008	DL
1487	580	521	Crow Wing	Little Pine Lake	18-0266-00		Lake	384	20	2008	DL
1488	581	522	Crow Wing	Little Pine River	07010105-50	18river_2	Stream			2007	DL
1489	582	523	Crow Wing	Lizzie Lake	18-0416-00		Lake	384	100	2007, 2008, MCBS 2011	DL
1490	583	524	Crow Wing	Long Lake	18-0031-00		Lake	80	4	2008	DL
1491	584	525	Crow Wing	Love Lake	18-0388-00		Lake	88	18	2008, MDNR APM	DL
1492	585	526	Crow Wing	Lower Dean Lake	18-0181-00		Lake	372	360	2007, 2008	DL
1493	586	527	Crow Wing	Lower Mission Lake	18-0243-00		Lake	739	50	2008, MDNR APM	DL
1494	587	528	Crow Wing	Lows Lake	18-0180-00		Lake	320	45	2007, 2008, MDNR APM	DL
1495	588	529	Crow Wing	Mallard Lake	18-0334-00		Lake	73	4	2008	DL
1496	589	530	Crow Wing	Maple Lake	18-0045-00		Lake	68	20	2008	DL
1497	590	531	Crow Wing	Mayo Lake	18-0408-00		Lake	278		MDNR APM	DL
1498	591	532	Crow Wing	Middle Cullen Lake	18-0377-00		Lake	405	2	2007, 2008	DL
1499	592	533	Crow Wing	Mississippi River	07010104-65	18r1	Stream		1	2007, 2008, UofM/MPCA 2013, MDNR APM	DL
1500	593	534	Crow Wing	Mitchell Lake	18-0294-00		Lake	460	3	2008	DL
1501	594	535	Crow Wing	Mollie Lake	18-0335-00		Lake	421	17	2008	DL
1502	595	536	Crow Wing	Mud Lake	18-0094-00		Lake	78	6	2008	DL
1503	596	537	Crow Wing	Mud Lake	18-0137-00		Lake	132	40	2008	DL
1504	597	538	Crow Wing	Mud Lake	18-0198-00		Lake	103	10	2008	DL
1505	598	539	Crow Wing	Mud Lake	18-0326-00		Lake	82	60	2008	DL
1506	599	540	Crow Wing	Nelson Lake	18-0164-00		Lake	323	100	2008	DL
1507	600	541	Crow Wing	Nisswa Lake	18-0399-00		Lake	213	25	2008, MDNR APM	DL
1508	601	542	Crow Wing	North Long Lake	18-0372-00		Lake	6178	10	2007, 2008, MDNR APM	DL
1509	602	543	Crow Wing	Olson Lake	18-0171-00		Lake	28	3	2008	DL
1510	603	544	Crow Wing	Ossawinnamakee	18-0352-00		Lake	739	1	2008, multi-year MDNR WR observations	DL
1511	604	545	Crow Wing	Pelican Lake	18-0308-00		Lake	8468		MDNR APM	DL
1512	605	546	Crow Wing	Perch Lake	18-0304-00		Lake	181	8	2008	DL
1513	606	547	Crow Wing	Pine Lake	18-0261-00		Lake	391	60	2008	DL
1514	607	548	Crow Wing	Pine River	07010105-50	18river_3	Stream			2007	DL
1515	608	549	Crow Wing	Platte Lake	18-0088-00		Lake	1768	350	2007, 2008, MDNR APM	DL
1516	609	550	Crow Wing	Pointon Lake	18-0105-00		Lake	193	14	2008, MDNR 2013	DL
1517	610	551	Crow Wing	Rat Lake	18-0410-00		Lake	100	2	2008	DL
1518	611	552	Crow Wing	Red Sand Lake	18-0386-00		Lake	569	28	2008, MDNR APM	DL
1519	612	553	Crow Wing	Rice (Blomberg's) Lake	18-0121-00		Lake	78	60	2008	DL
1520	613	554	Crow Wing	Rice (Clark Lake) Lake	18-0327-00		Lake	181	124	2008	DL
1521	614	555	Crow Wing	Rice (Deerwood) Lake	18-0068-00		Lake	185	170	2007, 2008	DL
1522	615	556	Crow Wing	Rice (Hesitation WMA) Lake	18-0053-00		Lake	168	138	2007, 2008, UofM/MPCA 2013	DL
1523	616	557	Crow Wing	Rice (Lowell WMA) Lake	18-0405-00		Lake	85	33	2008	DL
1524	617	558	Crow Wing	Rice (Pratt's) Lake	18-0316-00		Lake	100	90	2008	DL
1525	618	559	Crow Wing	Rice Bed Lake	18-0187-00		Lake	50	47	2008	DL
1526	619	560	Crow Wing	Rock Lake	18-0016-00		Lake	210	10	2008	DL
1527	620	561	Crow Wing	Rogers Lake	18-0184-00		Lake	249	4	2008	DL
1528	621	562	Crow Wing	Round (Round-Rice Bed WM	18-0032-00		Lake	82	5	2008	DL
1529	622	563	Crow Wing	Round Lake	18-0147-00		Lake	144	5	2008	DL
1530	623	564	Crow Wing	Round Lake	18-0373-00		Lake	1706		MDNR APM	DL
1531	624	565	Crow Wing	Roy Lake	18-0398-00		Lake	310	5	MDNR APM	DL
1532	625	566	Crow Wing	Scott Lake	18-0033-00		Lake	178		MDNR APM	DL
1533	626	567	Crow Wing	Sebie Lake	18-0161-00		Lake	180	2	2008	DL
1534	627	568	Crow Wing	Sewells Pond	18-0446-00		Lake	20	16	2008	DL
1535	628	569	Crow Wing	Sibley Lake	18-0404-00		Lake	412	10	2008, MDNR APM	DL
1536	629	570	Crow Wing	Smith Lake	18-0028-00		Lake	486	49	2008, MDNR APM	DL
1537	630	571	Crow Wing	South Long Lake	18-0136-00		Lake	1380	4	2008	DL
1538	631	572	Crow Wing	Stewart Lake	18-0367-00		Lake	254	5	2008	DL
1539	632	573	Crow Wing	Tamarack Lake	18-0318-00		Lake	34	30	2008	DL
1540	633	574	Crow Wing	Terry Lake	18-0162-00		Lake	102	55	2008	DL
1541	634	575	Crow Wing	Twentytwo Lake	18-0008-00		Lake	169	42	2008	DL
1542	635	576	Crow Wing	Twin Island Lake	18-0106-00		Lake	85	42	2008	DL
1543	636	577	Crow Wing	Unnamed (Blackies Slough)	18-0544-00		Lake	33	20	2008	DL
1544	637	578	Crow Wing	Unnamed (Lost Rice)	18-0228-00		Lake	157	80	2008	DL
1545	638	579	Crow Wing	Unnamed (Nokasippi R. Rice	18-0485-00		Lake	166	40	2008	DL
1546	639	580	Crow Wing	Unnamed (Total's Pothole)	18-0543-00		Lake	28	16	2008	DL
1547	548	489	Crow Wing	Unnamed Creek	07010104-67	18river_1	Stream			2007	DL
1548	640	581	Crow Wing	Unnamed Lake	18-0413-00		Lake	103	27	2008	DL
1549	641	582	Crow Wing	Unnamed Lake	18-0550-00		Lake	30	30	2008	DL
1550	642	583	Crow Wing	Upper Cullen Lake	18-0376-00		Lake	459	23	2007, 2008, MDNR APM	DL
1551	643	584	Crow Wing	Upper Dean Lake	18-0170-00		Lake	263	10	2008	DL

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1552	644	585	Crow Wing	Upper Hay Lake	18-0412-00		Lake	640	2	2008, MDNR APM	DL
1553	645	586	Crow Wing	Upper Mission Lake	18-0242-00		Lake	895	5	2008, MDNR APM	DL
1554	646	587	Crow Wing	Upper Whitefish Lake	18-0310-00		Lake	7969	50	20072008	DL
1555	647	588	Crow Wing	Velvet Lake	18-0284-00		Lake	167	2	2008	DL
1556	648	589	Crow Wing	Whipple Lake	18-0387-00		Lake	345	40	2008	DL
1557	649	590	Crow Wing	Whitefish Lake	18-0001-00		Lake	709	30	2008, MDNR APM	DL
1558	650	591	Crow Wing	Williams Lake	18-0024-00		Lake	47	3	2008	DL
1559	651	592	Crow Wing	Wilson Lake	18-0049-00		Lake	63	4	2008	DL
1560	652	593	Crow Wing	Wolf Lake	18-0112-00		Lake	218	25	2008	DL
1561	654	595	Douglas	Christina Lake	21-0375-00		Lake	3949		UofM/MPCA 2013, MDNR 2013	DL
1562	655	596	Douglas	Ida Lake	21-0123-00		Lake	4506		MDNR APM	DL
1563	656	597	Douglas	Ina Lake	21-0355-00		Lake	221		UofM/MPCA 2013	DL
1564	657	598	Douglas	Irene Lake	21-0076-00		Lake	691		MDNR APM	DL
1565	658	599	Douglas	Latoka Lake	21-0106-00		Lake	872		MDNR APM	DL
1566	659	600	Douglas	Long Prairie	07010108-50	S007-203				UofM/MPCA 2013	DL
1567	660	601	Douglas	Long Prairie	07010108-53	S007-204				UofM/MPCA 2013	DL
1568	661	602	Douglas	Louise Lake	21-0094-00		Lake	220		UofM/MPCA 2013,MDNR APM, MDNR 2013	DL
1569	662	603	Douglas	Mill Pond Lake	21-0034-00		Lake	48		UofM/MPCA 2013, MDNR 2013	DL
1570	663	604	Douglas	Miltona Lake	21-0083-00		Lake	5924		MDNR APM, MDNR 2013	DL
1571	664	605	Douglas	Taylor Lake	21-0105-00		Lake	98		MDNR APM	DL
1572	665	606	Douglas	Union Lake	21-0041-00		Lake	227		MDNR APM	DL
1573	666	607	Douglas	Unnamed Lake	21-0416-00		Lake	24		MCBS 2011 , south of Miltona Lake, MDNR 201	DL
1574	667	608	Freeborn	Spicer Lake	24-0045-00		Lake	125	100	2008	DL
1575	668	609	Freeborn	Trenton Lake	24-0049-00		Lake	184	18	2008	DL
1576	669	610	Goodhue	Sturgeon Lake	25-0017-01		Lake	830		2008, Restoration efforts underway	DL
1577	670	611	Houston	Blue Lake	28-0005-03		Lake	362		2008, see MDNR lake map veg.	DL
1578	671	612	Houston	Lawrence Lake	28-0005-01		Lake	142		2008, see USGS Long Term Resource Manageme	DL
1579	672	613	Houston	Miss. River backwater	28-0005-00	11HOUS044	Stream			MPCA_BioMon	DL
1580	673	614	Houston	Mississippi Pool 8 at Genoa	28-0005-99	S007-222	Stream			UofM/MPCA 2013	DL
1581	674	615	Houston	Mississippi Pool 8 at Reno Bo	28-0005-99	S007-556				UofM/MPCA 2013	DL
1582	675	616	Houston	Target Lake	28-0005-02		Lake	424		2008, see USGS Long Term Resource Manageme	DL
1583	676	617	Hubbard	Bass Lake 2	29-0132-00		Lake	21		MCBS 2011, MDNR 2013	DL
1584	677	618	Hubbard	Beden	29-0265-00		Lake	40		MCBS 2011, MDNR 2013	DL
1585	678	619	Hubbard	BelleTaine Lake	29-0146-00		Lake	1252		MDNR APM	DL
1586	679	620	Hubbard	Birch Creek	07010101-57	29r1	Stream			2008	DL
1587	2292		Hubbard	Clausens	29-0097-00		Lake	222		MDNR 2008	DL
1588	680	621	Hubbard	Crow Wing Lake	29-0116-00		Lake	47		2007, 2008	DL
1589	681	622	Hubbard	Crow Wing River	07010106-51	29river	Stream			2008	DL
1590	682	623	Hubbard	Deer Lake	29-0090-00		Lake	193		2008, MDNR APM	DL
1591	683	624	Hubbard	Duck Lake	29-0142-00		Lake	651		MDNR APM	DL
1592	684	625	Hubbard	Eagle Lake	29-0256-00		Lake	440	4	2008, MDNR APM	DL
1593	685	626	Hubbard	Eighth Crow Wing Lake	29-0072-00		Lake	493	1	2008, MDNR APM, MCBS 2011	DL
1594	686	627	Hubbard	Fifth Crow Wing Lake	29-0092-00		Lake	406	10	2007, 2008, MDNR APM, MCBS 2011	DL
1595	687	628	Hubbard	First Crow Wing Lake	29-0086-00		Lake	564	50	2008	DL
1596	688	629	Hubbard	First Crow Wing River	07010106-52	29river_1	Stream			2007	DL
1597	689	630	Hubbard	Fish Hook Lake	29-0242-00		Lake	1432		MDNR APM, MDNR 2013	DL
1598	690	631	Hubbard	Fishhook River	07010106-54	29r4	Stream			2008, MDNR APM	DL
1599	691	632	Hubbard	Fourth Crow Wing Lake	29-0078-00		Lake	523	130	2007, 2008, MDNR APM	DL
1600	692	633	Hubbard	Garfield Lake	29-0061-00		Lake	984	90	2007, 2008, MDNR APM	DL
1601	693	634	Hubbard	Hart Lake	29-0063-00		Lake	236	118	2007, 2008, MCBS 2011	DL
1602	1730	414	Hubbard	Hattie	29-0300-00		Lake	359		MDNR 2008	DL
1603	694	635	Hubbard	Hay Creek	07010106-61	29river_2	Stream			2007	DL
1604	695	636	Hubbard	Horseshoe Lake	29-0059-00		Lake	264		2008, MDNR APM, MCBS 2011	DL
1605	696	637	Hubbard	Island Lake	29-0254-00		Lake	522	60	2007, 2008, MDNR APM	DL
1606	697	638	Hubbard	Kabekona Lake	29-0075-00		Lake	2433		2007, 2008	DL
1607	698	639	Hubbard	Kabekona River	07010102-51	290075T2	Stream			2007, 2008	DL
1608	699	640	Hubbard	Lake Alice Lake	29-0286-00		Lake	150	15	2007, 2008	DL
1609	700	641	Hubbard	Lake George	29-0216-00		Lake	882	18	2007, 2008, MCBS 2011	DL
1610	701	642	Hubbard	Little Gulch Lake	29-0123-00		Lake	22		MCBS 2011, MDNR 2013	DL
1611	702	643	Hubbard	Little Sand Lake	29-0150-00		Lake	437		MDNR APM	DL
1612	703	644	Hubbard	Lower Bottle Lake	29-0180-00		Lake	712	10	2008	DL
1613	704	645	Hubbard	Lower Mud Lake	29-0267-00		Lake	30	30	2008	DL
1614	705	646	Hubbard	Mantrap Lake	29-0151-00		Lake	1770	200	2007, 2008	DL
1615	706	647	Hubbard	Mary Lake	29-0289-00		Lake	65		MCBS 2011, MDNR 2013	DL
1616	707	648	Hubbard	Mississippi River	07010101-92	29river_3	Stream			2007	DL
1617	710	651	Hubbard	Mud Lake	29-0065-00		Lake	68		MCBS 2011, MDNR 2013	DL
1618	709	650	Hubbard	Mud Lake	29-0119-00		Lake	146	30	2008	DL
1619	711	652	Hubbard	Necktie River	07010102-50	29r2	Stream			2007, 2008	DL
1620	712	653	Hubbard	Ninth Crow Wing Lake	29-0025-00		Lake	235		2008, MCBS 2011	DL
1621	713	654	Hubbard	Oak Lake	29-0060-00		Lake	58	1	2007, 2008	DL
1622	714	655	Hubbard	Plantagenet Lake	29-0156-00		Lake	2620		2008, MDNR APM	DL
1623	1742	426	Hubbard	Portage	29-0250-00		Lake	429		MDNR 2008	DL
1624	715	656	Hubbard	Potato Lake	29-0243-00		Lake	2239	30	MDNR APM, MCBS 2011	DL
1625	716	657	Hubbard	Rice Lake	29-0177-00		Lake	230	58	2007, 2008	DL
1626	717	658	Hubbard	Schoolcraft Lake	29-0215-00		Lake	176	35	2007, MCBS 20111	DL
1627	718	659	Hubbard	Second Crow Wing Lake	29-0085-00		Lake	228	5	2008	DL
1628	719	660	Hubbard	Seventh Crow Wing Lake	29-0091-00		Lake	251	10	2008, MCBS 2011	DL
1629	720	661	Hubbard	Shallow Lake	29-0089-00		Lake	295	9	2008	DL
1630	721	662	Hubbard	Shell River	07010106-68	29r5	Stream			2007, 2008	DL
1631	722	663	Hubbard	Shingobee Lake	29-0043-00		Lake	180		MCBS 2011, MDNR 2013	DL
1632	723	664	Hubbard	Sixth Crow Wing Lake	29-0093-00		Lake	358	5	2007, 2008, MCBS 2011	DL
1633	1744	428	Hubbard	Spring	29-0054-00		Lake	43		MDNR 2008	DL
1634	724	665	Hubbard	Spring Lake	29-0054-00		Lake	43		2007, 2008	DL
1635	1746	430	Hubbard	Tamarack	29-0094-00		Lake	36		MDNR 2008	DL
1636	725	666	Hubbard	Tenth Crow Wing Lake	29-0045-00		Lake	185	9	2008, MDNR APM	DL
1637	726	667	Hubbard	Third Crow Wing Lake	29-0077-00		Lake	636	40	2008, MDNR APM	DL
1638	727	668	Hubbard	Unnamed (Hay Creek) Lake	29-0554-00		Lake	38	20	2008	DL
1639	708	649	Hubbard	Unnamed Creek	07010106-72	29r3	Stream			2008	DL
1640	728	669	Hubbard	Upper Bottle Lake	29-0148-00		Lake	505	30	2007, 2008	DL
1641	729	670	Hubbard	Upper Mud Lake	29-0284-00		Lake	50	50	2008	DL
1642	1765	449	Hubbard	Upper Twin	29-0157-00		Lake	212	1	MDNR 2008	DL
1643	730	671	Isanti	German Lake	30-0100-00		Lake	340		2007, 2008	DL
1644	731	672	Isanti	Rice Creek	07030005-70	30river	Stream			2007	DL
1645	732	673	Isanti	Stanchfield Creek	07010207-51	13UM047				MPCA_BioMon	DL
1646	733	674	Isanti	Upper Rice Lake	30-0057-00		Lake	208	208	2008	DL
1647	734	675	Itasca	Ann Lake	31-0305-00		Lake	94	5	2008	DL
1648	335	676	Itasca	Aspen Lake	31-0690-00		Lake	86	5	2007, 2008	DL

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1649	336	677	Itasca	Bass Lake	31-0576-00		Lake	2844	427	2007, 2008, UofM/MPCA 2013	DL
1650	337	678	Itasca	Big Fork River	09030006-50	31r3	Stream			2007, 2008	DL
1651	338	679	Itasca	Big Sucker Lake	31-0124-00		Lake			UofM/MPCA 2013	DL
1652	339	680	Itasca	Birdseye Lake	31-0834-00		Lake	73	11	2008	DL
1653	340	681	Itasca	Blackberry Lake	31-0210-00		Lake	240	50	2007, 2008	DL
1654	341	682	Itasca	Blackwater Lake	31-0561-00		Lake	674	300	2007, 2008	DL
1655	342	683	Itasca	Blue Rock Lake	31-0919-00		Lake			MDNR APM	DL
1656	343	684	Itasca	Bluebill Lake	31-0265-00		Lake	144	14	2008	DL
1657	344	685	Itasca	Bosley Lake	31-0403-00		Lake	41	10	2008	DL
1658	345	686	Itasca	Bowstring Lake	31-0813-00		Lake	8900	1335	2007, 2008	DL
1659	346	687	Itasca	Bowstring River	09030006-55	S007-219	Stream			2008, UofM/MPCA 2013 (31r4)	DL
1660	347	688	Itasca	Buckman Lake	31-0272-00		Lake	222	33	2008	DL
1661	348	689	Itasca	Cameron Lake	31-0544-00		Lake	77	5	MDNR 2013	DL
1662	349	690	Itasca	Canoe Lake (Unnamed)	31-0519-00		Lake	52	5	MDNR 2013	DL
1663	350	691	Itasca	Clearwater Lake	31-0402-00		Lake	67	10	2008	DL
1664	351	692	Itasca	Coddington Lake	31-0883-00		Lake	70	18	2008	DL
1665	352	693	Itasca	Crescent Lake	31-0294-00		Lake	42	2	2008	DL
1666	353	694	Itasca	Crooked Lake	31-0203-00		Lake	80	12	2007, 2008	DL
1667	354	695	Itasca	Cut Foot Sioux Lake	31-0857-00		Lake	3222	322	2007, 2008	DL
1668	355	696	Itasca	Damon Lake	31-0944-00		Lake	53	20	2007, 2008	DL
1669	356	697	Itasca	Decker Lake	31-0934-00		Lake	292	58	2008	DL
1670	357	698	Itasca	Deer Lake	31-0334-00		Lake	1854		2007 - (listed as 31034400 in the harvester surv	DL
1671	358	699	Itasca	Dishpan Lake	31-0992-00		Lake	15	15	2008	DL
1672	359	700	Itasca	Dixon Lake	31-0921-00		Lake	666	67	2007, 2008	DL
1673	360	701	Itasca	Dora Lake	31-0882-00		Lake	477	89	2007, 2008	DL
1674	361	702	Itasca	Egg Lake	31-0817-00		Lake	118	11	2008	DL
1675	362	703	Itasca	Farley Lake	31-0902-00		Lake	33	5	2008	DL
1676	363	704	Itasca	First River Lake	31-0818-00		Lake	228	160	2007, 2008	DL
1677	364	705	Itasca	Fiske Lake	31-0918-00		Lake			MDNR APM	DL
1678	365	706	Itasca	Grass Lake	31-0727-00		Lake	117		2008, 1973 lake map - WR noted along south ar	DL
1679	366	707	Itasca	Gunny Sack Lake	31-0267-00		Lake	81	8	2008	DL
1680	367	708	Itasca	Hamrey Lake	31-0911-00		Lake	61	15	2008	DL
1681	368	709	Itasca	Hay Lake	31-0037-00		Lake	21		2008, UofM/MPCA 2013	DL
1682	369	710	Itasca	Helen Lake	31-0840-00		Lake	109	76	2008	DL
1683	370	711	Itasca	Herrigen Lake	31-0174-00		Lake	27	3	2008	DL
1684	371	712	Itasca	Hinken Creek	09030006-53	S007-207	Stream			UofM/MPCA 2013	DL
1685	372	713	Itasca	Hunters Lake	31-0450-00		Lake	162	16	2008	DL
1686	373	714	Itasca	Island Lake	31-0754-00		Lake	291	10	2008	DL
1687	374	715	Itasca	Kelly Lake	31-0291-00		Lake	31	19	2008	DL
1688	375	716	Itasca	Lawrence Lake	31-0231-00		Lake	382	19	2008, MDNR APM	DL
1689	735	717	Itasca	Leighton Lake	31-0032-00		Lake	242	12	2008	DL
1690	736	718	Itasca	Lillian Lake	31-0750-00		Lake	90	14	2008	DL
1691	737	719	Itasca	Little Ball Club Lake	31-0822-00		Lake	181	10	2008	DL
1692	738	720	Itasca	Little Cut Foot Sioux Lake	31-0852-00		Lake	1357	136	2008	DL
1693	739	721	Itasca	Little Drum Lake	31-0741-00		Lake	89	22	2008	DL
1694	740	722	Itasca	Little Island Lake	31-0179-00		Lake	26	3	2008	DL
1695	741	723	Itasca	Little Moose Lake	31-0610-00		Lake	234	12	2008	DL
1696	742	724	Itasca	Little Rice Lake	31-0716-00		Lake	157		2008, see 1976 MDNR lake map for WR location	DL
1697	743	725	Itasca	Little Spring Lake	31-0797-00		Lake	121	3	2008	DL
1698	744	726	Itasca	Little White Oak Lake	31-0740-00		Lake	493	25	2008	DL
1699	745	727	Itasca	Lost Lake	31-0900-00		Lake	26	5	2008	DL
1700	746	728	Itasca	Lower Pigeon Lake	31-0893-00		Lake	53	20	2008, MDNR APM	DL
1701	747	729	Itasca	Marble Lake	31-0271-00		Lake	155	20	2008	DL
1702	748	730	Itasca	Marie Lake	31-0507-00		Lake	51		2007	DL
1703	749	731	Itasca	Marie Lake	31-0937-00		Lake	45	10	2008	DL
1704	750	732	Itasca	Middle Pigeon Lake	31-0892-00		Lake	182	15	2008	DL
1705	751	733	Itasca	Mississippi River	07010101-75	31r6	Stream			2007, 2008, 2010, UofM/MPCA 2013, MDNR A	DL
1706	752	734	Itasca	Mississippi River above Clay	07010101-75	S007-163	Stream			UofM/MPCA 2013, MDNR APM	DL
1707	753	735	Itasca	Mississippi River below Clay	07010101-75	S006-923	Stream			UofM/MPCA 2013, MDNR APM	DL
1708	754	736	Itasca	Moose Lake	31-0242-00		Lake	70	10	MDNR 2013	DL
1709	755	737	Itasca	Morph Lake	31-0929-00		Lake	67	3	MDNR APM	DL
1710	756	738	Itasca	Mosomo Lake	31-0861-00		Lake	47	5	2008	DL
1711	757	739	Itasca	Mud Lake	31-0206-00		Lake	271	203	2008	DL
1712	758	740	Itasca	Munzer Lake	31-0360-00		Lake	108	3	2008	DL
1713	759	741	Itasca	Nagel Lake	31-0377-00		Lake	90	50	2008	DL
1714	760	742	Itasca	Natures Lake	31-0877-00		Lake	2885	2499	2007, 2008	DL
1715	761	743	Itasca	O'Donnell Lake	31-0303-00		Lake	47	10	2008	DL
1716	762	744	Itasca	Otter Lake	31-0301-00		Lake	117		2007, 2008	DL
1717	763	745	Itasca	Ox Hide Lake	31-0106-00		Lake	114		UofM/MPCA 2013	DL
1718	764	746	Itasca	Pigeon Dam Lake	31-0894-00		Lake	511	500	2008	DL
1719	765	747	Itasca	Pigeon River	07010101-60	31river_1	Stream			2007	DL
1720	766	748	Itasca	Pokegama Lake	31-0532-00		Lake	15600	100	2008, MDNR APM	DL
1721	767	749	Itasca	Popple River	09030006-51	S006-188	Stream			UofM/MPCA 2013	DL
1722	769	751	Itasca	Prairie Lake	31-0053-00		Lake	29	1	2007,2008, 2010	DL
1723	768	750	Itasca	Prairie Lake	31-0384-00		Lake	1167	45	2008	DL
1724	770	752	Itasca	Prairie River	07010103-50	S007-209	Stream			2007, 2008, UofM/MPCA 2013	DL
1725	771	753	Itasca	Rabbits Lake	31-0923-00		Lake	209	157	2008	DL
1726	772	754	Itasca	Raven Lake	31-0925-00		Lake	97	70	2008	DL
1727	773	755	Itasca	Rice Creek	09030006-63	31r1	Stream			2008	DL
1728	774	756	Itasca	Rice Lake	31-0201-00		Lake	115	6	2008	DL
1729	775	757	Itasca	Rice Lake	31-0315-00		Lake	37	15	2008	DL
1730	778	760	Itasca	Rice Lake	31-0707-00		Lake	24		2008, see MDNR lake map for WR locations	DL
1731	777	759	Itasca	Rice Lake	31-0717-00		Lake	959		2008, MCBS 2011	DL
1732	776	758	Itasca	Rice Lake	31-0876-00		Lake	911	729	2007, 2008	DL
1733	780	762	Itasca	Rice River	09030006-53	S006-208	Stream			UofM/MPCA 2013	DL
1734	779	761	Itasca	Rice River	09030006-54	31r2	Stream			2007, 2008	DL
1735	781	763	Itasca	Ruby Lake	31-0422-00		Lake	243	5	2008	DL
1736	782	764	Itasca	Sand Lake	31-0826-00		Lake	3391	50	2008	DL
1737	783	765	Itasca	Shallow Pond	31-0910-00		Lake	281	11	2008	DL
1738	784	766	Itasca	Simpson Lake	31-0867-00		Lake	35	5	2008	DL
1739	785	767	Itasca	Sioux Lake	31-0907-00		Lake	69	27	2008	DL
1740	786	768	Itasca	Skimmerhorn Lake	31-0939-00		Lake	30	6	2008	DL
1741	787	769	Itasca	Soneman Lake	31-0276-00		Lake	40	16	2008	DL
1742	788	770	Itasca	Spruce Lake	31-0347-00		Lake	58	58	2008	DL
1743	789	771	Itasca	Stevens	31-0718-00		Lake	224	11	2008	DL
1744	790	772	Itasca	Stone Axe Lake	31-0828-00		Lake	37	4	2008	DL
1745	791	773	Itasca	Swan Lake	31-0067-00		Lake	2472	50	2007, 2008, UofM/MPCA 2013, Smith_Lakes	DL

	A	B	C	D	E	F	G	H	I	J	K
1746	792	774	Itasca	Swan River	07010103-50	SwanR	Stream			Smith_Streams, (07010103-506)	DL
1747	793	775	Itasca	Third River	07010101-52	31river_2	Stream			2007	DL
1748	794	776	Itasca	Tuttle Lake	31-0821-00		Lake	56	16	2008	DL
1749	795	777	Itasca	Unnamed Lake	31-0066-00		Lake	23	3	2008	DL
1750	796	778	Itasca	Unnamed Lake	31-0204-00		Lake	28	3	2008	DL
1751	801	783	Itasca	Unnamed Lake	31-0288-00		Lake	27	4	MDNR 2013	DL
1752	797	779	Itasca	Unnamed Lake	31-0322-00		Lake	28	2	2008	DL
1753	798	780	Itasca	Unnamed Lake	31-0815-00		Lake	109	5	2008	DL
1754	799	781	Itasca	Unnamed Lake	31-0860-00		Lake	24	5	2008	DL
1755	800	782	Itasca	Unnamed Lake	31-0961-00		Lake	10	2	2008	DL
1756	802	784	Itasca	Upper Pigeon Lake	31-0908-00		Lake	86	10	2008	DL
1757	803	785	Itasca	Walters Lake	31-0298-00		Lake	120	18	2008	DL
1758	804	786	Itasca	Wart Lake	31-0859-00		Lake	14	5	2008	DL
1759	805	787	Itasca	White Fish Lake	31-0142-00		Lake	31	2	2008	DL
1760	806	788	Itasca	White Oak Lake	31-0776-00		Lake	905	271	2007, 2008	DL
1761	807	789	Itasca	Whitefish Lake	31-0843-00		Lake	493	10	2008	DL
1762	808	790	Itasca	Wilderness Lake	31-0901-00		Lake	26	4	2008	DL
1763	809	791	Itasca	Wolf Lake	31-0152-00		Lake	199	30	MDNR 2013	DL
1764	466	792	Kanabec	Ann Lake	33-0040-00		Lake	363	18	2007, 2008	DL
1765	470	796	Kanabec	Ann riparian wetland	0703004-511	Ann	Riparian wetland			MPCA_BioMon	DL
1766	467	793	Kanabec	Knife Lake	33-0028-00		Lake	1039		multi-year MDNR WR observations	DL
1767	468	794	Kanabec	Mud (Quamba) Lake	33-0015-00		Lake	226		multi-year MDNR WR observations	DL
1768	469	795	Kanabec	Rice Creek	07030004-57	33r5	Stream			2008	DL
1769	471	797	Kanabec	Unnamed Lake	33-0111-00		Lake	33	27	2008	DL
1770	472	798	Kandiyohi	Blaamyhre Lake	34-0345-00		Lake	121		2008, UofM/MPCA 2013	DL
1771	818	799	Kandiyohi	Depressional Wetland	34-0143-00	New London	Wetland			MPCA_BioMon	DL
1772	819	800	Kandiyohi	Glesne Lake	34-0352-00		Lake	205		2008, MCBS 2011	DL
1773	820	801	Kandiyohi	Glesne Slough (Unnamed) La	34-0353-00		Lake	16		UofM/MPCA 2013	DL
1774	821	802	Kandiyohi	Monongalia Lake	34-0158-00		Lake	2516		2008, UofM/MPCA 2013 seed stock lake	DL
1775	822	803	Kandiyohi	Ole Lake	34-0342-00		Lake	66		2008, MCBS 2011	DL
1776	823	804	Kandiyohi	Unnamed Lake	34-0611-00		Lake			UofM/MPCA 2013	DL
1777	824	805	Kandiyohi	Unnamed Wetland			Wetland	25		MPCA_BioMon	DL
1778	825	806	Koochiching	Nett Lake	36-0001-00		Lake	7369		2007, 2008	DL
1779	826	807	Koochiching	Rainy Lake	69-0694-00		Lake	24349		2007, 2008	DL
1780	827	808	Koochiching	Rat Root Lake	36-0006-00		Lake	734		2007, 2008	DL
1781	828	809	Koochiching	Tilson Creek	DNR	36r1	Stream	0		2007, 2008	DL
1782	829	810	Lake	August Lake	38-0691-00		Lake	228	9	MDNR 2013	DL
1783	830	811	Lake	Bald Eagle Lake	38-0637-00		Lake	1243		2008, 1854 List	DL
1784	831	812	Lake	Basswood Lake	38-0645-00		Lake	14610	485	2008, 1854 List	DL
1785	833	814	Lake	Bonga Lake	38-0762-00		Lake	138	138	2008, 1854 List	DL
1786	835	816	Lake	Camp East Creek	09030001-55	CECr	Stream			1854 List, T.60, R.10W, S.11,12 trib to Stony Rive	DL
1787	836	817	Lake	Campers Lake	38-0679-00		Lake	56	56	2007, 2008, 1854 List	DL
1788	837	818	Lake	Charity Lake	38-0055-00		Lake	26		2008, 1854 List	DL
1789	838	819	Lake	Christianson Lake	38-0750-00		Lake	158		2008, 1854 List	DL
1790	839	820	Lake	Clark Lake	38-0647-00		Lake	49		2007, 2008, 2010, 1854 List	DL
1791	840	821	Lake	Cloquet Lake	38-0539-00		Lake	176		2007, 2008, 2010, UofM/MPCA 2013, 1854 List	DL
1792	841	822	Lake	Cloquet River	04010202-50	38r1	Stream	0		2008, 1854 List	DL
1793	842	823	Lake	Comfort Lake	38-0290-00		Lake	42		2008, 1854 List, MCBS 2011	DL
1794	843	824	Lake	Cougar Lake	38-0767-00		Lake	71	1	2008, 1854 List	DL
1795	844	825	Lake	Cramer Homestead Lake	38-0246-00		Lake	26		1854 List, MDNR 2013	DL
1796	845	826	Lake	Cramer Lake	38-0014-00		Lake	69	55	2007, 2008, 1854 List	DL
1797	846	827	Lake	Crooked Lake	38-0024-00		Lake	272		2008, 1854 List	DL
1798	847	828	Lake	Crooked Lake	38-0817-00		Lake	5229		2008, 1854 List	DL
1799	848	829	Lake	Cross River Lake	38-0002-00		Lake	75	1	1854 List, MDNR 2013	DL
1800	849	830	Lake	Crown Lake	38-0419-00		Lake	69		2008, 1854 List	DL
1801	850	831	Lake	Driller Lake	38-0652-00		Lake	24		2008, 1854 List	DL
1802	851	832	Lake	Dumbbell Lake	38-0393-00		Lake	476	48	2008, 1854 List	DL
1803	852	833	Lake	Dumbbell River	09030001-63	14RN089	Stream			MPCA_BioMon	DL
1804	853	834	Lake	Dumbbell River Pool	38-0270-00		Lake	13		1854 List, MDNR 2013	DL
1805	854	835	Lake	Dunnigan Lake	38-0664-00		Lake	81		1854 List	DL
1806	855	836	Lake	Eighteen Lake	38-0432-00		Lake	102		1854 List, MDNR 2013	DL
1807	856	837	Lake	Ella Hall Lake	38-0727-00		Lake	372	1	2008, 1854 List	DL
1808	857	838	Lake	Fall Lake	38-0811-00		Lake	2322	23	2008, 1854 List	DL
1809	858	839	Lake	Farm Lake	38-0779-00		Lake	1292		2007, 2008, 2010, 1854 List	DL
1810	859	840	Lake	Flat Horn Lake	38-0568-00		Lake	52		2008, 1854 List, MCBS 2011	DL
1811	860	841	Lake	Fools Lake	38-0761-00		Lake	14	14	2008, 1854 List	DL
1812	861	842	Lake	Gabbro Lake	38-0701-00		Lake	927		2008, 1854 List	DL
1813	862	843	Lake	Garden Lake	38-0782-00		Lake	4236	212	2007, 2008, 1854 List	DL
1814	863	844	Lake	Gegoka Lake	38-0573-00		Lake	174	14	2007, 2008, MCBS 2011, 1854 List	DL
1815	864	845	Lake	Grass Lake	38-0635-00		Lake	24	1	MDNR 2013	DL
1816	865	846	Lake	Green Wing Lake	38-0264-00		Lake	34		1854 List, MDNR 2013	DL
1817	866	847	Lake	Greenwood Lake	38-0656-00		Lake	1469	15	2007, 2008, 1854 List, MCBS 2011	DL
1818	867	848	Lake	Grouse Lake	38-0557-00		Lake	149		1854 List, MDNR 2013	DL
1819	868	849	Lake	Harriet Lake	38-0048-00		Lake	265	53	MDNR 2013, 1854 List	DL
1820	869	850	Lake	Harris Lake	38-0736-00		Lake	121	18	2008, 1854 List	DL
1821	870	851	Lake	Hjalmer Lake	38-0758-00		Lake	109	2	2008, 1854 List	DL
1822	871	852	Lake	Hoist Creek	04010101-D8	HCr	Stream			1854 List	DL
1823	872	853	Lake	Hoist Lake	38-0251-00		Lake	117		2007, 2008, 2010, 1854 List	DL
1824	873	854	Lake	Horse River	09030001-71	38r5	Stream	0		2008, 1854 List, T.65, R. 11W, S.14,22,23,27,28	DL
1825	874	855	Lake	Hula Lake	38-0728-00		Lake	121	121	2007, 2008, 1854 List	DL
1826	875	856	Lake	Isabella Lake	38-0396-00		Lake	1318		2008, 1854 List	DL
1827	876	857	Lake	Isabella River	09030001-52	38r4	Stream			2008, 1854 List	DL
1828	877	858	Lake	Island River Lake	38-0289-00		Lake	148		MCBS 2011, MDNR 2013	DL
1829	878	859	Lake	Island River Lake	38-0842-00		Lake	49	49	2007, 1854 List T. 61N, R. 7 & 8W (T.61, R.8, S.	DL
1830	879	860	Lake	Kawishiwi Lake	38-0080-00		Lake	468		2008, 1854 List	DL
1831	880	861	Lake	Kawishiwi River	09030001-51	38r2	Stream	0		2008, 1854 List	DL
1832	881	862	Lake	Kitigan Lake	38-0559-00		Lake	84		1854 List, MDNR 2013	DL
1833	882	863	Lake	Kowalski Lake	38-0016-00		Lake	13	1	MDNR 2013 (near north side of G. H. Crosby Ma	DL
1834	883	864	Lake	Langley Lake	38-0648-00		Lake	14		1854 List	DL
1835	884	865	Lake	Lax Lake	38-0406-00		Lake	273		1854 List, MDNR 2013	DL
1836	885	866	Lake	Legler Lake	38-0649-00		Lake	51		1854 List, MDNR 2013	DL
1837	886	867	Lake	Little Gabbro Lake	38-0703-00		Lake	151		2008, 1854 List	DL
1838	887	868	Lake	Little Wampus Lake	38-0684-00		Lake	16		2008, 1854 List	DL
1839	888	869	Lake	Lobo Lake	38-0766-00		Lake	132	99	2008, 1854 List	DL
1840	889	870	Lake	Manomin Lake	38-0616-00		Lake	455	23	2008	DL
1841	890	871	Lake	Middle McDougal Lake	38-0658-00		Lake	104		2007, 2008, 2010, 1854 List	DL
1842	891	872	Lake	Moose Lake	38-0036-00		Lake	201		2008, 1854 List	DL

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1843	892	873	Lake	Moose Lake	38-0644-00		Lake	1300		1854 List, MDNR 2013	DL
1844	893	874	Lake	Mud Lake	38-0742-00		Lake	164		2008, 1854 List	DL
1845	894	875	Lake	Muskeg Lake	38-0788-00		Lake	178	71	2008, 1854 List	DL
1846	895	876	Lake	Newton Lake	38-0784-00		Lake	516		2008, 1854 List	DL
1847	896	877	Lake	Nine A M Lake	38-0445-00		Lake	27	14	2008, 1854 List	DL
1848	897	878	Lake	North McDougal Lake	38-0686-00		Lake	273		2008, 1854 List	DL
1849	898	879	Lake	Osier Lake	38-0420-00		Lake	72	28	MDNR 2013, 1854 List	DL
1850	899	880	Lake	Papoose Lake	38-0818-00		Lake	54	3	2008, 1854 List	DL
1851	900	881	Lake	Pea Soup Lake	38-0739-00		Lake	13		MDNR APM	DL
1852	901	882	Lake	Perent Lake	38-0220-00		Lake	1598		1854 List, MDNR 2013	DL
1853	902	883	Lake	Phantom Lake	38-0653-00		Lake	70		2008, 1854 List	DL
1854	903	884	Lake	Polly Lake	38-0104-00		Lake	479		1854 List	DL
1855	904	885	Lake	Railroad Lake	38-0655-00		Lake	11	1	2008, 1854 List	DL
1856	905	886	Lake	Rat Lake	38-0567-00		Lake	10		1854 List, MDNR 2013	DL
1857	906	887	Lake	Rice Lake	38-0465-00		Lake	206	206	2008, 1854 List	DL
1858	907	888	Lake	Riparian, stream wetland	DNR	11LAKE149	Wetland			MPCA_BioMon	DL
1859	908	889	Lake	Roe Lake	38-0139-00		Lake	76		2008, 1854 List	DL
1860	910	891	Lake	Sand Lake	38-0735-00		Lake	506	51	2007, 2008, 1854 List	DL
1861	911	892	Lake	Sand River	PCA Verify	38r3	Stream			(2008, below Stony Lake)	DL
1862	912	893	Lake	Scarp Lake (Cliff)	38-0058-00		Lake	39		1854 List, MDNR 2013	DL
1863	913	894	Lake	Scott Lake	38-0271-00		Lake	52		2008, 1854 List	DL
1864	914	895	Lake	Silver Island Lake	38-0219-00		Lake	1239		2008, 1854 List	DL
1865	915	896	Lake	Sink Lake	38-0540-00		Lake			1854 List	DL
1866	916	897	Lake	Slate Lake	38-0666-00		Lake	293		2008, 1854 List	DL
1867	917	898	Lake	Snowbank Lake	38-0529-00		Lake	4819	50	2008, 1854 List	DL
1868	918	899	Lake	Sonju Lake	38-0248-00		Lake			1854 List	DL
1869	919	900	Lake	Source Lake	38-0654-00		Lake	35	1	2008, 1854 List	DL
1870	920	901	Lake	Sourdough Lake	38-0708-00		Lake	17	17	2008, 1854 List	DL
1871	921	902	Lake	South Farm Lake	38-0778-00		Lake	618		1854 List, MDNR 2013	DL
1872	922	903	Lake	South Kawishiwi River	09030001-60	SKR	Stream			1854 List	DL
1873	923	904	Lake	South McDougal Lake	38-0659-00		Lake	277	3	2008, 1854 List	DL
1874	924	905	Lake	South Wigwam Lake	38-0001-00		Lake	63		1854 List, MDNR 2013	DL
1875	925	906	Lake	Stony Lake	38-0660-00		Lake	409	245	2007, 2008, 1854 List	DL
1876	926	907	Lake	Stony River	09030001-51	38r6	Stream	0		2007, 2008, 1854 List	DL
1877	927	908	Lake	Surprise Lake	38-0550-00		Lake	38		1854 List, MDNR 2013	DL
1878	928	909	Lake	Swallow Lake (Shallow,Deep)	38-0668-00		Lake	147		1854 List	DL
1879	929	910	Lake	Sylvania Lake	38-0395-00		Lake	86		1854 List, MDNR 2013	DL
1880	930	911	Lake	Twentythree Lake	38-0247-00		Lake	52		1854 List, MDNR 2013	DL
1881	931	912	Lake	Unnamed (Scott) Creek	09030001-59	Scott	Stream			1854 List	DL
1882	932	913	Lake	Upland Lake	38-0756-00		Lake	74	1	2008, 1854 List	DL
1883	933	914	Lake	Vera Lake	38-0491-00		Lake	262		2008, 1854 List	DL
1884	934	915	Lake	Wampus Lake	38-0685-00		Lake	146		2008, 1854 List	DL
1885	935	916	Lake	Wind Lake	38-0642-00		Lake	952	10	2008	DL
1886	936	917	Lake	Wood Lake	38-0729-00		Lake	587	125	2008, 1854 List	DL
1887	937	918	Lake	Wye Lake	38-0042-00		Lake	55		1854 List, MDNR 2013	DL
1888	938	919	Lake of the Woo	Baudette River	09030008-53	39r2	Stream	0		2007, 2008	DL
1889	939	920	Lake of the Woo	Bostick Creek	09030009-53	39r1	Stream			2008	DL
1890	940	921	Lake of the Woo	Lake of the Woods	39-0002-00		Lake	3E+05		2007, 2008	DL
1891	941	922	Lake of the Woo	Rainy River	09030008-50	39r5	Stream	0		2007, 2008, 2010	DL
1892	942	923	Lake of the Woo	Roseau Flowage	39000900	39IMP001		200	100	2008, T.159, R.36, S.32	DL
1893	943	924	Lake of the Woo	Silver Creek	09030008-51	39r3	Stream	0		2007, 2008	DL
1894	944	925	Lake of the Woo	Winter Road River	09030008-50	39r4	Stream	0		2007, 2008, 2010	DL
1895	945	926	Mahnomen	Depressional Wetland	44005400	07Mahn175	Wetland			MPCA_BioMon	DL
1896	946	927	Mahnomen	Depressional Wetland	DNR	09Mahn139	wetland			MPCA_BioMon	DL
1897	947	928	Mahnomen	Lone Long Lake	44-0002-00		Lake	117		2007, 2008, MCBS 2011	DL
1898	948	929	Mahnomen	McCraney Lake	44-0080-00		Lake	277		MDNR APM, MDNR 2013	DL
1899	949	930	Mahnomen	Roy Lake	44-0001-00		Lake	689		MCBS 2011, Aquatic Veg. Reports 2011, 2014	DL
1900	950	931	Mahnomen	Wild Rice River	09020108-51	14RD030	Stream			MPCA_BioMon	DL
1901	951	932	Mahnomen	Wild Rice River	09020108-51	14RD004	Stream			MPCA_BioMon	DL
1902	952	933	Mcleod	Depressional Wetland	DNR	05Mcle001	Wetland			MPCA_BioMon	DL
1903	953	934	Meeker	Evenson Lake	47-0118-00		Lake	130		MDNR APM	DL
1904	954	935	Meeker	Stella	47-0068-00		Lake	596		UofM/MPCA 2013, MDNR 2013	DL
1905	955	936	Mille Lacs	Dewitt Marsh Lake	48-0020-00		Lake	110	131	2008	DL
1906	956	937	Mille Lacs	Ernst Pool Lake	48-0036-00		Lake	300	200	2008	DL
1907	1965	649	Mille Lacs	Mille Lacs	48-0002-00		Lake	1E+05		MDNR 2013	DL
1908	957	938	Mille Lacs	Mille Lacs WMA, Headquarte	DNR	W9004009		500	13	2008	DL
1909	958	939	Mille Lacs	Mille Lacs WMA, Jones 1 Poo	DNR	W9004008		520	3	2008	DL
1910	960	941	Mille Lacs	Mille Lacs WMA, Olson Pool	DNR	W9004007		85	2	2008	DL
1911	961	942	Mille Lacs	Mille Lacs WMA, Townhall Po	DNR	W9004010		110	3	2008	DL
1912	959	940	Mille Lacs	MilleLacs WMA Korsness Poo	48-0035-00			54	35	2008	DL
1913	962	943	Mille Lacs	Ogechie Lake	48-0014-00		Lake	732		2008, MCBS 2011	DL
1914	963	944	Mille Lacs	Onamia Lake	48-0009-00		Lake	2250	1350	2007, 2008	DL
1915	964	945	Mille Lacs	Shakopee Lake	48-0012-00		Lake	771		2008, MCBS 2011	DL
1916	965	946	Mille Lacs	Unnamed (Pool 3)	48-0054-00		Lake	32	25	2008	DL
1917	966	947	Mille Lacs	Unnamed Lake	48-0043-00		Lake	60	10	2008	DL
1918	967	948	Mille Lacs	Unnamed Lake	48-0044-00		Lake	500		2008, Mille Lacs State WMA	DL
1919	968	949	Morrison	Alexander Lake	49-0079-00		Lake	2990		MDNR APM, MDNR 2013	DL
1920	969	950	Morrison	Coon Lake	49-0020-00		Lake	75	75	2008	DL
1921	970	951	Morrison	Fish Trap Lake	49-0137-00		Lake	1320		MDNR APM, MDNR 2013	DL
1922	971	952	Morrison	Hannah Lake	49-0014-00		Lake	109	27	2008	DL
1923	972	953	Morrison	Long Lake	49-0015-00		Lake	128	32	MDNR APM	DL
1924	973	954	Morrison	Long Prairie River	07010108-50	49river	Stream			2007	DL
1925	974	955	Morrison	Miller Lake	49-0051-00		Lake	39	9	2008	DL
1926	976	957	Morrison	Mud Lake	49-0027-00		Lake	23	9	2008, MDNR APM	DL
1927	975	956	Morrison	Mud Lake	49-0072-00		Lake	83	5	2008	DL
1928	977	958	Morrison	Peavy Lake	49-0005-00		Lake	140		2007, 2008	DL
1929	978	959	Morrison	Pelkey Lake	49-0030-00		Lake	113	10	2008	DL
1930	979	960	Morrison	Placid Lake	49-0080-00		Lake	537		2007, 2008	DL
1931	980	961	Morrison	Platte River	07010201-50	49r2	Stream			(RiceLake 49-0025-00 outlets to the Platte River	DL
1932	981	962	Morrison	Popple Lake	49-0033-00		Lake	153		2008, Popple Lake State WMA	DL
1933	982	963	Morrison	Rice Creek	07010201-61	49r1	Stream			2008, (connects Pelkey Lake 49-0003-00 with Ri	DL
1934	983	964	Morrison	Rice Lake	49-0025-00		Lake	323	250	2008	DL
1935	984	965	Morrison	Round Lake	49-0019-00		Lake	134	14	2008	DL
1936	985	966	Morrison	Shamineau Lake	49-0127-00		Lake	1453		MDNR APM, MDNR 2013	DL
1937	986	967	Morrison	Skunk Lake	49-0026-00		Lake	320	256	2008, MDNR APM	DL
1938	987	968	Morrison	Sullivan Lake	49-0016-00		Lake	1199	20	2008, MDNR APM	DL
1939	988	969	Morrison	Twelve Lake	49-0006-00		Lake	159	80	2008	DL

	A	B	C	D	E	F	G	H	I	J	K
1940	989	970	Otter Tail	Amor (Mud) Lake	56-0381-00		Lake	260		2008, MCBS 2011	DL
1941	990	971	Otter Tail	Beauty Shore Lake	56-0195-00		Lake	233		2008, MCBS 2011	DL
1942	991	972	Otter Tail	Big Pine Lake	56-0130-00		Lake	4726		MDNR APM	DL
1943	992	973	Otter Tail	Boedigheimer Lake	56-0212-00		Lake	169		MCBS 2011,MDNR 2013	DL
1944	993	974	Otter Tail	Bray Lake	56-0472-00		Lake	142		UofM/MPCA 2013, MDNR 2013	DL
1945	994	975	Otter Tail	Crystal Lake	56-0749-00		Lake	1412		MDNR APM	DL
1946	995	976	Otter Tail	Dead Lake	56-0383-00		Lake	7827		2008, MDNR APM	DL
1947	996	977	Otter Tail	Deer Lake	56-0298-00		Lake	468		MDNR APM, MDNR 2013	DL
1948	998	979	Otter Tail	Depressional Wetland	56-1554-00	Field	Wetland			MPCA_BioMon	DL
1949	997	978	Otter Tail	Depressional Wetland	DNR	07Otte140	Wetland			MPCA_BioMon	DL
1950	1992	676	Otter Tail	Duck	56-0925-00		Lake	41		MDNR 2008	DL
1951	999	980	Otter Tail	East Battle Lake	56-0138-00		Lake	1985		MDNR APM	DL
1952	1000	981	Otter Tail	East Leaf Lake	56-0116-02		Lake	423		MDNR APM, MDNR 2013	DL
1953	1038	1019	Otter Tail	East Loon Lake	56-0523-00		Lake	1073		MDNR APM, MDNR 2013	DL
1954	1001	982	Otter Tail	East Lost Lake	56-0378-00		Lake	505		MDNR APM, MDNR 2013	DL
1955	1002	983	Otter Tail	East Red River Lake	56-0573-00		Lake	292		2008, MPCA Lake Survey	DL
1956	1003	984	Otter Tail	Emma Lake	56-0194-00		Lake	473		2008, MCBS 2011	DL
1957	1004	985	Otter Tail	Fish Lake	56-0768-00		Lake			MDNR APM	DL
1958	1005	986	Otter Tail	Fogard Lake	56-0571-00		Lake			MDNR APM	DL
1959	1997	681	Otter Tail	Gourd	56-0139-00		Lake	986		MDNR 2008	DL
1960	1998	682	Otter Tail	Grass	56-0115-00		Lake	81		MDNR 2008	DL
1961	1006	987	Otter Tail	Head Lake	56-0213-00		Lake	499		2008, MDNR APM	DL
1962	1007	988	Otter Tail	Heilberger Lake	56-0695-00		Lake	212		MDNR APM, MDNR 2013	DL
1963	1008	989	Otter Tail	Hoffman Lake	56-1627-00		Lake	157		MDNR APM	DL
1964	1009	990	Otter Tail	Hoot Lake	56-0782-00		Lake	158		MDNR APM, MDNR 2013	DL
1965	1010	991	Otter Tail	Jim Lake	56-0364-00		Lake	100		MCBS 2011, MDNR 2013	DL
1966	1011	992	Otter Tail	Lake Sixteen	56-0100-00		Lake	107		2007, 2008, 2010	DL
1967	1012	993	Otter Tail	Lida North Lake	56-0747-01		Lake	73		MDNR APM, MDNR 2013	DL
1968	2004	688	Otter Tail	Long	56-0210-00		Lake	1098		MDNR 2008	DL
1969	1013	994	Otter Tail	Long Lake	56-0388-00		Lake	1400		MDNR APM	DL
1970	1014	995	Otter Tail	Long Lake	56-0784-00		Lake	746		MDNR APM	DL
1971	1015	996	Otter Tail	Maria Lake	56-0498-00		Lake	48	20	MDNR 2013	DL
1972	1016	997	Otter Tail	Marion Lake	56-0243-00		Lake	13845		MDNR APM	DL
1973	1017	998	Otter Tail	Middle Leaf Lake	56-0116-01		Lake	404		MDNR APM	DL
1974	2006	690	Otter Tail	Mud	56-0222-00		Lake	437		MDNR 2008	DL
1975	2013	697	Otter Tail	North Maple	56-0013-00		Lake	161		MDNR 2008	DL
1976	1018	999	Otter Tail	North Turtle Lake	56-0379-00		Lake	1603		MDNR APM	DL
1977	1019	1000	Otter Tail	Ottertail River	09020103-57	56r1	Stream	0		2007, 2008, 2010, MDNR APM	DL
1978	1020	1001	Otter Tail	Pelican Lake	56-0786-00		Lake	4314		MDNR APM, MDNR 2013	DL
1979	1021	1002	Otter Tail	Red River Lake	56-0711-00		Lake	330		MDNR APM, MDNR 2013	DL
1980	1023	1004	Otter Tail	Rice Lake	56-0211-00		Lake	263		2008, part of Rice-Boedigheimer Aquatic Manag	DL
1981	1022	1003	Otter Tail	Rice Lake	56-0363-00		Lake	350		2008, MCBS 2011	DL
1982	1024	1005	Otter Tail	Rose Lake	56-0360-00		Lake	1177		MDNR APM, MDNR 2013	DL
1983	1025	1006	Otter Tail	Rush Lake	56-0141-00		Lake	5340		2008, MDNR APM	DL
1984	1026	1007	Otter Tail	Scalp Lake	56-0358-00		Lake	244		MDNR APM, MDNR 2013	DL
1985	2027	711	Otter Tail	South Maple	56-0004-00		Lake	160		MDNR 2008	DL
1986	1027	1008	Otter Tail	South Turtle Lake	56-0377-00		Lake	743		MDNR APM, MDNR 2013	DL
1987	1028	1009	Otter Tail	Spitzer	56-0160-00		Lake	756		MDNR APM, MDNR 2013	DL
1988	1029	1010	Otter Tail	Stalker Lake	56-0437-00		Lake	1357		MDNR APM, MDNR 2013	DL
1989	1030	1011	Otter Tail	Star Lake	56-0385-00		Lake	4809		2007, 2008, 2010, MDNR APM	DL
1990	1031	1012	Otter Tail	Stuart	56-0191-00		Lake	747		MDNR APM	DL
1991	2031	715	Otter Tail	Tamarack	56-0192-00		Lake	440		MDNR 2008	DL
1992	2030	714	Otter Tail	Tamarack	56-0433-00		Lake	470		MDNR 2008	DL
1993	2036	720	Otter Tail	Unnamed	56-0927-00		Lake	35		MDNR 2008	DL
1994	1032	1013	Otter Tail	Unnamed (Cemetery) Lake	56-0024-00		Lake	45		MDNR APM	DL
1995	1033	1014	Otter Tail	Walker Lake	56-0310-00		Lake	694		MDNR APM	DL
1996	1034	1015	Otter Tail	West Battle Lake	56-0239-00		Lake	5565		2008, UofM/MPCA 2013	DL
1997	1035	1016	Otter Tail	West Leaf Lake	56-0114-00		Lake	729		MDNR APM, MDNR 2013	DL
1998	1036	1017	Otter Tail	West Lost Lake	56-0481-00		Lake	915		2008, MDNR APM	DL
1999	2049	733	Otter Tail	Wing River	56-0043-00		Lake	138		MDNR 2008	DL
2000	1037	1018	Otter Tail	Wright Lake	56-0783-00		Lake	69		MDNR APM	DL
2001	1039	1020	Pennington	Clearwater River	09020305-51	S002-121	Stream			UofM/MPCA 2013	DL
2002	2294		Pine	Cedar	58-0089-00		Lake	71		MDNR 2008	DL
2003	1040	1021	Pine	Crooked Lake	58-0026-00		Lake	94	85	2007, 2008	DL
2004	2053	737	Pine	Fox	58-0102-00		Lake	200		MDNR 2008	DL
2005	1041	1022	Pine	Grindstone River (SF)	07030003-51	96SC063	Stream			MPCA_BioMon	DL
2006	1042	1023	Pine	Hay Creek	07030001-51	58river	Stream			2007 (part of Hay Creek Flowage)	DL
2007	1043	1024	Pine	Hay Creek Flowage	58-0005-00		Lake	66	40	2008, 2010, UofM/MPCA 2013	DL
2008	1044	1025	Pine	Kettle River	07030003-50	58r2	Stream	0		2007, 2008	DL
2009	1045	1026	Pine	Little Island Lake	58-0061-00		Lake	36		1854 List, MDNR 2013	DL
2010	1046	1027	Pine	Little North Sturgeon Lake	58-0066-00		Lake	20		2008, 1854 List	DL
2011	2059	743	Pine	McCormick	58-0058-00		Lake	61		MDNR 2008	DL
2012	1047	1028	Pine	Mission Creek	07030004-54	S001-646	Stream			UofM/MPCA 2013	DL
2013	1048	1029	Pine	Moose Horn River	07030003-53	58r3	Stream	0		2007, 1854 List, 2010	DL
2014	1049	1030	Pine	Net Lake	58-0038-00		Lake	138		MDNR APM, 1854 List, MDNR 2013	DL
2015	1053	1034	Pine	Pokegama Creek (Pokegama	07030004-53	Yacht	Riparian wetland			MPCA_BioMon	DL
2016	1054	1035	Pine	Pokegama Creek (Pokegama	07030004-53	Yacht-B	Riparian, stream wetland			MPCA_BioMon	DL
2017	1050	1031	Pine	Pokegama Lake	58-0142-00	58r5	Lake	0		2007, 2008	DL
2018	1051	1032	Pine	Pokegama Lake	58-0142-00		Lake	1621	16	2008, MDNR APM	DL
2019	1052	1033	Pine	Riparian, stream wetland	07030001-54	09Pine142	Wetland			MPCA_BioMon	DL
2020	1055	1036	Pine	Snake River	07030004-58	58r4	Stream	0		2007	DL
2021	1056	1037	Pine	Snake River Bay	07030004-50	58000000				MDNR APM	DL
2022	1057	1038	Pine	Stanton Lake	58-0111-00		Lake	84	34	2008, MDNR APM	DL
2023	1058	1039	Pine	Willow River	07030003-50	58r1	Stream			2007, 2008	DL
2024	1059	1040	Polk	Bee Lake	60-0192-00		Lake	116		UofM/MPCA 2013, MDNR 2013	DL
2025	1060	1041	Polk	Eighteen Lake	60-0199-00		Lake	79		UofM/MPCA 2013, MDNR 2013	DL
2026	1061	1042	Polk	Hill River	09020305-53	14RD253	Stream			MPCA_BioMon	DL
2027	1062	1043	Polk	Poplar River	09020305-51	14RD218	Stream			MPCA_BioMon	DL
2028	1063	1044	Polk	Unnamed (Round) Lake	60-0721-00		Lake	9	2	2008	DL
2029	1064	1045	Pope	Grove Lake	61-0023-00		Lake	345		MDNR APM	DL
2030	1065	1046	Pope	Signalness Lake	61-0149-00		Lake	41		MDNR APM	DL
2031	2075	759	Pope	Westport	61-0029-00		Lake	209		MDNR 2013	DL
2032	1066	1047	Rice	Cedar Lake	66-0052-00		Lake	927	93	2008	DL
2033	1067	1048	Rice	Hatch Lake	66-0063-00		Lake	102	10	2008	DL
2034	1068	1049	Rice	Hunt Lake	66-0047-00		Lake	190	19	2008	DL
2035	1069	1050	Rice	Mud Lake	66-0054-00		Lake	269	54	2008	DL
2036	1070	1051	Rice	Weinberger Lake	66-0041-00		Lake	53	8	2008	DL

	A	B	C	D	E	F	G	H	I	J	K
2037	1071	1052	Rice	Willing Lake	66-0051-00		Lake	53	5	2008	DL
2038	1072	1053	Roseau	Bednar Impoundment	68-0150-00	68IMP002		240	40	2008, Impoundment on the East Branch Warroa	DL
2039	1073	1054	Roseau	Roseau River WMA - Pool 2	68-0006-00		Lake	4600	100	MDNR 2013	DL
2040	1074	1055	Roseau	Roseau River WMA - Pool 3	68-0007-00		Lake	3700	10	MDNR 2013	DL
2041	1075	1056	Scott	Blue Lake	70-0088-00		Lake	316	120	2008	DL
2042	1076	1057	Scott	Fisher Lake	70-0087-00		Lake	396	190	2008, UofM/MPCA 2013	DL
2043	1077	1058	Scott	Raven Stream W Branch	07020012-71	14MN132	Stream			MPCA_BioMon	DL
2044	1078	1059	Scott	Rice Lake	70-0025-00		Lake	328	160	2008	DL
2045	1079	1060	Sherburne	Big Mud Lake	71-0085-00		Lake	263	100	2008, UofM/MPCA 2013	DL
2046	1080	1061	Sherburne	Boyd Lake	71-0118-00		Lake	160	20	MDNR 2013	DL
2047	1081	1062	Sherburne	Buck Lake	DNR	71IMP007		30	26	2008	DL
2048	1082	1063	Sherburne	Jim Lake	71-0111-00		Lake	20	20	2008	DL
2049	1083	1064	Sherburne	Johnson Slough	71-0084-00		Lake	65	10	2008	DL
2050	1084	1065	Sherburne	Josephine Pool	71-0068-00		Lake	143	72	2008	DL
2051	2095	779	Sherburne	Long Pond	71-0036-00		Lake	82		MDNR 2008	DL
2052	1085	1066	Sherburne	Lower Roadside Lake	71-0376-00		Lake	8	7	2008	DL
2053	1086	1067	Sherburne	Muskrat Pool	71-0297-00	71IMP003		299	15	2008	DL
2054	1087	1068	Sherburne	Orrock Lake	71-0085-00	71IMP010		215	162	2008	DL
2055	1088	1069	Sherburne	Pool 1	DNR	71IMP001		2	2	2008	DL
2056	1089	1070	Sherburne	Pool 2	71008400	71IMP002		30	15	2008, T.34, R.27, S.6	DL
2057	1090	1071	Sherburne	Rice Lake	71-0142-00		Lake	187	2	2008	DL
2058	1091	1072	Sherburne	Schoolhouse Pool	DNR	71IMP009		225	90	2008	DL
2059	1092	1073	Sherburne	Unnamed Lake	71-0148-00		Lake	89		MDNR APM	DL
2060	1093	1074	Sherburne	Unnamed wetland	71-0154-00		Lake	49		MDNR APM	DL
2061	1094	1075	Sherburne	Unnamed wetland	71-0155-00		Lake	71		MDNR APM	DL
2062	1095	1076	Sherburne	Unnamed wetland	71-0216-00		Lake	8		MDNR APM	DL
2063	1096	1077	St. Louis	Alden Lake	69-0131-00		Lake	190		2008, 1854 List	DL
2064	1097	1078	St. Louis	Anchor Lake	69-0641-00		Lake	316	32	2008, 1854 List	DL
2065	1098	1079	St. Louis	Andy Lake	69-0618-00		Lake	15		1854 List, MDNR 2013	DL
2066	1099	1080	St. Louis	Angell Pool	DNR	W0889001		500	80	2008, part of the Canosia State WMA T.51, R.15	DL
2067	1101	1082	St. Louis	Balkan Lake	69-0860-00		Lake	36	2	2008	DL
2068	1102	1083	St. Louis	Bassett Lake	69-0041-00		Lake	436		1854 List, MDNR 2013	DL
2069	1103	1084	St. Louis	Bear Island River	09030001-60	69r8	Stream			2007, 2008, 1854 List	DL
2070	1104	1085	St. Louis	Bear Island River	09030001-66	14RN058	Stream			MPCA_BioMon	DL
2071	1105	1086	St. Louis	Bear Lake (Mudd)	69-0112-00		Lake	125	125	2008	DL
2072	1106	1087	St. Louis	Beartrap Lake	69-0089-00		Lake	131		2008, 1854 List	DL
2073	1107	1088	St. Louis	Beaver (Joker) Lake	69-0015-00		Lake	46	5	2008, 1854 List	DL
2074	1108	1089	St. Louis	Bezhik Creek	09030001-97	14RN036	Stream			MPCA_BioMon	DL
2075	1109	1090	St. Louis	Big Lake	69-0190-00		Lake	2049	20	2008, 1854 list	DL
2076	1110	1091	St. Louis	Big Rice Lake	69-0178-00		Lake	416	416	2008, 1854 List	DL
2077	1111	1092	St. Louis	Big Rice Lake	69-0669-00		Lake	2072	1700	2007, 2008, 1854 List	DL
2078	1112	1093	St. Louis	Birch Lake	69-0003-00		Lake	7628	381	2007, 2008, 1854 List, UofM/MPCA 2013	DL
2079	1113	1094	St. Louis	Black Lake	69-0740-00		Lake	118		2008, 1854 List	DL
2080	1114	1095	St. Louis	Blueberry Lake	69-0054-00		Lake	130	13	2008, 1854 List	DL
2081	1115	1096	St. Louis	Bootleg Lake	69-0452-00		Lake	352		2008, 1854 List	DL
2082	1117	1098	St. Louis	Bug Creek	04010201-54	BugCr	Stream			1854 List	DL
2083	1118	1099	St. Louis	Bug Lake (Whitchel)	69-0531-00		Lake	71	53	2008, 1854 List	DL
2084	1119	1100	St. Louis	Burntside Lake	69-0118-00		Lake	7314		2007, 2008, 2010, 1854 List	DL
2085	1120	1101	St. Louis	Burntside River	09030001-80	14RN051	Stream			MPCA_BioMon	DL
2086	1122	1103	St. Louis	Camp 97 Impoundment	69-0594-00		Lake	50		2008, 1854 List, MDNR APM	DL
2087	1123	1104	St. Louis	Camp Forty Creek	09030002-58	Camp40Cr	Stream			1854 List	DL
2088	1124	1105	St. Louis	Canary Lake	69-0055-00		Lake	22	1	2008, 1854 List	DL
2089	1125	1106	St. Louis	Caribou Lake	69-0489-00		Lake	569	3	2008, 1854 List	DL
2090	1126	1107	St. Louis	Cedar Island Lake	69-0568-00		Lake			1854 List	DL
2091	1127	1108	St. Louis	Comet Lake	69-0267-00		Lake	28		2008, 1854 List	DL
2092	1128	1109	St. Louis	Cranberry Lake	69-0147-00		Lake	69		2008, 1854 List	DL
2093	1129	1110	St. Louis	Crane Lake	69-0616-00		Lake	3396	600	2007, 2008, 1854 List	DL
2094	1130	1111	St. Louis	Day Brook	07010103-54	DayBr	Stream			HibbTac (multiple locations)	DL
2095	1132	1113	St. Louis	Dollar Lake	69-0534-00		Lake	51	51	2008, 1854 List	DL
2096	1133	1114	St. Louis	Duck Lake	69-0191-00		Lake	126		2008, 1854 List	DL
2097	1134	1115	St. Louis	Dunka River	09030001-51	DunkaR	Stream			1854 List	DL
2098	1135	1116	St. Louis	Eagles Nest 3 Lake	69-0285-03		Lake	1028		2008, 1854 List	DL
2099	1131	1112	St. Louis	East Robinson	69-0162-00	69IMP001	Lake	5		1854 List T.62, R.13, S.12	DL
2100	1136	1117	St. Louis	East Stone Lake	69-0638-00		Lake			2008, 1854 List	DL
2101	1137	1118	St. Louis	Echo Lake	69-0615-00		Lake	1139		2008, 1854 List	DL
2102	1138	1119	St. Louis	Echo River	09030002-53	EchoR	Stream			1854 List	DL
2103	1139	1120	St. Louis	Ed Shave Lake	69-0199-00		Lake	90		2008, 1854 List	DL
2104	1140	1121	St. Louis	Elbow River	09030002-60	ElbowR	Stream			MDNR 2015	DL
2105	1141	1122	St. Louis	Elliott Lake	69-0642-00		Lake	393	20	2008, 1854 List	DL
2106	1142	1123	St. Louis	Embarrass Lake	69-0496-00		Lake			1854 List,MPCA Lakes	DL
2107	1143	1124	St. Louis	Embarrass River	04010201-57	69r3	Stream	0		2007, 2008, 1854 List	DL
2108	1144	1125	St. Louis	Esquagama Lake	69-0565-00		Lake			1854 List	DL
2109	1145	1126	St. Louis	Fish Lake (east)	69-0491-00		Lake			1854 List, MDNR 2013	DL
2110	1146	1127	St. Louis	Fivemile Lake	69-0288-00		Lake	106	10	2008, 1854 List	DL
2111	1147	1128	St. Louis	Fourmile Lake	69-0281-00		Lake	86	1	2008, 1854 List	DL
2112	1148	1129	St. Louis	Fourth Lake	69-0573-00		Lake			1854 List	DL
2113	1149	1130	St. Louis	Gafvert Lake	69-0280-00		Lake	33	1	2008, 1854 List	DL
2114	1150	1131	St. Louis	Gill Lake	69-0667-00		Lake	18		2008, 1854 List	DL
2115	1151	1132	St. Louis	Grand Lake	69-0511-00		Lake	1742	10	2008, 1854 List	DL
2116	1152	1133	St. Louis	Grass Lake	69-0776-00		Lake	49	1	2008, 1854 List	DL
2117	1153	1134	St. Louis	Grassy Lake	69-0082-00		Lake	257		2008, 1854 List	DL
2118	1154	1135	St. Louis	Grassy Lake	69-0216-00		Lake	95		2008, 1854 list	DL
2119	1155	1136	St. Louis	Gull Lake	69-0092-00		Lake	196	20	2008, 1854 List	DL
2120	1156	1137	St. Louis	Hay Lake	69-0150-00		Lake	32	1	2008, 1854 List	DL
2121	1157	1138	St. Louis	Hay Lake	69-0417-00		Lake	82	45	2007, 2008, 1854 List	DL
2122	1158	1139	St. Louis	Hay Lake	69-0439-00		Lake	42	1	2008, 1854 List	DL
2123	1159	1140	St. Louis	Hay Lake	69-0441-00		Lake	47		2008, 1854 List	DL
2124	1160	1141	St. Louis	Hay Lake	69-0579-00		Lake	114	114	2008, 1854 List	DL
2125	1162	1143	St. Louis	Hockey Lake	69-0849-00		Lake	139	70	2007, 2008, 1854 List	DL
2126	1163	1144	St. Louis	Hoodoo Lake	69-0802-00		Lake	252	252	2007, 2008	DL
2127	1164	1145	St. Louis	Horseshoe Lake	69-0255-00		Lake	39	10	2008, 1854 List	DL
2128	1165	1146	St. Louis	Hush Lake	69-0988-00		Lake	14		1854 List	DL
2129	1166	1147	St. Louis	Indian Lake	69-0023-00		Lake	57		2008, 1854 List	DL
2130	1167	1148	St. Louis	Island Lake Reservoir	69-0372-00		Lake	8280		1854 List, MDNR 2013	DL
2131	1168	1149	St. Louis	Jeanette Lake	69-0456-00		Lake	612		2008, 1854 List	DL
2132	1169	1150	St. Louis	Johnson Lake	69-0117-00		Lake	473	24	2008, 1854 List	DL
2133	1170	1151	St. Louis	Kabustasa Lake (Rice)	69-0679-00		Lake	126		1854 List, MDNR 2013	DL

	A	B	C	D	E	F	G	H	I	J	K
2134	1171	1152	St. Louis	King Lake	69-0008-00		Lake	320	39	2008, 1854 List	DL
2135	1172	1153	St. Louis	Kingburg Lake	69-0771-00		Lake	19		1854 List, MDNR 2013	DL
2136	1173	1154	St. Louis	Knuckey (Mud) Lake	69-0800-00		Lake	71	18	2007, 2008	DL
2137	1174	1155	St. Louis	Kookoosh Lake	69-0009-00		Lake	17		1854 List	DL
2138	1175	1156	St. Louis	Kylen Lake	69-0034-00		Lake	16	2	2008, 1854 List	DL
2139	1176	1157	St. Louis	Lake George	69-0040-00		Lake	42		2007, 2008, 1854 List	DL
2140	1177	1158	St. Louis	Lapond Lake	69-0177-00		Lake	176	176	2008, 1854 List	DL
2141	1178	1159	St. Louis	Leeman Lake	69-0875-00		Lake	284	90	2008, 1854 List	DL
2142	1180	1161	St. Louis	Little Birch Lake	69-0271-00		Lake			2008, 1854 List	DL
2143	1181	1162	St. Louis	Little Cloquet River	04010202-59	69r6	Stream			2008, 1854 List	DL
2144	1182	1163	St. Louis	Little Indian Sioux River	09030001-64	69r7	Stream			2007, 2008, 2010, 1854 List	DL
2145	1184	1165	St. Louis	Little Rice Lake	69-0612-00		Lake	266	266	2007, 2008, UofM/MPCA 2013, 1854 List	DL
2146	1185	1166	St. Louis	Little Sandy Lake	69-0729-00		Lake	89	89	2008, Smith_Lakes, 1854 List	DL
2147	1186	1167	St. Louis	Little Stone Lake	69-0028-00		Lake	163		2007, 2008, 1854 List	DL
2148	1187	1168	St. Louis	Little Vermillion Lake	69-0608-00		Lake	558		2007, 2008, 1854 List	DL
2149	1188	1169	St. Louis	Low Lake	69-0070-00		Lake	353	71	2007, 2008, 1854 List	DL
2150	1189	1170	St. Louis	Lower Pauness Lake	69-0464-00		Lake	162	1	2008, 1854 List	DL
2151	1190	1171	St. Louis	Martin Lake	69-0768-00		Lake	71		2008, 1854 List	DL
2152	1191	1172	St. Louis	Mogie Lake	69-0391-00		Lake	16		1854 List, MDNR 2013	DL
2153	1193	1174	St. Louis	Moose Lake	69-0442-00		Lake	18		MDNR APM, MDNR 2013	DL
2154	1192	1173	St. Louis	Moose Lake	69-0798-00		Lake	82	62	2007, 2008, 1854 List	DL
2155	1194	1175	St. Louis	Moose River	09030001-54	69-river5	Stream	0		1854 List	DL
2156	1195	1176	St. Louis	Mud (Black Mallard) Lake	69-0047-00		Lake	49		2008, 1854 List	DL
2157	1196	1177	St. Louis	Mud Hen Lake	69-0494-00		Lake	165		2008, 1854 List	DL
2158	1197	1178	St. Louis	Mud Lake	69-0151-00		Lake	51		2008, 1854 List	DL
2159	1199	1180	St. Louis	Mud Lake	69-0652-00		Lake			1854 List	DL
2160	1198	1179	St. Louis	Mud Lake	69-0797-00		Lake	43	43	2008, 1854 List	DL
2161	1200	1181	St. Louis	Myrtle Lake	69-0749-00		Lake	876		2008, 1854 List	DL
2162	1201	1182	St. Louis	Nels Lake	69-0080-00		Lake	200	2	2008	DL
2163	1202	1183	St. Louis	Nichols Lake	69-0627-00		Lake	444	22	2008, 1854 List	DL
2164	1203	1184	St. Louis	Nina Moose River	09030001-65	69-river3	Stream			2007, 1854 List	DL
2165	1204	1185	St. Louis	One Pine Lake	69-0061-00		Lake	369	37	2008, 1854 List	DL
2166	1205	1186	St. Louis	Oriniack Lake	69-0587-00		Lake	748		2008, 1854 lList	DL
2167	1207	1188	St. Louis	Partridge River	04010201-55	S007-443	Stream			UofM/MPCA 2013, 1854 List	DL
2168	1208	1189	St. Louis	Partridge River	04010201-55	S007-513	Stream			UofM/MPCA 2013, 1854 List	DL
2169	1209	1190	St. Louis	Partridge River	04010201-552		Lake			MPCA Streams	DL
2170	1210	1191	St. Louis	Pelican Lake	69-0841-00		Lake	11944	119	2007, 2008	DL
2171	1211	1192	St. Louis	Pelican River	09030002-53	69river_	Stream			2007, 2008, MDNR 2015	DL
2172	1212	1193	St. Louis	Perch Lake	69-0688-00		Lake	79	32	2008, 1854 List	DL
2173	1213	1194	St. Louis	Petrel Creek	04010202-66	69r4	Stream	0		2007, 2008, 2010, 1854 List	DL
2174	1214	1195	St. Louis	Picket Lake	69-0079-00		Lake	78	7	2008, 1854 List	DL
2175	1215	1196	St. Louis	Pike River	09030002-50	S006-927	Stream			UofM/MPCA 2013	DL
2176	1216	1197	St. Louis	Pike River	09030002-50	69r1	Stream	0		2007, 2008, 2010, 1854 List	DL
2177	1217	1198	St. Louis	Pine Lake	69-0001-00		Lake	442		1854 List	DL
2178	1218	1199	St. Louis	Prairie Lake	69-0848-00		Lake	807	16	2008, 1854 List	DL
2179	473	1200	St. Louis	Prairie River	07010103-51	PrairieR	Stream			1854 List	DL
2180	474	1201	St. Louis	Rat (Jamer) Lake	69-0737-00		Lake	26		2008, 1854 List	DL
2181	476	1203	St. Louis	Rice Lake	69-0180-00		Lake	161		1854 List	DL
2182	475	1202	St. Louis	Rice Lake	69-0578-00		Lake	41	41	2008	DL
2183	477	1204	St. Louis	Rice Lake	69-0803-00		Lake	160		MDNR 2015	DL
2184	479	1206	St. Louis	Round Lake	69-0649-00		Lake	57		1854 List	DL
2185	480	1207	St. Louis	Ruth Lake	69-0014-00		Lake	47	9	2008, 1854 List	DL
2186	481	1208	St. Louis	Sand Lake	69-0736-00		Lake	792		MDNR 2013	DL
2187	482	1209	St. Louis	Sand River	09030002-50	S003-249	Stream			UofM/MPCA 2013	DL
2188	483	1210	St. Louis	Sand River	09030002-50	SandR	Stream			1854 List	DL
2189	810	1211	St. Louis	Sandy Lake	69-0730-00		Lake	121	121	2008, UofM/MPCA 2013, Smith_Lakes, 1854 Lis	DL
2190	811	1212	St. Louis	Second Creek	04010201-95	S007-220	Stream			UofM/MPCA 2013, 1854 List	DL
2191	812	1213	St. Louis	Second Creek	04010201-952		Stream			MPCA Streams	DL
2192	814	1215	St. Louis	Shannon Lake	69-0925-00		Lake	135	108	2007, 2008,	DL
2193	815	1216	St. Louis	Shannon River	09030005-60	69river_1	Stream			2007, 2008	DL
2194	816	1217	St. Louis	Shiver Creek Impoundment	0410201-A37	ShiverCrImp				1854 List	DL
2195	817	1218	St. Louis	Side Lake	69-0699-00		Lake	25	15	2008, 1854 List	DL
2196	1219	1219	St. Louis	Simian Lake	69-0619-00		Lake	81	5	2008, 1854 List	DL
2197	1220	1220	St. Louis	Sixmile Lake	69-0283-00		Lake	103		2008, 1854 List	DL
2198	1221	1221	St. Louis	Smith (Little Pequaywan) Lak	69-0111-00		Lake	220		1854 List	DL
2199	1222	1222	St. Louis	St. Louis Estuary	04010201-53	S007-444	Stream			UofM/MPCA 2013	DL
2200	1223	1223	St. Louis	St. Louis R.(FR 1060)	04010201-64	StLR_2	Stream			1854 List	DL
2201	1224	1224	St. Louis	St. Louis River	04010201-53	69r2	Stream			2007, 2008, 2010 headwaters, Norway Pt	DL
2202	1225	1225	St. Louis	St. Louis River (FR 790)	04010201-64	StLR_4	Stream			1854 List	DL
2203	1226	1226	St. Louis	St. Louis River (FR 791)	04010201-64	StLR_5	Stream			1854 List	DL
2204	1228	1228	St. Louis	St. Louis River (Norway Pt)	04010201-64	StLR_3	Stream			1854 List	DL
2205	1229	1229	St. Louis	St.Louis Estuary (2)	04010201-53	Tallas	Stream			1854 List	DL
2206	1234	1234	St. Louis	Sturgeon Lake	69-0939-01		Lake	1624		2008, UofM/MPCA 2013	DL
2207	1235	1235	St. Louis	Sturgeon Lake, Middle	69-0939-02		Lake	133		UofM/MPCA 2013	DL
2208	1233	1233	St. Louis	Sturgeon River	09030005-52	S004-870	Stream			UofM/MPCA 2013	DL
2209	1236	1236	St. Louis	Sullivan Lake	69-0246-00		Lake	36		1854 List, MDNR 2013	DL
2210	1237	1237	St. Louis	Sunset Lake	69-0764-00		Lake	309	6	2008, 1854 List	DL
2211	1238	1238	St. Louis	Susan Lake	69-0741-00		Lake	305		2008, 1854 List	DL
2212	1239	1239	St. Louis	Turpela Lake	69-0427-00		Lake	76	61	2008, UofM/MPCA 2013	DL
2213	1240	1240	St. Louis	Twin (East Twin) Lake	69-0163-00		Lake	224		2008, 1854 List	DL
2214	1241	1241	St. Louis	Twin Lake	69-0504-00		Lake	18	1	2008, 1854 List	DL
2215	1242	1242	St. Louis	Twin Lake	69-0695-00		Lake	115		2008, 1854 List	DL
2216	1243	1243	St. Louis	Twin Lakes (East Twin)	69-0174-00		Lake	140		1854 List, MDNR 2013	DL
2217	1244	1244	St. Louis	Unnamed (FDL2) Lake	69-1454-00		Lake			1854 List, MDNR 2013	DL
2218	1245	1245	St. Louis	Unnamed Lake	69-0634-00		Lake	101	20	2008, 1854 List	DL
2219	1246	1246	St. Louis	Upper Bug Lake	69-0406-00		Lake	23		2008, 1854 List	DL
2220	1247	1247	St. Louis	Upper Pauness Lake	69-0465-00		Lake	215	1	2008, 1854 List	DL
2221	1248	1248	St. Louis	Vang Lake	69-0876-00		Lake	126	3	2008, 1854 List	DL
2222	1249	1249	St. Louis	Vermilion River	09030002-53	69-river4	Stream			2007, 2008, MDNR 2013, MPCA_BioMon	DL
2223	1250	1250	St. Louis	Vermilion River Lake	69-0613-00		Lake	1125	562	2008, 1854 List	DL
2224	1251	1251	St. Louis	Vermillion (Rice Bay)	69-0378-00		Lake	49110	250	2008, 1854 List	DL
2225	1252	1252	St. Louis	Wabuse Lake	69-0408-00		Lake	64	51	2008, 1854 List	DL
2226	1253	1253	St. Louis	Wagon Wheel Lake	69-0735-00		Lake	11	6	2008, 1854 List	DL
2227	1254	1254	St. Louis	Washusk Number One Lake	69-0409-00		Lake	51	40	2008, 1854 List	DL
2228	1255	1255	St. Louis	Washusk Number Two Lake	69-0410-00		Lake	24		1854 List, MDNR 2013	DL
2229	1256	1256	St. Louis	White Iron Lake	69-0004-00		Lake	3238		2008, 1854 List	DL
2230	1257	1257	St. Louis	White Lake	69-0571-00		Lake	56		1854 List	DL

	A	B	C	D	E	F	G	H	I	J	K
2231	1258	1258	St. Louis	Wild Rice Reservoir	69-0371-00		Lake	2133	1	2008, UofM/MPCA 2013, 1854 List	DL
2232	1259	1259	St. Louis	Wolf Lake	69-0143-00		Lake	456		2008, UofM/MPCA 2013, MDNR APM, MCBS 20	DL
2233	1260	1260	St. Louis	Wynne Lake	69-0434-02		Lake	764		1854 List, MDNR 2013	DL
2234	1261	1261	Stearns	Beaver Lake	73-0023-00		Lake	158		MDNR APM	DL
2235	2293		Stearns	Cedar	73-0226-00		Lake	152		MDNR 2008	DL
2236	2172	856	Stearns	Crow	73-0279-00		Lake	461		MDNR 2008	DL
2237	2174	858	Stearns	Fish	73-0281-00		Lake	204		MDNR 2008	DL
2238	1262	1262	Stearns	Goodners Lake	73-0076-00		Lake	285		MDNR APM, MDNR 2013	DL
2239	1263	1263	Stearns	Grand Lake	73-0055-00		Lake	666		MDNR APM, MDNR 2013	DL
2240	2184	868	Stearns	Little Rice	73-0167-00		Lake	56		MDNR 2008	DL
2241	2187	871	Stearns	Lower Spunk	73-0123-00		Lake	269		MDNR 2008	DL
2242	1264	1264	Stearns	McCormic Lake	73-0273-00		Lake	211		2008, UofM/MPCA 2013	DL
2243	2189	873	Stearns	Middle Spunk	73-0128-00		Lake	242		MDNR 2008	DL
2244	1265	1265	Stearns	Ochotto Lake	73-0122-00		Lake	40		MDNR APM	DL
2245	1266	1266	Stearns	Padua Lake	73-0277-00		Lake	100		UofM/MPCA 2013	DL
2246	1267	1267	Stearns	Raymond Lake	73-0285-00		Lake	126		2008, UofM/MPCA 2013	DL
2247	1268	1268	Stearns	Restored Wedland	73-0077-00		Lake			MDNR APM	DL
2248	1269	1269	Stearns	South Twin Lake	73-0276-00		Lake	64	15	MDNR 2013	DL
2249	1270	1270	Stearns	Tamarack Lake	73-0278-00		Lake	470	235	2008	DL
2250	1271	1271	Stearns	Unnamed (Tower WMA)	73-0343-00		Lake	10	10	MDNR 2013	DL
2251	1272	1272	Stearns	Unnamed Lake	73-0274-00		Lake	127	100	MDNR 2013	DL
2252	1273	1273	Steele	Oak Glen Lake	74-0004-00		Lake	350	4	2008	DL
2253	1274	1274	Steele	Rice Lake	74-0001-00		Lake	697	467	2008, MDNR APM	DL
2254	1275	1275	Todd	Beauty Lake	77-0035-00		Lake	255		MDNR APMMDNR 2013	DL
2255	1276	1276	Todd	Beck Lake	77-0056-00		Lake	57	25	2008	DL
2256	1277	1277	Todd	Big Swan Lake	77-0023-00		Lake	918		UofM/MPCA 2013, MDNR APM, MDNR 2013	DL
2257	1278	1278	Todd	Cass County Lake	77-0004-00		Lake	25	18	2008	DL
2258	1279	1279	Todd	Charlotte Lake	77-0120-00		Lake	181		MDNR APM, MDNR 2013	DL
2259	1280	1280	Todd	Jaeger Lake	77-0075-00		Lake	46	28	2008	DL
2260	1281	1281	Todd	Little Birch Lake	77-0089-00		Lake	793		UofM/MPCA 2013, MDNR APM, MDNR 2013	DL
2261	1282	1282	Todd	Little Osakis Lake	77-0201-00		Lake	124		MDNR APM	DL
2262	1284	1284	Todd	Long Lake	77-0027-00		Lake	372		MDNR APM, MDNR 2013	DL
2263	1283	1283	Todd	Long Lake	77-0069-00		Lake	356	338	2007, 2008	DL
2264	1285	1285	Todd	Long Prairie River	07010108-50	77-river1	Stream			2007, UofM/MPCA 2013	DL
2265	1286	1286	Todd	Mud Lake	77-0087-00		Lake	398	318	2007, 2008	DL
2266	1287	1287	Todd	Rice Lake	77-0061-00		Lake	675	60	2008	DL
2267	1288	1288	Todd	Robbinson Pond	77-0378-00	77IMP001		60	30	2008,Location: T.131, S.32, S. 24	DL
2268	1289	1289	Todd	Rogers Lake	77-0073-00		Lake	185	130	2007, 2008	DL
2269	1290	1290	Todd	Turtle Creek	07010108-51	77-river2	Stream			2007	DL
2270	1291	1291	Todd	Turtle Lake	77-0088-00		Lake	124		MDNR APM	DL
2271	1292	1292	Todd	Twin Lake	77-0021-00		Lake	317	159	2008	DL
2272	1293	1293	Todd	Unnamed Lake	77-0176-00		Lake	40	2	2008	DL
2273	1294	1294	Todd	Unnamed Lake	77-0178-00		Lake	42	23	2008	DL
2274	1295	1295	Todd	West Nelson Lake	77-0005-00		Lake	84	70	2008	DL
2275	1296	1296	Wabasha	Maloney Lake	79-0001-03		Lake			UofM/MPCA 2013	DL
2276	1297	1297	Wabasha	Mississippi Pool 4/Robinson	79-0005-02		Lake			UofM/MPCA 2013	DL
2277	1298	1298	Wabasha	Unnamed Lake	DNR	W0580001		160	25	2008	DL
2278	1299	1299	Wadena	Blueberry Lake	80-0034-00		Lake	555	30	2008	DL
2279	1300	1300	Wadena	Burgen Lake	80-0018-00		Lake	92	86	2008	DL
2280	1301	1301	Wadena	Crow Wing River	07010106-51	81river	Stream			2007	DL
2281	1302	1302	Wadena	Finn Lake	80-0028-00		Lake	148	30	2008	DL
2282	1303	1303	Wadena	Granning Lake	80-0012-00		Lake	50	50	2008	DL
2283	1304	1304	Wadena	Lower Twin Lake	80-0030-00		Lake	267	5	2008, MCBS2011	DL
2284	1305	1305	Wadena	Round Lake	80-0019-00		Lake	58	58	2008	DL
2285	1306	1306	Wadena	Stocking Lake	80-0037-00		Lake	356		MDNR APM, MDNR 2013	DL
2286	1307	1307	Wadena	Strike Lake	80-0013-00		Lake	76	76	2008	DL
2287	1308	1308	Wadena	Unnamed Lake	80-0007-00		Lake	16	16	2008	DL
2288	1309	1309	Wadena	Yaeger Lake	80-0022-00		Lake	384	346	2008	DL
2289	1310	1310	Waseca	Lily Lake	81-0067-00		Lake	118		UofM/MPCA 2013, MDNR APM, MDNR 2013	DL
2290	1311	1311	Washington	Mud Lake	82-0168-00		Lake	230		MDNR APM, MDNR 2013	DL
2291	1312	1312	Washington	Rice Lake	82-0146-00		Lake	116		MDNR APM, MDNR 2013	DL
2292	2303		Wright	Cedar	86-0034-00		Lake	191		MDNR 2008	DL
2293	1313	1313	Wright	Clearwater Lake	86-0252-00		Lake	3704		MDNR APM	DL
2294	1314	1314	Wright	Sandy Lake	86-0224-00		Lake	118	150	2008	DL
2295	1315	1315	Wright	Sugar Lake	86-0233-00		Lake	1145		MDNR APM	DL
2296	1316	1316	Wright	Unnamed Lake	86-0231-00		Lake	18		UofM/MPCA 2013	DL
2297	486	427	Cook	Caribou Lake	16-0360-00		Lake	714	7	2008,1854 List	7050
2298	487	428	Cook	Christine Lake	16-0373-00		Lake	192	19	2008, 7050.0470, 1854 List	7050
2299	493	434	Cook	Fourmile Lake	16-0639-00		Lake	593	42	2008, 7050.0470, 1854 List	7050
2300	504	445	Cook	Marsh Lake	16-0488-00		Lake	62	31	2007, 2008, 7050.0470, 1854 List	7050
2301	506	447	Cook	Moore Lake	16-0489-00		Lake	64	48	2008, 7050.0470, 1854 List	7050
2302	509	450	Cook	Northern Light Lake	16-0089-00		Lake	443	133	2008, 7050.0470, 1854 List	7050
2303	516	457	Cook	Rice Lake	16-0453-00		Lake	230	92	2007, 2008, 7050.0470, 1854 List	7050
2304	524	465	Cook	Swamp River Reservoir	16-0901-00		Lake	165	153	2008, 7050.0470, 1854 List	7050
2305	533	474	Cook	White Pine Lake	16-0369-00		Lake	374		2008, 7050.0470, 1854 List	7050
2306	832	813	Lake	Bluebill Lake	38-0261-00		Lake	44	11	2008, 7050.0470, 1854 List	7050
2307	834	815	Lake	Cabin Lake	38-0260-00		Lake	71	55	2007, 2008, 7050.0470, 1854 List	7050
2308	909	890	Lake	Round Island Lake	38-0417-00		Lake	58	58	2007, 2008, 7050.0470, 1854 List	7050
2309	1100	1081	St. Louis	Artichoke Lake	69-0623-00		Lake	306		2008, 7050.0470, 1854 List	7050
2310	1116	1097	St. Louis	Breda Lake	69-0037-00		Lake	137	135	2007, 2008, 7050.0470, 1854 List	7050
2311	1121	1102	St. Louis	Butterball (Long) Lake	69-0044-00		Lake	442	400	2007, 2008, 7050.0470, 1854 List	7050
2312	1161	1142	St. Louis	Hay Lake	69-0435-00		Lake	78	78	2008, 7050.0470, 1854 List, MPCA Lakes, MDNR	7050
2313	1179	1160	St. Louis	Lieuna (Lieung) Lake	69-0123-00		Lake	476	10	2008, 7050.0470, 1854 List, MDNR APM	7050
2314	1206	1187	St. Louis	Papoose Lake	69-0024-00		Lake	16	16	2008, 7050.0470, 1854 List	7050
2315	478	1205	St. Louis	Round Lake	69-0048-00		Lake	336		2008, 7050.0470, 1854 List	7050
2316	813	1214	St. Louis	Seven Beaver Lake	69-0002-00		Lake	1508	1282	2007, 20008, 7050.0470, 1854 List	7050
2317	1227	1227	St. Louis	St. Louis River (hdwtrs)	04010201-63	StLR_1	Stream			7050.0470 (04010201-631), 1854 List	7050
2318	1230	1230	St. Louis	Stone (Tommila) Lake	69-0035-00		Lake	87	85	2008, 7050.0470, 1854 List	7050
2319	1232	1232	St. Louis	Stone Lake	69-0046-00		Lake	230	173	2007, 2008, 2010, 7050.0470, 1854 List, MCBS 2	7050
2320	1231	1231	St. Louis	Stone Lake	69-0686-00		Lake	160	24	2008, 7050.0470, 1854 List	7050

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**MPCA Wild Rice Waters database (July 19, 2016)**										**Received by Advisory Committee dated Jan. 25, 2017**		
2	Column L "STATUS_LIST" codes :												
3	"DL" = Draft List												
4	"II" = Insufficient Information												
5	"7050" = wild rice water currently in Minn. R. 7050.0470												
6					Secondary					MNDNR2008			
7	OBJECTID	Line_Number	COUNTYNAME	NAME	Name	MPCA_WID	ALT_SITE_ID	WB_Type	ACRES	ESTACRE	REFERENCE_SOURCE	STATUS_LIST	
8	2148	832	St. Louis	Sabin		69-0434-01		Lake			1854 List	II	
9	2334		Becker	Albertson		03-0266-00		Lake	73		MDNR 2008	II	
10	2305		Wright	Albion		86-0212-00		Lake	238		MDNR 2008	II	
11	2340		Brown	Altematt		08-0054-00		Lake			MDNR 2008	II	
12	2299		Stearns	Anna		73-0126-00		Lake	133		MDNR 2008	II	
13	2354		Scott	Artic		70-0085-00		Lake			MDNR 2008	II	
14	2335		Becker	Axberg		03-0660-00		Lake	47		MDNR 2008	II	
15	2336		Becker	Bass		03-0480-00		Lake	28		MDNR 2008	II	
16	1652	336	Crow Wing	Bass		18-0229-00		Lake	114	1	MDNR 2008	II	
17	2337		Becker	Bean		03-0411-00		Lake	19		MDNR 2008	II	
18	1318	2	Aitkin	Bear		01-0064-00		Lake	127	1	MDNR 2008	II	
19	1712	396	Freeborn	Bear		24-0028-00		Lake	1560		MDNR 2008	II	
20	2351		Kandiyohi	Bear		34-0148-00		Lake	128		MDNR 2008	II	
21	2306		Wright	Beaver Dam		86-0296-00		Lake	253		MDNR 2008	II	
22	2341		Clearwater	Berg		15-0025-00		Lake	50		MDNR 2008	II	
23	2353		Otter Tail	Berger		56-1149-00		Lake	190		MDNR 2008	II	
24	2352		Morrison	Bernhart		49-0135-00		Lake	39		MDNR 2008	II	
25	2296		Pine	Big Pine		58-0138-00		Lake	399		MDNR 2008	II	
26	2300		Stearns	Big Rice		73-0168-00		Lake	282		MDNR 2008	II	
27	2343		Dakota	Blackhawk		19-0059-00		Lake			MDNR 2008	II	
28	1533	217	Cass	Bluebill		11-0397-00		Lake	51	1	MDNR 2008	II	
29	2307		Wright	Butler		86-0198-00		Lake	131		MDNR 2008	II	
30	1657	341	Crow Wing	Butterfield		18-0231-00		Lake	225	1	MDNR 2008	II	
31	2308		Wright	Butternut		86-0253-00		Lake	203		MDNR 2008	II	
32	2345		Goodhue	Cannon River			25r2	Stream			MDNR 2008	II	
33	2331		Anoka	Carlos Avery - Pool 16			W9001016	Lake	67		MDNR 2008	II	
34	2332		Anoka	Carlos Avery - Pool 17			W9001017	Lake	185		MDNR 2008	II	
35	2333		Anoka	Carlos Avery - Pool 23			W9001023	Lake	1600		MDNR 2008	II	
36	1365	49	Anoka	Carlos Avery WMA Pool 15		DNR	W9001015		365	1	MDNR 2008	II	
37	1366	50	Anoka	Carlos Avery WMA Pool 6		02-0029-00	W9001006		200	1	MDNR 2008	II	
38	1658	342	Crow Wing	Carlson		18-0395-00		Lake	45	1	MDNR 2008	II	
39	2309		Wright	Carrigan		86-0097-00		Lake	162		MDNR 2008	II	
40	1697	381	Dakota	Chub		19-0020-00		Lake	301	1	MDNR 2008	II	
41	2301		Sherburne	Clitty		71-0116-00		Lake	56		MDNR 2008	II	
42	2355		St. Louis	Cloquet River			69r5	Stream			MDNR 2008	II	
43	2347		Itasca	Clubhouse		31-0540-00		Lake			MDNR 2008	II	
44	1661	345	Crow Wing	Cole		18-0127-00		Lake	114	1	MDNR 2008	II	
45	2348		Itasca	Cophenhagen		31-0539-00		Lake			MDNR 2008	II	
46	1972	656	Morrison	Crookneck		49-0133-00		Lake	200		MDNR 2008	II	
47	1535	219	Cass	Crow Wing River		07010106-72	11r3	Stream			MDNR 2008	II	
48	1391	75	Becker	Dahlberg		03-0577-00		Lake	77		MDNR 2008	II	
49	1990	674	Otter Tail	Davies		56-0311-00		Lake	69		MDNR 2008	II	
50	1537	221	Cass	Donkey (Little Mule)		11-0280-00		Lake	54		MDNR 2008	II	
51	2079	763	Rice	Dudley		66-0014-00		Lake	83		MDNR 2008	II	
52	1617	301	Clearwater	Duncan		15-0024-00		Lake	18		MDNR 2008	II	
53	1455	139	Beltrami	Dutchman		04-0067-00		Lake	171		MDNR 2008	II	
54	1368	52	Anoka	East Twin		02-0020-00		Lake	171	1	MDNR 2008	II	
55	1875	559	Kandiyohi	Eight		34-0146-00		Lake	89		MDNR 2008	II	
56	1725	409	Hubbard	Eleventh Crow Wing		29-0036-00		Lake	752		MDNR 2008	II	
57	1768	452	Isanti	Elizabeth		30-0083-00		Lake	323		MDNR 2008	II	
58	2173	857	Stearns	Fifth		73-0180-00		Lake	76		MDNR 2008	II	
59	2093	777	Sherburne	Fremont		71-0016-00		Lake	466		MDNR 2008	II	
60	2123	807	St. Louis	Gansey		69-0913-00		Lake	74		MDNR 2008	II	
61	1540	224	Cass	Gijik		11-0185-00		Lake	118	1	MDNR 2008	II	
62	2310		Wright	Gilchrist		86-0064-00		Lake	388		MDNR 2008	II	
63	1521	205	Brown	Gilman (Rice)		08-0035-00		Lake	164		MDNR 2008	II	
64	2311		Wright	Gonz		86-0019-00		Lake	152		MDNR 2008	II	
65	1607	291	Chisago	Goose		13-0083-00		Lake	710		MDNR 2008	II	
66	1371	55	Anoka	Grass		02-0092-00		Lake	12		MDNR 2008	II	
67	1370	54	Anoka	Grass		02-0113-00		Lake	36		MDNR 2008	II	
68	1464	148	Beltrami	Grass		04-0216-00		Lake	233		MDNR 2008	II	
69	1541	225	Cass	Grass		11-0090-00		Lake	16		MDNR 2008	II	
70	1542	226	Cass	Grass		11-0315-00		Lake	113		MDNR 2008	II	
71	1665	349	Crow Wing	Grass		18-0362-00		Lake	45	1	MDNR 2008	II	
72	1718	402	Hennepin	Grass		27-0080-00		Lake	326		MDNR 2008	II	
73	1717	401	Hennepin	Grass		27-0135-00		Lake	7		MDNR 2008	II	
74	1769	453	Isanti	Grass		30-0017-00		Lake	51		MDNR 2008	II	
75	1770	454	Isanti	Grass		30-0142-00		Lake	33		MDNR 2008	II	
76	1808	492	Itasca	Grass		31-0144-00		Lake	40		MDNR 2008	II	
77	1809	493	Itasca	Grass		31-0527-00		Lake	19		MDNR 2008	II	
78	1855	539	Kanabec	Grass		33-0013-00		Lake	24		MDNR 2008	II	
79	1948	632	McLeod	Grass		43-0013-00		Lake	62		MDNR 2008	II	
80	1939	623	Mahnomen	Grass		44-0047-00		Lake	22		MDNR 2008	II	
81	1999	683	Otter Tail	Grass		56-0717-00		Lake	72		MDNR 2008	II	
82	2000	684	Otter Tail	Grass		56-0723-00		Lake	37		MDNR 2008	II	
83	2055	739	Pine	Grass		58-0125-00		Lake	84		MDNR 2008	II	
84	2076	760	Ramsey	Grass		62-0074-00		Lake	139		MDNR 2008	II	
85	2175	859	Stearns	Grass		73-0294-00		Lake	157		MDNR 2008	II	
86	2239	923	Wright	Grass		86-0243-00		Lake	92		MDNR 2008	II	
87	2240	924	Wright	Grass		86-0257-00		Lake	2		MDNR 2008	II	
88	2176	860	Stearns	Gravel		73-0204-00		Lake	55		MDNR 2008	II	
89	1667	351	Crow Wing	Green		18-0233-00		Lake	14	1	MDNR 2008	II	
90	1398	82	Becker	Halverson		03-0412-00		Lake	18		MDNR 2008	II	
91	1327	11	Aitkin	Hammal		01-0161-00		Lake	376	1	MDNR 2008	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
92	1328	12	Aitkin	Hay		01-0059-00		Lake	133	1	MDNR 2008	II	
93	2204	888	Todd	Hayden		77-0080-00		Lake	253		MDNR 2008	II	
94	2179	863	Stearns	Henry		73-0160-00		Lake	62		MDNR 2008	II	
95	2178	862	Stearns	Henry		73-0237-00		Lake	191		MDNR 2008	II	
96	2312		Wright	Henshaw		86-0213-00		Lake	277		MDNR 2008	II	
97	1544	228	Cass	Hole-In-Bog		11-0197-00		Lake	76		MDNR 2008	II	
98	1466	150	Beltrami	Holland (Little Rice Pond)		04-0023-00		Lake	22		MDNR 2008	II	
99	1732	416	Hubbard	Holland-Lucy		29-0095-00		Lake	44		MDNR 2008	II	
100	1812	496	Itasca	Irene		31-0878-00		Lake	10	1	MDNR 2008	II	
101	1813	497	Itasca	Irma		31-0634-00		Lake	337		MDNR 2008	II	
102	2205	889	Todd	Jacobson		77-0143-00		Lake	40		MDNR 2008	II	
103	1330	14	Aitkin	Jenkins		01-0100-00		Lake	127	1	MDNR 2008	II	
104	2233	917	Wadena	Jim Cook		80-00027-02	80002700		238		MDNR 2008	II	
105	2081	765	Rice	Kelly		66-0015-00		Lake	62		MDNR 2008	II	
106	1856	540	Kanabec	Kent		33-0035-00		Lake	34		MDNR 2008	II	
107	2094	778	Sherburne	Kliever Marsh		71-0003-00		Lake	37		MDNR 2008	II	
108	1857	541	Kanabec	Knife		33-0028-00		Lake	1259		MDNR 2008	II	
109	1772	456	Isanti	Krone		30-0140-00		Lake	142		MDNR 2008	II	
110	2207	891	Todd	Lawrence		77-0083-00		Lake	172		MDNR 2008	II	
111	2346		Isanti	Lindgren		30-01444-00		Lake	75		MDNR 2008	II	
112	2183	867	Stearns	Linneman		73-0127-00		Lake	108		MDNR 2008	II	
113	1553	237	Cass	Little Boy		11-0369-00		Lake	71		MDNR 2008	II	
114	2209	893	Todd	Little Fishtrap		77-0074-00		Lake	51		MDNR 2008	II	
115	2003	687	Otter Tail	Little McDonald		56-0328-00		Lake	1506		MDNR 2008	II	
116	2210	894	Todd	Little Pine		77-0134-00		Lake	16		MDNR 2008	II	
117	2211	895	Todd	Little Pine (Little Rice)		77-0042-00		Lake	71		MDNR 2008	II	
118	1334	18	Aitkin	Little Prairie		01-0016-00		Lake	78	1	MDNR 2008	II	
119	1473	157	Beltrami	Little Rice		04-0170-00		Lake	72		MDNR 2008	II	
120	1734	418	Hubbard	Little Rice		29-0183-00		Lake	27	1	MDNR 2008	II	
121	2132	816	St. Louis	Little Rice		69-0180-00		Lake	161		MDNR 2008	II	
122	2212	896	Todd	Little Rice		77-0054-00		Lake	71		MDNR 2008	II	
123	1774	458	Isanti	Little Stanchfield		30-0044-00		Lake	155		MDNR 2008	II	
124	1735	419	Hubbard	Little Stony		29-0080-00		Lake	55		MDNR 2008	II	
125	1825	509	Itasca	Logging Slough (Stevens)		31-0708-00		Lake	232		MDNR 2008	II	
126	2313		Wright	Long		86-0194-00		Lake	255		MDNR 2008	II	
127	1975	659	Morrison	Longs		49-0104-00		Lake	60		MDNR 2008	II	
128	1736	420	Hubbard	Loon		29-0020-00		Lake	112		MDNR 2008	II	
129	1828	512	Itasca	Lost		31-0289-00		Lake	89		MDNR 2008	II	
130	2242	926	Wright	Louisa		86-0282-00		Lake	183		MDNR 2008	II	
131	1474	158	Beltrami	Lower Red		04-0035-02		Lake	2E+05		MDNR 2008	II	
132	2342		Clearwater	Lower Red		15-0202-00		Lake			MDNR 2008	II	
133	2096	780	Sherburne	Lundberg Slough		71-0109-00		Lake	50		MDNR 2008	II	
134	2338		Becker	Lyman WPA			03IMP003	Lake			MDNR 2008	II	
135	1564	248	Cass	Mad Dog		11-0193-00		Lake	27		MDNR 2008	II	
136	1976	660	Morrison	Madaline		49-0101-00		Lake	50		MDNR 2008	II	
137	1675	359	Crow Wing	Mahnomen		18-0126-00		Lake	238	1	MDNR 2008	II	
138	2243	927	Wright	Malardi		86-0112-00		Lake	149		MDNR 2008	II	
139	2314		Wright	Mallard Pass		86-0185-00		Lake	51		MDNR 2008	II	
140	1475	159	Beltrami	Manomin Creek		07010101-5	04r1	Stream			MDNR 2008	II	
141	2315		Wright	Maple		86-0197-00		Lake	82		MDNR 2008	II	
142	2316		Wright	Maple Unit		86-0157-00		Lake	177		MDNR 2008	II	
143	2317		Wright	Mary		86-0049-00		Lake	331		MDNR 2008	II	
144	1338	22	Aitkin	McKinney		01-0199-00		Lake	52		MDNR 2008	II	
145	1964	648	Mille Lacs	Mikkelson Pool		48-0035-00	W9004001				MDNR 2008	II	
146	2244	928	Wright	Millstone		86-0152-00		Lake	221		MDNR 2008	II	
147	2318		Wright	Mink		86-0229-00		Lake	304		MDNR 2008	II	
148	2344		Faribault	Minnesota		22-0033-00		Lake	1915		MDNR 2008	II	
149	1829	513	Itasca	Moose (Rice)		31-0121-00		Lake	108		MDNR 2008	II	
150	1339	23	Aitkin	Moulton		01-0212-00		Lake	282	1	MDNR 2008	II	
151	1415	99	Becker	Mud		03-0016-00		Lake	86		MDNR 2008	II	
152	1706	390	Douglas	Mud		21-0236-00		Lake	50		MDNR 2008	II	
153	1779	463	Isanti	Mud		30-0065-00		Lake	300		MDNR 2008	II	
154	1780	464	Isanti	Mud		30-0106-00		Lake	81		MDNR 2008	II	
155	1778	462	Isanti	Mud		30-0117-00		Lake	99		MDNR 2008	II	
156	1978	662	Morrison	Mud		49-0018-00		Lake	29		MDNR 2008	II	
157	1977	661	Morrison	Mud		49-0095-00		Lake	105		MDNR 2008	II	
158	2008	692	Otter Tail	Mud		56-0132-00		Lake	155		MDNR 2008	II	
159	2005	689	Otter Tail	Mud		56-1148-00		Lake	134		MDNR 2008	II	
160	2190	874	Stearns	Mud		73-0161-00		Lake	55		MDNR 2008	II	
161	2217	901	Todd	Mud		77-0070-00		Lake	219		MDNR 2008	II	
162	2319		Wright	Mud		86-0026-00		Lake	128		MDNR 2008	II	
163	2320		Wright	Mud		86-0219-00		Lake	66		MDNR 2008	II	
164	2009	693	Otter Tail	Mud (Amor)		56-0381-00		Lake	231		MDNR 2008	II	
165	1340	24	Aitkin	Mud (Grayling WMA)		01-0029-00		Lake	400	1	MDNR 2008	II	
166	2010	694	Otter Tail	Mud (McGowan)		56-0215-00		Lake	138		MDNR 2008	II	
167	2014	698	Otter Tail	North Rice		56-0349-00		Lake	103		MDNR 2008	II	
168	1781	465	Isanti	North Stanchfield		30-0143-00		Lake	153		MDNR 2008	II	
169	1739	423	Hubbard	Oelschlager Slough		29-0006-00		Lake	328		MDNR 2008	II	
170	1740	424	Hubbard	Paine		29-0217-00		Lake	258		MDNR 2008	II	
171	2297		Pine	Passenger		58-0076-00		Lake	75		MDNR 2008	II	
172	1941	625	Mahnomen	Peabody		DNR	44-wetld1				MDNR 2008	II	
173	1418	102	Becker	Pearl		03-0486-00		Lake	268		MDNR 2008	II	
174	2321		Wright	Pelican		86-0031-00		Lake	2793		MDNR 2008	II	
175	2220	904	Todd	Pendergast		77-0207-00		Lake	93		MDNR 2008	II	
176	2017	701	Otter Tail	Peterson		56-0471-00		Lake	141		MDNR 2008	II	
177	1567	251	Cass	Pickerel		11-0352-00		Lake	66		MDNR 2008	II	
178	2221	905	Todd	Pine Island		77-0077-00		Lake	156		MDNR 2008	II	
179	2349		Kanabec	Pomroy		33-0009-00		Lake	267		MDNR 2008	II	
180	2098	782	Sherburne	Pool 31		71-0187-00	71IMP011	Lake			MDNR 2008	II	
181	2082	766	Rice	Pooles		66-0046-00		Lake	182		MDNR 2008	II	
182	2322		Wright	Pools		86-0102-00		Lake	166		MDNR 2008	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
183	1832	516	Itasca	Pothole		31-0991-00		Lake	8		MDNR 2008	II	
184	2019	703	Otter Tail	Rankle		56-0935-00		Lake	57		MDNR 2008	II	
185	2146	830	St. Louis	Rat		69-0922-00		Lake	73		MDNR 2008	II	
186	2020	704	Otter Tail	Reed		56-0876-00		Lake	155		MDNR 2008	II	
187	1372	56	Anoka	Rice		02-0008-00		Lake	371		MDNR 2008	II	
188	1373	57	Anoka	Rice		02-0043-00		Lake	64	1	MDNR 2008	II	
189	1420	104	Becker	Rice		03-0173-00		Lake	37		MDNR 2008	II	
190	1421	105	Becker	Rice		03-0285-00		Lake	51		MDNR 2008	II	
191	1486	170	Beltrami	Rice		04-0250-00		Lake	124		MDNR 2008	II	
192	1519	203	Blue Earth	Rice		07-0059-00		Lake	255		MDNR 2008	II	
193	1711	395	Fillmore	Rice		07040008-58	23r1				MDNR 2008	II	
194	1526	210	Carver	Rice		10-0078-00		Lake	244		MDNR 2008	II	
195	1571	255	Cass	Rice		11-0138-00		Lake	55	1	MDNR 2008	II	
196	1710	394	Faribault	Rice		22-0007-00		Lake	266		MDNR 2008	II	
197	1709	393	Faribault	Rice		22-0075-00		Lake	976		MDNR 2008	II	
198	1721	405	Hennepin	Rice		27-0116-00		Lake	353		MDNR 2008	II	
199	1720	404	Hennepin	Rice		27-0132-00		Lake	294		MDNR 2008	II	
200	1783	467	Isanti	Rice		30-0018-00		Lake	42		MDNR 2008	II	
201	1834	518	Itasca	Rice		31-0942-00		Lake	39		MDNR 2008	II	
202	1859	543	Kanabec	Rice		33-0011-00		Lake	172		MDNR 2008	II	
203	1929	613	Le Sueur	Rice		40-0016-00		Lake	182		MDNR 2008	II	
204	1931	615	Le Sueur	Rice		40-0037-00		Lake	21		MDNR 2008	II	
205	1930	614	Le Sueur	Rice		40-0114-00		Lake	11		MDNR 2008	II	
206	1949	633	McLeod	Rice		43-0042-00		Lake	60		MDNR 2008	II	
207	1942	626	Mahnomen	Rice		44-0024-00		Lake	120		MDNR 2008	II	
208	1953	637	Meeker	Rice		47-0087-00		Lake	69		MDNR 2008	II	
209	1966	650	Mille Lacs	Rice		48-0010-00		Lake	512		MDNR 2008	II	
210	1984	668	Nicollet	Rice		52-0033-00		Lake	118		MDNR 2008	II	
211	2021	705	Otter Tail	Rice		56-0006-00		Lake	6		MDNR 2008	II	
212	2022	706	Otter Tail	Rice		56-0702-00		Lake	26		MDNR 2008	II	
213	2071	755	Pope	Rice		61-0069-00		Lake	191		MDNR 2008	II	
214	2083	767	Rice	Rice		66-0048-00		Lake	331		MDNR 2008	II	
215	2088	772	Scott	Rice		70-0001-00		Lake	55		MDNR 2008	II	
216	2089	773	Scott	Rice		70-0060-00		Lake	27		MDNR 2008	II	
217	2099	783	Sherburne	Rice		71-0015-00		Lake	11		MDNR 2008	II	
218	2100	784	Sherburne	Rice		71-0078-00		Lake	505		MDNR 2008	II	
219	2195	879	Stearns	Rice		73-0196-00		Lake	1568		MDNR 2008	II	
220	2222	906	Todd	Rice		77-0235-00		Lake	28		MDNR 2008	II	
221	2234	918	Wadena	Rice		80-0024-00		Lake	8		MDNR 2008	II	
222	2237	921	Waseca	Rice		81-0022-00		Lake	214		MDNR 2008	II	
223	2236	920	Waseca	Rice		81-0088-00		Lake	75		MDNR 2008	II	
224	2245	929	Wright	Rice		86-0002-00		Lake	57		MDNR 2008	II	
225	2246	930	Wright	Rice		86-0032-00		Lake	246		MDNR 2008	II	
226	2247	931	Wright	Rice		86-0164-00		Lake	93		MDNR 2008	II	
227	1932	616	LeSueur	Rice		DNR	40wtld1				MDNR 2008	II	
228	1861	545	Kanabec	Rice (Erickson)		33-0031-00		Lake	39		MDNR 2008	II	
229	1835	519	Itasca	Rice (Round)		31-0777-00		Lake	363		MDNR 2008	II	
230	1714	398	Goodhue	Rice Bottoms		07040002-50	25r1				MDNR 2008	II	
231	2101	785	Sherburne	Rice Creek		07010203-51	71-river1	Stream			MDNR 2008	II	
232	1374	58	Anoka	Rice Creek		07010206-58	02r1	Stream			MDNR 2008	II	
233	1520	204	Blue Earth	Rice Creek		07020011-53	07r1	Stream			MDNR 2008	II	
234	2077	761	Redwood	Rice Creek		DNR	64r1	Stream			MDNR 2008	II	
235	1527	211	Carver	Rice Marsh		10-0001-00		Lake	77		MDNR 2008	II	
236	2147	831	St. Louis	Rice River		09030005-51	69-river9	Stream			MDNR 2008	II	
237	1375	59	Anoka	Rondeau		02-0015-00		Lake	552		MDNR 2008	II	
238	1344	28	Aitkin	Round		01-0137-00		Lake	634	1	MDNR 2008	II	
239	1376	60	Anoka	Rum River		07010207-55	02r2	Stream			MDNR 2008	II	
240	1611	295	Chisago	Rush		13-0069-01	13006900		3170		MDNR 2008	II	
241	2298		Pine	Rush		58-0078-00		Lake	88		MDNR 2008	II	
242	2196	880	Stearns	Sagatagan		73-0092-00		Lake	170		MDNR 2008	II	
243	2150	834	St. Louis	Sand Point		69-0617-00		Lake	4848		MDNR 2008	II	
244	1943	627	Mahnomen	Sargent		44-0108-00		Lake	174		MDNR 2008	II	
245	2323		Wright	School		86-0025-00		Lake	76		MDNR 2008	II	
246	2324		Wright	School Section		86-0180-00		Lake	266		MDNR 2008	II	
247	2197	881	Stearns	Schultz Slough		73-0201-00		Lake	29		MDNR 2008	II	
248	1784	468	Isanti	Section		30-0060-00		Lake	130		MDNR 2008	II	
249	1967	651	Mille Lacs	Section 3 Pool		48-0043-00	W9004005				MDNR 2008	II	
250	2350		Lake	Sells		33-0018-00		Lake	64		MDNR 2008	II	
251	2325		Wright	Shakopee		86-0255-00		Lake	206		MDNR 2008	II	
252	2025	709	Otter Tail	Sharp		56-0482-00		Lake	160		MDNR 2008	II	
253	2357		Todd	Sheets		77-0122-00		Lake	100		MDNR 2008	II	
254	2356		St. Louis	Sioux River			69r9	Stream			MDNR 2008	II	
255	1347	31	Aitkin	Sixteen		01-0124-00		Lake	18	1	MDNR 2008	II	
256	1981	665	Morrison	Skunk		49-0007-00		Lake	32		MDNR 2008	II	
257	2249	933	Wright	Smith		86-0250-00		Lake	330		MDNR 2008	II	
258	2028	712	Otter Tail	South Rice		56-0352-00		Lake	121		MDNR 2008	II	
259	1785	469	Isanti	South Stanchfield		30-0138-00		Lake	433		MDNR 2008	II	
260	1348	32	Aitkin	Spectacle		01-0156-00		Lake	107	1	MDNR 2008	II	
261	1743	427	Hubbard	Spider		29-0117-00		Lake	593		MDNR 2008	II	
262	2326		Wright	Spring		86-0200-00		Lake	63		MDNR 2008	II	
263	1578	262	Cass	Stephens		11-0213-00		Lake	104	1	MDNR 2008	II	
264	2224	908	Todd	Stones		77-0081-00		Lake	63		MDNR 2008	II	
265	1351	35	Aitkin	Sugar		01-0084-00		Lake	23	1	MDNR 2008	II	
266	1350	34	Aitkin	Sugar		01-0087-00		Lake	416	1	MDNR 2008	II	
267	1745	429	Hubbard	Sunday		29-0144-00		Lake	62		MDNR 2008	II	
268	1624	308	Clearwater	Tamarack		15-0056-00		Lake	21		MDNR 2008	II	
269	1625	309	Clearwater	Tamarack		15-0136-00		Lake	115		MDNR 2008	II	
270	2327		Wright	Taylor		86-0204-00		Lake	78		MDNR 2008	II	
271	1584	268	Cass	Thirty-Six		11-0173-00		Lake	49	1	MDNR 2008	II	
272	1957	641	Meeker	Thoen (Grass)		47-0154-00		Lake	216		MDNR 2008	II	
273	2225	909	Todd	Thunder		77-0066-00		Lake	215		MDNR 2008	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
274	2106	790	Sibley	Titlow		72-0042-00		Lake	924		MDNR 2008	II	
275	2157	841	St. Louis	Trettel Pool		DNR	W0889002		30		MDNR 2008	II	
276	1747	431	Hubbard	Tripp		29-0005-00		Lake	155	1	MDNR 2008	II	
277	2226	910	Todd	Tucker		77-0139-00		Lake	43		MDNR 2008	II	
278	1588	272	Cass	Twin		11-0484-00		Lake	168		MDNR 2008	II	
279	1749	433	Hubbard	Twin		29-0293-00		Lake	7		MDNR 2008	II	
280	2159	843	St. Louis	Twin		69-0505-00		Lake	25		MDNR 2008	II	
281	1862	546	Kanabec	Twin or East		33-0019-00		Lake	27		MDNR 2008	II	
282	1788	472	Isanti	Typo		30-0009-00		Lake	273		MDNR 2008	II	
283	1357	41	Aitkin	Unnamed		01-0020-00		Lake	19	1	MDNR 2008	II	
284	1358	42	Aitkin	Unnamed		01-0262-00		Lake	14	1	MDNR 2008	II	
285	1431	115	Becker	Unnamed		03-0087-00		Lake	23		MDNR 2008	II	
286	1429	113	Becker	Unnamed		03-0140-00		Lake	43		MDNR 2008	II	
287	1433	117	Becker	Unnamed		03-0598-00		Lake	36		MDNR 2008	II	
288	1434	118	Becker	Unnamed		03-0599-00		Lake	34		MDNR 2008	II	
289	1432	116	Becker	Unnamed		03-0600-00		Lake	59		MDNR 2008	II	
290	1694	378	Crow Wing	Unnamed		18-0055-00		Lake	70	1	MDNR 2008	II	
291	1690	374	Crow Wing	Unnamed		18-0201-00		Lake	16	1	MDNR 2008	II	
292	1756	440	Hubbard	Unnamed		29-0019-00		Lake	15		MDNR 2008	II	
293	1750	434	Hubbard	Unnamed		29-0021-00		Lake	16		MDNR 2008	II	
294	1759	443	Hubbard	Unnamed		29-0084-00		Lake	87		MDNR 2008	II	
295	1755	439	Hubbard	Unnamed		29-0114-00		Lake	24		MDNR 2008	II	
296	1751	435	Hubbard	Unnamed		29-0115-00		Lake	16		MDNR 2008	II	
297	1752	436	Hubbard	Unnamed		29-0118-00		Lake	21		MDNR 2008	II	
298	1757	441	Hubbard	Unnamed		29-0158-00		Lake	60		MDNR 2008	II	
299	1753	437	Hubbard	Unnamed		29-0179-00		Lake	16		MDNR 2008	II	
300	1758	442	Hubbard	Unnamed		29-0263-00		Lake	20		MDNR 2008	II	
301	1863	547	Kanabec	Unnamed		33-0029-00		Lake	21		MDNR 2008	II	
302	1887	571	Kandiyohi	Unnamed		34-0236-00		Lake	117		MDNR 2008	II	
303	2038	722	Otter Tail	Unnamed		56-0198-00		Lake	69		MDNR 2008	II	
304	2035	719	Otter Tail	Unnamed		56-0284-00		Lake	83		MDNR 2008	II	
305	2044	728	Otter Tail	Unnamed		56-1259-00		Lake	12		MDNR 2008	II	
306	2042	726	Otter Tail	Unnamed		56-1273-00		Lake	126		MDNR 2008	II	
307	2034	718	Otter Tail	Unnamed		56-1517-00		Lake	23		MDNR 2008	II	
308	2045	729	Otter Tail	Unnamed		56-1550-00		Lake	14		MDNR 2008	II	
309	2043	727	Otter Tail	Unnamed		56-1578-00		Lake	29		MDNR 2008	II	
310	2084	768	Rice	Unnamed		66-0103-00		Lake	26		MDNR 2008	II	
311	2160	844	St. Louis	Unnamed		69-0640-00		Lake	10		MDNR 2008	II	
312	2302		Sherburne	Unnamed		71-0025-00		Lake	31		MDNR 2008	II	
313	2229	913	Todd	Unnamed		77-0140-00		Lake	61		MDNR 2008	II	
314	2227	911	Todd	Unnamed		77-0197-00		Lake	53		MDNR 2008	II	
315	2358		Todd	Unnamed		77-0202-00		Lake	70		MDNR 2008	II	
316	2232	916	Wabasha	Unnamed		79-0012-00		Lake	8		MDNR 2008	II	
317	2250	934	Wright	Unnamed		86-0258-00		Lake	18		MDNR 2008	II	
318	1761	445	Hubbard	Unnamed (Boubora)		29-0082-00		Lake	48	1	MDNR 2008	II	
319	1865	549	Kanabec	Unnamed (Jones)		33-0012-00		Lake	11		MDNR 2008	II	
320	1595	279	Cass	Unnamed (MPL)		11-0777-00		Lake	40		MDNR 2008	II	
321	2046	730	Otter Tail	Unnamed (Nycklemoe)		56-1083-00		Lake	198		MDNR 2008	II	
322	1589	273	Cass	Unnamed (Rice Swamp)		11-0698-00		Lake	11		MDNR 2008	II	
323	1355	39	Aitkin	Unnamed (Rice)		01-0419-00		Lake	16	1	MDNR 2008	II	
324	1596	280	Cass	Unnamed (Rice)		11-0615-00		Lake	11		MDNR 2008	II	
325	1762	446	Hubbard	Unnamed (Thirteen)		29-0079-00		Lake	38		MDNR 2008	II	
326	1866	550	Kanabec	Unnamed (Twin)		33-0014-00		Lake	30		MDNR 2008	II	
327	1763	447	Hubbard	Unnamed (Waboose #1)		29-0099-00		Lake	26		MDNR 2008	II	
328	1864	548	Kanabec	Unnamed (WL Imp Pool 1)		33-0072-00		Lake	31	1	MDNR 2008	II	
329	1764	448	Hubbard	Upper Bass		29-0034-00		Lake	30		MDNR 2008	II	
330	1597	281	Cass	Upper Loon		11-0225-00		Lake	114		MDNR 2008	II	
331	1511	195	Beltrami	Upper Red		04-0035-01	4003500		1E+05		MDNR 2008	II	
332	2105	789	Sherburne	Upper Roadside		71-0375-00	71IMP005				MDNR 2008	II	
333	1969	653	Mille Lacs	West Fork Groundhouse River		07030004-53	48IMP002	Stream	50		MDNR 2008	II	
334	1382	66	Anoka	West Twin		02-0033-00		Lake	18		MDNR 2008	II	
335	2328		Wright	White		86-0214-00		Lake	145		MDNR 2008	II	
336	1603	287	Cass	White Oak		11-0016-00		Lake	68	1	MDNR 2008	II	
337	1604	288	Cass	Widow		11-0273-00		Lake	197		MDNR 2008	II	
338	1970	654	Mille Lacs	Wildlife Impoundment		48-0047-00		Lake			MDNR 2008	II	
339	2329		Wright	Willima		86-0209-00		Lake	246		MDNR 2008	II	
340	1363	47	Aitkin	Wolf		01-0019-00		Lake	168		MDNR 2008	II	
341	1183	1164	St. Louis	Little Mesaba Lake		69-0436-00		Lake	207		MDNR 2008, 1854 List	II	
342	2167	851	Stearns	Achman		73-0125-00		Lake	49		MDNR 2013	II	
343	1528	212	Cass	Ada		11-0250-00		Lake	1092		MDNR 2013	II	
344	1630	314	Cook	Alder		16-0114-00		Lake	342		MDNR 2013	II	
345	1439	123	Beltrami	Alice		04-0151-00		Lake	96		MDNR 2013	II	
346	1383	67	Becker	Alvin		03-0184-00		Lake	20		MDNR 2013	II	
347	1868	552	Kandiyohi	Andrew		34-0206-00		Lake	781		MDNR 2013	II	
348	2090	774	Sherburne	Ann		71-0069-00		Lake	226		MDNR 2013	II	
349	2107	791	St. Louis	Ash		69-0864-00		Lake	678		MDNR 2013	II	
350	2108	792	St. Louis	Astrid		69-0589-00		Lake	114		MDNR 2013	II	
351	1767	451	Isanti	Athens WMA		30-0026-00		Lake	101		MDNR 2013	II	
352	2109	793	St. Louis	Auto		69-0731-00		Lake	100		MDNR 2013	II	
353	1384	68	Becker	Bad Medicine		03-0085-00		Lake	782		MDNR 2013	II	
354	1317	1	Aitkin	Ball Bluff		01-0046-00		Lake	178		MDNR 2013	II	
355	1440	124	Beltrami	Balm		04-0329-00		Lake	512		MDNR 2013	II	
356	2110	794	St. Louis	Ban		69-0742-00		Lake	396		MDNR 2013	II	
357	1631	315	Cook	Barker		16-0358-00		Lake	166		MDNR 2013	II	
358	1529	213	Cass	Barnum		11-0281-00		Lake	139		MDNR 2013	II	
359	1441	125	Beltrami	Barr		04-0327-00		Lake	28		MDNR 2013	II	
360	2111	795	St. Louis	Barrs		69-0132-00		Lake	134		MDNR 2013	II	
361	1386	70	Becker	Bass		03-0127-00		Lake	142		MDNR 2013	II	
362	1385	69	Becker	Bass		03-0332-00		Lake	138		MDNR 2013	II	
363	1442	126	Beltrami	Bass		04-0191-00		Lake	56		MDNR 2013	II	
364	1530	214	Cass	Bass		11-0474-00		Lake	264		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
365	1938	622	Mahnomen	Bass		44-0006-00		Lake	700		MDNR 2013	II	
366	1961	645	Mille Lacs	Bass		48-0016-00		Lake	12		MDNR 2013	II	
367	1959	643	Mille Lacs	Bass		48-0017-00		Lake	14		MDNR 2013	II	
368	1960	644	Mille Lacs	Bass		48-0018-00		Lake	22		MDNR 2013	II	
369	1653	337	Crow Wing	Bassett		18-0026-00		Lake	32		MDNR 2013	II	
370	1791	475	Itasca	Batson		31-0704-00		Lake	107		MDNR 2013	II	
371	1889	573	Koochiching	Battle		36-0024-00		Lake	268		MDNR 2013	II	
372	1443	127	Beltrami	Baumgartner		04-0021-00		Lake	27		MDNR 2013	II	
373	1792	476	Itasca	Bear		31-0157-00		Lake	328		MDNR 2013	II	
374	1986	670	Otter Tail	Bear		56-0069-00		Lake	217		MDNR 2013	II	
375	2112	796	St. Louis	Bear Island		69-0115-00		Lake	2667		MDNR 2013	II	
376	1632	316	Cook	Bearskin		16-0228-00		Lake	522		MDNR 2013	II	
377	2113	797	St. Louis	Beast		69-0837-00		Lake	96		MDNR 2013	II	
378	1722	406	Hubbard	Beauty		29-0292-00		Lake	54		MDNR 2013	II	
379	1987	671	Otter Tail	Beers		56-0724-00		Lake	255		MDNR 2013	II	
380	1793	477	Itasca	Bello		31-0726-00		Lake	492		MDNR 2013	II	
381	1444	128	Beltrami	Beltrami		04-0135-00		Lake	701		MDNR 2013	II	
382	1445	129	Beltrami	Bemidji		04-0130-02	4013000		6920		MDNR 2013	II	
383	1446	130	Beltrami	Benjamin		04-0033-00		Lake	36		MDNR 2013	II	
384	1387	71	Becker	Besseau (Bijou)		03-0638-00		Lake	229		MDNR 2013	II	
385	2168	852	Stearns	Big		73-0159-00		Lake	446		MDNR 2013	II	
386	2201	885	Todd	Big Birch		77-0084-00		Lake	2025		MDNR 2013	II	
387	1794	478	Itasca	Big Calf		31-0884-00		Lake	24		MDNR 2013	II	
388	1388	72	Becker	Big Cormorant		03-0576-00		Lake	3380		MDNR 2013	II	
389	1531	215	Cass	Big Deep		11-0277-00		Lake	532		MDNR 2013	II	
390	1724	408	Hubbard	Big Sand		29-0185-00		Lake	1738		MDNR 2013	II	
391	2169	853	Stearns	Big Spunk		73-0117-00		Lake	410		MDNR 2013	II	
392	1515	199	Big Stone	Big Stone		06-0152-00		Lake	6028		MDNR 2013	II	
393	1654	338	Crow Wing	Big Trout		18-0315-00		Lake	1486		MDNR 2013	II	
394	1893	577	Lake	Bill		38-0085-00		Lake	51		MDNR 2013	II	
395	2091	775	Sherburne	Birch		71-0057-00		Lake	149		MDNR 2013	II	
396	1655	339	Crow Wing	Black Bear		18-0140-00		Lake	235		MDNR 2013	II	
397	2114	798	St. Louis	Black Duck		69-0842-00		Lake	1264		MDNR 2013	II	
398	1532	216	Cass	Blackwater		11-0274-00		Lake	761		MDNR 2013	II	
399	2115	799	St. Louis	Blackwood		69-0850-00		Lake	25		MDNR 2013	II	
400	1795	479	Itasca	Bluewater		31-0395-00		Lake	356		MDNR 2013	II	
401	2116	800	St. Louis	Bog		69-0811-00		Lake	30		MDNR 2013	II	
402	1656	340	Crow Wing	Bonnie		18-0259-00		Lake	83		MDNR 2013	II	
403	1319	3	Aitkin	Boot		01-0055-00		Lake	77		MDNR 2013	II	
404	1364	48	Anoka	Boot		02-0028-00		Lake	130		MDNR 2013	II	
405	1447	131	Beltrami	Borden		04-0027-00		Lake	30		MDNR 2013	II	
406	1869	553	Kandiyohi	Brenner		34-0339-00		Lake	81		MDNR 2013	II	
407	1698	382	Douglas	Brophy		21-0102-00		Lake	281		MDNR 2013	II	
408	1988	672	Otter Tail	Brown		56-0315-00		Lake	164		MDNR 2013	II	
409	1796	480	Itasca	Buck		31-0340-00		Lake	18		MDNR 2013	II	
410	1448	132	Beltrami	Bullhead		04-0002-00		Lake	35		MDNR 2013	II	
411	1894	578	Lake	Bunny		38-0293-00		Lake	41		MDNR 2013	II	
412	1797	481	Itasca	Burrows		31-0413-00		Lake	322		MDNR 2013	II	
413	1870	554	Kandiyohi	Calhoun		34-0062-00		Lake	1396		MDNR 2013	II	
414	1389	73	Becker	Campbell		03-0419-00		Lake	547		MDNR 2013	II	
415	1449	133	Beltrami	Carla		04-0058-00		Lake	25		MDNR 2013	II	
416	1450	134	Beltrami	Carter		04-0056-00		Lake	30		MDNR 2013	II	
417	1320	4	Aitkin	Cartie		01-0189-00		Lake	27		MDNR 2013	II	
418	1321	5	Aitkin	Cedar		01-0065-00		Lake	260		MDNR 2013	II	
419	1534	218	Cass	Cedar		11-0289-00		Lake	121		MDNR 2013	II	
420	1895	579	Lake	Cedar		38-0810-00		Lake	472		MDNR 2013	II	
421	1971	655	Morrison	Cedar		49-0140-00		Lake	250		MDNR 2013	II	
422	2170	854	Stearns	Cedar		73-0255-00		Lake	243		MDNR 2013	II	
423	2171	855	Stearns	Cedar Island		73-0133-00		Lake	995		MDNR 2013	II	
424	2117	801	St. Louis	Central		69-0637-00		Lake	75		MDNR 2013	II	
425	1633	317	Cook	Chester		16-0033-00		Lake	50		MDNR 2013	II	
426	1451	135	Beltrami	Chinaman		04-0017-00		Lake	72		MDNR 2013	II	
427	1322	6	Aitkin	Clear		01-0093-00		Lake	590		MDNR 2013	II	
428	1989	673	Otter Tail	Clear		56-0559-00		Lake	378		MDNR 2013	II	
429	1659	343	Crow Wing	Clearwater		18-0038-00		Lake	917		MDNR 2013	II	
430	2052	736	Pine	Close		58-0071-00		Lake	34		MDNR 2013	II	
431	2202	886	Todd	Coal		77-0046-00		Lake	178		MDNR 2013	II	
432	1660	344	Crow Wing	Coffee		18-0039-00		Lake	24		MDNR 2013	II	
433	1798	482	Itasca	Coleman		31-0943-00		Lake	57		MDNR 2013	II	
434	1605	289	Chisago	Comfort		13-0053-00		Lake	220		MDNR 2013	II	
435	1896	580	Lake	Cook		38-0004-00		Lake	89		MDNR 2013	II	
436	1947	631	McLeod	Coon		43-0020-00		Lake	118		MDNR 2013	II	
437	1390	74	Becker	Cotton		03-0286-00		Lake	1916		MDNR 2013	II	
438	1799	483	Itasca	Cottonwood		31-0594-00		Lake	109		MDNR 2013	II	
439	1962	646	Mille Lacs	Cranberry		48-0007-00		Lake	240		MDNR 2013	II	
440	1452	136	Beltrami	Crandall		04-0070-00		Lake	74		MDNR 2013	II	
441	1871	555	Kandiyohi	Crook		34-0357-00		Lake	82		MDNR 2013	II	
442	1800	484	Itasca	Crooked		31-0193-00		Lake	423		MDNR 2013	II	
443	1662	346	Crow Wing	Cross Lake Reservoir		18-0312-00		Lake	1884		MDNR 2013	II	
444	1536	220	Cass	Dade		11-0214-00		Lake	103		MDNR 2013	II	
445	1323	7	Aitkin	Dam		01-0096-00		Lake	633		MDNR 2013	II	
446	2118	802	St. Louis	Dark		69-0790-00		Lake	244		MDNR 2013	II	
447	1950	634	Meeker	Darwin		47-0076-00		Lake	200		MDNR 2013	II	
448	1801	485	Itasca	Day		31-0637-00		Lake	46		MDNR 2013	II	
449	1802	486	Itasca	Dead Horse		31-0622-00		Lake	96		MDNR 2013	II	
450	1367	51	Anoka	Deer		02-0059-00		Lake	376		MDNR 2013	II	
451	1453	137	Beltrami	Deer		04-0230-00		Lake	287		MDNR 2013	II	
452	1872	556	Kandiyohi	Deer		34-0344-00		Lake	115		MDNR 2013	II	
453	1634	318	Cook	Deer Yard		16-0253-00		Lake	358		MDNR 2013	II	
454	1454	138	Beltrami	Dellwater		04-0331-00		Lake	147		MDNR 2013	II	
455	1897	581	Lake	Denley		38-0773-00		Lake	45		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
456	1393	77	Becker	Detroit		03-0381-00		Lake	3089		MDNR 2013	II	
457	1852	536	Kanabec	Devils		33-0033-00		Lake	121		MDNR 2013	II	
458	1324	8	Aitkin	Diamond		01-0171-00		Lake	80		MDNR 2013	II	
459	1873	557	Kandiyohi	Diamond		34-0044-00		Lake	1697		MDNR 2013	II	
460	1898	582	Lake	Diana		38-0459-00		Lake	49		MDNR 2013	II	
461	1325	9	Aitkin	Douglas		01-0009-00		Lake	75		MDNR 2013	II	
462	1899	583	Lake	Dragon		38-0552-00		Lake	85		MDNR 2013	II	
463	1803	487	Itasca	Dry Creek		31-0869-00		Lake	98		MDNR 2013	II	
464	1538	222	Cass	Dry Sand		11-0514-00		Lake	191		MDNR 2013	II	
465	1991	675	Otter Tail	Duck		56-0483-00		Lake	96		MDNR 2013	II	
466	1394	78	Becker	Dumbbell		03-0124-00		Lake	149		MDNR 2013	II	
467	1804	488	Itasca	Dunbar		31-0904-00		Lake	273		MDNR 2013	II	
468	1522	206	Carlton	Eagle		09-0057-00		Lake	410		MDNR 2013	II	
469	1805	489	Itasca	East		31-0798-00		Lake	92		MDNR 2013	II	
470	1993	677	Otter Tail	East Annalaide		56-0001-00		Lake	97		MDNR 2013	II	
471	1635	319	Cook	East Bearskin		16-0146-00		Lake	643		MDNR 2013	II	
472	1900	584	Lake	East Chub		38-0674-00		Lake	98		MDNR 2013	II	
473	2068	752	Pope	East Johanna (Rocky Mountain)		61-0002-00		Lake	98		MDNR 2013	II	
474	1874	558	Kandiyohi	East Solomon		34-0246-00		Lake	601		MDNR 2013	II	
475	1663	347	Crow Wing	Eastham		18-0202-00		Lake	68		MDNR 2013	II	
476	1395	79	Becker	Elbow		03-0065-00		Lake	65		MDNR 2013	II	
477	1994	678	Otter Tail	Elbow		56-0306-00		Lake	193		MDNR 2013	II	
478	2119	803	St. Louis	Elbow		69-0744-00		Lake	1528		MDNR 2013	II	
479	2120	804	St. Louis	Elephant		69-0810-00		Lake	782		MDNR 2013	II	
480	1853	537	Kanabec	Eleven		33-0001-00		Lake	320		MDNR 2013	II	
481	1876	560	Kandiyohi	Elizabeth		34-0022-02	34002200		1153		MDNR 2013	II	
482	1715	399	Grant	Elk		26-0040-00		Lake	171		MDNR 2013	II	
483	2092	776	Sherburne	Elk		71-0141-00		Lake	352		MDNR 2013	II	
484	1877	561	Kandiyohi	Elkhorn		34-0119-00		Lake	79		MDNR 2013	II	
485	1995	679	Otter Tail	Ellingson		56-0178-00		Lake	158		MDNR 2013	II	
486	2121	805	St. Louis	Ely		69-0660-00		Lake	827		MDNR 2013	II	
487	2069	753	Pope	Emily		61-0180-00		Lake	2164		MDNR 2013	II	
488	1726	410	Hubbard	Emma		29-0186-00		Lake	85		MDNR 2013	II	
489	1456	140	Beltrami	Erick		04-0229-00		Lake	75		MDNR 2013	II	
490	1396	80	Becker	Eunice		03-0503-00		Lake	370		MDNR 2013	II	
491	1727	411	Hubbard	Evergreen		29-0227-00		Lake	206		MDNR 2013	II	
492	1457	141	Beltrami	Fagen		04-0060-00		Lake	35		MDNR 2013	II	
493	2203	887	Todd	Fairy		77-0154-00		Lake	303		MDNR 2013	II	
494	1806	490	Itasca	Fawn		31-0609-00		Lake	174		MDNR 2013	II	
495	1369	53	Anoka	Fish		02-0065-00		Lake	332		MDNR 2013	II	
496	1606	290	Chisago	Fish		13-0068-00		Lake	323		MDNR 2013	II	
497	1854	538	Kanabec	Fish		33-0036-00		Lake	440		MDNR 2013	II	
498	1928	612	Le Sueur	Fish		40-0051-00		Lake	84		MDNR 2013	II	
499	2238	922	Wright	Fish		86-0183-00		Lake	104		MDNR 2013	II	
500	2122	806	St. Louis	Fishing		69-0270-00		Lake	17		MDNR 2013	II	
501	1996	680	Otter Tail	Fladmark		56-0727-00		Lake	55		MDNR 2013	II	
502	1618	302	Clearwater	Floating Moss		15-0483-00		Lake	3		MDNR 2013	II	
503	1458	142	Beltrami	Flora		04-0051-00		Lake	178		MDNR 2013	II	
504	1636	320	Cook	Flour		16-0147-00		Lake	352		MDNR 2013	II	
505	1397	81	Becker	Floyd		03-0387-00		Lake	1212		MDNR 2013	II	
506	1901	585	Lake	Folly		38-0265-00		Lake	16		MDNR 2013	II	
507	1878	562	Kandiyohi	Foot		34-0181-00		Lake	544		MDNR 2013	II	
508	1807	491	Itasca	Forest		31-0663-00		Lake	29		MDNR 2013	II	
509	1902	586	Lake	Fourth McDougal		38-0657-00		Lake	14		MDNR 2013	II	
510	1459	143	Beltrami	Fox		04-0162-00		Lake	148		MDNR 2013	II	
511	1951	635	Meeker	Francis		47-0002-00		Lake	1172		MDNR 2013	II	
512	1699	383	Douglas	Freeborn		21-0162-00		Lake	250		MDNR 2013	II	
513	1728	412	Hubbard	Frontenac		29-0241-00		Lake	224		MDNR 2013	II	
514	1539	223	Cass	Fucat		11-0641-00		Lake	10		MDNR 2013	II	
515	1460	144	Beltrami	Funk		04-0073-00		Lake	140		MDNR 2013	II	
516	1879	563	Kandiyohi	Games		34-0224-00		Lake	557		MDNR 2013	II	
517	2070	754	Pope	Gilchrist		61-0072-00		Lake	330		MDNR 2013	II	
518	1461	145	Beltrami	Gilstad		04-0024-00		Lake	256		MDNR 2013	II	
519	1462	146	Beltrami	Gimmer		04-0020-00		Lake	77		MDNR 2013	II	
520	1326	10	Aitkin	Glacier		01-0042-00		Lake	139		MDNR 2013	II	
521	1664	348	Crow Wing	Gladstone		18-0338-00		Lake	457		MDNR 2013	II	
522	2124	808	St. Louis	Goldmine Slough Section - Vermilion		09030002-53	R001-46G				MDNR 2013	II	
523	2125	809	St. Louis	Golf Course Pond (Upper Twin)		69-1345-00		Lake	1		MDNR 2013	II	
524	2235	919	Waseca	Goose		81-0016-00		Lake	370		MDNR 2013	II	
525	1637	321	Cook	Gordon		16-0569-00		Lake	167		MDNR 2013	II	
526	2054	738	Pine	Grace		58-0029-00		Lake	78		MDNR 2013	II	
527	1463	147	Beltrami	Grant		04-0217-00		Lake	200		MDNR 2013	II	
528	1666	350	Crow Wing	Grave		18-0110-00		Lake	177		MDNR 2013	II	
529	1810	494	Itasca	Grave		31-0624-00		Lake	538		MDNR 2013	II	
530	2001	685	Otter Tail	Gray		56-0353-00		Lake	92		MDNR 2013	II	
531	2177	861	Stearns	Great Northern		73-0083-00		Lake	113		MDNR 2013	II	
532	1608	292	Chisago	Green		13-0041-00		Lake	1830		MDNR 2013	II	
533	1880	564	Kandiyohi	Green		34-0079-00		Lake	5821		MDNR 2013	II	
534	1973	657	Morrison	Green Prairie Fish		49-0035-00		Lake	193		MDNR 2013	II	
535	2056	740	Pine	Greigs		58-0013-00		Lake	58		MDNR 2013	II	
536	1465	149	Beltrami	Grenn		040-241-00		Lake	70		MDNR 2013	II	
537	1619	303	Clearwater	Haggerty		15-0002-00		Lake	149		MDNR 2013	II	
538	1729	413	Hubbard	Halverson		29-0220-00		Lake	19		MDNR 2013	II	
539	1399	83	Becker	Hanson		03-0177-00		Lake	35		MDNR 2013	II	
540	1543	227	Cass	Hardy		11-0209-00		Lake	108		MDNR 2013	II	
541	1615	299	Clay	Hartke		14-0336-00		Lake	18		MDNR 2013	II	
542	1811	495	Itasca	Hartley		31-0154-00		Lake	271		MDNR 2013	II	
543	1933	617	Lincoln	Hawksnest		41-0045-00		Lake	270		MDNR 2013	II	
544	2085	769	Roseau	Hayes		68-0004-00		Lake	187		MDNR 2013	II	
545	2126	810	St. Louis	Headquarters		69-0766-00		Lake	65		MDNR 2013	II	
546	1400	84	Becker	Hernando DeSoto		03-0032-00		Lake	180		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
547	1700	384	Douglas	Hidden		21-0058-00		Lake	17		MDNR 2013	II	
548	1903	587	Lake	Hide (Bearskin)		38-0553-00		Lake	22		MDNR 2013	II	
549	1731	415	Hubbard	Hinds		29-0249-00		Lake	310		MDNR 2013	II	
550	1638	322	Cook	Holly		16-0366-00		Lake	78		MDNR 2013	II	
551	1904	588	Lake	Homestead		38-0269-00		Lake	50		MDNR 2013	II	
552	1329	13	Aitkin	Horseshoe		01-0154-00		Lake	53		MDNR 2013	II	
553	1545	229	Cass	Horseshoe		11-0284-00		Lake	142		MDNR 2013	II	
554	1546	230	Cass	Horseshoe		11-0358-00		Lake	245		MDNR 2013	II	
555	1609	293	Chisago	Horseshoe		13-0073-00		Lake	226		MDNR 2013	II	
556	2127	811	St. Louis	Horseshoe		69-0232-00		Lake	96		MDNR 2013	II	
557	1547	231	Cass	Hovde		11-0394-00		Lake	115		MDNR 2013	II	
558	1668	352	Crow Wing	Hubert		18-0375-00		Lake	1344		MDNR 2013	II	
559	1401	85	Becker	Hungry		03-0166-00		Lake	245		MDNR 2013	II	
560	1701	385	Douglas	Indian		21-0136-00		Lake	83		MDNR 2013	II	
561	1402	86	Becker	Island		03-0153-00		Lake	1209		MDNR 2013	II	
562	1467	151	Beltrami	Island		04-0265-00		Lake	368		MDNR 2013	II	
563	1548	232	Cass	Island		11-0257-00		Lake	173		MDNR 2013	II	
564	1733	417	Hubbard	Island		29-0088-00		Lake	235		MDNR 2013	II	
565	2180	864	Stearns	Island		73-0104-00		Lake	118		MDNR 2013	II	
566	1905	589	Lake	Island River		DNR	H-1-92-21-15	Stream			MDNR 2013	II	
567	1549	233	Cass	Iverson		11-0194-00		Lake	80		MDNR 2013	II	
568	1906	590	Lake	Jack		38-0441-00		Lake	51		MDNR 2013	II	
569	1669	353	Crow Wing	Jack Pine		18-0023-00		Lake	149		MDNR 2013	II	
570	2128	812	St. Louis	James		69-0734-00		Lake	19		MDNR 2013	II	
571	1814	498	Itasca	Jay Gould		31-0565-00		Lake	455		MDNR 2013	II	
572	1952	636	Meeker	Jennie		47-0015-00		Lake	1089		MDNR 2013	II	
573	1468	152	Beltrami	Jessie		04-0052-00		Lake	50		MDNR 2013	II	
574	1815	499	Itasca	Jessie		31-0786-00		Lake	1782		MDNR 2013	II	
575	1550	234	Cass	Johnson		11-0363-00		Lake	92		MDNR 2013	II	
576	1403	87	Becker	Jones		03-0123-00		Lake	36		MDNR 2013	II	
577	1907	591	Lake	Jouppi		38-0909-00		Lake	7		MDNR 2013	II	
578	1404	88	Becker	Juggler		03-0136-00		Lake	434		MDNR 2013	II	
579	1469	153	Beltrami	Julia		04-0166-00		Lake	492		MDNR 2013	II	
580	2129	813	St. Louis	Kangas		69-0057-00		Lake	35		MDNR 2013	II	
581	1908	592	Lake	Katherine		38-0538-00		Lake	77		MDNR 2013	II	
582	2130	814	St. Louis	Kelly		69-0901-00		Lake	21		MDNR 2013	II	
583	1816	500	Itasca	Kenogama		31-0928-00		Lake	580		MDNR 2013	II	
584	1620	304	Clearwater	Kibbee / Shuckhart		15-0114-00		Lake	61		MDNR 2013	II	
585	1333	17	Aitkin	Kingsley Pothole		01-0138-00		Lake	33		MDNR 2013	II	
586	1639	323	Cook	Knight		16-0807-00		Lake	99		MDNR 2013	II	
587	2181	865	Stearns	Koronis (Mud)		73-0200-01		Lake	156		MDNR 2013	II	
588	1771	455	Isanti	Krans		30-0020-00		Lake	47		MDNR 2013	II	
589	1892	576	Lac Qui Parle	Lac Qui Parle		37-0046-00		Lake	8400		MDNR 2013	II	
590	2206	890	Todd	Lady		77-0032-00		Lake	207		MDNR 2013	II	
591	1817	501	Itasca	Lammon Aid		31-0096-00		Lake	64		MDNR 2013	II	
592	1818	502	Itasca	Larson		31-0317-00		Lake	190		MDNR 2013	II	
593	1819	503	Itasca	Lauchoh		31-0692-00		Lake	50		MDNR 2013	II	
594	2182	866	Stearns	Laura		73-0020-00		Lake	147		MDNR 2013	II	
595	2002	686	Otter Tail	Leek (Trowbridge)		56-0532-00		Lake	640		MDNR 2013	II	
596	1405	89	Becker	Leif		03-0575-00		Lake	519		MDNR 2013	II	
597	2131	815	St. Louis	Leora		69-0521-00		Lake	276		MDNR 2013	II	
598	1552	236	Cass	Life Raft		11-0406-00		Lake	45		MDNR 2013	II	
599	1881	565	Kandiyohi	Lillian		34-0072-00		Lake	1608		MDNR 2013	II	
600	2208	892	Todd	Lily		77-0358-00		Lake	56		MDNR 2013	II	
601	1621	305	Clearwater	Lindberg		15-0144-00		Lake	92		MDNR 2013	II	
602	1773	457	Isanti	Linderman		30-0023-00		Lake	70		MDNR 2013	II	
603	1470	154	Beltrami	Lindgren		04-0153-00		Lake	84		MDNR 2013	II	
604	1406	90	Becker	Little Bass		03-0337-00		Lake	87		MDNR 2013	II	
605	1820	504	Itasca	Little Bowstring		31-0758-00		Lake	314		MDNR 2013	II	
606	1702	386	Douglas	Little Chippewa		21-0212-00		Lake	282		MDNR 2013	II	
607	1821	505	Itasca	Little Cowhorn		31-0198-00		Lake	157		MDNR 2013	II	
608	1822	506	Itasca	Little Dixon		31-0936-00		Lake	31		MDNR 2013	II	
609	1974	658	Morrison	Little Elk WMA		07010104-52	W0069101				MDNR 2013	II	
610	1471	155	Beltrami	Little Gilstad		04-0016-00		Lake	40		MDNR 2013	II	
611	1640	324	Cook	Little Iron		16-0355-00		Lake	121		MDNR 2013	II	
612	1407	91	Becker	Little Long		03-0009-00		Lake	14		MDNR 2013	II	
613	1554	238	Cass	Little Long		11-0323-00		Lake	33	1	MDNR 2013	II	
614	1719	403	Hennepin	Little Long		27-0179-00		Lake	117		MDNR 2013	II	
615	1555	239	Cass	Little Moss		11-0489-00		Lake	93		MDNR 2013	II	
616	1408	92	Becker	Little Mud		03-0188-00		Lake	63		MDNR 2013	II	
617	2057	741	Pine	Little Mud		58-0106-00		Lake	19		MDNR 2013	II	
618	1670	354	Crow Wing	Little Pelican		18-0351-00		Lake	402		MDNR 2013	II	
619	1671	355	Crow Wing	Little Rabbit		18-0139-00		Lake	153		MDNR 2013	II	
620	1472	156	Beltrami	Little Rabideau		04-0359-00		Lake	25		MDNR 2013	II	
621	1556	240	Cass	Little Reservoir		11-0002-00		Lake	14		MDNR 2013	II	
622	1823	507	Itasca	Little Sand		31-0853-00		Lake	222		MDNR 2013	II	
623	1409	93	Becker	Little Sugar Bush		03-0313-00		Lake	222		MDNR 2013	II	
624	2213	897	Todd	Little Swan		77-0034-00		Lake	178		MDNR 2013	II	
625	2058	742	Pine	Little Tamarack		58-0028-00		Lake	58		MDNR 2013	II	
626	1557	241	Cass	Little Thunder		11-0009-00		Lake	264		MDNR 2013	II	
627	1824	508	Itasca	Little Trout		31-0394-00		Lake	78		MDNR 2013	II	
628	1558	242	Cass	Little Twin		11-0487-00		Lake	114		MDNR 2013	II	
629	1940	624	Mahnomen	Little Vanose		44-0169-00		Lake	149		MDNR 2013	II	
630	2133	817	St. Louis	Locator		69-0936-00		Lake	140		MDNR 2013	II	
631	1337	21	Aitkin	Long		01-0089-00		Lake	433		MDNR 2013	II	
632	1336	20	Aitkin	Long		01-0101-00		Lake	33		MDNR 2013	II	
633	1560	244	Cass	Long		11-0023-00		Lake	112		MDNR 2013	II	
634	1559	243	Cass	Long		11-0258-00		Lake	229		MDNR 2013	II	
635	1561	245	Cass	Long		11-0480-00		Lake	218		MDNR 2013	II	
636	1703	387	Douglas	Long		21-0343-00		Lake	205		MDNR 2013	II	
637	1827	511	Itasca	Long		31-0266-01	31026600	Lake	238		MDNR 2013	II	

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638	1826	510	Itasca	Long		31-0570-00		Lake	117		MDNR 2013	II	
639	2135	819	St. Louis	Long		69-0495-00		Lake	366		MDNR 2013	II	
640	2134	818	St. Louis	Long		69-0653-00		Lake	157		MDNR 2013	II	
641	2136	820	St. Louis	Long		69-0765-00		Lake	472		MDNR 2013	II	
642	2186	870	Stearns	Long		73-0105-00		Lake	31		MDNR 2013	II	
643	2185	869	Stearns	Long		73-0139-00		Lake	478		MDNR 2013	II	
644	2215	899	Todd	Long		77-0149-00		Lake	215		MDNR 2013	II	
645	2214	898	Todd	Long		77-0357-00		Lake	98		MDNR 2013	II	
646	2241	925	Wright	Long		86-0246-00		Lake	85		MDNR 2013	II	
647	1516	200	Big Stone	Long Tom		06-0029-00		Lake	110		MDNR 2013	II	
648	2137	821	St. Louis	Longyear		69-0857-00		Lake	188		MDNR 2013	II	
649	1410	94	Becker	Loon		03-0489-00		Lake	236		MDNR 2013	II	
650	1562	246	Cass	Loon		11-0226-00		Lake	220		MDNR 2013	II	
651	1641	325	Cook	Loon		16-0448-00		Lake	1197		MDNR 2013	II	
652	1672	356	Crow Wing	Loon / Ward		18-0111-00		Lake	54		MDNR 2013	II	
653	1673	357	Crow Wing	Lower Cullen		18-0403-00		Lake	469		MDNR 2013	II	
654	1674	358	Crow Wing	Lower Hay		18-0378-00		Lake	720		MDNR 2013	II	
655	1563	247	Cass	Lower Sucker		11-0313-00		Lake	598		MDNR 2013	II	
656	1713	397	Freeborn	Lower Twin		24-0027-00		Lake	480		MDNR 2013	II	
657	1737	421	Hubbard	Many Arm		29-0257-00		Lake	71		MDNR 2013	II	
658	1775	459	Isanti	Marget		30-0070-00		Lake	188		MDNR 2013	II	
659	2188	872	Stearns	Marie		73-0014-00		Lake	145		MDNR 2013	II	
660	2138	822	St. Louis	Marion		69-0755-00		Lake	174		MDNR 2013	II	
661	1517	201	Big Stone	Marsh		06-0001-00		Lake	6100		MDNR 2013	II	
662	2086	770	Roseau	Marvin		68-0002-00		Lake	199		MDNR 2013	II	
663	1704	388	Douglas	Mary		21-0092-00		Lake	2559		MDNR 2013	II	
664	1776	460	Isanti	Matson		30-0141-00		Lake	89		MDNR 2013	II	
665	1411	95	Becker	Maud		03-0500-00		Lake	540		MDNR 2013	II	
666	1676	360	Crow Wing	Mayo		18-0408-00		Lake	148		MDNR 2013	II	
667	2231	915	Wabasha	McCarthy		79-0006-00		Lake	57		MDNR 2013	II	
668	1412	96	Becker	Meadow		03-0371-00		Lake	66		MDNR 2013	II	
669	1476	160	Beltrami	Meadow		04-0050-00		Lake	118		MDNR 2013	II	
670	2139	823	St. Louis	Meadow		69-0165-00		Lake	21		MDNR 2013	II	
671	1413	97	Becker	Melissa		03-0475-00		Lake	1827		MDNR 2013	II	
672	1523	207	Carlton	Merwin		09-0058-00		Lake	51		MDNR 2013	II	
673	1909	593	Lake	Micmac		38-0233-00		Lake	121		MDNR 2013	II	
674	1738	422	Hubbard	Midge		29-0066-00		Lake	588		MDNR 2013	II	
675	1565	249	Cass	Mile		11-0207-00		Lake	76		MDNR 2013	II	
676	2216	900	Todd	Mill		77-0050-00		Lake	166		MDNR 2013	II	
677	1777	461	Isanti	Mimi's Pool		DNR	W0098001		5		MDNR 2013	II	
678	1705	389	Douglas	Mina		21-0108-00		Lake	447		MDNR 2013	II	
679	1642	326	Cook	Mistletoe		16-0368-00		Lake	151		MDNR 2013	II	
680	1910	594	Lake	Mitawan		38-0561-00		Lake	202		MDNR 2013	II	
681	2097	781	Sherburne	Mitchell		71-0081-00		Lake	156		MDNR 2013	II	
682	1643	327	Cook	Moose		16-0043-00		Lake	452		MDNR 2013	II	
683	1911	595	Cook	Moose		16-0043-00		Lake	452		MDNR 2013	II	
684	1890	574	Koochiching	Moose		36-0008-00		Lake	50		MDNR 2013	II	
685	2140	824	St. Louis	Moose		69-0806-00		Lake	942		MDNR 2013	II	
686	1341	25	Aitkin	Mud		01-0035-00		Lake	65		MDNR 2013	II	
687	1416	100	Becker	Mud		03-0187-00		Lake	144		MDNR 2013	II	
688	2007	691	Otter Tail	Mud		56-0484-00		Lake	585		MDNR 2013	II	
689	2141	825	St. Louis	Mukooda		69-0684-00		Lake	748		MDNR 2013	II	
690	2011	695	Otter Tail	Murphy		56-0229-00		Lake	358		MDNR 2013	II	
691	2142	826	St. Louis	Murphy		69-0646-00		Lake	356		MDNR 2013	II	
692	1477	161	Beltrami	Muskrat		04-0054-00		Lake	37		MDNR 2013	II	
693	1478	162	Beltrami	Muskrat		04-0240-00		Lake	106		MDNR 2013	II	
694	1479	163	Beltrami	Nelson		04-0057-00		Lake	29		MDNR 2013	II	
695	1882	566	Kandiyohi	Nest		34-0154-00		Lake	1019		MDNR 2013	II	
696	1417	101	Becker	Net		03-0334-00		Lake	243		MDNR 2013	II	
697	1912	596	Lake	Newfound		38-0619-00		Lake	652		MDNR 2013	II	
698	2012	696	Otter Tail	Nitche		56-0126-00		Lake	72		MDNR 2013	II	
699	1831	515	Itasca	No-ta-she-bun (Willow)		31-0775-00		Lake	232		MDNR 2013	II	
700	1677	361	Crow Wing	Nokay		18-0104-00		Lake	782		MDNR 2013	II	
701	1644	328	Cook	North		16-0331-00		Lake	549		MDNR 2013	II	
702	2191	875	Stearns	North Brown's		73-0147-00		Lake	312		MDNR 2013	II	
703	1610	294	Chisago	North Center		13-0032-01	13003200		760		MDNR 2013	II	
704	1518	202	Big Stone	North Rothwell		06-0147-00		Lake	228		MDNR 2013	II	
705	1830	514	Itasca	North Twin		31-0190-00		Lake	250		MDNR 2013	II	
706	2143	827	St. Louis	North Twin		69-0419-00		Lake	67		MDNR 2013	II	
707	2218	902	Todd	North Twin		77-0158-00		Lake	71		MDNR 2013	II	
708	1883	567	Kandiyohi	Norway		34-0251-00		Lake	2496		MDNR 2013	II	
709	1934	618	Lincoln	Oak		41-0062-00		Lake	107		MDNR 2013	II	
710	2060	744	Pine	Oak		58-0048-00		Lake	444		MDNR 2013	II	
711	1678	362	Crow Wing	Olander		18-0091-00		Lake	89		MDNR 2013	II	
712	2061	745	Pine	Olive		58-0044-00		Lake	12		MDNR 2013	II	
713	1782	466	Isanti	Olson Impoundment		30-0094-00		Lake	24		MDNR 2013	II	
714	2015	699	Otter Tail	Orwell		56-0945-00		Lake	396		MDNR 2013	II	
715	1480	164	Beltrami	Ose		04-0089-00		Lake	68		MDNR 2013	II	
716	2192	876	Stearns	Otter		73-0015-00		Lake	125		MDNR 2013	II	
717	1566	250	Cass	Ox Yoke		11-0355-00		Lake	199		MDNR 2013	II	
718	2144	828	St. Louis	Pat Zakovec Impoundment		69-1463-00		Lake	72		MDNR 2013	II	
719	2016	700	Otter Tail	Paul		56-0335-00		Lake	334		MDNR 2013	II	
720	2193	877	Stearns	Pearl		73-0037-00		Lake	755		MDNR 2013	II	
721	2219	903	Todd	Peat		77-0055-00		Lake	28		MDNR 2013	II	
722	1716	400	Grant	Pelican		26-0002-00		Lake	3680		MDNR 2013	II	
723	2194	878	Stearns	Pelican		73-0118-00		Lake	344		MDNR 2013	II	
724	1858	542	Kanabec	Pennington		33-0030-00		Lake	132		MDNR 2013	II	
725	1935	619	Lincoln	Perch		41-0067-00		Lake	206		MDNR 2013	II	
726	1481	165	Beltrami	Peterson		04-0119-00		Lake	78		MDNR 2013	II	
727	1482	166	Beltrami	Peterson		04-0177-00		Lake	66		MDNR 2013	II	
728	1483	167	Beltrami	Peterson		04-0235-00		Lake	305		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
729	1622	306	Clearwater	Peterson		15-0083-00		Lake	114		MDNR 2013	II	
730	1979	663	Morrison	Pierz		49-0024-00		Lake	186		MDNR 2013	II	
731	1645	329	Cook	Pike		16-0252-00		Lake	850		MDNR 2013	II	
732	1419	103	Becker	Pine		03-0200-00		Lake	540		MDNR 2013	II	
733	1568	252	Cass	Pine		11-0292-00		Lake	256		MDNR 2013	II	
734	1741	425	Hubbard	Pine		29-0197-00		Lake	46		MDNR 2013	II	
735	1980	664	Morrison	Pine		49-0081-00		Lake	197		MDNR 2013	II	
736	2145	829	St. Louis	Pleasant		69-0655-00		Lake	360		MDNR 2013	II	
737	1679	363	Crow Wing	Pointon		18-0105-00		Lake	193		MDNR 2013	II	
738	1484	168	Beltrami	Polly Wog		04-0168-00		Lake	35		MDNR 2013	II	
739	1569	253	Cass	Portage		11-0490-00		Lake	352		MDNR 2013	II	
740	2018	702	Otter Tail	Portage		56-0140-00		Lake	289		MDNR 2013	II	
741	1913	597	Lake	Pose		38-0455-00		Lake	76		MDNR 2013	II	
742	1485	169	Beltrami	Preston		04-0009-00		Lake	10		MDNR 2013	II	
743	2078	762	Renville	Preston		65-0002-00		Lake	678		MDNR 2013	II	
744	1514	198	Benton	Pularskis		05-0009-00		Lake	138		MDNR 2013	II	
745	1680	364	Crow Wing	Rabbit		18-0093-01	18009300		840		MDNR 2013	II	
746	1524	208	Carlton	Railroad		09-0174-00		Lake	7		MDNR 2013	II	
747	2051	735	Pennington	Red Lake River Reservoir		57-0051-00		Lake	75		MDNR 2013	II	
748	1914	598	Lake	Redskin		38-0440-00		Lake	43		MDNR 2013	II	
749	1833	517	Itasca	Reed		31-0074-00		Lake	72		MDNR 2013	II	
750	1681	365	Crow Wing	Reno		18-0067-00		Lake	181		MDNR 2013	II	
751	1570	254	Cass	Reservoir		11-0003-00		Lake	60		MDNR 2013	II	
752	1884	568	Kandiyohi	Ringo		34-0172-00		Lake	774		MDNR 2013	II	
753	1954	638	Meeker	Ripley		47-0134-00	47013400		1060		MDNR 2013	II	
754	1487	171	Beltrami	Roadside		04-0075-00		Lake	46		MDNR 2013	II	
755	2248	932	Wright	Rock		86-0182-00		Lake	181		MDNR 2013	II	
756	1623	307	Clearwater	Rockstad		15-0075-00		Lake	128		MDNR 2013	II	
757	2023	707	Otter Tail	Rose		56-0620-00		Lake	107		MDNR 2013	II	
758	2087	771	Roseau	Roseau River WMA Pool 1-West		68-0005-00	68000502		1016		MDNR 2013	II	
759	1343	27	Aitkin	Round		01-0023-00		Lake	571		MDNR 2013	II	
760	1342	26	Aitkin	Round		01-0070-00		Lake	188		MDNR 2013	II	
761	1345	29	Aitkin	Round		01-0204-00		Lake	736		MDNR 2013	II	
762	2024	708	Otter Tail	Rusch		56-1641-00		Lake	100		MDNR 2013	II	
763	2102	786	Sherburne	Rush		71-0147-00		Lake	161		MDNR 2013	II	
764	1682	366	Crow Wing	Rush-Hen (Rush)		18-0311-00		Lake	782		MDNR 2013	II	
765	1683	367	Crow Wing	Rushmeyer		18-0082-00		Lake	43		MDNR 2013	II	
766	1684	368	Crow Wing	Ruth		18-0212-00		Lake	623		MDNR 2013	II	
767	1422	106	Becker	Sallie		03-0359-00		Lake	1287		MDNR 2013	II	
768	1572	256	Cass	Sanborn		11-0361-00		Lake	224		MDNR 2013	II	
769	1423	107	Becker	Sand		03-0659-00		Lake	199		MDNR 2013	II	
770	1573	257	Cass	Sand		11-0275-00		Lake	36		MDNR 2013	II	
771	1574	258	Cass	Sand		11-0279-00		Lake	144		MDNR 2013	II	
772	2062	746	Pine	Sand		58-0081-00		Lake	575		MDNR 2013	II	
773	2149	833	St. Louis	Sand		69-0736-00		Lake	792		MDNR 2013	II	
774	2103	787	Sherburne	Sand Prairie WMA		DNR	W0152601				MDNR 2013	II	
775	2104	788	Sherburne	Sandy		71-0040-00		Lake	70		MDNR 2013	II	
776	1915	599	Lake	Sapphire		38-0446-00		Lake	42		MDNR 2013	II	
777	2151	835	St. Louis	Schelins		69-0624-00		Lake	164		MDNR 2013	II	
778	1488	172	Beltrami	School		04-0114-00		Lake	74		MDNR 2013	II	
779	1346	30	Aitkin	Section 25		01-0127-00		Lake	48		MDNR 2013	II	
780	1916	600	Lake	Section 29		38-0292-00		Lake	97		MDNR 2013	II	
781	1424	108	Becker	Senical		03-0365-00		Lake	122		MDNR 2013	II	
782	1891	575	Koochiching	Seretha		36-0009-00		Lake	58		MDNR 2013	II	
783	1836	520	Itasca	Shoal		31-0534-00		Lake	661		MDNR 2013	II	
784	1575	259	Cass	Silver		11-0202-00		Lake	104		MDNR 2013	II	
785	1917	601	Lake	Slate (Spider)		38-0666-00		Lake	354		MDNR 2013	II	
786	1837	521	Itasca	Smith		31-0547-00		Lake	39		MDNR 2013	II	
787	1944	628	Mahnomen	Snetsinger		44-0121-00		Lake	213		MDNR 2013	II	
788	2026	710	Otter Tail	Snow		56-0110-00		Lake	72		MDNR 2013	II	
789	1838	522	Itasca	South Ackerman		31-0795-00		Lake	22		MDNR 2013	II	
790	2152	836	St. Louis	South Bog		69-0807-00		Lake	20		MDNR 2013	II	
791	1612	296	Chisago	South Center		13-0027-00		Lake	913		MDNR 2013	II	
792	1613	297	Chisago	South Lindstrom		13-0028-00		Lake	664		MDNR 2013	II	
793	1576	260	Cass	Spider		11-0221-00		Lake	21		MDNR 2013	II	
794	2223	907	Todd	Spier		77-0148-00		Lake	53		MDNR 2013	II	
795	1955	639	Meeker	Spring		47-0032-00		Lake	202		MDNR 2013	II	
796	1918	602	Lake	Square		38-0074-00		Lake	127		MDNR 2013	II	
797	2153	837	St. Louis	St. Mary's		69-0651-00		Lake	249		MDNR 2013	II	
798	1982	666	Morrison	Stanchfield		49-0118-00		Lake	145		MDNR 2013	II	
799	1646	330	Cook	Star		16-0405-00		Lake	120		MDNR 2013	II	
800	1685	369	Crow Wing	Star		18-0359-00		Lake	153		MDNR 2013	II	
801	1577	261	Cass	Steamboat		11-0504-00		Lake	1761		MDNR 2013	II	
802	1936	620	Lincoln	Steep Bank		41-0082-00		Lake	208		MDNR 2013	II	
803	1956	640	Meeker	Stella		47-0068-00		Lake	626		MDNR 2013	II	
804	2154	838	St. Louis	Stone		69-0027-00		Lake	228		MDNR 2013	II	
805	1579	263	Cass	Stony		11-0371-00		Lake	523		MDNR 2013	II	
806	1707	391	Douglas	Stowe		21-0264-00		Lake	533		MDNR 2013	II	
807	1426	110	Becker	Strawberry		03-0323-00		Lake	1607		MDNR 2013	II	
808	1647	331	Cook	Strobus		16-0370-00		Lake	11		MDNR 2013	II	
809	1349	33	Aitkin	Studhorse		01-0110-00		Lake	63		MDNR 2013	II	
810	1489	173	Beltrami	Stump		04-0130-01		Lake	323		MDNR 2013	II	
811	2063	747	Pine	Sturgeon		58-0067-00		Lake	1456		MDNR 2013	II	
812	1839	523	Itasca	Sugar		31-0926-00		Lake	1585		MDNR 2013	II	
813	1919	603	Lake	Sullivan		38-0755-00		Lake	45		MDNR 2013	II	
814	1614	298	Chisago	Sunrise		13-0031-00		Lake	810		MDNR 2013	II	
815	1580	264	Cass	Swamp		11-0483-00		Lake	592		MDNR 2013	II	
816	1920	604	Lake	Swamp		38-0285-00		Lake	33		MDNR 2013	II	
817	2198	882	Stearns	Swamp		73-0069-00		Lake	40		MDNR 2013	II	
818	1985	669	Nicollet	Swan		52-0034-00		Lake	9346		MDNR 2013	II	
819	2155	839	St. Louis	Swan		69-0863-00		Lake	85		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
820	1490	174	Beltrami	Swenson		04-0085-00		Lake	394		MDNR 2013	II	
821	2029	713	Otter Tail	Sybil		56-0387-00		Lake	654		MDNR 2013	II	
822	1983	667	Morrison	Sylvan		49-0036-00		Lake	260		MDNR 2013	II	
823	1648	332	Cook	Tait		16-0384-00		Lake	386		MDNR 2013	II	
824	1581	265	Cass	Ten		11-0467-00		Lake	28		MDNR 2013	II	
825	1491	175	Beltrami	Ten Mile		04-0267-00		Lake	98		MDNR 2013	II	
826	1582	266	Cass	Ten Mile		11-0413-00		Lake	4640		MDNR 2013	II	
827	2032	716	Otter Tail	Ten Mile		56-0613-00		Lake	1445		MDNR 2013	II	
828	1583	267	Cass	Third River Flowage		11-0147-00	11014701		2260		MDNR 2013	II	
829	1840	524	Itasca	Third Sucker		31-0122-00		Lake	34		MDNR 2013	II	
830	2156	840	St. Louis	Thirty-Six		69-0854-00		Lake	110		MDNR 2013	II	
831	1686	370	Crow Wing	Thompson		18-0172-00		Lake	20		MDNR 2013	II	
832	1352	36	Aitkin	Thornton		01-0174-00		Lake	186		MDNR 2013	II	
833	1585	269	Cass	Three Island		11-0177-00		Lake	168		MDNR 2013	II	
834	1616	300	Clay	Tilde		14-0004-00		Lake	256		MDNR 2013	II	
835	1586	270	Cass	Tobique		11-0132-00		Lake	24		MDNR 2013	II	
836	1921	605	Lake	Tommy		38-0425-00		Lake	8		MDNR 2013	II	
837	1587	271	Cass	Trillium		11-0270-00		Lake	149		MDNR 2013	II	
838	1841	525	Itasca	Trout		31-0216-00		Lake	1953		MDNR 2013	II	
839	1842	526	Itasca	Trout		31-0410-00		Lake	1792		MDNR 2013	II	
840	2158	842	St. Louis	Trout		69-0498-00		Lake	9237		MDNR 2013	II	
841	1649	333	Cook	Tucker		16-0417-00		Lake	168		MDNR 2013	II	
842	1945	629	Mahnomen	Tulaby		44-0003-00		Lake	849		MDNR 2013	II	
843	1353	37	Aitkin	Turner		01-0074-00		Lake	63		MDNR 2013	II	
844	1748	432	Hubbard	Twenty		29-0231-00		Lake	88		MDNR 2013	II	
845	1787	471	Isanti	Twin		30-0004-00		Lake	59		MDNR 2013	II	
846	1786	470	Isanti	Twin		30-0046-00		Lake	31		MDNR 2013	II	
847	1687	371	Crow Wing	Twin (East Twin)		18-0148-02		Lake	25		MDNR 2013	II	
848	2065	749	Polk	Union		60-0217-00		Lake	910		MDNR 2013	II	
849	1359	43	Aitkin	Unnamed		01-0314-00		Lake	16		MDNR 2013	II	
850	1354	38	Aitkin	Unnamed		01-0372-00		Lake	22		MDNR 2013	II	
851	1360	44	Aitkin	Unnamed		01-0450-00		Lake	5		MDNR 2013	II	
852	1381	65	Anoka	Unnamed		02-0029-00		Lake	1037		MDNR 2013	II	
853	1380	64	Anoka	Unnamed		02-0030-00		Lake	235		MDNR 2013	II	
854	1379	63	Anoka	Unnamed		02-0031-00		Lake	635		MDNR 2013	II	
855	1377	61	Anoka	Unnamed		02-0101-00		Lake	148		MDNR 2013	II	
856	1378	62	Anoka	Unnamed		02-0505-00		Lake	1732		MDNR 2013	II	
857	1430	114	Becker	Unnamed		03-0175-00		Lake	25		MDNR 2013	II	
858	1496	180	Beltrami	Unnamed		04-0080-00		Lake	130		MDNR 2013	II	
859	1494	178	Beltrami	Unnamed		04-0090-00		Lake	27		MDNR 2013	II	
860	1495	179	Beltrami	Unnamed		04-0103-00		Lake	43		MDNR 2013	II	
861	1497	181	Beltrami	Unnamed		04-0117-00		Lake	48		MDNR 2013	II	
862	1500	184	Beltrami	Unnamed		04-0131-00		Lake	45		MDNR 2013	II	
863	1499	183	Beltrami	Unnamed		04-0146-00		Lake	34		MDNR 2013	II	
864	1502	186	Beltrami	Unnamed		04-0202-00		Lake	18		MDNR 2013	II	
865	1501	185	Beltrami	Unnamed		04-0220-00		Lake	28		MDNR 2013	II	
866	1503	187	Beltrami	Unnamed		04-0232-00		Lake	32		MDNR 2013	II	
867	1498	182	Beltrami	Unnamed		04-0370-00		Lake	223		MDNR 2013	II	
868	1590	274	Cass	Unnamed		11-0714-00		Lake	19		MDNR 2013	II	
869	1591	275	Cass	Unnamed		11-0776-00		Lake	18		MDNR 2013	II	
870	1592	276	Cass	Unnamed		11-0862-00		Lake	10		MDNR 2013	II	
871	1626	310	Clearwater	Unnamed		15-0049-00		Lake	26		MDNR 2013	II	
872	1693	377	Crow Wing	Unnamed		18-0154-00		Lake	57		MDNR 2013	II	
873	1689	373	Crow Wing	Unnamed		18-0422-00		Lake	20		MDNR 2013	II	
874	1691	375	Crow Wing	Unnamed		18-0424-00		Lake	16		MDNR 2013	II	
875	1688	372	Crow Wing	Unnamed		18-0504-00		Lake	28		MDNR 2013	II	
876	1708	392	Douglas	Unnamed		21-0075-00		Lake	32		MDNR 2013	II	
877	1754	438	Hubbard	Unnamed		29-0057-00		Lake	54		MDNR 2013	II	
878	1760	444	Hubbard	Unnamed		29-0608-00		Lake	9		MDNR 2013	II	
879	1789	473	Isanti	Unnamed		30-0063-00		Lake	55		MDNR 2013	II	
880	1790	474	Isanti	Unnamed		30-0116-00		Lake	36		MDNR 2013	II	
881	1843	527	Itasca	Unnamed		31-0094-00		Lake	30		MDNR 2013	II	
882	1844	528	Itasca	Unnamed		31-1223-00		Lake	65		MDNR 2013	II	
883	1885	569	Kandiyohi	Unnamed		34-0150-01	34015000		19		MDNR 2013	II	
884	1886	570	Kandiyohi	Unnamed		34-0391-00		Lake	16		MDNR 2013	II	
885	1968	652	Mille Lacs	Unnamed		48-0047-00		Lake	25		MDNR 2013	II	
886	2033	717	Otter Tail	Unnamed		56-0094-00		Lake	23		MDNR 2013	II	
887	2039	723	Otter Tail	Unnamed		56-0101-00		Lake	14		MDNR 2013	II	
888	2041	725	Otter Tail	Unnamed		56-0143-00		Lake	31		MDNR 2013	II	
889	2037	721	Otter Tail	Unnamed		56-1031-00		Lake	35		MDNR 2013	II	
890	2064	748	Pine	Unnamed		58-0170-00		Lake	70		MDNR 2013	II	
891	2073	757	Pope	Unnamed		61-0007-00		Lake	32		MDNR 2013	II	
892	2072	756	Pope	Unnamed		61-0091-00		Lake	47		MDNR 2013	II	
893	2074	758	Pope	Unnamed		61-0287-00		Lake	195		MDNR 2013	II	
894	2199	883	Stearns	Unnamed		73-0017-00		Lake	47		MDNR 2013	II	
895	2228	912	Todd	Unnamed		77-0259-00		Lake	50		MDNR 2013	II	
896	2251	935	Wright	Unnamed		86-0244-00		Lake	78		MDNR 2013	II	
897	1427	111	Becker	Unnamed		DNR	being assign*		6		MDNR 2013	II	
898	1428	112	Becker	Unnamed		DNR	W0127601		20		MDNR 2013	II	
899	1504	188	Beltrami	Unnamed (Addition)		04-0144-00		Lake	12		MDNR 2013	II	
900	2040	724	Otter Tail	Unnamed (Beaver Pond Lake)		56-1126-00		Lake	28		MDNR 2013	II	
901	1937	621	Lincoln	Unnamed (Bohemian)		41-0109-00		Lake	111		MDNR 2013	II	
902	1845	529	Itasca	Unnamed (Dishpan)		31-1210-00		Lake	106		MDNR 2013	II	
903	1594	278	Cass	Unnamed (Egg)		11-0975-00		Lake	15		MDNR 2013	II	
904	1505	189	Beltrami	Unnamed (Great Lake Pond)		04-0203-00		Lake	44		MDNR 2013	II	
905	1593	277	Cass	Unnamed (Greenhill)		11-0786-00		Lake	12		MDNR 2013	II	
906	1846	530	Itasca	Unnamed (Hecemovich) (Shamrock)		31-0229-00		Lake	14		MDNR 2013	II	
907	1506	190	Beltrami	Unnamed (Horseshoe)		04-0301-00		Lake	24		MDNR 2013	II	
908	1695	379	Crow Wing	Unnamed (Island)		18-0382-00		Lake	139		MDNR 2013	II	
909	1507	191	Beltrami	Unnamed (Kinn)		04-0100-00		Lake	32		MDNR 2013	II	
910	2066	750	Polk	Unnamed (Leo)		60-0220-00		Lake	34		MDNR 2013	II	

	A	B	C	D	E	F	G	H	I	J	K	L	M
911	1627	311	Clearwater	Unnamed (Little Pine)		15-0293-00		Lake	32		MDNR 2013	II	
912	1435	119	Becker	Unnamed (Little Round)		03-0008-00		Lake	12		MDNR 2013	II	
913	1692	376	Crow Wing	Unnamed (Little Whale)		18-0510-00		Lake	36		MDNR 2013	II	
914	1508	192	Beltrami	Unnamed (Moose)		04-0112-00		Lake	58		MDNR 2013	II	
915	2047	731	Otter Tail	Unnamed (Olson)		56-0436-00		Lake	42		MDNR 2013	II	
916	1509	193	Beltrami	Unnamed (Parkers)		04-0106-00		Lake	48		MDNR 2013	II	
917	1847	531	Itasca	Unnamed (Pinnett)		31-0337-00		Lake	18		MDNR 2013	II	
918	2067	751	Polk	Unnamed (Tamarack)		60-0247-00		Lake	92		MDNR 2013	II	
919	1356	40	Aitkin	Unnamed (Twin Lakes)		01-0413-00		Lake	10		MDNR 2013	II	
920	1492	176	Beltrami	Unnamed (Twin Pothole North)		04-0010-00		Lake	9		MDNR 2013	II	
921	1493	177	Beltrami	Unnamed (Twin Pothole South)		DNR	not assigned		7		MDNR 2013	II	
922	1922	606	Lake	Unnamed (Two Fifty Four)		38-0254-00		Lake	12		MDNR 2013	II	
923	1848	532	Itasca	Unnamed (Wildlife Marsh)		31-1209-00		Lake	70		MDNR 2013	II	
924	1436	120	Becker	Upper Cormorant		03-0588-00		Lake	963		MDNR 2013	II	
925	1510	194	Beltrami	Upper Lindgren		04-0179-00		Lake	56		MDNR 2013	II	
926	1598	282	Cass	Upper Milton		11-0081-00		Lake	27		MDNR 2013	II	
927	1696	380	Crow Wing	Upper South Long		18-0096-00		Lake	793		MDNR 2013	II	
928	1361	45	Aitkin	Vanduse		01-0058-00		Lake	233		MDNR 2013	II	
929	1525	209	Carlton	Venoah		09-0009-00		Lake	82		MDNR 2013	II	
930	2161	845	St. Louis	Vermilion Falls Section - Vermilion		09030002-53	R001-46V				MDNR 2013	II	
931	1599	283	Cass	Vermillion		11-0029-00		Lake	408		MDNR 2013	II	
932	1600	284	Cass	Vermillion River		07010106-50	11r1	Stream			MDNR 2013	II	
933	1650	334	Cook	Vern		16-0409-00		Lake	230		MDNR 2013	II	
934	1849	533	Itasca	Wabana		31-0392-00		Lake	2146		MDNR 2013	II	
935	1437	121	Becker	Waboose		03-0213-00		Lake	249		MDNR 2013	II	
936	1766	450	Hubbard	Waboose		29-0098-00		Lake	158		MDNR 2013	II	
937	1923	607	Lake	Wager		38-0458-00		Lake	10		MDNR 2013	II	
938	1850	534	Itasca	Wagner		31-0912-00		Lake	63		MDNR 2013	II	
939	1438	122	Becker	Wahbegon		03-0082-00		Lake	121		MDNR 2013	II	
940	1888	572	Kandiyohi	Wakanda Lake		34-0169-00		Lake	1792		MDNR 2013	II	
941	1946	630	Mahnomen	Wakefield		44-0122-00		Lake	149		MDNR 2013	II	
942	1651	335	Cook	Wampus		16-0196-00		Lake	33		MDNR 2013	II	
943	1924	608	Lake	Wanless		38-0049-00		Lake	78		MDNR 2013	II	
944	1958	642	Meeker	Washington		47-0046-00		Lake	2524		MDNR 2013	II	
945	1925	609	Lake	Watonwan		38-0079-00		Lake	58		MDNR 2013	II	
946	1601	285	Cass	Webb		11-0311-00		Lake	619		MDNR 2013	II	
947	1602	286	Cass	Welch		11-0493-00		Lake	191		MDNR 2013	II	
948	1926	610	Lake	West Chub		38-0675-00		Lake	124		MDNR 2013	II	
949	1628	312	Clearwater	West Four-Legged		15-0028-01		Lake	129		MDNR 2013	II	
950	2252	936	Wright	West Lake Sylvia		86-0279-00		Lake	1027		MDNR 2013	II	
951	2048	732	Otter Tail	West Silent		56-0519-00		Lake	340		MDNR 2013	II	
952	1629	313	Clearwater	Whipple		15-0014-00		Lake	30		MDNR 2013	II	
953	2162	846	St. Louis	White		69-0030-00		Lake	134		MDNR 2013	II	
954	2163	847	St. Louis	White Iron		69-0004-00		Lake	3429		MDNR 2013	II	
955	1867	551	Kanabec	White Lily		33-0008-00		Lake	32		MDNR 2013	II	
956	2164	848	St. Louis	Whiteface Reservoir		69-0375-00		Lake	4980		MDNR 2013	II	
957	1512	196	Beltrami	Whitefish		04-0300-00		Lake	122		MDNR 2013	II	
958	2165	849	St. Louis	Whitewater		69-0376-00		Lake	599		MDNR 2013	II	
959	1362	46	Aitkin	Wilkins		01-0102-00		Lake	366		MDNR 2013	II	
960	2230	914	Todd	William		77-0180-00		Lake	131		MDNR 2013	II	
961	1851	535	Itasca	Wilson		31-0320-00		Lake	84		MDNR 2013	II	
962	1927	611	Lake	Wilson		38-0047-00		Lake	666		MDNR 2013	II	
963	1513	197	Beltrami	Wolf		04-0079-00		Lake	1206		MDNR 2013	II	
964	2166	850	St. Louis	Wolf		69-0161-00		Lake	301		MDNR 2013	II	
965	2050	734	Otter Tail	Zorns		56-0497-00		Lake	49		MDNR 2013	II	
966	2200	884	Stearns	Zumwalde		73-0089-00		Lake	111		MDNR 2013	II	
967	2295		Lake	Good		38-0726-00		Lake	175		MPCA Bio2015	II	
968	653	594	Douglas	Anka Lake		21-0353-00		Lake	208		UofM/MPCA 2013, MDNR 2013	II	

Technical Review Comments on MPCA's Proposed Flexible Standard for Sulfate in Wild Rice Beds

Proposed Minnesota Pollution Control Agency Rulemaking

John Pastor, PhD (November 2017)

Background and Research

I am a Professor of Biology at the University of Minnesota Duluth, past Co-Chair of the Natural History Section of the Ecological Society of America, and an Honorary Member of the Faculty of Forest Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden.

I received my B.S. in Geology from the University of Pennsylvania in 1974, and my Ph.D. in Forestry and Soil Science in 1980 from the University of Wisconsin-Madison. I've also done post-doctoral research in the Environmental Sciences Division at Oak Ridge National Laboratory. I've authored two books on ecology, over 100 peer-reviewed papers, and over 20 book chapters. My papers have been cited over 17,000 times by other scientists. My *curriculum vitae* is provided (attachment A) with these comments.

For the past ten years, my research has focused on the ecology of wild rice, including the effects of sulfate pollution and iron on wild rice. This work has been funded by the National Science Foundation, Minnesota Pollution Control Agency, Fond du Lac and Grand Portage Bands of Lake Superior Chippewa, and Minnesota Sea Grant. I was the lead researcher for the hydroponic experiments and tank mesocosm studies of sulfate and wild rice coordinated by the Minnesota Pollution Control Agency (MPCA) in the Wild Rice Sulfate Standard Study funded by the Minnesota Legislature. However, our mesocosm studies of wild rice and sulfates began several years before the MPCA study and have continued through 2017.

Results of the first several years of my research regarding effects of sulfate and sulfide on the life cycle of wild rice in hydroponic and mesocosm experiments were published in a peer-reviewed journal article (Pastor *et al*. 2017) provided (attachment B) with these comments.

For the past several years, I have continued mesocosm research designed to test the MPCA's hypothesis that sediment iron would protect wild rice from the effects of high surface water concentrations of sulfate. The results of this research are reflected in a Minnesota Sea Grant Progress 2016 report (attachment C) and a Minnesota Sea Grant Progress 2017 report (attachment D) provided with these comments. One of my graduate students, Sophia LaFond-Hudson, studied iron and sulfur cycling in the root zones of wild rice in an experimental growing wild rice in buckets. Her 2016 Master's thesis on this research (LaFond-Hudson, 2016) is also provided with my comments (attachment E). The 2016 Sea Grant Progress Report and Ms. LaFond-Hudson's thesis were provided to the MPCA in the summer of 2016. I also presented a slide presentation on the experimental effects of iron and sulfate on wild rice to the MPCA and Wild Rice Sulfate Standard Study Advisory Committee in August 2016. That slide presentation is also provided with my comments (attachment F).

I was contacted by WaterLegacy to review the MPCA's proposal to replace Minnesota's existing fixed standard of 10 milligrams per liter (mg/L) sulfate applicable to water used for the production of wild rice (Minn. R. 7050.0224, subp. 2) with a flexible standard derived through the use of an equation. Throughout the past six years, I have read numerous MPCA draft proposals, internal memos, peer review materials, submitted and published articles and comments of various entities and experts. In preparing these comments, I also reviewed the MPCA's draft rule, Statement of Need and Reasonableness and Exhibit 1 Technical Support Document.

Summary

1) Our recent research at the University of Minnesota Duluth demonstrates that sulfide, not sulfate, is toxic to seedlings of wild rice. The MPCA proposes that iron can protect wild rice by precipitating with the sulfide. However, the addition of iron to mesocosms with high sulfate concentrations did not entirely mitigate the toxic effects of sulfide to seedlings. Our research also demonstrates that precipitation of iron sulfide on wild rice roots can inhibit nutrient uptake needed to ripen seeds, so iron sulfide can have negative effects on wild rice sustainability. Setting sulfate limits based on the level of sediment iron is premature and is not reasonable.

2) In addition, the MPCA's model assumes that concentrations of sulfide, sulfate, reactive iron and organic matter are in a steady state. This is not a reasonable assumption, especially once sulfate loading increases from various sources of pollution.

3) Both historic field data and the recent field surveys performed by the University of Minnesota as part of the Wild Rice Sulfate Standards Study demonstrate that concentrations of sulfate in surface water above 10 mg/L proposed in the MPCA's flexible standard may not adequately protect wild rice.

Statement of the problem

The State of Minnesota now has a fixed standard of "10 mg/L sulfate applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels" (Minn. R. 7050.0224, subp. 2). This standard, developed during the 1970s, is based on research by DNR botanist John Moyle, who found that "No large stands of rice occur in water having sulfate content greater than 10 ppm [parts per million, or mg/L], and rice generally is absent from water with more than 50 ppm" (Moyle 1944).

Application of Minnesota's sulfate standard has been rare and controversial. To put this in perspective, EPA drinking water standards for sulfate are 250 mg/L, while EPA standards for sulfide in surface waters to protect aquatic life are very low; 2 parts per billion (2ug/L). Although ecologists, including John Moyle, have long believed that wild rice toxicity resulted from conversion of sulfate to sulfide in sediments with low concentrations of oxygen, little experimental data confirmed that hypothesis. Research was designed to evaluate what factors resulted in wild rice toxicity and whether limiting sulfate was necessary to prevent sulfide-induced toxicity.

Sulfate, Sulfide and Iron Research

Sulfate is released to surface waters by several industrial processes, but *sulfate* is transformed into *sulfide* in waterlogged sediments with low concentrations of oxygen. Our initial investigations of the effects of sulfate and sulfide on the life cycle of wild rice (*Zizania palustris* L.) in hydroponic solutions and in outdoor mesocosm tanks demonstrated that sulfide, not sulfate, is toxic to seedlings of wild rice. In hydroponic solutions, sulfate had no effect on seed germination or juvenile seedling growth and development, but sulfide greatly reduced juvenile seedling growth and development at concentrations greater than 320 µg/L.

When we added sulfate to experimental mesocosm tanks where wild rice was grown in sediments from a wild rice lake under low oxygen conditions similar to those in a natural environment, sulfate additions to overlying water increased sulfide production in sediments. Seedling emergence, seedling survival, vegetative growth and seed production all declined in proportion to the amount of sulfate added and the amount of sulfide produced.

In each spring after the initial planting in 2011, the number of seedlings that emerged from the sediment declined significantly with increased sulfate concentrations ($p < 0.001$). The rate of seedling survival also declined significantly with increased sulfate concentrations ($p < 0.001$) and became worse in each subsequent year ($p < 0.001$). The rate of decline in seedling survival with amended sulfate was twice as high in 2014 and 2015 as it was in 2012 and 2013 (Pastor *et al*. 2017).

Elevated sulfate and presumably sulfide concentrations decreased vegetative growth, measured as plant biomass ($p < 0.001$), and the rate of decline increased significantly during the course of the experiment. Although the overall number of seeds produced per plant did not change across sulfate concentrations, the proportion of seeds produced that were filled and thus able to propagate declined significantly with increasing sulfate concentrations ($p < 0.001$). The proportion of filled seeds declined more steeply with each successive year ($p < 0.001$) (Pastor *et al.* 2017).

These declines in seed production and seedling survival lead to the extinction of wild rice populations after 5 years at sulfate concentrations comparable to drinking water standards (Pastor *et al*. 2017). Populations of wild rice exposed to sulfate concentrations of 150 mg/L have continued to decline over the course of the mesocosm experiments, nearing the point of extinction (Progress Report 2017). In addition, we have noticed a parallel decline in other species in the tanks with enhanced sulfate concentrations. These species include the larvae of dragonflies and caddisflies, which are important foods for fish such as walleye that typically inhabit wild rice lakes. Therefore, the decline in population densities with enhanced sulfate concentrations may not be limited to wild rice but in fact may happen to other important species of the food web.

The MPCA also coordinated a parallel field study of over 100 wild rice lakes. The MPCA's preliminary findings seemed to support retaining the existing 10 mg/L sulfate limit to protect wild rice from sulfide-induced toxicity. However, the MPCA is currently proposing to replace its 10 mg/L fixed sulfate standard with a flexible standard based on a model which attempts to predict sulfide concentrations in sediment of each individual lake from the concentration of sulfate in surface waters and the concentrations of reactive iron and organic matter in sediments from these lakes.

Geochemistry supports the MPCA's basic premise that iron may reduce sulfide concentrations in sediments. Sulfate is converted to sulfide by microorganisms that also obtain energy by decomposing organic matter. Iron is present in many forms in wild rice beds but the more important form for the purpose of this model is ferrous iron, a form that can reduce the reactivity of sulfide in sediment.

However, MPCA's proposed model relies on a critical assumption that is tenuous and has not been experimentally verified. The MPCA assumes that any precipitation of sulfide by iron helps to protect wild rice. Our experimental mesocosm research has substantially undermined this assumption. During the course of our initial mesocosm (tank) experiments, we noticed that wild rice roots in tanks with more than 50 mg/L sulfate had become blackened. In contrast, plants grown in the low sulfate treatments had orange stains on the roots throughout the annual life cycle. Using SEM elemental scans, we identified the black plaques as iron sulfide (FeS) plaques, whereas the orange stains had iron but no sulfide and are most likely iron (hydr)oxides. (Pastor *et al*. 2017; Sea Grant Report 2017).

Figure 1. Orange healthy roots (left) of wild rice grown under low sulfate concentrations near the current standard and black iron sulfide coatings on roots of plants grown with high sulfate concentrations.

We learned that iron sulfide precipitates rapidly on wild rice roots in midsummer at the time when the plants are beginning to flower and take up additional nutrients for the ripening seeds. The iron sulfide precipitates gave the roots a black appearance, compared to amber or rust colored roots on healthy plants exposed to sulfate concentrations near the current fixed standard of 10 mg/L. Seed nitrogen, seed count and seed weight were all markedly reduced in plants with back root surfaces exposed to high sulfate surface water concentrations (300 mg/L) because these black iron sulfide precipitates inhibit the uptake of nutrients necessary for the filling and ripening of seeds necessary for propagation of wild rice. This happened even though the amount of iron remaining in the sediment was sufficient to remove sulfide from sediment porewater. These experiments are detailed in Progress Report (2017) and LaFond-Hudson (2016). Plants grown at lower concentrations of sulfate had black iron sulfide coatings in proportionally lower amounts, as well as proportionally reduced seed production (Pastor et al. 2017).

Our experimental mesocosms contained sediment iron near the median of that observed in field conditions. Our more recent experiments, in which we tripled the amount of sediment iron in the first growing season and removed litter to reduce carbon supply for microbes under sulfate conditions of 300 mg/L, began in 2015. During the three years of this experiment, sulfate amendments had the greatest effect on outcomes, reducing seedling survival, plant growth, and seed production. Litter removal had no effect on seedlings, vegetative growth, or seed production. Adding iron without sulfate had no effect on seedling survival, plant growth, or seed production. Iron amendments in the presence of sulfate increased seedling survival compared with seedlings grown under sulfate amendments alone, but seedling survival in the tanks with both iron and sulfate additions was still less than in control tanks. (Progress Report 2017). Our experiments found that precipitation of iron sulfide in the sediment may temporarily ameliorate the effects of sulfate on seedling survival, but by the spring of year three, iron amendment no longer had an effect on seedling survival, possibly because almost all the added iron had been precipitated. (Progress Report 2017).

Our experiments demonstrate that precipitation of sulfide in the presence of high levels of iron has both ameliorative and negative effects on wild rice growth. Iron additions may partly ameliorate sulfide toxicity to seedlings in spring. However, precipitation of iron sulfide plaques on roots during the flowering and seed production period of wild rice's life cycle appears to block uptake of nitrogen, leading to fewer and smaller seeds with reduced nitrogen content. The net effect of sulfate additions to wild rice populations is to drive the populations to extinction within 4 or 5 years at high concentrations of sulfate (300 mg/l), even when iron was added to the sediments. Sulfate loading greatly reduce population viability at lower concentrations.

How and whether iron mitigates sulfide toxicity to wild rice is not fully understood and appears not to be related to the amount of reactive iron in sediments in the simple way assumed by MPCA's model. Therefore, setting sulfate standards based on the amount of reactive iron in sediments is premature at best. Based on current scientific evidence, an equation determining "protective" sulfate levels based on iron in sediments and available carbon is not a defensible strategy to protect wild rice.

Finally, MPCA claims, on p. 82 in their Statement of Need and Reasonableness, that concentrations of sulfate above the allowable standard in one year out of ten would not have a significant impact on wild rice populations in the long run. They cite our experiments in support of this conclusion. While I agree that it is important to determine the allowable frequency and degree of excursions to avoid impacts on wild rice, I must also point out that our experiments were not designed to determine what these might be. At present, a one-in-ten year allowable excursion is premature and requires further experiments designed specifically to determine what level of excursions does not harm the long term sustainability of wild rice populations.

Steady State Concentrations

In addition to assuming a simple relationship between iron in sediments and survival of wild rice, MPCA's model assumes that the concentrations of sulfide, sulfate, reactive iron, and organic matter in the sites from which the equation was developed are in steady state, which means that their concentrations do not change over long periods of time.

MPCA claims that the assumption of steady state is verified by data that concentrations of these elements of the model did not change during one growing season. But one growing season is insufficient to test the assumption of steady state. The steady state assumption must be tested against data across years, particularly in systems subject to transient changes to sulfate from industrial discharges. Until longer-term information is obtained, we do not know if these ecosystems are in a steady state from one year to the next. If the ecosystems are not in steady state, then the calculation that a certain sulfate concentration in surface water creates lower-than-toxic levels of sulfide during one year may not apply to subsequent years. A sulfate concentration deemed "protective" in year one could become toxic in subsequent years.

Once sulfate inputs to a wild rice bed increase as a result from discharge of wastewater, ecosystems will no longer be in steady state. Microbes in the sediments will convert some of this sulfate to additional sulfide and the sulfide will precipitate with some of the reactive iron and convert it to iron sulfide precipitates. But the iron in these precipitates will no longer be available to precipitate any additional sulfide. The reactive iron removed by precipitation with sulfide must be replenished by inputs of additional iron for the initial calculation to remain valid. In an ecosystem, it cannot be assumed that natural inputs of reactive iron from streams and groundwater or from weathering of sediments will keep pace with sulfate pollution.

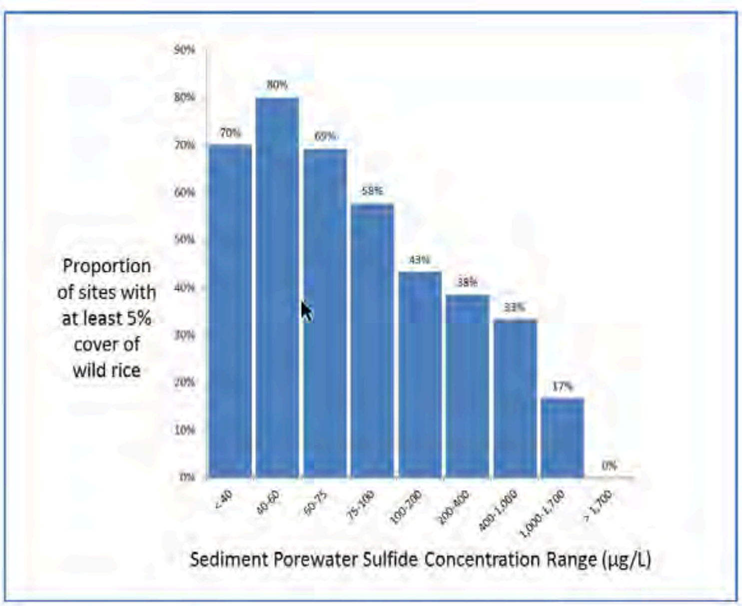
The amount of reactive iron in a localized area will decline with increased sulfate loading, just as a checkbook balance declines when withdrawals increase without a matching increase in deposits. MPCA's model does not demonstrate that natural inputs of iron would replenish the reactive iron in the sediment commensurate with sulfate discharge. The model assumes, without evidence, that iron input will remain at a rate sufficient to ameliorate sulfide toxicity from the additional sulfate without creating additional adverse consequences for wild rice survival.

As also pointed out by Prof. David Schimpf (Schimpf, 2015), a decision to allow sulfate concentrations in surface waters above their current levels in certain sites could look reasonable for a while, but become inadvisable and fail to protect wild rice over time.

Concentrations of Sulfate Greater than 10 mg/L May Not Adequately Protect Wild Rice

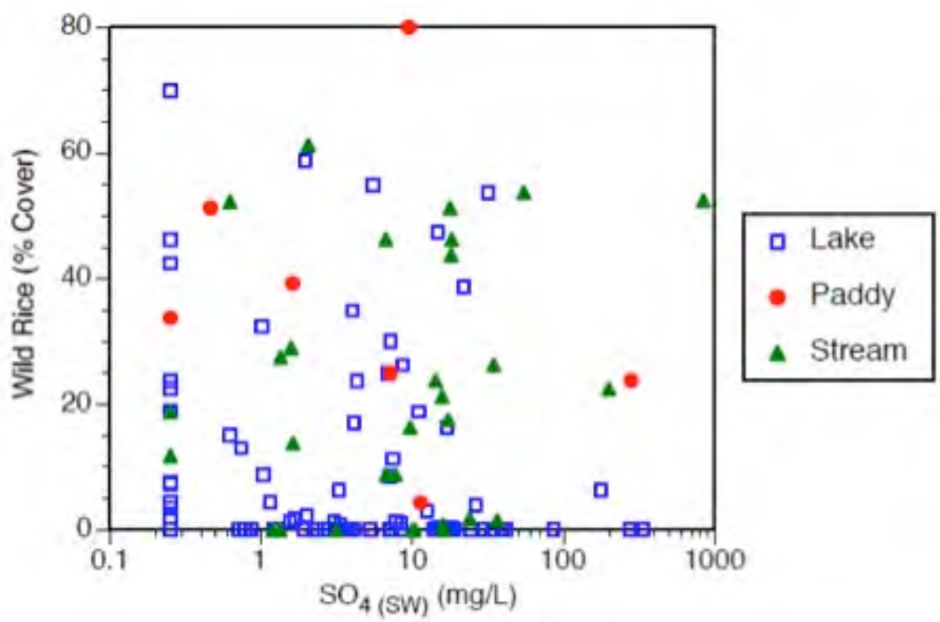
Professor Shimpf has also raised the concern that the MPCA's proposal, by focusing on the presence of wild rice may redefine "protect wild rice" in a weaker sense than that of the existing standard, which was based on John Moyle's field research finding no large stands of wild rice in Minnesota where sulfate exceeded 10 mg/L and that wild rice was "generally absent" where sulfate exceeded 50 mg/L. (Schimpf, 2015)

Data from MPCA's survey lakes demonstrate a decline in wild rice abundance at sulfide concentrations above 75 µg/L, which is below MPCA's proposed EC10 of 120 µg/L. (MPCA, 2014). In addition, a standard that is based on 5% wild rice cover may not protect wild rice sustainability.



MPCA's flexible standard, based on calculating a "protective sulfate concentration" to attain a sulfide level of 120 ug/L, would allow sulfate concentrations more than an order of magnitude above the current sulfate limit of 10 mg/L in many cases and could sometimes result in allowing sulfate concentrations two orders of magnitude higher than the current standard. For example, the MPCA has calculated that a "protective sulfate concentration" for the St. Louis Estuary would range from 99.5 mg/L to 241.1 mg/L, while a "protective" concentration of sulfate for the Embarrass River would be 1248.9 mg/L. (See MPCA spreadsheet, attachment G).

Current data collected by MPCA demonstrate that allowing sulfate concentrations much greater than 10 mg/L (the current standard) may not protect wild rice. This chart prepared by an MPCA staff scientist from the 119 field study sites [1] shows that over 70% of wild rice ecosystems are found in sulfate concentrations of 10 mg/L or less and 94 % are found in lakes or streams with sulfate concentrations below 50 mg/L. Even though the MPCA field survey was designed to study sites with wild rice present despite high sulfate levels (MPCA, 2014), field survey findings strongly corroborate Moyle's (1944) conclusions.



This figure illustrates the infrequency of wild rice presence and density in waters with sulfate concentrations above the current standard of 10 mg/L. Based on its model and equation, MPCA's proposed flexible standard would allow for much higher concentrations of sulfate to be defined as "protective" if high levels of iron were present. Sulfate limits set for individual water bodies above the current standard of 10 mg/L incur increased risk to the sustainability of wild rice populations.

Sandy Lake provides an example of the decline of wild rice populations in the presence of sulfate exceeding the existing 10 mg/L standard despite high sediment iron concentrations. Sandy Lake (MN DNR ID 69-0730-00, in St. Louis County) had extensive and productive wild rice populations in the past. Sandy Lake has received discharge from a nearby tailings pond of an iron mine since the

[1] Edward Swain, MPCA, "The world's 4 species of wild rice," slide presentation to Minnesota Native Plant Society, Feb. 4, 2016.

mid-1960s. The MPCA sampled water and sediment and counted wild rice stem density in Sandy Lake 10 times from June through September in 2013 (Appendix G). The sulfate concentration in Sandy Lake during 2013 averaged 95 mg/L, which is not significantly different from the calculated average allowable sulfate concentration using MPCA's flexible standard model of 79 mg/L, although it is significantly higher than the existing wild rice sulfate limit of 10 mg/L. The sediment of Sandy Lake has high iron content, 23,540 ug/g, which is nearly three times the statewide average (8800 µg/mg) for all non-paddy wild rice water bodies sampled by MPCA. Despite this high iron content, wild rice was largely absent at all times and sampling locations in Sandy Lake, except for two locations with very low population densities (0.6 stems per m^2 at one location on Sept. 17 and 3.8 stems per m^2 at another location on Sept. 21). These low densities are highly unlikely to be viable in the long run.

If MPCA's model is correct, then wild rice should be present and abundant in Sandy Lake because of the high sediment iron content and the similarity of the concentration of sulfate in the water compared to the allowable sulfate concentrations. And yet, despite the high iron content of the sediment, MPCA could barely find any wild rice in Sandy Lake. Although wild rice is present in Sandy Lake and thus appears in MPCA's modeling as a lake with wild rice despite high sulfate concentrations the populations of wild rice in Sandy Lake are clearly not healthy, especially compared to what is known to have been present in the past.

Conclusion

The Wild Rice Sulfate Standard Study wild rice research funded by the Minnesota Legislature and coordinated by the MPCA has made important contributions to our understanding of the process of sulfide-induced toxicity resulting from sulfate concentrations in surface waters in the presence of iron and other factors. However, based on my training and experience, it is my opinion that the weight of the scientific evidence supports retaining Minnesota's existing sulfate standard of 10 mg/L to protect wild rice. As sulfate concentrations rise above the current standard, the risk to sustainable wild rice populations increases because of increased sulfide production.

Although the MPCA's conceptual framework pertaining to sulfate reduction to sulfide and iron sulfide precipitation has substantial merit, making the leap from this conceptual understanding to the MPCA's proposed flexible standard equation makes important assumptions about the ameliorative effects of iron and the continuation of a steady state over time despite sulfate addition to the ecosystems. These assumptions cannot be defended based on scientific evidence. Both experimental research and field data suggest that sulfate concentrations above 10 mg/L may not protect wild rice and that sulfate concentrations an order of magnitude or more above 10 mg/L, as would be allowed in some water bodies by MPCA's proposed flexible standard, are likely to result in decline and extinction of wild rice over time.

Attachments

A. John Pastor *curriculum vitae*.

B. John Pastor *et al*., Effects of sulfate and sulfide on the life cycle of Zizania palustris in hydroponic and mesocosm experiments, Ecological Applications, 27(1), 2017, pp. 321-336.

C. John Pastor, Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palustris*), August 18, 2016 slide presentation.

D. John Pastor, The biogeochemical Habitat of Wild Rice, Minnesota Sea Grant Report May 5, 2016.

E. John Pastor, Progress Report on Experiments on Effects of Sulfate and Sulfide on Wild Rice, June 28, 2017.

F. Sophia LaFondn Hudson, Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palustris*) May 2016, Masters dissertation.

G. MPCA, Field Data with CPSC (All MN Data), Aug. 17, 2016.

Additional References

John Moyle, Wild Rice in Minnesota, Journal of Wildlife Management, Vol. 8, No. 3 (1944)

MPCA, Analysis of the Wild Rice Sulfate Standard Study: Draft for Scientific Peer Review, June 9, 2014.

David Schimpf, Comments on the Minnesota Pollution Control Agency's draft proposed approach for Minnesota's sulfate standard to protect wild rice (March 24, 2015), Dec. 14, 2015.

Ed Swain, MPCA, Plant-of-the-month: The world's 4 species of wild rice (Zizania Linnaeus) slide presentation at Minnesota Native Plan Society, Feb. 4, 2016.

John Pastor Technical Review Comments - Wild Rice Rule
November 2017

Attachment A

(27 pages)

JOHN PASTOR
Department of Biology
University of Minnesota Duluth
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Education
Ph.D., Forestry and Soil Science, University of Wisconsin, Madison, June 1980
M.S., Soil Science, University of Wisconsin, Madison, December 1977
B.S., Geology, University of Pennsylvania, May 1974

Present Positions
Professor, Dept. of Biology, University of Minnesota Duluth (July 1996 – present)

Director, Natural History Minor, University of Minnesota Duluth (March 2009 – present)

Previous Positions
Associate Director of Graduate Studies, Ecological, Organismal, and Population Biology Track, Integrated Biosciences Graduate Program, University of Minnesota Duluth (March 2006 – May 2009)

Director of Graduate Studies, Biology Graduate Program, University of Minnesota Duluth (July 2000 – August 2009)

Visiting Scientist, Dept. of Animal Ecology, Swedish University of Agricultural Sciences, Umeå, Sweden (June – July 1998, and annually thereafter)

Visiting Scientist, Macaulay Land Use Research Institute, Aberdeen, Scotland (May 1997)

Distinguished Visiting Professor, College of Forestry, University of Washington, Seattle, Washington (March 1991)

Visiting Scientist, Institute of Applied Ecology, Shenyang, People's Republic of China (July – August 1988)

Senior Research Associate, Natural Resources Research Institute, University of Minnesota Duluth (July 1985 – 2006)

Postdoctoral Fellow, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831 (August 1983 – June 1985)

Postdoctoral Research Associate, Department of Forestry, University of Wisconsin, Madison, WI 53706 (June 1980 – July 1983)

Graduate Student, Departments of Soil Science and Forestry, University of Wisconsin, Madison, WI 53706 (September 1975 – May 1980)

Staff Geologist, Ralph Stone Engineers, Los Angeles, CA 97821 (September 1974 – August 1975)

Research Interests

Species effects on nutrient cycling, plant-herbivore interactions, northern ecosystems, mathematical ecology

Awards and Honors

Honorary Life Member, Finnish Society of Forest Science, elected May 1999

First Recipient, Chancellor's Distinguished Research Award, University of Minnesota Duluth, November 1999

Institute of Scientific Information, Highly Cited List, Ecology and Environment, 2002 – 2012

Sabra and Dennis Anderson Scholar/Teacher Award, College of Science and Engineering, University of Minnesota Duluth, May 2007

University of Minnesota Council of Graduate Students Outstanding Faculty Award, April 2010

Doctores honoris causa, Faculty of Forest Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden, October 2010

Distinguished Ecologist Lecture, Colorado State University, April 2012

Teaching

Courses

Dept. of Biology, University of Minnesota Duluth: Biology 5776, "Ecosystem Ecology" (Spring 1990, Fall 1993, Fall 1998 and alternate years to present)

Dept. of Fisheries and Wildlife, University of Minnesota, St. Paul: Fisheries and Wildlife 8579, "Ecosystem Analysis and Simulations" (Winter 1993)

Province of Ontario and Lakehead University: "Ontario Advanced Forestry Program", Lecturer, 1992 and 1993

Dept. of Biology, University of Minnesota Duluth: Biology 5774, "Forest Ecology" (Summer 1994), with George Host

Dept. of Biology, University of Minnesota Duluth: Biology 5155, "Evolutionary Biology" (Fall 1994), with Carl Richards

Dept. of Biology, University of Minnesota Duluth: Biology 8871, "Graduate Seminar: Soil Genesis" (Winter 1994)

Dept. of Biology, University of Minnesota Duluth: Biology 8871, "Graduate Seminar: Measurement of Ecological Diversity" (Winter 1995 and Winter 1998)

Dept. of Biology, University of Minnesota Duluth: Biology 3871, "Issues in Global Change" (Winter 1996)

Dept. of Biology, University of Minnesota Duluth: Biology 5821, "Mathematical Ecology" (Fall 1997 and alternate years to present)

Dept. of Biology, University of Minnesota Duluth: Biology, "Graduate Seminar: Species Diversity in Time and Space" (Winter 1997)

Dept. of Biology, University of Minnesota Duluth: Biology 1102, "Biology & Society" (Spring 1998)

Dept. of Biology, University of Minnesota Duluth: Biology, "Graduate Seminar: Ecological Stoichiometry" (Spring 2005)

Dept. of Biology, University of Minnesota Duluth: Biology 5583, "Animal Behavior" (Spring 1999 – present)

Dept. of Biology, University of Minnesota Duluth: Biology 1097, "Biological Illustration" (Fall 1999 – present)

Dept. of Biology, University of Minnesota Duluth: Biology 8099, "The Biological Practitioner" (Fall 1997 – 2005)

Dept. of Biology, University of Minnesota Duluth: Integrated BioSciences 8011, "Integrated Biological Systems" (Fall 2006 – present)

Dept. of Biology, University of Minnesota Duluth: Integrated BioSciences 8201, "Ecological Processes" (Spring 2007 – present)

Graduate Students and Postdoctoral Fellows

Pamela McInnes, M.S. Wildlife Conservation, 1989 (co-advised with Y. Cohen)
Thesis title: Moose browsing and boreal forest dynamics, Isle Royale, Michigan, USA

Carmen Chapin, M.S. Biology, 1994
Thesis title: Nutrient limitations in the northern pitcher plant *Sarracenia purpurea*.

Ron Moen, Ph.D. Wildlife Conservation, 1995 (co-advised with Y. Cohen)
Thesis title: Evaluating foraging strategies with linked spatially explicit models of moose energetics, plant growth, and moose population dynamics

Cindy Hale, M.S. Biology, 1996
Thesis title: Comparison of structural and compositional characteristics and coarse woody debris dynamics in old-growth versus mature hardwood forests of Minnesota, USA

John Terwilliger, M.S. Biology, 1997
Thesis title: Small mammals, ectomycorrhizae, and conifer succession in beaver meadows

Jean Fujikawa, M.S. Wildlife Conservation, 1997 (co-advised with Y. Cohen)
Thesis title: Interfacing songbird habitats with simulation processes

Scott McGovern, M.S. Biology, 1999
Thesis title: The effects of nitrogen, bacteria, and tachinid parasitoids on the nutrition of the spruce budworm (*Choristoneura fumiferana* Clem.)

Bingbing Li, M.S. Applied and Computational Mathematics, 2001
Thesis title: Mapping and modelling change in a boreal forest landscape

David VanderMeulen, M.S. Water Resources Science, 2001
Thesis title: Decay and nutrient dynamics of litter from peatland plant species

Nathan DeJager, M.S. Biology, 2004
Thesis title: Interactions between moose and the fractal geometries of birch (*Betula pubescens* and *B. pendula*) and Scots Pine (*Pinus sylvestris*)

Wendy Graves, M.S. Applied and Computational Mathematics, 2004 (co-advised with B. Peckham)
Thesis title: A Bifurcation Analysis of a Differential Equations Model for Mutualism

Laura Zimmerman, M. S., Applied and Computational Mathematics, 2006 (co-advised with B. Peckham)
Thesis title: A producer-consumer model with stoichiometry

Rachel Durkee Walker, Ph.D. Water Resources Science, 2008
Thesis title: Wild rice: the dynamics of its population cycles and the debate over its control at the Minnesota Legislature

Laurence Lin, M.S. Applied and Computational Mathematics, 2008 (co-advised with B. Peckham and H. Stech)
Thesis title: A stoichiometric model of two producers and one consumer

Nathan DeJager, Ph.D. Ecology, Evolution, and Behavior, 2008
Thesis title: Multiple scale spatial dynamics of the moose-forest-soil ecosystem of Isle Royale National Park, MI, USA

Rachel MaKarrall, M.S. Biology, 2009 (co-advised with T. Craig)
Thesis title: Creating useful tools for learning insect anatomy

Diana Ostrowski, M.S. Integrated BioSciences, 2009
Thesis title: White-tailed deer browsing and the conservation of forest songbirds and understory vegetation: A natural experiment within the Apostle Islands National Lakeshore

Angela Hodgson, Ph.D. Ecology, Evolution, and Behavior, 2010
Thesis title: Temporal changes in spatial patterns in a boreal ecosystem, causes and consequences

Lauren Hildebrandt, M.S., Integrated BioSciences, 2011
Thesis title: Decay and nutrient dynamics of wild rice litter in response to N and P availability and litter quality

Lee Sims, M.S. Integrated BioSciences, 2011
Thesis title: Light, nitrogen, and phosphorus effects on growth, allocation of biomass and nutrients, reproduction, and fitness in wild rice (*Zizania palustris* L.)

Angelique Edgerton, M.S. Integrated BioSciences, 2013
Thesis title: Structure of relict arctic plant communities along the north shore of Lake Superior

David Wedin, Postdoctoral Fellow, 1990 – 1992

Scott Bridgham, Postdoctoral Fellow, 1993 – 1995 (co-advised with C. Johnston)

Ron Moen, Postdoctoral Fellow, 1995 – 1998 (co-advised with Y. Cohen)

Terry Brown, Postdoctoral Fellow, 1997 – 2000 (co-advised with C. Johnston)

Thesis Opponent for the Following Ph.D. students

Otso Suominen, Ph.D. Biology, Turku University, Turku, Finland, 1999
Thesis title: Mammalian herbivores, vegetation, and invertebrate assemblages in boreal forests: feeding selectivity, ecosystem engineering and trophic effects

Johan Olofsson, Ph.D. Ecology and Environmental Science, Umeå University, Umeå, Sweden, 2001
Thesis title: Long term effects of herbivory on tundra ecosystems

Sari Stark, Ph.D. Biology, University of Oulu, Oulu, Finland, 2002
Thesis title: Reindeer grazing and soil nutrient cycling in boreal and tundra ecosystems

Caroline Lundmark, Ph.D. Wildlife, Fish, and Conservation, Swedish University of Agricultural Sciences, 2008
Thesis title: Morphological and behavioural adaptations of moose to climate, snow, and forage

Professional Service

National Science Foundation

Ad Hoc Reviewer for Ecosystems, Ecology, Long-Term Research in Environmental Biology, Computational Biology, Mathematics, Geography, Hydrology, and Polar Programs

Review Team, Louisiana State University's application to National Science Foundation's EPSCOR Program (January 1986)

Ecosystems Studies Panel (March 1989 – October 1991; reappointed October 2004 – October 2008)

Review Team, Central Plains Long-Term Ecological Research Site (June 1990)

Review Team, Jornada Long-Term Ecological Research Site (May 1991)

Terrestrial Ecology and Global Change (TECO) Research Panel (June 1995)

Research Training Centers Panel (April 1996)

Board, National Center for Ecological Analysis and Synthesis (September 1998 – September 1999)

Long Term Ecological Research Panel (April 2000; reappointed April 2010)

Biocomplexity Panel (June 2000)

Frontiers in Integrated Biological Research Panel (December 2002; reappointed November 2004)

Long-Term Research in Environmental Biology (LTREB) Workshop (September 2003)

Review Team, Coweeta Long-Term Ecological Research Site (June 2005)

Review Team, Bonanza Creek and Toolik Lake Long-Term Ecological Research Sites (June 2007)

Review Team, Virginia Coast Reserve Long-Term Ecological Research Site (September 2009)

National Academy of Sciences / National Research Council

Committee on Scholarly Communications with the People's Republic of China (March 1991 – December 1991)

Committee to Review the Environmental Protection Agency's Environmental Monitoring and Assessment Program (July 1991 – March 1995)

Committee to Review the U.S. Navy's Extremely Low Frequency Submarine Communication Ecological Monitoring Program (March 1995 – June 1997)

Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial Environments (January 1997 – July 2000)

Review Coordinator for Progress Towards Adaptive Monitoring and Assessment for the Comprehensive Everglades Restoration Plan (September 2002 – February 2003)

Department of Interior

Review Team, Value of Downed Logs in Second Growth Douglas-Fir, Bureau of Land Management (August 1986)

Technical Advisor, U.S. Fish and Wildlife Service and Bell Museum, Endangered Species Exhibition (October 1993 – October 1994)

Department of Agriculture

Committee to Review U.S. Dept. of Agriculture's Research Initiative Program on Water Quality and Ecosystems (August 1993)

U.S. Dept. of Agriculture, National Research Initiative Program, Ecosystems Panel (March 1994)

Environmental Protection Agency

Review Team, Environmental Protection Agency's Research Initiative on Forest Ecosystems (March 1988)

Chair, Review Team, Corvallis Laboratory (August 2001)

NASA

Panel Member, Earth Observing System satellite (September 1988)

U.S. Congress

Testimony on Voyageurs National Park and Boundary Waters Wilderness, U.S. House of Representatives, Subcommittee on National Parks, Forests, and Lands (October 28, 1995 and July 16, 1996)

Testimony on Voyageurs National Park and Boundary Waters Wilderness, U.S. Senate, Committee on Energy and Natural Resources (July 18, 1996)

The White House

National Environmental Monitoring and Research Workshop, National Science and Technology Council (September 1996)

National Sciences and Engineering Research Council, Canada

Grant Selection Committee for Evolution and Ecology (August 1996 – June 1998)

State of Minnesota

Expert Witness on the Effects of Global Climate Change on Minnesota's Ecosystems, Attorney General's Office (1994)

Testimony on the Effects of Global Climate Change on Minnesota's Ecosystems, House Environmental Policy Committee (April 1998)

Local Governments

Co-Founder, City of Duluth Tree Commission (October 1994); Board Member (October 1994 – October 1999); Chair (October 1998 – October 1999)

City of Duluth Secondary Education Mathematics Curriculum Committee (October 1995 – October 1996)

City of Duluth Cities for Climate Protection Program, Steering Committee (November 2001 – October 2002)

University of Minnesota

Chair, Search Committee, Director of the Center for Water and the Environment, Natural Resources Research Institute (1990)

University of Minnesota Duluth Campus Planning Committee (1994)

College of Science and Engineering Executive Committee (May 1998-June 1999; reappointed September 2004 – June 2005)

Chair, Search Committee, Vertebrate Physiologist, Dept. of Biology (September 1998 – June 1999)

Research Ethics Advocates Committee (November 2000 – November 2001)

College of Science and Engineering Academic Standards Committee (September 2001 – 2002)

College of Science and Engineering Integrated Biosciences Program Executive Committee (June 2000 – May 2009)

College of Science and Engineering Single Semester Leave Committee (October 2003)

Chair, University of Minnesota Duluth Graduate Council (September 2004 – May 2005)

College of Science and Engineering Curriculum Committee (September 2007 – June 2009)

Office of Vice-President for Research, Research and Scholarship Advisory Panel (September 2010 – present).

Office of Vice-President for Research, Minnesota Futures Proposal Review Committee (June 2012).

Professional Journals and Societies

Member, Society of American Naturalists, American Mathematical Society, Ecological Society of America

Ad Hoc Reviewer for Science, Nature, Ecology, Forest Science, Canadian Journal of Forest Research, Canadian Journal of Botany, Biogeochemistry, Climatic Change, and other journals

Chair, Committee on Ecosystems and Macroscale Phenomenon, Society of Conservation Biology (April 1988).

Secretary, Association of Ecosystem Research Centers (November 1993 – November 1994)

Associate Editor, The American Naturalist (September 1990 – June 1994)

Associate Editor, Silva Fennica (December 1993 – December 1998)

Ad Hoc Associate Editor, Ecology (May 1994 – August 1996)

Associate Editor, Vegetatio (now Plant Ecology) (March 1995 – March 1998)

Associate Editor, Conservation Ecology (October 1995 – June 2004)

Associate Editor, Ecosystems (January 2001 – present)

R.H. MacArthur Award Committee, Ecological Society of America (2012)

Private Organizations

Joint Coordinating Committee, Climate Systems Modeling Initiative, University Corporation for Atmospheric Research (January 1989 – January 1990)

Technical Advisor, North Central Caribou Corporation (January 1992 – October 1995)

Board of Directors, Voyageurs Region National Park Association (January 1993 – January 2003)

Board of Directors, Sigurd Olson Environmental Institute, Northland College (May 1995 – September 1998)

Board of Directors, Biodiversity Fund, Duluth-Superior Area Community Foundation (October 2010-present)

Board of Trustees, Minnesota, South Dakota, and North Dakota Chapter of The Nature Conservancy (July 2013-present)

Symposia and Workshops, Co-Organizer

"Geomorphology and Ecosystem Processes," Ecological Society of America Annual Meeting, Syracuse, New York, August 1986 (co-organizer with D. Schimel)

"Sustainability of Boreal Regions: Sources and Consequences of Variability," MacArthur Foundation and the Beijer Institute, Itasca State Park, Minnesota, October 1997 (co-organizer with C.S. Holling and S. Light). The papers from this symposium were published in a special issue of *Conservation Ecology*.

"The Role of Large Herbivores in Ecosystem Processes", World Wildlife Fund, Hällnäs, Sweden, May 2002 (co-organizer with K. Danell). The papers from this symposium were published in Danell, K., R. Bergström, P. Duncan, and J. Pastor, (editors). 2006. *Large Mammalian Herbivores, Ecosystem Dynamics, and Conservation*. Cambridge University Press, Cambridge, Great Britain.

"Mathematical Problems of Global Climate Change", Mathematical Biosciences Institute, Columbus, Ohio, June 2006. (co-organizer with D. Schimel and J. Harte).

"Modeling Nutrient Constraints: Stoichiometry of Cells, Populations, and Ecosystems", Society of Industrial and Applied Mathematics Conference on Applications of Dynamical Systems, Snowbird, Utah, May 2007 (co-organizer with B. Peckham).

Symposia and Workshops, Invited Speaker

"Predicting the Consequences of Intensive Forest Harvesting on Long-Term Productivity," Swedish University of Agricultural Sciences, Jaadrås, Sweden, May 1986

"Positive Feedbacks and the Global Carbon Cycle," Oak Ridge National Laboratory, Tennessee, May 1987

"Influence of Large Mammals on Ecosystem Processes," Symposium at the Ecological Society of America Annual Meeting, Columbus, Ohio, August 1987

"Ecology and Forest Policy for the Lake States," Society of American Foresters Annual Meeting, Minneapolis, Minnesota, October 1987

"Problems in Conservation Biology," Society of Conservation Biology, Hawk's Kay, Florida, June 1988

"Modeling Forest Response to Climatic Change," Scientific Committee on Problems of the Environment, Oxford, England, September 1988

"Ecology for a Changing Earth," National Science Foundation, Santa Fe, New Mexico, December 1988

"Climate Systems Modeling Initiative - First Workshop," University Corporation for Atmospheric Research, Boulder, Colorado, January 1989

"Production-decomposition linkages in northern forests and grasslands and response to climate change," Scientific Committee on Problems of the Environment, Woods Hole, Massachusetts, April 1989

"Explaining Records of Past Global Changes," Global Change Institute, Aspen, Colorado, July 1989

"New Perspectives for Watershed Management: Balancing Long-Term Sustainability with Cumulative Environmental Change," University of Washington and Oregon State University, Seattle, Washington, November 1990

"Hydrological-Geochemical-Biological Interactions in Forested Catchments," Gordon Conference, Holderness School, New Hampshire, July 1991

"Workshop on Northern Herbivory," National Science Foundation, LTER Program, Ecosystems Center, Woods Hole, Massachusetts, November 1992

"Biodiversity of Arctic and Alpine Tundra," Scientific Committee on Problems of the Environment, Kongsvold Biological Station, Oppdal, Norway, August 1993

“Functional Roles of Biodiversity: A Global Perspective,” Scientific Committee on Problems of the Environment, Asilomar, California, March 1994

“Ungulates in Temperate Forest Ecosystems,” Netherlands Institute for Forestry and Nature Research, Wageningen, The Netherlands, April 1995

“Control and Chaos,” National Science Foundation, Hawaii, June 1995

“Managing Ungulates as Components of Ecosystems,” The Wildlife Society Annual Conference, Portland, Oregon, September 1995

“Synthesis, Science, and Ecosystem Management,” National Center for Ecological Analysis and Synthesis, Santa Barbara, California, November 1996

“Hydrobiogeochemistry of Forested Catchments,” Gordon Conference, Colby-Sawyer College, New London, New Hampshire, August 1997

“Herbivore-Plant Interactions,” Third European Congress of Mammalogy, Jyväskylä, Finland, June 1999

“How Nutrient Cycles Constrain Carbon Balances in Boreal Forests and Arctic Tundra,” GCTE-IGBP, Abisko, Sweden, June 1999

“Understanding Ecosystems: The Role of Quantitative Models in Observation, Synthesis, and Prediction,” Cary Conference IX, Institute of Ecosystem Studies, Millbrook, New York, May 2001

“Third North American Forest Ecology Conference,” Duluth, Minnesota, June 2001

“Biogeochemistry of Wetlands,” Duke University Wetland Center, Durham, North Carolina, June 2001

“Twenty-fifth National Indian Timber Symposium” Intertribal Timber Council, Fond du Lac Reservation, Minnesota, June 2001

“Fifth International Moose Symposium”, Lillehammer, Norway, August 2002

“The Importance of Spatial Heterogeneity on Ecosystem Ecology”, Cary Conference X, Institute of Ecosystem Studies, Millbrook, New York, May 2003

“Third ManOMin Watershed Conference: Rainy River Basin”, International Falls, Minnesota, November 2003

“New Directions in Research in Grazing Ecology”, The Macaulay Institute, Aberdeen, Scotland, December 2003

“Novel Approaches to Climate Change”, Aspen Institute of Physics, Aspen, Colorado, June 2005

“Wild Rice Roundtable”, Ecological Society of America Annual Meeting, Milwaukee, Wisconsin, Aug. 4, 2008

"Understanding the Vegetation and Hydrology of Upper Midwest Wetlands", Fond du Lac Band of Lake Superior Ojibway, Carlton, MN, Sept. 22, 2010.

Research Grant Support

Dept. of Energy, "Changes in forest carbon storage with intensive management and climatic change," $93,567 (1985 – 1987). To Pastor

Environmental Protection Agency, "Factors controlling the recovery of aquatic systems from disturbance," $221,032 (1986 – 1987). To Niemi, Naiman, and Pastor

National Science Foundation, "The effects of large mammal browsing on the dynamics of northern ecosystems," $258,645 (1987-1989) to Pastor and Naiman; $419,170 (1989 – 1992) to Pastor and Mladenoff

National Science Foundation, "Reconstructing forest stand histories and soil development from paleoecological evidence," $405,000 (1987 – 1989). To Davis and Pastor

National Science Foundation, "A cooperative facility for research on the ecology of spatial heterogeneity," $403,066 (1988 – 1990). To Johnston and Pastor

Dept. of Energy, "Response of northern ecosystems to global change," $45,150 (1989). To Pastor, Gorham, and Shaver

National Science Foundation, "Animal influences on the aquatic landscape: vegetative patterns, successional transitions, and nutrient dynamics," $430,974 (1989 – 1992). To Naiman, Johnston, and Pastor and $660,000 (1992-1995) to Johnston and Pastor

NASA, "Regional modeling of trace gas production in grassland and boreal ecosystems," $240,000 (1989 – 1992). To Johnston and Pastor

Legislative Commission on Minnesota's Resources, "The relationship between heavy metal biogeochemistry and airborne spectral radiometry as an exploration method," $250,000 (1989 – 1991). To Hauck and Pastor

U.S. Forest Service and The Nature Conservancy, "A landscape approach to biological diversity management using geographic information systems and a forest succession model," $32,000 (1989 – 1991). To Mladenoff and Pastor

U.S. Forest Service and The North Central Caribou Corporation, "Woodland caribou assessment of northern Minnesota," $40,000 (1990 – 1991). To Pastor and Mladenoff

National Science Foundation, "The use of fractal and chaos theory to verify, simplify, and extend forest ecosystem models," $220,975 (1991 – 1993). To Cohen and Pastor

National Science Foundation, “Spatial modelling of forest ecosystem landscapes and bird species diversity,” $200,000 (1994 – 1996). To Cohen, Pastor, and Niemi

U.S. Forest Service, "Investigating ecological and economic interactions between soil and forest conditions and harvesting regimes on the Chippewa National Forest," $25,000 (1992 – 1993). To Pastor and Mladenoff

National Science Foundation, "Moose foraging strategy, energetics, and ecosystem processes in boreal landscapes," $90,000 (1993 – 1994). To Pastor, Mladenoff, and Cohen

National Science Foundation, "Long-term dynamics of moose populations, community structure, and ecosystem properties on Isle Royale," $250,000 (1993 – 1998). To Pastor, Mladenoff and Cohen

National Science Foundation, "Direct and indirect effects of climate change on boreal peatlands," $800,000 (1993 – 1997). To Bridgham, Pastor, Malterer, and Janssens

National Science Foundation, “Landscape control of trophic structure in arctic Alaskan lakes,” $200,000 (1995 – 1997). To Hershey, McDonald, Pastor, and Richards

Legislative Commission on Minnesota's Resources, "Forest management to maintain structural and species diversity," $160,000 (1995 – 1997). To Pastor and Rusterholz

National Science Foundation, "Moose foraging strategy, energetics, and ecosystem processes in boreal landscapes," $765,000 (1995 – 2000). To Pastor and Cohen

National Science Foundation, “Grizzly bear digging in subalpine meadows: Influences on plant distributions and nitrogen availability,” $111,549 (1995 – 1998). To Stanford and Pastor

National Science Foundation, “Control of productivity and plant species segregation by nitrogen fluxes to wetland beaver meadows,” $600,000 (1997 – 2000). To Johnston, Pastor, and Mooers

National Science Foundation, “Carbon and energy flow and plant community response to climate change in peatlands,” $1,200,000 (1997-2001). To Bridgham, Pastor, and Chen

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November 2017

Attachment B
(16 pages)

Ecological Applications, 27(1), 2017, pp. 321–336

Effects of sulfate and sulfide on the life cycle of *Zizania palustris* in hydroponic and mesocosm experiments

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Abstract. Under oxygenated conditions, sulfate is relatively non-toxic to aquatic plants. However, in water-saturated soils, which are usually anoxic, sulfate can be reduced to toxic sulfide. Although the direct effects of sulfate and sulfide on the physiology of a few plant species have been studied in some detail, their cumulative effects on a plant's life cycle through inhibition of seed germination, seedling survival, growth, and seed production have been less well studied. We investigated the effect of sulfate and sulfide on the life cycle of wild rice (*Zizania palustris* L.) in hydroponic solutions and in outdoor mesocosms with sediment from a wild rice lake. In hydroponic solutions, sulfate had no effect on seed germination or juvenile seedling growth and development, but sulfide greatly reduced juvenile seedling growth and development at concentrations greater than 320 μg/L. In outdoor mesocosms, sulfate additions to overlying water increased sulfide production in sediments. Wild rice seedling emergence, seedling survival, biomass growth, viable seed production, and seed mass all declined with sulfate additions and hence sulfide concentrations in sediment. These declines grew steeper during the course of the 5 yr of the mesocosm experiment and wild rice populations became extinct in most tanks with concentrations of 250 mg SO_4/L or greater in the overlying water. Iron sulfide precipitated on the roots of wild rice plants, especially at high sulfate application rates. These precipitates, or the encroachment of reducing conditions that they indicate, may impede nutrient uptake and be partly responsible for the reduced seed production and viability.

Key words: hydroponics; life cycles; sulfate; sulfide; toxicity; wetlands; wild rice; Zizania palustris.

Introduction

Under oxygenated conditions, sulfate, the most abundant form of dissolved sulfur in aquatic systems, is relatively non-reactive, and is therefore relatively non-toxic. However, where oxygen is absent and organic matter is present, sulfate can serve as an electron acceptor for heterotrophic microbial metabolism, producing reactive reduced sulfur species. When sulfate concentrations limit the activity of sulfur-reducing microbes, an increase in sulfate can enhance the decomposition of organic matter and initiate a cascade of interrelated biogeochemical reactions (Garrels and Christ 1965) that alter the bioavailability of phosphorus and other nutrients (Lamers et al. 2002), and generate alkalinity (Giblin et al. 1990). One of the most reactive products of sulfate reduction is hydrogen sulfide, which we here term "sulfide." If dissolved sulfide persists in the rooting zone of aquatic plants, it can inhibit root growth and metabolism (Mendelssohn and McKee 1988, Koch and Mendelssohn 1989, Koch et al. 1990, Lamers et al. 2002, 2013, Gao et al. 2003, Armstrong and Armstrong 2005, Geurts et al. 2009, Martin and Maricle 2015) and photosynthesis (Pezeshki 2001). If root biomass and metabolism are reduced by elevated sulfide concentrations, then the plant's ability to take up limiting nutrients may be impaired (DeLaune et al. 1983, Koch et al. 1990, Gao et al. 2002, 2003, Armstrong and Armstrong 2005, Lamers et al. 2013).

Although the direct effects of sulfide on the physiology of individual plants of a few species have been studied in some detail, the cumulative effects of sulfide on a plant's life cycle through possible inhibition of seed germination, seedling survival, and seed production have been less well studied. Sulfide could affect any or all of these stages of a plant's life cycle, either directly by toxicity to seeds and seedlings or indirectly by decreasing nutrient uptake through roots during seed formation. If so, then populations may become sparser and less viable over several life cycles. Population effects could be realized rapidly in non-clonal annual aquatic emergent plant species that

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rely exclusively on seed production, germination, and seedling survival to produce the next generation of emergent shoots. A seed bank in the sediment would facilitate recovery of a population after one or two catastrophic growing seasons, but would become depleted if chronic sulfide toxicity does not allow occasional successful growth and reproduction to restock the seed bank.

Northern wild rice (*Zizania palustris* L., hereafter wild rice) is an annual graminoid (Family Poaceae, Tribe Oryzeae), which is most abundant in the rivers and lakes in the Lake Superior region. Because of its widespread distribution and tendency to form large monotypic stands, wild rice is an important component of the food supply for the aquatic and avian herbivores and seed consumers, such as muskrats and waterfowl. Reduction of these wild rice populations could, therefore, have cascading effects on diverse aquatic food webs. In addition, the native Ojibwe people of the Lake Superior and Lake Michigan region teach that they were led to this region to find "the food that grows upon the water," which is wild rice. The Ojibwe identify their origins with wild rice and consider themselves "people of the rice" (Vennum 1998). The resource is also important to Menominee and Dakota peoples of the region. Efforts to enhance the productivity, perpetuation, and restoration of natural wild rice populations are of great importance to state and tribal natural resource agencies for both ecological and cultural reasons.

The wild rice life cycle begins when seeds from the previous year or years germinate in mid to late May. Juvenile seedlings grow through the water column in early to mid-June. Upon reaching the surface, the seedling generates a floating leaf that fixes carbon into carbohydrates for root production and nutrient uptake. By the end of June, nitrogen and other nutrients are translocated out of the floating leaf into an aerial shoot emerging from the leaf axil, and the floating leaf dies. The early stages of the vegetative growth of the aerial shoot happen during the next two weeks and vegetative growth continues until the emergence of flowering heads in late July. Seed production and ripening begins in early to mid-August with seed production completed by early- to mid-September. The productivity of wild rice is primarily limited by nitrogen and secondarily by phosphorus; increased nitrogen supply accelerates development of the life cycle and reduces allocation to roots (Sims et al. 2012*a*) and increases the number of inflorescences, seeds per inflorescence, and mean seed mass, resulting in more seedlings produced the following year, and hence greater fitness (Sims et al. 2012*b*).

Historic observations suggested that wild rice usually occurs in waters where sulfate concentrations were near or below 10 mg/L and populations are uncommon where sulfate concentrations exceeded 50 mg/L (Moyle 1944, 1945). Based on Moyle's (1944, 1945) research, the State of Minnesota sulfate standard for waterbodies supporting wild rice is 10 mg/L; Wisconsin, Michigan, and Ontario currently do not have sulfate standards for wild rice waters. For comparison, the EPA non-enforceable, aesthetic (taste) secondary water quality sulfate standard for human consumption is 250 mg/L (*available online*).[7]

This research is part of a larger study coordinated by the Minnesota Pollution Control Agency on the effect of sulfate on wild rice, which included an extensive survey of potential wild rice waters across Minnesota containing surface water sulfate ranging from <2 mg/L to >600 mg/L. This study was carried out because of recent interest in the nature of the relationship between sulfate and wild rice, especially with respect to potential anthropogenic sulfate enhancements to wild rice ecosystems such as sewage treatment plants, agricultural runoff, and mining of ores containing metallic sulfides. The mechanisms responsible for the decreased wild rice density with increased sulfate concentrations observed by Moyle (1944, 1945) have not been investigated until this study.

Although we have a fairly extensive understanding of the general aspects of the life cycle of wild rice in natural stands in relation to nutrient availability and sediment chemistry (Keenan and Lee 1988, Day and Lee 1990, Meeker 1996, Lee 2002, Pastor and Walker 2006, Walker et al. 2010, Hildebrandt et al. 2012, Sims et al. 2012*a, b*), the way in which sulfate in surface water can affect the life cycle of wild rice, and hence its population dynamics, is much less well understood. The objectives of our research are to (1) determine the relative effects of sulfate and sulfide on seed germination, seedling viability, vegetative growth, and seed production; (2) determine the response of wild rice populations and population viability to sulfate in the overlying water and the production of sulfide in sediment porewaters.

Methods

The effects of sulfate and sulfide on wild rice were tested in two different ways: (1) a laboratory hydroponic culture system and (2) an outdoor mesocosm system that better mimicked natural wild rice waters, but does not control the chemical exposures as precisely as the hydroponic experiments did. Short-term (10 or 11 days) hydroponic exposures of seeds and seedlings to sulfate and sulfide were conducted to examine effects on seed germination, seedling growth, and survival. Full life cycle tests were conducted in mesocosms where wild rice grew in sediment taken from a natural wild rice lake. These multi-year outdoor tests examined the effects of elevated surface water sulfate and the associated increased sedimentary sulfide concentrations on germination, survival, growth, and reproduction.

Hydroponic experiments

Li et al. (2009) published one of the few dose-response studies of aquatic macrophytes (*Typha* and *Cladium*) to sulfide, which requires the maintenance of anaerobic

[7] http://water.epa.gov/drink/contaminants/secondarystandards.cfm

conditions. Malvick and Percich (1993) developed a simple hydroponic system to investigate effects of nutrients on germination and early growth of wild rice, but their system could only be implemented under aerobic conditions. We used these two studies as starting points for the development of our methods.

Wild rice seeds used for all hydroponic experiments were collected on 30 August 2012 from Little Round Lake (Minnesota Lake ID 03-0302, 46.97° N, 95.74° W; average surface water sulfate <0.5 mg/L and porewater sulfide = 77 μg/L, n = 5). The seeds were stored at 4°C in polyethylene bottles in a darkened room until needed for experiments. Immediately before each experiment, a subsample of these seeds was selected that were intact, filled, not green (unripe), and not moldy. To obtain seedlings for juvenile seedling response to sulfate or sulfide, the selected seeds were allowed to germinate in aerobic deionized water until a 1–2 cm long mesocotyl shoot appeared, which usually occurred 5–7 days after germination. The mesocotyl is the embryonic stem that will develop into the mature stem.

Once the seeds or seedlings were selected, they were picked up with forceps and transferred to the appropriate test in appropriate containers. The hydroponic solution was one-fifth strength Hoagland's solution in 5 mmol/L PIPES buffer to maintain a pH of 6.8 ± 0.03 (mean ± SD) in the solution, similar to that observed in the porewater of mesocosm experiments. Nitrogen was supplied only as ammonium (0.16 mmol/L NH_4Cl) to mimic natural concentrations of inorganic nitrogen in wild rice waters (Walker et al. 2010). The Hoagland's solution contained sulfate only in trace amounts as $ZnSO_4$ (0.5 μmol/L) and $CuSO_4$ (0.15 μmol/L). This nutrient solution was then augmented with appropriate amounts of anhydrous Na_2SO_4 or $Na_2S \cdot 9H_2O$ to achieve desired sulfate or sulfide treatment concentrations. The one-fifth Hoagland's solution and PIPES buffer were chosen based on previous trials to determine proper strengths and buffers that would support seedling growth without adverse effects (see Appendix S1 for composition of our modification of Hoagland's Solution).

Germination of wild rice seeds under aerobic conditions subject to various concentrations of sulfate.—The selected seeds were placed into each of six numbered plastic cups to total 50 seeds each, then randomly assigned and transferred to each of six 1-pint Mason jars (1 pint = 473 mL) containing six sulfate treatment concentrations of 0 (trace), 10, 50, 100, 400, or 1600 mg SO_4/L. These sulfate treatments (trace to 1600 mg/L) bracket the large range encountered across Minnesota's geologically diverse landscape (10th and 90th percentiles of 0.2 and 285 mg/L, respectively; MPCA 2016), plus some mine pits over 1000 mg/L that may overflow into wild rice waters. This seed counting and random transfer was repeated twice more to result in six treatment levels with three replicate jars per treatment. The jars were covered with plastic covers fitted with rubber stoppers to facilitate solution exchanges. Two holes in the plastic lids were left open to facilitate air exchange and to prevent the solutions from becoming anaerobic. The experiment proceeded in a growth chamber at 20°C in the dark to simulate conditions measured in sediments during the growing season, which we have measured in our mesocosms (see *Results*). The solutions were exchanged with fresh solution of the appropriate treatment concentration every three days. Dissolved oxygen in the solutions across all treatments was initially 8.280 ± 0.218 mg/L (mean ± SD) and dropped to 2.85 ± 0.60 mg/L by the end of three days, still well above anoxic levels required for production of sulfide. Solution pH and sulfate were measured on each initial batch of sulfate treatment and on the exchanged solution from each jar. The germinated seedlings were harvested after 11 days. The number of successfully germinated seeds, determined as those that produced a mesocotyl at least 1 cm in length, were counted. The length of the mesocotyl was measured for each seed. The germinated seeds were then dried at 65°C for 3 d. The mesocotyl was then carefully separated from the seed hull and weighed.

Germination of wild rice seeds under anoxic conditions subject to various concentrations of sulfide.—The techniques used here were the same as for the germination trials under various sulfate concentrations, except that extra care was necessary to ensure anaerobic conditions. Fifty seeds were chosen as above and then placed in 700 mL borosilicate glass bottles capped using phenolic screw caps with chlorobutyl septa 5 mm thick. The one-fifth Hoagland's nutrient solution was deoxygenated with oxygen-scrubbed nitrogen before being added to the bottles. PIPES buffer was added to the test solution to maintain consistent pH levels of 6.8 ± 0.03 throughout an experiment. Bottles were filled completely with the deoxygenated nutrient solution and without introducing any air bubbles and then capped with the septa. Stock sulfide solutions (20–30 mmol/L) were prepared as needed by adding $Na_2S \cdot 9\ H_2O$ (sodium sulfide nonahydrate) to deionized and deoxygenated water. The concentration of the stock sulfide solution was checked periodically against a stock solution that had been standardized using an iodimetric titration. An appropriate amount of the stock solutions was added to each bottle with a Hamilton gas-tight glass syringe through the septa while simultaneously withdrawing an equivalent volume of the Hoagland's solution by means of a second syringe through the septum. All of the syringes used in this and other experiments were purged three times with oxygen-scrubbed ultra-pure nitrogen from a tilled PVDF gas sampling bag (Saint-Gobain No. D1075016-10), which had also been purged three times before filling. Added stock sulfide solution volumes range between 0.2 and 3.0 mL depending on target exposure concentrations and the nominal concentration of stock sulfide solution. The target sulfide concentrations were 0 (trace), 96, 320, 960, and 2880 μg/L. These sulfide treatments (trace to 2880 μg/L) bracket the range encountered across shallow aquatic systems in Minnesota that potentially could host wild rice (5th and 95th percentiles of 26 and 1631 μg/L, n = 108; A. Myrbo, *unpublished data*).

The bottles were placed in a growth chamber in continuous darkness at 20° ± 1°C. Solutions were exchanged every two days if during the week or three days if over a weekend. The solution in each jar was sampled for sulfide analysis at the beginning and end of each two- or three-day cycle. The pH of the solution in each jar was measured at the end of each two- or three-day cycle. To obtain the initial pH of the solution, one additional replicate jar for each treatment but without seeds was filled with one-fifth Hoagland's solution, then the sulfide treatment was added using syringes as above and the jar was opened and pH was measured immediately. Total dissolved sulfide ($H_2S + HS^-$) was measured on a Hach DR5000 spectrophotometer using a colorimetric methylene blue method (4500 S2-D; Eaton et al. 2005) as implemented with Hach method 8131. The method was adapted for a lower detection limit (~15 μg/L) using a photo cell with a 5 cm path length. All measurements of dissolved sulfide in both hydroponics and mesocosm experiments refer to the sum of all dissolved inorganic reduced sulfur ($H_2S + HS^-$). The samples of hydroponic water were added directly from the gas tight syringe to the sulfuric acid reagent, followed immediately by the potassium dichromate reagent. After 11 days, the germinated seeds were harvested and measured as described for the experiments on effects of sulfate on germination.

Growth of juvenile wild rice seedlings under aerobic conditions subject to various concentrations of sulfate.— We examined growth of juvenile seedlings at concentrations of 0, 10, 50, 100, 400, and 1600 mg SO_4/L. Twenty replicated 70-mL unsealed glass Kimax tubes (Cole-Parmer, Vernon Hills, IL, USA) were used for each test concentration. One seedling germinated and selected as described was placed with forceps into each Kimax tube, which was then filled with one-fifth Hoagland's solution and an appropriate amount of sulfate. The filled tubes (solution and seed) were placed into every other opening in Nalgene Resmer (ThermoFisher Scientific, Waltham, MA, USA) test tube holding racks so that light could penetrate to all sides of each tube. A total of six 40-tube racks, each containing 20 tubes, were used to hold the test tubes. Screw caps were placed loosely on the tubes to allow for oxygen exchange across the solution surface and thereby prevent the development of anaerobic conditions. The tubes were placed in a Percival environmental growth chamber where we measured 288 ± 22 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of photosynthetically active radiation immediately above the plants using a Decagon PAR – 80 Ceptometer (Decagon Devices, Pullman, WA, USA). Tests were performed under a 16 h:8 h light:dark schedule. All racks were placed in the growth chamber so that the spaces between the racks were the same as the spaces within the racks and the tops of the tubes are within 30 cm of the bottom of the lights. The location of each rack in the growth chamber remained the same for the test duration. Test solutions in the tubes were renewed every two days. Temperature was maintained at 21°C during lighted periods and 19°C during dark periods and the humidity was maintained at 85%. Plants were harvested after 10 days and the seed hull was carefully removed. Stem and leaf length was measured to the nearest millimeter by placing the stem with leaf stretched out on a flat surface next to ruler with the zero mark aligned with the point of stem-root transition. Total root lengths were measured in duplicate scans of the entire root system using the program WinRhizo (Regent Instruments, Quebec, Canada). Seedlings were weighed after drying at 100°C for 48 h. Control juvenile seedlings did not have any visible phytotoxic or developmental symptoms at any time and the controls had additional stem growth of at least 5.0 cm during the 10-d test.

Growth of juvenile wild rice seedlings under anaerobic conditions subject to various concentrations of sulfide.— Germinated seedlings were chosen using the same techniques described for aerobic conditions. Seven seedlings 1–2 cm in length that fit the criteria as described, were placed with a forceps in 125-mL borosilicate glass jars capped using phenolic screw caps with 5 mm thick chlorobutyl septa. Each sulfide concentration was replicated in this way in three separate jars. Deoxygenated Hoagland's nutrient solution was added as described above. Seedlings were grown in the same environmental growth chamber under the same temperature and light conditions as for the sulfate experiments but with solution sulfide concentrations of 0, 96, 320, 960, and 2880 μg/L. Solutions were exchanged every two days if during the week or three days if over a weekend. Sulfide concentrations were measured at the beginning and end of each two–three day solution exchange period. Because the plants were photosynthesizing and producing oxygen, the sulfide concentration declined during these two–three day periods. This was especially so for the lowest sulfide concentrations (less than ~300 μg/L) in which less than 10% remained after two days, but 70–90% of sulfide remained after two days for sulfide concentrations greater than 650 μg/L. We therefore used the time-weighted average sulfide concentration over the 10 days period to characterize the sulfide concentrations the plants were exposed to. Seedlings were harvested after 10 days, the seed hull was carefully removed, and the stem and leaf lengths and total plant mass were determined. Because many of the plants, especially at high sulfide concentrations, did not grow at all (see Results below) the roots and shoots were very fragile and no attempt was made to dissect the plants into subcomponents as with the experiment on the effects of sulfate on seedling growth.

Statistical analyses of hydroponic experiments.—The general procedure for each set of sulfate and sulfide exposure experiments was first to examine seed germination or seedling growth response across a wide range of concentrations spanning three orders of magnitude of either sulfate or sulfide as noted. The main effect of sulfate or sulfide concentrations on the variable of interest was then tested with an analysis of variance using SigmaPlot (SYSTAT Software, San Jose, CA), USA. When the residuals were not normally distributed or the data did not have equal variance between treatments, then the data were transformed by taking the natural logarithms, which then passed normality and equal variance tests. If there were no effects across this wide range of concentrations in this experiment, then it was repeated to test whether the results were a false negative. If there were significant main effects, then Tukey's pairwise comparisons were performed to determine in which part of the range of concentrations significant effects occurred. Further experiments were then conducted twice using this narrower range of concentrations centered on the region of significant change to more precisely refine the range of response of seedling germination or growth to sulfate or sulfide concentrations.

If there was a significant effect of sulfide on seedling growth, then the biomass growth of seedlings (mg) over the 10-d period was regressed against the time-weighted total dissolved sulfide concentrations (μg/L) with a four-parameter sigmoidal function using SigmaPlot nonlinear regression

$$\text{Plant growth} = y_{\min} + \frac{y_{\max}}{1+\exp\{-[(S^{2-}-x0)/b]\}} \quad (1)$$

where $y_{\min}$ is the right-side (minimum) horizontal asymptote (minimum growth response) $y_{\max}$ is the height of the left-side horizontal asymptote (maximum growth response) above $y_{\min}$, S^{2-} is total dissolved inorganic sulfide ($H_2S + HS^-$), $x0$ is the sulfide concentration at the inflection point of the curve, and b is a parameter that scales μg/L of sulfide concentration to mg of biomass growth. The 50% effects concentration (EC50, the concentration of sulfide that caused a 50% reduction in change in plant mass compared to controls) was calculated from this regression.

The sulfate experiment had to be conducted under aerobic conditions while the sulfide experiment had to be conducted under anaerobic conditions. Therefore, redox statuses of the solutions were necessarily confounded with sulfur speciation. To test the effect of redox status on seedling growth, we compared the growth of plants from both the lowest concentrations of the sulfate (aerobic) and sulfide (anaerobic) experiment using a single-factor analysis of variance.

Mesocosm experiments

Experimental design.—We constructed mesocosms using the same procedures and designs previously reported by Walker et al. (2010) for a 5-yr experiment on the interaction of the nitrogen cycle and wild rice population dynamics.

In late spring of 2011, polyethylene stock tanks (400 L, 132 × 78 × 61 cm; High Country Plastics, Caldwell, ID, USA) were fitted with overflow drain pipes and buried to ground level. The drain pipes are connected to 20-L polyethylene overflow buckets buried adjacent to each tank. Water tables were set by the inflow to the drain pipe at 23 cm above the sediment surface. The tanks were leveled and then partly filled with 10 cm of clean sand washed with the same well water later added to the tanks (see next paragraph). The sand layer was then covered with 12 cm of surface sediment collected from a natural wild rice bed in Rice Portage Lake (Minnesota Lake ID 09-0037, 46.70° N, 92.70° W) on the Fond du Lac Band of Lake Superior Chippewa Reservation, Minnesota. Rice Portage Lake is approximately 337 ha, of which approximately 50 ha are wild rice beds (Minnesota Department of Natural Resources 2008). Ten to 20 cm of sediment over sand is sufficient to support the rooting depths we have observed in natural wild rice lakes. The sediments were kept saturated and then thoroughly homogenized in a large stock tank prior to distribution into the tanks. Analyses of five volumetric samples of the mixed sediment indicate a homogenous material (C = 14.8% ± 1.7%, N = 1.12% ± 0.13%, S [acid volatile sulfur] = 0.005% ± 0.003%). Sediment bulk density was 0.27 ± 0.01 g/cm^3 (Walker et al. 2010). These nutrient and bulk density values are similar to those of other wild rice beds (Keenan and Lee 1988, Day and Lee 1990). No new sediment has been added to the stock tanks since the mesocosms were established in 2011.

The tanks were immediately filled with water obtained from a nearby well after sediment additions to prevent the sediment from drying. Water was added cautiously from a garden hose to prevent redistribution and suspension of sediment. During the growing season, water levels were maintained at 23 cm above the sediment surface by weekly additions of water to the drain pipe heights or by allowing water to drain through the pipe into the overflow buckets. Rainfall N concentrations as NO_3-N and NH_4-N ranged from 0.2 to 1.99 mg/L while the NO_3-N and NH_4-N concentrations in the well water are always <0.2 mg/L (Walker et al. 2010). Sulfate concentrations in well water averaged 10.73 ± 0.75 mg/L (n = 36) and in rainwater averaged 2.13 ± 1.02 mg/L (n = 16). The sediments comprise a natural inoculation source for microbes and a background supply of nutrients for plant growth source. The sediments and plant litter remain submerged in the mesocosms year round with water levels set at approximately 20 cm in late fall.

Wild rice was planted once in late spring 2011 from seeds obtained from Swamp Lake (Minnesota Lake ID 16-0256, 47.85° N, 90.58° W), a 37-ha lake on the Grand Portage Band of Lake Superior Chippewa Reservation, Minnesota. Seeds from each year's crop were allowed to fall unimpeded into the tanks to provide the seed source for the next year's population; no further seeding from external seed sources occurred.

End-of-season plant density in Minnesota wild rice lakes monitored by the 1854 Treaty Authority averages 40 plants/m^2 (Vogt 2010). Accordingly, the seedlings were thinned to this density (30 plants per tank) in late spring or early summer each year before the floating leaf stage was achieved. The seedlings removed from each tank during thinning in 2012–2015 were counted to estimate seed germination and early seedling success.

Immediately after installation and seeding, beginning in late June 2011, the tanks were treated with different amounts of sulfate to achieve several target sulfate concentrations in the overlying water. There were five overlying water sulfate concentrations and six replicate tanks per sulfate concentration, for a total of 30 tanks. Nominal water column sulfate concentrations of 50, 100, 150, and 300 mg SO_4/L were maintained in sulfate-amended tanks. Aside from incidental sulfate in the make-up water from a well and rainwater, control tanks did not receive any sulfate amendments and overlying water concentrations ranged from 2 to 10 mg/L (average of 7 mg/L) depending on rainfall, evapotranspiration, and loss via sulfate reduction in the sediment. The overlying water sulfate concentrations in the mesocosm experiments bracket both the existing 10 mg/L Minnesota statutory standard for wild rice waters and the EPA drinking water standard of 250 mg/L. Samples of the water column were taken weekly and analyzed for sulfate concentration using a Lachat QuikChem 8000 Autoanalyzer (Method 10-116-10-1-A, Hach Co., Loveland, CO, USA). When necessary (approximately every two weeks), the sulfate concentration was adjusted to near the desired nominal concentrations with appropriate amounts of 10 g/L sodium sulfate (Na_2SO_4; Fisher Chemical S421, Thermo Fisher Scientific, Waltham, MA, USA) stock solution and well water. The sodium sulfate stock solution was first mixed in 1–2 L of water from the tank, then added back to the tank's overlying water with mild mixing.

Plant, sediment, and water sampling and analyses.—In each year from 2011 to 2015, five plants in each tank were randomly chosen in early summer for detailed measurements throughout the growing season and to be destructively sampled at the end of the growing season. In late August to September, ripe seeds from these plants were collected every two or three days by gently removing them, leaving unripe seeds behind for the next collection date. The seeds from each individual plant were placed in a paper envelope and marked with the tank identification number. The plants were then harvested for determination of biomass, root:shoot mass ratios and total seed production by counting seed peduncles along the flowering stem.

Seeds from each of the five sampled plants were separated into filled (viable) seeds and empty (nonviable) seeds, counted, and weighed. A subsample of seeds collected in all years except 2013 were dried at 60°C for determination of moisture content to convert wet mass to dry mass. The five sample plants were separated into root and shoot (stem + leaves), and then weighed. Root:shoot ratios and seed masses and numbers from the five sampled plants were applied to total aboveground population masses and total plant numbers to determine total root and seed biomass and number and total biomass in each tank.

While harvesting the plants for growth and biomass measurements, we noticed that plants in the tanks amended with sulfate had blackened roots while plants grown in the control tanks had white or light tan or orange roots. To investigate this further, a sample of roots from a plant from one control tank and a plant from one 300 mg/L amended tank were collected and placed immediately in water in which dissolved oxygen had been purged by bubbling with oxygen-free N_2. These samples were analyzed for Fe and S concentrations by energy-dispersive X-ray spectroscopy (EDS) using a Hitachi TM-1000 scanning electron microscope (Hitachi High Technologies, Schaumburg, IL, USA) fitted with a Quantax EDS unit (Bruker Corporation, Billerica, MA, USA). The nominal spot size was 0.2 μm and the analysis volume was ~5 μm^3. The sample of blackened roots was analyzed at seven points and the sample of tan/orange control roots was analyzed at five points.

All aboveground plant material was collected from each tank at the end of the growing season and weighed to determine total aboveground biomass. A subsample was taken to determine wet:dry ratios for moisture correction after drying at 60°C. All aboveground plant material except for the five sample plants were returned to each tank. All stems in each stank were counted at the time of harvesting the aboveground plant biomass to determine end of growing season plant density.

In 2013, significant seedling mortality occurred in all tanks after thinning but before the floating leaf stage. We believe this early season mortality was due to a record cold and late spring in northern Minnesota in April and May of 2013; ice stayed on lakes an average of 3 weeks later than the median ice-out date (data *available online*).[8] The reduced overall emergence of plants in the spring of 2013 precluded the destructive sampling of five sample plants in each tank at the end of the 2013 growing season because this harvesting would have greatly decreased the number of viable seeds returned to the sediment for the following growing season. Instead, during 2013 all seeds were harvested from each and every plant in the tanks, sorted as described above on each collection day, and returned to the tanks within 24 h of collection without drying in order to maintain their viability for future populations. To determine wet-dry conversion ratios for these seeds, additional seeds were collected at the same collection times from an adjacent experiment on wild rice (Walker et al. 2010) for moisture determination after drying them at 60°C.

Polycarbonate porewater equilibrators (peepers) with sampling ports spaced 1.5 cm intervals were used to make in situ measurements of geochemical profiles of sulfur and iron species at discrete depths in the sediment porewater of a subset of tanks in August of 2013. Care was taken that the installation and extraction of the peepers did not disturb any plants. The method for collecting samples for sulfate, sulfide, and ferrous iron with peepers was modified from Koretsky et al. (2007). Sulfide and iron were quantified in samples immediately with minimal oxygen exposure using a colorimetric methylene blue method (4500 S2-D; Eaton et al. 2005) as implemented with Hach method 8131 for sulfide and a colorimetric phenanthroline method for iron (3500-Fe-B; Eaton et al. 2005). Sulfate was quantified with ion chromatography on a Dionex ICS 1100 system (Thermo Fisher Scientific, Waltham, MA, USA) after acidifying samples to pH < 3

[8] http://climate.umn.edu/doc/journal/ice_out_recap_2013.htm

using hydrochloric acid and purging gently with oxygen-free nitrogen gas.

In August 2013 and 2015, we also used 10-cm long Rhizon samplers (Rhizosphere Research Products B.V., Wageningen, The Netherlands) to obtain porewater for sulfide analysis. The sampler was inserted vertically into the sediment and connected to an evacuated 125-mL serum bottle. Sulfide samples were prepared without removing the butyl rubber stopper for inline distillation by automated flow injection colorimetric analysis (4500 S2-E; Eaton et al. 2005).

On 6 October 2015, a 10-cm long sediment core was taken from each mesocosm and homogenized. Extractable iron was quantified following a 30-min exposure to 0.5 mol/L HCl, following Balogh et al. (2009), at the Minnesota Department of Health Environmental Laboratory. Total organic carbon was determined using the method of oxidative combustion-infrared analysis (U.S. EPA 2004), after pre-treatment with acid to remove inorganic carbon, at Pace Analytical Services in Virginia, Minnesota, USA.

Statistical analyses of mesocosm experiments.—The effects of sulfate concentrations on plant attributes were tested by repeated measures analysis of variance followed by pairwise comparisons between attributes of plants in the control tanks and each higher sulfate concentration. We also regressed each plant attribute against average annual sulfate concentration for each year. Correlations were assessed using Pearson's correlation test. This combination of both analysis of variance and regression was used as recommended by Cottingham et al. (2005). We used target sulfate concentrations as categorical variables in analyses of variance and growing season actual sulfate concentrations in regression analyses.

Results

Hydroponic experiments

Effect of sulfate on seed germination.—Between 71% and 76% of the seeds pre-selected as filled and mold-free germinated at each sulfate concentration. Sulfate exposure concentrations of 0, 10, 50, 100, 400, and 1600 mg SO_4/L did not affect germination success, mesocotyl lengths, or the masses of the stem plus leaf (if any) and roots (P > 0.10 for each test). The experiment was repeated with the same results.

Effect of sulfide on seed germination.—Sulfide concentrations of 0, 96, 320, 960, and 2880 μg/L did not affect germination success of seeds, mesocotyl masses, or mesocotyl lengths (P > 0.10 for each test). The experiment was repeated with the same results.

Effect of aerobic and anaerobic conditions on seed germination.—There were no differences in germination rates under anaerobic compared with aerobic conditions when concentrations of sulfur were at trace (<1 μmol/L) amounts of $CuSO_4$ and $ZnSO_4$ in the Hoagland's solution. Mean mesocotyl lengths in the anaerobic solutions (7.8 cm) were significantly reduced (P < 0.05) by 38% compared with mean mesocotyl lengths in the aerobic solutions (12.5 cm).

Effect of sulfate on seedling growth.—Sulfate concentrations of 0, 10, 50, 100, 400, and 1600 mg SO_4/L did not affect the growth of juvenile seedling stem length, juvenile stem mass, juvenile root mass, or total juvenile seedling mass (P > 0.10 for each test). Sulfate decreased juvenile root length slightly (P < 0.02) but only at 1600 mg SO_4/L compared with 50 mg SO_4/L. The experiment was repeated with the same results.

Effect of sulfide on seedling growth.—To examine the effects of sulfide on early seedling growth, we began by growing juvenile seedlings under a wide range of nominal sulfide exposure concentrations of 0, 96, 320, 960, and 2880 μg/L in anoxic solutions in a first trial. Both roots and stems of control plants (no added sulfide) increased significantly (P < 0.05) over the exposure, approximately doubling in size compared with initial lengths and masses. In seedlings exposed to sulfide concentrations 320 μg/L or more, stem and leaf masses (P < 0.01) and total plant masses (P < 0.001) were significantly depressed by an average of 60% and 75%, respectively, relative to controls. Root lengths were only weakly depressed with increasing sulfide concentration (P < 0.10).

To narrow the range of toxicity, we then conducted two additional trials focusing on the effects of sulfide on juvenile seedling growth at concentrations less than 1600 μg/L sulfide. The second trial examined growth at exposure concentrations of 0, 200, 400, 800, 1600 μg/L sulfide and the third trial examined growth at exposure concentrations of 0, 160, 320, 640, and 1280 μg/L sulfide. Consistent with the first trial, the biomass of all control plants increased significantly ($P < 0.05$) during the 10 d of

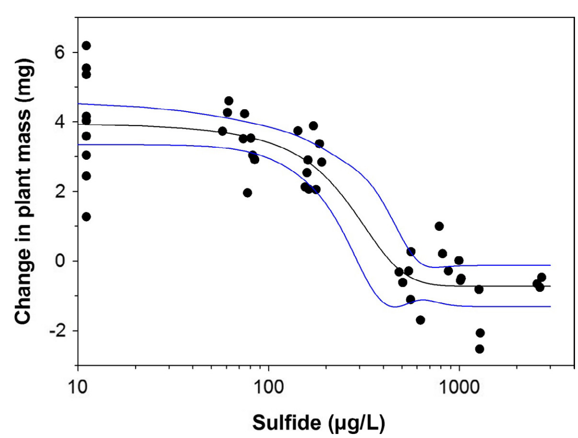

FIG. 1. Growth of wild rice seedlings declines with increasing sulfide concentrations in hydroponic solutions. Individual data points are from three separate experimental runs (see *Methods* and *Results* sections). Fitted sigmoidal response curve (Eq. 1) is shown in black, 95% confidence intervals in blue; r^2 = 0.80, y_{min} = −0.7172, y_{max} = 5.1353, $x0$ = 245.9051, b = −103.8853.μ (Color figure can be viewed at wileyonlinelibrary.com.)

exposure, approximately doubling in size compared with initial lengths and masses, and exposure to sulfide across these narrower ranges of concentration again significantly depressed stem plus leaf lengths and total masses of juvenile seedlings.

Because all three trials produced similar effects, we performed a pooled analysis of variance using data from all three. Exposures of seedlings to sulfide concentrations of 320 µg/L or greater significantly reduced growth rates ($P < 0.01$) of wild rice seedlings compared to the control by 88% or greater; Fig. 1). Seedlings exposed to sulfide concentrations at 320 µg/L or greater hardly grew at all and in some cases their mass decreased during the 10-d course of the exposure (Fig. 1). But exposures at sulfide concentrations less than 320 µg/L did not significantly reduce growth rates ($P > 0.10$) compared with the controls (Fig. 1). There was a sigmoidal response of seedling growth to elevated sulfide concentrations, with an inflection point at approximately 245 µg/L (Fig. 1; see figure caption for parameter values and r^2 for Eq. 1). The EC50 calculated from this regression was 227 µg sulfide/L.

Effect of aerobic and anaerobic conditions on seedling growth.—Under micromolar concentrations of sulfur from trace amounts of $CuSO_4$ and $ZnSO_4$ in the Hoaglands solution, stem lengths were 10% longer ($P < 0.02$), root lengths were 73% shorter ($P < 0.001$), and total plant masses were 16% less ($P < 0.01$) under anaerobic conditions compared to aerobic conditions.

Mesocosm experiment

Sulfate concentrations in overlying water.—The average monthly measured sulfate concentrations in amended tanks were consistently within 80–100% of nominal target concentrations of 50, 100, 150, and 300 mg/L (Table 1). The sulfate concentrations sometimes decreased after large rainfall events.

Porewater sulfide concentrations with sulfate additions.—Profiles of sulfate, sulfide, and iron in the mesocosm porewaters showed patterns consistent with sulfate diffusion from the overlying water into the surficial 5 cm of sediment with subsequent reduction to sulfide (Fig. 2). Concentrations of sulfide were typically highest in upper 3–5 cm, which is the rooting zone of seedlings. Sediment in tanks contained on average 8.3 ± 0.8 mg/g extractable iron; extractable iron did not vary with average surface

Table 1. Target and measured sulfate concentrations in overlying water in the mesocosm experiment.

	Measured growing season mean sulfate concentrations (mg/L)					
Target sulfate concentration	12 Jul–30 Aug 2011	6 Jun–28 Aug 2012	5 Jun–27 Aug 2013	27 May–26 Aug 2014	5 May–4 Sep 2015	Average over all years
0	8.05 (0.34)	8.0 (0.31)	7.05 (0.18)	5.8 (0.16)	6.16 (0.25)	7.01 (0.45)
50	50.0 (1.58)	34.0 (1.26)	37.2 (1.02)	43.3 (0.8)	41.7 (1.26)	41.2 (2.73)
100	97.7 (4.33)	77.1 (1.76)	79.7 (1.41)	87.2 (1.29)	85.3 (2.03)	85.4 (3.58)
150	135.0 (3.73)	126.0 (2.08)	127.0 (1.55)	131.0 (1.68)	132.0 (2.56)	130.0 (1.57)
300	254.0 (7.35)	263.0 (3.32)	268.0 (2.37)	273.0 (2.52)	272.0 (4.08)	266.0 (3.50)

Note: Values in parentheses are SE.

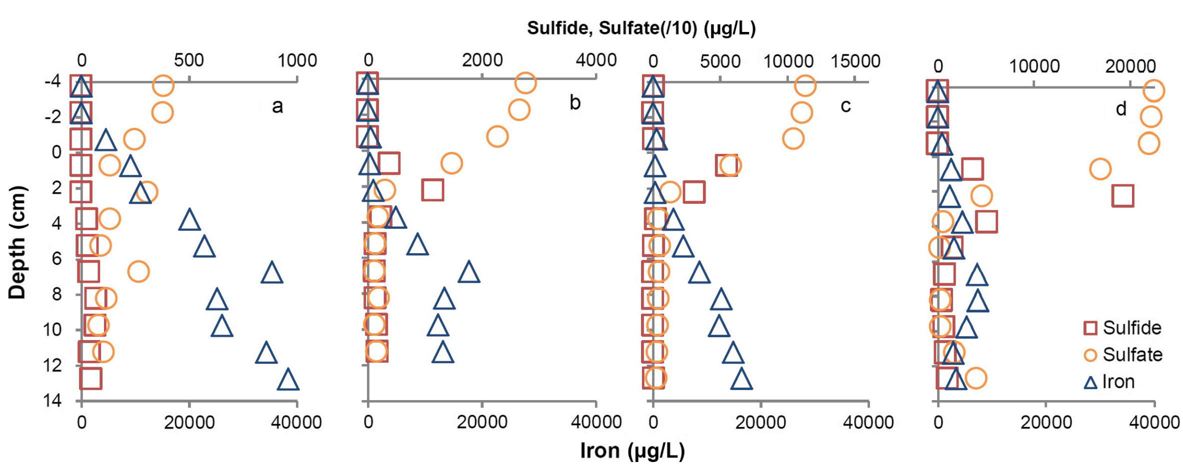

Fig. 2. Vertical profiles of sulfate, sulfide, and iron in mesocosms with different measured sulfate concentrations in the overlying water measured during August 2013. Average annual overlying water sulfate concentrations were (a) 7.05 mg/L, (b) 37.2 mg/L, (c) 127 mg/L, and (d) 268 mg/L. Note different scales for sulfate and sulfide in panels b, c, and d. (Color figure can be viewed at wileyonlinelibrary.com.)

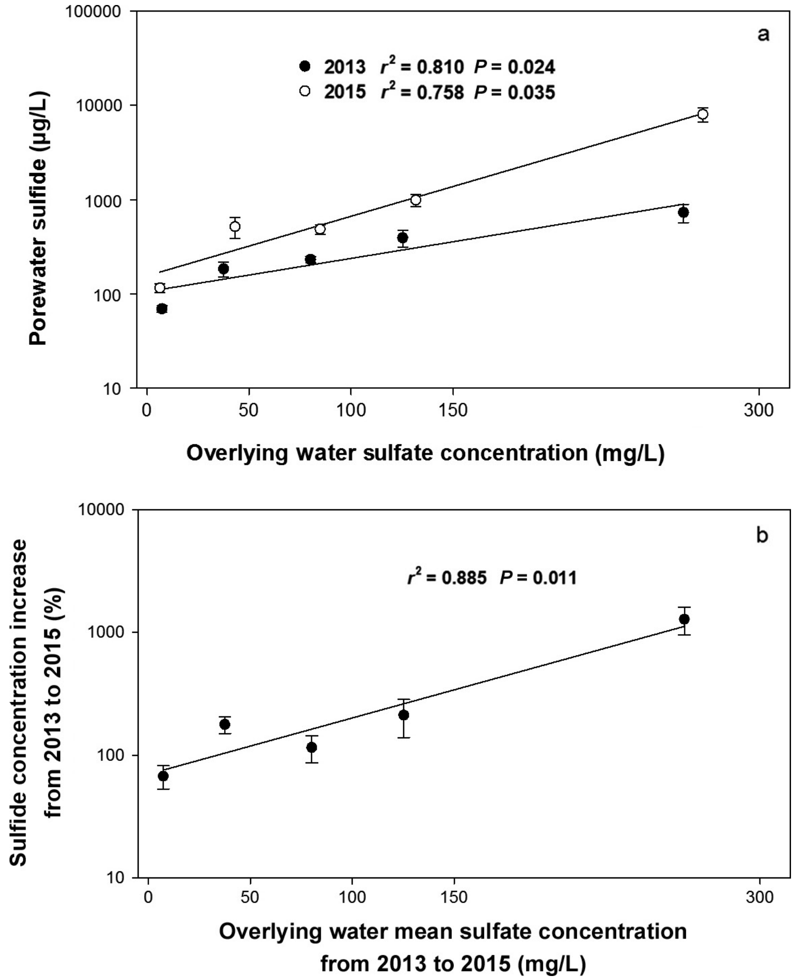

Fig. 3. (a) Porewater sulfide concentrations are strongly correlated with measured concentrations of sulfate in overlying water in the mesocosms and (b) the sulfide concentrations increased from 2013 to 2015 in proportion to sulfate concentrations. Symbols are means and standard errors.

water sulfate concentration (linear regression $r^2 = 0.02$). Sediment in control tanks contained less than 0.15 mg/g acid volatile sulfides (1 mol/L hydrochloric acid, Allen et al. 1991) while sediment in 300 mg/L sulfate tanks contained over 1.75 mg/g in 2013.

Porewater sulfide concentrations obtained from the upper 10 cm of sediment with Rhizon samplers were highly correlated with sulfate concentrations in the overlying water in both 2013 and 2015 (Fig. 3a). Concentrations were higher in 2015, and disproportionately higher in the higher sulfate treatments (Fig. 3b), which could be a consequence of progressively less precipitation with iron, which was a limited quantity.

Effects of sulfate and sulfide on seedling emergence rate and seedling survival.—In each spring after the initial planting in 2011, the number of seedlings that emerged from the sediment (Fig. 4a) declined significantly with increased sulfate concentrations ($P < 0.001$). Emergence rates differed from year to year ($P < 0.001$) but the rate of decline in seedling emergence with amended sulfate concentrations (slopes of regressions in Fig. 4a) did not change significantly from year to year (sulfate × year interaction $P = 0.598$).

The subsequent survival of those seedlings remaining after thinning (Fig. 4b) also declined significantly with increased sulfate concentrations ($P < 0.001$) and year ($P < 0.001$). The rate of decline in seedling survival with amended sulfate was twice as high in 2014 and 2015 than in 2012 and 2013. The number of surviving seedlings was not correlated with the number of seedlings that had been removed by thinning in any given year ($P > 0.10$), so the magnitude of thinning itself had no effect on seedling survival in the same year. The number of surviving seedlings was also not correlated ($P > 0.10$) with the production of straw litter from the previous year, so the decline in seedling survival was not an artifact of inhibition by thatch accumulation or nitrogen immobilization into fresh litter (Walker et al. 2010).

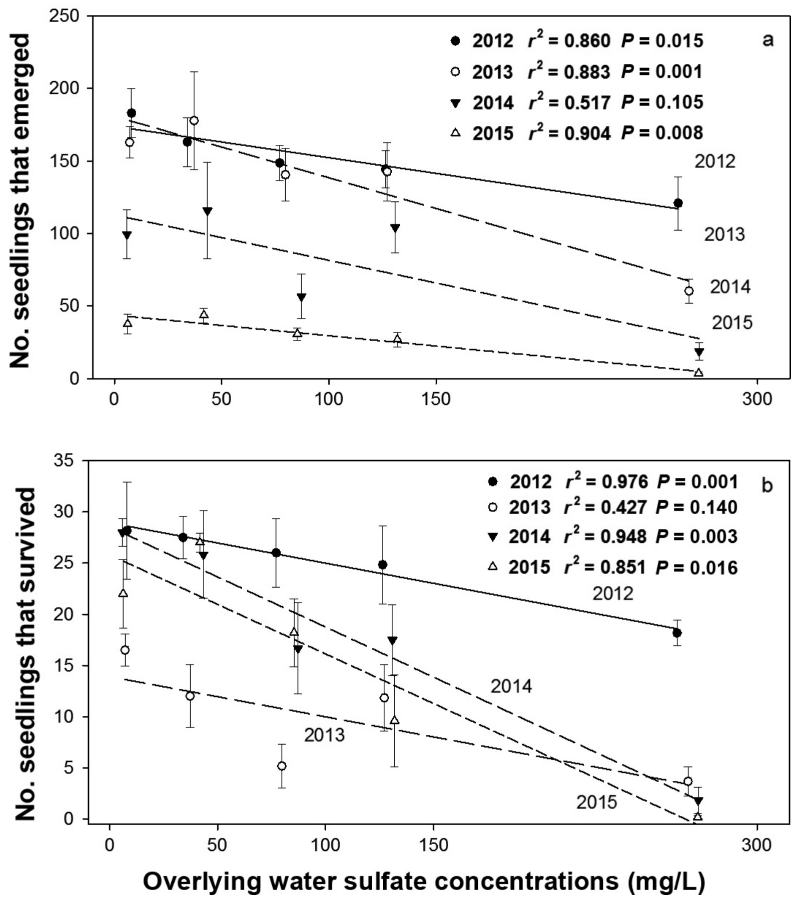

FIG. 4. Emergence (a) and survival (b) of seedlings in mesocosms declines with increasing measured sulfate concentrations in the overlying water. Symbols are means and standard errors.

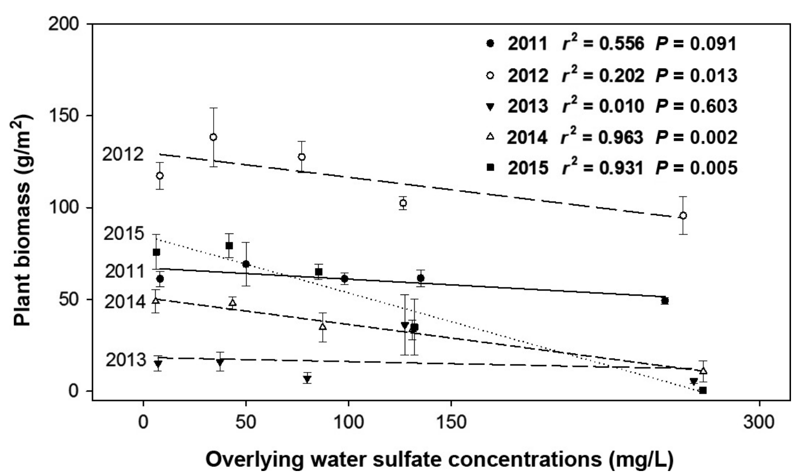

FIG. 5. Vegetative biomass in mesocosms declines with increasing measured sulfate concentrations in the overlying water. Symbols are means and standard errors.

In each year, there were no differences between control tanks and tanks amended to 50 mg/L SO_4, but seedling emergence and survival were significantly lower ($P < 0.05$) in tanks amended to 100 mg/L SO_4 or greater compared to control tanks.

Effects of sulfate and sulfide on vegetative growth.—Elevated sulfate and presumably sulfide concentrations decreased plant biomass (P < 0.001) and the rate of decline increased significantly during the course of the experiment, but most especially in 2015 (sulfate × year

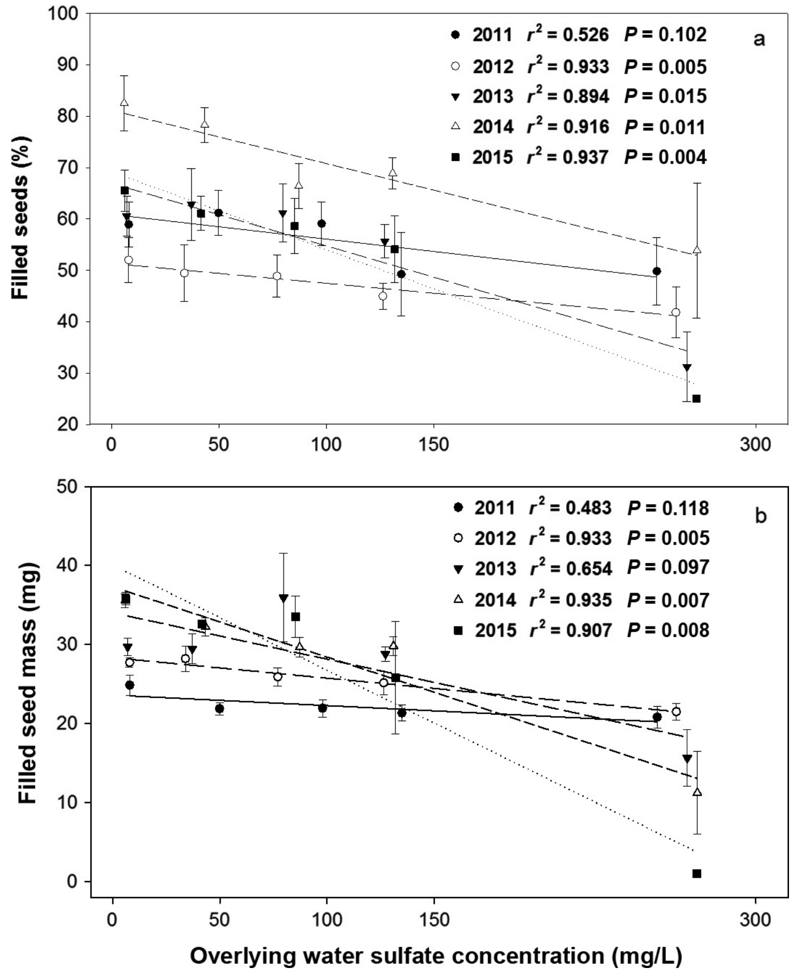

FIG. 6. (a) The proportion of seeds that were filled and (b) the mean seed mass in mesocosms both declined with increasing measured sulfate concentrations in the overlying water. Symbols are means and standard errors.

interaction statistically significant at $P < 0.001$; see Fig. 5 and the figure legend for r^2 and P levels). By 2015, wild rice was extinct in all but one replicate in the 300 mg/L treatment, which supported only two plants. Root and shoot masses of individual plants were highly correlated ($r = 0.998$, $P < 0.001$) and root:shoot ratios were nearly constant between 0.210 and 0.224. Therefore, while the amounts of root and shoot productions were significantly affected by elevated sulfate concentrations, the proportional allocation of production between roots and shoots was not.

Effects of sulfate and sulfide on seed production.—The number of seeds produced per plant (both filled and empty, as determined from peduncle counts) did not change significantly across all sulfate concentrations (not displayed), but the proportion of seeds produced that were filled declined significantly with increasing sulfate concentrations (Fig. 6a, $P < 0.001$). Although 55–80% of seeds from control plants were filled during all four years, the slopes of the regressions of the proportions of filled seeds against sulfate concentration declined more steeply with each successive year (sulfate × year interaction significant at $P < 0.001$). By 2015, the proportions of filled seeds were as low as 25% in the tanks with the highest sulfate concentrations.

Individual seed masses declined with increased sulfate concentrations (Fig. 6b, $P < 0.001$). The seed masses declined more steeply with increasing sulfate concentrations with each successive year (sulfate × year interaction significant at $P < 0.001$).

In each year, seed production did not differ between control tanks and tanks amended to 50 mg/L SO_4, but seed mass and the proportion of viable seeds were significantly lower ($P < 0.05$) in tanks amended to 100 mg/L SO_4 or greater compared to control tanks.

Blackened roots associated with elevated sulfate.—Beginning in 2012 and continuing for each subsequent year, plants in the tanks amended with sulfate had blackened roots while plants grown in the control tanks had white or light tan or orange roots when we

Table 2. Summary of the effects of sulfate and sulfide on the stages in the life cycle of wild rice.

	Effects of increased sulfate and/or sulfide	
Wild rice life cycle stage	Hydroponic experiments	Mesocosm experiments
Germination rate	no effect of sulfate or sulfide	not assessed
Juvenile seedling growth	significant negative effect of sulfide, no effect of sulfate	not assessed
Seedling emergence from sediment	not assessed	significant negative effect of sulfate addition, probably a result of reduced seed viability rather than direct effects of sulfide
Seedling survival	not assessed	significant negative effect of sulfate addition, most likely through sulfide production
Mature plant growth	not assessed	significant negative effect of sulfate addition, most likely through sulfide production
Seed production (number of seeds per plant)	not assessed	no effect of sulfate or sulfide
Seed viability, both individual seed mass and proportion of filled seeds	not assessed	significant negative effect of sulfate addition, most likely through sulfide production

harvested them at senescence. Visual estimates of the proportion of blackened roots increased progressively from approximately 50% in the tanks with sulfate concentrations approximately 50 mg/L to 100% in tanks with sulfate concentrations approximately 300 mg/L. These roots were pliable and white in cross sections cut with a knife, so they appeared to be still alive. In these cross sections, the blackening appeared to be crusted plaques on the root surfaces. The blackened roots from the 300 mg/L amended tank averaged 28.3% ± 9.8% Fe and 13.4% ± 4.6% S by mass, both much greater than tan/orange roots from the control tanks, which averaged 5.0% ± 3.9% Fe and 0.34% ± 0.29% S. We are investigating the chemistry of these plaques further, but our analyses thus far suggest that the blackening was caused by precipitation of some form of iron sulfide.

Discussion

Table 2 summarizes the major effects of sulfate and sulfide in these experiments. In the mesocosms, the correlation between sulfate concentrations in overlying water and sulfide concentrations in porewater (Fig. 3a) is so strong within a given year that we can reasonably use sulfate concentrations in overlying water as a surrogate for increased sulfide concentrations in sediment porewater. Porewater sulfide increased substantially between 2013 and 2015 (Fig. 3a, b). The sulfide production in these sulfate-amended mesocosms will eventually overwhelm the available iron and accumulate free sulfide in the porewater, which may be responsible for the disproportionately higher sulfide in the highest treatment in 2015 (Fig. 3b). The mesocosms did not mimic the steady state that occurs in the natural environment because sulfate in overlying water was resupplied but iron was not. Mechanistic models that include the interaction between sulfide and iron (e.g., Wang and Van Cappellen 1996, Eldridge and Morse 2000) include the continuous addition of iron from the overlying to the sediment, successfully modeling the steady-state relationship between sulfate, sulfide, and iron observed in the environment. The sedimentation of new iron to the sediment occurs in the natural environment, but was not included in this mesocosm experiment. Nevertheless, the experiment successfully exposed wild rice to progressively higher concentrations of porewater sulfide and documented the biological effects.

The porewater sulfide concentrations observed in natural waterbodies will vary depending on each site's surface water sulfate and sedimentary concentrations of organic matter and iron (Eldridge and Morse 2000). The sediment organic matter and extractable iron in this experiment (8.1% and 8.3 mg/g) are within the range of 67 Minnesota wild rice waterbodies; organic matter is lower than the median of 9.1%, and the iron is higher than the median of 4.8 mg/g (5th to 95th percentiles of 0.9–31.0% and 1.6–15.3 mg/g, respectively; A. Myrbo, *unpublished data*).

Upwelling groundwater through sediment would cause a waterbody to deviate from the conceptual model presented here; upward groundwater flow would not only counter downward diffusion of sulfate, but could also supply water with chemistry completely different than the overlying water. In a survey of 46 Wisconsin lakes, Nichols and Shaw (2002) found that the occurrence of wild rice is associated with areas of inflowing groundwater. In some cases, upwelling groundwater may supply sulfate to the reduction zone in littoral sediments (Krabbenhoft et al. 1998), so the effect of groundwater is unpredictable. Wild rice waters most likely to exhibit elevated porewater sulfide are those with relatively high organic matter, which allows enhanced microbial activity, and relatively low iron, which minimizes removal of porewater sulfide as a FeS precipitate (Heijs et al. 1999, Eldridge and Morse 2000).

Elevated sulfate concentrations were not directly toxic to wild rice seedlings in hydroponic solutions, in agreement with results reported by Fort et al. (2014). But adding sulfate to overlying waters in the mesocosms with wild rice sediment increased porewater sulfide concentrations most strongly in the upper 5 cm of sediment in 2013, after three field seasons of sulfate amendments (Fig. 2).

Sulfide was clearly toxic to early seedling growth in hydroponic experiments at concentrations above 320 μg/L, as indicated by slower growth or even zero or negative growth in a few cases (Fig. 1). Sulfide concentrations in excess of 320 μg/L were observed in the upper 5 cm of sediment when sulfate concentrations in the overlying water exceeded 20–50 mg/L (depending on season, Fig. 2).

The upper 2–5 cm of sediment is where seed germination and very early seedling growth most likely takes place. Wild rice seeds are shaped like torpedoes and penetrate the sediment aided by their long awns, which act as rudders and keep the seed vertical as it falls through the water column (Ferren and Good 1977). It is likely that the seeds are buried in the upper 2–5 cm of this sediment where oxygen is low and sulfide concentrations are greatest (Fig. 2). To survive, the seedling must germinate in and grow through this zone of high sulfide concentrations. In nature, the mesocotyl may elongate up to 6 cm (Aiken 1986), allowing a buried seed to emerge through up to "3 inches of flooded soil" (Oelke et al. 1982). After emergence into the overlying oxygenated water, the mesocotyl differentiates into the mature stem. Wild rice is unusual among grasses in that the stem develops before the root, probably because the seedling may have to grow between 50 and 100 cm before reaching the water surface, at which time floating leaves supply energy for root development (Aiken 1986). This is consistent with the enhanced stem plus leaf growth of seedlings we observed under anaerobic conditions without elevated sulfide concentrations. Root growth, in contrast, was reduced by anaerobic conditions in our hydroponic experiments, as it has been previously observed for wild rice (Campiranon and Koukkari 1977) and white rice (Kordan 1972, 1974*a, b*).

Elevated sulfide concentrations greatly reduced shoot and leaf elongation in our hydroponic experiments, particularly at concentrations greater than 320 μg/L. The toxic effect of sulfide on shoot and leaf elongation and seedling growth (Fig. 1) overrides the enhanced growth that normally happens under anaerobic conditions. Seedlings in the mesocosms with elevated sulfate (and hence sulfide) concentrations likely were inhibited from emerging successfully from the sediment and reaching aerobic conditions higher in the water column, resulting in reduced survival in the mesocosms.

It is possible that high ionic strength or salinity in the mesocosms with the higher concentrations of elevated sulfate could be the cause of reduced seedling emergence and survival. However, the hydroponic experiments demonstrated that seeds and seedlings could withstand sulfate concentrations of up to 1600 mg SO_4/L without adverse effects. This sulfate concentration is half the salinity of seawater (Schlesinger 1991). Electrical conductivity in the mesocosms was correlated with sulfate concentrations but, in 2012, we saw only small effects of sulfate on seedling emergence and survival even though electrical conductivity was high then as it was in 2015. High ionic strength alone is therefore probably not the cause of the progressively greater declines in seedling emergence and survival in the mesocosms.

It is likely that the observed negative effects on wild rice seedling growth and survival can be directly attributed to the toxic effects of sulfide because of the coherence between the mesocosm experiments and the hydroponic experiments, which isolated the toxic effect of sulfide on seedling growth from any direct effect of sulfate. The progressive decline in seedling emergence and survival during the 5-yr course of the experiment could have resulted from increasingly greater sulfide concentrations (Fig. 3) and progressive titration of reactive forms of ferrous iron out of the system as insoluble iron sulfide. The cumulative effects of this progressive loss of reactive ferrous iron could have allowed more sulfide to remain in solution (Fig. 3) and thereby have increasingly toxic effects on seedling emergence and survival. The possible loss of reactive ferrous iron during the 5-yr course of the experiment may have been partly responsible for the declines in population densities, even to extinction at the highest sulfate concentrations.

Elevated sulfate concentrations in the mesocosm water progressively reduced vegetative production over the five years, but to much less extent than seed production was reduced. The proportion of seeds that were filled, as well as their mean masses, decreased by over 30% and as much as 50% in the 300 mg/L mesocosm treatment by year five of the experiment. Reduced seed production and seed masses followed by reduced seedling emergence and survival the following year depressed population growth in successive years eventually driving wild rice populations to extinction at high sulfate concentrations. It is likely that this extinction was driven by reduced seed production, seedling emergence, and seedling survival that depleted the seed bank over the fine years of the experiment, and cumulative impacts on sediment chemistry from repeated sulfate additions could have exacerbated the decline.

The strong decline in measures of seed viability with increased sulfate concentrations at the end of the growing season (Fig. 6) compared with the weaker decline in vegetative growth in early to mid-growing season (Fig. 5) could not have been due to decreased N or P availability late in the growing season. Litter from the previous year has begun mineralizing N and P at this point in the growing season (Walker et al. 2010, Hildebrandt et al. 2012). The production of sulfide is correlated with many other chemical changes associated with the sulfate-enhanced anaerobic decay of organic matter (Lamers et al. 2002), including increased phosphate solubility. Phosphorus availability could not be controlled independent of sulfide in sediment, and sediment porewater and overlying water phosphate concentrations were elevated in sulfate amended tanks (A. Myrbo, *unpublished data*) most likely because precipitation of sulfide with reduced iron liberates phosphate (Caraco et al. 1989, Lamers et al. 2002). Since N and P availability were likely not limiting late in the growing season, it is unlikely that reduced N or P availability were responsible for the decline in seed production with increased sulfate concentrations. Therefore, by deduction, it must have been uptake that was limiting.

Sixty percent of annual N uptake in wild rice plants occurs early in the growing season but there is a second burst of nitrogen and phosphorus uptake in August during seed filling and ripening (Grava and Raisanen 1978, Sims et al. 2012*a*). Even though N and P were most bioavailable in August when wild rice seeds were being developed and filled, there was coincident peak accumulation of sulfide in the sediment porewater (Fig. 2). When exposed to high sulfide concentrations, roots of white rice (*Oryza sativa*) often become suberized (Armstrong and Armstrong 2005) with subsequent possible reduction in nutrient uptake across the thicker root membranes (DeLaune et al. 1983, Koch et al. 1990, Armstrong and Armstrong 2005, Lamers et al. 2013). Suberization of roots in response to high sulfide concentrations at this stage in wild rice's life cycle might inhibit nutrient uptake, resulting in fewer and smaller filled seeds.

Another possible mechanism for impaired nutrient uptake might be the precipitation of black iron sulfide plaques on the roots of plants that grew in mesocosms with elevated sulfate and sulfide concentrations. Our EDS analyses suggest that the tan or orange coatings on roots of plants grown under low sulfate concentrations may be iron hydroxide plaques, which are often found on healthy wild rice roots (Jorgenson et al. 2012). The existence of tan or orange coatings, consistent with iron hydroxide plaques, strongly suggests that the immediate vicinity of the roots is oxidized when sulfate concentrations are low, most likely due to radial oxygen loss through the aerenchyma tissues within the roots (Stover 1928, Colmer 2003, Yang et al. 2014). Blackened roots, however, are often observed in white rice (*Oryza sativa*) populations subjected to elevated sulfate concentrations or organic carbon (Jacq et al. 1991, Gao et al. 2003, Sun et al. 2015) and our EDS observations suggest that the blackened plaques on our roots are some form of iron sulfide. Sun et al. (2015) also found that these black plaques contain substantial amounts of iron sulfides. Precipitation of iron sulfide plaques on roots, whether a direct inhibitor of nutrient uptake or a harbinger of the encroachment of reducing conditions to nearer the root tissue, may be partly responsible for the reduced proportion of filled seeds as sulfate concentrations increased (Fig. 6). Further experiments using labeled ^{15}N would be useful to determine whether reduced nutrient uptake during seed filling is the cause of reduced seed production.

Suberization of roots and precipitation of iron sulfide plaques may not be independent. Enhanced suberization when the root tissue is exposed to sulfide (Armstrong and Armstrong 2005) might cause decreased radial oxygen loss from roots of wetland plants (Joshi et al. 1975, Gao et al. 2002, Armstrong and Armstrong 2005). If radial oxygen loss from roots is essential to maintaining low concentrations of hydrogen sulfide in the immediate vicinity of roots (Eldridge and Morse 2000), then sulfide concentrations in the rhizosphere could encroach nearer to the root surface when radial oxygen loss from roots is impaired. Iron (hydr)oxide present on or near the roots under these conditions could be reduced to iron sulfide and precipitated on the roots. Nutrient uptake during the stage of seed filling therefore might be impaired directly by suberization of roots followed by precipitation of iron sulfides on the roots if suberization reduces radial oxygen loss.

Conclusions

In our hydroponic experiments, elevated sulfide concentrations are directly toxic to seedlings. In our mesocosm experiments, sulfate amendments increased sulfide concentrations in the rooting zone, which then apparently decreased seedling emergence and survival. The reductions in seedling emergence and survival in the mesocosms are consistent with the toxic effects of sulfide on seedling growth in the hydroponic experiments.

The vegetative growth phase of wild rice's life cycle did not appear to be as strongly affected by sulfide as the production of viable seeds. The mechanisms behind reduced seed production and viability with increased sulfate and hence sulfide production in sediments are more difficult to discern, but may involve reduction of nutrient uptake during seed set by iron sulfide plaques on roots of mature plants (Jacq et al. 1991) or by increased suberization with elevated sulfide concentrations later in the summer (Armstrong and Armstrong 2005).

In natural wild rice ecosystems, the extent to which sulfate is reduced to sulfide, and to which sulfide persists in porewaters, are controlled by factors such as the sedimentary concentrations of iron and organic matter, and groundwater flow, among others, all of which may differ from the conditions in our mesocosms. But our experiments strongly suggest that the reduction of sulfate to sulfide in sediments, to the extent that it occurs in natural systems, may cause populations to decline by adversely affecting the reproductive phases of wild rice's life cycle.

Acknowledgments

This research was supported by the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa with reservation funds and water quality funds provided by the Environmental Protection Agency; by Minnesota's Clean Water Fund; and by Minnesota SeaGrant. The Grand Portage Reservation provided seeds and the Fond du Lac Reservation provided sediment from a wild rice lake for the mesocosm experiment, and Nancy Schuldt and Margaret Watkins, Water Quality Specialists from these reservations, provided advice on the design of this experiment. Russ Erickson at EPA's Mid-Continent Ecology Division in Duluth, Minnesota provided advice on statistical analysis of the hydroponic data. A Review Panel convened by the Minnesota Pollution Control Agency also made excellent suggestions for data analysis and interpretation. We thank all these people for their assistance. We thank Leon Lamers and an anonymous reviewer for many helpful comments on an earlier version of the manuscript.

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Supporting Information

Additional Supporting Information may be found online at: http://onlinelibrary.wiley.com/doi/10.1002/eap.1452/full

John Pastor Technical Review Comments - Wild Rice Rule
November 2017

Attachment C

(25 pages)


Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palustris*)
John Pastor
Dept. of Biology
University of Minnesota Duluth

Does Iron Control Sulfide Toxicity to Wild Rice?

- **Long term Mesocosm Experiment**

- **Bucket Experiment**

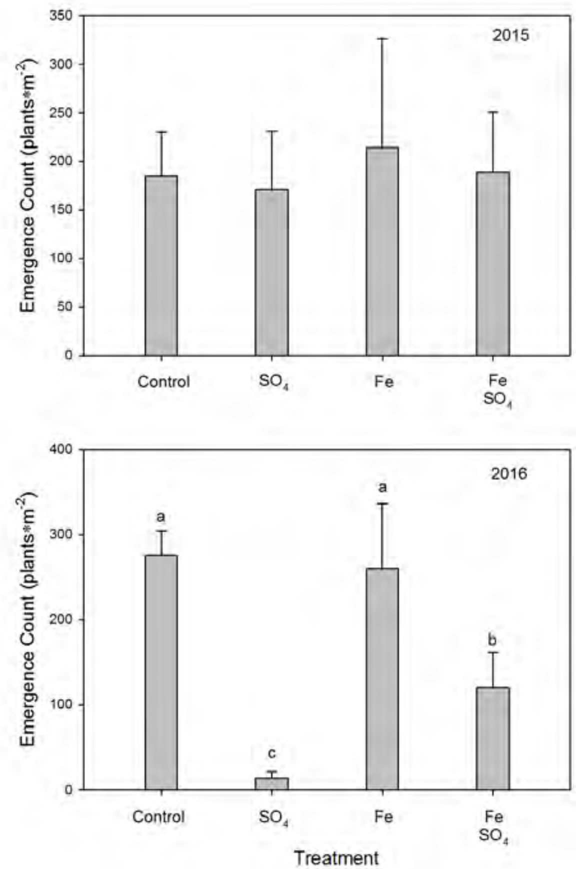
Mesocosm Experimental Design:

- 40 stock tanks
- Sulfate – control (c. 7 mg/L) & 300 mg/L
  added as Na_2SO_4 to water column
- Fe – control & tripled extractable Fe in sediment (220 g/ m^2 added as $FeCl_2$ in four aliquots into sediment in July and August 2014)
- Litter – present or removed (no significant effect)
- Thinned to 30 plants per tank
- Sediment from Rice Portage Lake

- 6 plants marked and harvested for seeds, plant growth, and allocation to roots and shoots
- Rest of tank harvested and weighed but returned to tank (or not if no litter)
- 2014 & 2015

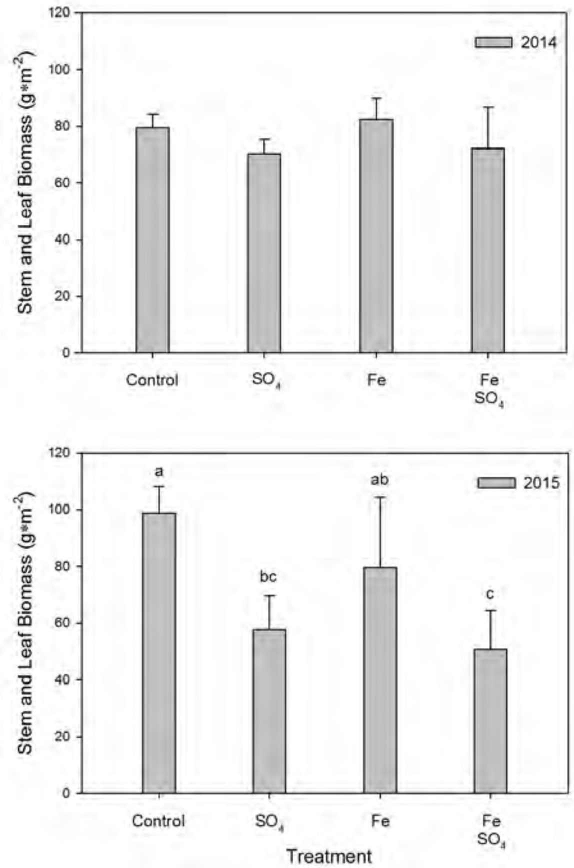
Seedling emergence depressed in the presence of sulfate by 2015

Fe partly compensated for the effect of sulfate/sulfide



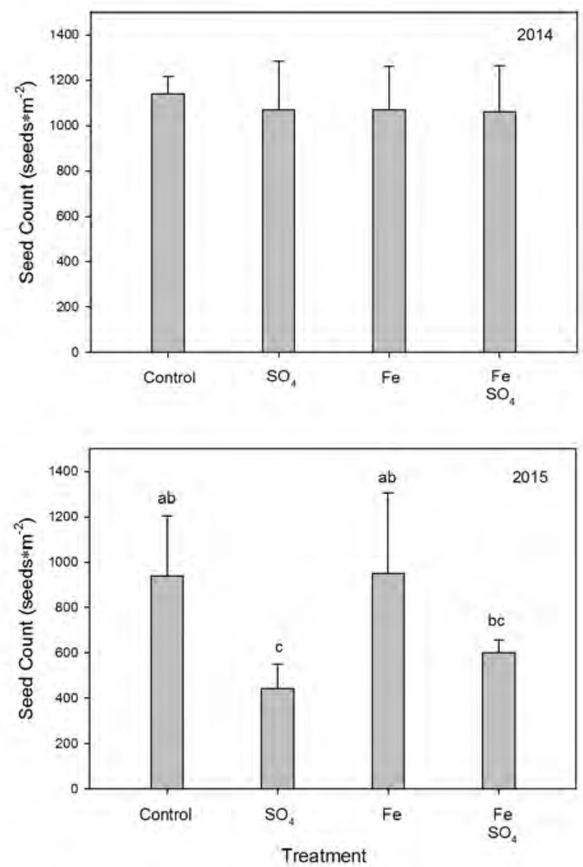
Vegetative growth depressed in the presence of sulfate by 2015

Fe had no effect by itself and no compensating effect in the presence of sulfate



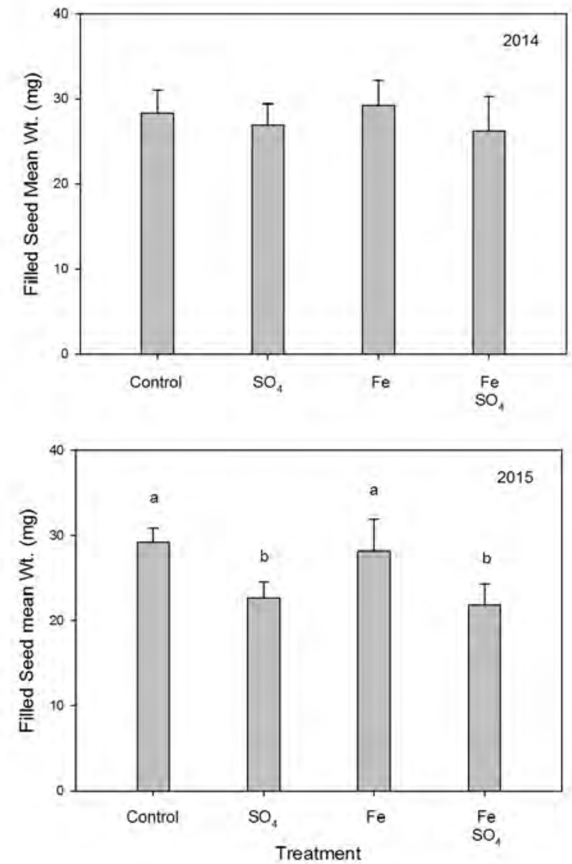
Seed count depressed in the presence of sulfate by 2015

Fe had no effect by itself and no compensating effect in the presence of sulfate



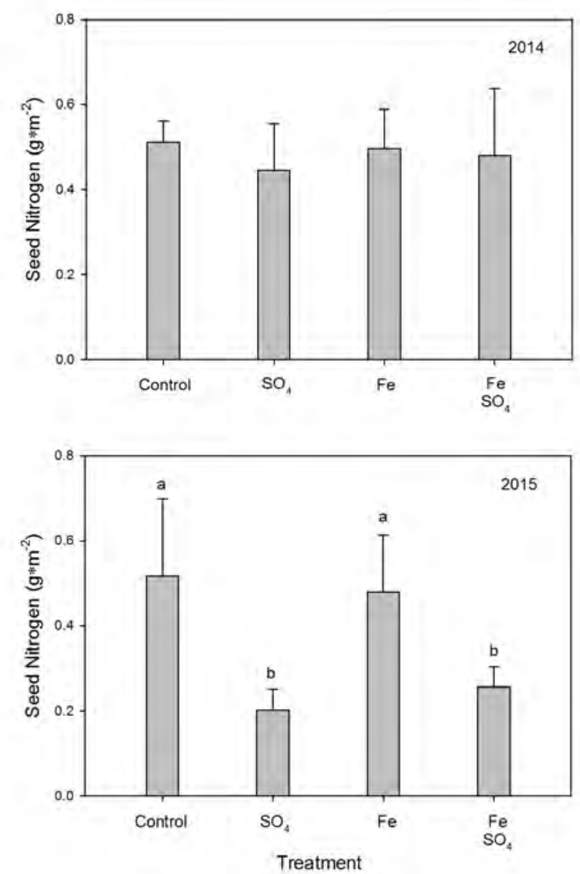
Seed weight depressed in the presence of sulfate by 2015

Fe had no effect by itself and no compensating effect in the presence of sulfate



Seed nitrogen depressed in the presence of sulfate by 2015

Fe had no effect by itself and no compensating effect in the presence of sulfate



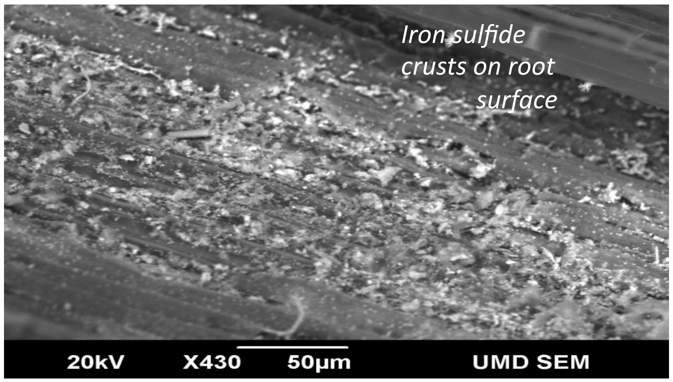
Preliminary Conclusions – Mesocosm Experiment

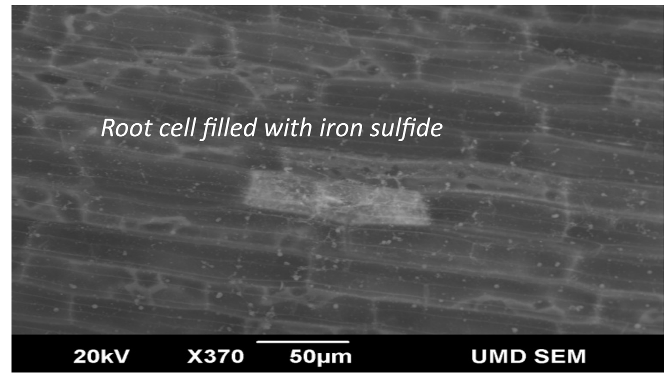
- Fe additions partly compensated for toxic effect of sulfide on seedling emergence, possibly by precipitating FeS

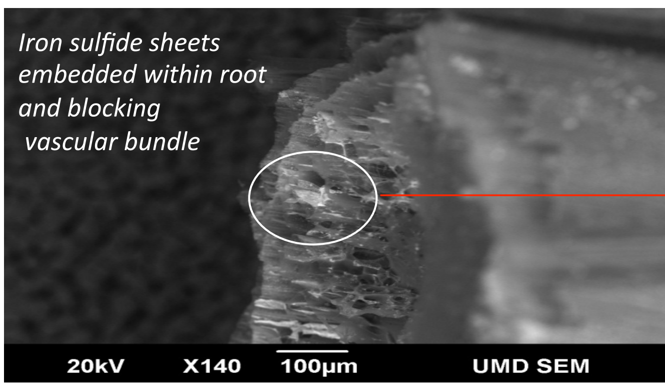
- Fe additions did not compensate for depression of vegetative growth or seed production and nitrogen content

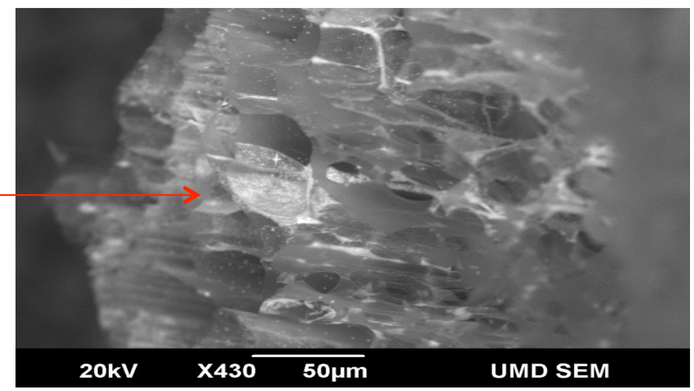
Iron plaques

SEM Scans of Iron Sulfide Precipitates on Roots









Scans courtesy of Dr. Bryan Bandli, UMD

What geochemical conditions are associated with iron sulfide plaque formation?

How do iron sulfide plaques change seasonally?

Do iron sulfide plaques inhibit nitrogen uptake?

Bucket Experimental Design:

- 40 buckets: 300 mg/L SO_4
- 40 buckets: control
- 1 wild rice plant per bucket
- Sediment from Rice Portage Lake

- 8 plants harvested per sample date
  - every 2 weeks during flowering
  - weekly during seed production
- Pore water sampled one day prior to harvest
- Sediment sampled start and end of growing season

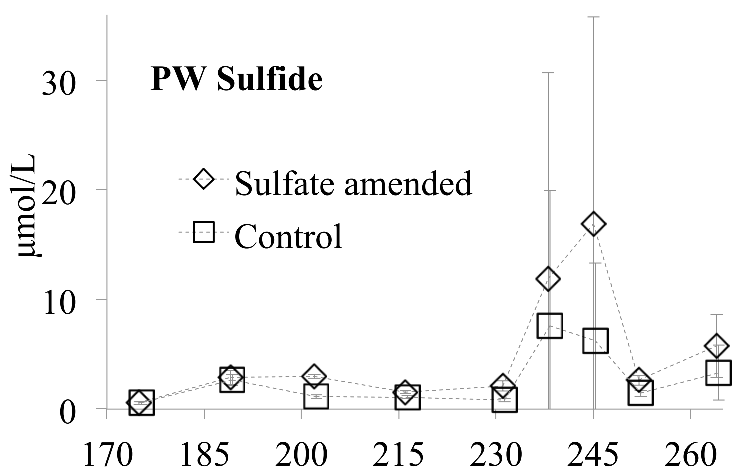
Methods: Pore water collection & analysis

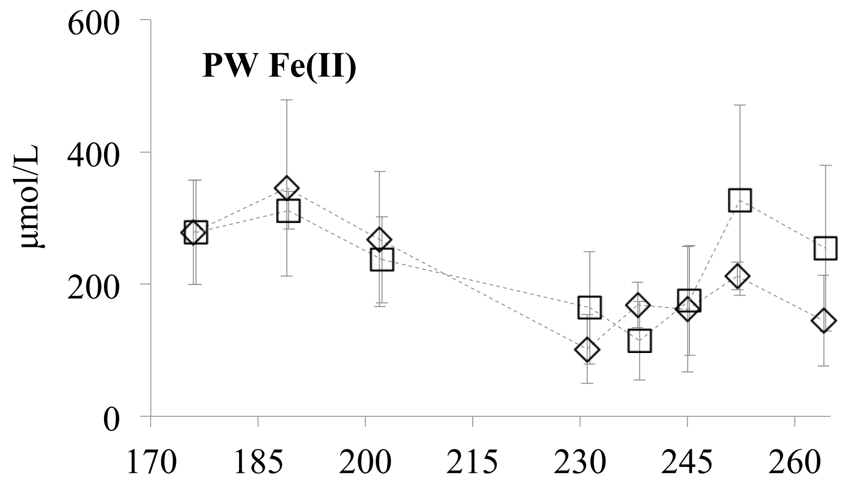
- Sampling procedure: rhizons attached to preloaded, vacuumed bottles

Analyte	Analysis
Sulfide	spectrophotometry (methylene blue)
Sulfate	ion chromatrography
Fe2+	spectrophotometry (phenanthroline)
pH	electrode

Methods: Root AVS & Fe

- Root collection
  - Placed in jar underwater in degassed DI water
- AVS quantification
  - Extracted for 4 hours with 1M HCl
  - Quantified with a sulfide ion-selective electrode
- Fe quantification
  - Aliquot of acid analyzed on AA
  - Ferrous iron quantified on spec

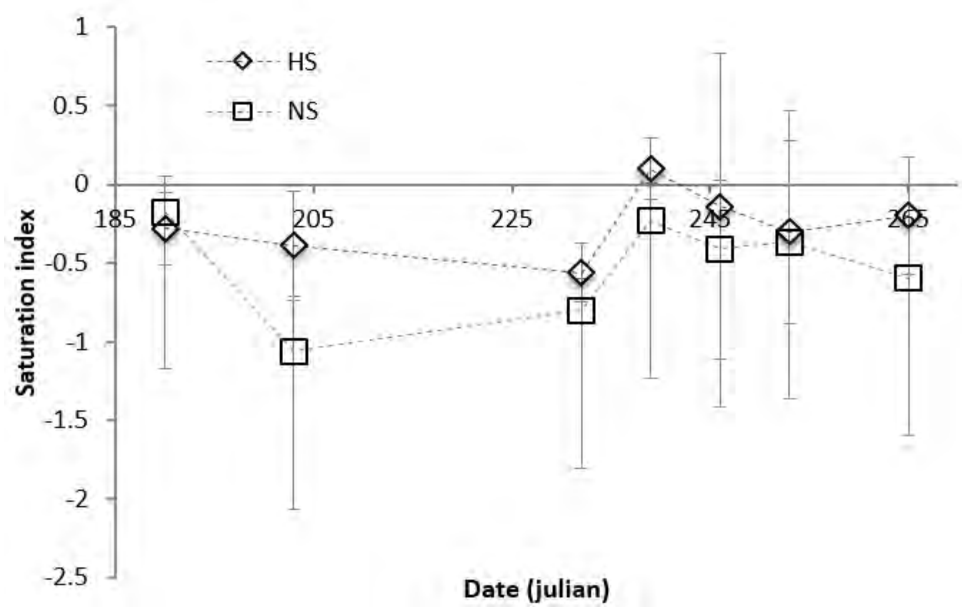

PW Sulfide
µmol/L
0
10
20
30
Sulfate amended
Control
170
185
200
215
230
245
260

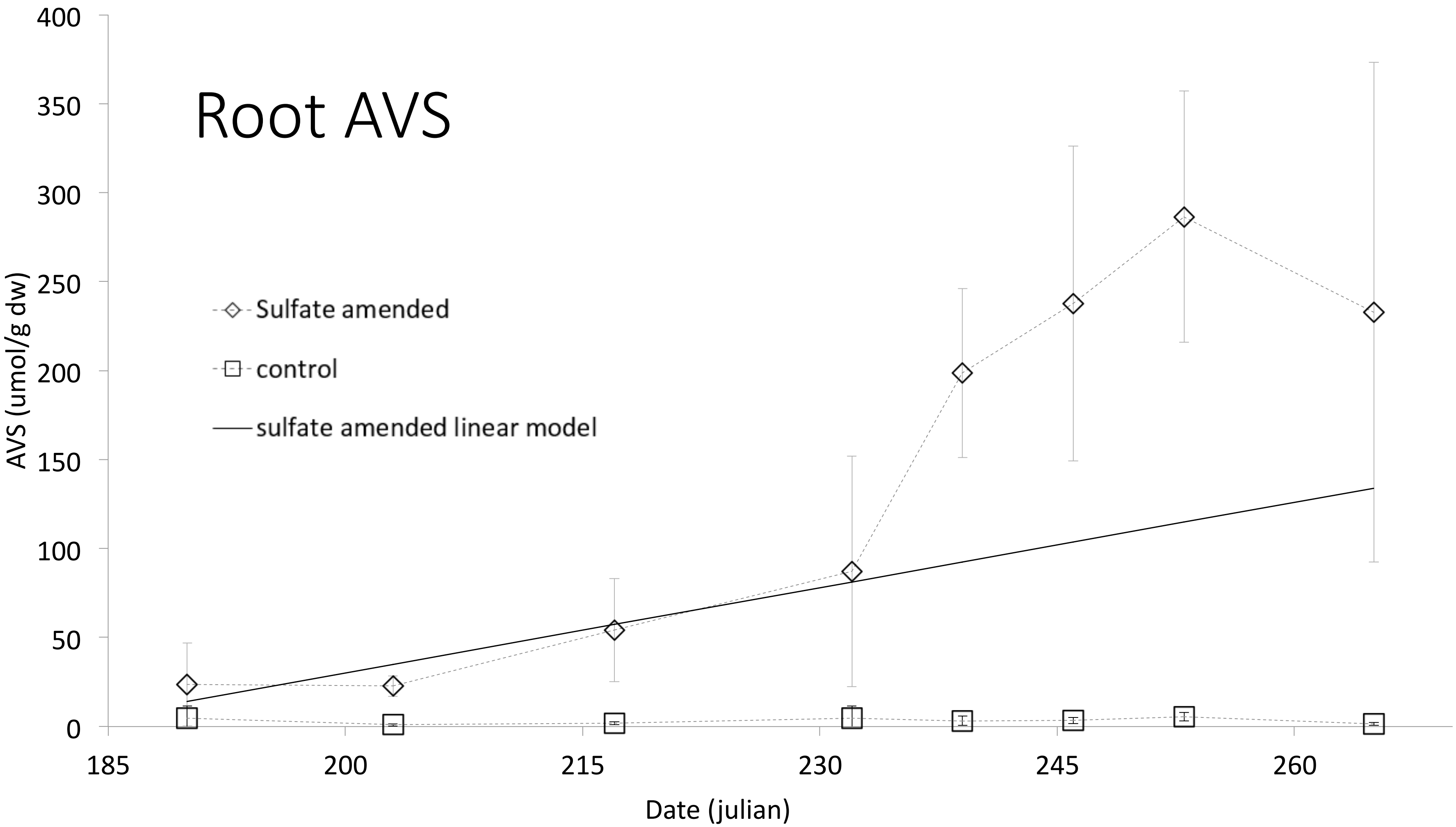

PW Fe(II)
µmol/L
0
200
400
600
170
185
200
215
230
245
260

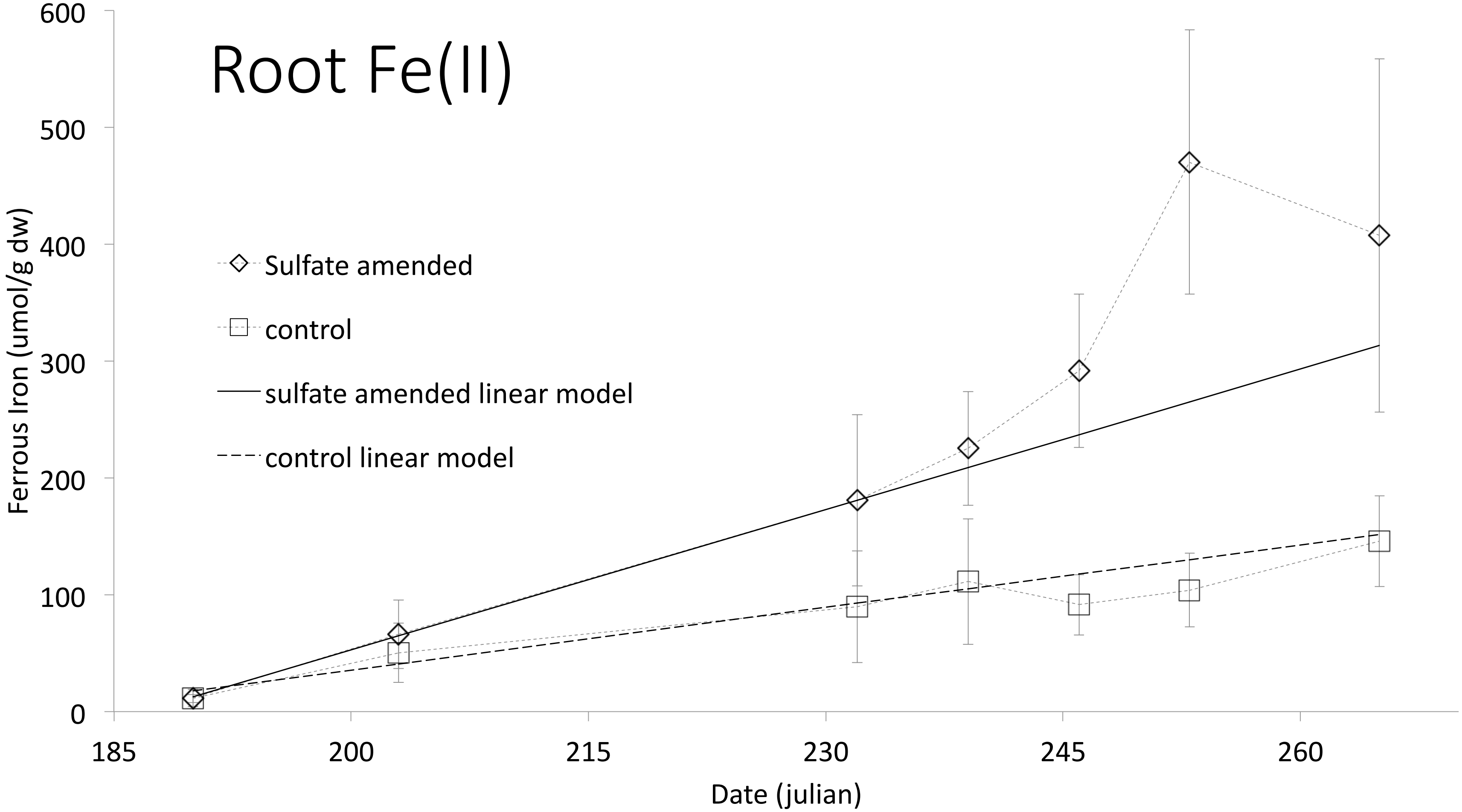
Saturation Index in Bulk Sediment

Pore water 2 cm from roots is *undersaturated* with respect to FeS

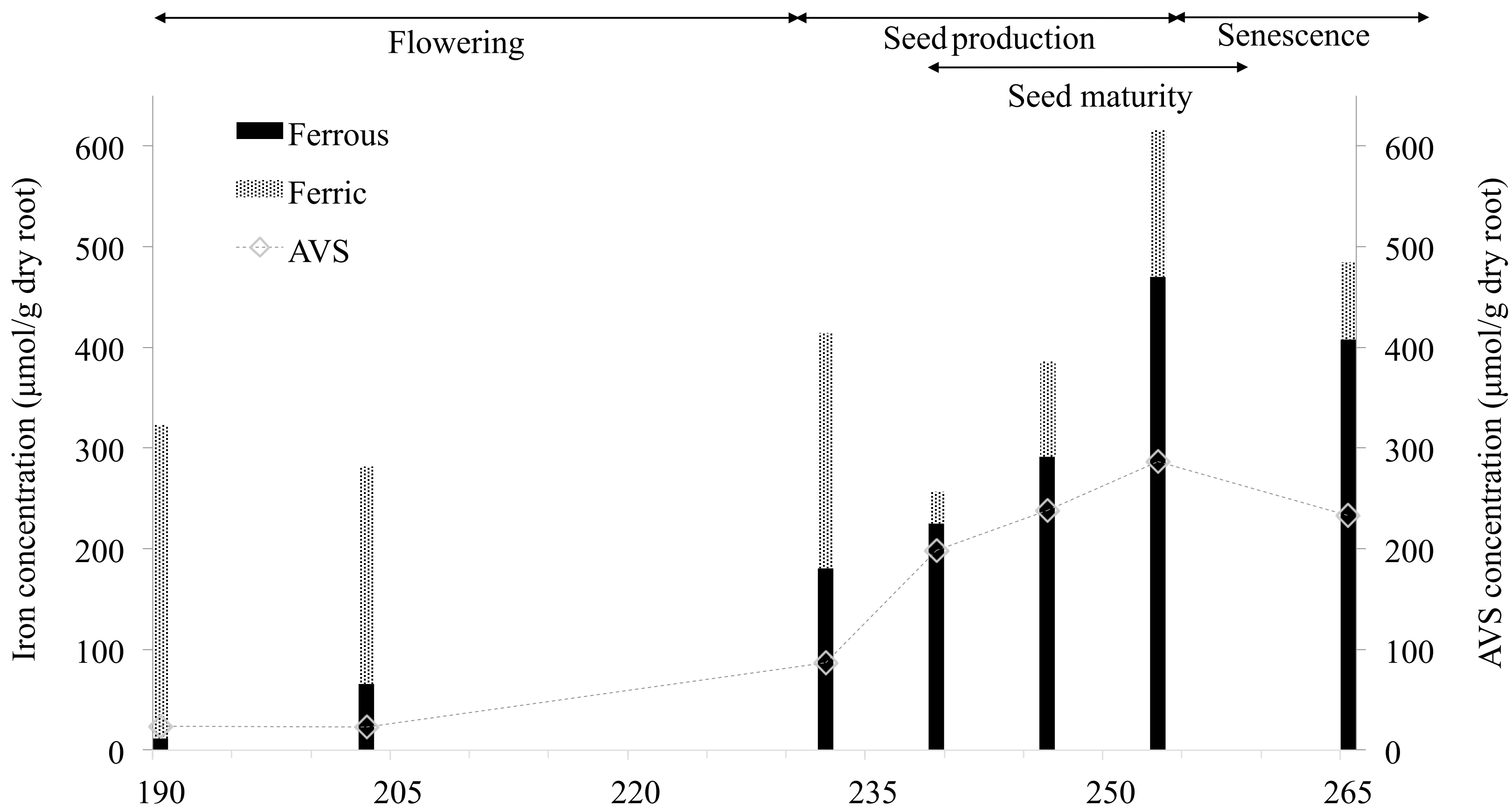
$SI = \log[IAP]/K_{sp}$, where $IAP = [Fe^{2+}][HS^{-}]/[H^{+}]$ and $K_{sp} = 10^{-2.95}$

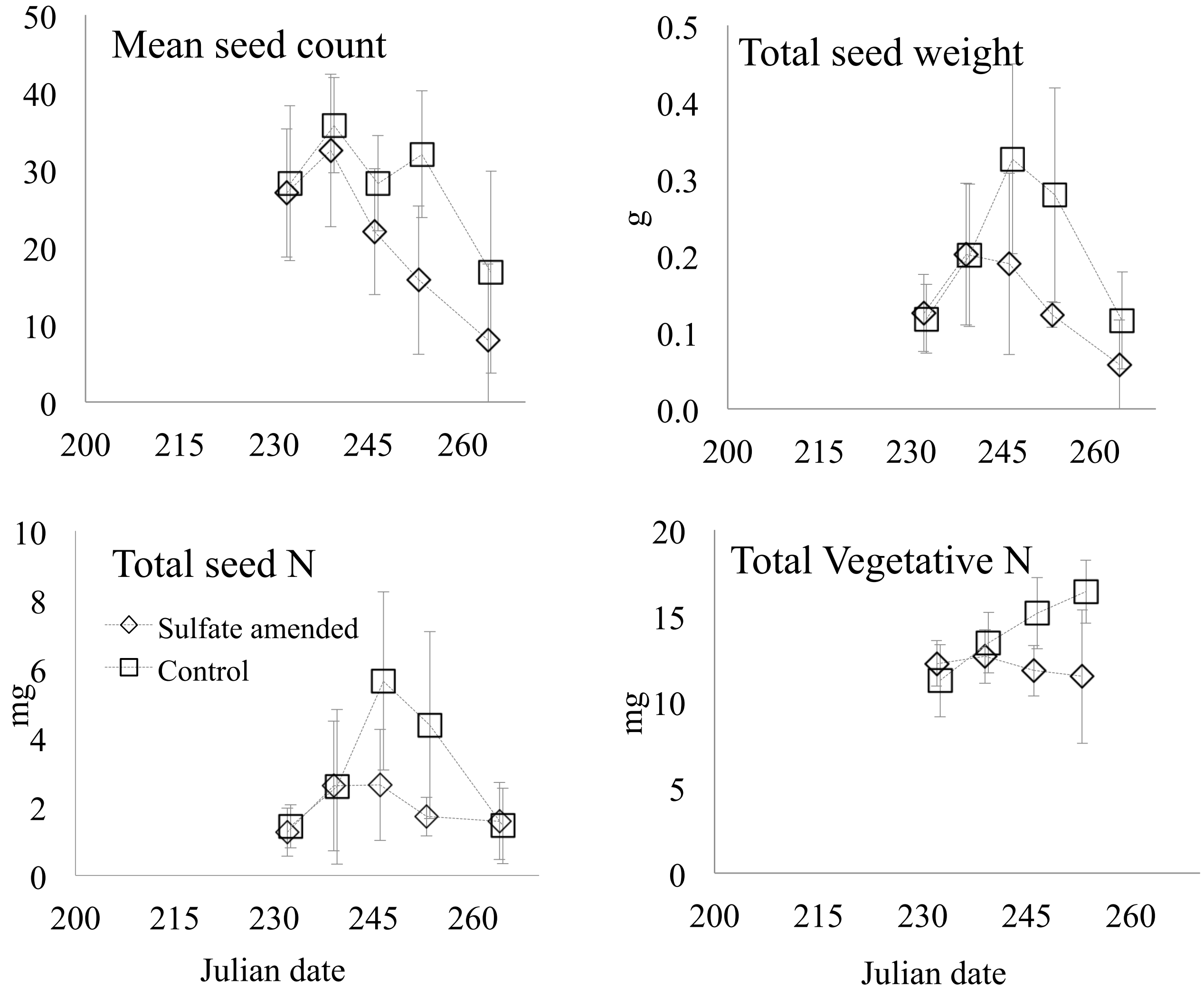



Root AVS
Sulfate amended
control
sulfate amended linear model
AVS (umol/g dw)
Date (julian)
0
50
100
150
200
250
300
350
400
185
200
215
230
245
260


Root Fe(II)
Sulfate amended
control
sulfate amended linear model
control linear model
Ferrous Iron (umol/g dw)
Date (julian)
0
100
200
300
400
500
600
185
200
215
230
245
260

Root iron speciation on amended roots




Mean seed count
50
40
30
20
10
0
200
215
230
245
260
Total seed weight
0.5
0.4
0.3
0.2
0.1
0.0
g
200
215
230
245
260
Total seed N
10
8
6
4
2
0
mg
Sulfate amended
Control
200
215
230
245
260
Julian date
Total Vegetative N
20
15
10
5
0
mg
200
215
230
245
260
Julian date

Repeated measures ANOVA (F values)	Sulfate	d.f.	Time	Sulfate x Time	d.f.
Pore water geochemistry					
Iron	5.16	1, 5	5.51***	1.14	6, 35
pH	3.25	1, 6	12.5***	1.45	6, 36
Saturation index	2.68	1, 4	2.19*	0.50	6, 34
Sulfide	239***	1, 3	8.17***	1.09	5, 27
Root geochemistry					
AVS (during flowering)	66.1***	1, 5	1.10	0.40	3, 17
AVS (during seed production)	148***	1, 6	5.46**	1.76	4, 24
Weak acid extractable iron	0.53	1, 6	2.65**	2.42**	7, 42
Ferrous Iron	127***	1, 6	57.2***	3.34**	6, 36
% Ferrous Iron	235***	1, 6	41.5***	4.91***	6, 36
Biological variables (during seed maturity)					
Plant weight	5.00*	1, 6	0.40	0.31	3, 18
Seed N (total mass)	5.84*	1, 6	1.10	1.22	2, 12
Seed weight	4.88*	1, 6	0.59	0.94	2, 12
Seed count	5.00*	1, 6	1.89	0.70	2, 12
Vegetative N (plant+seed mass)	5.43*	1, 6	0.32	1.71	2, 12

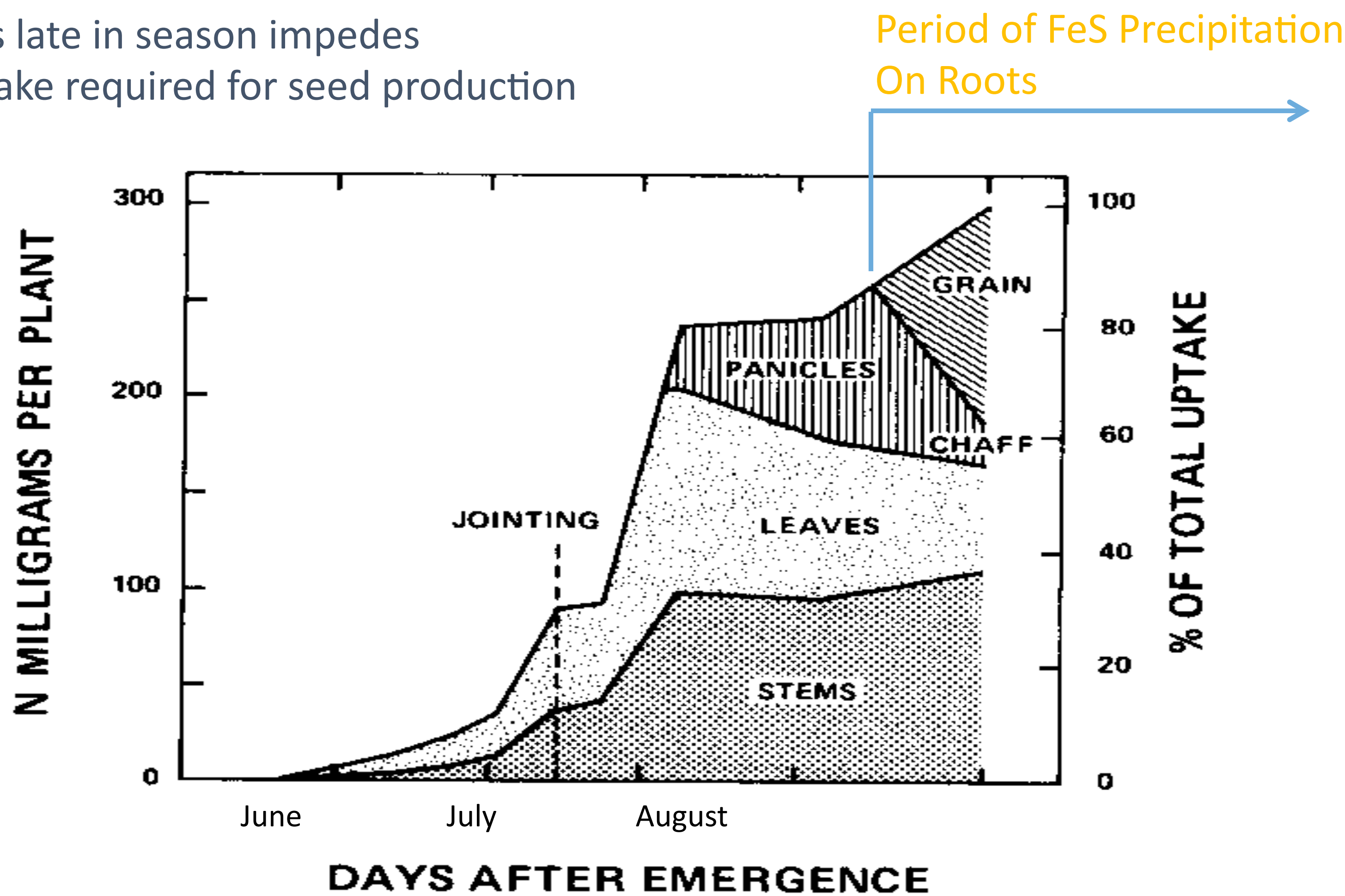
Significance levels

* 0.05 < p <0.10

** 0.001 <p<0.05

*** p <0.001

FeS_x on roots late in season impedes nitrogen uptake required for seed production



Grava and Raisanen 1978

Preliminary Conclusions – Bucket Experiment

- Iron oxides act as oxidized buffer during early-mid season
- Iron oxide buffer is overwhelmed by sulfide around the start of seed production
- Seed stage may be disproportionately harmed by sulfide because it coincides with iron sulfide precipitation on roots


Acknowledgements
NAH-GAH-CHI-WA-NONG
FOND DU LAC
RESERVATION
Minnesota Pollution
Control Agency
Sea Grant
Minnesota

John Pastor Technical Review Comments - Wild Rice Rule
November 2017

Attachment D
(4 pages)

[redacted]

MINNESOTA
SEA GRANT COLLEGE PROGRAM
RESEARCH ANNUAL REPORT

PI NAME: John Pastor

PROJECT NUMBER: R/CE-04-14
Chart String: 1000 10340 20857 00041968

PROJECT END DATE: June 30, 2016

REPORT DATE: May 5, 2016

PROJECT TITLE: The Biogeochemical Habitat of Wild Rice

PROGRESS TOWARD OBJECTIVES: (summarize your progress over the last 12 months)

With Sea Grant funding, we continued one long-term experiment and initiated two others. The long-term experiment consisted of adding sulfate to tanks containing wild rice grown in wild rice sediment to achieve surface water concentrations of ambient (7), 50, 100, 150, and 300 ppm SO4. After five years (two under SeaGrant funding, the wild rice populations in the 300 ppm tanks have gone extinct and the populations in the 150 ppm tanks are nearing extinction (Pastor et al. submitted). Extinction was caused by toxic levels of sulfide (from sulfate reduction) to seedlings and from reduced seed production. Proportional decreases in population productivity have happened in the other amended tanks.

During the course of these experiments, wild rice roots in tanks with more than 50 mg/L sulfate had become blackened. In contrast, plants grown in the low sulfate treatments had orange stains on the roots throughout the annual life cycle (Fig. 1). Using SEM elemental scans, we identified the black plaques as iron sulfide (FeS) plaques whereas the orange stains had iron but no sulfide and are most likely iron (hydr)oxides.

To sort out these two potential effects of FeS precipitation in roots and on sediments, we initiated two additional experiments. One is a large scale tank experiment in which additions of sulfate to 300 ppm, a tripling of sediment iron, and removal of litter (to reduced labile carbon for microbes) were applied in a crossed factorial design. After two years, sulfate amendments had the greatest effect, reducing production as in the first experiment regardless of iron amendment and litter removal. Iron amendment had no statistically significant effect, but plants grown under both sulfate and iron amendments had the lowest vegetative and seed production of all. Litter removal had no effect. While we cannot yet conclude from this experiment that iron has a strong depressive effect on wild rice growth via FeS plaques on roots, we can conclude that iron has no beneficial effect by reducing the toxicity of sulfide.

We also initiated a third experiments aimed at quantifying the development of these FeS root plaques. In this experiment, wild rice was grown individually in buckets with and without sulfate amendments (to 300 ppm). We sampled plants every two weeks to determine the phenology of the development of FeS plaques on the roots. We made two surprising observations. First, accumulation of FeS plaques on roots of plants grown under high sulfate concentrations increased very rapidly and suddenly in midsummer even while porewater sulfide in the bulk sediment remained unchanged. And second, by the end of the growing season, FeS concentrations were two orders of magnitude higher on black root surfaces than in the surrounding sediment; after a single annual growing season, the black roots contained approximately 5% (by mass) of the total amount of sulfur in the experimental sediments. FeS in the bulk sediment also increased during the growing season but much more slowly and without an obvious breakpoint in accumulation rate. These observations suggest an overwhelmingly dominant, plant-induced change towards conditions more conducive to FeS precipitation in the immediate vicinity of the roots that begins in the middle of the growing season and controls the rates and location of sulfur transformations.

Plants with the black FeS plaques on their roots produced fewer and less viable seeds, perhaps because the plaques potentially impair the uptake of phosphorus and nitrogen (Pastor et al. submitted). The rapid accumulation of FeS plaques occurs at the time that wild rice plants are beginning to flower and take up additional nutrients for the ripening seeds. This suggests that even if the precipitation of FeS in the bulk sediment reduces aqueous sulfide, precipitation on the root surfaces somehow impedes seed formation, perhaps by blocking nutrient uptake.

Last summer, we also added ^{15}N periodically throughout the growing season to plants amended with 300 mg/L sulfate and plants without sulfate addition. These experiments are providing a more detailed look at the plant-side nutrient fluxes in the context of the changing rates of sulfur accumulation on root surfaces. Preliminary results suggest that nitrogen uptake by wild rice may be inhibited by plaque formations, especially during the period of seed filling and ripening. If nitrogen uptake is inhibited by FeS plaques, then this may explain why wild rice plants with FeS plaques on roots had smaller seeds and a greater proportion of the seeds were not filled (Pastor et al. submitted).

DIFFICULTIES ENCOUNTERED AND ACTIONS TAKEN TO OVERCOME THEM:

Before we began the ^{15}N experiment last year, we had to spend the previous summer in pilot trials determining how much ^{15}N to add to create a measureable signal in the plants while overcoming the strength of the microbial sink in the sediment. This took up one entire summer The following summer was spent determining the approximate joint phenology of FeS plaque formation and ^{15}N uptake. Now that we know the proper amount of ^{15}N to add and the approximate joint phenology of its uptake in relation to FeS plaque formation, we have devised a sampling schedule wherein we will sample at high frequencies during the time of FeS plaque formation to determine how it coincides with nitrogen uptake. This will allow us to determine whether FeS plaques form at a constant increment controlled entirely by inorganic geochemistry of the sediments, or whether FeS plaques grow exponentially as they progressively cut off radial oxygen losses from the roots. We are, under separate documentation, requesting a no-cost extension of unspent graduate student funds to support Ms. Sophie LaFond-Hudson to continue these experiments which will be part of her Ph.D. thesis in Water Resources Sciences at the University of Minnesota.

RESULTS TO DATE: (please provide a brief summary of your results)

See above. Paper submitted acknowledging SeaGrant support:

Pastor, J., B. Dewey, N. W. Johnson, E.B. Swain, P. Monson, E.B. Peters, and A. Myrbo. Effects of sulfate and sulfide on the life cycle of wild rice (*Zizania palustris*) in hydroponic and mesocosm experiments. Ecological Applications: submitted.

ASSESS PROGRESS RELATIVE TO ORIGINAL SCHEDULE AND FINAL DEADLINE:

We have accomplished all of our original goals involving the tank experiments. The ^{15}N experiments were begun in response to a recommendation of the proposal review panel that we include some isotopic amendments to determine the effect of sulfate amendments on nutrient cycling. However, in order to do that with any precision, we needed to spend two years in pilot experiments to determine the amount of ^{15}N to add and its phenology relative to the growth of FeS plaques at high sulfate concentrations. With one more year's fieldwork we will be able to accomplish this objective.

OUTREACH OR PRODUCTS: Please list any products (Web or print), presentations, articles, media interviews, teacher training, K-12 education, etc. that you or your student(s) have from this research thus far. Is there anything our Communications or Extension staff can do to help you connect your research with stakeholders?

PERFORMANCE MEASURES: We are required to provide performance measures to National Sea Grant each year. You may not have anything at all in some of these categories, and that is expected. All we need at this point is your best guess and an explanation of how you arrived at your answer.

Measure 1: Economic and societal benefits derived from the discovery and application of new sustainable coastal, ocean, and Great Lakes products from the sea.

We are reporting these results to the Minnesota Pollution Control Agency and to the various tribal units of Lake Superior Chippewa who are in discussion about setting sulfate standards for waters entering wild rice beds. Many of these waters also enter Lake Superior and the estuaries of some major rivers such as the St. Louis and Fish Rivers once supported extensive wild rice beds which the states of Minnesota and Wisconsin are trying to restore. These results will help inform these restoration efforts by helping the state agencies determine how many and which acres could be restored to wild rice populations.

Measure 2: Cumulative number of coastal, marine, and Great Lakes issue-based forecast capabilities developed and used for management. *(typically interpreted to include most computer models)*

Not applicable

Measure 3: Percentage/number of tools, technologies, and information services that are used by managers (NOAA and/or its partners and customers) to improve ecosystem-based management.

See answer to Measure 1.

Measure 4: Acres of ecosystems protected or restored as a result of Sea Grant's involvement.

Not directly applicable, but see answer to Measure 1.

Measure 5: Number of environmentally-responsible fisheries and/or aquaculture production or harvesting techniques implemented.

Not applicable.

Measure 6: Number of communities who adopt/implement sustainable, economic and environmental development practices and policies, or hazard resiliency practices.

See answer to Measure 1.

Measure 7: Number of environmental curricula adopted by formal and informal educators.

John Pastor uses these results in his class in Integrated Biological Systems and Nathan Johnson uses these results in his class in Environmental Modelling. In addition, classes from Fond du Lac Community College routinely tour these experiments as part of their curriculum in wild rice management.

OTHER METRICS OF INTEREST TO NOAA: Please answer any that apply to your project (none may, and that is fine).

1. Did or will your project help develop or update sustainable development ordinances, policies, or plans? If so, in what community?

   See answer to Measure 1 above. The communities are the States of Minnesota and Wisconsin and the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa.

2. Did your project help a community implement a sustainable development plan? If so, what community?

   Potentially it will help the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa.

3. Did your project help develop or update a port or waterfront redevelopment ordinance, policy, or plan? If so, what port or community?

Not applicable

4. Did you help a port or waterfront implement a redevelopment plan? If so, what port or community?

Not applicable

5. Did your project help develop or update polluted runoff management ordinances, policies, or plans? If so, for what community?

Potentially the results of this research will help inform the State of Minnesota as it reviews its sulfate criteria for wild rice beds, especially in regard to runoff from iron and copper-nickel mines in northern Minnesota.

6. Did your project help implement a polluted runoff management ordinance, policy, or plan? If so, for what community?

Not applicable (yet).

PLANS FOR THE NEXT 6 MONTHS:

Continue to monitor the changes in wild rice populations in the tank experiments and initiate another ^{15}N addition experiment to distinguish between different models of FeS plaque formation and their effect on nitrogen uptake.

NAMES OF STUDENTS BEING SUPPORTED BY THIS GRANT AND THEIR LEVEL (e.g, grad (MS, PhD), undergrad, etc). For grad students, please indicate whether their thesis research is related to this project.

Ms. Sophie LaFond-Hudson, completed MS - WRS research on this project and is initiating Ph.D. –WRS research on it as well. Advisors: Profs. Nathan Johnson and John Pastor

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November 2017

Attachment E
(3 pages)

June 28, 2017

Progress Report on Experiments on Effects of Sulfate and Sulfide on Wild Rice

John Pastor, Dept. of Biology, University of Minnesota Duluth

This memo is a brief report on our ongoing experiments on the effects of sulfate and sulfide on wild rice, funded by EPA through the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa Water Quality Programs, the State of Minnesota, and Minnesota Sea Grant.

Our hypothesis is that sulfate amendments are detrimental to wild rice populations when it is reduced to the more toxic sulfide. We have initiated several long-term experiments to test this hypothesis and elucidate the underlying mechanisms. The longest experiment consisted of adding sulfate to 100 gallon stock tanks containing wild rice grown in wild rice sediment to achieve surface water concentrations of ambient (7), 50, 100, 150, and 300 mg/l SO_4. Sulfide concentrations in sediments increased in proportion to sulfate concentrations (Pastor et al. 2017). After five years (2011-2015), the wild rice populations in the 300 mg/l tanks have gone extinct and the populations in the 150 mg/l tanks are nearing extinction (Pastor et al. 2016; Fig. 1). Extinction was caused by toxic levels of sulfide (from sulfate reduction) to seedlings (Fig. 1) and from reduced seed production (Fig. 2). Proportional decreases in population productivity have happened in the other amended tanks. Raw data from this experiment has been archived at: http://onlinelibrary.wiley.com/doi/10.1002/eap.1452/full

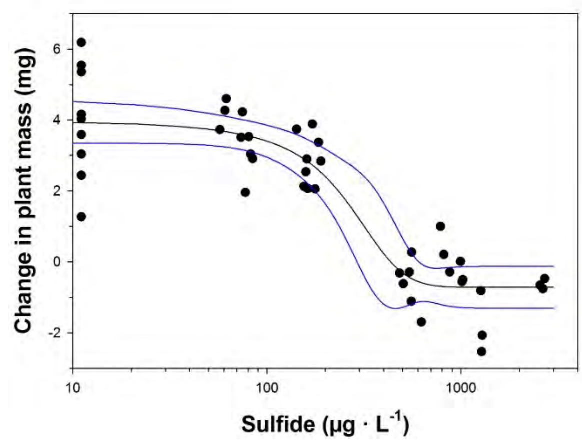

Figure 1. Reduction in seedling growth with increased sulfide concentrations in a hydroponucs experiment (Pastor et al. 2017).

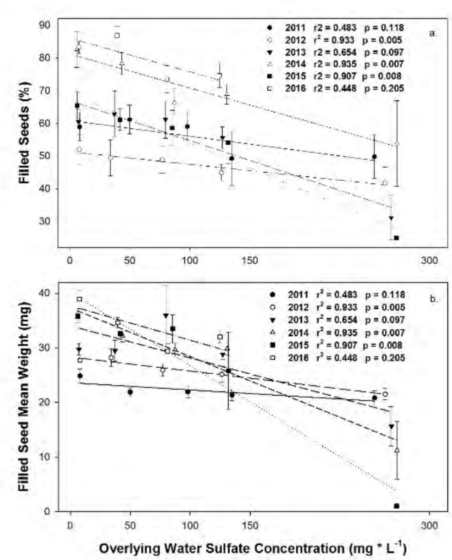

Figure 2. Reduction in seed production with increased sulfate concentrations in stock tank experiments (2011-2015 data from Pastor et al. 2017, with 2016 data added).

During the course of these experiments, wild rice roots in tanks with more than 50 mg/l sulfate had become blackened. In contrast, plants grown in the low sulfate treatments had orange stains on the roots throughout the annual life cycle. Using SEM elemental scans, we identified the black plaques as iron sulfide (FeS) plaques whereas the orange stains had iron but no sulfide and are most likely iron (hydr)oxides. Precipitation of iron sulfide on roots may inhibit nutrient uptake, thus leading to reduced seed production. On the other hand, precipitation of iron sulfide in sediments could neutralize the toxicity of sulfide to seedlings.

To sort out these two potential effects of FeS precipitation in roots and on sediments, we initiated two additional experiments. One is a long-term tank experiment in which additions of sulfate to 300 mg/l, a tripling of sediment iron in the first growing season, and removal of litter (to reduced labile carbon for microbes) were applied in a crossed factorial

June 28, 2017

design. This experiment began at the beginning of the 2015 growing season. During the first three years of this experiment, sulfate amendments had the greatest effect, reducing seedling survival, plant growth, and seed production regardless of iron amendment and litter removal. Litter removal had no effect on seedlings, vegetative growth, or seed production. In the first two growing seasons, adding iron without sulfate had no effect on seedling survival, plant growth, or seed production. Iron amendments in the presence of sulfate increased seedling survival compared with seedlings grown under sulfate amendments alone, but seedling survival in the iron + sulfate tanks was still less than in control tanks. We believe the partially ameliorative effects of iron on seedling survival was due to precipitation of iron sulfide in the sediment, thus partly neutralizing sulfide toxicity to seedlings. However, by the spring of year 3 (2017), the amendment of iron no longer appears to have any effect on seedling survival, possibly because all the iron we added has been titrated out of the tanks by precipitation with sulfide either in the sediment or on the plant roots.

Figure 3. Orange iron (hydr(oxide) stains on healthy wild rice roots in low sulfate environments (left) and black iron sulfide plaques on roots in high sulfate environments (right).

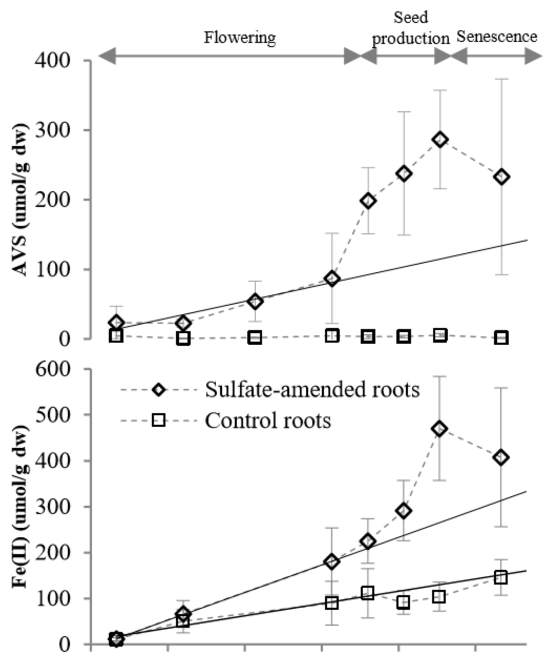

Figure 4. Time course of (top) sulfide and (middle) ferrous iron accumulation on plant roots in sulfate amended and control conditions (LaFond-Hudson et al. submitted).

We also initiated a third experiment aimed at quantifying the development of FeS root plaques (Fig. 3). In this experiment, wild rice was grown individually in buckets with and without sulfate amendments (to 300 mg/l). We sampled plants every two weeks to determine the phenology of the development of FeS plaques on the roots. We made two surprising observations. First, accumulation of FeS plaques on roots of plants grown under high sulfate concentrations increased very rapidly and suddenly in midsummer at the time that wild rice plants are beginning to flower and take up additional nutrients for the ripening seeds (Fig. 4). And second, by the end of the growing season, FeS concentrations were two orders of magnitude higher on black root surfaces than in the surrounding sediment; after a single annual growing season, the black roots contained approximately 5% (by mass) of the total amount of sulfur in the experimental sediments. FeS in the bulk sediment also increased during the growing season but much more slowly and without an obvious breakpoint in accumulation rate. These observations suggest an overwhelmingly dominant, plant-induced change towards conditions more conducive to FeS

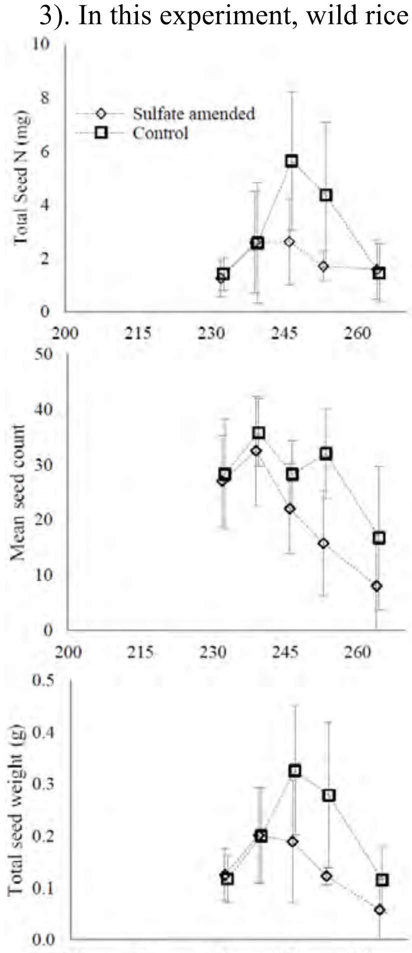

Figure 5. Seed nitrogen, seed count, and seed weight are higher in control plants with orange roots compared with plants with black roots grown under 300 mg/L sulfate (Lafond-Hudson et al. submitted).

precipitation in the immediate vicinity of the roots that begins in the middle of the growing season and controls the rates and location of sulfur transformations.

Plants with the black FeS plaques on their roots produced fewer and smaller seeds containing less nitrogen (Fig. 5), perhaps because the plaques potentially impair the uptake of nitrogen. This suggests that even if the precipitation of FeS in the bulk sediment reduces aqueous sulfide and partly ameliorates sulfide toxicity to seedlings, precipitation on the root surfaces somehow impedes seed formation, perhaps by blocking nutrient uptake.

In summary, our long-term experiments on the biogeochemistry of sulfate in wild rice habitat demonstrates that sulfate is not toxic in and of itself to wild rice, but when reduced to sulfide is directly toxic to seedlings. Iron additions may partly ameliorate sulfide toxicity to seedlings in spring, but precipitation of iron sulfide plaques on roots during the flowering and seed production period of wild rice's life cycle appears to block uptake of nitrogen, leading to fewer and smaller seeds with reduced nitrogen content. The net effect of sulfate additions to wild rice populations is to drive the populations to extinction within 4 or 5 years at high concentrations of sulfate (300 mg/l) and to greatly reduce population viability at lower concentrations.

PUBLICATIONS TO DATE:

LaFond-Hudson, S., N. Johnson, J. Pastor, and B. Dewey. Submitted. Iron sulfide formation on root surfaces controlled by the life cycle of wild rice (*Zizania palustris*). Nature Geosciences.

Pastor, J., B. Dewey, N. W. Johnson, E.B. Swain, P. Monson, E.B. Peters, and A. Myrbo. 2017. Effects of sulfate and sulfide on the life cycle of wild rice (*Zizania palustris*) in hydroponic and mesocosm experiments. Ecological Applications 27: 321-336.

John Pastor Technical Review Comments - Wild Rice Rule
November 2017

Attachment F

(39 pages)

Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palustris*)

A thesis
SUBMITTED TO FACULTY OF THE
UNIVERSITY OF MINNESOTA
BY

Sophia LaFond-Hudson

IN PARTIAL FULFILLMENT OF THE REQUIERMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

Nathan Johnson, John Pastor

May 2016

Acknowledgements

I would like to acknowledge several people who contributed substantially to this project. The members of my committee, Dr. Nathan Johnson, Dr. John Pastor and Dr. Elizabeth Austin-Minor provided intellectual guidance during the experimental setup, data analysis, and writing process. Brad Dewey played an important role in this project by sampling the biological data, assisting with harvesting and cleaning roots, and answering question after question about the experimental setup and methods. Dan Fraser was likewise very helpful in answering any questions about equipment. I am very grateful for the help I received from Marissa Samuelson, who assisted considerably with geochemical sampling and cleaning roots. Finally, I would like to again thank my advisors, Dr. Johnson and Dr. Pastor, for being generous with their excellent advice and constant encouragement.

Abstract

Iron (hydr)oxides typically form on roots of many wetland plants, including wild rice (*Zizania palustris*), an annual macrophyte with significant cultural, economic, and ecological value. Iron (hydr)oxides are thought to protect macrophytes from toxic reduced species, such as sulfide, by providing an oxidized barrier around the roots. However, wild rice grown under high sulfate loading develops a black iron sulfide precipitate on the root surface, and produces fewer and lighter seeds, leading to a decreased population in the long term. In order to investigate the role of iron sulfide root precipitates in impaired seed production, wild rice plants grown in buckets were exposed to sulfate loading of 300 mg/L, and harvested biweekly for extraction of root acid volatile sulfide (AVS) and weak acid extractable iron and analysis of plant and seed N. In sulfate-amended plants, AVS on roots accumulated over the course of the growing season, and accumulated rapidly just prior to seed production. Simultaneously, iron speciation of the root precipitate shifted from Fe(III) to Fe(II), consistent with a transition from iron (hydr)oxide to iron sulfide. A mechanism is herein proposed by which sulfide-induced suberization of roots decreases radial oxygen loss that keeps the rhizosphere oxidized, leading to reduction of iron (hydr)oxides and subsequent iron sulfide accumulation. Plants amended with sulfate produced fewer, lighter seeds with less nitrogen. We suggest that sulfide inhibits N uptake, and seeds are disproportionately harmed because rapid AVS accumulation occurs during the reproductive life stage.

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Introduction

Iron (hydr)oxide plaques have been observed on the roots of wild rice (*Zizania palustris*), a culturally significant macrophyte that forms large monotypic stands in the lakes and rivers of Minnesota, Wisconsin, northern Michigan, and Ontario (Lee and McNaughton 2004, Jorgenson et al. 2013). Iron (hydr)oxide plaques commonly form on the roots of wetland plants growing in anoxic, reduced sediments as a result of a redox gradients found in the rooting zone (Mendelssohn and Postek 1982, Jacq et al. 1991, Snowden and Wheeler 1995, Christensen and Sand-Jensen 1998). Redox gradients in the rhizosphere are caused by radial oxygen loss, a process in which wetland plants release oxygen into the rhizosphere through their roots via arenchyma tissue (Armstrong and Armstrong 2005, Schmidt et al. 2011). When Fe(II) is transported from anoxic sediment into the oxygenated rhizosphere, it is oxidized to Fe(III), which combines with oxygen from the roots to form insoluble iron oxides or hydroxides. Iron plaque formation can occur abiotically, but it is also associated with iron-oxidizing bacteria in many cases (St. Cyr 1993, Neubauer et al. 2007). Iron plaques have been proposed as a mechanism to protect plants from reduced toxic substances such as hydrogen sulfide, because they form an oxidized barrier around the roots (Koch and Mendelssohn 1989, Mendelssohn et al. 1995). However, during previous sulfur addition experiments, black iron sulfide root coatings, characteristic of iron sulfide minerals, have been observed on wild rice roots (Pastor et al., in review). Black root coatings have also been observed in white rice grown in surface water with high sulfate concentrations (Jacq et al. 1991, Gao et al. 2003, Sun et al. 2015).

The iron and sulfur chemistry of aquatic plant rooting zones involves a set of interrelated biogeochemical processes. Sulfate and iron (III) oxides are both redox active species that play a role in degradation of organic matter in aquatic sediments. During aerobic respiration, electrons are transferred from organic compounds to oxygen, but in anaerobic respiration alternative electron acceptors are used, including nitrate, ferric iron, sulfate, and carbon dioxide. Organisms use the more thermodynamically favorable electron acceptors first; nitrate is used before ferric iron, and carbon dioxide is used only when more favorable electron acceptors have been consumed. This thermodynamic ordering manifests itself as stratified microbial communities with distance away from an oxic-anoxic boundary (Boudreau 1996, Van Cappellen and Wang 1996). Anaerobic respiration produces reactive reduced species as byproducts, including ammonia, ferrous iron, sulfide, and methane. Iron-reducing and sulfate-reducing bacteria facilitate production of ferrous iron and sulfide respectively, after which ferrous iron and sulfide can combine to produce iron monosulfide (FeS) or pyrite (FeS_2). Alternatively, ferrous iron and sulfide can undergo oxidization back to ferric iron and sulfate abiotically via bioturbation or water level fluctuations (Thamdrup et al. 1994, Eimers et al. 2003) or biotically via iron or sulfide oxidizing bacteria (lithoautotrophy). Despite the predictability of the sequence of electron acceptors used in anaerobic respiration, coincident iron reduction and sulfate reduction in close proximity has been documented, during which the subsequently produced sulfide reacts abiotically with nearby iron (hydr)oxides to produce reduced iron and elemental sulfur (Hansel et al. 2014, Kwon et al. 2013).

Macrophytes can accelerate iron and sulfur cycling by enhancing redox gradients when radial oxygen loss creates an oxic layer around the root surface. Oxidation of Fe(II) to Fe(III) oxides immobilizes iron on or very near the root surface. Conversely, oxidation of sediment FeS by radial oxygen loss mobilizes previously bound sulfur as soluble sulfate (Choi et al. 2006). Cycling is dynamic near the rhizosphere because oxidation potential (Eh) changes abruptly over just a few millimeters. Just outside the oxic layer, the sediment can be strongly reducing. Heterotrophic iron and sulfate reduction can be stimulated by root exudates released by the plant (Kimura et al., 1981), and, in the case of an annual plant like wild rice, senesced plant material at the end of the growing season each year (Jacq et al. 1991). Several studies have compared sediment with and without vegetation and found higher sulfide or FeS concentrations in sites with plants (Holmer & Nielsen, 1997, Jacq et al. 1991, Lee & Dunton 2000). The increase in reduced species is attributed to larger pools of organic matter to drive reduction.

In Minnesota, surface water sulfate concentrations are regulated in wild rice waters because high surface water sulfate concentrations are associated with decreased wild rice abundance (Moyle, 1945, MPCA Analysis of the Wild Rice Sulfate Standard Study, 2014). It has recently been shown that sulfide, the reduced form of sulfate, is toxic to wild rice seedlings (Pastor et al., in review). In other wetland plants, sulfide is thought to interrupt metabolism by inhibiting metallo-enzymes in the electron transport chain during respiration (Allam and Hollis 1972, Koch and Mendelssohn 1989, Koch et al. 1990, Lamers et al. 2013; Armstrong and Armstrong 2005, Martin and Maricle 2015). Inhibition of ATP production deprives a plant of energy required for nutrient uptake. Sulfide has been shown to reduce nutrient uptake in white rice (*Oryza sativa*), a plant physiologically similar to wild rice (Joshi et al. 1975), so it is plausible that sulfide may also inhibit nutrient uptake in wild rice.

Pastor et al. (in review) found that exposure to sulfide decreased mean seed weight and the proportion of filled seeds more significantly than by having immediate toxic effects on plant growth and physiology. Wild rice takes up nitrogen, its limiting nutrient, in three main bursts: 30% is taken up during early season vegetative growth, 50% is taken up during early flowering, and 20% is taken up during late flowering and seed production (Grava and Raisanen, 1978). The effects of sulfide exposure on wild rice are consistent with nitrogen limitation during seed production, but it is not well understood why the seed production life stage is disproportionately harmed by sulfide. Is iron sulfide plaque accumulation a geochemical mechanism that controls the impact of sulfide on nitrogen uptake?

The objective of this study is to understand how iron and sulfur cycle near root surfaces and how this cycling affects nitrogen uptake by wild rice during its life stages, especially seed production. We investigate the drivers of iron sulfide plaque formation and seek to answer if plant and seed nitrogen uptake are adversely affected by iron sulfide accumulation on root surfaces.

Methods

Experimental Design

Sediment was collected from Rice Portage Lake (MN Lake ID 09003700, 46.703810, -92.682921) on the Fond du Lac Band of Lake Superior Chippewa Reservation in Carlton County, Minnesota in late May, 2015 and placed in a 400L Rubbermaid stock tank where it was homogenized by shovel. Initial carbon in the sediment was 14.8 ± 1.70% and initial nitrogen was 1.12 ± 0.13 %. Eighty 4 L plastic pails were then filled with 3 L of the sediment. Each 4 L pail was placed inside of a 20 L bucket which was filled with 12 L of water to provide a 12-15 cm water column. The overlying water of 40 randomly chosen buckets was then amended with an aliquot of stock solution (5.15g of Na_2SO_4 dissolved in 200ml of deionized water) to result in 300 mg/L (3.125 mM) sodium sulfate. The amendment concentration was chosen as such because when used in previous mesocosm experiments, wild rice populations went extinct within five years (Pastor et al. in review), but it is only slightly higher than the EPA drinking water secondary standard (250mg/L) and is a concentration found in some Minnesota lakes (MPCA Analysis of the Wild Rice Sulfate Standard Study, 2014). The overlying water was sampled twice throughout the trial and adjusted to 300mg/L SO_4 with appropriate amounts of Na_2SO_4 stock solution. The other 40 buckets did not receive any sulfate and on 6/23/15 (day 174, Julian date) had an average surface water sulfate concentration of 14.44 ± 1.01 mg/L, consistent with the local groundwater sulfate concentration. In each bucket, two seeds which were harvested in 2014 from Swamp Lake on the Grand Portage Reservation (MN Lake ID 16000900, 47.951856, -89.856844) were planted on 5/15/15 (Julian day 135). Once shoots reached a height of approximately 20 cm during the aerial stage, plants were thinned to one plant per bucket.

Sampling of pore water, roots, and stems began midsummer (63 days after planting/germination), at the start of flowering and the second burst of nitrogen uptake (Grava and Raisanen, 1978), and continued until plants had thoroughly senesced, for a total of eight sample dates, not including initial sediment and pore water sampling. Sampling occurred every two weeks for the first four sample dates, (flowering, days 189-232) and weekly for the last four sample dates (seed production, days 238-265), for a total of eight sample dates. One week prior to each sampling date, 40 ml of enriched ^{15}N

solution were injected into the sediment of four randomly selected sulfate-amended buckets and four control buckets. For the first two sample dates, the labeling solution was prepared by adding 0.88 mg of 10% $^{15}N-NH_4Cl$ to 500 ml DI water. For all other sample dates, 2.2mg of 10% $^{15}N-NH_4Cl$ were added to 500 ml of DI water to account for an increase in plant biomass later in the growing season. The solution was injected into the sediment of the 4L pail in four locations uniformly spaced around the center of the pail, approximately 2 cm from the outer edge and 2 cm from the bottom. Immediately before injection, the overlying water was removed from the outer pail, leaving 2-5 cm above the sediment in the internal pail, to keep the $^{15}N-NH_4Cl$ contained in the sediment for uptake by the wild rice roots. On each sample date, one week after injection of ^{15}N, the four sulfate-amended and four control buckets were sampled for pore water sulfide, pore water sulfate, pore water iron, and pH. After pore water sampling, the wild rice plant was destructively harvested for analysis of vegetative ^{15}N, vegetative total N, and root AVS and weak acid extractable iron. The bulk sediment was sampled for solid phase S and Fe analysis at the beginning and at the end of the growing season.

Pore water sampling and analysis

Prior to extracting pore water samples, pH was measured *in-situ* with a ThermoScientific Orion pH electrode at a depth of 5 cm below the sediment surface and 2 cm from the stem of the wild rice plant. Pore water was sampled using 5-cm length, 2-mm diameter tension lysimeter filters (Rhizons, Seeberg-Elverfeldt et al., 2005) attached with a hypodermic needle to an evacuated, oxygen-free serum bottle sealed with a 20 mm thick butyl-rubber stopper (Bellco Glass, Inc). The entire filter end of the Rhizon was inserted vertically into the sediment just below the surface. The goal was to draw water from approximately the upper 5 cm of sediment without drawing surface water. The filter was placed with minimal jostling to avoid creating a cavity around the filter that would allow surface water to enter the sediment and contaminate the pore water. The Rhizon was placed approximately 2 cm away from the stem of the wild rice plant and on the opposite side from where pH was measured.

Pore water sulfide samples were drawn into 50-mL serum bottles preloaded with 0.2% 1 M ZnAc and 0.2% 6 M NaOH to preserve sulfide. Sulfide bottles were left to fill overnight, then stored at 4C in the sealed serum bottles used for sample collection for approximately 30 days before sulfide was quantified. Samples for pore water sulfate analysis were withdrawn from sulfide sampling bottles and filtered through a Dionex 1cc metal cartridge and a 0.45 μm polyethersulfone filter approximately three months after they were collected. Pore water iron was collected in 8-mL serum bottles preloaded with 40% deionized water, 40% phenanthroline, 20% acetate buffer, and 1% concentrated hydrochloric acid. Iron bottles were filled until the solution turned light red, approximately ten minutes. If the solution turned red before 8 mL were collected, samples were diluted with deionized water to bring the total solution to 8 mL. Iron samples were quantified within two hours of sampling. Iron and sulfide were quantified colorimetrically using the phenanthroline and methylene blue methods, respectively, on a HACH DR5000 UV-Vis spectrophotometer (Eaton et al., 2005). Sulfate was quantified using a Dionex ICS-1100 Integrated IC system (AS-DV Autosampler) (Eaton et al., 2005).

Solid phase sampling and analysis

Samples for the bulk sediment initial conditions were obtained after homogenization of the sediment prior to placement in the buckets (day 152). Five replicate samples were placed in jars and analyzed for AVS and simultaneously extracted iron. At the end of the season, mini-cores of intact sediment were retrieved immediately before wild rice plants were sampled.

On each sample date throughout the summer, wild rice roots were collected for AVS and weak acid extractable iron. Each plant was removed from the sediment and immediately rinsed in buckets of deoxygenated water continuously bubbled with nitrogen. While submerged in deoxygenated water, the stem was cut just above the root ball so that the shoots and seeds could be saved for ^{15}N analysis. Roots were then placed in jars full of deoxygenated water, which were immediately placed in a plastic bag flushed with nitrogen and transported to an oxygen-free glove box. In the glove box, the roots were cleaned of extra organic matter prior to removing a 1-2 g section of wet root mass for AVS and iron analysis. From both sediment and roots, AVS was extracted using 7.5 ml 1 N HCl for 4 hours using a modified diffusion method (Brouwer and Murphy 1994). During a room temperature acid incubation with gentle mixing, sulfide was trapped in an inner vial containing Sulfide Antioxidant Buffer (SAOB) and subsequently quantified using a ThermoScientific sulfide ion-selective electrode with a detection limit ranging from 0.01-40 mmol/L. Ferrous iron was quantified colorimetrically using the phenanthroline method on a HACH DR5000 UV-Vis spectrophotometer (Eaton et al., 2005), and weak acid extractable iron was quantified using a Varian fast sequential flame atomic absorption spectrometer with an acetylene torch.

A subset of roots was tested for chromium(II)-reducible sulfur (CRS) to determine whether AVS was extracting all total reduced inorganic sulfur on the roots. A diffusion-based CRS method was used, which can fully extract amorphous iron sulfide and pyrite and can partially extract elemental sulfur (Burton et al. 2008). Chromic acid for CRS analysis was prepared according to Burton et al. (2008). Inside an oxygen-free glove box, a section of root from a plant previously analyzed for AVS was placed in the analysis bottle. An inner vial containing SAOB was also placed inside the bottle prior to sealing. Bottles were taken out of the glove box and injected with chromic acid. CRS was extracted for 48 hours and quantified using a ThermoScientific sulfide ion-selective electrode.

Isotope sampling and analysis

For analysis of ^{15}N uptake, the plants were sub-sampled by cutting at the stem to root transition. If seeds were present, they were removed prior to sampling the plant and saved for separate analysis. The plants and seeds were rinsed with deionized water and dried in paper bags for seven days at 65C. The dried plants were weighed, placed in polycarbonate vials with stainless steel balls, and shaken in a SPEX 800M mixer mill until the samples were in a powdered form. Seeds were counted, weighed, and powdered using the same method. The samples were transferred to glass vials and dried again overnight at 65C with caps loosely covering the vials. Samples were quantified for total N and $\delta^{15}N$ on a Finnigan Delta Plus XP isotope ratio monitoring mass spectrometer.

Data analysis

Geochemical parameters and measured attributes of plants were analyzed using repeated measures analysis of variance to determine differences between sulfate amendments and controls. A paired t test was used to determine differences between AVS and CRS concentrations on roots. A two-factor ANOVA was used to compare preplanting and post-senescence sediment concentrations of iron and AVS between treatments. Analyses were performed using the statistical software SAS. Logarithmic transformations were used when data was non-normal. A reciprocal transformation was used for dry weight of plants, as a logarithmic transformation was not effective. Data for root AVS were split into pre-seed production and post-seed production because the full-season data was not able to be transformed.

The saturation index was calculated to determine if the pore water was saturated enough to precipitate iron sulfide (equation 1). A positive saturation index value indicates precipitation, and a negative value indicates dissolution. The K_{sp} value used was $10^{-2.95}$ (Stumm and Morgan, 1995).

$SI = log \frac{[IAP]}{K_{sp}}$ where $IAP = \frac{[Fe^{2+}][HS^{-}]}{[H^{+}]}$ Equation 1

Changes in the accumulation rates of root AVS and ferrous iron were tested by fitting linear regressions to the concentrations of root AVS and Fe^{2+} prior to seed production (days 189-231). The model was extrapolated to late season sample dates (days 232-264) to test if accumulation rates changed between flowering and seed production.

A mixing model was used to determine the proportion of seed nitrogen originating from the pore water and the proportion translocated from the stems (equations 2 and 3). The $\delta^{15}N$ of the seeds was measured, and the $\delta^{15}N$ of the pore water and the stems were approximated. In equation 2, δ_{sample} is the isotopic signature of nitrogen in the seed, $\delta_{source1}$ is the isotopic signature of the pore water ammonium, f_1 is the proportion of nitrogen coming from the pore water, $\delta_{source2}$ is the isotopic signature of nitrogen in the plant stem, and f_2 is the proportion of the nitrogen sourced from the plant stem. Seed nitrogen can be sourced only from the pore water or the stems, so the proportions from both components must sum to one (equation 3).

$\partial_{sample} = \partial_{source1} \times f_1 + \partial_{source2} \times f_2$ Equation 2

$f_1 + f_2 = 1$ Equation 3

Results

Pore water

Although sulfate was 40x higher in the overlying water of sulfate-amended plants, pore water sulfide concentrations were only approximately twice as high in the in the rooting zone of sulfate-amended plants compared to the control over the entire growing season. Sulfide concentration and variability increased in the pore water of both amended and control rooting zones one week after the first seeds were produced (day 238, Julian date) and returned to initial concentrations two weeks later (day 245, Fig. 1a). Pore water sulfide data did not fit any parametric model, so a repeated measures ANOVA was not performed.

Pore water iron concentrations were not correlated with sulfate amendment (Table 1). Pore water iron decreased until shortly after seed production began (day 238) in both amendments. The minimum iron concentration occurred at the same time that a peak in pore water sulfide developed (Fig 1b). Shortly before senescence (days 252 and 264), the iron concentrations returned to values similar to concentrations during the first month of data collection.

The pore water pH and saturation index were not correlated with sulfate amendment (Table 1). The pH of the pore water peaked at the start of seed production (days 231-238, Fig.1c). This peak occurred approximately one week before the iron minimum and the sulfide maximum. The saturation index peaked one week after the first seeds were produced, when pH and sulfide were elevated and iron was low (day 238, Appendix Table 1). The average saturation index was above zero only in the sulfate-amended buckets on day 238. The saturation index gradually declined for the rest of the growing season.

Sulfate concentrations ranged from 10-30 times higher in the pore water of plants amended with sulfate (Table 1). Sulfate increased in the amended pore water until seed production began, when it declined precipitously from 2300 μmol/L to 770 μmol/L over 15 days (Fig 1d). In the pore water of control plants, sulfate concentrations followed a similar trend, but at lower concentrations. Control sulfate peaked at 230 μmol/L before decreasing to 34 μmol/L. Sulfate declined just prior to an increase in pore water sulfide.

Table 1. Results of repeated measures ANOVA testing effect of sulfate, time and interaction of sulfate and time on geochemical and biological variables. Tests for pore water and root parameters include data from the entire growing season, whereas tests for biological parameters only include data from mature seed production. *F* values and degrees of freedom (*d.f.*) are given. Tests for time and sulfate x time have the same number of degrees of freedom. Significance levels are shown using asterisks (***indicates $p < 0.001$, **indicates $0.001 < p < 0.05$, *indicates $0.05 < p < 0.10$).

Repeated measures ANOVA (F values)	Sulfate	d.f.	Time	Sulfate x Time	d.f.
Pore water geochemistry					
Iron	5.16	1, 5	5.51***	1.14	6, 35
pH	3.25	1, 6	12.5***	1.45	6, 36
Saturation index	2.68	1, 4	2.19*	0.50	6, 34
Sulfate	239***	1, 3	8.17***	1.09	5, 27
Root geochemistry					
AVS (during flowering)	66.1***	1, 5	1.10	0.40	3, 17
AVS (during seed production)	148***	1, 6	5.46**	1.76	4, 24
Weak acid extractable iron	0.53	1, 6	2.65	2.42**	7, 42
Ferrous Iron	127***	1, 6	57.2***	3.34**	6, 36
% Ferrous Iron	235***	1, 6	41.5***	4.91***	6, 36
Biological variables (during seed maturity)					
Plant N (total mass)	1.53	1, 6	0.35	0.25	2, 12
Plant weight	5.00*	1, 6	0.40	0.31	3, 18
Seed N (total mass)	5.84*	1, 6	1.10	1.22	2, 12
Seed weight	4.88*	1, 6	0.59	0.94	2, 12
Seed count	5.00*	1, 6	1.89	0.70	2, 12
Seed δ15N	1.47	1, 6	2.45	0.05	2, 12
Seed N%	1.70	1, 6	3.04*	0.40	2, 12
Vegetative N (plant+seed mass)	5.43*	1, 6	0.32	1.71	2, 12

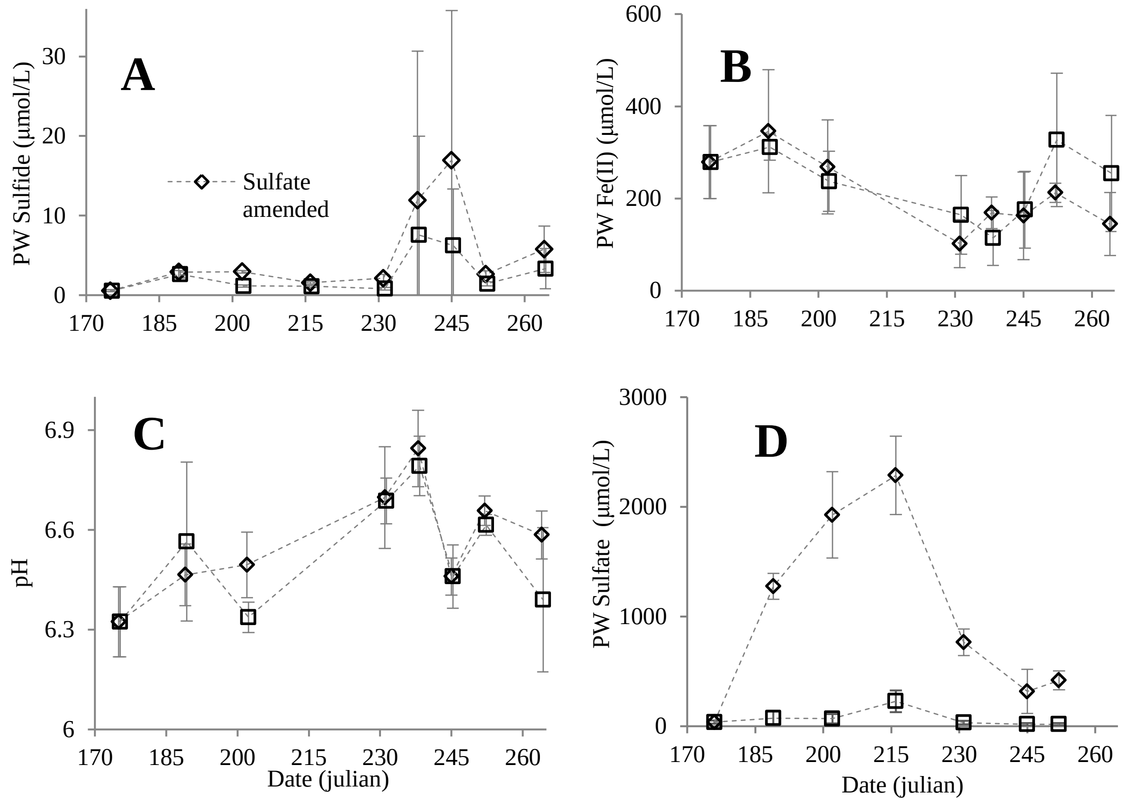

Figure 1. Pore water (PW) data measured in buckets during summer of 2015. Diamonds indicate data from buckets amended with 300 mg/L sulfate. Squares represent data from control buckets. Time is shown in Julian days. Error bars indicate one standard deviation. Control data points are slightly offset to show overlap in error bars.

Roots

Wild rice plants grown in sediment with high overlying water sulfate concentrations developed a black coating on their root surfaces (Appendix Fig. 1). A SEM scan of the roots showed that the root precipitate contained iron and sulfur in approximately a 1:1 ratio (Dan Jones, unpublished data). The oxic/anoxic interface was often recorded on the root; the black coating started on the stem just above the root ball and extended downwards along the entire length of the roots. Adventitious roots that grew at the surface of the sediment remained white, the natural color of wild rice root tissue. Control plants, grown in sediment with low overlying water sulfate, formed very little black color on their roots, instead appearing amber, a color characteristic of iron (hydr)oxides.

Roots grown under elevated sulfate (hereafter “amended roots”) accumulated AVS concentrations up to two orders of magnitude higher than the control roots by late summer. Amended root AVS peaked at 298 ± 74 umol/g dw immediately prior to senescence (Fig 2a). Concentrations of AVS on roots grown under control surface water sulfate (hereafter “control roots”) did not consistently increase, and averaged of 3.2±1.7 umol/g dw. For amended roots, the rate of accumulation of root AVS appeared relatively constant (linear) until the first day seeds were produced (day 232), when the rate of AVS accumulation appeared to increase abruptly. During seed production, AVS concentrations were greater than that predicted by a linear model (constant accumulation rate), suggesting that the net rate of AVS accumulation on amended roots increased rapidly when seed production began. Points after the first day of seed production (day 231) fell outside of a 95% CI of a linear regression on the points during flowering (days 190-231, Appendix Fig. 2). Concentrations of CRS on both amended and control roots did not differ from AVS concentrations on the same roots, indicating that crystalline forms of FeS did not make up a significant proportion of reduced sulfur (paired t test, p=0.27, t=0.63, n=20).

Ferrous iron accumulation paralleled AVS accumulation on amended roots (Fig 2b). Root ferrous iron concentrations were elevated and accumulated faster on the amended roots compared to the control (Table 1). Ferrous iron on control roots and amended roots increased linearly, but ferrous iron on amended roots increased at a higher rate until the first seeds were produced (day 232). During seed production, ferrous iron concentrations on amended roots were greater than those predicted by a linear model, while Fe(II) accumulation on control roots appeared to slow.

Weak acid extractable iron (sum of Fe(II) + Fe(III) concentrations on roots, hereafter "total extractable iron") was variable, but did not differ significantly between treatments (Table 1). The average total extractable iron remained relatively constant in both treatments during flowering; however, during the first week of seed production (days 232 and 239) the total extractable iron dropped by about 150-250 umol/g on both the amended and control roots, and then gradually increased over the following three weeks (Fig. 3). Total extractable iron changed seasonally from mostly Fe(III) to mostly Fe(II) on sulfate-amended roots, especially during the first week of seed production (days 232 and 239). This abrupt shift in iron speciation occurred the same week that total extractable iron decreased and at about the same time as the increase in AVS accumulation rate (Fig. 3). Immediately prior to seed production, total extractable iron on the amended roots was 46 ± 11% Fe(II), and after one week of seed production, the composition of iron was 87 ± 10% Fe (II). During this same week, control root Fe(II) increased from 20 ± 11% to 48 ± 16%.

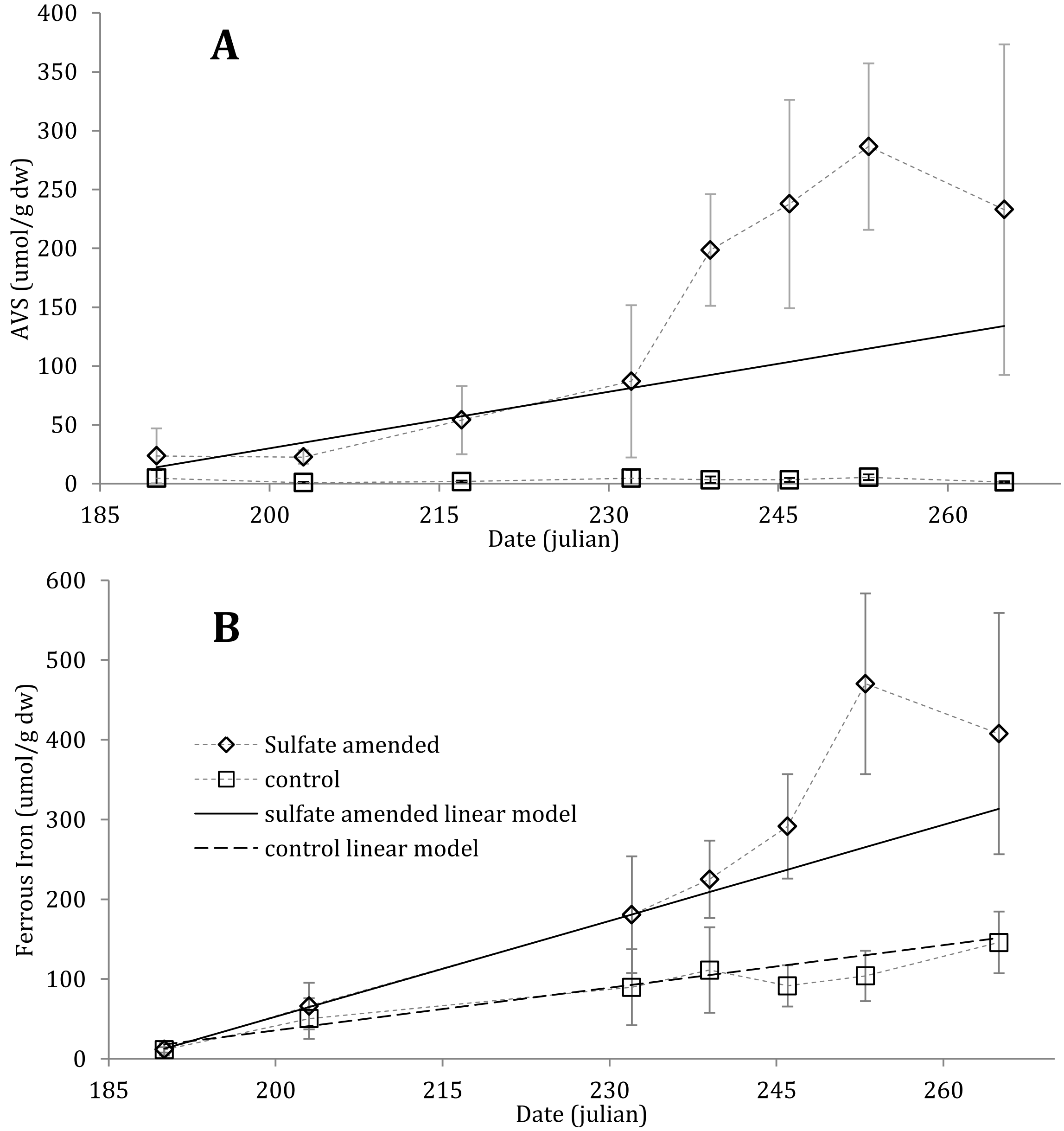

Figure 2. Solid phase acid volatile sulfide (A) and ferrous iron (B) concentrations on roots. Diamonds represent the average concentration on roots of four sulfate-amended plants, and squares represent the average of four control plants. The dashed line shows a linear model fit to the data from day 190 to day 232. Time is expressed in Julian dates. Error bars show one standard deviation.

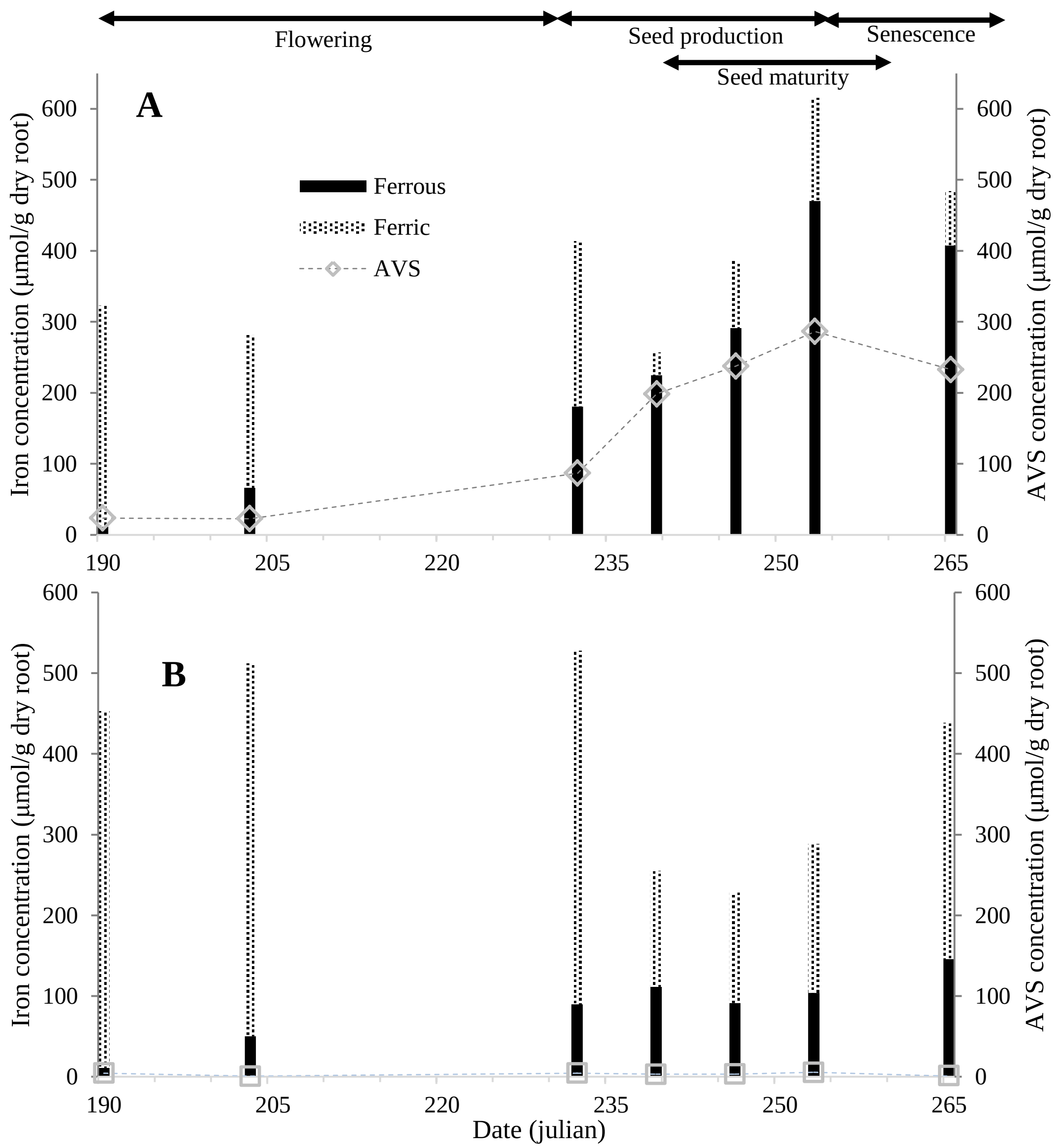

Figure 3. Seasonal iron speciation with root AVS overlain in sulfate-amended bucket. The dotted pattern indicates ferric iron and the solid black represents ferrous iron. A). Sulfate-amended bucket iron. Grey diamonds show root AVS concentrations in sulfate-amended buckets. B). Control bucket iron. Grey squares show root AVS concentrations in control buckets. Error bars are omitted for clarity.

Sediment

Sediment AVS was significantly different between treatments, but total extractable iron was not. In both the sulfate-amended and control sediment, AVS increased during the growing season, but more AVS accumulated in the amended sediment (2-factor ANOVA, time x treatment interaction, f=5.08, df=1,18, p=0.037). Amended sediment AVS increased from 0.39 umol/g in early summer to 4.7 μmol/g at the end of the growing season, whereas the control sediment only increased from 0.39 μmol/g to 0.88 umol/g. There was no difference in total extractable iron between the amended and control sediment at the beginning or end of the growing season (2-factor ANOVA, f=0.65, df=1,18, p=0.429).

Biological effects

Plant sampling began at the start of the flowering stage (days 190-230). The first seeds were collected on 8/20/15 (day 232), but were unripe and not yet filled. In this paper, seed production is referred to as days 230 to day 264, but mature seeds were not produced until one week after the start of seed production (day 239). On the last sample date (day 265) seeds were collected, but were unfilled. Stems and leaves were no longer green, indicating that the plants had senesced. Of the four replicates in the sulfate amendment on this date, two plants did not produce seeds. Thus, "mature seed production" refers to dates 239-253.

Total seed nitrogen, total seed weight, and seed count were all lower in sulfate-amended plants during mature seed production, a time that coincided with elevated FeS on roots (days 239-253, Table 1, Fig 4). Sulfate addition was not correlated with seed δ^{15}N or seed N %. During mature seed production and senescence, the dry weight of the sulfate-amended plants was lower than that of control plants. Total vegetative (plant + seeds) N was unaffected by sulfate until the last two sample dates prior to senescence, when it was lower in sulfate-amended plants (Fig 4d, two-sample t test, p=0.031, p=0.047, n=8 for both dates).

A mixing model was used to determine the fraction of total seed nitrogen coming from the pore water and the fraction translocated from the stem (Appendix Fig. 3). In the days following a spike of enriched nitrogen to sediment pore water, there were two possible sources of nitrogen in the seeds; wild rice can translocate nitrogen from its stem or take nitrogen up from the pore water. The plant $\delta^{15}N$ was estimated to be 4.5‰ from the average of 12 unlabeled plants harvested on the first two sample dates. The pore water $\delta^{15}N$ was approximated to be 180‰ and calculated from the percent by mass of $^{15}NH_4$ added ($\delta^{15}N$ =26,200‰) and the percent by mass of ammonia already present in the pore water ($\delta^{15}N$ assumed to be 0‰). The two-component mixing model showed no difference in fraction of nitrogen uptake from pore water between the amended and control plants (repeated measures ANOVA, $p=0.83$, $f=0.05$, $df=1,6$). In both control and amended plants, the fraction of total seed nitrogen originating from the pore water increased two weeks into seed production (day 246) from 27 ± 18 % to 51 ± 19%, but returned to 29 ± 19 % a week later (day 253). The elevated proportion coming from the pore water coincides with the day seeds contained the most nitrogen (Fig 4c). On this day, total seed nitrogen was significantly lower in the sulfate amended plants than in the control plants (two-sample t test, $p=0.047$, $n=8$). Plant N (excluding seeds), however, was not different between amended and control plants on this day (two-sample t test, $p=0.41$, $n=8$).

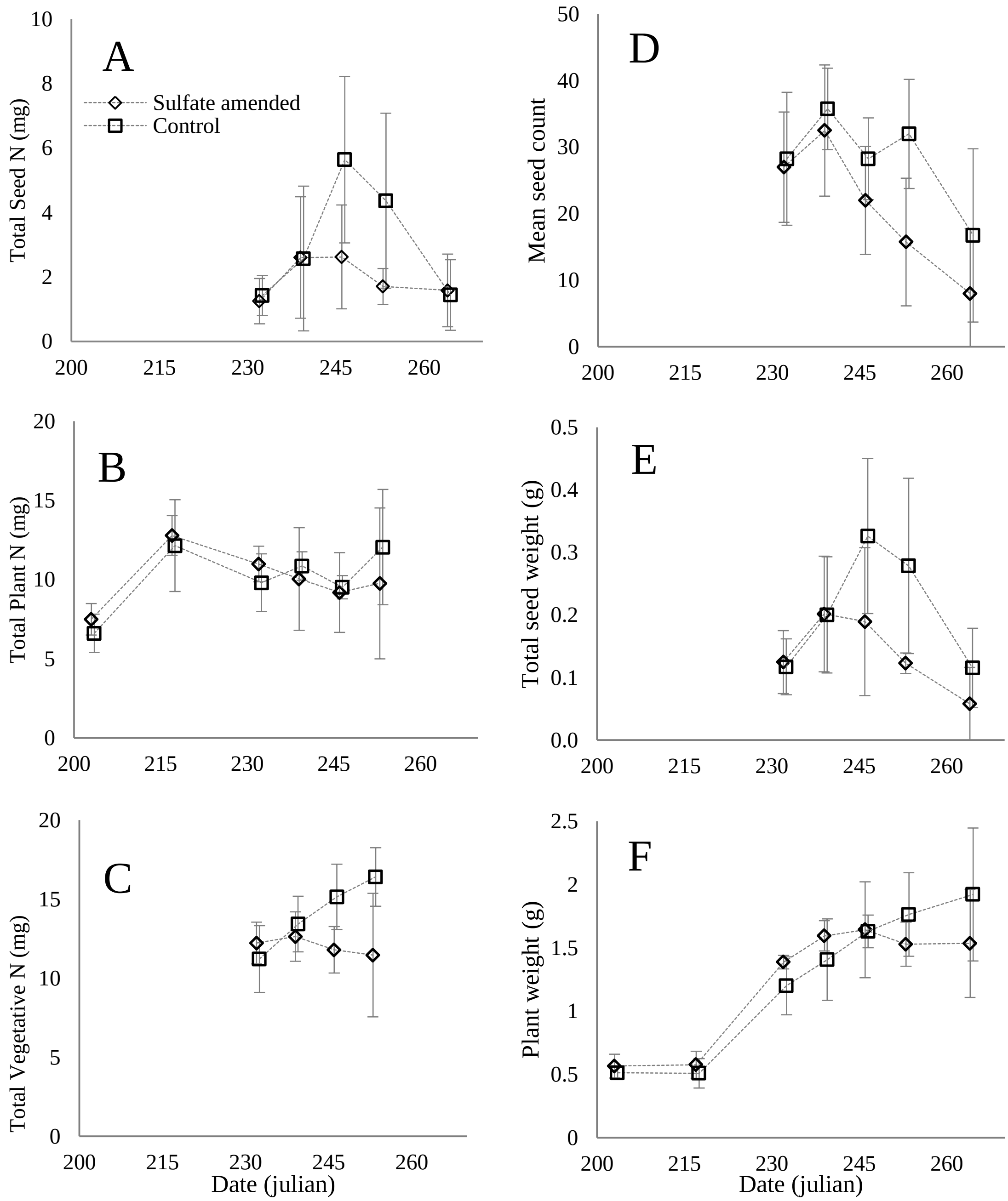

Figure 4. Biological endpoints. Diamonds represent plants grown in surface water with 300 mg/L sulfate added while squares show data from control plants. Each data point represents four replicates. Error bars represent one standard deviation. A) Weekly total mass of nitrogen in seeds of sulfate amended and control plants. B) Total mass of nitrogen in the plant (stems+leaves), excluding seeds, over the course of the growing season. C) Weekly total vegetative nitrogen in amended and control plants. Total vegetative nitrogen was calculated by summing nitrogen from seeds, stems, and leaves. D) Weekly seed count in amended plants and control plants. E) Weekly total seed mass in amended plants and control plants. F) Dry mass of plants over the course of the growing season.

Discussion

Our observations suggest a tight coupling of iron and sulfur cycling in the rooting zone of wild rice. Iron (hydr)oxides form on wild rice roots early in the growing season, but roots that are exposed to high sulfate loading (300 mg/L) develop iron sulfides later in the growing season. An inflection point in iron sulfide accumulation occurs at the start of seed production, shortly after rapid depletion of sulfate in the pore water, and defines an increase in the net rate of FeS accumulation. The rapid increase in net FeS accumulation suggests a change in a process that controls the way iron and sulfur cycle in the rhizosphere, and the timing suggests that this process may be tied to and have important implications for rice physiology. Previous research has suggested that an accumulation of FeS occurs after plant senescence (Jacq 1991), but our observations clearly show accumulation of FeS during the reproductive life stage of wild rice.

The change in FeS accumulation rate is consistent with an inhibition of radial oxygen loss. Sulfate accumulation in the pore water during the flowering stage suggests that the rhizosphere is relatively oxidized. The initially linear FeS accumulation rate on plant roots suggests constant rates of sulfide production and sulfide oxidation, with a higher rate of sulfide production than oxidization (net accumulation). However, sulfide exposure in white rice leads to the formation of suberin in the cell walls of roots which is hypothesized to create a barrier that limits diffusion of toxic solutes into the plant (Armstrong and Armstrong, 2005). The barrier not only excludes toxic solutes like sulfide, but also traps oxygen inside the roots, suppressing radial oxygen loss (Krishnamurthy et al. 2009, Soukup et al. 2006). A relatively rapid transition to anoxia of the rhizosphere appears to have occurred at the onset of seed production, possibly as a result of suberin-induced suppression of radial oxygen loss. Under the anoxic conditions, the net accumulation of reduced species likely increased because fewer reduced species cycled back to their oxidized form.

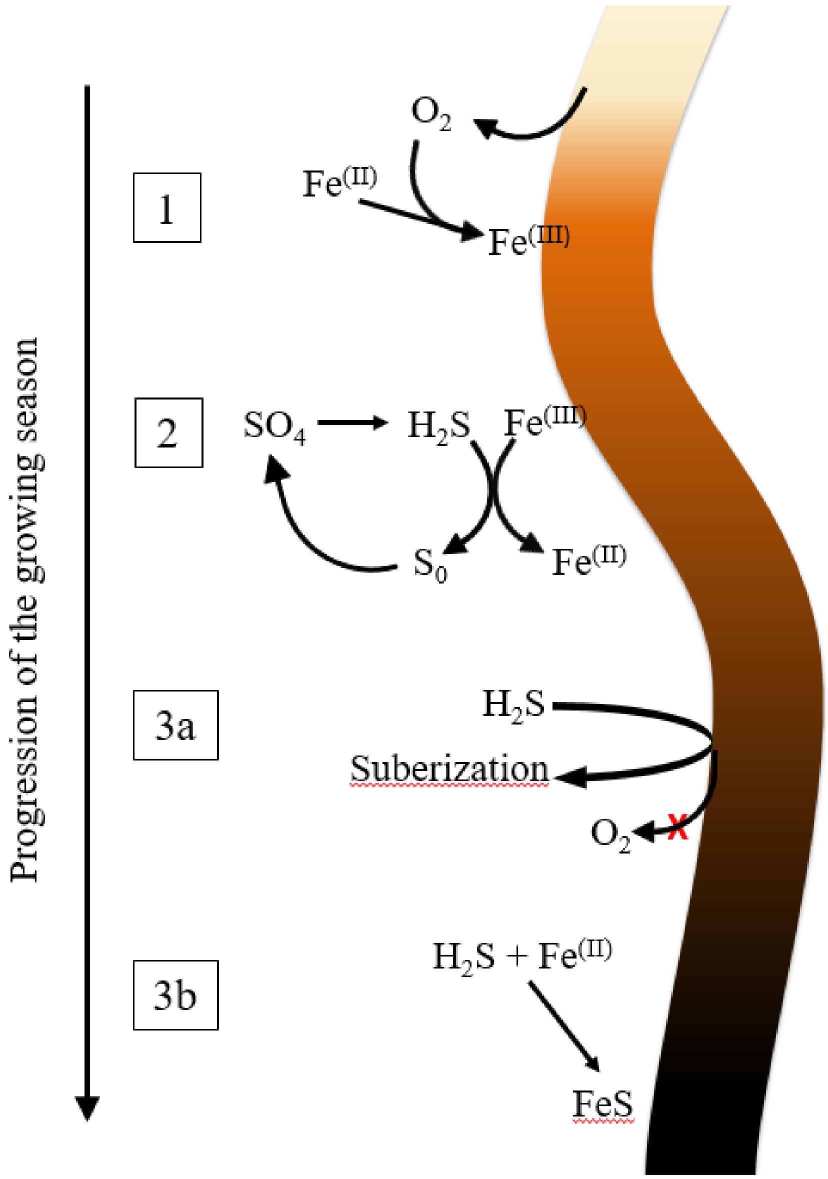

Figure 5. Proposed mechanism of iron sulfide formation on wild rice roots. Roots are protected by iron (hydr)oxides [1], but reduced by sulfide [2]. Exposure of roots to sulfide induces suberization of root cells, which leads to decreased radial oxygen loss [3a]. Rhizosphere anoxia allows iron sulfides to precipitate [3b].

A hypothesized pathway for how the rice roots might transition from iron (hydr)oxide plaques to iron sulfide plaques over the growing season is outlined in Figure 5. Initially, radial oxygen loss creates oxic conditions in the rooting zone, causing ferrous iron within the rhizosphere to precipitate as iron (hydr)oxides and accumulate on root surfaces (Fig. 5, [1] label). At this initial stage, the root is protected from reduced species by both radial oxygen loss and iron (hydr)oxide plaques, an electron accepting sink. Before sulfide can penetrate to the root, the iron (hydr)oxide plaques, effectively acting as an electron accepting buffer, must be reduced (Fig. 5, [2] label). As sulfide erodes the accumulated ferric iron barrier (Hansel et al. 2014, Kwon et al. 2013), sulfide can then reach the root surface and cause suberization (Fig. 5, [3a] label). Once radial oxygen loss is suppressed by suberin formation, the electron accepting buffer capacity of iron (hydr)oxides can no longer be replenished. The remaining quantity of iron (hydr)oxides can be more rapidly reduced due to a net change in the flow of electrons to the rooting zone. Upon depletion of iron (hydr)oxides, sulfide accumulates rapidly, since neither iron (hydr)oxides or a supply of radial oxygen loss are available to oxidize sulfide (Fig 5, [3b] label). As sulfide penetrates closer to the root surface, it precipitates with available iron, and the redox potential of the rhizosphere shifts to more reducing conditions.

The rapid accumulation of sulfur on roots in amended plants seems inconsistent with the relatively small difference in sulfur and iron concentrations in pore water. The saturation index (SI), which is calculated from pore water concentrations two centimeters from the stem, indicates that the pore water is undersaturated with respect to iron sulfide. The thermodynamic understanding of mineral precipitation and dissolution is that minerals precipitate when pore water is saturated and dissolve when pore waters are undersaturated (Stumm & Morgan, 1995). The rapid accumulation of iron sulfide on roots in the setting of undersaturated pore water suggests that the transition of iron (hydr)oxide to iron sulfide on the roots occurs very close to the surface of the root, and thus depends on near-root-surface processes more than on pore water concentrations. Sulfide on root surfaces must be supplied externally, either from reduction of surface water sulfate, or from mobilization of AVS on sediment, but ferrous iron in the FeS plaques could be sourced from the reduction of iron (hydr)oxides already accumulated on the root surface earlier in the season. Indeed, a decrease in solid-phase iron on the roots, a shift in iron speciation, and an accumulation of pore water iron all occur simultaneously, which is consistent with loss of soluble ferrous iron off of the root surface during the redox transition. Thus, if the ferrous iron in FeS plaques is sourced from the iron (hydr)oxides on the root, saturation index calculations based on pore water iron concentrations may not be relevant to understanding FeS formation on roots. Additionally, the decline of pore water sulfate followed by rapid accumulation of AVS on the root surfaces suggests that a large amount of sulfur passes through the pore water pool very quickly. Iron sulfide formation is strongly favorable thermodynamically and kinetically rapid (Rickard, 1995). Using pore water sulfide concentrations to calculate the saturation index may underestimate the amount of sulfur available to precipitate on root surfaces, as pore water sulfide may act as a transient phase between pore water sulfate and root AVS. The transience of sulfide in pore waters near rice rhizospheres was noted by Hara (2013) who observed black iron sulfide zones around white rice seeds grown in sulfate-amended sediment, but was unable to quantify any sulfide, despite measuring redox potentials low enough to support sulfide production.

In this experiment, iron sulfide plaques occurred concomitantly with lower seed nitrogen and fewer seeds. Less nitrogen was present in the total seed mass of the amended plants, and fewer seeds were produced. This is likely a strategy for optimizing reproduction; amended plants produce fewer filled seeds but each filled seed is fully viable (Pastor et al., in reveiw). The two-component isotope mixing model suggests that the amended plants were not able to compensate for inhibition of nitrogen uptake by translocating a greater percentage of seed nitrogen from the stem and leaves. Between the sulfate and control, no difference was observed in the fraction of N uptake from the pore water. The decreased total seed N in sulfate amended plants appears to be an equally proportioned result of decreased uptake from pore water and decreased translocation from the plant.

Biological variables were only affected during seed production. During the biomass growth life stages, little difference in total plant weight and total plant N was observed. Biomass may not have been impacted because sulfide can produce a fertilization effect by sequestering iron bound with phosphate, releasing free phosphate

(Geurts et al. 2009, Caraco et al. 1989, Smolders et al. 2003, Lamers et al. 2002). However, nitrogen, rather than phosphorus, is the limiting nutrient for wild rice (Sims et al. 2012), so the fertilization effect is likely minimal in wild rice. In the long term, Pastor et al. (in review) showed that sulfide takes several years to affect a population of wild rice, because although sulfide showed no effect on germination and very little effect on biomass of wild rice, sulfide greatly decreased the number of juvenile seedlings that survive and the number of filled seeds produced by the plant. The results from our study suggest that during seed production, the buffering capacity of iron (hydr)oxides has been overwhelmed by sulfide and no longer protects the plant from sulfide. Similarly, juvenile seedlings may be vulnerable to sulfide because they have not yet grown out of the water column and are thus unable to transport oxygen from the atmosphere to their roots. The life stages of wild rice affected by sulfide are consistent with times during which an oxic barrier around the roots is absent.

Accumulation of FeS on roots may have implications for wetland cycling of iron and sulfide. After senescence, roots coated with FeS decay and become incorporated into the bulk sediment. Jacq et al. (1991) found significant accumulation of FeS on white rice roots after senescence, likely because the dead root material stimulated continued iron and sulfate reduction. Additionally, Jacq et al. (1991) found that sediment in a planted rice paddy contained higher FeS concentrations than an unplanted rice paddy. Because wild rice is an annual plant, the amount of root FeS that accumulates over a growing season is added to the sediment each year. Choi et al. (2006) likewise found that in a riparian wetland containing *Phragmites australis* and *Zizania latifolia*, AVS concentrations were higher in the top 6 cm of non-vegetated sediment, but vegetated sediment had higher concentrations of AVS 6-14 cm below the sediment-water interface. If AVS on roots is supplied mainly from reduction of surface water sulfate, burial of FeS coated roots may be supplying sulfide to the sediment faster than pore water precipitation of iron sulfide in the bulk sediment. If root AVS is supplied largely by mobilization of sediment AVS, which Choi et al. suggests can be caused by radial oxygen loss, then sediment AVS concentration may be an important parameter in determining iron sulfide accumulation and concomitant inhibition of nitrogen uptake in wild rice. Knowledge of the main sources of sulfur for root AVS will be crucial in managing wild rice in sulfur-impacted systems.

Conclusion & Directions for Future Work

The timing of our observations of rhizosphere AVS accumulation in conjunction with decreased total seed N in sulfate-amended plants suggests that nitrogen uptake by wild rice is affected only after significant sulfide accumulation on root surfaces. In this experiment, elevated sulfide on plant roots coincides with the plant's reproductive stage. We propose that root surface iron (hydr)oxides delay sulfide from entering the plant, effectively acting as a buffer against early and mid-season sulfide exposure. When the oxic barrier on the root surface is overwhelmed, iron sulfide accumulates rapidly, as shown by the doubling of AVS and the shift in iron speciation from about 50% Fe(II) to 90% Fe(II) within just one week. In this experiment, the oxic barrier was overwhelmed just prior to seed production; concurrently, reduced seed count, total seed weight, and total seed nitrogen were observed.

Many questions remain about the cause of the redox shift in the rhizosphere. We propose a mechanism in which sulfide-induced suberization of roots facilitates reduction of the oxic barrier, but a seasonal change in wild rice physiology could also facilitate a rapid transition to anoxia. Control roots, like sulfate-amended roots, lost about half of their total extractable iron at the start of seed production, and accumulated some ferrous iron even in the absence of significant S accumulation. Is there a seasonal shift in redox potential in wild rice rhizospheres, regardless of the presence of sulfur? Seasonal measurements of redox potential and magnitude of radial oxygen loss may provide insight into the comparative influence of plant processes and sulfur loading on shifting redox conditions in the rhizosphere. Is the bacterial community affected more by rhizosphere geochemistry or by life stages of the plant? Seasonal microbial community analysis could also elucidate the relative causes of the rhizosphere anoxia, as a significant seasonal shift in the microbial community of control plants would indicate plant controlled redox conditions. If the redox conditions of the rhizosphere are controlled by iron and sulfur geochemistry as proposed, would a lower initial concentration of iron on roots result in erosion of the iron (hydr)oxide barrier and subsequent inhibition of nitrogen uptake earlier in the growing season? If so, would plant biomass and nitrogen also be decreased? A similar study to this one could be done in which total iron concentrations of the sediment were varied to produce different initial concentrations of iron (hydr)oxides on roots.

Finally, from a management perspective, it would be useful to understand the sources of sulfur on root surfaces and the sediment parameters that control those sources. Is the sulfide on the roots sourced primarily from surface water sulfate or from mobilization of sediment AVS? Could a lake that has previously received high sulfur loads but currently has low surface water sulfate contain wild rice with significant iron sulfide plaques? This question has implications for restoration of wild rice in sulfur-impacted lakes.

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Appendix

Table 1. Average and standard deviation of the saturation index in sulfate amended and control pore waters. The K_{sp} value used was $10^{-2.95}$.

Date (julian)	Sulfate-amended	Control
177	-1.436 ± 0.228	-1.436 ± 0.228
190	-0.282 ± 0.346	-0.175 ± 0.354
203	-0.390 ± 0.189	-1.061 ± 0.204
232	-0.560 ± 0.195	-0.802 ± 0.242
239	0.099 ± 0.969	-0.232 ± 0.435
245	-0.140 ± 0.580	-0.410 ± 0.837
256	-0.302 ± 0.376	-0.365 ± 0.333
263	-0.199 ± 0.198	-0.597 ±0.581

Figure 1. Sulfate-amended root (left) and control root (right). Sulfate-amended root has black color extending from about 0.5 cm above the root ball down to the tips of the roots (not shown). Control root has amber color characteristic of iron (hydr)oxides, especially 2-3 cm below root ball.

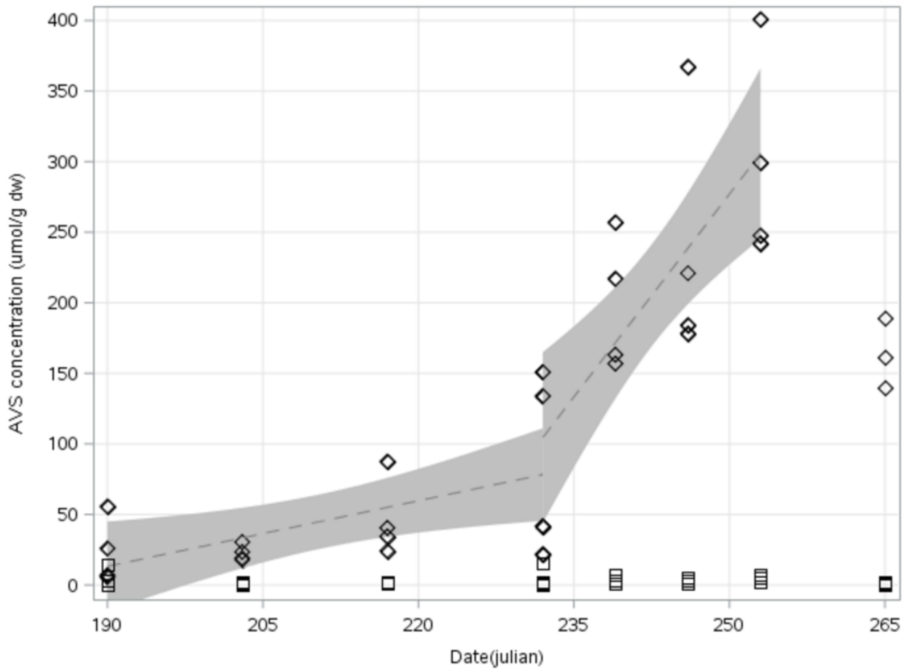

Figure 2. A 95% confidence interval around a regression of time and AVS on sulfate amended roots depicting the change in rate of sulfide accumulation. Diamonds represent sulfate amended plants, and squares represent control plants. The plant is in the flowering stage until day 232, when it starts producing seeds. The last sample date was during senescence, and is therefore not included in the 95% confidence interval.

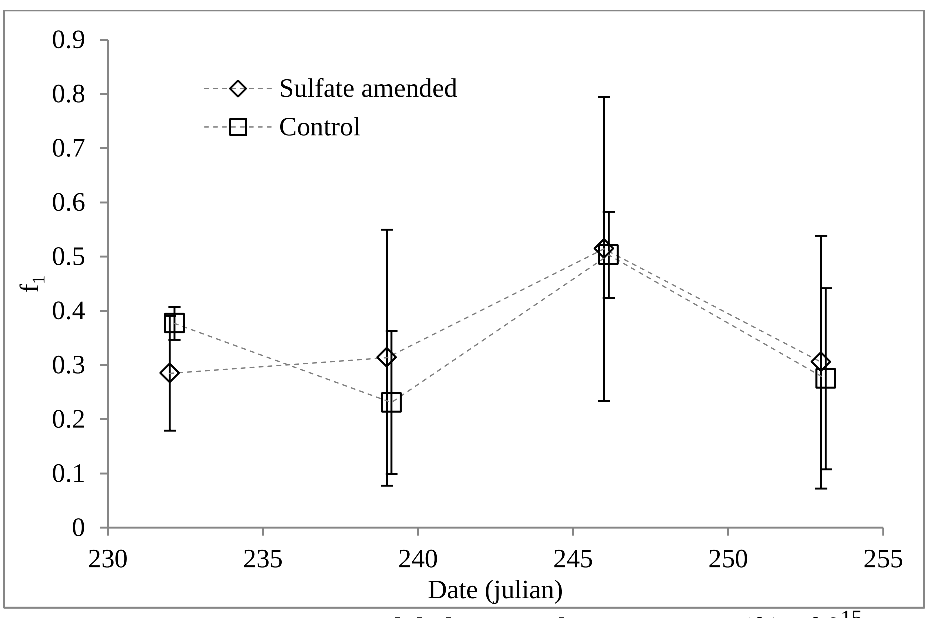

Figure 3. Isotopic mixing model showing the proportion (f_1) of $\delta^{15}N$ in seeds that originated from ammonium in the pore water during seed production. Diamonds represent sulfate amended plants, and squares represent control plants. Each data point is the average of four replicates. Error bars are one standard deviation.

John Pastor Technical Review Comments - Wild Rice Rule
November 2017

Attachment G

(13 pages)

LacCore_field_ID	Site_name	Unique site ID	DNR/State ID	Date	Lat	Long	Calculated Wild rice ave stems/m2	surface water SO4 (mg SO4/L)	pore water Total Sulfide (TS, mg S/L)	Sediment Fe (µg/g)	Sediment TOC (%)	potential SO4 standard CPSC120
P-35	Anka	26	21-0353-00-201	9/16/11	46.0769	-95.7377	3.0	2.23	0.493	2170	14.84	1.2
FS-192	Anka	26	21-0353-00-202	8/29/12	46.07689	-95.7292	2.3	8.44	0.53	1498	22.85	0.4
P-34	Anka	26	21-0353-00-201	9/16/11	46.0769	-95.7292	25.9	2.23	0.671	1485	23.57	0.3
FS-134	Bass	43	31-0576-00-207	9/18/12	47.2844	-93.6276	64.0	1.01	0.0664	3740	26.12	1.8
FS-85	Bean	8	03-0411-00-201	8/21/12	46.9337	-95.8706	0.0	85	16	1967	11.85	1.4
FS-87	Bee	60	60-0192-00-202	8/23/12	47.6527	-96.0504	39.8	11	0.67	3054	13.62	2.7
FS-193	Big Mud	79	71-0085-00-201	8/30/12	45.4529	-93.7418	14.3	< 0.5	0.0308	12943	18.63	29.5
FS-216	Big Sucker	39	31-0124-00-203	9/12/12	47.3919	-93.2658	3.8	7.78	0.145	3559	21.45	2.1
FS-205	Big Swan	86	77-0023-00-207	8/10/12	45.8795	-94.7418	56.3	5.47	0.0527	1719	4.81	3.1
FS-204	Big Swan	86	77-0023-00-207	8/10/12	45.8795	-94.742	133.7	5.49	0.0914	1731	5.94	2.4
FS-89	Birch	67	69-0003-00-205	9/10/12	47.7358	-91.943	33.1	8.61	0.1	16938	31.2	26.7
P-12	Birch	67	69-0003-00-205	8/30/11	47.7357	-91.9428	68.6	3.58	0.104	12431	26.8	17.7
FS-52	Blaamyhre	48	34-0345-00-203	8/1/12	45.364	-95.186	102.2	0.62	0.078	3517	9.33	5.5
FS-214	Bowstring	116	S007-219	9/11/12	47.7024	-94.0608	69.7	1.34	0.256	1974	24.34	0.6
FS-126	Bray	58	56-0472-00-202	8/20/12	46.4518	-95.8783	7.6	1.65	0.072	3937	21.95	2.5
FS-63	Caribou	72	69-0489-00-206	9/3/12	46.8913	-92.3135	0.0	1.21	0.0938	13791	29.44	19.3
P-53	Carlos Avery Pool 9	4	02-0504-00-201	8/19/11	45.3179	-93.0587	43.0	0.35	0.029	37965	16.51	270.0
FS-109	Carlos Avery Pool 9	4	02-0504-00-202	7/3/12	45.3192	-93.0611	52.8	< 0.5	< 0.011	14736	12.51	61.0
FS-339	Christina	28	21-0375-00-315	7/31/13	46.0734	-95.7567	0.6	14.6	1.93	1741	8.96	1.5
FS-373	Clearwater	96	S002-121	9/9/13	47.9372	-95.6909	3.2	34.4	0.0354	5315	3.33	41.8
FS-189	Clearwater	96	S002-121	8/28/12	47.9372	-95.6906	4.5	23.8	0.117	2856	1.27	40.2

FS-327	Clearwater	96	S002-121	7/17/13	47.9371	-95.6906	0.3	23.7	0.117	3521	1.82	39.1
FS-314	Clearwater	96	S002-121	6/24/13	47.9372	-95.6907	0.6	28	0.0664	3946	2.68	30.6
FS-337	Clearwater	98	S004-204	7/29/13	47.5175	-95.3906	69.1	0.95	0.0608	14564	24.58	26.6
FS-88	Clearwater	98	S004-204	8/24/12	47.5174	-95.3904	148.3	2.04	0.0488	9874	22.17	14.2
P-31	Cloquet	52	38-0539-00-201	9/14/11	47.4313	-91.4844	74.4	0.81	0.024	4252	6.58	12.1
FS-128	Cromwell	14	14-0103-00-201	8/22/12	46.9651	-96.3171	0.0	41.2	1.22	2948	2.85	16.2
FS-369	Dark	77	69-0790-00-202	9/5/13	47.6389	-92.7781	11.8	176	0.052	2037	0.82	35.4
FS-352	Dark	77	69-0790-00-202	8/15/13	47.6388	-92.7782	2.9	173	0.136	5120	3.61	35.3
FS-368	Dark	77	69-0790-00-202	9/5/13	47.6387	-92.7782	11.1	175	0.305	3354	1.94	33.0
FS-322	Dark	77	69-0790-00-202	7/10/13	47.6389	-92.7781	3.2	175	0.131	2480	1.48	25.5
FS-64	Dead Fish	12	09-0051-00-202	9/4/12	46.7454	-92.6865	0.0	0.71	0.0608	14387	22.4	29.0
P-44	Dead Fish	12	09-0051-00-202	9/20/11	46.7451	-92.6863	48.7	0.3	0.056	9685	16.6	19.4
FS-378	Duck Lake WMA	22	18-0178-00-202	9/12/13	46.7521	-93.8851	113.0	< 0.5	0.0251	12151	26.57	17.1
FS-86	Eighteen	61	60-0199-00-202	8/22/12	47.6397	-96.0607	40.1	4.29	0.164	1860	3.1	6.1
FS-309	Eighteen	62	60-0199-00-203	6/13/13	47.6369	-96.0599	0.0	4.36	0.127	4478	16.52	4.4
FS-328	Eighteen	62	60-0199-00-203	7/18/13	47.6369	-96.0599	44.2	3.34	0.25	5106	24.65	3.5
FS-359	Eighteen	62	60-0199-00-203	8/20/13	47.6367	-96.06	21.0	2.83	0.118	5500	30.88	3.1
P-6	Elk	15	15-0010-00-203	8/25/11	47.1946	-95.2254	25.9	0.28	0.04	8480	10.24	26.8
FS-137	Elk	15	15-0010-00-204	9/19/12	47.1952	-95.2249	42.7	< 0.5	0.0936	6334	10.07	15.6
FS-333	Embarrass	73	69-0496-00-203	7/26/13	47.5333	-92.2976	0.0	18.2	0.0866	11179	0.47	1821.2
FS-95	Embarrass	73	69-0496-00-203	9/14/12	47.5334	-92.2979	0.0	18.8	0.0298	21847	1.89	1248.9
FS-76	Field	45	34-0151-00-201	7/25/12	45.2964	-94.9058	0.0	< 0.5	0.0687	7586	8.68	26.3
FS-195	Fisher	78	70-0087-00-201	8/31/12	44.7942	-93.4061	20.7	6.85	0.136	11140	5.76	90.1
FS-81	Flowage	1	01-0061-00-204	8/7/12	46.688	-93.337	0.0	0.78	0.134	12470	32.34	14.2
P-51	Flowage	1	01-0061-00-205	9/22/11	46.6896	-93.338	160.2	0.56	0.014	5627	20.1	5.4
P-52	Flowage	1	01-0061-00-206	9/22/11	46.6895	-93.338	123.1	0.56	0.018	4641	18.1	4.2
P-52	Flowage	1	01-0061-00-205	9/22/11	46.6895	-93.338	123.1	0.56	0.018	3706	16.52	3.1

P-52	Flowage	1	01-0061-00-206	9/22/11	46.6895	-93.338	123.1	0.56	0.018	4302	21.79	2.9
FS-194	Gilchrist	91	86-0064-00-201	8/31/12	45.2309	-93.824	0.0	6.98	0.355	3117	20.81	1.7
FS-51	Glesne Slough	49	34-0353-00-201	7/31/12	45.3514	-95.1887	99.6	< 0.5	0.061	7983	3.01	103.2
P-23	Gourd	10	04-0253-00-201	9/7/11	47.812	-94.9654	38.4	0.69	0.038	2675	27.4	0.9
FS-104	Gourd	10	04-0253-00-201	6/27/12	47.8121	-94.965	0.0	0.27		1776	36.87	0.3
FS-213	Gull	9	04-0120-00-204	9/10/12	47.6558	-94.6945	9.5	1.14	0.0778	3527	16.01	2.9
P-20	Gull	9	04-0120-00-203	9/6/11	47.6559	-94.6944	15.6	0.78	0.103	1608	5.08	2.5
FS-367	Hay	33	31-0037-00-202	9/4/13	47.287	-93.1009	141.0	22.1	0.0447	15436	3.44	312.7
P-45	Hay	33	31-0037-00-201	9/21/11	47.2874	-93.1017	0.0	10.24	0.087	12403	4.36	154.6
P-46	Hay	33	31-0037-00-201	9/21/11	47.2869	-93.1018	0.0	10.24	0.026	16139	7.69	130.0
FS-130	Hay	33	31-0037-00-202	9/6/12	47.2874	-93.102	141.0	31.7	0.0738	13154	5.79	123.3
FS-221	Hay Creek Flowage	59	58-0005-00-202	9/17/12	46.0894	-92.4104	97.7	1.95	0.119	9456	22.05	13.2
FS-375	Height of Land	5	03-0195-00-210	9/10/13	46.913	-95.6111	117.5	< 0.5	< 0.011	1795	0.86	26.2
FS-127	Height of Land	5	03-0195-00-210	8/21/12	46.9133	-95.6095	111.1	< 0.5	< 0.011	2112	1.32	21.5
FS-318	Height of Land	5	03-0195-00-210	6/26/13	46.9135	-95.6124	43.0	1.21	0.0658	1349	1.13	10.9
FS-338	Height of Land	5	03-0195-00-210	7/30/13	46.913	-95.6116	94.2	< 0.5	0.0554	2641	4.58	7.4
P-1	Height of Land	5	03-0195-00-209	8/22/11	46.9129	-95.6095	62.9	0.24	0.053	1298	1.76	6.0
FS-131	Hinken	113	S007-207	9/5/12	47.7271	-93.9923	46.8	< 0.5	0.0876	2960	4.53	9.4
FS-185	Hoffs Slough	85	76-0103-00-201	8/1/12	45.3255	-95.7059	0.0	273	0.0343	3512	0.75	112.3
FS-353	Holman	42	31-0227-00-202	8/12/13	47.3009	-93.3444	0.0	68	0.583	5094	30.6	2.7
FS-218	Holman	42	31-0227-00-202	9/13/12	47.3005	-93.3445	0.0	24.2	1.01	3035	29.74	1.0
FS-182	Hunt	65	66-0047-00-208	7/27/12	44.3275	-93.4443	0.0	17.1	0.0729	2412	1.21	30.8
FS-191	Ina	27	21-0355-00-202	8/29/12	46.0715	-95.7281	30.2	7.08	0.274	2216	9.09	2.3
FS-136	Itasca	16	15-0016-00-208	9/19/12	47.2343	-95.2049	23.6	< 0.5	0.0636	1496	2.23	5.9
P-7	Itasca	16	15-0016-00-207	8/25/11	47.2332	-95.1985	20.1	0.26	0.064	1650	6.01	2.2
P-5	Itasca	16	15-0016-00-208	8/25/11	47.2381	-95.2065	45.8	0.26	0.056	1355	7.4	1.2
FS-207	Kelly Lake	64	66-0015-00-204	8/13/12	44.3542	-93.3743	0.0	1.92	0.0927	4387	27.33	2.3

FS-79	Lady Slipper	53	42-0020-00-203	7/27/12	44.5723	-95.6216	0.0	330	1.63	3314	1.85	34.1
FS-78	Lady Slipper	53	42-0020-00-202	7/27/12	44.5699	-95.6275	0.0	335	1.68	2719	1.66	26.5
P-55	Lady Slipper	53	42-0020-00-204	9/22/11	44.5702	-95.6274	0.0	107.71	14.84	2814	2.09	21.5
P-61	Lily	90	81-0067-00-202	9/28/11	44.194	-93.6469	51.5	0.66	0.041	6180	14.06	10.0
P-62	Lily	90	81-0067-00-202	9/28/11	44.194	-93.6469	0.0	0.64		5069	13.39	7.2
FS-180	Lily	90	81-0067-00-202	7/26/12	44.1947	-93.647	38.2	< 0.5	0.0295	5095	28.07	3.0
P-47	Little Birch	87	77-0089-00-101	9/21/11	45.7747	-94.7996	25.9	3.2	0.05	4503	4.46	21.4
P-47	Little Birch	87	77-0089-00-101	9/21/11	45.7747	-94.7996	25.9	3.2	0.191	2236	1.75	17.1
P-47	Little Birch	87	77-0089-00-101	9/21/11	45.7747	-94.7996	25.9	3.2	0.191	3544	5.11	11.5
P-47	Little Birch	87	77-0089-00-101	9/21/11	45.7747	-94.7996	25.9	3.2	0.191	2253	8.37	2.7
FS-54	Little Birch	87	77-0089-00-207	8/3/12	45.7779	-94.7978	70.0	7.4	0.0353	1794	6.02	2.6
P-4	Little Flat	6	03-0217-00-201	8/24/11	46.9981	-95.6641	83.1	0.22	0.011	7479	33.13	5.2
FS-250	Little Rice	75	69-0612-00-201	9/20/12	47.7086	-92.4389	29.3	1.03	0.0293	9488	26.45	10.7
FS-342	Little Round	7	03-0302-00-203	8/5/13	46.9721	-95.7358	58.3	< 0.5	0.0676	4447	25.16	2.6
FS-138	Little Round	7	03-0302-00-203	9/20/12	46.9726	-95.735	78.0	< 0.5	0.128	3069	27.48	1.2
FS-374	Little Round	7	03-0302-00-202	9/10/13	46.9745	-95.738	37.6	0.12	0.0391	2018	14.8	1.1
FS-319	Little Round	7	03-0302-00-203	6/27/13	46.9724	-95.735	17.5	< 0.5	0.117	3579	39.84	1.0
P-3	Little Round	7	03-0302-00-202	8/24/11	46.9759	-95.7404	57.2	0.46	0.032	1689	20.91	0.5
FS-223	Little Sucker	40	31-0126-00-202	9/14/12	47.3765	-93.246	0.0	13.7	0.534	6297	16.56	8.5
FS-203	Long Prairie	110	S007-203	8/9/12	45.9729	-95.1603	58.3	6.66	0.0391	5074	4.35	27.8
FS-202	Long Prairie	110	S007-204	8/9/12	46.0072	-95.2634	13.4	7.71	0.0793	2897	2.85	15.7
FS-200	Louisa	94	86-0282-00-205	8/8/12	45.2998	-94.258	0.0	7.04	0.192	7824	8.76	27.6
FS-226	Louise	25	21-0094-00-202	8/14/12	45.9331	-95.4148	46.5	4.09	0.0746	1833	0.83	28.5
FS-60	Lower Panasa	38	31-0112-00-205	8/29/12	47.3018	-93.2521	0.0	33.6	0.243	8048	14.12	16.5
FS-357	Lower Panasa	38	31-0112-00-204	8/15/13	47.3026	-93.2561	0.0	28.5	1.26	2347	2.42	12.7
P-25	Lower Rice	107	S006-985	9/8/11	47.3793	-95.4834	114.4	1.02	0.097	2337	17.76	1.2
P-26	Lower Rice	109	S007-164	9/8/11	47.3817	-95.4926	120.1	0.55	0.07	2364	6.76	3.8

FS-133	Mahnomen	21	18-0126-02-201	9/17/12	46.4985	-93.9958	0.0	16.9	0.308	18746	7.7	173.2
FS-377	Mahnomen	21	18-0126-02-201	9/11/13	46.4986	-93.9956	0.0	21.1	0.0283	16540	7.47	141.1
FS-175	Maloney	88	79-0001-00-201	7/23/12	44.2251	-91.9321	0.0	3.15	0.0608	15126	4.57	214.0
P-64	Maloney	88	79-0001-00-201	9/29/11	44.2243	-91.9328	0.0	1.83		10382	4.05	119.9
P-63	Maloney	88	79-0001-00-201	9/29/11	44.2243	-91.9328	148.7	1.83	0.01	10269	4.24	111.2
FS-187	McCormic	81	73-0273-00-203	8/2/12	45.722	-94.9121	8.9	1.54	0.144	1512	1.1	14.0
FS-230	Mill Pond	23	21-0034-00-202	8/16/12	46.0715	-95.2218	80.9	7.36	0.192	3969	3.14	25.6
FS-229	Mill Pond	23	21-0034-00-202	8/16/12	46.0716	-95.2218	102.2	7.16	0.109	5143	7.86	14.0
FS-225	Miltona	24	21-0083-00-205	8/13/12	46.0496	-95.4217	0.0	4.11	0.0694	2624	1.77	22.9
FS-201	Mink	92	86-0229-00-206	8/8/12	45.274	-94.0269	0.0	1.31	0.0373	1740	1.53	12.4
FS-129	Mink	92	86-0229-00-207	8/23/12	45.2767	-94.0299	0.0	1.22	0.182	4247	13.63	5.0
FS-80	Mission	95	S001-646	8/6/12	45.8623	-93.0011	87.5	0.62	0.0485	9231	4.83	77.5
FS-83	Mississippi Crow Win	111	S007-205	8/8/12	46.4386	-94.1251	0.0	3.13	0.127	13451	3.88	207.8
FS-211	Mississippi Pool 4/Ro	89	79-0005-02-201	8/16/12	44.3611	-91.9897	57.6	17.7	0.0714	9265	1.55	304.2
FS-336	Mississippi Pool 4/Ro	89	79-0005-02-201	7/30/13	44.3613	-91.9901	46.5	55.3	0.0602	8193	1.41	269.0
FS-210	Mississippi Pool 4/Ro	89	79-0005-02-202	8/16/12	44.3593	-91.9881	35.3	15.7	0.07	6450	1.16	214.5
FS-371	Mississippi Pool 5 / Sp	123	S007-660	9/10/13	44.2016	-91.8443	39.8	34.4	0.069	3582	0.11	1161.0
FS-335	Mississippi Pool 5 / Sp	123	S007-660	7/30/13	44.1953	-91.841	63.0	47.7	0.0342	4362	0.25	634.7
FS-212	Mississippi Pool 5 / Sp	123	S007-660	8/17/12	44.1993	-91.8461	29.6	17.2	0.0224	3674	0.22	531.7
FS-372	Mississippi Pool 5 / Sp	123	S007-660	9/10/13	44.2016	-91.8443	26.7	34.8	0.0536	3330	0.33	270.9
FS-312	Mississippi Pool 5 / Sp	123	S007-660	6/21/13	44.2018	-91.8444	35.7	28.3	0.0844	3563	0.67	132.2
FS-370	Mississippi Pool 8 at C	118	S007-222	9/9/13	43.5765	-91.2337	17.8	33.3	0.062	6558	1.43	172.4
FS-208	Mississippi Pool 8 at C	118	S007-222	8/14/12	43.5758	-91.2334	41.4	18	0.176	2178	0.41	92.3
FS-334	Mississippi Pool 8 at C	118	S007-222	7/29/13	43.5758	-91.2344	52.8	44.2	0.102	1969	0.4	78.3
FS-311	Mississippi Pool 8 at C	118	S007-222	6/20/13	43.5766	-91.2341	12.7	29.3	0.107	1544	0.62	29.0
FS-209	Mississippi Pool 8 at F	122	S007-556	8/15/12	43.6025	-91.2686	72.3	18.1	0.0711	9187	2.29	187.6
P-14	Mississippi River abov	108	S007-163	9/1/11	47.2379	-93.7196	163.2	1.09	0.053	7964	6.43	41.4

FS-354	Mississippi River abov	108	S007-163	8/13/13	47.2376	-93.7187	132.7	1.18	0.0532	7052	5.76	37.4
FS-58	Mississippi River abov	108	S007-163	8/28/12	47.2386	-93.7197	0.0	1.19	0.0806	8636	9.08	32.0
FS-57	Mississippi River belo	103	S006-923	8/28/12	47.2551	-93.6342	0.0	10.3	0.134	4225	1.2	91.3
P-15	Mississippi River belo	103	S006-923	9/1/11	47.2547	-93.6344	100.2	3.65	0.035	8667	6.07	52.2
FS-355	Mississippi River belo	103	S006-923	8/13/13	47.2553	-93.634	78.3	10.2	0.0819	10479	8.98	47.1
FS-313	Monongalia	46	34-0158-01-203	6/23/13	45.3334	-94.9293	50.0	34.7	0.0941	6028	19.44	6.4
FS-340	Monongalia	46	34-0158-02-203	7/31/13	45.3331	-94.9292	87.9	33.6	0.122	5530	22.1	4.7
FS-379	Monongalia	46	34-0158-02-203	9/13/13	45.3332	-94.9292	154.4	34.6	0.242	5436	26.42	3.7
P-42	Monongalia (Middle F	45.5	34-0158-01-201	9/20/11	45.3481	-94.9509	5.7	16.51	0.042	46471	14.76	455.4
FS-77	Monongalia (near hw	46	34-0158-02-204	7/26/12	45.3331	-94.9268	121.3	21.7	1.37	4953	18.66	4.6
FS-75	Mortenson	44	34-0150-02-201	7/24/12	45.3	-94.9062	0.0	< 0.5	0.103	9071	12.09	25.0
FS-176	North Geneva	29	24-0015-00-209	7/24/12	43.7876	-93.271	0.0	15.6	1.54	2212	13.45	1.5
FS-132	Ox Hide	35	31-0106-00-203	9/7/12	47.335	-93.2134	10.5	26.4	0.042	14936	14.43	52.7
FS-198	Ox Hide	35	31-0106-00-203	9/7/12	47.335	-93.2134	0.6	26.4	0.0751	8743	24.51	10.0
FS-350	Ox Hide	35	31-0106-00-203	8/14/13	47.3351	-93.2132	0.0	25.9	0.119	3889	12.12	4.9
FS-344	Padua	82	73-0277-00-202	8/6/13	45.6231	-95.0187	9.5	< 0.5	0.0806	4520	12.61	6.2
P-29	Padua	82	73-0277-00-203	9/13/11	45.6202	-95.0192	3.4	0.76	0.13	4927	20.15	4.2
FS-220	Padua	82	73-0277-00-202	8/7/12	45.623	-95.0186	0.0	0.86	0.23	2291	9.77	2.3
FS-92	Partridge	119	S007-443	9/12/12	47.5207	-92.1909	4.1	36.3	0.0741	29463	5.87	571.7
P-13	Partridge	119	S007-443	8/31/11	47.5212	-92.1899	65.9	10.39	0.075	11026	1.44	464.3
FS-331	Partridge	119	S007-443	7/24/13	47.5212	-92.1904	60.5	14.6	0.112	10082	1.68	325.0
FS-366	Partridge	119	S007-443	9/3/13	47.5213	-92.19	47.7	34.2	0.057	7671	1.79	178.1
FS-365	Partridge	119	S007-443	9/3/13	47.5212	-92.1901	76.7	34.1	0.0393	9179	2.5	168.6
FS-301	Partridge	119	S007-443	5/28/13	47.5213	-92.1903	0.0	14.8	0.125	9491	3.94	104.3
FS-302	Partridge	121	S007-513	5/30/13	47.5153	-92.1894	0.0	43.1	0.0624	24784	6.27	378.8
FS-364	Partridge	121	S007-513	8/30/13	47.5138	-92.1894	105.7			28890	8.19	369.5
FS-332	Partridge	121	S007-513	7/24/13	47.5137	-92.1894	79.6	54.4	0.102	20512	8.34	187.1

FS-316	Partridge	121	S007-513	6/28/13	47.5137	-92.1899	0.0	24.9	0.098	6291	2.6	77.8
FS-55	Pelkey	55	49-0030-00-202	8/26/12	45.9962	-94.2273	0.0	3.42	0.0522	30642	17.32	168.8
P-10	Pike	104	S006-927	8/30/11	47.7325	-92.3468	43.0	8.31	0.063	15572	10.9	80.0
FS-91	Pike	104	S006-927	9/11/12	47.7327	-92.3473	3.5	14.2	0.0656	6565	4.72	41.4
FS-190	Pine	18	15-0149-00-205	8/28/12	47.6841	-95.5414	114.9	14.7	0.368	4477	7.08	12.2
FS-84	Pleasant	13	11-0383-00-207	8/10/12	46.9228	-94.4874	0.0	< 0.5	0.0218	7065	23.99	6.8
P-27	Pleasant	13	11-0383-00-206	9/9/11	46.928	-94.4757	28.6	0.49		5331	30.37	3.0
FS-215	Popple	101	S006-188	9/11/12	47.7254	-94.0817	36.3	< 0.5	0.0269	2971	14.42	2.4
FS-196	Prairie	115	S007-209	9/3/12	47.2519	-93.4884	44.6	9.63	0.0709	15071	10.51	78.4
FS-82	Rabbit	20	18-0093-02-204	8/8/12	46.5313	-93.9285	0.0	15.3	0.22	10903	11.79	36.7
P-28	Raymond	83	73-0285-00-203	9/12/11	45.629	-95.0234	68.6	0.82	0.094	3922	10.06	6.2
FS-343	Raymond	83	73-0285-00-203	8/6/13	45.629	-95.0233	61.4	1.92	0.0903	3270	7.59	6.1
FS-53	Raymond	83	73-0285-00-203	8/2/12	45.6286	-95.0225	61.1	< 0.5	0.0787	1905	4.79	3.8
FS-56	Rice	19	18-0053-00-203	8/27/12	46.3389	-93.8915	19.4	< 0.5	0.0259	83421	31.88	558.1
FS-376	Rice	19	18-0053-00-203	9/11/13	46.3394	-93.8918	46.5	< 0.5	0.0451	65261	33.36	329.7
P-69	Rice	19	18-0053-00-203	9/27/11	46.3394	-93.8913	43.0	0.23	0.021	50389	35.55	185.8
FS-304	Rice	19	18-0053-00-203	6/10/13	46.3387	-93.8906	5.7	< 0.5	0.0236	48287	33.61	183.1
FS-324	Rice	19	18-0053-00-203	7/15/13	46.3392	-93.8918	56.7	< 0.5	0.11	44704	33.18	160.3
FS-181	Rice	66	66-0048-00-203	7/27/12	44.3332	-93.4734	0.0	5.22	0.777	3829	21.67	2.4
FS-345	Rice	80	73-0196-00-216	8/7/13	45.3865	-94.6313	0.0	6.85	2.08	2012	14.83	1.1
FS-184	Rice	80	73-0196-00-216	7/30/12	45.3864	-94.6309	0.0	2.58	2.97	1523	15.03	0.6
FS-179	Rice	84	74-0001-00-201	7/25/12	44.0842	-93.0737	0.0	3.84	0.217	4152	19.07	3.2
FS-199	Rice	102	S006-208	9/5/12	47.6742	-93.6547	75.4	1.57	0.0552	3273	10.88	4.0
FS-231	Rice	2	02-0008-00-206	8/17/12	45.1604	-93.121	0.0	3.6	0.145	2159	7.98	2.6
P-11	Sand	97	S003-249	8/30/11	47.6348	-92.4235	14.4	7.69	0.046	22677	17.49	93.5
FS-90	Sand	97	S003-249	9/11/12	47.6351	-92.4234	2.9	15.9	0.152	7287	9.68	21.4
FS-321	Sandy-1	76	69-0730-00-203	7/9/13	47.6255	-92.5885	0.0	122	0.189	36502	29.51	124.9

FS-306	Sandy-1	76	69-0730-00-203	6/11/13	47.6255	-92.5884	0.0	11	0.0918	35357	28.53	122.3
FS-251	Sandy-1	76	69-0730-00-203	9/21/12	47.6254	-92.5886	3.8	3.05	0.123	35905	33.08	105.5
FS-382	Sandy-1	76	69-0730-00-203	9/17/13	47.6255	-92.5885	0.0	67.9	0.135	26645	32.28	61.2
FS-320	Sandy-2	76	69-0730-00-204	7/9/13	47.6188	-92.5936	0.0	118	3.08	19749	15.43	83.3
FS-348	Sandy-2	76	69-0730-00-204	8/13/13	47.6186	-92.5934	0.0	123	0.305	13216	8.23	81.6
FS-381	Sandy-2	76	69-0730-00-204	9/17/13	47.6187	-92.5931	0.0	126	0.0342	16172	11.67	79.2
FS-305	Sandy-2	76	69-0730-00-204	6/11/13	47.6187	-92.5937	0.0	135	1.08	19094	22.23	50.4
FS-380	Sandy-2	76	69-0730-00-204	9/17/13	47.6187	-92.5939	0.6	126	0.0342	17868	22.7	43.3
FS-349	Sandy-3	76	69-0730-00-205	8/13/13	47.6191	-92.5898	0.0	122	0.0697	14897	20.46	34.6
P-24	Second	17	15-0091-00-201	9/7/11	47.8255	-95.3635	37.3	0.87	0.139	3813	25.67	1.9
FS-105	Second	17	15-0091-00-202	6/27/12	47.8258	-95.3637	48.4	0.74	0.119	2527	33.3	0.6
FS-310	Second	117	S007-220	6/14/13	47.5205	-92.1925	57.6	316	0.0927	31190	4.22	946.8
FS-384	Second	117	S007-220	9/19/13	47.5204	-92.1925	27.7		0.104	22634	3.42	657.3
FS-303	Second	117	S007-220	5/30/13	47.5204	-92.1925	0.0	303	0.0991	13086	2.2	388.6
FS-323	Second	117	S007-220	7/11/13	47.5204	-92.1925	76.4	405	0.067	10036	2.91	166.9
FS-351	Second	117	S007-220	8/15/13	47.5205	-92.1925	66.8	838	0.0447	7088	1.84	148.0
FS-197	Snowball	36	31-0108-00-202	9/4/12	47.3355	-93.244	0.0	8.4	0.0936	4213	6	13.2
FS-347	Snowball	36	31-0108-00-202	8/12/13	47.3356	-93.2439	0.0	8.2	0.097	1136	1.19	7.4
FS-177	South Geneva	30	24-0015-02-208	7/24/12	43.7709	-93.2851	0.0	14.1	3.19	1618	16.71	0.6
P-16	St. Louis	106	S006-929	9/1/11	47.4015	-92.3773	0.0	24.5	0.025	1488	0.1	240.3
FS-69	St. Louis	114	S007-208	9/7/12	47.4671	-91.9279	0.0	1.33	0.181	11429	27.16	14.8
P-17	St. Louis	114	S007-208	9/1/11	47.4668	-91.9355	68.6	1.23	0.04	9654	30.4	9.3
FS-66	St. Louis Estuary	112	S007-206	9/5/12	46.6545	-92.2739	0.0	16	0.0445	6169	1.73	122.0
FS-330	St. Louis Estuary	120	S007-444	7/22/13	46.6518	-92.2372	11.8	6.71	0.0901	5817	1.55	124.3
FS-315	St. Louis Estuary	120	S007-444	6/24/13	46.6516	-92.2373	0.0	8.1	0.147	6056	1.68	122.0
FS-300	St. Louis Estuary	120	S007-444	5/27/13	46.6515	-92.2376	0.0	9.4	0.0713	4499	1.26	97.2
FS-363	St. Louis Estuary	120	S007-444	8/26/13	46.6518	-92.2372	31.2			4761	1.4	95.5

FS-67	St. Louis Estuary Poke	105	S006-928	9/5/12	46.6859	-92.1606	0.0	9.97	0.112	14015	3.66	241.1
FS-341	Stella	54	47-0068-00-205	8/1/13	45.066	-94.4339	57.6	24.7	0.0884	1786	1.35	15.1
P-30	Stella	54	47-0068-00-203	9/14/11	45.0659	-94.4339	31.6	7.59	0.08	2159	2.88	8.8
FS-188	Stella	54	47-0068-00-204	8/27/12	45.0683	-94.4334	0.3	18.1	1.79	1257	2.34	4.0
FS-224	Stone Lake	68	69-0046-00-201	9/19/12	47.5039	-91.8857	21.0	3.26	0.0533	5225	18.87	5.1
FS-94	Sturgeon	100	S004-870	9/13/12	47.656	-92.9315	37.9	1.62	0.0659	2505	0.65	69.6
FS-61	Swan	34	31-0067-02-206	8/30/12	47.2888	-93.2127	12.4	12.5	0.332	5827	22.71	5.0
FS-62	Swan	34	31-0067-02-206	8/30/12	47.289	-93.2124	3.8	14	0.221	4821	22.53	3.5
FS-125	Tamarac	56	56-0192-00-203	8/19/12	46.3637	-95.5714	0.0	2.33	0.0768	21908	18.41	82.3
FS-356	Trout	41	31-0216-00-212	8/14/13	47.2591	-93.3942	0.0	39.1	0.103	11992	12.59	40.7
FS-219	Trout	41	31-0216-00-212	9/13/12	47.2592	-93.3942	0.0	38.6	0.117	12535	15	35.9
FS-93	Turpela	71	69-0427-00-201	9/12/12	47.4613	-92.2371	1.0	3.3	0.115	6979	31.08	4.9
FS-183	Unnamed	50	34-0611-00-201	7/30/12	45.2675	-94.865	64.9	16.8	0.15	2157	5.61	4.0
P-57	Unnamed	50	34-0611-00-201	9/23/11	45.2675	-94.865	74.4	6.42	0.286	2311	6.48	3.8
P-57	Unnamed	50	34-0611-00-201	9/23/11	45.2675	-94.865	74.4	6.42	0.065	2193	8.1	2.6
P-57	Unnamed	50	34-0611-00-201	9/23/11	45.2675	-94.865	74.4	6.42	0.065	1946	13.8	1.1
P-57	Unnamed	50	34-0611-00-201	9/23/11	45.2675	-94.865	74.4	6.42	0.065	1689	12.6	0.9
FS-383	Upper Panasa	37	31-0111-00-204	9/18/13	47.3059	-93.2676	0.0	33.6	0.0399	19148	2.86	590.3
FS-59	Upper Panasa	37	31-0111-00-202	8/29/12	47.306	-93.2652	0.0	29.6	0.126	895	0.43	15.8
FS-139	Welby family farm	93	86-0231-00-202	9/21/12	45.3592	-94.0782	17.2	< 0.5	0.118	7267	30.76	5.3
FS-228	West battle	57	56-0239-00-204	8/15/12	46.2906	-95.6049	144.8	4.03	0.189	3108	17.37	2.1
FS-186	Westport	63	61-0029-00-204	8/1/12	45.6897	-95.217	0.0	7.11	1.79	4917	20.15	4.2
FS-346	Westport	63	61-0029-00-205	8/8/13	45.7042	-95.203	6.7	6.3	0.205	3262	19.66	2.0
FS-65	Wild Rice	11	09-0023-00-202	9/4/12	46.6712	-92.6055	0.0	< 0.5	0.083	13650	28.82	19.4
P-36	Wild Rice Reservoir	70	69-0371-00-204	9/16/11	46.9098	-92.1636	17.2	1.13	0.023	5555	3.75	39.5
FS-68	Wolf	69	69-0143-00-101	9/6/12	47.2564	-91.963	8.9	2.01	0.119	9526	17.19	18.0
P-19	Wolf	69	69-0143-00-202	9/2/11	47.2586	-91.9618	128.8	1.54	0.139	8240	25.1	8.7

LacCore_field_ID	Site_name	UniqID	DNRStateID	Date	Lat	Long	WRavestemM2	WRpresent	SO4mg_L	TSmgL	SedFeμgg	SedTOCpct	CPSC120
P-34	Anka	26	21-0353-00-201	9/16/11	46.0769	-95.7292	25.9	YES	2.23	0.671	1485	23.57	0.3
FS-134	Bass	43	31-0576-00-207	9/18/12	47.2844	-93.6276	64.0	YES	1.01	0.0664	3740	26.12	1.8
FS-85	Bean	8	03-0411-00-201	8/21/12	46.9337	-95.8706	0.0	NO	85	16	1967	11.85	1.4
FS-87	Bee	60	60-0192-00-202	8/23/12	47.6527	-96.0504	39.8	YES	11	0.67	3054	13.62	2.7
FS-193	Big Mud	79	71-0085-00-201	8/30/12	45.4529	-93.7418	14.3	YES	< 0.5	0.0308	12943	18.63	29.5
FS-216	Big Sucker	39	31-0124-00-203	9/12/12	47.3919	-93.2658	3.8	YES	7.78	0.145	3559	21.45	2.1
FS-204	Big Swan	86	77-0023-00-207	8/10/12	45.8795	-94.742	133.7	YES	5.49	0.0914	1731	5.94	2.4
P-12	Birch	67	69-0003-00-205	8/30/11	47.7357	-91.9428	68.6	YES	3.58	0.104	12431	26.8	17.7
FS-52	Blaamyhre	48	34-0345-00-203	8/1/12	45.364	-95.186	102.2	YES	0.62	0.078	3517	9.33	5.5
FS-214	Bowstring	116	S007-219	9/11/12	47.7024	-94.0608	69.7	YES	1.34	0.256	1974	24.34	0.6
FS-126	Bray	58	56-0472-00-202	8/20/12	46.4518	-95.8783	7.6	YES	1.65	0.072	3937	21.95	2.5
FS-63	Caribou	72	69-0489-00-206	9/3/12	46.8913	-92.3135	0.0	NO	1.21	0.0938	13791	29.44	19.3
FS-109	Carlos Avery Pool 9	4	02-0504-00-202	7/3/12	45.3192	-93.0611	52.8	YES	< 0.5	< 0.011	14736	12.51	61.0
FS-339	Christina	28	21-0375-00-315	7/31/13	46.0734	-95.7567	0.6	YES	14.6	1.93	1741	8.96	1.5
FS-314	Clearwater	96	S002-121	6/24/13	47.9372	-95.6907	0.6	YES	28	0.0664	3946	2.68	30.6
FS-88	Clearwater	98	S004-204	8/24/12	47.5174	-95.3904	148.3	YES	2.04	0.0488	9874	22.17	14.2
P-31	Cloquet	52	38-0539-00-201	9/14/11	47.4313	-91.4844	74.4	YES	0.81	0.024	4252	6.58	12.1
FS-128	Cromwell	14	14-0103-00-201	8/22/12	46.9651	-96.3171	0.0	NO	41.2	1.22	2948	2.85	16.2
FS-322	Dark	77	69-0790-00-202	7/10/13	47.6389	-92.7781	3.2	YES	175	0.131	2480	1.48	25.5
P-44	Dead Fish	12	09-0051-00-202	9/20/11	46.7451	-92.6863	48.7	YES	0.3	0.056	9685	16.6	19.4
FS-378	Duck Lake WMA	22	18-0178-00-202	9/12/13	46.7521	-93.8851	113.0	YES	< 0.5	0.0251	12151	26.57	17.1
FS-86	Eighteen	61	60-0199-00-202	8/22/12	47.6397	-96.0607	40.1	YES	4.29	0.164	1860	3.1	6.1
FS-137	Elk	15	15-0010-00-204	9/19/12	47.1952	-95.2249	42.7	YES	< 0.5	0.0936	6334	10.07	15.6
FS-95	Embarrass	73	69-0496-00-203	9/14/12	47.5334	-92.2979	0.0	NO	18.8	0.0298	21847	1.89	1248.9
FS-76	Field	45	34-0151-00-201	7/25/12	45.2964	-94.9058	0.0	NO	< 0.5	0.0687	7586	8.68	26.3

FS-195	Fisher	78	70-0087-00-201	8/31/12	44.7942	-93.4061	20.7	YES	6.85	0.136	11140	5.76	90.1
P-52	Flowage	1	01-0061-00-206	9/22/11	46.6895	-93.338	123.1	YES	0.56	0.018	4302	21.79	2.9
FS-194	Gilchrist	91	86-0064-00-201	8/31/12	45.2309	-93.824	0.0	NO	6.98	0.355	3117	20.81	1.7
FS-51	Glesne Slough	49	34-0353-00-201	7/31/12	45.3514	-95.1887	99.6	YES	< 0.5	0.061	7983	3.01	103.2
FS-104	Gourd	10	04-0253-00-201	6/27/12	47.8121	-94.965	0.0	NO	0.27		1776	36.87	0.3
P-20	Gull	9	04-0120-00-203	9/6/11	47.6559	-94.6944	15.6	YES	0.78	0.103	1608	5.08	2.5
FS-130	Hay	33	31-0037-00-202	9/6/12	47.2874	-93.102	141.0	YES	31.7	0.0738	13154	5.79	123.3
FS-221	Hay Creek Flowage	59	58-0005-00-202	9/17/12	46.0894	-92.4104	97.7	YES	1.95	0.119	9456	22.05	13.2
P-1	Height of Land	5	03-0195-00-209	8/22/11	46.9129	-95.6095	62.9	YES	0.24	0.053	1298	1.76	6.0
FS-131	Hinken	113	S007-207	9/5/12	47.7271	-93.9923	46.8	YES	< 0.5	0.0876	2960	4.53	9.4
FS-185	Hoffs Slough	85	76-0103-00-201	8/1/12	45.3255	-95.7059	0.0	NO	273	0.0343	3512	0.75	112.3
FS-218	Holman	42	31-0227-00-202	9/13/12	47.3005	-93.3445	0.0	NO	24.2	1.01	3035	29.74	1.0
FS-182	Hunt	65	66-0047-00-208	7/27/12	44.3275	-93.4443	0.0	NO	17.1	0.0729	2412	1.21	30.8
FS-191	Ina	27	21-0355-00-202	8/29/12	46.0715	-95.7281	30.2	YES	7.08	0.274	2216	9.09	2.3
P-5	Itasca	16	15-0016-00-208	8/25/11	47.2381	-95.2065	45.8	YES	0.26	0.056	1355	7.4	1.2
FS-207	Kelly Lake	64	66-0015-00-204	8/13/12	44.3542	-93.3743	0.0	NO	1.92	0.0927	4387	27.33	2.3
P-55	Lady Slipper	53	42-0020-00-204	9/22/11	44.5702	-95.6274	0.0	NO	107.71	14.84	2814	2.09	21.5
FS-180	Lily	90	81-0067-00-202	7/26/12	44.1947	-93.647	38.2	YES	< 0.5	0.0295	5095	28.07	3.0
FS-54	Little Birch	87	77-0089-00-207	8/3/12	45.7779	-94.7978	70.0	YES	7.4	0.0353	1794	6.02	2.6
P-4	Little Flat	6	03-0217-00-201	8/24/11	46.9981	-95.6641	83.1	YES	0.22	0.011	7479	33.13	5.2
FS-250	Little Rice	75	69-0612-00-201	9/20/12	47.7086	-92.4389	29.3	YES	1.03	0.0293	9488	26.45	10.7
P-3	Little Round	7	03-0302-00-202	8/24/11	46.9759	-95.7404	57.2	YES	0.46	0.032	1689	20.91	0.5
FS-223	Little Sucker	40	31-0126-00-202	9/14/12	47.3765	-93.246	0.0	NO	13.7	0.534	6297	16.56	8.5
FS-202	Long Prairie	110	S007-204	8/9/12	46.0072	-95.2634	13.4	YES	7.71	0.0793	2897	2.85	15.7
FS-200	Louisa	94	86-0282-00-205	8/8/12	45.2998	-94.258	0.0	NO	7.04	0.192	7824	8.76	27.6
FS-226	Louise	25	21-0094-00-202	8/14/12	45.9331	-95.4148	46.5	YES	4.09	0.0746	1833	0.83	28.5
FS-357	Lower Panasa	38	31-0112-00-204	8/15/13	47.3026	-93.2561	0.0	NO	28.5	1.26	2347	2.42	12.7
P-26	Lower Rice	109	S007-164	9/8/11	47.3817	-95.4926	120.1	YES	0.55	0.07	2364	6.76	3.8
P-25	Lower Rice	107	S006-985	9/8/11	47.3793	-95.4834	114.4	YES	1.02	0.097	2337	17.76	1.2
FS-377	Mahnomen	21	18-0126-02-201	9/11/13	46.4986	-93.9956	0.0	NO	21.1	0.0283	16540	7.47	141.1
P-63	Maloney	88	79-0001-00-201	9/29/11	44.2243	-91.9328	148.7	YES	1.83	0.01	10269	4.24	111.2

FS-187	McCormic	81	73-0273-00-203	8/2/12	45.722	-94.9121	8.9	YES	1.54	0.144	1512	1.1	14.0
FS-229	Mill Pond	23	21-0034-00-202	8/16/12	46.0716	-95.2218	102.2	YES	7.16	0.109	5143	7.86	14.0
FS-225	Miltona	24	21-0083-00-205	8/13/12	46.0496	-95.4217	0.0	NO	4.11	0.0694	2624	1.77	22.9
FS-129	Mink	92	86-0229-00-207	8/23/12	45.2767	-94.0299	0.0	NO	1.22	0.182	4247	13.63	5.0
FS-80	Mission	95	S001-646	8/6/12	45.8623	-93.0011	87.5	YES	0.62	0.0485	9231	4.83	77.5
FS-83	Mississippi Crow Wing	111	S007-205	8/8/12	46.4386	-94.1251	0.0	NO	3.13	0.127	13451	3.88	207.8
FS-210	Mississippi Pool 4/Robinson Lake	89	79-0005-02-202	8/16/12	44.3593	-91.9881	35.3	YES	15.7	0.07	6450	1.16	214.5
FS-312	Mississippi Pool 5 / Spring	123	S007-660	6/21/13	44.2018	-91.8444	35.7	YES	28.3	0.0844	3563	0.67	132.2
FS-311	Mississippi Pool 8 at Genoa	118	S007-222	6/20/13	43.5766	-91.2341	12.7	YES	29.3	0.107	1544	0.62	29.0
FS-209	Mississippi Pool 8 at Reno Bottoms	122	S007-556	8/15/12	43.6025	-91.2686	72.3	YES	18.1	0.0711	9187	2.29	187.6
FS-58	Mississippi River above Clay Boswe	108	S007-163	8/28/12	47.2386	-93.7197	0.0	NO	1.19	0.0806	8636	9.08	32.0
FS-355	Mississippi River below Clay Boswe	103	S006-923	8/13/13	47.2553	-93.634	78.3	YES	10.2	0.0819	10479	8.98	47.1
FS-379	Monongalia	46	34-0158-02-203	9/13/13	45.3332	-94.9292	154.4	YES	34.6	0.242	5436	26.42	3.7
P-42	Monongalia (Middle Fork Crow R)	45.5	34-0158-01-201	9/20/11	45.3481	-94.9509	5.7	YES	16.51	0.042	46471	14.76	455.4
FS-75	Mortenson	44	34-0150-02-201	7/24/12	45.3	-94.9062	0.0	NO	< 0.5	0.103	9071	12.09	25.0
FS-176	North Geneva	29	24-0015-00-209	7/24/12	43.7876	-93.271	0.0	NO	15.6	1.54	2212	13.45	1.5
FS-350	Ox Hide	35	31-0106-00-203	8/14/13	47.3351	-93.2132	0.0	NO	25.9	0.119	3889	12.12	4.9
FS-220	Padua	82	73-0277-00-202	8/7/12	45.623	-95.0186	0.0	NO	0.86	0.23	2291	9.77	2.3
FS-301	Partridge	119	S007-443	5/28/13	47.5213	-92.1903	0.0	NO	14.8	0.125	9491	3.94	104.3
FS-316	Partridge	121	S007-513	6/28/13	47.5137	-92.1899	0.0	NO	24.9	0.098	6291	2.6	77.8
FS-55	Pelkey	55	49-0030-00-202	8/26/12	45.9962	-94.2273	0.0	NO	3.42	0.0522	30642	17.32	168.8
FS-91	Pike	104	S006-927	9/11/12	47.7327	-92.3473	3.5	YES	14.2	0.0656	6565	4.72	41.4
FS-190	Pine	18	15-0149-00-205	8/28/12	47.6841	-95.5414	114.9	YES	14.7	0.368	4477	7.08	12.2
P-27	Pleasant	13	11-0383-00-206	9/9/11	46.928	-94.4757	28.6	YES	0.49		5331	30.37	3.0
FS-215	Popple	101	S006-188	9/11/12	47.7254	-94.0817	36.3	YES	< 0.5	0.0269	2971	14.42	2.4
FS-196	Prairie	115	S007-209	9/3/12	47.2519	-93.4884	44.6	YES	9.63	0.0709	15071	10.51	78.4
FS-82	Rabbit	20	18-0093-02-204	8/8/12	46.5313	-93.9285	0.0	NO	15.3	0.22	10903	11.79	36.7
FS-53	Raymond	83	73-0285-00-203	8/2/12	45.6286	-95.0225	61.1	YES	< 0.5	0.0787	1905	4.79	3.8
FS-324	Rice	19	18-0053-00-203	7/15/13	46.3392	-93.8918	56.7	YES	< 0.5	0.11	44704	33.18	160.3
FS-199	Rice	102	S006-208	9/5/12	47.6742	-93.6547	75.4	YES	1.57	0.0552	3273	10.88	4.0
FS-179	Rice	84	74-0001-00-201	7/25/12	44.0842	-93.0737	0.0	NO	3.84	0.217	4152	19.07	3.2

FS-181	Rice	66	66-0048-00-203	7/27/12	44.3332	-93.4734	0.0	NO	5.22	0.777	3829	21.67	2.4
FS-184	Rice	80	73-0196-00-216	7/30/12	45.3864	-94.6309	0.0	NO	2.58	2.97	1523	15.03	0.6
FS-231	Rice	2	02-0008-00-206	8/17/12	45.1604	-93.121	0.0	NO	3.6	0.145	2159	7.98	2.6
FS-349	Sandy-3	76	69-0730-00-205	8/13/13	47.6191	-92.5898	0.0	NO	122	0.0697	14897	20.46	34.6
FS-351	Second	117	S007-220	8/15/13	47.5205	-92.1925	66.8	YES	838	0.0447	7088	1.84	148.0
FS-105	Second	17	15-0091-00-202	6/27/12	47.8258	-95.3637	48.4	YES	0.74	0.119	2527	33.3	0.6
FS-347	Snowball	36	31-0108-00-202	8/12/13	47.3356	-93.2439	0.0	NO	8.2	0.097	1136	1.19	7.4
FS-177	South Geneva	30	24-0015-02-208	7/24/12	43.7709	-93.2851	0.0	NO	14.1	3.19	1618	16.71	0.6
P-16	St. Louis	106	S006-929	9/1/11	47.4015	-92.3773	0.0	NO	24.5	0.025	1488	0.1	240.3
P-17	St. Louis	114	S007-208	9/1/11	47.4668	-91.9355	68.6	YES	1.23	0.04	9654	30.4	9.3
FS-66	St. Louis Estuary	112	S007-206	9/5/12	46.6545	-92.2739	0.0	NO	16	0.0445	6169	1.73	122.0
FS-363	St. Louis Estuary	120	S007-444	8/26/13	46.6518	-92.2372	31.2	YES			4761	1.4	95.5
FS-67	St. Louis Estuary Pokegama Bay	105	S006-928	9/5/12	46.6859	-92.1606	0.0	NO	9.97	0.112	14015	3.66	241.1
FS-188	Stella	54	47-0068-00-204	8/27/12	45.0683	-94.4334	0.3	YES	18.1	1.79	1257	2.34	4.0
FS-224	Stone Lake	68	69-0046-00-201	9/19/12	47.5039	-91.8857	21.0	YES	3.26	0.0533	5225	18.87	5.1
FS-94	Sturgeon	100	S004-870	9/13/12	47.656	-92.9315	37.9	YES	1.62	0.0659	2505	0.65	69.6
FS-62	Swan	34	31-0067-02-206	8/30/12	47.289	-93.2124	3.8	YES	14	0.221	4821	22.53	3.5
FS-125	Tamarac	56	56-0192-00-203	8/19/12	46.3637	-95.5714	0.0	NO	2.33	0.0768	21908	18.41	82.3
FS-219	Trout	41	31-0216-00-212	9/13/12	47.2592	-93.3942	0.0	NO	38.6	0.117	12535	15	35.9
FS-93	Turpela	71	69-0427-00-201	9/12/12	47.4613	-92.2371	1.0	YES	3.3	0.115	6979	31.08	4.9
P-57	Unnamed	50	34-0611-00-201	9/23/11	45.2675	-94.865	74.4	YES	6.42	0.065	1689	12.6	0.9
FS-59	Upper Panasa	37	31-0111-00-202	8/29/12	47.306	-93.2652	0.0	NO	29.6	0.126	895	0.43	15.8
FS-139	Welby family farm	93	86-0231-00-202	9/21/12	45.3592	-94.0782	17.2	YES	< 0.5	0.118	7267	30.76	5.3
FS-228	West battle	57	56-0239-00-204	8/15/12	46.2906	-95.6049	144.8	YES	4.03	0.189	3108	17.37	2.1
FS-346	Westport	63	61-0029-00-205	8/8/13	45.7042	-95.203	6.7	YES	6.3	0.205	3262	19.66	2.0
FS-65	Wild Rice	11	09-0023-00-202	9/4/12	46.6712	-92.6055	0.0	NO	< 0.5	0.083	13650	28.82	19.4
P-36	Wild Rice Reservoir	70	69-0371-00-204	9/16/11	46.9098	-92.1636	17.2	YES	1.13	0.023	5555	3.75	39.5
P-19	Wolf	69	69-0143-00-202	9/2/11	47.2586	-91.9618	128.8	YES	1.54	0.139	8240	25.1	8.7

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November 22, 2017

SUBMITTED ELECTRONICALLY
Administrative Law Judge LauraSue Schlatter
Office of Administrative Hearings
P.O. Box 64620
600 N Robert St.
St. Paul, MN 55164

RE: **Proposed Rules Amending the Sulfate Water Quality Standard Applicable to Wild Rice and Identification of Wild Rice Waters, Minnesota Rules parts 7050.0130, 7050.0220, 7050.0224, 7050.0470, 7050.0471, 7053.0135, 7053.0205, and 7053.0406; Revisor's ID Number** 4324.
OAH Docket No. 80-9003-34519.

Dear Administrative Law Judge Schlatter,

These comments are submitted on behalf of WaterLegacy regarding the above-captioned Minnesota Pollution Control Agency (MPCA) proposed rules pertaining to the water quality standard applicable to wild rice. WaterLegacy is a Minnesota non-profit organization with approximately 10,000 members and supporters, formed to protect Minnesota water resources and the communities that depend on them.

WaterLegacy has been working to protect wild rice since 2010, when industry representatives first approached the MPCA and requested that the numeric limit on sulfate pollution be changed administratively, without rulemaking.[1] WaterLegacy intervened in 2011 when the Chamber of Commerce sued in state court on behalf of several mining companies to prevent implementation of Minnesota's wild rice sulfate limit. The standard was upheld on a motion for summary judgment in state district court,[2] and the Chamber's claims were dismissed by the Minnesota Court of Appeals.[3]

WaterLegacy served on the MPCA's Wild Rice Standards Study Advisory Committee from 2011 through 2017, and attended all meetings of the Peer Review Panel for the MPCA's proposed rulemaking, as well as those of the Advisory Committee and read every document released by the MPCA through the course of this rulemaking process as well as expert opinions and published literature. In addition, WaterLegacy has secured through the Data Practices Act and analyzed thousands of pages of MPCA internal documents pertaining to the wild rice sulfate standard and its implementation in permits since 1973.

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[1] WaterLegacy, Preserve Minnesota's Wild Rice Standard, Nov. 1 2010, Exhibit 1.
[2] *Minnesota Chamber of Commerce (MCC) v. Minn. Pollution Control Agency (MPCA)*, 2012 Minn. Dist. LEXIS 194 (Minn. Dist. Ct., Ramsey County, May 10, 2012), Exhibit 2.
[3] *Minnesota Chamber of Commerce (MCC) v. Minn. Pollution Control Agency (MPCA*), 2012 Minn. App. Unpub. LEXIS 1199 (Mn. Ct. App., Dec. 17, 2012), Exhibit 3.

Based on applicable law, the rulemaking record, internal MPCA documents, documentation of the history of implementation of Minnesota's existing rule, scientific research and expert opinions, WaterLegacy has reached the following conclusions, discussed in detail in these comments and its attached exhibits:

1) Under applicable legal standards, MPCA bears the burden to demonstrate that its proposed rule rescinding and revising the existing wild rice sulfate standard is needed, reasonable, and within the Agency's authority under the federal Clean Water Act. (p. 4)

2) MPCA's failure to enforce Minnesota's existing wild rice standard, and the history of industry opposition and legislative interference undermine MPCA's claims that its proposed rule revisions are intended or needed to provide "effective protection" of wild rice or "clarify" its implementation. (p. 7)

3) MPCA's proposal to rescind Minnesota's existing water quality standard limiting sulfate to 10 milligrams per liter (mg/L) in wild rice waters is neither needed nor reasonable and is inconsistent with protecting the designated use of waters for wild rice under the Clean Water Act. (p. 11)

4) MPCA's proposal to adopt an equation that would calculate sulfate limits for each water body based on the flawed assumption that sediment iron protects wild rice from the harmful effects of sulfate conversion to sulfide would neither provide effective protection of wild rice nor clarify implementation, is neither needed nor reasonable, and is inconsistent with the requirements of the federal Clean Water Act. (p. 18)

5) MPCA's proposal to restrict the water bodies in which any wild rice sulfate standard would apply to an arbitrary and exclusive list would remove a designated use protected under existing Minnesota rules and de-list wild rice waters identified by Minnesota state agencies, including waters downstream of existing and potential mining discharge. Such de-listing is neither needed nor reasonable and exceeds the MPCA's delegated statutory authority under the federal Clean Water Act. (p. 30)

6) MPCA's proposed rule stating criteria by which wild rice waters can be added in future rulemaking is unnecessary, arbitrary and provides no benefit to those seeking to protect wild rice from sulfate pollution. (p. 40)

7) MPCA's proposed implementation mechanisms for its sulfate equation are biased against protection of wild rice and inconsistent with any effective implementation of water quality standards. They are neither needed nor reasonable and exceed the MPCA's delegated statutory authority under the federal Clean Water Act. (p. 42)

8) MPCA's proposal to remove protection of thousands of wild rice waters from material impairment or degradation as a result of factors other than sulfate pollution - such as hydrologic alteration - is baseless and inconsistent with the rule's history, its stated purpose, and the Clean Water Act. (p. 50)

9) MPCA's failure to evaluate the impact of its proposed rules on eutrophication, aquatic life, methylmercury contamination of fish, and degradation of Treaty resources within

> tribal Ceded Territories, as compared to enforcement of Minnesota's existing rule, is unreasonable, arbitrary and inconsistent with the Clean Water Act. (p. 53)

On the basis of the discussion and authorities described below as well as the expert opinions and exhibits attached with our comments, WaterLegacy respectfully requests that the following sections of the MPCA's proposed rulemaking be rejected as unnecessary to further the MPCA's stated rule objectives, arbitrary, capricious and unreasonable, and outside the scope of the Agency's delegated authority under the Clean Water Act.

> Proposed rule **Minn. R. 7050.0130, Subp. 2a** (lines 1.6 to 1.10) and **Minn. R. 7053.0135, Subp. 2a** (lines 66.11-66.12) defining method to allow annual averaging of flow and make sulfate standards less stringent due to an excessive calculation of dilution.
>
> Proposed phrase in **Minn. R. 7050.0130, Subp. 6c** (line 2.3) stating "and are identified in part 7050.0471," which sets an arbitrary limit excluding "wild rice waters."
>
> Proposed deletion of **Minn. R. 7050.0220, Subparts 3a (31)** (lines 3.15 to 3.16), **4a (31)** (lines 4.10 to 4.11), **5a (19)** (lines 5.7 to 5.8), **6a (14)** (lines 5.22 to 5.23) removing existing limit for sulfates of 10 mg/L where "wild rice present."
>
> Proposed addition to **Minn. R. 7050.0220, Subparts 3a** (line 3.17), **4a** (line 4.12), **5a** (lines 4.23 to 4.24, 5.8), **6a** (line 5.24), applying the equation in proposed 7050.0224, subpart 5, to replace the sulfate limit.
>
> Proposed phrase "4D when applicable to a wild rice water listed in part 7050.0471" arbitrarily limiting protection of water quality standards to certain wild rice waters in proposed rule text for **Minn. R. 7050.0220, Subp. 1 (B)(1)** (lines 2.19 to 2.20), **(B)(2)** (lines 2.22 to 2.23), **(B)(3)** (line 3.3), **(B)(4)** (line 3.5); Subp**. 3a** (lines 3.8 to 3.9); **Subp. 4a** (line 4.3); **Subp. 5a** (lines 4.20 to 4.21); **Subp. 6a** (line 5.14).
>
> Proposed deletion of **Minn. R. 7050.0224, Subp. 1** (lines 6.8 to 6.14) and proposed rule at **Minn. R. 7050.0224, Subp. 6** (lines 9.13 to 9.18) arbitrarily excluding most wild rice waters so that they would not be protected from material impairment or degradation.
>
> Proposed deletion of **Minn. R. 7050.0224, Subp. 2** (line 7.8 to 7.19) deleting fixed wild rice sulfate standard by removing the words "Sulfates (SO_4) 10 mg/L, applicable to water used for the production of wild rice."
>
> Proposed rule **Minn. R. 7050.0224, Subp. 5** (lines 7.17 to 9.12) proposing use of an equation that would fail to protect wild rice, a rule for exceedance of standards that allows excessive pollution, implementation methods biased against the protection of wild rice, and error-prone sampling of parameters by dischargers.
>
> Proposed rule **Minn. R. 7050.0471, Subp. 2** (lines 11.18 to 12.6) constraining theoretical future identification of wild rice waters.

Proposed rule **Minn. R. 7053.0205, Subp. 7, Item E** (lines 66.22 to 67.2) applying a flow rate that makes sulfate standards less stringent and cross-referencing the rule that allows extended exceedances.

Proposed rule **Minn. R. 7053.0406, Subp. 1** (lines 67.6 to 67.10) biasing implementation against application of a sulfate water quality standard.

DISCUSSION

1) Under applicable legal standards, MPCA bears the burden to demonstrate that its proposed rule rescinding and revising the existing wild rice sulfate standard is needed, reasonable, and within the Agency's authority under the federal Clean Water Act.

Minnesota statutes provide that a rule is invalid if it violates constitutional provisions, exceeds the statutory authority of the agency or was adopted without compliance with statutory rulemaking procedures. Minn. Stat. §§14.44; 14.45. An agency seeking to promulgate a rule must provide a statement of the "need for and reasonableness of" the rule. Minn. Stat. §§ 14.23; 14.131.

A rule that is arbitrary and capricious violates substantive due process, and "in determining if the agency acted arbitrarily and capriciously the court must make a 'searching and careful' inquiry of the record to ensure that the agency action has a rational basis." *Manufactured Housing Institute v. Pettersen*, 347 N.W. 2d 238, 244 (Minn. 1984); *Citizens to Preserve Overton Park v. Volpe*, 401 U.S. 402, 416, 91 S. Ct. 814 (1971). A rule is invalid when it is "not rationally related to the objective sought to be achieved" and will be stricken when the court concludes, after making a "careful and searching inquiry of the record" that a proposed rule "is arbitrary and not supported by substantial evidence in the record." *Builders Ass'n of the Twin Cities v. Minn. Dep't of Labor & Indus*., 872 N.W. 2d 263, 268, 269 (Minn. Ct. App. 2015).

When an agency seeks to rescind an existing standard, it must be taken into consideration that revocation "constitutes a reversal of the agency's former views as to the proper course" to implement policies committed to it. There is then, "at least a presumption that those policies will be carried out best if the settled rule is adhered to." *Motor Vehicle Mfrs. Assn. v. State Farm Mut. Automobile Ins. Co*., 463 U.S. 29, 41-42, 103 S. Ct. 2856 (1983). "Accordingly, an agency changing its course by rescinding a rule is obligated to supply a reasoned analysis for the change beyond that which may be required when an agency does not act in the first instance." *Id*., at 42.

The mere fact that there is "some rational basis within the knowledge and experience" of regulators will not suffice to validate agency rulemaking. *Bowen v. American Hospital A*ss'n, 476 U.S. 610, 627, 476 U.S. 610,106 S. Ct. 2101 (1986). "[D]eference cannot fill the lack of an evidentiary foundation on which the Final Rules must rest," and "An agency's action must be upheld, if at all, on the basis articulated by the agency itself." *Id.*, at 643, citing *Motor Vehicle Mfrs. Assn.* v. *State Farm Mut. Automobile Ins. Co*., 463 U.S., at 50. The history of the regulations may expose the "inappropriateness" of the deference requested by government and create an "irresistible" inference as to the mission with which the proposed rules were principally concerned. *Bowen v. American Hospital A*ss'*n* 476 U.S. at 645, 646-647.

The MPCA's statutory authority to replace Minnesota's wild rice sulfate standard is governed by the federal Clean Water Act and its implementing regulations as well as by state statute under a legislative structure often described as "cooperative federalism." The MPCA's authority to establish water quality standards and to classify the waters to which such standards apply,[4] must comply with the requirements of the Clean Water Act. 33 U.S.C. §1342(b). While states are given leeway to enact more stringent standards or procedures than required by the Act to protect and clean up their waters, state statutes and rules must, at a minimum, satisfy and conform to the Act and United States Environmental Protection Agency (EPA) regulations. 33 U.S.C. §1311(b)(1)(C).

Minnesota Rules contain multiple references to the structure of cooperative federalism, whereby state actions with respect to water quality must comply with federal requirements under the Clean Water Act. The permit program by which the MPCA authorizes pollution discharge pollution and the program by which the MPCA identifies waters that are impaired are subject to the Clean Water Act requirements. Minn. R. 7050.0255, Subp. 25, Subp. 39. Variances may only be effective if approved by the EPA in accordance with the Clean Water Act. Minn. R. 7050.0190, Subp. 4. Minnesota water quality standards as a whole are "in addition to any requirements imposed by the Clean Water Act and its implementing regulations," and "In the case of a conflict between the requirements of this chapter and the requirements of the Clean Water Act or its implementing regulations, the more stringent requirement controls." Minn. R. 7050.0210, Subp. 6c.

Recent case law confirms that a proposed amendment to alter a water quality standard pertaining to sulfate pollution must conform to Clean Water Act standards. In the case of *El Dorado Chem. Co. (El Dorado) v. U.S. EPA,* 763 F. 3d 950 (8th Cir. 2014), the El Dorado Chemical Company, facing the prospect of limits on sulfate and chloride discharge, filed a petition seeking to modify Arkansas water quality standards to increase maximum permissible discharge concentrations. The state revised its standards, and submitted them to the EPA, which rejected the revision.

The Eighth Circuit upheld the EPA's determination that the weaker standard was not appropriately protective of aquatic life. The Court described the "statutory reality":

> [S]tates do not have unfettered discretion under the CWA. States may establish and revise water quality standards, yet all new and revised water quality standards must be submitted to the EPA. 33 U.S.C. § 1313(c)(2)(A). The EPA has the power to reject a state's proposed water quality standard, and even promulgate its own standards in some circumstances. *Id*. § 1313(c)(3).

El Dorado v. U.S. EPA, *supra*, 763 F. 3d at 956.

EPA review of State water quality standards involves a determination under 40 C.F.R. §131.5(a):

> (1) Whether the State has adopted water uses which are consistent with the requirements of the Clean Water Act;
> (2) Whether the State has adopted criteria that protect the designated water uses;
> (3) Whether the State has followed its legal procedures for revising or adopting standards;

[4] Minn. Stat. §115.03, Subd.1 (b), (c) and §115.44.

(4) Whether the State standards which do not include the uses specified in section 101(a)(2) of the Act are based upon appropriate technical and scientific data and analyses, and;
(5) Whether the State submission meets the requirements included in § 131.6 of this part.

State water quality rules must meet "minimum requirements" under Clean Water Act regulations, 40 C.F.R. §131.6, including the following:

(a) Use designations consistent with the provisions of sections 101(a)(2) and 303(c)(2) of the Act.
(b) Methods used and analyses conducted to support water quality standards revisions.
(c) Water quality criteria sufficient to protect the designated uses.

The State "bears the burden of adducing evidence that the proposed water quality criteria meet the requirements of the CWA." *El Dorado v. U.S. EPA*, *supra*, 763 F. 3d at 959. Designated uses must be "consistent with the requirements" of the Clean Water Act, and water quality criteria must "protect the designated water uses." *Id.* at 953.

Minnesota's wild rice standard limiting sulfates to 10 parts per million (mg/L) and designating the beneficial use to which that sulfate limit applies was adopted by the MPCA as part of formal rulemaking proceedings conducted in 1973. The rule was submitted to and approved by the EPA to comply with the requirements of the 1972 amendments to the Clean Water Act.[5] The MPCA's statutory authority to rescind or revise Minnesota's existing wild rice sulfate limit is constrained by the federal Clean Water Act and its implementing regulations, as well as by Minnesota Statutes.

As the Director of EPA's Region 5 Water Division wrote on behalf of the EPA Administrator in March 2015,

> Minnesota's existing sulfate criterion at 7050.0224, Subp. 2. is approved by the U.S. Environmental Protection Agency and is effective for all purposes under the Clean Water Act until such time as Minnesota adopts and EPA approves revisions. Any revisions to this water quality criterion must be submitted to EPA for review and approval pursuant to 33 U.S.C. § 1313(c)(2)(A) and CW A §303(c)(2)(A). . . If and when Minnesota submits water quality criteria changes to EPA, 40 CFR § 131.6 specifies the requirements for submittal which, at a minimum, include the methods and analyses conducted to support the standards revisions and a description of how the criteria are sufficient to protect the designated use. Federal regulations require that criteria be protective of a state's designated uses, and EPA's approval is based, among other things, on determining that there is scientifically defensible basis for finding that the criteria are sufficient to protect designated uses (see generally 40 CFR §§ 131.5, 131.11, and 131.21). Absent such a showing, EPA would be unable to approve a revised criterion.[6]

[5] *In the Matter of Proposed Amendments to the Regulation for the Establishment of Standards of Quality and Purity for Interstate Waters,* Hearing Testimony Excerpts, Exhibit 4, autop. 3-4.
[6] U.S. EPA (T. Hyde), Letter to P. Maccabee re possible changes to Minnesota's water quality criteria for sulfate to protect wild rice, Mar. 10, 2015, Exhibit 5.

2) MPCA's failure to enforce Minnesota's existing wild rice standard, and the history of industry opposition and legislative interference undermine MPCA's claims that its proposed rule revisions are intended or needed to provide "effective protection" of wild rice or "clarify" its implementation.

When an agency seeks to rescind or revise an existing standard, review of regulatory history can illuminate whether or not a proposed revision would, in fact, improve achievement of the initial policy. The history of a regulation may also shed light on whether the stated mission for revising a regulation is actually the main concern of the agency proposing its revision.

In its Statement of Need and Reasonableness (SONAR), the MPCA suggests that the proposed wild rice quality standard rules are needed to: "revise the existing standard to provide the most effective protection for the wild rice grain from sulfate-related impacts, and clarify implementation of the standard."[7]

However, the record of MPCA's failure to enforce the existing wild rice sulfate standard, the industry lobbying that has opposed *any* implementation of the standard – particularly one that is clear, and the political constraints on the MPCA's ability to enforce the wild rice sulfate standard irrespective of resource protection needs or even existing permits, belies the MPCA's justification for the proposed rule.

Minnesota's existing wild rice sulfate limit of 10 mg/L in waters used for the production of wild rice[8] was adopted based on the recommendation of the Minnesota Department of Natural Resources (DNR) and the finding that "sulfate concentrations above this level are a serious detriment to the growth of wild rice."[9] During the past 44 years since Minnesota's wild rice sulfate standard was adopted, the MPCA has only applied this standard once to limit sulfate pollution.

In 1971, *before* the 1973 wild rice rule was adopted, Minnesota Power's Clay Boswell coal plant had an average annual limit of 8 mg/L of sulfate, with a provision that if sulfate concentrations in May and June exceeded 10 mg/L, "the company shall suspend all discharge" from the pond providing the effluent.[10] In 1975, the MPCA sought to apply the recently-adopted 10 mg/L sulfate standard to discharge from the Clay Boswell coal plant.

Minnesota Power sought a variance, and a contested case was held resulting in a variance imposing a 40 mg/L sulfate limit from late April to mid-June and a 60 mg/L sulfate limit at other times.[11] However, just a few years later, someone at the MPCA negotiated with Minnesota Power to remove the wild rice sulfate concentration limit from its discharge permit without

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[7] MPCA, SONAR, p. 19.
[8] Minn. R. 7050.0224, Subp. 2.
[9] *In the Matter of Proposed Amendments to the Regulation for the Establishment of Standards of Quality and Purity for Interstate Waters*, Findings of Fact, Sept. 6, 1973, Exhibit 6, p. 11, ¶ 22
[10] MPCA, Permit for Construction and Operation of Disposal System, Minnesota Power and Light Co., Oct. 13, 1971, Exhibit 7, p. 3, ¶ 8.
[11] *In the Matter of the Applications for National Pollutant Discharge Elimination System Permits to Discharge from three Steam Electric Generating Plants of Minnesota Power and Light Co., Findings of Fact*, Conclusions and Recommendations, Oct. 28, 1975, Exhibit 8, p. 10, ¶36.

requiring a variance. Internal MPCA documents in 2001 reflect, "Basically, no one knows how this deal was struck without a variance."[12]

From the mid-1970s until 2010, the MPCA did not enforce the wild rice sulfate standard at all. In 2010, as part of the environmental review process for new and expanding mine projects, the EPA wrote letters to the MPCA advising that Minnesota must apply its 10 parts per million wild rice sulfate standard to protect wild rice in downstream waters. In connection with the Keetac taconite mine extension project, the EPA rejected the suggestion in the draft environmental impact statement (EIS) that the "current state rule establishes pollutant standards *to be used as a guide* for determining the suitability of waters for such uses, including the production of wild rice." The EPA wrote that "the current applicable Minnesota water quality standard for sulfate in these waterbodies is 10 mg/L."[13]

The EPA also wrote that the MPCA should apply Minnesota's wild rice sulfate standard to on-site and downstream waters potentially affected by the proposed PolyMet copper-nickel mine:

> The revised/supplemental DEIS should clarify the application of the Minnesota wild rice sulfate water quality standards in Minn. R.Ch. 7050.0220 and 7050.0224, given that the DEIS acknowledges the presence of isolated patches of wild rice in the Upper Partridge River, and describe whether sulfates from the project will impact the St. Louis River. We recommend the revised/supplemental DEIS include the 10 mg/L sulfate number within the tables of lists of applicable standards and predicted water quality (Page 4.1-141) and include a discussion of how it applies to on-site and downstream waters potentially affected.[14]

Since 2010, when the EPA advised Minnesota that its existing 10 mg/L wild rice sulfate limit must be enforced, the mining industry and other industrial dischargers represented by the Minnesota Chamber of Commerce have made a concerted effort to eliminate this water quality standard and prevent its application to control sulfate discharge.

On December 17, 2010, the Minnesota Chamber of Commerce submitted a letter and petition initiating this wild rice sulfate rule revision process in response to the fact that "the MPCA recently has stated its intent to take regulatory action" based on the wild rice sulfate rule, a situation the Chamber described as "untenable."[15] In its petition, the Chamber argued that the MPCA had no authority to regulate discharge to protect "waters where natural beds of wild rice exist" and that current scientific research "suggests sulfate limits of up to 3,000 mg/L are not harmful to wild rice."[16]

On December 18, 2010, on behalf of five named mining companies (Cliffs Natural Resources, United Taconite LLC, PolyMet Corp., Mesabi Mining LLC and United States Steel Corporation) the Minnesota Chamber of Commerce also filed suit in Minnesota state district court to

[12] MPCA (D. White) Emails RE: rice, Feb. 15 - Mar. 30, 2001, p. 1, Exhibit 9.
[13] U.S. EPA (K. Westlake), Comments for the Draft Environmental Impact Statement (EIS) for the U.S. Steel Keetac Taconite Mine Expansion Project, Jan. 27, 2010, Excerpt, p. 7, autop. 5, Exhibit 10.
[14] U.S. EPA (K. Westlake), Comments for the Draft Environmental Impact Statement (EIS) for the NorthMet Project, Feb. 18, 2010, p. 15, autop. 9, Exhibit 11.
[15] MPCA Statement of Need and Reasonableness (SONAR), Ex. S-3b, p. 1.
[16] *Id.*, p. 2.

invalidate and block enforcement of the wild rice sulfate standard. The Minnesota district court upheld the wild rice sulfate standard on its merits and dismissed the Chamber's complaint in its entirety.[17] The Court of Appeals affirmed the dismissal of all counts of the Chamber's complaint, finding a lack of jurisdiction to consider its claims.[18]

In 2011, while the Chamber's lawsuit was pending, mining industry lobbyists requested legislative action to eliminate the wild rice sulfate standard or set a less stringent numeric limit on sulfate. In response to inquiry from legislative authors, the EPA sent a letter stating that a proposed revision to the wild rice sulfate limit would require submittal to EPA under Clean Water Act regulations. The EPA further explained, "Federal regulations require that criteria be protective of a state's designated uses and EPA's approval is based, among other factors, on determining that there is a scientifically defensible basis for finding that the criteria are sufficient to protect designated uses."[19]

The EPA further stated that proposed bills "which generally prevent MPCA from including sulfate limitations in permits until a new standard is developed" would have the effect of preventing the MPCA from applying effluent limits in NPDES permits based on federally approved water quality standards. The EPA explained EPA's authority to disapprove permits or even to withdraw the state's authority to administer the NPDES program in accordance with the requirements of the Clean Water Act.[20]

Legislation adopted in 2011 did not change or eliminate the wild rice sulfate standard outright; it established a study process to consider amending Minnesota rules pertaining to wild rice. The 2011 Session Law authorized monitoring or sulfate minimization in a schedule of compliance, but provided that, to the extent allowable under the Clean Water Act, the MPCA shall "ensure, to the fullest extent possible, that no permittee is required to expend funds for design and implementation of sulfate treatment technologies."[21]

In 2011, the MPCA issued two water pollution discharge permits for U.S. Steel permits with extended schedules of compliance. The Keetac mine expansion permit included a wild rice sulfate limit, but compliance at the mine was delayed for 7 years until August 17, 2018, and compliance at the tailing basin delayed by 8 years, until August 17, 2019.[22]

In 2015, removing the caveat that such avoidance must also be allowable under the Clean Water Act, the Minnesota Legislature passed a law telling the MPCA they could not issue, modify or renew water pollution discharge permits that "require permittees to expend money for design or implementation of sulfate treatment technologies of other forms of sulfate mitigation."[23] A 2016 session law went one step further, providing that the U.S. Steel final sulfate limits set in 2011

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[17] *MCC v. MPCA*, (Minn. Dist. Ct.), *supra*, Exhibit 2.
[18] *MCC v. MPCA*, (Minn. Ct. App.), *supra*. Exhibit 3.
[19] U.S. EPA (T. Hyde), Letter to Sen. Bakk and Rep. Dill, May 13, 2011, pp. 1-2, Exhibit 12.
[20] *Id*., at 2.
[21] Laws of Minnesota, 2011 First Special Session, ch.2, article 4, section 32, SONAR Attachment 1.
[22] MPCA, Letter and Findings of Fact, Conclusions of Law and Order approving issuance of NPDES/SDS Permits MN0031879 and MN0055948 to U. S. Steel Corp. for Keetac mine facility in Keewatin, MN, Nov. 15, 2011, Exhibit 13, autop. 8, 9, 15, 17.
[23] Laws of Minnesota 2015, First Special Session ch. 4, article 4, section 136, SONAR Attachment 1.

resulting from the wild rice water quality standard “are no longer valid,” the compliance schedule permit conditions related to those final limits “are no longer valid.”[24]

Since the Keetac permits were issued in 2011, no permits issued by MPCA have included a limit on sulfates to protect wild rice.

Despite a Joint Priority Agreement with the EPA to eliminate the MPCA’s backlog of NPDES[25] mining discharge permits, the MPCA has failed to update water pollution permits that have been out-of-date for decades; failed to set permit conditions requiring compliance with water quality standards, including Minnesota’s wild rice sulfate limit; and failed to penalize permit violations. As a result, in July 2015, WaterLegacy filed a petition with the EPA for Withdrawal of Program Delegation from the State of Minnesota for NPDES Permits Related to Mining Facilities.[26]

In response to WaterLegacy’s Petition for Minnesota NPDES Program Withdrawal, the EPA adopted a detailed Protocol for Responding to Issues Related to Permitting and Enforcement.[27] EPA also asked for a statement, in light of Minnesota wild rice sulfate standard Session Laws enacted in 2015 and 2016, “whether the current scope of MPCA’s authority remains adequate to issue permits in compliance with all applicable CWA requirements, including whether MPCA continues to have adequate authority to implement all of its federally approved water quality standards consistent with CWA Section 301(b)(1)(C).”[28] EPA’s investigation of WaterLegacy’s Petition for Program Withdrawal is ongoing.

Internal MPCA documents reflect the Agency’s understanding of its obligation under the Clean Water Act; “Minnesota is required to enforce the state assembled and federally approved water standards, including the wild rice sulfate standard.”[29] The MPCA has also recognized, “The CWA requires us to designate beneficial uses. It does not require us to ‘designate’ or name all of the specific water bodies protected for that use,” and that the standard could be applied case-by-case “using available site-specific information” about wild rice and sulfate.[30]

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[24] Laws of Minnesota 2016, Chapter 165, Section 1, Exhibit 14.
[25] National Pollution Discharge Elimination System (NPDES) permits control water pollution from point sources under Clean Water Act delegated authority.
[26] WaterLegacy Petition for Withdrawal of Program Delegation from the State of Minnesota for NPDES Permits Related to Mining Facilities (Petition for Withdrawal of Authority), Exhibit 15 and WaterLegacy Exhibits to Petition for Withdrawal of NPDES Authority, July 2, 2015, Exhibit 16. As of Nov. 21, 2017, materials related to this Petition are available on the EPA website at https://www.epa.gov/mn/npdes-petition-program-withdrawal-minnesota.
[27] U.S. EPA, Final Protocol for Responding to Issues Related to Permitting and Enforcement presented in the WaterLegacy Petition for Withdrawal of Program Delegation from the State of Minnesota for NPDES Permits Related to Mining Facilities, Mar. 8, 2016, Exhibit 17.
[28] U.S. EPA (T. Hyde), Letter to MPCA re MPCA Legal Authority to Implement its Authorized NPDES Program While Working Under Laws of Minnesota 2015, 1" Spec. Sess. Chapter 4, Article 4, Section 136, April 5, 2016, Exhibit 18. *See also* U.S. EPA (T. Hyde), Letter to MPCA re MPCA's Legal Authority to Implement its Authorized NPDES Program While Working Under Laws of Minnesota 2016, Chapter 165, Section 1, June 28, 2016, Exhibit 19.
[29] MPCA, MPCA Wild Rice Sulfate Standard (updated 1/28/13), Confidential Jan. 28, 2103, Exhibit 20A.
[30] Email MPCA (K. Kessler) re Talking points in response to wild rice standard questions, Feb. 3, 2013, Exhibit 20B; *see also* MPCA, Wild Rice Sulfate Standard and Impaired Waters Listing, Nov. 4, 2013, Exhibit 20C.

The sordid history of Minnesota's failure to implement the wild rice sulfate standard despite years of prodding by the EPA and the MPCA's clear recognition of its responsibilities reveals the political power dynamics behind this rulemaking. This history also contradicts the MPCA's assertions that the proposed rule is needed either for "effective protection" of wild rice from sulfate impacts or to "clarify" its implementation.

Since political interference has prevented effective enforcement of the existing rule, there is no evidence from which a fact-finder could determine that a change in the rule language, rather than a change in political pressure is needed in order to better protect wild rice. Industry opposition and legislative interference, not the text of a simple fixed water quality standard, have impeded "effective protection" of wild rice from sulfate and sulfide toxicity.

Second, there is no evidence that any lack of clarity in the existing rule has interfered with implementation of sulfate limits. In the Minnesota Power Clay Boswell permit action, an orderly hearing resulted in a variance and no judicial review was sought. In 2010, the EPA clearly explained to the MPCA how Minnesota's existing wild rice sulfate standard should be applied to protect downstream wild rice waters in permits for the Keetac mine expansion and the PolyMet proposed mine. U.S. Steel did not appeal the Keetac permits. A Minnesota district court found that Minnesota's existing wild rice sulfate rule was not void for vagueness[31] and the Court of Appeals held that scrutiny of the MPCA's implementation of the wild rice sulfate standard was premature and hypothetical unless and until the agency sought to enforce the rule and a company sought recourse through the administrative process.[32]

The regulatory history also illuminates the mission behind the petition for rulemaking. The Minnesota Chamber of Commerce, on behalf of itself and mining industry members, sought through litigation as well as through this rulemaking process to eliminate sulfate limits on natural stands of wild rice in order to avoid the costs of pollution control. Industrial dischargers have continued to advocate for removing the existing standard without replacing it or for weakening the standard by at least two orders of magnitude.[33] The politicians who hold the Agency's purse strings sought to delay and impede imposition of limits on sulfate discharge, particularly sulfate discharge from mining companies.

The next section of this discussion further illuminates the effects of political pressure on the development of this rulemaking process.

3) MPCA's proposal to rescind Minnesota's existing water quality standard limiting sulfate to 10 milligrams per liter (mg/L) in wild rice waters is neither needed nor reasonable and is inconsistent with protecting the designated use of waters for wild rice under the Clean Water Act. (p. 11)

As previously discussed, Minnesota's water quality standard limiting sulfate to 10 mg/L in water used for the production of wild rice was adopted in 1973 to protect the use of waters to support the growth of wild rice. Under Clean Water Act regulations, this standard may not be rescinded

[31] *MCC v. MPCA*, (Minn. Dist. Ct.), *supra*, Exhibit 2, slip op. 17.
[32] *MCC v. MPCA*, (Minn. Ct. App.), *supra*. Exhibit 3.
[33] Hearing testimony before Administrative Law Judge in St. Paul, Oct. 23, 2017.

unless the MPCA can meet its burden of proof to show that wild rice will be protected despite the removal of this standard.

The Clean Water Act supports a presumption in favor of retaining an existing water quality standard that has been duly enacted and approved by the EPA. EPA need not review a state's denial of a petition for rulemaking, *National Wildlife Fed'n v. Browner*, 127 F. 3d 1126 (D.C. Cir. 1997), but EPA has a non-discretionary duty to review a state's proposal to change a state's water quality standard, *El Dorado v. U.S. EPA, supra*, 763 F. 3d at 956.

Dr. David Schimpf, an emeritus associate professor of biology at the University of Minnesota appointed by the MPCA to serve as an external technical advisor, explained in his comments on the MPCA's draft rule proposal, "I believe that a new standard is not the default position, but that the existing standard is the default position."[34]

When the National Highway Traffic Safety Administration sought to rescind automobile safety standards requiring passive restraints, the Supreme Court found that the "first and most obvious reason for finding the rescission arbitrary and capricious" was that agency apparently gave no consideration to making the standard more effective. *Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co*., *supra*, 463 U.S. at 46. For nearly a decade the industry had "waged the regulatory equivalent of war," but industry's decision to use a seatbelt technology that would not meet the standard's objectives "hardly constitutes cause to revoke the Standard itself." *Id.*, at 49.

MPCA's initial findings and recommendations proposed retaining Minnesota's 10 mg/L wild rice sulfate standard, and considering potential site-specific sulfate standards as needed. However, that strategy was abruptly abandoned in February 2014. Neither MPCA's SONAR nor its Technical Support Document (TSD) evaluate how wild rice could be most effectively protected by enforcing the existing wild rice standard and delimiting the rare cases where a site-specific standard would be needed and appropriate to protect wild rice.

During the years when hydroponic, mesocosm and field survey research was being done under MPCA auspices, WaterLegacy anticipated that the MPCA would preserve the existing standard if it was needed and reasonable to protect wild rice. We first realized that something had gone awry when the planned February 27, 2014 release of the MPCA's preliminary findings to the Wild Rice Standards Study Advisory Committee[35] and to the press[36] was abruptly cancelled.[37]

The first explanation for the aborted briefing was provided in a *Star Tribune* investigative news story more than a month later. That story asserted that the wild rice initiative was halted by a rebellion of Iron Range politicians who had taken their concerns to the Governor.[38]

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[34] D. Schimpf, Comments on MPCA draft proposed approach for Minnesota's sulfate standard to protect wild rice (March 24, 2015), submitted Dec. 14, 2015, p. 1, Exhibit 21.
[35] MPCA (P. Engelking) Email re MPCA release of preliminary recommendations and response to advisory e-mail, Feb. 25, 2014, Exhibit 22.
[36] MPCA (A. Foss) Email re DNT-Minnesota sulfate limit expected Thursday, Feb. 26, 2014, Exhibit 23
[37] MPCA (P. Engelking) Email re MPCA release of preliminary recommendations and response to advisory e-mail, Feb. 26, 2014, Exhibit 24.
[38] J. Marcotty, Iron Range rebellion halted wild rice initiative, *Star Tribune*, Apr. 6, 2014, Exhibit 25.

WaterLegacy secured MPCA internal documents through a Minnesota's Data Practices Act request; these documents revealed that politics had trumped science.

The Findings and Preliminary Recommendations drafted by MPCA's scientists in February 2014 had proposed preserving Minnesota's wild rice sulfate standard, stating, "The 10 mg/L sulfate standard is needed and reasonable to protect wild rice production from sulfate-driven sulfide toxicity."[39] These Findings and Recommendations are reprinted below:

> **Findings and Preliminary Recommendations Regarding the Wild Rice Sulfate Standard**
>
> Key Findings:
>
> 1. **Sulfate is not directly toxic to wild rice**. Both the MPCA Study and the research commissioned by the Minnesota Chamber of Commerce support this conclusion. However, sulfate in the surface water can be converted by bacteria to sulfide in the rooting zone of wild rice (see Figure 1).
> 2. **Sulfide is toxic to wild rice.** The MPCA Study demonstrated that elevated sulfide concentrations were toxic to wild rice seedlings. Hydroponic experiment data showed deleterious effects of sulfide on seedling plant growth when sulfide exceeded the range of 150 to 300 µg/L.
> 3. **Sulfide in the sediment is affected by the amount of sulfate in the water column, and the amount of iron in the sediment**. Data from a majority of the field sampling sites show that the range of 150 to 300 µg/L sulfide in the sediment relates to a water column concentration of sulfate between 4.3 and 16.2 mg/L. This range illustrates that conditions at some of the field sites are more effective than others at converting sulfate to sulfide, in part due to the availability of iron in the sediment (see Figure 1).
>
> Preliminary Conclusions and Recommendations:
>
> 1. **The 10 mg/L sulfate standard is needed and reasonable to protect wild rice production from sulfate-driven sulfide toxicity.** The MPCA will also consider including a sediment sulfide concentration as a component of this water quality standard, in the range of 150 to 300 µg/L sulfide.
> 2. **The 10 mg/L wild rice sulfate standard should continue to apply to both lakes and streams**. Analysis of the field data does not support placing lakes and streams into separate subclasses. Iron availability, not water body type, appears to be a key controlling factor in the concentration of sulfide.
> 3. **Site-specific standards are expected for some waters**. Considerable data suggest that in some cases the development of a site-specific standard would be protective of wild rice production. This is most likely to occur in waters where the sediment iron is elevated and therefore a higher sulfate water column concentration may not result in a sulfide sediment concentration above 150 to 300 µg/L. There are also data to suggest that a site-specific standard lower than 10 mg/L may be needed for waters where sulfate is more efficiently converted to sulfide
> 4. **MPCA will continue to explore if the sulfate standard is needed to protect paddy-grown wild rice production.** The Study data do not suggest that paddy-grown wild rice is less susceptible to impacts from elevated sulfide. However, the land- and water-management

[39] MPCA, Wild Rice Sulfate Standard - Summary of Findings and Preliminary Recommendations Legislative Briefing Document, February, 2014, Exhibit 26.

activities associated with paddy wild rice production likely reduce the potential for sulfide production in the sediment

5. **MPCA does not currently have a recommendation regarding the "period of susceptibility" of wild rice to sulfate effects, but will continue to analyze data to further explore this question.** The sediment incubation experiment data show that sulfate can be converted to sulfide in both warm and cold conditions, and that sediment sulfide concentrations decrease once sulfate concentrations in the overlying water decrease. This is a complex interaction and more data analysis is needed before recommendations can be developed about this important question; any recommendation may also need to consider site-specific factors that affect this question
6. **Consideration should be given to changing the use class of the wild rice sulfate standard:** The MPCA is considering moving the wild rice sulfate standard from Class 4 where it currently resides to Class 2 and creating a new subclass to clarify that the wild rice sulfate standard is designed to protect the growth of wild rice grains for consumption by humans and wildlife. The MPCA is also considering revising the term "water used for production of wild rice." The MPCA has received comments asserting this wording is not the best descriptor for natural stands of wild rice that provide benefits to humans and wildlife.

MPCA internal emails reveal that MPCA presented these findings and recommendations to a group of Iron Range legislators prior to their planned release.[40] On February 26, the day before the Findings were set for release, the Governor's staff wrote, "This is a big deal and it is blowing up this morning." MPCA's Commissioner was directed to meet/talk with the Governor and with Iron Range Resources and Rehabilitation Board Commissioner Tony Sertich.[41] Commissioner Stine responded to the Governor's office, "Agree - the meeting with range legislators went poorly." He then spoke with MPCA staff.[42]

Later that evening, the MPCA communicated to legislators, the wild rice researchers, and the tribes that the MPCA "thought we would be ready to release preliminary findings on the wild rice sulfate standard on Thursday, but we are not."[43]

Internal memos confirm that the MPCA's media release "current up to when the plug got pulled" would have supported the 10 mg/L sulfate standard. The record suggests that but for the reaction of Iron Range politicians, the MPCA would have advised the public, "The existing sulfate water quality standard of 10 milligrams per liter is reasonable and should remain in effect . . . The existing sulfate standard should continue to apply to both lakes and streams."[44] Until February 26, 2017, when intense political pressure was brought to bear, the MPCA had concluded that preserving Minnesota's existing sulfate water quality was needed and reasonable to protect wild rice.

[40] MPCA (K. Koudelka) Emails re MPCA Legislative Briefing on Wild Rice Sulfate Study, Feb. 21 and Feb. 25, 2014, Exhibit 27.
[41] MPCA (Commissioner Stine) and Governor's Staff (J. Tincher) Emails re Sulfate Standard, Feb. 26, 2014, Exhibit 28.
[42] *Id*.
[43] MPCA (K. Koudelka) Email re Postpone Legislative Briefing on Wild Rice Study, Feb. 26, 2014, Exhibit 29; MPCA (S. Lotthammer) Emails re Postpone release of preliminary findings on wild rice sulfate standard, Feb. 26, 2104, Exhibit 30.
[44] MPCA (R. Pribble) Email Wild rice preliminary finding, Mar. 3, 2014 and attached draft media release for Feb. 27, 2014, Exhibit 31.

Three additional government agencies have recently determined that a fixed sulfate limit of 10 mg/L is needed to protect wild rice. The Fond du Lac Band of Lake Superior Chippewa, a tribal government with authority under the Clean Water Act[45] to set water quality standards on the Band's reservation, has enacted a wild rice sulfate standard of 10 mg/L applicable to any lake or stream which supports wild rice growth.[46] The Grand Portage Band of Lake Superior Chippewa, a tribal government which also has authority under the Clean Water Act to set water quality standards on the Band's reservation, has enacted a 10 mg/L limit on sulfates in wild rice habitat.[47] The EPA reviewed and approved Fond du Lac's water quality standards in 2001,[48] and Grand Portage's water quality standards in 2005.[49] EPA approval of tribal water quality standards under the Clean Water Act is identical to approval of state water quality standards. Tribal water quality standards must designate uses of water consistent with the Clean Water Act, demonstrate the methods and analyses used to support water quality standards, and set water quality criteria sufficient to protect the designated uses of the waters.[50]

In addition, across Minnesota, every Chippewa/Ojibwe and Dakota tribal government - each of which represents a community committed to the effective protection of wild rice – has concluded that Minnesota's existing fixed sulfate limit of 10 mg/L should be maintained to protect wild rice. The six Bands of the Minnesota Chippewa Tribe in a March 2017 letter to Commissioner Stine and the eleven independent sovereign Ojibwe and Dakota nations of the Minnesota Indian Affairs Council in a May 2017 letter to the Commissioner, both recommended that the MPCA:

> Maintain the existing, simple-to-implement sulfate criterion that has been demonstrated to be protective of the water quality necessary to support wild rice, with rare exceptions afforded the option to demonstrate a site-specific standard that is protective of wild rice in that waterbody.[51]

MPCA's scientific Peer Review Panel did not have an opportunity to review whether Minnesota's Wild Rice Sulfate Standard Study[52] supported Minnesota's existing 10 mg/L wild rice sulfate standard. Although WaterLegacy requested that the charge questions to the Panel provide "sufficient latitude to provide independent analysis" without assuming the validity of the Agency's "iron mitigation" and sulfide prediction hypothesis,[53] the MPCA's charge to the Panel

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[45] Treatment as a state authority under the Clean Water Act is provided in 33 U.S.C. §1377(e).
[46] Fond du Lac Band of Lake Superior Chippewa Water Quality Standards, ord. #12/98 as amended 2001, Section 301 (m), contained in SONAR Ex. 46.
[47] Grand Portage Reservation Water Quality Standards, XI General Standards 10, adopted 2005 revised 2006, contained in SONAR Ex. 45.
[48] EPA, Water Quality Standards Regulations: Fond du Lac Band of the Minnesota Chippewa Tribe https://www.epa.gov/wqs-tech/water-quality-standards-regulations-fond-du-lac-band-minnesota-chippewa-tribe
[49] EPA, Water Quality Standards Regulations: Grand Portage Band of the Minnesota Chippewa Tribe https://www.epa.gov/wqs-tech/water-quality-standards-regulations-grand-portage-band-minnesota-chippewa-tribe
[50] 33 U.S.C. §§ 1251(a)(2), 1313(c)(2)(A); 40 C.F.R. 131.6 (a)-(c).
[51] Minnesota Chippewa Tribe letter to MPCA Commissioner Stine, Mar. 15, 2017. Exhibit 32; Minnesota Indian Affairs Council letter to MPCA Commissioner Stine, May 25, 2017, Exhibit 33.
[52] Studies funded by Minn. Laws 2011, 1 Sp. c.2, art. 4, § 32(a), SONAR Attachment 1.
[53] WaterLegacy, Comments and Proposed Charge Questions for Peer Review of the Wild Rice Sulfate Standard Studies, July 8, 2014, Exhibit 34.

focused on its hypothesis and excluded review of whether the studies supported the existing sulfate limit or some change to that standard.[54]

John Pastor is a Professor of Biology at the University of Minnesota Duluth, past Co-Chair of the Natural History Section of the Ecological Society of America, and an Honorary Member of the Faculty of Forest Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden. He received his Ph.D. in Forestry and Soil Science in 1980 from the University of Wisconsin-Madison and has authored two books on ecology, over 100 peer-reviewed papers, and over 20 book chapters.

For the past ten years, Dr. Pastor's research has focused on the ecology of wild rice, including the effects of sulfate pollution and iron on wild rice. This work has been funded by the National Science Foundation, MPCA, the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa, and Minnesota Sea Grant. Dr. Pastor was the lead researcher for the hydroponic experiments and tank mesocosm studies of sulfate and wild rice coordinated by the MPCA in the Wild Rice Sulfate Standard Study funded by the Minnesota Legislature. His mesocosm studies of wild rice and sulfates began several years before the MPCA study and have continued through 2017.[55]

During the past six years, Dr. Pastor has read numerous MPCA draft proposals, internal memos, peer review materials, submitted and published articles and comments of various entities and experts. He has also reviewed the MPCA's Statement of Need and Reasonableness (SONAR) and Technical Support Document (TSD) in connection with this proposed rulemaking. Dr. Pastor has reviewed Minnesota's Wild Rice Sulfate Standard Study to evaluate whether the various components of this research support retaining the existing standard or adopting the equation proposed by the MPCA.[56]

Dr. Pastor's Technical Review Comments on the MPCA's proposed rule explain his mesocosm research where wild rice was grown in tanks under conditions similar to those in a natural environment. In these experiments, loading surface water with sulfate increased the level of sulfide production in sediments. Seedling emergence, seedling survival, vegetative growth and seed production all declined in proportion to the amount of sulfate added and the amount of sulfide produced. In each spring after the initial planting in 2011, the number of seedlings that emerged from the sediment declined significantly with increased sulfate concentrations ($p < 0.001$). The rate of seedling survival also declined significantly with increased sulfate concentrations ($p < 0.001$) and became worse in each subsequent year ($p < 0.001$). The rate of decline in seedling survival with amended sulfate was twice as high in 2014 and 2015 than in 2012 and 2013 (Pastor *et al*. 2017).[57]

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[54] MPCA Charge for Peer Review (June 2014), SONAR Ex. 7.
[55] John Pastor, Ph.D., Technical Review Comments on MPCA's Proposed Flexible Standard for Sulfate in Wild Rice Beds, Nov. 2017 (Pastor Technical Review 2017), p. 1, submitted herein with Attachments A through F.
[56] *Id*.
[57] *Id.*, p. 3 citing John Pastor *et al.*, Effects of sulfate and sulfide on the life cycle of Zizania palustris in hydroponic and mesocosm experiments, Ecological Applications, 27(1), 2017, Attachment B to Pastor Technical Review 2017.

Elevated sulfate concentrations decreased vegetative growth, measured as plant biomass ($p < 0.001$), and the rate of decline increased significantly during the course of the experiment. Although the overall number of seeds produced per plant did not change across sulfate concentrations, the proportion of seeds produced that were filled and thus able to propagate declined significantly with increasing sulfate concentrations ($p < 0.001$). The proportion of filled seeds declined more steeply with each successive year ($p < 0.001$) (Pastor *et al.* 2017).[58]

These declines in seed production and seedling survival led to the extinction of wild rice populations after 5 years at sulfate concentrations comparable to drinking water standards (Pastor *et al*. 2017). Populations of wild rice exposed to sulfate concentrations of 150 mg/L have continued to decline over the course of the mesocosm experiments, nearing the point of extinction (Progress Report 2017).[59]

In Dr. Pastor's Technical Review, he explained that even though the MPCA field survey was designed to study sites with wild rice present despite high sulfate levels, 70% of wild rice was found in sulfate concentrations of 10 mg/L or less and 94% of the wild rice water bodies had sulfate concentrations of 50 mg/L or less.[60] Dr. Pastor cited John Moyle's research finding "No large stands of rice occur in water having sulfate content greater than 10 ppm [parts per million, or mg/L], and rice generally is absent from water with more than 50 ppm" (Moyle 1944)[61] and noted that the field survey findings corroborate Dr. Moyle's conclusions supporting a sulfate limit of 10 mg/L to protect wild rice. "Sulfate limits set for individual water bodies above the current standard of 10 mg/L incur increased risk to the sustainability of wild rice populations."[62]

Dr. Pastor concluded,

> The Wild Rice Sulfate Standard Study wild rice research funded by the Minnesota Legislature and coordinated by the MPCA has made important contributions to our understanding of the process of sulfide-induced toxicity resulting from sulfate concentrations in surface waters in the presence of iron and other factors. However, based on my training and experience, it is my opinion that the weight of the scientific evidence supports retaining Minnesota's existing sulfate standard of 10 mg/L to protect wild rice. As sulfate concentrations rise above the current standard, the risk to sustainable wild rice populations increases because of increased sulfide production.[63]

Although Dr. Moyle's initial findings were published in 1944, it should be noted that Dr. Moyle's field research through the mid-1970s confirmed his view that, in Minnesota, "There are no large stands in waters in which the concentration of the sulfate ion exceeds 10 parts per million."[64] In 1975, Dr. Moyle restated his opinion that the upper limit for self-perpetuating wild

[58] *Id.*
[59] *Id., citing* John Pastor, Progress Report on Experiments on Effects of Sulfate and Sulfide on Wild Rice, June 28, 2017, Attachment E to Pastor Technical Review 2017.
[60] *Id*., p. 7
[61] *Id*., p. 2.
[62] *Id*., p. 7.
[63] *Id*., p. 8
[64] J. Moyle, Wild Rice – Some Notes, Comments and Problems, Minn. Department of Conservation, Spec. Pub. No. 47, Sept. 2, 1975, Exhibit 35.

rice stands in Minnesota is about 40 ppm, with most self-perpetuating stands below 10 ppm.[65] Dr. Moyle's writings suggest that his sampling data base included more than 1,500 field samples of hundreds of bodies of water.[66]

The MPCA cannot meet its burden of proof to demonstrate that rescinding Minnesota's existing wild rice sulfate standard is needed or reasonable to effectively protect wild rice. There is not only a presumption, but overwhelming evidence that the policy to protect the beneficial use of waters for wild rice reflected in the adoption and EPA approval of Minnesota's wild rice sulfate standard in 1973 would be carried out best by preserving and enforcing the existing rule limiting sulfate to 10 mg/L to protect wild rice.

Changes to MPCA Proposed Rule Sections

The following sections of the MPCA's proposed rule must be rejected as unnecessary, unreasonable and inconsistent with Clean Water Act requirements:

> Proposed deletion of **Minn. R. 7050.0220, Subparts 3a (31)** (lines 3.15 to 3.16), **4a (31)** (lines 4.10 to 4.11), **5a (19)** (lines 5.7 to 5.8), **6a (14)** (lines 5.22 to 5.23) removing existing limit for sulfates of 10 mg/L where "wild rice present."
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> Proposed deletion of **Minn. R. 7050.0224, Subp. 2** (line 7.8 to 7.19) rescinding fixed wild rice sulfate standard by removing the words "Sulfates (SO_4) 10 mg/L, applicable to water used for the production of wild rice." WaterLegacy does not object to deletion of the phrase "during periods when the rice may be susceptible to damage by high sulfate levels" (lines 7.9 to 7.10) and would recommend replacing the term "water used for production of wild rice" (lines 7.8 to 7.9) with the phrase "wild rice waters," defined as recommended in section 5 of these comments.

4) MPCA's proposal to adopt an equation that would calculate sulfate limits for each water body based on the flawed assumption that sediment iron protects wild rice from the harmful effects of sulfate conversion to sulfide would neither provide effective protection of wild rice nor clarify implementation, is neither needed nor reasonable, and is inconsistent with the requirements of the federal Clean Water Act.

The MPCA has stated that its proposed sulfate equation should be tested according to whether it would provide effective protection of wild rice and clarify implementation.[67] Under applicable law, the rule must be measured against its stated purpose.[68] In addition, the Clean Water Act

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[65] J. Moyle, Review of Relationship of Wild Rice to Sulfate Concentration of Waters, Mar. 16, 1975, Exhibit 36.
[66] *Id*. (reference to 283 lakes); *see also* J. Moyle, Relationships between the chemistry of Minnesota surface waters and wildlife management, *J. Wildlife Mgt*., Vol. 20, No. 3, July 1956 (reference to 1,546 water analyses), Exhibit 37.
[67] MPCA, SONAR, p. 19.
[68] *Bowen v. American Hospital A*ss'n, *supra*, 476 U.S. at 643, "For the principle of agency accountability recited earlier means that, 'an agency's action must be upheld, if at all, on the basis articulated by the agency itself," citing *Motor Vehicle Mfrs. Assn*. v. *State Farm Mut. Automobile Ins. Co*., *supra*, 463 U.S. at 50.

requires that new or revised water quality standards "protect the public health or welfare, enhance the quality of water and serve the purposes of this Act,"[69] and its implementing regulations require that water quality standards must protect the designated use and be based on appropriate technical and scientific data and analyses.[70]

The MPCA's proposed equation to identify sulfate limits water body by water body fails all of these tests. The MPCA's assumption that iron protects wild rice from the harmful effects of sulfate loading is premature and inconsistent with both laboratory experiments and field experience. The statistical analysis used to calculate what the MPCA has suggested would be "protective" levels of sulfate is flawed and raises at least as many questions as it answers. The MPCA's proposed equation and the sulfate levels deemed to be "protective" by the MPCA's formula haven't historically sustained wild rice and would not adequately protect wild rice. The effects of the MPCA's proposed equation allowing elevated sulfate where sediment iron is high are particularly troubling as applied to impacted waters downstream of mining discharge.

Within weeks after the "plug got pulled" on the MPCA's February 2014 Findings and Preliminary Recommendations, the MPCA floated a new "Preliminary Analysis" that proposed "sediment porewater sulfide can be predicted from sulfate and iron."[71] In June 2014, the MPCA took this proposal a step further, stating that the MPCA could protect wild rice from elevated sulfide using multiple quantile regression statistics to relate sulfate and iron to sulfide in porewater.[72] The MPCA's June 2014 Analysis of the Wild Rice Sulfate Study was submitted to the Peer Review Panel for scientific review.

The Peer Review Panel did not endorse using the MPCA's equation synthesis to predict sulfide levels or to protect wild rice from toxicity. The Peer Review Panel Summary Report[73] stated,

> Although the conceptual model described in the Synthesis is qualitatively correct, the current Synthesis goes too far in implying that sulfide concentrations in sediment can be predicted accurately by the multiple quantile regression model based on sulfate concentrations in the overlying water and acid-extractable iron in sediments. (*Summary Report*, p. 9)
>
> The conceptual model seems qualitatively correct, but it presents an overly optimistic impression about our ability to predict whether toxic sulfide levels will occur in a given wild rice stand from the sulfate concentrations in surface water and acid-extractable iron in sediment. (*Summary Report*, p. 33)

The Panel specifically expressed concern that the MPCA's proposal to create a regulatory standard was premature, since there had been no experiments to evaluate whether iron would mitigate the ecological effects on wild rice of elevated sulfates:

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69 33 U.S.C. §1313(c)(2)(A); 40 C.F.R. §131.3(b).

70 40 C.F.R. §§131.5, 131.6, 131.11. *See also* EPA, Water Quality Standards Handbook (1994 as updated), https://www.epa.gov/wqs-tech/water-quality-standards-handbook, Chapter 3, Water Quality Criteria (EPA 823 B 17 001 2017), pp. 1-2.

71 MPCA, Wild Rice Sulfate Study Preliminary Analysis (March 2014), SONAR Ex. 5, p. 13.

72 MPCA, Analysis of the Wild Rice Sulfate Standard Study: Draft for Scientific Peer Review (June 9, 2014), SONAR Ex. 6, pp. 45-47.

73 The full report is provided in Eastern Research Group Summary Report of the Meeting to Peer Review MPCA's Draft Analysis of the Wild Rice Sulfate Standard Study, Sept. 25, 2014, SONAR Ex. 9. Excerpts from this report are provided in Exhibit 38 to these comments.

> It would be useful to have an experiment that examines whether iron would mitigate the ecological effects on wild rice of added sulfide levels. Additionally, current models do not account for the effects from oxygenated rhizospheres and iron plaques on root systems. MPCA needs to understand the mechanism of toxicity better before claiming to understand how iron mitigates sulfide stress. A reviewer responded that there is a substantial amount of literature about interactions between sulfate, sulfide, and iron. Another reviewer noted that these studies are on perennials, and wetland annuals have not been studied in any detail. For a regulatory standard it would be inappropriate to extrapolate from other species. (*Summary Report*, p. 28)

Gertie H.P. Arts, PhD, a senior ecologist with expertise in macrophyte (plants large enough to be seen by the unassisted eye) aquatic ecology and ecotoxicology,[74] served as a member of the scientific review panel. Dr. Arts emphasized in her post-meeting comments that the MPCA's hypotheses needed to be tested in an experimental setting, e.g. in mesocosms.

> As the analysis of the field data survey is based on correlations, those correlations can be used for hypothesis generation. Subsequently, causal relationships need to be tested experimentally. (Appendix F, *Reviewer Post-Meeting Comments* p. F-5)
>
> In general, I support the synthesis performed by MPCA. Appropriate study components have been chosen. However, as stated before, I suggest to use the field study for hypothesis generation. These hypotheses can be tested in an experimental setting, e.g., in mesocosms. (Appendix F, *Reviewer Post-Meeting Comments* p. F-9)

Dr. John Pastor, at the University of Minnesota in Duluth (UMD), began precisely this type of mesocosm experiment during the next growing system. He and a colleague, Nate Johnson, Ph.D., also supervised a student, Sophia LaFond-Hudson, who studied the effects of iron and sulfate amendment on the various stages of wild rice growth and development in 40 experimental buckets. As explained in Dr. Pastor's Technical Review and attachments, this experimental research performed at the University of Minnesota since 2015 has substantially undermined the MPCA's assumption that precipitation of sulfide in the presence of iron helps to protect wild rice.[75]

In the course of Dr. Pastor's initial mesocosm experiments, he noticed that wild rice roots in tanks with more than 50 mg/L sulfate had become blackened. In contrast, plants grown in the low sulfate treatments had orange stains on the roots throughout the annual life cycle. Using scanning electron microscope elemental scans, UMD research identified the black plaques as iron sulfide (FeS) plaques, whereas the oranges stains had iron but no sulfide and were probably iron (hydr)oxides. The orange healthy roots on the left are from wild rice grown under low

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[74] Curriculum vitae of Gertie H.P. Arts attached as Exhibit 39 is available online at https://www.slideshare.net/GertieHPArts/cv-gertie-arts-november-2015.

[75] Pastor Technical Review 2017, *supra*, pp. 3-5. Additional discussion of the UMD iron and sulfide research is contained in Attachments as follows: J. Pastor, Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palustris*), slide presentation to MPCA Wild Rice Standards Study Advisory Committee, Aug. 18, 2016 (Attach. C); J. Pastor, The Biogeochemical Habitat of Wild Rice, Sea Grant Research Annual Report, May 5, 2016 (Attach. D); J. Pastor, Progress Report on Effects of Sulfate and Sulfide on Wild Rice, June 28, 2017 (Attach. E); S. LaFond-Hudson, Iron and Sulfur Cycling in the Rhizosphere of Wild Rice (*Zizania palu*stris), May 2016 (Attach. F).

sulfate concentrations, at or near the current standard, and the black iron sulfide coatings on the right are on roots of plants grown with high sulfate concentrations.[76]

Dr. Pastor explains that the UMD research showed that seed nitrogen, seed count and seed weight were all markedly reduced in plants with high sulfate (300 mg/L) and black root surfaces, because the black iron sulfide precipitates inhibited the uptake of nutrients necessary for the filling and ripening of seeds necessary for propagation of wild rice. The amount of black iron sulfide on the roots of the plants and the effect on reduced seed production were proportionate to the concentration of sulfate in the experiments.[77]

Dr. Pastor's mesocosm experiments tripled the amount of sediment iron in the first growing season and removed litter to reduce carbon supply for microbes under high sulfate conditions. During the three years of this experiment, sulfate reduced seedling survival, plant growth, and seed production, regardless of iron amendment and litter removal. In mesocosms without added sulfate, neither litter removal nor added iron affected wild rice. When sulfate levels were increased, adding iron temporarily ameliorated the effects of increased sulfate on seedling survival compared with seedlings grown only with sulfate loading. However seedling survival in the tanks with both iron and sulfate additions was still less than in control tanks, particularly over time.[78]

In addition, precipitation of iron sulfide plaques on roots during the flowering and seed production period of wild rice's life cycle resulted in fewer and smaller seeds with reduced nitrogen content. The effect of sulfate additions in mesocosms, including those where iron was

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[76] Pastor Technical Review 2017, *supra*, pp. 3-4.
[77] *Id*., p. 4. The iron and sulfate experiments are detailed in Attachments C (Pastor Slide Presentation 2016), D (Pastor Sea Grant Annual Report 2016), E (Pastor Progress Report 2017) and F (LaFond Hudson Thesis 2016) to the Pastor Technical Review.
[78] *Id*., pp. 4-5. *See also* Attachment E (Pastor Progress Report 2017).

added, was to drive the populations to extinction within 4 or 5 years in concentrations of 300 mg/L and to greatly reduce population viability at lower concentrations.[79]

Based on this experimental research, Dr. Pastor summarized, "Setting sulfate limits based on the level of porewater iron is premature and is not reasonable."[80] He explained,

> How and whether iron mitigates sulfide toxicity to wild rice is not fully understood and appears not to be related to the amount of reactive iron in sediments in the simple way assumed by MPCA's model. Therefore, setting sulfate standards based on the amount of reactive iron in sediments is premature at best. Based on current scientific evidence, an equation determining "protective" sulfate levels based on iron in sediments and available carbon is not a defensible strategy to protect wild rice.[81]

MPCA first learned of the UMD experimental research to test the iron mitigation hypothesis in the summer of 2016. MPCA's lead scientist for this rulemaking, Ed Swain, Ph.D., reviewed Sophia LaFond-Hudson's thesis on wild rice, iron and sulfur,[82] stating in June 2016, "Sophie's thesis (which read like a paper ready to submit) is very impressive."[83] In August 2016, Dr. Pastor presented his iron and sulfur research and the data from Ms. LaFond-Hudson's thesis to MPCA staff and the Wild Rice Standards Study Advisory Committee.[84] None of this UMD research on iron mitigation or detriment is discussed in either the MPCA's SONAR or Technical Support Document (TSD) for the MPCA's proposed rulemaking.

The Peer Review Panel also raised questions about the chemistry behind the MPCA's equation-based flexible standard. The chair of the Panel, Patrick L. Brezonik, Ph.D., a chemist with expertise in the kinetics of chemical processes in aquatic systems,[85] suggested the MPCA had gone too far in asserting that the multiple quantile regression analysis model could accurately predict concentrations of sulfide in sediment porewaters. Dr. Brezonik noted that if sulfate reduction (change to sulfide) occurred, ferric oxy-hydroxides (iron compounds) presumably would be depleted.[86] He suggested that the complexity of chemistry made the MPCA's proposal to predict a maximum sulfide concentration from surface water sulfate and iron content unrealistic; "If for no other reason than the uncertainties in the kinetics of solid-phase FeS formation, the statement at the beginning of the paragraph is not realistic."[87]

Dr. Pastor's Technical Review also questions the MPCA's assumption that concentrations of

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[79] *Id*. Iron was also present in groundwater in the well used to replenish mesocosm water levels. *See* Attachment B (Pastor *et al*., Ecol. App. Paper 2017, p. 325).
[80] *Id*., p. 2.
[81] *Id*., p. 5.
[82] LaFond-Hudson Thesis 2016 is Attachment F to Pastor Technical Review 2017.
[83] MPCA (E. Swain), N. Johnson, J. Pastor and P. Maccabee Emails re Wild Rice Sulfate, Sulfide and Iron Research, June 13 to June 30, 2016, autop. 2, Exhibit 40. Email also indicate MPCA also received Dr. Pastor's 2016 Sea Grant Report, Attachment D to Pastor Technical Review 2017, in June of 2016.
[84] Pastor Slide Presentation 2016, Attach. C to Pastor Technical Review.
[85] Curriculum vitae of Dr. Patrick L. Brezonik attached in Exhibit 41is available online at https://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/docs/peer_review/brezonik_cv.pdf.
[86] Excerpts from Peer Review Summary Report, *supra* Exhibit 38, autop. 5.
[87] *Id.* Dr. Brezonik referred to the paragraph in MPCA, Draft for Scientific Peer Review (June 9, 2014), SONAR Ex. 6, lines 1258-1260 at p. 52.

sulfide, sulfate, reactive iron, and organic matter will remain in a steady state over long periods of time. He explains that once sulfate from discharge is added to wild rice bed from wastewater discharge, an ecosystem would no longer be in a steady state. Microbes in the sediments will convert some of the sulfate to sulfide, which will then precipitate with some of the reactive iron, and the iron bound up in the precipitate will no longer be available to precipitate any additional sulfide.[88]

Dr. Pastor cautioned, "In an ecosystem, it cannot be assumed that natural inputs of reactive iron from streams and groundwater or from weathering of sediments will keep pace with sulfate pollution."[89] This principle of chemistry would be salient for the protection of wild rice. "If the ecosystems are not in steady state, then the calculation that a certain sulfate concentration in surface water creates lower-than-toxic levels of sulfide during one year may not apply to subsequent years. A sulfate concentration deemed "protective" in year one could become toxic in subsequent years."[90] Dr. Pastor concluded that the MPCA's proposed equation based standard is based on assumptions that cannot be scientifically supported,

> MPCA's proposed flexible standard equation makes important assumptions about the ameliorative effects of iron and the continuation of a steady state over time despite sulfate addition to the ecosystems. These assumptions cannot be defended based on scientific evidence.[91]

Since the MPCA first proposed an equation-based water quality standard for sulfate, the Agency has proposed three different statistical models from which individual waterbody sulfate standards would be calculated. In 2014, the MPCA proposed a multiple quantile logistic regression model for the Peer Review Panel.[92] In 2015, the MPCA proposed a structural equation model (SEM) in its draft rule proposal.[93] Now, in 2016, the MPCA has proposed a multiple binary logistic regression (MBLR) model.[94]

The MPCA's SEM approach was a deterministic model allowing direct calculation of the expected sulfide level and comparison of that expected sulfide level with the actual observed level of sulfide in field survey sediments. John William Shipley, Professor in the University of Sherbrooke Department of Biology and the author of two scientific textbooks and 16 peer-reviewed publications regarding the development and ecological application of structural equations modeling, reviewed the MPCA's proposed SEM model. In addition to criticizing technical aspects of the SEM approach, Dr. Shipley concluded that the MPCA's model had "quite poor 'within-sample' predictive ability and could not reliably distinguish between lakes whose porewater sulfide concentration is below or above the critical value."[95]

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[88] Pastor Technical Review 2017, *supra*, pp. 5-6.
[89] *Id*., p. 6.
[90] *Id*., p. 5.
[91] *Id*., p. 8.
[92] MPCA Analysis of the Wild Rice Sulfate Standard Study: Draft for Scientific Peer Review (June 9, 2014), SONAR Ex. 6.
[93] MPCA Proposed Approach for Minnesota's Sulfate Standard to Protect Wild Rice (Draft Proposal) (March 24, 2015), SONAR Ex. 10.
[94] MPCA Technical Support Document (TSD), SONAR Exhibit 1.
[95] Bill Shipley, Evaluation of the structural equations model described in the document entitled "March 2015 proposed approach for Minnesota's sulfate standard to protect wild rice" by the Minnesota Pollution Control Agency, dated March 24, 2015, prepared Nov. 4, 2015, pp. 4-5, Exhibit 42.

Dr. Joel Roberts, Mathematics Professor emeritus at the University of Minnesota, compared the 2015 SEM equation's expected sulfide results with the observed field survey results and concluded that the MPCA proposal appeared to be "an unreliable method to protect wild rice from excess sulfide.[96] Dr. Roberts was particularly concerned that the equation might significantly underpredict sulfide in high-sulfide waters, such as Sandy Lake in St. Louis County, where sulfide levels as high as 3,080 µg/L had been measured, despite the presence of high levels of iron in the sediments.[97]

MPCA's 2016 new MBLR equation calculates a "protective" sulfate concentration based on the probability that sulfide levels will be below a certain threshold (120 µg/L), rather than by calculating an expected sulfide level. More than half of the "protective" sulfate concentrations calculated with this formula for field survey sites are above the existing standard of 10 mg/L and many far exceed this standard.[98]

Internal MPCA documents raise questions about the development of MPCA's new equation. The MPCA based its formula on the "Class B" data set, which excludes multiple samples, although sulfate was higher when multiple samples were included,[99] and 70% of the variability in sulfide variables was due to differences in the repeated measures within the sites.[100] The MPCA stated that the "general consensus" based on analysis of the experimental and field data was that the EC10 (10% effect concentration) for wild rice presence was between 50 and 100 µg/L.[101] However, the MPCA seems to have selected an EC10 sulfide threshold of 120 µg/L based on statistical error rates in predicting sulfide.[102]

The Technical Support Document (TSD) acknowledges that the "most defensible" EC10 based on the field research is 58 µg/L for all sites or 93 µg/L for sites with sufficient transparency to support wild rice.[103] MPCA's method of selecting an EC10 of 120 µg/L appears to combine a statistical approach and visual identification of the point where the proportion of sites with any wild rice present appears to decline.[104] In addition, the MPCA's probability equation was derived to equalize the risk that it would be over-protective (reducing sulfate more than necessary) and under-protective (reducing sulfate less than needed to protect wild rice).[105]

Dr. Joel Roberts reviewed the MPCA's 2016 multiple binary linear regression (MBLR) formula to evaluate whether it resolved concerns with the MPCA's 2015 SEM model and to

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[96] Joel Roberts, Memorandum Regarding Wild Rice Sulfate Standard Calculations Comparing Expected and Observed Sulfide Levels in Field Study Data and Interpreting Statistical Analysis, December 16, 2015, p. 1, Exhibit 43.
[97] *Id*., pp.
[98] MPCA Field Survey Data with calculated protective sulfate level (sorted by CPSC), Exhibit 44.
[99] MPCA (M. Shore), Which data set should we use? Feb. 9, 2016, p. 5, Exhibit 45.
[100] MPCA (M. Shore), Which data set should we use? Updated, Feb. 12, 2016, p. 5, Exhibit 46.
[101] MPCA (M. Shore), Developing a logistic regression model for the sulfate standard, Mar 10, 2016, p. 2 Exhibit 47.
[102] MPCA (M. Shore), Looking at the CPSC for different sulfide values Updated, Mar. 29, 2016, Exhibit 48.
[103] MPCA, TSD, p. 36.
[104] *Id*., pp. 36-39.
[105] *Id*., p. 46.

see if it raised new questions.[106] Dr. Roberts noted that the type of impartial direct comparison with actual field data that he had performed in 2015 to determine the quantitative goodness of fit was not possible with the new equation, since it predicted a probability rather than an actual sulfide level.[107]

He found that some limited comparisons could be made using the tools provided in the TSD. First, Dr. Roberts verified the calculated protective sulfate concentration (CPSC) obtained by the MPCA for each sampling event in the field survey. He then compared the CPSC with the actual surface water sulfate level at each site. Reviewing data for all field survey sampling other than rice paddies, for 170 of the 238 (71%) sampling events, the CPSC calculated was higher than the existing sulfate level.[108]

Dr. Roberts pointed out that, in addition to the added cost, implementation of an equation-based standard also involves the possibility of sampling error, a concern that had not been resolved by the new formula. Dr. Roberts cited the degree of uncertainty reflected in the MPCA's 2015 proposal and reviewed comparable calculated protective sulfate concentrations for the same water bodies using the 2016 equation. He found a wide divergence in prediction of a protective sulfate level, particularly in sites where the CPSC is higher than the current 10 mg/L standard.[109]

At Second Creek, based on sampling dates within the same year, CPSC ranged from 166.92 mg/L to 657.30, nearly four times higher. At Mississippi Pool 5, again within the same sampling year, the CPSC ranged from 132.16 mg/L to 1160.97, a level 8.78 times higher. For Lake Monongalia, where various locations within the water body were sampled, calculate CPSC ranges from a low of 3.66 mg/L to 455.39, more than two orders of magnitude of variation.[110]

Dr. Roberts examined the equation structure with an iron exponent approaching two, and expressed the concern that, like the prior 2015 formula, this function would be likely to lead to inflated estimates for sulfate concentrations at the upper end of the range.[111]

Dr. Roberts noted that he had compared CPSC values for field survey sites using the MPCA's 2015 formula with its EC20 sulfide threshold of 165 μg/L and the 2016 formula with its EC10 sulfide threshold of 120 μg/L. Somewhat surprisingly given the change from EC20 to EC10, spreadsheet calculation showed a seemingly random pattern of changes.[112] When both the 2015 SEM formula and the MPCA's new MBLR equation were used to calculate a protective sulfate concentration for the same EC10 120 μg/L sulfide threshold, *in every case the new formula resulted in a less protective sulfate standard than the 2015 formula*. In almost 80% of the cases, the 2015 SEM equation would have resulted in sulfate standards less than half of those

[106] Joel Roberts, Ph.D., Memorandum Regarding Proposed Wild Rice Rule Change, November 22, 2017, submitted herein with Attachments 1 through 4 (Roberts Memorandum 2017).
[107] *Id*., pp. 1-2.
[108] *Id*., p. 2, comparison data provided in Attach. 2 to Roberts Memorandum 2017.
[109] *Id*., pp. 3-4.
[110] *Id*., pp. 3-4, pertinent data provided in Attach. 3 to Roberts Memorandum 2017.
[111] *Id*., pp. 4-5.
[112] *Id*., p. 5.

currently proposed by MPCA.[113]

Dr. Roberts questioned why the 2016 MBLR did not lead to more protective calculated sulfate levels even as the sulfide threshold became more stringent. He reviewed the change from a deterministic to a probabilistic formula. He then questioned the structure of MPCA's 2016 formula, which predicts a 50% chance that wild rice will be protected at the EC10 level. Dr. Roberts suggested that a 50/50 chance of meeting the EC10 "seems inadequate for protecting wild rice."[114]

Dr. Roberts concluded that the MPCA's proposed MBLR equation "is inadequate for explaining the data from the Wild Rice Field Study. It does not resolve all of the concerns raised by the 2015 SEM equation. And it is inadequate for protecting Minnesota's Wild Rice."[115]

Mesocosm experiments have exposed flaws in the underlying hypothesis that sediment iron protects wild rice from sulfide toxicity. In addition, both expert analysis and review of field survey data reveal problems with predictions and policy in the MPCA's proposed formula. Finally, real world evidence of effects on wild rice health and abundance of sulfate concentrations similar to those MPCA has proposed as "protective" undermines the claim that MPCA's proposed equation-based sulfate standard would adequately protect wild rice.

In 2015, a technical advisor to the MPCA, Dr. David Schimpf, commented that the MPCA's proposal based on the "presence" of wild rice, without regard to its abundance, "redefines 'protect wild rice' into a much weaker sense than that of the existing standard."[116] Rather than accept a finding of wild rice "presence" at various sites as an indication that wild rice can tolerate elevated sulfate levels, it is necessary to review what has happened to wild rice abundance under high sulfate and sulfide conditions.

In his Technical Review, Dr. Pastor noted that data from MPCA's field survey demonstrates a decline in wild rice abundance at sulfide concentrations above 75 µg/L, which is below MPCA's proposed EC10 of 120 µg/L. He cautioned that a standard that is based on 5% wild rice cover may not protect wild rice sustainability.[117] Dr. Pastor further explained that the MPCA's proposal to calculate a "protective" sulfate concentration to attain a sulfide level of 120 µg/L, would allow sulfate concentrations more than an order of magnitude above the current sulfate limit of 10 mg/L in many cases and could sometimes result in allowing sulfate concentrations two orders of magnitude higher than the current standard, noting that a "protective sulfate concentration" for the St. Louis River Estuary would range from 99.5 mg/L to 241.1 mg/L, while the MPCA's "protective" concentration of sulfate for the Embarrass River would be 1248.9 mg/L.[118]

Dr. Pastor reviewed MPCA field survey data showing that over 70% of wild rice ecosystems in in the field survey sites were found in sulfate concentrations of 10 mg/L or less and 94 % are

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[113] *Id*., p. 6, pertinent data provided in Attach. 4 to Roberts Memorandum 2017.
[114] *Id*., p. 7.
[115] *Id*., p. 7
[116] Schimpf Comments, 2015, *supra*, Exhibit 21, p. 2.
[117] Pastor Technical Review 2017, *supra*, p. 6.
[118] *Id*., pp. 6-7.

found in lakes or streams with sulfate concentrations below 50 mg/L.[119] He concluded that even though the MPCA field survey was designed to study sites with wild rice present despite high sulfate levels (MPCA, 2014), the field survey findings strongly corroborate Moyle's (1944) conclusions.[120]

Dr. Pastor highlighted data from Sandy Lake, a water body that has received sulfate and iron discharge since the mid-1960s from U.S. Steel's Minntac tailings basin, as an example of the decline of wild rice populations in the presence of sulfate exceeding the existing 10 mg/L standard despite high sediment iron concentrations. The MPCA sampled water and sediment and counted wild rice stem density in Sandy Lake 10 times from June through September in 2013, finding wild rice largely absent except for two sampling events with very low densities (0.6 stems per m^2 on Sept. 17 and 3.8 stems per m^2 on Sept. 21 in another location).[121]

The sediment of Sandy Lake has high iron content, an average of 23,540 ug/g, which is nearly three times the statewide average (8800 ug/g) for all non-paddy wild rice water bodies sampled by MPCA. Dr. Pastor found that the average calculated allowable sulfate concentration using MPCA's flexible standard (79 mg/L) is not significantly different from the sampled average actual sulfate in Sandy Lake (95 mg/L).[122] Reviewing this data and his knowledge about wild rice ecology at Sandy Lake, Dr. Pastor concluded:

> If MPCA's model is correct, then wild rice should be present and abundant in Sandy Lake because of the high sediment iron content and the similarity of the concentration of sulfate in the water compared to the allowable sulfate concentrations. And yet, despite the high iron content of the sediment, MPCA could barely find any wild rice in Sandy Lake. Although wild rice is present in Sandy Lake and thus appears in MPCA's modeling as a lake with wild rice despite high sulfate concentrations the populations of wild rice in Sandy Lake are clearly not healthy, especially compared to what is known to have been present in the past.[123]

Sandy Lake historically "produced good stands of wild rice" and, "Wild rice harvesters utilized the lakes when suitable crops were present." The 1854 Treaty Authority summarized, "Rice production generally declined through the 1970s and 1980s, with little or no rice found in the lakes during a 1987 survey. Rice production has since remained poor."[124] MPCA has also acknowledged that Sandy Lake is near the largest tailings basin in Minnesota "which is known to leak sulfate into surface and ground water" and that "The site is controversial, having lost its documented wild rice population."[125]

[119] *Id*., p. 7.
[120] *Id*.
[121] *Id*., p. 8.
[122] *Id*.
[123] *Id*.
[124] 1854 Treaty Authority, Sandy Lake and Little Sandy Lake Monitoring (2010-2016), Dec. 2016, autop. 2, Exhibit 49.
[125] Email MPCA (E. Swain) to C. Pollman re Sandy Lake Sites, May. 14, 2015, Exhibit 50.

Sandy Lake is not unique. Other water bodies demonstrate impairment of wild rice downstream of mining sulfate discharge despite high levels of sediment iron.[126]

The lower Partridge River is a wild rice water impacted by historic and existing iron and sulfate discharge from the LTVSMC taconite mine and tailings basin; it would be downstream of sulfate discharge from the proposed PolyMet copper-nickel mine project.[127] MPCA's Technical Support Document states that the lower Partridge River (S007-443) should be considered a "false positive," where wild rice is present despite sulfate levels above 10 mg/L (average sampled level of 24.1 mg/L) and sulfide levels below 120 µg/L.[128] Under the MPCA's proposed equation, calculated "protective" sulfate concentrations ranged from 104.3 mg/L to 571.7 mg/L depending on the sampling date, any of which would allow PolyMet a massive potential increase in sulfate.[129]

However, if Minnesota's existing wild rice sulfate rule were preserved, the lower Partridge River would be considered an impaired water under the Clean Water Act[130] subject to study and reduction of sulfate levels. In fact, in its August 2013 draft proposal for an initial list of wild rice impaired waters, the MPCA proposed to list the lower Partridge River as an impaired water.[131]

In asserting that the lower Partridge River should be considered a "false positive," the MPCA looked only at its equation, not at the wild rice. Leonard Anderson, a biology teacher, avid researcher, hand harvester, and citizen scientist for decades, reported his field observations of wild rice in the lower Partridge River to the MPCA in 2010:

> Four of us paddled the lower Partridge and adjacent St Louis River reaches. Above the junction with the Partridge River at river mile 161, the St Louis River was full of high quality rice with several hundred waterfowl feeding and resting in the rice. Next, we entered the lower Partridge River and searched for wild rice. There were stands there, but they were in such poor health that even though we were there to harvest wild rice, the plants were so stunted that you could not bend the stalks over the side of a canoe to harvest the grain. The plants averaged about 10 inches in height and the color was more reddish than green. Most plants had no viable seed. [132]

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[126] Although information on calculated protective sulfate concentrations is not widely available – WaterLegacy obtained spreadsheets used in this report under the Data Practices Act – mining companies have shared with MPCA their analysis of MPCA's equation results. See Barr, Sampling Locations with Data Used to Calculate Proper Proposed Sulfate Concentration (165 µg/L), 2015 (found in MPCA, E. Swain paper files), Exhibit 51.
[127] MPCA proposes to list the lower Partridge River (04010201-552) as a wild rice water in Minn. R. 7050.0471, Subp. 3(B)(44) This is the same water body as S007-443, as shown in MPCA Wild Rice Waters database July 19, 2016, Exhibit 52. For relationship to PolyMet proposed mine, see MPCA Staff Recommendation, Revised Draft Waters Used for the Production of Wild Rice – Partridge and Embarrass Rivers, Aug. 13, 2012, Exhibit 53 (MPCA, Draft PolyMet WR Waters).
[128] MPCA, TSD, p. 61.
[129] MPCA Field Survey data with CPSC, Attach. G to Pastor Technical Review 2017, *supra*.
[130] Clean Water Act Section 303(d), 33 U.S.C. § 1313(d)
[131] Exhibits to WaterLegacy Petition for Withdrawal of Authority, *supra*, Exhibit 16, p. 400.
[132] Preserve Minnesota's Wild Rice Standard, *supra*, Exhibit 1, Field Observation of Wild Rice Waters, pp. 3-4.

Len Anderson noted that data from John Moyle, documented in DNR Fisheries Report No 69, April 2, 1944, showed sulfate concentrations of only 0.3 mg/L in the Partridge River. He concluded, "Recent impacts of mining have raised sulfate levels to the point that natural wild rice beds are no longer productive, but are still alive."[133]

Embarrass Lake is another wild rice water downstream of historic LTVSMC taconite mining discharge and downstream of potential discharge from the proposed PolyMet copper-nickel mine tailings basin.[134] According to the MPCA, survey results from 2009 and 2010 showed "the presence of several small areas of sparse wild coverage along much of the shoreline" of the lake, "indicating that lake/shoreline conditions are conducive to the presence of wild rice" in amounts sufficient to be used as a food source for wildlife, although 2011 surveys found no wild rice.[135] The U of M field survey found no wild rice in either 2012 or 2013.[136]

Tribal scientists have long expressed concern about the impacts of mining pollution on the Embarrass River chain of lakes, including Embarrass Lake. A 2010 letter from the Grand Portage Band of Chippewa to state and federal agencies explained, "natural wild rice is no longer dense in the upper portion of the Embarrass River due to inundation of polluted water from the LTV area 5 mine pit lake and tailings basin discharges," The Band emphasized that the historic concentration of sulfate measured by Dr. Moyle in the 1940's, before the mining impacts was 0.2 mg/L.[137]

Field survey sulfate levels in the Embarrass Lake averaged 18.5 mg/L. Based on high but fluctuating iron levels, the MPCA's proposed equation would set a "protective" sulfate concentration of 1248.9 mg/L based on the 2012 sampling or a sulfate "limit" of 1,821.2 mg/L based on the 2013 sampling.[138] Even the lowest sulfate standard calculated under the new MPCA formula would be 120 times the existing 10 mg/L sulfate rule and at least 66 times higher than the existing sulfate levels. Either of these sulfate limits could extirpate aquatic life,[139] as well as eliminating requirements for sulfate controls at PolyMet's proposed copper-nickel processing plant and tailings basin.

From his decades of hand harvesting and experience in the field, Len Anderson cautioned, "Wild rice may survive above 10 mg/L, but it does not thrive." He pleaded, "The remnant stands of wild rice in the Partridge, Embarrass and entire St Louis must be protected. . . Anything less would be a betrayal of the rights of us that harvest and eat this valued wild grain and the waterfowl that depend on it."[140]

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[133] *Id.*, p. 4
[134] MPCA proposes to list Embarrass Lake (69-0496-00) as a wild rice water in proposed Minn. R. 7050.0471, Subp. 3(B)(18). *See also* MPCA, Draft PolyMet WR Waters, Exhibit 53, *supra*, regarding location downstream of proposed PolyMet mine.
[135] *Id.*, autop. 6.
[136] MPCA Field Survey data with CPSC, Appx. G to Pastor Technical Review 2017, *supra*.
[137] Grand Portage Band, Comments on PolyMet's Refined Embarrass Lake Wild Rice Mitigation, Nov. 4, 2010, pp. 3-4, Exhibit 54.
[138] MPCA Field Survey data with CPSC (sorted by water body), Attach. G to Pastor Technical Review 2017, *supra*.
[139] Concerns about sampling implementation are discussed in these comments *infra*, Section 7.
[140] Preserve Minnesota's Wild Rice Standard, *supra,* Exhibit 1, Field Observation of Wild Rice Waters, p. 4.

Based on his academic and research experience, Dr. John Pastor has concluded:

> Both experimental research and field data suggest that sulfate concentrations above 10 mg/L may not protect wild rice and that sulfate concentrations an order of magnitude or more above 10 mg/L, as would be allowed in some water bodies by MPCA's proposed flexible standard, are likely to result in decline and extinction of wild rice over time.[141]

MPCA's proposal to use a formula to allow elevated sulfate concentrations in the presence of iron would not protect the designated use of waters for wild rice. This proposed rule would violate the Clean Water Act and its implementing regulations, would relieve the obligation of mining industry dischargers to control sulfate pollution, and would impair wild rice.

Changes to MPCA Proposed Rule Sections

The following sections of the MPCA's proposed rule must be rejected as unnecessary, unreasonable and inconsistent with Clean Water Act requirements:

> Proposed addition to **Minn. R. 7050.0220, Subparts 3a** (line 3.17), **4a** (line 4.12), **5a** (lines 4.23 to 4.24, 5.8), **6a** (line 5.24), applying the equation in proposed 7050.0224, subpart 5, to replace the sulfate limit.
>
> Proposed rule **Minn. R. 7050.0224, Subp. 5** (lines 7.17 to 9.12) prescribing use of an equation that would fail to protect wild rice, as well as a rule for exceedance of standards that allows excessive pollution, implementation methods biased against the protection of wild rice, and error-prone sampling of parameters by dischargers.

5) MPCA's proposal to restrict the water bodies in which any wild rice sulfate standard would apply to an arbitrary and exclusive list would remove a designated use protected under existing Minnesota rules and de-list wild rice waters identified by Minnesota state agencies, including waters downstream of existing and potential mining discharge. Such de-listing is neither needed nor reasonable and exceeds the MPCA's delegated statutory authority under the federal Clean Water Act.

Claims made in the MPCA's SONAR and in public hearings that the proposed rule would "keep the beneficial use substantially the same"[142] use an imprecision of language to obscure the MPCA's proposal to arbitrarily and capriciously remove the protection of wild rice from sulfate currently afforded by Minnesota Rules.

Minnesota Rules currently limit sulfate to 10 mg/L in waters where wild rice is "present," Minn. R. 7050.0220, Subparts 3a (31), 4a (31), 5a (19 and 6a (14), which waters are also described as "waters used for the production of wild rice." Minn. R. 7050.0224, Subp. 2. Minnesota's rules designating waters used for the production of wild rice and waters where wild rice is present were enacted in 1973 and approved by the EPA under the Clean Water Act.

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[141] Pastor Technical Review 2017, *supra*, p. 8.
[142] SONAR, p. 13. The term "beneficial use," used by the MPCA in this rulemaking is not defined in the proposed rules or in existing rules, and its meaning is unclear.

Minnesota's existing wild rice water quality standard protects wild rice from sulfate for "wildlife designated public uses and benefits." Minn. R. 7050.0224, Subp. 1. The rule also describes the value of wild rice as "a food source for wildlife and humans" and as a resource of "ecological importance." *Id*. The text of this rule, similar language in other Minnesota laws, EPA's advice on the rule's implementation, a Minnesota district court decision, and the internal record of MPCA's understandings all contradict any assertion that the existing rule protects "substantially the same" designated use as the MPCA's proposed truncated list of wild rice waters.

Rescission of Minnesota's existing protection of waters used for the production of wild rice where wild rice is present and adoption in its stead of a list of waters that excludes many known and previously designated wild rice waters is arbitrary and capricious, has no basis in science, delists wild rice waters identified by the Minnesota Department of Natural Resources in consultation with tribes, and presents a clear violation of the Clean Water Act. As with the MPCA's proposed rescission of Minnesota's existing wild rice sulfate limit of 10 mg/L in favor of an equation that would allow high concentrations of sulfate in the presence of sediment iron, the MPCA's proposed rules would fail to protect wild rice and would specifically fail to protect critical wild rice waters directly downstream of existing and proposed mining industry discharge.

The structure of the Clean Water Act is based on the states' delegated authority to establish "designated uses" of waters, set water quality standards to protect those uses, and impose effluent limits to protect the "designated uses" of waters.[143] Under the Clean Water Act and implementing regulations a state may not use a new designation to remove an existing use of a water body.[144] Existing uses are uses "actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards,"[145]

Where a "designated use" pertains to fish, shellfish, recreation or wildlife, this type of use has special protection under Section 101(a)(2) of the Clean Water Act[146] and may not be removed as a designated use of that water body without a use attainability analysis specific to that water body.[147] A use attainability assessment is a specific structured scientific assessment of the factors demonstrating that the attainment of the use is not feasible.[148] Where the designated use of a water body also involves an *existing* wildlife use protected under Section 101(a)(2) of the Clean Water Act, such as a water where wild rice has been present any time since November 28, 1975, the State may not remove that use under the Clean Water Act.[149] As the EPA has explained, "If a designated use is an existing use for a particular water body, the existing use cannot be removed unless a use requiring more stringent criteria is added."[150]

Minnesota's existing wild rice rule was enacted in 1973. On its face it would apply a sulfate limit

[143] *See e.g*. 40 C.F.R. §131.3(b)(f).
[144] 40 C.F.R. §131.10(h)(1).
[145] 40 C.F.R. § §131.3(e); 131.12(a); *See e.g.*, *Ohio Valley Envtl. Coalition v. Horinko*, 279 F. Supp. 2d 732, 751 (W. D. Va. 2003).
[146] Section 101(a)(2) of the Clean Water Act is 33 U.S.C. §1251(a)(2).
[147] 40 C.F.R. § 131.10(j).
[148] *Id*.
[149] 40 C.F.R. §131.10(h)(1).
[150] EPA, Water Quality Standards Handbook, Ch. 2: Designation of Uses (EPA-823-B-12-002-2012), p. 9, available at https://www.epa.gov/sites/production/files/2014-10/documents/handbook-chapter2.pdf

to any water body where wild rice was present or any water used for the production of wild rice as of that date. Although the Minnesota Chamber of Commerce, on behalf of its mining industry members, has asserted that the only waters "used for the production" of wild rice are agricultural rice paddies, the clear intent of Minnesota's wild rice sulfate standard was to protect "the natural and cultivated growth of wild rice."[151] In dismissing the Chamber's lawsuit challenging the existing wild rice sulfate standard as "unconstitutionally vague," a Minnesota district court judge held, "MPCA's application of the wild rice sulfate standard to protect naturally growing wild rice in ambient waters of the state is legally valid because it is consistent with the plain language of the water quality standard."[152]

Understanding the term "production" of wild rice to mean natural growth of a wildlife resource is consistent with other Minnesota statutes. Minnesota law pertaining to dams in the Mississippi River headwaters requires a plan to consider water elevations "desirable for the production of wild rice in the wild rice producing areas" and "desirable for the production and maintenance of wildlife resources."[153] State laws provide funding for wetlands and lakes for "maximum migratory waterfowl production," and explain how people can enter, use and hunt in a federal "waterfowl production area."[154] The MPCA has not disputed that Minnesota's wild rice sulfate rule refers to "the growth and harvesting of natural stands of wild rice."[155]

The plain language of Minnesota's existing wild rice sulfate water quality standard does not impose any specific numerical or narrative acreage or density requirement. The structure of Minnesota water quality designations and the history of Minnesota practice belies MPCA's claim in this proposed rulemaking that a proposed "beneficial use" of wild rice based on a minimum acreage and density is "substantially the same" as a wild rice designated use under existing law.

A joint report of the MPCA and the DNR for the Mining Simulation Project in 1990 explained the rule unequivocally; "MPCA applies a sulfate criterion to effluent discharges to waters where wild rice is present."[156] In 2001, an MPCA staff internal email from Gerald Blaha explained that the listings of specific wild rice waters in 7050.0470 "were not all inclusive, not even for the Lake Superior Basin." As a result "a determination as to whether a water supports, or has historically supported, wild rice is reflected by current and past observations of the presence of wild rice stands."[157] Mr. Blaha clarified that Class 4 waters are considered wild rice waters when wild rice is present, citing Minnesota rules preventing material degradation of fish "and other biota normally present" in any class of waters by the discharge of sewage, industrial waste, or other wastes."[158]

[151] Wild Rice Hearing Testimony Excerpts 1973, *supra*, Exhibit 4, autop. 5.
[152] *MCC v. MPCA* (Minn. Dist. Ct.), *supra, slip op.* 14, Exhibit 2.
[153] Minn. Stat. §103G.421, Subd. 3(a)(2) and (3).
[154] Minn. Stat. §97A.075, Subd. 2(a)(1); Minn. Stat. §97A.098; Minn. R. 6240.2600.
[155] MPCA, SONAR p. 29
[156] MDNR, MPCA and Project Environment Foundation, Report on the Mining Simulation Project, Jan. 1990, p. 30, autop. 3, excerpted in Exhibit 55.
[157] MPCA (G. Blaha) Email re MOA with Indian Bands regarding Wild Rice Beds, Aug. 22, 2001, included in email string of MPCA (G. Blaha) re MOA with Indian Bands regarding Wild Rice Beds, Mar. 10, 2010, autop. 2, Exhibit 56.
[158] *Id*., quoting Minn. R. 7050.0222, subp. 7 emphasis in the original removed. Minnesota rules were recently amended so that this subpart doesn't specify biota, but it appears that biota are included in the definition of fish and the aquatic community in Minn. R.7050.0150, Subp. 4, Item I.

In its comments on the PolyMet Draft environmental impact statement (EIS) in 2010, the EPA recommended that a revised EIS apply the 10 mg/L sulfate limits given "the presence of isolated patches of wild rice in the Upper Partridge River."[159] When, in 2010, the MPCA began asking mining companies to help assess the applicability of the wild rice sulfate standard for waters in a project area, the MPCA requested a field survey "to observe whether wild rice is actually present in all waters in the project area that were determined to have the potential for wild rice."[160] In 2013, when the MPCA was proposing to list wild rice/sulfate impaired waters,[161] the MPCA stated that a water body would be considered a "water used for the production of wild rice" through an evaluation process similar to that for discharge permits: "These wild rice stands can be existing stands in a waterbody or they can be previously documented stands present within a waterbody in the recent past dating back to November 28, 1975."[162]

MPCA's proposed rules are a radical departure from Minnesota's existing rule limiting sulfate in waters where wild rice is present or was present in the recent past. MPCA's proposed rules are also a radical departure from Minnesota's existing rule and practice allowing an evidence-based process to determine whether a water supports or has historically supported wild rice.

The MPCA's proposed rule limits "wild rice waters" to the *identified* water bodies newly named in Part 7050.0471:

> Minn. R. 7050.0130, Subp. 6c. Wild rice waters. "Wild rice waters" means those water bodies that contain natural beds of wild rice as defined by Laws 2011, First Special Session chapter 2, article 4, section 32, paragraph (b), and are identified in part 7050.0471.

To emphasize that only the MPCA's *identified* wild rice waters would be protected from sulfate discharge under the new rule,[163] the MPCA's proposal continues:

> Minn. R. 7050.0224, Subp. 5, Item A. The standards in items B and C apply to wild rice waters identified in part 7050.0471 to protect the use of the grain of wild rice as a food source for wildlife and humans.

Although the MPCA was reluctant to answer questions about whether *unlisted* wild rice waters would be protected under it proposed rule,[164]the SONAR clearly states that no sulfate standard could be applied to protect wild rice, irrespective of the evidence, unless and until a rule was enacted listing that water:

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[159] EPA, Comment on PolyMet Draft EIS, Feb. 18, 2010, *supra*, p. 15, Exhibit 10.
[160] As an example, see MPCA (A. Foss) Letter to Essar Steel re Request Information on Wild Rice, Jan. 12, 2010, Exhibit 57.
[161] This effort was forestalled as a result of political pressure. *See* WaterLegacy Petition for Withdrawal of Authority, *supra*, Exhibit 15, pp. 2, 21-24; and WaterLegacy Petition for Withdrawal of Authority Exhibits, *supra*, Exhibit 16, pp. 319-415, 434.
[162] MPCA, Proposed 2013 Wild Rice/Sulfate Impaired Waters Assessment Approach, May 1, 2013, Exhibit 58.
[163] The chimera that rulemaking might add wild rice waters in the future is not relevant to determine whether the MPCA's current proposed rule would remove protection from wild rice waters.
[164] Public hearing in St. Paul, Nov. 2, 2017.

> "The proposed revisions specifically identify each water to which the numeric sulfate standard is applicable, eliminating the existing phrase "water used for production of wild rice," which resulted in the need for case-by-case determination of whether a water body met the definition." (MPCA, SONAR, pp. 14-15)
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> "The definition of a wild rice water requires that wild rice waters must be identified in Minn. R. 7050.0471; therefore, the standard does not apply until a water is specifically identified in rule." (MPCA, SONAR, p. 15)

There are thousands of water bodies in Minnesota where wild rice is present or was present in the recent past. In 2007, the Minnesota Legislature[165] required the Minnesota Department of Natural Resources, the Minnesota agency that has been studying wild rice since the 1920s, to prepare a study of natural wild rice waters to identify threats to wild rice and make recommendations to legislative committees on protecting and increasing natural wild rice stands in the state. To fulfill these requirements, the DNR established a technical team of wild rice experts from State, Tribal and Federal governments as well as academia and the private sector.[166]

In reporting its inventory of wild rice waters to the Legislature in 2008, the DNR identified 1,292 lakes or river/stream segments where "stands of natural wild rice were present or occurred in recent history."[167] The DNR cautioned that, despite the best efforts of participants, the inventory was not a comprehensive list of Minnesota wild rice waters: "Although this inventory provides a marked improvement in our understanding of natural wild rice distribution in Minnesota, it should be considered a minimum estimate. The data for many wild rice lakes, streams and rivers is incomplete of totally lacking."[168]

Should MPCA's proposed list of wild rice waters be adopted as the exclusive list of designated wild rice waters, *337* wild rice waters listed by DNR in its 2008 report to the Legislature would no longer be designated as wild rice waters.[169]

In 2013, the MPCA submitted a call for data to various agencies and to the public at large seeking information on additional wild rice waters. In response, the DNR submitted a list of approximately 800 wild rice waters in addition to those in the DNR's 2008 inventory.[170] However, MPCA excluded from this call for data the listing of any wild rice water that did not have estimated wild rice acreage of two acres or more.[171] MPCA then declined to list

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[165] Minnesota Session Law 2007, Chapter 57, Article 1, Section 163.
[166] MDNR, Natural Wild Rice in Minnesota, Feb. 15, 2008, provided as MPCA SONAR Ex. 21, p. 1 available online at http://files.dnr.state.mn.us/fish_wildlife/wildlife/shallowlakes/natural-wild-rice-in-minnesota.pdf
[167] *Id.*, p. 53
[168] *Id.*, p. 12
[169] MPCA, Wild Rice Development Spreadsheet Oct. 20, 2017 (sorted), Exhibit 59; *see also* Excerpt from Oct. 20, 2017 Wild Rice Development Spreadsheet to show only listed MDNR 2008 waters rejected by MPCA for insufficient information, Exhibit 59A.
[170] MDNR (A. Geisen) and MPCA (G. Blaha) Emails re "Call for Data" Request for Wild Rice Waters, Apr. 30-May 13, 2013, with attached MDNR spreadsheet, Exhibit 60.
[171] MPCA SONAR, p. 44.

approximately 625 water bodies that DNR identified in 2013 as wild rice waters.[172] In total, for this rulemaking the MPCA declined to list 997 water bodies that others, primarily wild rice scientists at state and tribal agencies, had identified as wild rice waters.[173]

The MPCA conducted no analysis pursuant to the Clean Water Act to determine whether any wild rice waters that would currently be considered waters used for the production of wild rice met federal criteria for removal of their wild rice designated use.

The MPCA also provided no criteria in its proposed rule to justify denying protection from sulfate and sulfide of "water bodies that contain natural beds of wild rice" but are not listed in proposed Minnesota Rule 7050.0471.[174]

The record establishes that Minnesota's existing wild rice sulfate rule protects all waters where wild rice is present or has been present in recent history as waters used for the production of wild rice. What MPCA has suggested in its SONAR, despite the lack of text in its proposed rule, is that limitation of Minnesota's wild rice sulfate standard to approximately 1,300 named waters is based on defining the wild rice designated use to require "a demonstrated harvest of the wild rice by humans or evidence of the use of the grain as a food source by wildlife."[175] Even if adding another layer of proof to an existing designated use of waters were permissible under the Clean Water Act - which we believe it is not - the MPCA has failed to demonstrate any scientific basis for applying an acreage or density requirement to demonstrate a wildlife benefit.

To the extent that MPCA has "developed and applied criteria" to limit its list of wild rice waters,[176] those criteria have been a moving target. In 2013, the MPCA proposed that wild rice waters must have one-acre coverage in a lake or 0.1 acre coverage per river mile with a density of 1 stem per 0.5 square meter so that wild rice would provide 11.5 days worth of food for one Mallard duck.[177] In 2014, the MPCA proposed a minimum of 9,000 wild rice stems for a lake or 900 stems per river mile.[178] In March 2015, the MPCA proposed that a wild rice population must have a minimum of 8,000 stems in a lake or a minimum of 800 stems over a river mile, stating this amount of wild rice would feed approximately 12 ducks during a one-week migratory stop.[179] In July 2016, the MPCA proposed requiring 0.25 acres of wild rice with a stem density of at least 8 stems per square meter or 0.5 acres with a stem density of at least 4 stems per

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172 The number of wild rice waters proposed by DNR in 2013 that are not listed by MPCA is approximate, since this information was provided in the MPCA Wild Rice Waters Draft List updated as of Jan. 25, 2017, as reflected in Exhibit 52A, showing "insufficient information" waters derived from Exhibit 52. The MPCA's October 2017 Wild Rice Development Spreadsheet, *supra*, Exhibit 59, did not separately break out which agencies proposed wild rice waters in 2013 that MPCA rejected from listing.
173 MPCA, Wild Rice Development Spreadsheet, Oct. 20, 2017, *supra*, Exhibit 59.
174 *See* MPCA proposed rules Minn. R. 7050.0130, Subp. 6c and Minn. R. 7050.0224, Subp. 5, Item A.
175 MPCA, SONAR, p. 12.
176 *Id*., p. 41
177 MPCA, Draft Discussion Document: Defining "Water Used for the Production of Wild Rice," Jan. 7, 2013, Exhibit 61, autop. 2-3.
178 MPCA, WUFPOWR Determinations, Mar. 3, 2014, Exhibit 61, autop. 4.
179 MPCA's proposed approach for Minnesota's sulfate standard to protect wild rice, Mar. 24, 2015, SONAR Ex. 10, pp. 9, 21

meter.[180] Using yet a new metric for feeding ducks, the MPCA believed that this size wild rice bed would, at a minimum, meet the food energy needs of a pair of ducks for two months.[181]

MPCA staff had learned long before the current rule was proposed that there is no scientific basis to require any specific acreage or density for wild rice to benefit wildlife. In 2011, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) staff pointed out that they knew of no "research that defines the number of plants or the density of a rice bed that would make it usable to blackbirds, muskrat, geese, or other wildlife. A single plant can provide nutrition to wildlife."[182] By spring 2016, MPCA staff had reached a similar conclusion, noting that 2015 scientific research by leaders in the field called into question whether "giving-up densities" exist, showed that ducks don't leave a location even when they are no longer feeding, and showed that food availability may be only one of the factors that determine where ducks eat.[183] The bottom line: "How small a patch would ducks use? Don't know. Many things influence this other than food availability such as lack of disturbance, escape cover and thermal cover."[184]

Tribal scientists with the Fond du Lac and Grand Portage Bands criticized the MPCA's "incongruous rationale" based on protecting a certain amount of food for ducks, emphasizing that there is "no supporting evidence that demonstrates it would be protective of wild rice waters." For trout streams, they noted, "[A] relevant analogy might be if the MPCA considered the question 'how much does a merganser duck eat?' "[185]

DNR biologists have also suggested that a plant ecology approach would be appropriate to identify wild rice waters:

> I [Donna Perleberg, DNR biologist] offered a "plant ecology" approach to the question of "what constitutes a wild rice population?" I suggested that the objective seems to be to distinguish between a "viable population" of wild rice and single plants that may be "incidental occurrences" in the waterbody. As an analogy, I suggested that if our goal was to identify cedar forests, we would not include a single cedar tree planted in a parking lot.
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> Welby [Smith DNR botanist] supported the "plant community" approach and noted that when folks see "very dense" stands of wild rice (the MPCA photos that are being used as "good examples" of wild rice), those are anomalies from a statewide, ecological viewpoint. Wild rice may be present at a range of densities and the monotypic stand may not necessarily be the "typical" state.[186]

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[180] MPCA Draft Technical Support Document: Refinements to Minnesota's Sulfate Water Quality Standard to Protect Wild Rice (July 18, 2016), SONAR Ex. 12, pp. 8-9

[181] MPCA, SONAR, p. 61.

[182] GLIFWC, Comments on Draft Staff Recommendation: Waters Used for the Production of Wild Rice – Partridge and Embarrass Rivers, Nov. 17, 2011, p. 4, Exhibit 62.

[183] MPCA, Wild Rice Waters Criteria and Summary of discussions with DNR wildlife and wild rice staff on May 17, 2016, autop. 1, 3, 5, Exhibit 63.

[184] *Id*., p. 2.

[185] Fond du Lac and Grand Portage Bands, Comments on MPCA's March 2015 Proposed Approach for Minnesota's Sulfate Standard to Protect Wild Rice, Dec. 18, 2015, p. 4, Exhibit 64.

[186] MDNR (D. Perleberg) Email and Notes of Meeting with MPCA on Waters of Wild rice Production, Jan. 4, 2014 to Jan. 13, 2014, autop. 3, Exhibit 65. MPCA has acknowledged in discussions with Wild

MPCA's statements in the SONAR that water bodies must be two acres in size or described as "thick," "dense" or "lush" to serve as a wild rice use[187] are contrived as well as unscientific. These factors may be sufficient to justify *listing* named wild rice waters. However to exclude all other wild rice waters from sulfate water quality standard protection would conclusively presume, without evidence or recourse, that such wild rice waters provide no wildlife benefits and that they have provided no benefits at any time since November 28, 1975. Such an exclusion and conclusive presumption would be arbitrary, capricious, lacking in scientific basis, and inconsistent with the Clean Water Act.

Exclusion of wild rice beds that are small or sparse from the protection of sulfate water quality standards would not protect wild rice. Since DNR began keeping records of wild rice in the 1920s, wild rice has been lost or has greatly declined in many lakes.[188] Wild rice populations have inherent cyclic variability, so even a healthy wild rice bed may appear sparse or may not be observed during a particular monitoring year. Small isolated populations of wild rice may be necessary to preserve the genetic diversity of wild rice.[189] Perhaps most troubling, failure to protect relatively sparse wild rice from sulfate pollution may result in the complete extinction of wild rice beds already impaired as a result of sulfate discharge.

In objecting to the MPCA's proposed acreage and density criteria as insufficiently protective of wild rice, Wild Rice Advisory Committee member Len Anderson highlighted an additional concern, "Do the stands on the Partridge and Embarrass River constitute a "stand" of wild rice? I am sure the ducks think they do. If PolyMet can get these stands in effect "declassified" as a stand, then they are home free. The same could be said for Minntac and Western Lake Superior Sanitary District and many others."[190]

Even a brief review of the MPCA's proposed listing of wild rice waters demonstrates that Mr. Anderson's concerns may be well founded. Critical waters immediately downstream of existing and proposed mining discharge are excluded from the list of wild rice waters. They would receive no protection from sulfate pollution if the MPCA's proposed rule were adopted.

At the U.S. Steel Minntac tailings basin, sulfate pollution has impaired wild rice for decades and the MPCA has failed to update its discharge permit or control sulfate pollution for a quarter of a century.[191] On the east side of the tailings basin, Sandy Lake, Little Sandy Lake and the Sand River have declining stands of natural wild rice.[192] On the west side of the tailings basin, Dark

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Rice Advisory Committee members that other beneficial uses (such as trout streams) don't require a certain density of fish, so long as there is evidence that finding a fish is not an "anomaly."
[187] MPCA, SONAR, pp. 44, 47-49.
[188] MPCA (Swain), Email re historical wild rice records, Oct. 12, 2015, Exhibit 66. *See also* MPCA, Post-Hearing Response, Wild Rice Rule Amendments, described *infra*, Exhibit 78, autop. 2.
[189] L. Anderson Email to MPCA re Wild Rice Advisory Committee Meeting and attached discussion, Protecting the genetic diversity of wild rice, June 4 -8, 2015, autop. 5-6, Exhibit 67.
[190] *Id*., autop. 5.
[191] *See* WaterLegacy Petition for Withdrawal of Authority, *supra*, Exhibit 15, pp. 17-19, WaterLegacy Petition for Withdrawal of Authority Exhibits, *supra*, Exhibit 16, pp. 207-303.
[192] *See* discussion, *supra*, at p. 27.

Lake is the only water body where wild rice is present. Minnesota's wild rice water quality standard would only apply to control sulfate discharge on the west side of the Minntac tailings basin if Dark Lake were recognized as a wild rice water. [193]

The University of Minnesota field survey done for the wild rice sulfate standards study demonstrates that Dark Lake is a wild rice water. Dark Lake was surveyed on four occasions, and *wild rice was present on each occasion*.[194] MPCA has stated, "Where a site was identified as having wild rice, the MPCA added it to the proposed list of wild rice waters, with four exceptions," which were excluded because "sparse or limited wild rice plants were observed." Dark Lake was one of those four "exceptions."[195]

MPCA's exclusion of Dark Lake doesn't pass the smell test. Review of the U of M field survey data demonstrates that wild rice cover at Dark Lake wasn't exceptionally sparse. On September 5, 2013, Dark Lake had 12.8% wild rice cover and 11.8 stems per square meter. Ranked by the percentage of wild rice cover, Dark Lake was not peculiarly sparse; 67 sampling events below it and 36 individual water bodies where wild rice was present had lower rates of wild rice cover.[196] In excluding Dark Lake from its list of wild rice waters, MPCA knew that wild rice observed in Dark Lake was mature and appeared healthy.[197]

Even more salient, MPCA knew that Minntac tailings basin discharge since the mid-1960s had impacted sulfate levels in Dark Lake; sulfate measured in the field survey of Dark Lake averaged 175 mg/L, more than 17 times higher than Minnesota's sulfate standard of 10 mg/L.[198] If wild rice in Dark Lake did not currently appear abundant, MPCA need look no farther than the failure to control sulfate pollution from Minntac to understand the cause.

Even more troubling, the MPCA's proposed list of identified wild rice waters excludes the Upper Partridge River east of Colby Lake, the wild rice water that would be in closest proximity to the proposed PolyMet copper-nickel mine and potential seepage and discharge of sulfate from mine pits and mine site waste storage.[199] Both PolyMet and Great Lakes Indian Fish and Wildlife Commission (GLIFWC) maps document the presence of wild rice in the Upper Partridge River, immediately downstream of the proposed PolyMet mine.[200] The EPA's comments on the

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[193] WaterLegacy, Minntac Tailings Basin Draft Permit Comments, Dec. 23, 2016, p. 11, Exhibit 68; *see also* MPCA, Minntac Tailings Basin Aerial Photo from Draft Permit, Exhibit 69.
[194] U of M Field Survey Data for MPCA (pertinent columns sorted by water body), Feb. 6, 2015, Exhibit 70.
[195] MPCA SONAR, p. 44.
[196] U of M Field Survey Data for MPCA (pertinent columns sorted by wild rice coverage), Feb. 6, 2015, Exhibit 70A. Sorting by average stems per square meter has a similar result; 61 sampling events below it and 36 individual water bodies where wild rice was present had lower stem counts.
[197] MPCA (G. Blaha) Emails re Dark Lake 9/5/2013 Survey Update, Sept. 6, 2013, autop. 1, Exhibit 71.
[198] U of M Field Survey Data (sorted by water body), *supra*, Exhibit 70. Porewater sulfide also averaged 156 µg/L, above the MPCA's proposed sulfide threshold.
[199] MDNR et al. PolyMet NorthMet Final EIS, Figure 4.2.2-1 Watersheds Map, Nov. 2015, Exhibit 72.
[200] PolyMet, 2009 Wild Rice and Sulfate Monitoring and 2010 Wild Rice and Water Quality Monitoring Report excerpt maps, autop. 8, 16, Exhibit 73; GLIFWC, Comments on Draft Staff Recommendations Waters Used for the Production of Wild Rice – Partridge and Embarrass Rivers, *supra*, map on autop. 10, Exhibit 62

PolyMet draft EIS in 2010 also specifically cited the presence of wild rice in the Upper Partridge River.[201]

In this case, there is no question that, absent the MPCA's proposed delisting of wild rice waters, the Upper Partridge River would have been protected from sulfate pollution. MPCA's internal documents confirm that, by August 13, 2012, the MPCA had determined, "*The lower portion of the 'upper' Partridge River, from river mile approximately 22 just upstream of the railroad bridge near Allen Junction in the NW1/4, Sec. 15, T58N, R14W to Colby Lake, is a water used for production of wild rice.*"[202]

Although the MPCA's proposed list of wild rice waters includes three segments of the Partridge River, the latitude and longitude for each of these reaches indicates that they are in the "lower" Partridge River, west from Colby Lake and farther downstream of the impacts of sulfate discharge from the proposed PolyMet sulfide mine.[203] The Upper Partridge River is neither identified in the MPCA's table of wild rice waters rejected for listing due to "insufficient information" nor illustrated on the MPCA's public map of wild rice waters.[204] The SONAR does not mention, let alone explain why the water used for production of wild rice closest to the proposed PolyMet mine has been excluded from protection from sulfide discharge.

WaterLegacy doesn't know how many other wild rice waters downstream of existing sulfate dischargers and proposed sulfide mines have been excluded from the MPCA's proposed list of wild rice waters. Whether this exclusion is intentional, inadvertent or simply due to the limits of a listing process which does not consider evidence case-by-case when the threat to wild rice is imminent, the failure to list critical wild rice waters downstream of the Minntac and proposed PolyMet mine facilities highlights deficiencies of the MPCA's proposed rule. Changing Minnesota's existing designation of waters protected from sulfate pollution when wild rice is present to an arbitrary and exclusive list of wild rice waters is unreasonable, unnecessary, capricious, and inconsistent with the MPCA's delegated authority under the Clean Water Act and would fail to protect the use of waters for wild rice to benefit wildlife as well as human beings.

Changes to MPCA Proposed Rule Sections

The following sections of the MPCA's proposed rule must be rejected as unnecessary, unreasonable and inconsistent with Clean Water Act requirements:

> Proposed phrase in **Minn. R. 7050.0130, Subp. 6c** (line 2.3) stating "and are identified in part 7050.0471," which sets an arbitrary limit excluding hundreds if not thousands of "wild rice waters." Water Legacy proposes either to place a period after the words "paragraph (b)"

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[201] U.S. EPA, Comment on PolyMet Draft EIS, *supra*, Exhibit 11 at p. 15, autop. 19.
[202] MPCA, Draft PolyMet WR Waters, *supra*, Exhibit 53, autop. 2 and map at autop. 13.
[203] Excerpt from MPCA Wild Rice Development Spreadsheet, *supra*, Exhibit 59, providing latitude and longitude of proposed Partridge River wild rice waters, Maps of (Lower) Partridge River locations by longitude and latitude, Exhibit 74.
[204] MPCA's listed and "insufficient information" wild rice waters are shown in MPCA's Wild Rice Development Spreadsheet, Oct. 20, 2017, *supra*, Exhibit 59. See also MPCA's maps and listing at https://public.tableau.com/profile/mpca.data.services#!/vizhome/wild_rice_v4/Story?publish=yes

on line 2.3 or to change the phrase after "paragraph (b)" to read " ~~and are~~ including wild rice waters identified in parts 7050.0470, subp. 1 and 7050.0471."

Proposed deletion of **Minn. R. 7050.0220, Subparts 3a (31)** (lines 3.15 to 3.16), **4a (31)** (lines 4.10 to 4.11), **5a (19)** (lines 5.7 to 5.8), **6a (14)** (lines 5.22 to 5.23) removing existing limit for sulfates of 10 mg/L where "wild rice present." WaterLegacy would not object to using the phrase "in wild rice waters" in place of the phrase "wild rice present" if the definition of "wild rice waters" were changed as proposed immediately above.

Proposed phrase "4D when applicable to a wild rice water listed in part 7050.0471" arbitrarily limiting protection of water quality standards to certain wild rice waters in proposed rule change for **Minn. R. 7050.0220, Subp. 1 (B)(1)** (lines 2.19 to 2.20), **(B)(2)** (lines 2.22 to 2.23), **(B)(3)** (line 3.3), **(B)(4)** (line 3.5); Subp**. 3a** (lines 3.8 to 3.9); **Subp. 4a** (line 4.3); **Subp. 5a** (lines 4.20 to 4.21); **Subp. 6a** (line 5.14). If MPCA's equation is rejected, "4D" waters also need not be specified.

6) MPCA's proposed rule stating criteria by which wild rice waters can be added in future rulemaking is unnecessary, arbitrary and provides no benefit to those seeking to protect wild rice from sulfate pollution.

The MPCA's proposed rule section requiring that the commissioner must solicit evidence that supports identifying additional wild rice waters as part of triennial review[205] is, at best, superfluous.

The triennial review process is mandated by the Clean Water Act and its implementing regulations. Federal regulations already require that, at least once every three years, States must hold public hearings for the purpose of reviewing applicable water quality standards. In this process, "Any water body segment with water quality standards that do not include the uses specified in section 101(a)(2) of the Act shall be re-examined every three years to determine if any new information has become available." Further, if new information indicates that a Section 101(a)(2) use such as a wildlife use is attainable, "the State shall revise its standards accordingly."[206]

As compared with having no language at all, the proposed rule adds *no* requirements that would increase the likelihood that additional wild rice waters would be listed in rulemaking. It would provide no benefit to citizen stakeholders or tribal rights holders who seek to protect wild rice.

More troubling, the MPCA's proposed text on triennial review perpetuates the arbitrary and unscientific barriers to listing wild rice waters that were described in the preceding section and provides a particular barrier to acceptance of tribal oral histories. MPCA's proposed Minnesota Rule 7050.0471, Subpart 2 should be rejected in its entirety as unnecessary, unreasonable and inconsistent with the protection of wild rice from sulfate pollution.

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[205] MPCA proposed Minn. R. 7050.0471, Subp. 2 (lines 11.18 to 12.6).
[206] 40 C.F.R. §131.20(a).

The MPCA's removal of designated uses of Minnesota waters for the production of wild rice by excluding all waters where wild rice is present that are not on its list is not "saved" by the triennial review provisions. The MPCA has used this provision to underscore that - irrespective of evidence - it will not add any wild rice water prior to additional rulemaking.[207]

Although the MPCA's proposed text requires triennial solicitation of evidence for identifying additional wild rice waters, it neither requires rulemaking at any future time nor describes any situation where the MPCA would be required to list an additional wild rice water.[208] MPCA's SONAR makes it clear no one should expect new rulemaking to add wild rice waters: "Amending water quality standards is a complicated, time consuming, and resource-intensive process and a number of factors determine when the MPCA proposes rulemaking."[209] To ensure that nobody would think that listing acceptable evidence of wild rice waters might create an obligation to list an additional wild rice water, the MPCA has also insisted that types of information the Agency will seek "are not criteria that automatically identify a water as a wild rice water."[210] In fact, any additional wild rice water proposed would require a Statement of Need and Reasonableness.[211]

As discussed in the preceding section, there is no scientific basis for requiring a cumulative total of at least two acres of wild rice in order to identify a water body where wild rice provides a benefit to wildlife. The concept that a "wild rice beneficial use" can only be demonstrated by showing human harvest or the "use of the grain for food for wildlife" suggests that an undefined something beyond the fact that wild rice was present must be proved, [212] creating yet another barrier to the listing of wild rice waters.

The way in which the proposed triennial review describes written or oral histories provides yet one more reason to reject this proposed text. Oral histories of wild rice harvest are particularly salient to protection of tribal Treaty resources and are often referenced in tribal comments. Although the SONAR[213] and MPCA's hearing presentations may suggest that MPCA "recognizes the validity of written or oral histories about wild rice," the proposed rule text belies this assertion. Written or oral histories about wild rice are only "acceptable" as evidence if they "meet the criteria of validity, reliability, and consistency."[214] No other form of evidence must meet these criteria to be considered "acceptable."

This "triennial review" provision is at best ineffectual and, at worst, an impediment to protection of additional wild rice waters and an unfortunate disrespect of oral histories. It should be rejected as unnecessary and unreasonable.

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[207] MPCA, SONAR pp. 58-59
[208] MPCA proposed Minn. R. 7050.1471, Subp. 2.
[209] MPCA, SONAR, p. 59.
[210] *Id.*, p. 63.
[211] *Id.*
[212] Proposed Minn. R. 7070.0471, Subp. 2 (lines 11.20 to 11.24) states "The evidence must demonstrate that the wild rice beneficial use exists or has existed on or after November 28, 1975, in the water body, such as by showing a history of human harvest or use of the grain as food for wildlife."
[213] MPCA, SONAR, p. 62.
[214] MPCA proposed Minn. R. 7050.0471, Subp. 2, Item A.

Changes to MPCA Proposed Rule Sections

The following sections of the MPCA's proposed rule must be rejected as unnecessary, unreasonable and inconsistent with Clean Water Act requirements:

> Proposed subpart **Minn. R. 7050.0471, Subp. 2** (lines 11.18 to 12.6) should be rejected in its entirety.

7) MPCA's proposed implementation mechanisms for its sulfate equation are biased against protection of wild rice and inconsistent with any effective implementation of water quality standards. They are neither needed nor reasonable and conflict with the MPCA's delegated authority under the Clean Water Act.

MPCA's proposed implementation mechanisms for its sulfate equation are biased against protection of wild rice. They protect dischargers rather than wild rice under low-flow conditions. Although the MPCA has acknowledged that maintaining a seasonal limit on sulfate is inconsistent with scientific research, annual averaging of pollution levels and allowance of years of exceedance is unprecedented and inconsistent with application of chronic water quality standards under the Clean Water Act. The proposed sampling by dischargers invites manipulation, exacerbating the unprotective nature of an equation allowing elevated sulfate discharge in the presence of iron.

In addition, MPCA's proposed methods for divergence from equation-based standards are one-sided, facilitating implementation of a less-stringent water quality standard but not a more-stringent limit. The proposed rules contain a prohibition on setting wild rice sulfate limits if the commissioner determines that wild rice beneficial use won't be harmed. This provision has the potential to undermine the application of any water quality standard at all. In its supporting documents, MPCA seems to invite variances and predict years of delay, suggesting that the proposed rules are intended to continue the State's practice and policy of avoiding the imposition of controls on sulfate discharge irrespective of adverse impacts on wild rice and aquatic ecosystems.

None of these provisions were suggested by the Session Law authorizing the rulemaking. Most of these provisions were never discussed with the Wild Rice Standards Study Advisory Committee. Many are inconsistent with Clean Water Act regulations and guidance as well as unprecedented in Minnesota law.

Low Flows

First, the MPCA's proposed rules adopt a novel rule undermining the protection of wild rice from sulfate under low-flow conditions. Under Minnesota water quality standards, point and nonpoint sources of water pollution "shall be controlled so that the water quality standards will be maintained at all stream flows that are equal to or greater than the 7Q10 for the critical month or months unless another flow condition is specifically stated as applicable in this chapter." Minn. R. 7050.0210, Subp 7.[215] A 7Q10 is the lowest seven-consecutive-day average in 10 years.

[215] A thirty-day ten-year flow (30Q10) is allowed under Minnesota rules for ammonia discharge. Minn. R. 7053.0205, Subp. 7, Item B; 7053.0135, Subp. 4. A122Q average over the summer months is allowed in

Requiring that water quality standards be maintained at the "7Q10" means that, even with low dilution based on the lowest 7-day flow in a 10-year period, the concentration of the pollutant won't be exceeded. For a small stream, the 7Q10 might be zero, so no dilution at all might be applicable to relax the application of a pollution standard.

Protection of fish, aquatic biota, wildlife or recreational uses from pollutants under low-flow conditions is part and parcel of Clean Water Act regulations requiring that water quality criteria protect designated uses.[216] EPA guidance explains, "To ensure that adopted criteria are protective of the designated uses, states and tribes generally establish critical low-flow values to support implementation of the applicable criteria through such programs as NPDES permitting."[217] Under the Clean Water Act, appropriate low-flow values are important to protect designated uses, "Low flows in the receiving water typically aggravate the effects of effluent discharges because, during a low-flow event, there is less water available for dilution, resulting in higher instream concentrations of pollutants."[218] EPA has generally approved a 7Q10 value to implement chronic criteria, and has also approved a "4B3" value, representing the lowest four-consecutive-day average flow event expected to occur within three years.[219]

The MPCA's proposed rule for control of sulfate would apply a "365Q10," allowing dilution based on the annual average ten-year flow.[220] Uniquely, discharges of sulfate in sewage, industrial waste or other wastes affecting wild rice waters would be able to relax the applicable pollution standard to take into dilution averaged over an entire year.[221]

In practice, the MPCA would allow every sulfate discharger to use year-round dilution based on averaging of snow melt and other highest water flow conditions even if the discharge were taking place during the driest week of the year, when far less flow would be available to dilute sulfate pollution. MPCA's proposed rule would relax pollution limits based on annual average flow even in shallow streams, common natural habitats for wild rice, which may have little or no flow available to dilute pollution.

The MPCA's proposal to use a dilution rate based on annual average flows would make application of sulfate criteria in discharge permits less stringent. This unprecedented dilution allowance would conflict with Clean Water Act regulations and guidance and fail to protect the designated use of waters for growth of wild rice.

Annual Average Sulfate

Current Minnesota law limiting sulfate to 10 mg/L in waters where wild rice is present applies to "periods when the rice may be susceptible to damage by high sulfate levels." Minn. R.

reservoirs, where the volume of water and residence time is controlled. Minn. R. 7050.0150, Subp. 4, Item W.

[216] 40 C.F.R. §131.11(a). State implementation policies pertaining to low flows are specifically subject to EPA review and approval under the Clean Water Act. 40 C.F.R. §131.13.

[217] EPA, Water Quality Standards Handbook, Ch. 5: General Policies, EPA 820-B-14-004 Sept. 2014, p. 11, https://www.epa.gov/sites/production/files/2014-09/documents/handbook-chapter5.pdf

[218] *Id*.

[219] *Id*., p. 13.

[220] MPCA proposed definition in Minn. R. 7050.0130, Subp. 2a and Minn. R. 7053. 0135, Subp. 2a, where this definition is incorporated by reference.

[221] MPCA proposed text describing sulfate control requirements in Minn. R. 7050.0224, Subp. 5, Item D and 7053.0205, Subp. 7, Item E incorporates the average annual flow.

7050.0224, Subp. 2. In 2012, MPCA applied this provision to avoid application of an effluent limit based on the10 mg/L sulfate standard for the Mesabi Nugget iron processing facility. Mesabi Nugget, which accumulated sulfate and other pollutants in a huge pit, was issued a permit that restricted discharge from this pit during spring and summer months, rather than applying an effluent limit for sulfate to protect wild rice.[222] WaterLegacy objected to MPCA's plan to allow seasonal release of elevated sulfates rather than require pollution prevention and control.

As required by the 2011 legislation, the Wild Rice Sulfate Standards Study included research to determine during what times wild rice was susceptible to sulfate discharge. University of Minnesota scientists concluded that, regardless of cold temperatures, a vast majority of the sulfate added to sediments reacts to form sulfide.[223] The MPCA accepted this finding; "The current scientific understanding is that sulfide in the porewater affects wild rice health and that the creation of this sulfide occurs throughout the year . . .the phrase "periods when the rice may be susceptible" is no longer scientifically supported. Essentially, wild rice is susceptible at all times.[224]

Research demonstrating that wild rice is susceptible to sulfate discharge and formation of sulfide year-round should preclude a permitting strategy, like that used for Mesabi Nugget, to allow elevated sulfate discharge during the fall and winter to avoid the wild rice sulfate standard. But the MPCA's proposal to use an annual average concentration of sulfate to determine if a numeric sulfate standard is exceeded[225] could similarly reduce the need for strict compliance. Applying an annual sulfate average means that on any given day or in any given month sulfate concentrations in a wild rice water could be higher than the numeric limit, "as long as the value averaged over the whole year is below the numeric sulfate standard."[226]

MPCA attempts to justify use of an annual average since sulfate is not a direct toxicant upon wild rice.[227] However, other pollutants controlled by water quality standards are not direct toxicants. Discharge limits for mercury, for example, are set to prevent the methylation of mercury and the bioaccumulation of mercury in the aquatic food chain. Mercury monitoring and effluent limits are generally based on a daily maximum and a calculated monthly

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[222] *In the Matter of the Reissuance of NPDES/SDS Permit No. MN0067687, Including a Variance from Water Quality Standards, to Mesabi Nugget Delaware, LLC, St. Louis County Hoyt Lakes, Minnesota*, Findings of Fact Conclusions of Law and Order, Oct. 24, 2012, p. 15, Exhibit 75. The MPCA also granted Mesabi Nugget a variance from water quality standards for hardness, bicarbonates, total dissolved salts and specific conductance, which variance was overturned by the EPA as a result of litigation by the Fond du Lac and Grand Portage Bands, WaterLegacy and MCEA. *See* U.S. EPA Letter to MPCA re EPA Disapproval of Variance for Mesabi Nugget Delaware, LLC, July 2, 2014, Exhibit 76. The Mesabi Nugget plant has not operated since January 2015, and the permit has not been updated.
[223] W. DeRocher, N. Johnson, *Temperature Dependent Diffusion Rates of Sulfate in Aquatic Sediments*, Report Dec. 31, 2013, available at ftp://files.pca.state.mn.us/pub/wild_rice/Johnson_Sediment_Incubation_Experiment/Temperature_Dependent_Diffusion_Rates_of_Sulfate_in_Aquatic_Sediments_final.pdf
[224] MPCA, SONAR, p, 20.
[225] MPCA proposed Minn. R. 7050.0224, Subp. 5, Item B.
[226] MPCA, SONAR, p. 79.
[227] MPCA, TSD, p. 91.

average.[228] EPA guidance generally recommends that water quality criteria for chronic water quality standards be implemented with an averaging period no longer than 30 days.[229]

MPCA further proposes that its implementation of any equation-based wild rice sulfate limit would include no maximum daily sulfate concentrations, since to do so would be "over-protective" or "overly restrictive."[230] In an NPDES permit, MPCA proposes that effluent limits for sulfate "will typically be expressed as a 12-month moving total mass," rather than with concentration limits.[231] We have been unable to identify any other modern water quality standard applied in this manner.

With a mass-based annual limit, a sulfate discharger could discharge hundreds or even a thousand of parts per million of sulfate in wild rice waters during a time of low water flow, threatening wild rice sustainability and aquatic life. The MPCA's proposal for annual averaging and mass based limits is inconsistent with Clean Water Act guidance and with the protection of the designated use of waters for wild rice.

Years of Violation

MPCA's proposed rules discussed so far would allow a higher level of sulfate than that suggested by the calculated sulfate standard due to the use of annual flow averaging. They would further would reduce the need for sulfate controls by using an annual average for compliance, rather than the customary and recommended daily maximum and monthly average. In addition, even if sulfate was elevated over an entire year, the proposed rules would only consider this an "exceedance" of the standard if the discharger violated the wild rice sulfate standard for more than one year out of ten.[232]

Minnesota rules describe "frequency" as the number of times that a water quality can be exceeded in a specified period of time without causing acute or chronic toxic effects on an aquatic community, human health or wildlife.[233] There is no scientific data supporting the MPCA's recommendation that a wild rice sulfate standard could be exceeded for a full year every ten years without harming wild rice.

The MPCA has assumed that porewater sulfide would diminish if sulfate in surface water is reduced after a year,[234] but there is no experimental or field evidence to confirm that assumption. The MPCA cited Dr. Pastor's 2016 mesocosm research[235] where three plants in two mesocosms

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[228] See for example, Aitkin Agri-Peat Inc. – Cromwell Location NPDES/SDS Draft Permit MN0055662, June 2013, Excerpts, Exhibit 77.
[229] EPA Water Quality Standards Handbook Ch. 3: Water Quality Criteria, EPA 823 B 17 001 2017, p. 15, available at https://www.epa.gov/sites/production/files/2014-10/documents/handbook-chapter3.pdf
[230] MPCA, TSD, p. 94; MPCA, SONAR, p. 80.
[231] MPCA, SONAR, p. 105.
[232] MPCA proposed rules Minn. R. 7050.0224, Subp. 5, Item B.
[233] Minn. R. 7050.0218, Subp. 3, Item AA.
[234] MPCA, TSD, p. 95.
[235] MPCA, TSD, p, 96 *citing* Pastor, J. 2017b, Progress Report on Experiments on Effects of Sulfate and Sulfide on Wild Rice, June 28, 2017, Report to the Fond du Lac Band of Lake Superior Chippewa, Cloquet, Minnesota. That Progress Report, provided with Dr. Pastor's Technical Review, *supra*, as Attachment E, described experiments designed to test the MPCA's theory that iron mitigated sulfide toxicity to wild rice resulting from elevated sulfate. The Progress Report concluded at p. 3, "Iron additions may partly ameliorate sulfide toxicity to seedlings in spring, but precipitation of iron sulfide

out of five had plants germinate when sulfate additions stopped for a year to claim that "it is unlikely that one year of elevated sulfate will have will have a long-term negative effect on wild rice growth and reproduction, so long as sulfate concentrations do not remain elevated above the allowable annual average for multiple years in a row."[236]

The MPCA did not explain how the germination (not even seed production) of three plants in less than half of a tiny sample in one year demonstrated the absence of adverse effects on a wild rice population or how the complete cessation of sulfate loading to a tank would compare to ongoing sulfate discharge, which would continue, even if a facility complied with its permit in future years. The MPCA cited no experimental or field data to support its assertion, "A waterbody's wild rice population will be able to persist at a high average stem density if the annual average sulfate concentration does not exceed the calculated standard very often."[237] MPCA then admitted it had little basis to define what "very often" means: "Because of the limitations of available environmental knowledge, the severity of an excursion cannot be rigorously related to the impact on a wild rice population. Nevertheless, MPCA expects that a wild rice population will not be significantly harmed by an exceedance that occurs only once in ten years."[238]

Dr. John Pastor reviewed the MPCA's claims, allegedly based on his mesocosm data, that concentrations of sulfate above the allowable standard in one year out of ten would not have a significant impact on wild rice populations in the long run. He disagreed with the MPCA's inference that his experiments support its conclusion:

> While I agree that it is important to determine the allowable frequency and degree of excursions to avoid impacts on wild rice, I must also point out that our experiments were not designed to determine what these might be. At present, a one-in-ten year allowable excursion is premature and requires further experiments designed specifically to determine what level of excursions does not harm the long term sustainability of wild rice populations.[239]

The Clean Water Act requires that implementation of water quality standards, including the length and frequency of allowable excursions, be set to assure the protection of the designated use of waters. There is no precedent and no federal guidance that would endorse one year out of ten years of excursion above a water quality standard, particularly when the exceedance itself would have resulted from year-long average pollution above the standard. MPCA's unsupported "expectations" that negative effects will not be "long-term" or that a population will not be "significantly harmed" are neither appropriate under Minnesota rule describing "frequency" nor consistent with the Clean Water Act. MPCA's proposal to allow standard must be rejected as unscientific, unreasonable and inconsistent with the Agency's delegated authority under the Act.

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plaques on roots during the flowering and seed production period of wild rice's life cycle appears to block uptake of nitrogen, leading to fewer and smaller seeds with reduced nitrogen content." Neither the MPCA's TSD nor its SONAR mention these tests of the iron mitigation hypothesis.

236 MPCA, TSD, p. 96. *See also* MPCA, SONAR, pp. 82-83.

237 MPCA, SONAR, p. 83.

238 *Id*.

239 Pastor Technical Review 2017, *supra*, p. 5.

Sampling by Dischargers
MPCA has proposed that, at least for new or expanding dischargers, the discharger rather than the Agency will be responsible for selecting sediment sample areas and conducting sampling. This implementation proposal is an invitation to mischief and should be rejected as unreasonable and unlikely to protect wild rice.

These comments have previously highlighted the degree of variability in sampling results for sediment iron and sulfide in the University of Minnesota field survey.[240] Even when researchers were unbiased and had no financial interest in the outcome of the sampling, a calculated "protective" sulfate concentration based on sediment sampling could allow more than eight times as much sulfate as would be allowed if a sample were taken on another date in the same water body. If samples were taken in different locations within a waterbody, the variability could exceed two orders of magnitude.[241] Sulfate concentrations in surface water are far less variable.[242]

Due to the potential that dischargers could pre-test and select sampling dates and locations to provide the least stringent calculated sulfate standard, members of the Wild Rice Standards Study Advisory Committee asked MPCA at the February, 2017 meeting who would be doing the sampling to set "protective" sulfate standards. MPCA manager Shannon Lotthammer assured the Committee that the MPCA would be doing most of the sampling and that the scrutiny will be there.[243]

However, under the proposed rule, at least for new or expanding discharges, the discharger not the MPCA will be responsible for sediment sampling and analysis.[244] The MPCA acknowledges, "The process of selecting the sediment sample areas can be very complex in a natural setting . . The sampler must use best professional judgement (sic.) to select sample areas that accurately characterize the wild rice water."[245]

Where with millions of dollars at stake, the best professional judgment of a consultant hired by a discharger would be to select a sediment sample date and area to maximize the calculation of a high "protective" sulfate concentration. Sediment sampling by dischargers further reduces the likelihood that the MPCA's proposed sulfate equation would protect wild rice.

Avoiding the Sulfate Standard
In addition to the provisions described above each of which make potential application of the MPCA's proposed equation-based standard less stringent, the MPCA's proposed rules have three provisions to facilitate avoidance of the sulfate limit. Each is inconsistent with the Clean Water Act and biased against the protection of wild rice from sulfate pollution.

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[240] *See* discussion pages 24-25, *supra*.
[241] Roberts Memorandum 2017, *supra*, pp. 3-4 and Attachment 3.
[242] *See* discussion page 24, *supra*; MPCA, Which data set should we use? *supra,* Exhibit 46, p. 5.
[243] Commenter was present and took detailed notes at this February 15, 2017 meeting.
[244] MPCA proposed rule Minn. R. 7050.0224, Subp. 5, Item B (1)(c) and d (2) and Item E describe the sampling needed and incorporate by reference the Sampling and Analytical Methods for Wild Rice Waters. MPCA, SONAR, p. 84 describes discharger responsibility for sampling.
[245] *Id*., p. 86.

Minnesota's existing rules for water quality standards require proof that a modification of a water quality standard is "more appropriate than the statewide or ecoregion standard for a particular water body, reach, or segment" before a site-specific standard can be applied.[246] MPCA's proposed rule for its wild rice sulfate equation would permit a less stringent "alternative" standard without requiring compliance with Minnesota's existing rule.

The MPCA could establish an alternative *less stringent* sulfate standard any time data demonstrates that sulfide concentrations in pore water are 120 µg/L or less when surface water concentrations are at the calculated sulfate standard.[247] This less stringent standard would be applied based only on the assumptions in MPCA's formula, without any consideration of the condition of the wild rice.

MPCA explains that its "alternative" standard provision responds to "false positives" in its equation and would forego the requirements for establishing a site-specific standard. A site-specific standard "requires detailed analysis, public notice and comment, and EPA approval," but all of these activities "are beyond the analysis and approval associated with determining the protective sulfate numeric value when porewater sulfide is below the protective threshold proposed in this rulemaking."[248]

Although the MPCA states that its equation creates the same number of "false negatives" as false positives,[249] MPCA's proposed rule provides no "alternative" standard automatically making a sulfate limit *more stringent* whenever actual sulfide porewater exceeds 120 µg/L despite sulfate concentrations above the calculated "protective" level.

The MPCA's next rule provision to undermine the application of any effective limits on sulfate discharge allows the commissioner to apply a different level of proof to set a site-specific sulfate standard than that required for any other water quality standard. Rather than presuming that statewide equation limit applies, MPCA's proposed rule would allow application of a *less stringent* sulfate standard at a specific site if "the beneficial use is not harmed."[250] Even if there were clear agreement about what is meant by a current showing that wild rice "is not harmed" and even if adverse impacts on wild rice from sulfate pollution were always immediately evident – neither of which are true – this proposed rule would erode the application of water quality standards by shifting the burden of proof and requiring case-by-case demonstration of harm in order to limit pollution.

Unsurprisingly, MPCA's proposed rules contain no corresponding provision allowing the MPCA to set a *more stringent* sulfate standard any time the commissioner finds that wild rice is harmed by sulfate concentrations at or below the calculated "protective" sulfate limit.

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[246] Minn. R. 7050.0220, Subp. 7, adopted consistent with Clean Water Act regulations 40 C.F.R. §131.11(b)(1)(ii).
[247] MPCA proposed rule Minn. R. 7050.0224, Subp. 5, Item B (2).
[248] MPCA, SONAR, p. 90.
[249] *Id*., p. 79.
[250] MPCA proposed rule Minn. R. 7050.0224, Subp. 5, Item C.

Most troubling, MPCA's proposed rules say that if the MPCA determines that a polluter's effluent will not affect "wild rice beneficial use in the wild rice water" the commissioner "*must not establish a water-quality based effluent limitation*" for sulfate to protect wild rice.[251] This type of language in a water quality standard is unprecedented and unreasonable. In fact, it undermines the very concept of water quality standards to control polluted discharge.

The fundamental premise of the Clean Water Act is that states and authorized tribes must set and apply water quality standards to control effluent in order to protect the designated uses of water bodies.[252] A water quality standard, by its nature, resolves the question in law and in practice of whether effluent exceeding that standard will fail to protect a designated use. Although a discharger can challenge the reasonableness of its permit, the question of whether a standard is more protective than necessary is not open to challenge each time a discharger receives a pollution limit.

This is not an academic question. Throughout this rulemaking process and in hearings before the Administrative Law Judge, the Minnesota Chamber of Commerce and industrial dischargers have advocated to eliminate Minnesota's existing 10 mg/L wild rice sulfate standard and apply no other sulfate limit to discharge to protect wild rice.[253] MPCA's proposed rules would give dischargers unprecedented ability to weaken or entirely avoid the new wild rice sulfate standard. Such provisions are unreasonable, inconsistent with the State's authority under the Clean Water Act and arbitrarily and inappropriately biased against the protection of the designated use of waters for wild rice.

Implementation Intent

MPCA has not proposed rule language explicitly facilitating variances or delaying the implementation of its proposed wild rice sulfate standard. However, the text of the SONAR appears both to encourage variances and to reassure mining facilities that they need not be concerned about imposition of sulfate limits in the near future.

The MPCA's SONAR states that, although variances have not been common in the past, "this is likely to change." The SONAR then seems to predetermine the outcome of dischargers' applications for variances, stating "the MPCA recognizes that sulfate treatment is currently prohibitively expensive for many dischargers" and that industrial and municipal dischargers may apply for variances from the standard "until economically feasible treatment systems can be designed and constructed."[254] Although no evidence has yet been adduced, the MPCA seems to have already decided that treatment is prohibitive and not economically feasible.

For municipal dischargers, the MPCA appears poised to approve variances as a matter of routine. MPCA has promised a "streamlined application and review process," that individual applications "will not require the level of staff effort normally required for a variance review" and that little more information will be needed to finalize a variance decision since much of the information needed by MPCA to decide on these variances is "already known."[255]

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[251] MPCA proposed rule Minn. R. 7053.0406, Subp. 1 (emphasis added).
[252] *See e.g*. 33 U.S.C § 1251 *et seq*.; 33 U.S.C. §§1311(a), 1313(c), 1319(a), 1342(b); 40 C.F.R. §131.3.
[253] This position was clearly articulated in testimony in St. Paul on October 23, 2017.
[254] MPCA, SONAR, p. 107.
[255] *Id*., at 109.

The MPCA has also sought to reassure mines and related facilities that the Agency is sympathetic to "the potential for costs incurred by any business to affect shareholders, employees, purchasers of the product, and local communities" and that actually limiting sulfate discharge will not happen soon: "Obtaining sediment data, calculating the standard, establishing effluent limits, reissuing permits, and all the activities associated with permit reissuance will require many years."[256]

The MPCA's biased and unprotective implementation rules and the intent expressed in documents supporting the proposed rule undermine the application of sulfate standards to control sulfate discharge. The following proposed rule provisions should all be rejected as unreasonable, unnecessary, inimical to protection and protection of wild rice designated uses, and outside the MPCA's delegated authority under the Clean Water Act:

> Proposed rule **Minn. R. 7050.0130, Subp. 2a** (lines 1.6 to 1.10) and **Minn. R. 7053.0135, Subp. 2a** (lines 66.11-66.12) defining 365Q10 flow with once in ten-year recurrence to make sulfate standards less stringent due to an excessive calculation of dilution.
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> Proposed rule **Minn. R. 7050.0224, Subp. 5** (specifically lines 7.22 to 7.24, 8.13 to 8.14, 8.18 to 9.12) proposing a rule for exceedance that allows excessive pollution for more than a year, implementation methods biased against the protection of wild rice that make application of sulfate standards less stringent or prevent their application, and error-prone sampling of parameters by dischargers.
>
> Proposed rule **Minn. R. 7053.0205, Subp. 7, Item E** (lines 66.22 to 67.2) applying a flow rate that makes sulfate standards less stringent and cross-referencing the rule that allows extended exceedances.
>
> Proposed rule Minn**. R. 7053.0406, Subp. 1** (lines 67.6 to 67.10) biasing implementation against application of a sulfate water quality standard.

8) MPCA's proposal to remove protection of thousands of wild rice waters from material impairment or degradation as a result of factors other than sulfate pollution - such as hydrologic alteration - is baseless and inconsistent with the rule's history, its stated purpose, and the Clean Water Act.

Minnesota's existing wild rice water quality standard includes a narrative standard to protect wild rice and its aquatic habitat from impairment or degradation. On its face, this narrative standard applies to all Minnesota wild rice waters. MPCA's proposal to restrict protection of the wild rice narrative standard to only a very limited number of wild rice waters lacks any basis in technical or scientific data and analyses, is arbitrary, unreasonable, and inconsistent with the Clean Water Act, and would fail to protect the designated use of waters for wild rice under a number of man-made alterations.

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[256] *Id.*, at 148. See also p. 118, "The process of sampling and calculating the applicable sulfate standard will be an ongoing process the MPCA expects to take many years to complete."

Under the Clean Water Act, water quality standards "consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses." 33 U.S.C. §1313(c)(2)(A). Water quality criteria may be "expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use." 40 CFR § 131.3(b). The Supreme Court explained in *PUD No. 1 of Jefferson County v. Washington Dep't of Ecology*, 511 U.S. 700, 715-716, 114 S. Ct. 1900 (1994), that both designations of the uses of water and "criteria," including those expressed in "broad, narrative terms," may be needed to protect a designated use.

The Court also explained that a sufficient alteration of water quantity could destroy all of its designated uses. Citing the Clean Water Act's "definition of pollution as "the man-made or man induced alteration of the chemical, physical, biological, and radiological integrity of water,"[257] the Court found that the Act was intended to protect both "the physical and biological integrity of water." *Id.*, 511 U.S. at 719.

Minnesota's existing wild rice standard states at Minnesota Rules 7050.0224, Subp. 1:

> The numeric and narrative water quality standards in this part prescribe the qualities or properties of the waters of the state that are necessary for the agriculture and wildlife designated public uses and benefits. Wild rice is an aquatic plant resource found in certain waters within the state. The harvest and use of grains from this plant serve as a food source for wildlife and humans. In recognition of the ecological importance of this resource, and in conjunction with Minnesota Indian tribes, selected wild rice waters have been specifically identified [WR] and listed in part 7050.0470, subpart 1. The quality of these waters and the aquatic habitat necessary to support the propagation and maintenance of wild rice plant species must not be materially impaired or degraded. If the standards in this part are exceeded in waters of the state that have the class 4 designation, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, detrimental, or injurious with respect to the designated uses.

The MPCA's proposed changes to Minnesota's wild rice standard would remove reference to the ecological importance of wild rice and restrict to only 24 Minnesota wild rice waters the wild rice narrative standard preventing material impairment or degradation of the quality of waters and the aquatic habitat necessary to support the propagation and maintenance of wild rice plant species.[258]

Although MPCA suggests otherwise in its current SONAR,[259] the Agency's post-hearing comments in the 1997 wild rice standard rulemaking did not state that the new narrative standard was applicable only to 24 Minnesota wild rice waters. The MPCA explained that the narrative standard was needed due to declines of natural wild rice throughout the State, not in a handful of

[257] Citing 33 U.S.C. § 1362(19).
[258] MPCA proposed Minn. Rule 7050.0224, Subp. 1 deleting narrative standard and Minn. R. 7050.0224, Subp. 6 excluding most wild rice waters from amended narrative standard.
[259] MPCA, SONAR, pp. 30, 116.

listed waters and specifically referenced the threat posed by hydrologic modifications. This text is excerpted below:

> There is evidence demonstrating a decline in the number and aerial distribution of natural wild rice stands throughout the State of Minnesota. Some of these declines may be attributable to responses to: plant diseases; animal, fish or insect destruction; competition from other aquatic plants; and loss of suitable growing habitat due to the natural succession of the wild rice water bodies. In other instances, these declines may be attributed to human activities resulting from hydrologic modifications or water quality impacts that can affect the habitat conditions necessary for the continued maintenance of this plant species. The proposed amendments which specifically list 24 wild rice waters in Minn. R. 7050.0470 and the wild rice waters narrative standard in Minn. R. 7050.0224 are intended to provide a greater public awareness regarding the ecological importance of wild rice and create a regulatory basis to promote the study of the physical, chemical, and biological factors that are needed to maintain and enhance the continued propagation of this unique plant species.[260]

The MPCA's Technical Support Document also states that it is important to keep in mind that porewater sulfide is not the only environmental variable that affects wild rice. Additional factors, including reduced water transparency, elevated temperature and unfavorable hydrology are also associated with the absence of wild rice.[261]

The wild rice narrative standard may be needed to protect wild rice waters from dams or discharge that flood wild rice beds, thermal pollution that increases water temperature, or nutrients that result in chemical changes that reduce transparency. MPCA's proposed rule change to restrict the wild rice narrative standard to 24 waters would fail to protect wild rice designated use in many other Minnesota wild rice waters that may be threatened by anthropogenic actions other than sulfate discharge. MPCA has provided no technical or scientific justification to restrict application of the narrative standard that protects wild rice.

Proposed rule provisions restricting to only 24 waters the narrative standards protecting wild rice from degradation and impairment are arbitrary, capricious, unsupported by an appropriate basis and inconsistent with the Clean Water Act and should be rejected:

> Proposed deletion of **Minn. R. 7050.0224, Subp. 1** (lines 6.8 to 6.14) and proposed rule at **Minn. R. 7050.0224, Subp. 6** (lines 9.13 to 9.18) arbitrarily excluding most wild rice waters so that they would not be protected from material impairment or degradation.

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[260] *In the Matter of Proposed Amendments to Rules Governing Water Quality Standards, Minn. R. ch. 7050, and Proposed New Rules Governing Water Quality Standards, Standard Implementation, and Nondegradation Standards for Great Lakes Initiative Pollutants in the Lake Superior Basin, Minn. R. ch. 7052,* MPCA Staff Initial Post-Hearing Response Excerpts, Oct. 14, 1997, Exhibit 78.
[261] MPCA, TSD, p. 39.

9) MPCA's failure to evaluate the impact of its proposed rules on eutrophication, aquatic life, methylmercury contamination of fish, and degradation of Treaty resources within tribal Ceded Territories, as compared to enforcement of Minnesota's existing rule is unreasonable, arbitrary, and inconsistent with the Clean Water Act.

If the MPCA were proposing a new water quality standard to protect wild rice by limiting sulfate pollution, the Agency might choose to examine the benefits of new sulfate pollution control to other designated uses of waters, but this analysis would not be required.

However, Minnesota has an existing water quality standard limiting sulfate to 10 mg/L in waters where wild rice is present. The EPA has instructed and the MPCA has repeatedly acknowledged that Minnesota is required to enforce its existing 10 mg/L wild rice sulfate standard under the Clean Water Act.[262] In fact, Minnesota's ability to maintain its legal authority to issue water pollution discharge permits, rather than have dischargers subject to federal control, is contingent on the state's compliance with its Clean Water Act delegated duties and responsibilities.[263]

The record is clear that MPCA's failure to enforce the existing rule is not due to any lack of understanding of the rule's requirements, but rather due to the extraordinary political pressure brought upon the regulatory agency, culminating in legislation actually precluding the MPCA's application of its existing wild rice rule.[264]It is unreasonable, arbitrary and inconsistent with the Clean Water Act for the MPCA to fail to evaluate the effects of its proposed rule as compared with enforcement of Minnesota's existing wild rice sulfate standard of 10 mg/L.

The MPCA's proposed rule would permit elevated sulfate concentrations in waters where sulfate dischargers would otherwise be required to control sulfate to comply with Minnesota's existing 10 mg/L wild rice sulfate standard. In addition to the effects of such elevated sulfate concentrations on wild rice discussed in previous Sections of these comments, elevated sulfate levels have the potential to increase eutrophication of lakes, mortality of aquatic life, and methylmercury contamination of fish, with resulting neurotoxicity to human beings as well as wildlife that eat contaminated fish.

Each of these adverse effects of elevated sulfate has the potential to have a disproportionate effect on low income rural communities and tribal members who rely on wild rice and fish for subsistence and in tribal Ceded Territories, where the existing wild rice sulfate standard, if appropriately enforced, would protect water quality and Treaty resources.

MPCA's failure to analyze each of these potential adverse effects of its proposed rule change is unreasonable and inconsistent with the Clean Water Act and the Agency's own policies.

The MPCA does not dispute that additions of sulfate to water bodies increases sulfide production, resulting in increased release of phosphorus from sediments both as a result of a chemical reaction of sulfide with iron in the sediments and as a result of increased decomposition

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[262] *See* comment discussion, *supra*, and Exhibits 5, 10, 11, 12, 15, 16, 18, 19, 120A, 20B, 20C, *supra*.
[263] *See* 33 U.S.C. §§ 1319(a)(2) and 1342(c)(3); 40 C.F.R. §§123.63, 123.64; WaterLegacy Petition for Withdrawal of Authority, *supra*, Exhibit 15 and Exhibits to the Petition, provided in Exhibit 16, *supra*.
[264] See comment discussion, *supra*, and Exhibits 14, 15, 16, *supra*.

of organic matter.[265] Dr. M. Siobhan Fennessy, an environmental scientist on the MPCA's Peer Review Panel, explained that increased sulfate and sulfate reduction to sulfide results in decomposition of organic matter and increased availability of nutrients such as nitrogen and phosphorus. Dr. Fennessy cautioned that "the focus on sulfide and iron to the exclusion of other sediment compounds oversimplifies the chemistry of these systems."[266]

The impact of increased eutrophication on water quality and aquatic life is summarized in Minnesota rules adopted in an attempt to control nutrient loading from anthropogenic sources:

> "Eutrophication" means the increased productivity of the biological community in water bodies in response to increased nutrient loading. Eutrophication is characterized by increased growth and abundance of algae and other aquatic plants, reduced water transparency, reduction or loss of dissolved oxygen, and other chemical and biological changes. The acceleration of eutrophication due to excess nutrient loading from human sources and activities, called cultural eutrophication, causes a degradation of water quality and possible loss of beneficial uses.[267]

Scientific research has also demonstrated that some aquatic insects upon which the aquatic food chain depends are vulnerable to impacts to sulfate. According to the MPCA, the lowest level at which it has been determined that sulfate may become toxic is 75 mg/L in soft-water conditions. The next most protective sulfate toxicity benchmark used by other jurisdictions is 124 mg/L, which is applied more generally to ambient water conditions.[268] In Northern Minnesota's St. Louis River watershed, the highest sulfate concentrations "are observed in small streams in the immediate vicinity of mining features."[269] Sulfate concentrations from several streams with impairments of biological integrity have exceeded 124 mg/L in at least one sample.[270]

In addition to the effects of sulfate alone, combinations of salts, including sulfate, that result in ionic concentrations above natural background levels can kill sensitive aquatic insects.[271] The MPCA has stated that the EPA benchmark (300 uS/cm) for conductivity should be considered to develop a standard to protect aquatic life in Minnesota streams and has documented locations in the St. Louis River Watershed where conductivity is elevated to the point it threatens aquatic life.[272] Excessive sulfate and/or elevated conductivity in mining-impacted streams (Spring Mine Creek, Wyman Creek) has been identified as a potential stressor resulting in low fish counts and limited aquatic diversity.[273]

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[265] MPCA, TSD, pp. 11, 99.
[266] MPCA Peer Review Panel Summary Report Excerpts, *supra*, Exhibit 38, autop. 6.
[267] Minn. R. 7050.0150, Subp. 4, Item L.
[268] MPCA, St. Louis River Watershed Stressor Identification Report, Dec. 2016 Excerpts, p. 39-40, autop. 11-12, Exhibit 79.
[269] *Id*., p. 37, autop. 9.
[270] *Id*., p. 40, autop. 12.
[271] See U.S. EPA, A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams, (Final Report), EPA/600/R-10/023F, 2011, available at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=233809
[272] MPCA, St. Louis River Watershed Stressor Identification Report, *supra*, Exhibit 79, pp. 33, 35; autop. 5, 7.
[273] *Id*., pp. 22, 35, 40, 286-288, 299-311; autop. 3, 7, 12, 35-37, 48- 60. For Wyman Creek, iron concentrations over five times higher than EPA's aquatic life standard of 1,000 μg/L were also cited as a potential stressor for aquatic life. *Id*., p. 268-269; autop. 17-18.

Finally, research has established that increased sulfide production resulting from sulfate loading can increase the conversion of inorganic mercury to methylmercury, the form of mercury that bioaccumulates in fish. Increased production of methylmercury is a significant concern, given that bioaccumulation of methylmercury in fish is a major cause of water quality impairments in Minnesota.[274]

The harmful effects of methylmercury contamination of fish are well-known. Dr. Margaret Saracino, a Duluth child and adolescent psychiatrist has explained the particular vulnerability of fetuses, infants and children to morbidity resulting from methylmercury exposure:

> When pregnant women eat fish high in methylmercury, the fetus is then exposed to this lipophilic heavy metal. The placenta is not protective and the blood brain barrier is not well formed until after age two years, which makes fetuses, infants and young children most vulnerable to methylmercury's neurotoxic effects. Neurons in the developing brain multiply at a rapid rate and are particularly vulnerable to toxic effects of heavy metals, hence brain damage is more likely to occur during this vulnerable time. Neurotoxicity is also transferred to the infant through breast milk.
>
> The adverse effects of methylmercury depend on timing and amount of exposure. Methylmercury is a strong toxin that influences enzymes, cell membrane function, causes oxidative stress, lipid peroxidation and mitochondria dysfunction, affects amino acid transport and cellular migration in the developing brain. Exposure in utero can cause motor disturbances, impaired vision, dysesthesia, and tremors. Even lower level exposure can result in lower intelligence, poor concentration, poor memory, speech and language disorders, and decrease in visual spatial skills in children exposed to methylmercury in utero. Fetuses, infants, and young children are four to five times more sensitive to the adverse effects of methylmercury exposure than adults.[275]

Research performed by Amy Myrbo, Ph.D., in connection with Dr. Pastor's experimental mesocosms has demonstrated that increased sulfide production resulting from sulfate loading both increases release of inorganic mercury from sediment into the water and increases the proportion of mercury that is converted to toxic methylmercury.[276] Dr. Myrbo found that in mesocosms with sulfate loading of either 100 mg/L or 300 mg/L, methylmercury increased 5.9 times as compared to the control experiment where no sulfate was added.[277] Sulfate loading also increased release of inorganic mercury from sediments to the water, with a maximum increase at sulfate loading of 300 mg/L of 2.2 times over the experimental control.[278]

It has long been suggested that that there is a "sweet spot" where sulfate and sulfide concentrations are optimal for mercury methylation. Dr. Myrbo concluded that there is substantial evidence that sulfide levels above concentrations of 300-3000 μg/L have an inhibitory effect on mercury methylation.[279] The levels of sulfate loading observed in mesocosms and the

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[274] MPCA, TSD, pp. 99-100.
[275] M. Saracino, Summary Opinion regarding Morbidity Associated with Methylmercury Exposure and other Neurotoxic Chemicals Potentially Released by the PolyMet NorthMet Copper-nickel Mine Project, Dec. 7, 2015, p. 2, Exhibit 80.
[276] Myrbo, et al., Increase in nutrients, mercury, and methylmercury as a consequence of elevated sulfate reduction to sulfide in experimental wetland mesocosms (2017*), J. Geophys. Research: Biogeosciences*, 122, Exhibit 81.
[277] *Id*., Table 1, autop. 25.
[278] *Id*.
[279] *Id*., autop. 4.

MPCA's proposed sulfide threshold of 120 μg/L are well within the sweet spot where increased sulfate loading would increase mercury methylation.

An example of potential mercury contamination effects of MPCA's proposed rescission of Minnesota's current 10 mg/L sulfate limit in favor of an equation is provided where the St. Louis River meets Lake Superior. Many reaches of the St. Louis River are impaired due to mercury in fish tissue and/or mercury in the water column.[280] MPCA research shows that walleye fish tissue in the lower St. Louis River, in particular, has significantly higher mercury concentrations than other walleye in the region.[281]

MPCA's calculated "protective" sulfate levels from applying its formula to field survey data for the St. Louis Estuary range from 95.5 mg/L to 241.1 mg/L,[282] levels that are not only up to 24 times higher than Minnesota's 10 mg/L sulfate standard but are also up to 24 times higher than actual sulfate standards in these waters.[283] According to Dr. Myrbo's recent paper, these calculated allowable sulfate concentrations and the sulfide threshold they are based on would be in the sweet spot for maximum conversion of mercury to toxic methylmercury.

In addition to impacts on wild rice presence and abundance,[284] increased sulfate loading under the MPCA's proposed rules would impact nutrients and eutrophication, aquatic ecosystems that support fish, and methylmercury contamination of fish in wild rice waters. These impacts would fall disproportionately on low-income citizens in Northern Minnesota who depend on wild rice and fish for subsistence.

Due to the geographic distribution of Minnesota's remaining wild rice waters - where the existing 10 mg/L sulfate limit would apply absent the proposed rule change - these adverse environmental and health impacts would also fall disproportionately on indigenous people whose culture and subsistence depend on the ability to harvest wild rice and fish. Although the MPCA mapped reservations as "Native American Lands,"[285] the Agency did not analyze the impacts of increased sulfate discharge on tribal Ceded Territories or Treaty resources. A map superimposing Ojibwe/Chippewa Ceded Territories and lands appropriated from or ceded by Dakota peoples is attached with these comments.[286]

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[280] MPCA, Draft 2018 Minnesota Impaired Waters List Excerpt (St. Louis River), Exhibit 82. Complete Draft Impaired Waters List available at https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list

[281] MPCA (B. Monson), St. Louis River Fish Mercury, Feb. 10, 2012, p. 4, Exhibit 83.

[282] *See* MPCA, Field Survey Data with CPSC (sorted by water body), *supra*, Attachment G to Pastor Technical Review 2017, (sites S007-444, S007-206, S006-928).

[283] See Attachment 2 (Field Data CPSC and Actual Sulfate Ratios) to Roberts Memorandum 2017, *supra*, at row 45, St. Louis Estuary Pokegama Bay. Although MPCA's proposed rule would not classify the St. Louis River Estuary Pokegama Bay site (S006-928) as a wild rice water, MPCA Spreadsheet WR Dev Oct. 10, 2017, *supra*, Exhibit 59, there is field sampling evidence of wild rice in Pokegama Bay. See PolyMet 2009 and 2010 Wild Rice Reports, *supra*, Exhibit 73, autop. 10, 19.

[284] Since increased sulfate loading also reduced seed weight and viability in experimental mesocosms, Pastor Technical Review 2017, *supra*, p. 4, it is also possible that sulfate loading affects wild rice nutrition.

[285] MPCA's assertion with respect to proposed waters that are wholly or partially within a federally recognized Indian reservation, that "MPCA has the authority to identify and list wild rice waters as 4D waters to which the standard applies for all waters of the state, which includes waters within Indian reservations," SONAR, p. 52, seems to reflect a misunderstanding of law. See 33 U.S.C. §1377(e); 40 C.F.R. §131.7.

[286] Map, Anishinaabeg Ceded Territories and Dakota Ceded and Congressionally appropriated lands superimposed on MPCA Figure 7 map from page 139 of the SONAR, Exhibit 84.

It is unreasonable for the MPCA to propose to change the wild rice sulfate standard without analyzing the potential harms of eutrophication, decline in aquatic life diversity, and methylmercury contamination of fish resulting from sulfate concentrations above 10 mg/L in waters where wild rice is present and waters downstream of wild rice waters. These harms could be prevented or ameliorated if Minnesota's existing wild rice sulfate standard were enforced.

It is also unreasonable for the MPCA to dismiss environmental justice concerns[287] without comparing the proposed rule to enforcement of Minnesota's existing 10 mg/L sulfate limit, and without evaluating impacts of the changed rule on eutrophication, fish diversity and abundance and human health consequences of mercury contamination of fish to persons who rely on wild rice and fish for subsistence, particularly Native American people who depend on resources in Ceded Territories. The MPCA is obligated, under its own policy, to prevent such disproportionate negative environmental consequences.[288]

For the reasons stated in this Section, all of the MPCA's proposed rules previously identified in these comments are unreasonable, arbitrary, and inconsistent with MPCA's authority under the Clean Water Act and the Agency's own policies and should be rejected.

CONCLUSION

The MPCA's proposed rulemaking to change Minnesota's wild rice sulfate standard was initiated by the Minnesota Chamber of Commerce to protect its members - mining and other industrial dischargers - from the costs of controlling sulfate discharge. Political pressure from these dischargers and Iron Range politicians has prevented enforcement of Minnesota's existing sulfate standard and has tainted the process of developing the standard itself. The MPCA's SONAR for the proposed rules describe in detail mining facility sulfate discharge and potential challenges and costs to the mining industry if control of sulfate discharge were to be required.[289]

Neither the Clean Water Act nor the MPCA's stated purpose for this rulemaking allow these powerful interests to guide decisions on whether the proposed rules are needed, reasonable and within the scope of Minnesota's delegated authority under the Clean Water Act. The proposed rules must be judged on whether the rescission of the current numeric wild rice sulfate criterion; the adoption of a flawed equation that allows elevated sulfate where there are high levels of sediment iron; the revision of the designated use of waters to exclude thousands of waters where wild rice is an existing use; the use of implementation methods that bias against the protection of wild rice; and the restriction of a narrative criterion to protect wild rice from material impairment to only 24 waters in the state serves to protect Minnesota's wild rice. These are questions of chemistry, biology, population ecology, federal as well as state law and, ultimately of values.

The Minnesota Chippewa Tribe and the Minnesota Indian Affairs Council have emphasized, for both the Ojibwe and Dakota people wild rice "is the preeminent cultural resource of this region

[287] MPCA, SONAR, pp. 135-136.
[288] MPCA, Policy: Incorporating Environmental Justice Principles and Practices (EJ Policy) into Minnesota Pollution Control Agency Operations, Oct. 11, 2012, Exhibit 85.
[289] MPCA, SONAR, pp. 173-176, 184,

and central to our cultural heritage."[290] A technical advisor to the MPCA's Standards Study process has stated, "More than almost any other form of life in Minnesota afforded some protective measures by the State, its Zizania palustris variety palustris [wild rice] has national significance." Thus, "The State has a wider-than-usual responsibility here that must be addressed when considering revision of the sulfate standard."[291]

Elevated sulfate discharge threatens wild rice, increases eutrophication of lakes, impairs aquatic life, increases methylmercury contamination of fish – affecting human health, and disproportionately impacts low-income people and tribal communities. To protect all of these important values and designated uses of waters, it is time for Minnesota regulators not only to enforce Minnesota's existing wild rice sulfate standard but to determine what other water quality criteria for sulfate and other salts and ions are needed to more broadly protect aquatic life, fish and human health.

Based on the detailed arguments made in our preceding comments, the expert opinions and exhibits submitted with these comments, applicable science and law, WaterLegacy respectfully requests that each of the specific proposed rule provisions highlighted in our comments in the introduction to these pages[292] and in each individual Section be rejected on the grounds that it is unnecessary, arbitrary, capricious and unreasonable, and exceeds the MPCA's delegated authority under the Clean Water Act.

Rejection of these proposed rule provisions would provide clarity to control sulfate pollution of wild rice waters and most effectively protect wild rice.

Respectfully submitted,

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[290] Minnesota Chippewa Tribe letter to MPCA, *supra*, Exhibit 32, p. 1; Minnesota Indian Affairs Council letter to MPCA, *supra*, Exhibit 33, p. 1.
[291] Schimpf Comments 2015, *supra*, Exhibit 21, pp. 11-12.
[292] Pages 3-4 of these comments.