BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	
CHICAGO AREA WATERWAYS SYSTEM	)	R08-09 Subdocket D
(CAWS) AND THE LOWER DES PLAINES	)	(Rulemaking- Water)
RIVER: PROPOSED AMENDMENTS TO	)	
35 Ill. Adm. Code Parts 301, 302, 303 and 304	)	
(Aquatic Life Use Designations)	)	

NOTICE OF FILING

To:

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Illinois Pollution Control Board
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SERVICE LIST

PLEASE TAKE NOTICE that on April 30, 2014 I electronically filed with the Clerk of the Pollution Control Board of the State of Illinois, **ENVIRONMENTAL GROUPS' POST HEARING COMMENTS ON SUBDOCKET D**, a copy of which is attached hereto and herewith served upon you.

Respectfully Submitted,

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DATED: April 30, 2014

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ENVIRONMENTAL GROUPS' POST HEARING COMMENTS ON SUBDOCKET D

In its Order and Opinion of October 3, 2013 regarding Subdocket C (R08-09C), the Illinois Pollution Control Board ("Board") adopted use designations for the various waters and segments of the Chicago Area Waterway System (CAWS) and the Brandon Pool and Upper Dresden Island Pool (UDIP) of the Lower Des Plaines River. These aquatic life and recreational use designations are settled for current purposes. In this Subdocket D, the Board must determine the water quality criteria that are protective of the uses that it has designated.

The Board's task in Subdocket D is made easier by the fact that the Illinois Environmental Protection Agency (IEPA) and the parties that have participated in this proceeding over the years appear now to be in agreement as to the criteria that should be adopted to protect the various waters of the CAWS. (*See* PC 1366 ("Report of Metropolitan Water Reclamation District of Greater Chicago and Environmental Groups Regarding Proposed Aquatic Life Designated Uses").) It appears that IEPA and the other participants also agree to some extent regarding the chemical criteria that should be adopted to protect the Brandon Pool and the UDIP. However, the parties are not in agreement regarding certain other criteria that must be adopted to protect the uses that the Board has designated as Aquatic Life Use B waters (applicable to the Brandon Island Pool and the Chicago Sanitary and Ship Canal) and the UDIP. This is particularly true as to temperature criteria.

The record that has been compiled since 2007 in filings and hearings before the Board demonstrates that the Board must adopt substantially more stringent temperature criteria than the criteria currently proposed by IEPA in order to protect the aquatic life uses that have been designated by the Board for the Brandon Pool and the UDIP. t. It will be shown below by the Environmental Law and Policy Center, the Natural Resources Defense Council, Openlands, Prairie Rivers Network, Friends of the Chicago River, and Sierra Club that:

- The Maximum Daily temperatures proposed by IEPA for the Brandon Pool as 35 IAC 302.408(c) and the UDIP as 35 IAC 302.408(d) are not protective of the aquatic life uses designated for those waters,
- The excursion allowance of 3.6 ° F for 2% of the year in IEPA's proposed 35 IAC 302.408(a) is unjustifiable, not protective of aquatic life and should be stricken from the final rule,

- The IEPA proposal for period averages is not protective of aquatic life because a) they fail to protect growth of aquatic life and b) they allow temperatures to occur in the Lower Des Plaines that will lead key species of aquatic life to avoid those waters.

I. LEGAL AND REGULATORY BACKGROUND

The Clean Water Act ("CWA") establishes a comprehensive program "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" by reducing and eventually eliminating the discharge of pollutants into those waters. 33 U.S.C. § 1251(a). As a key part of this program, CWA Section 303 sets forth a framework for the establishment and review of water quality standards. 33 U.S.C. § 1313. Sections 303(a)-(c) of the CWA require states to establish water quality standards. 33 U.S.C. § 1313(a)-(c). These standards, which amount to a description of the desired condition of a waterway, consist principally of: (a) designated beneficial uses for waters, such as water supply, recreation, fish propagation, or navigation; (b) water quality criteria, which define the amounts of pollutants, in either numeric or narrative form, that the waters can contain without impairment of their designated beneficial uses; and (c) antidegradation requirements, which are designed to protect and maintain existing uses and water quality that exceeds that necessary to support beneficial uses. 33 U.S.C. § 1313(c)(2)(A); 40 C.F.R. §§ 131.6, 131.10-12.

Water quality standards are not self-executing. Instead, permits issued for discharges of pollutants must include limitations to achieve the applicable water quality standard for the receiving water body. 33 U.S.C. §§ 1311(b)(1)(c), 1342(a)(1), 40 CFR 122.44(d). Regulations, not directly at issue here, allow for practical considerations to be taken into account in developing permits that will protect standards. *See*, e.g., 40 C.F.R. § 122.47 (describing compliance schedules that allow time for dischargers to meet limits "as soon as possible").

Water quality criteria must be based on a "sound scientific rationale" and be protective of designated uses including "the most sensitive use." 40 C.F.R. §131.11(a). Further, the standards as finally adopted by the Board must be submitted to the United States Environmental Protection Agency (U.S. EPA) for approval under Section 303(c) of the Clean Water Act, 33 USC 1313(c), in a package that includes "the methods used and the analyses conducted" and "water quality criteria sufficient to protect the designated uses." 40 CFR §131.6.

II. THE ISSUES CURRENTLY BEFORE THE BOARD

The most significant issues in Subdocket D relate to the temperature criteria for waters designated by the IPCB's October 3, 2013 Opinion and Order ("the Order") as Aquatic Life Use B (ALU B) and the UDIP which is its own aquatic life use category under the Order.

Except as to temperature, dissolved oxygen and ammonia, IEPA proposed the same toxic chemical criteria for Aquatic Life Use B and UDIP that are now applicable to the Illinois General Use waters.[1]

III. THE IEPA PROPOSED TEMPERATURE CRITERIA FOR ALU B WATERS AND THE UDIP AS DEVELOPED BY CHRIS YODER AND IEPA

The current position of the IEPA regarding appropriate criteria for the ALU B waters appears to be stated in the Agency's Motion to Amend Regulatory Proposal Filed in 2007, Amendments to Part 302 Proposal and Testimony of Scott Twait, which was filed on May 23, 2013. The current position of IEPA regarding criteria for the UDIP appears to be stated in the Comments of the Illinois EPA on the Illinois Pollution Board's Subdocket C First Notice Opinion, filed November 4, 2013, after the Order which revised the Board's earlier draft designation for the UDIP.

The scientific and policy basis for the current IEPA proposals, however, was largely stated in filings made in 2007 and testimony given by agency witnesses in hearings that were held before the Board in 2008. The key scientific document for the temperature standards is the "Temperature Criteria Options for the Lower Des Plaines River" report to U.S. EPA and Illinois EPA of November 23, 2005 (the "Yoder Report") written by Chris O. Yoder and Edward T. Rankin of Midwest Biodiversity Institute. (Ex. 15) This report and Mr. Yoder's testimony before the Board given January 30 to February 1, 2008 are critical to understanding the current IEPA proposal.

The Yoder Report

Chris Yoder is an expert regarding fish and fish habitat in the Midwest. (Tr. 1/30/08 at 9-11; Ex. 13 at 1.) IEPA and U.S. EPA hired Yoder to help IEPA develop the basis for temperature criteria for the Lower Des Plaines River. (Ex. 2 at 10.) To determine the "potential assemblage" of fish that could live in the area, Yoder looked at historical records of fish species that have lived in the Des Plaines and Illinois Rivers or that live now in the Kankakee River. (Ex. 15 at 7-10; Tr. 1/30/08 at 141-42; 1/31/08 at 45-47.) From this list he selected the species for which data on thermal effects are available to develop a list of "Representative Aquatic Species" (RAS) for purposes of his model. (Tr. 1/31/08 at 42-44). Yoder then used this subset of the potential assemblage to generate thermal endpoints (which can be used to develop criteria).

Yoder's approach is intended to protect representative species, but does not guarantee that all species that might find their way into the waters will be protected. The approach relies on the "inherent assumption … that all of the species not included in the RAS will be protected by extension." (Ex. 15 at 7.) However, Yoder acknowledges that the species "that are generally regarded as being highly to moderately tolerant to a variety of environmental impacts tend to be over-represented, which is a common occurrence in databases for most water quality parameters"

[1] Because there is thought to be no breeding of young fish in ALU B waters, the stronger March to October DO and ammonia standards designed to protect young fish are not applicable to ALU B waters under the IEPA proposal. Although the Environmental Groups do not agree that the Brandon Pool is properly designated as ALU B, they will not seek to reargue that issue in Subdocket D and will not here discuss the DO or ammonia criteria, which flow logically from the definition of ALU B.

... and that "there remains a significant risk that the most sensitive groups of species will not be adequately protected." (*Id*.)

Yoder developed an RAS list of 27 species that it was thought could live in a "theorized Modified Use" for the UDIP that reflects existing habitat modifications. (Ex. 15 at 15). This "Modified Use" list includes the White Sucker, (Ex. 15 at 9), which has actually been found in the UDIP, albeit in small numbers. (*Id.*; Ex. 367; Ex. 327 at 4-5; Midwest Biodiversity Institute, "Evaluation of Potential Biological Impacts of Adding Hydroelectric Power Units to Two Dams on the Upper Illinois Waterway" at 6 (Oct. 14, 2011) (attached to this comment as Attach. 1) Yoder also identified 8 tolerant fish species that could live in the highly modified "Secondary Contact/Indigenous Use waters" that the Board subsequently designated as ALU B. (Tr. 1/31/08 at 47-49.)

Yoder's model incorporates values from scientific literature regarding the "upper incipient lethal temperature" (UILT) and the "critical thermal maximum" (CTM) of fish species included in the RAS lists. (Tr. 1/30/08 at 55 and Tr. 1/30/08 at 216). These short-term survival endpoints correlate with thermal maximum temperature criteria. (Tr. 1/30/08 at 121-22). The UILT and the CTM are determined for each species by putting fish into a tank and heating the water until 50% of them die. (Tr. 2/1/08 at 158-59.) The CTM procedure raises the temperature quickly, and because the fish suffer fatal damage before they are observed to be dead, a downward adjustment of 2 ° C must be made to the CTM temperature found using that method. (Ex. 15 at 5; Tr. 1/30/08 at 219-21, 231-32.)

Using the list of 27 species that represent the Modified Use (i.e. UDIP), Yoder's model found that the fish species with the lowest short-term survival endpoint (i.e. UILT or adjusted CTM), was White Sucker with a UILT of 88.7 ° F. (Ex. 15 at 67; SR Attach. HH.) Yoder then subtracted 2° C to find the long-term survival number, 85.1 ° F, (SR Attach. HH), based on a "long-standing rule of thumb." (Tr. 1/30/08 at 154-55; Tr. 2/1/08 at 157.) The long-term survival number correlates with monthly average thermal criteria. (Tr. 1/30/08 at 176.)

With regard to the "Secondary Contact/Indigenous Use waters" list of species, the lowest short-term survival endpoint (UILT) is that for the Bluntnose minnow at 90.3 ° F, (Ex. 15 at 70), from which Yoder then subtracted 2 ° C to develop a long-term survival temperature of 86.7 ° F for the ALU B waters.[2]

Yoder also presented data for the Optimum temperatures (the temperature at which the fish can most efficiently perform), the Growth temperatures (the mean weekly average temperatures for growth) and the Upper Avoidance Temperature (a sharply defined upper temperature which an organism at a given acclimation temperature will avoid) for the species in each RAS list. (Ex. 15 at 6, 66.) The Growth temperatures for 5 of the 27 RAS are exceeded by this long-term survival endpoint (the proposed 85.1 °F monthly average), including Northern Pike, Emerald Shiner, Walleye, White Sucker, and Bluntnose Minnow. (Ex. 15 at 66.[3])The Upper Avoidance

[2] The initial Yoder Report (SR Attach. GG and Ex. 15) used another figure but IEPA has submitted a replacement for Table 3 of the Yoder Report (SR Attach. HH), and has since corrected its proposal to include the correct figure. (*See e.g.*, IEPA Mot. To Amend 20, May 24, 2013.).
[3] See Tr. 1/30/08 at 177-78; 1/31/08 at 30 for explanation for how Table 3F works.

Temperatures for the White Sucker and Northern Pike are also lower than 85.1 °F. (Ex. 15 at 66.)

All of the above-discussed temperatures were calculated to prevent unacceptably high summer temperatures. Yoder also proposed non-summer daily maximum temperature options (e.g. 45 ° F or 46 ° F for January and non-summer monthly average temperatures (e.g. 38.4 °F or 39.5 °F January) to maintain somewhat natural temperatures in Fall, Winter and Spring. (Ex. 15 at 18.) Yoder's proposal for appropriate seasonal ambient temperatures was based on the temperatures that normally prevail upstream of the Brandon Pool at Illinois Rt. 83 and the Calumet Sag Channel. (Ex. 15 at 15-19.) These figures were calculated because of the need to maintain seasonal temporal variation for the health of the fishery, specifically to not interfere with fish reproduction. (Tr. 1/31/08 at 114, 121-22.) According to Yoder, "Non-summer season criteria are derived to maintain seasonal norms and cycles of increasing and decreasing temperatures. Important physiological functions such as gamete development, spawning, and growth should be assured since these are products of each species long term adaptation to natural climatic and regional influences of which temperature is a controlling factor." (Yoder Report at p. 15).

The IEPA Temperature Proposal

The actual IEPA proposal was not formulated in the Yoder Report. Instead, "the Agency used the conclusions and options presented in this report to develop temperature standards for the CAWS and Lower Des Plaines River." (Ex. 2 at 10.) Although one could have framed a proposal that used all of Yoder's data and conclusions, IEPA used only a portion of Yoder's data and conclusions and fashioned a proposal that included allowances for abnormally high temperatures that were not contemplated in the Yoder Report.

Without discussing the various changes and corrections that IEPA has made since it got the Yoder report in 2005, our understanding of IEPA's proposal for the UDIP is:

+ Daily maximum temperature **all year** is 88.7 °F.[4]
+ Period average during the critical summer period (June 16 to September 15) is 85.1.[5]
+ Period averages for other months have been determined by taking the 90th percentile highest figure at Route 83 and the Cal Sag Channel and ranges from 53.6 F for February to 76.5 ° F for September 16-3[6] and,
+ Proposed Section 35 IAC 302.408(a) which states:

> Water temperature shall not exceed the maximum limits in the applicable table [referring to the tables for ALU A, ALU B and UDIP] that follows during more than two percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the applicable table that follows by more than 2 ° C (3.6 F).[7]

[4] (IEPA Mot. To Amend 19, May 24, 2013; PC# 1390 at 16.)
[5] (IEPA Mot. To Amend 19, May 24, 2013; PC# 1390 at 16.)
[6] (IEPA Mot. To Amend 19, 84, May 24, 2013; PC# 1390 at 16.)
[7] (IEPA Mot. To Amend 19, May 24, 2013.)

This last provision effectively allows the temperature of the UDIP to go up to 92.7° F for many hours in the summer, potentially over an unbroken 7-day period (365 days x 2% = 7.3 days).

IEPA's proposal for the ALU B waters is similar except that the "Daily Maximum" all year is 90.3 °F and the Period Average number for June 16 to September 15 is 86.7 °F. The non-summer period averages allowed are identical to those for the UDIP.[8]

Finally, IEPA has added a provision meant to address the issue of cold shock. Cold shock refers to the fact that fish cannot tolerate rapid decreases of temperature and will die if temperatures drop suddenly, as sometimes happens when a power plant is shut down in the winter. (Tr. 1/31/08 at 125-26.) Instead of addressing this problem with either the non-summer daily maximum temperatures suggested in the Yoder Report or the provisions of the General Use standards that require maintaining seasonal temperatures and prohibiting an increase in temperature of more than 5 °F above natural temperature (see 35 IAC 302.211(b)(c) and (d)), IEPA proposes a narrative criteria for ALU A and ALU B waters that states:

> Water temperatures of discharges to the CAWS Aquatic Life Use A Waters and CAWS and Brandon Pool Aquatic Life Use B Water shall be controlled in a manner to protect fish and aquatic life uses from the deleterious effects of cold shock.[9]

IEPA failed to propose similar cold shock language for the UDIP, which is presumably an oversight in its November 4, 2013 filing. The IPCB rule should apply the cold shock provisions to all waters subject to this rulemaking.

IV. THE IEPA TEMPERATURE STANDARDS ARE NOT PROTECTIVE

Analysis of the evidence assembled by IEPA in this proceeding shows that the IEPA has presented the Board with the data needed to establish protective temperature standards. However, IEPA's proposal for thermal criteria is not supported by that data, and is not protective of designated uses.

Initially, it is instructive to compare the proposed UDIP and Brandon Pool standards with the Ohio standards for the Ohio River. Midwest Generation actually suggested looking to Ohio standards in this case as a model. (PC 1277 at 10.) In fact, the Ohio River standards offer a lenient model for standards that should be applied to the Brandon Pool and the UDIP because, like the Des Plaines, no one claims the Ohio River, which has numerous dams, much barge traffic and horrible chemicals coming from W.Va., is anything like a pristine water but much of the Ohio River is well south of the Lower Des Plaines River. Nonetheless, the "Instantaneous Maximum" that has been set by the State of Ohio for the Ohio River is 89 ° F, over three degrees Fahrenheit less than IEPA would allow the UDIP to hit 2% of the time and 1.3 °F less than IEPA would allow the Brandon Pool to reach routinely. *See*, Ohio Admin. Code 3745-1-32, Table 32-3. (attached to this comment as Attach. 2 at 8) Also, the period averages for the Ohio River are

[8] (IEPA Mot. To Amend 19-20, May 24, 2013.)
[9] (IEPA Mot. To Amend 20, May 24, 2013.)

generally over 1 °F less than those IEPA has proposed for the UDIP, and over 3 °F less than those proposed by IEPA for the Brandon Pool.

Months-dates	Ohio River Period Average (F)	UDIP Period Average (F)	ALU B Period Average (F)	Ohio River Instantaneous Maximum (F)	UDIP Daily Maximum (F)	ALU B Daily Maximum (F)
January 1-31	45	54.3	54.3	50	88.7	90.3
February 1-28	45	53.6	53.6	50	88.7	90.3
March 1-15	51	57.2	57.2	56	88.7	90.3
March 16-31	54	57.2	57.2	59	88.7	90.3
April 1-15	58	60.8	60.8	64	88.7	90.3
April 16-30	64	62.1	62.1	69	88.7	90.3
May 1-15	68	69.2	69.2	73	88.7	90.3
May 16-31	75	71.4	71.4	80	88.7	90.3
June 1-15	80	74.2	74.2	85	88.7	90.3
June 16-30	83	85.1	86.7	87	88.7	90.3
July 1-31	84	85.1	86.7	89	88.7	90.3
August 1-31	84	85.1	86.7	89	88.7	90.3
September 1-15	84	85.1	86.7	87	88.7	90.3
September 16-30	82	77.0	77.0	86	88.7	90.3
October 1-15	77	73.2	73.2	82	88.7	90.3
October 16-31	72	69.6	69.6	77	88.7	90.3
November 1-30	67	66.2	66.2	72	88.7	90.3
December 1-31	52	59.9	59.9	57	88.7	90.3

The IEPA proposal currently before the Board should be seen as illegally under-protective for at least the following reasons:

- The Daily Maximum thermal standard for summer based on the UILT is not protective,
- The 2% 3.6 ° F excursion allowance is unjustifiable,
- The Daily Maximum allowed for off-summer months is not protective, and
- The proposal ignores impacts on fish Growth and Avoidance.

The UILT is not protective

Use of the UILT as a daily maximum thermal standard is not protective of designated uses. The UILT is the temperature at which 50% of the individuals of the species to be protected are dead. (Tr. 2/1/08 at 158-59.) This can be compared to the standard method for establishing acute standards for toxic pollutants: first, one identifies the level of toxin that kills 50% of the organisms the standard is meant to protect. That level is known as the "LC50." An acute (i.e. not to be exceeded) criteria is then set by dividing the LC50 in half, because it is not acceptable to kill 50% of what we are trying to protect.[10]

Obviously, the method of correcting the LC 50 to get to a protective number by dividing the number by two cannot be used to derive temperature criteria from the UILT, but other methods have been recommended. US EPA suggests subtracting 2 ° C (3.6 ° F) from the UILT to adjust for this problem.[11] The method recommended by U.S. EPA would bring the allowable UDIP Daily Maximum temperature down to 85.1 °F and the allowable Brandon Pool Daily Maximum down to 88.3 °F. Colorado also recently incorporated a safety factor to account for the inadequacy of the UILT as a Daily Maximum when it adopted its thermal criteria.[12]

The 2% 3.6 ° F excursion allowance is not protective, particularly if combined with using the UILT to set the Acute Value

This is IEPA's rationale for allowing an excursion of 3.6 ° F over the Daily Maximum for 2% of the time :

> Because fish can tolerate short-term elevations in temperature, the current water quality standards in Illinois allow for a certain amount of excursions before there is an exceedance of the standard. The excursions under the current General Use Standard [302.211(e)] and Secondary Contact and Indigenous Aquatic Life Standards [302.408] are limited both in their degree and frequency. The Agency is proposing to allow excursions from the daily maximum criteria to occur two percent of the time. This is between the one percent for General Use and the five percent for the existing Secondary Contact and Indigenous Aquatic Life Standards. Currently, the excursion hours allowed under Midwest Generation's thermal adjusted standard at the I-55 bridge also allow two percent excursion hours. The Agency is also proposing to limit the allowable excursions of the daily maximum up to 2 ° Celsius (or 3.6 Fahrenheit). This is between the 1.7 ° C

[10] (*See*, USEPA, Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses, Office of Research and Development, PB85-227049 (Jan. 1985), available at http://owpubauthor.epa.gov/scitech/swguidance/standards/criteria/current/upload/2009_01_13_criteria_85guidelines.pdf; Tr. 12/17/13 at 94.)

[11] USEPA1986 Gold Book (EPA's most recent guide as to temperature standards) and the April 2003 EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards, available at http://yosemite.epa.gov/r10/water.nsf/Water+Quality+Standards/WQS+Temperature+Guidance/,

[12] See, Colorado Water Quality Forum, "Temperature-Margin of Safety," attached to this comment as Attach. 3 and *available at*: http://colowqforum.org/pdfs/temperature/documents/Margin%20of%20Safety.pdf; and Colorado Department of Public Health and Environment, "Temperature Criteria Methodology Policy Statement 06-01, attached to this comment as Attach. 4.

> (or 3 ° F) excursion allowance for the General Use standard and 3.8 ° C (or 7 ° F) for the existing Secondary Contact and Indigenous Aquatic Life Standards.[13]

While Twait's logic is Solomonic, there is no scientific basis for this baby-splitting. It is not supported, as Twait attempts, by the basis underpinning the existing standards. The General Use standard, while subject to the excursion mentioned by Twait, is also subject to a number of other limits that restrict the exclusion's harmful effects, including the prohibition against "abnormal temperature changes that may adversely affect aquatic life" (35 IAC 302.211(b)), the prohibition of a temperature rise more than 5 °F above natural temperatures (302.211(d)), and the requirement that "daily and seasonal temperature fluctuations which existed before the addition of the heat due to other than natural cause shall be maintained." (302.211(c)). Such restrictions are not contained in the IEPA's proposed UDIP and ALU B criteria.

Moreover, nobody claims that the existing Secondary Contact and Indigenous Aquatic Life standard is protective. Actually, neither the General Use standard nor the Secondary Contact and Indigenous Aquatic Life standard have been re-considered for decades to determine if they are still protective. Similarly, the Commonwealth Edison/Midwest Generation thermal adjusted standard allowing a 3 degree F rise up to 93 °F at the I-55 bridge was established over 20 years ago, at a time when chemical water quality in the Lower Des Plaines was significantly worse than it is now. Given these chemical improvements, there might have been more improvement in the fish community in the UDIP but for the heat as was testified by several witnesses. (Ex. 327 at 3; Tr. 1/29/08 at 105-06.)

Still further, Chris Yoder testified that aquatic systems crash somewhere between 86 °F and 90°F. (Tr. 1/31/08 at 106-110.). Contrary to the IEPA proposal, Yoder stated that the UILT figures and the daily maximum temperatures he proposed using the UILT data "should not be exceeded." (Tr. 1/3/08 at 51-53, 105.)

But the most obvious problem with IEPA's logic is that they are double-counting the ability of fish to survive short-term temperature stress. As discussed above, IEPA's proposed daily maximum (set at the UILT) is already 3.6 ° F above the Daily Maximum criterion that USEPA would set using UILT as an endpoint. The IEPA proposal then allows thermal excursions of an *additional* 3.6 ° F above the already-dubious daily maximum set at the level that kills half of the most-sensitive species.

If the UILT is legitimate to use as a daily maximum temperature (despite the fact that the UILT kills 50% of one or more of the species to be protected), it is only because the water temperature presumably will not stay at that high UILT level for long. As Yoder testified, fish can survive temperature stress only for a "fairly short duration" and temperatures need to get down to below the average "within a matter of days." (Tr. 2/1/08 at 163-64.) If that is the case, IEPA should not be allowing still additional excursions that could last for days based on the theory that it is all right to expose fish briefly to lethal temperatures.

[13] (Ex. 2 (Twait discussing proposed 35 IAC 302.408(a).)

The Daily Maximum Temperature Allowed in off-Summer Months is not protective

The best thing that can be said of the IEPA proposal for the Daily Maximum temperature for off-summer months is that dischargers of heated effluent probably cannot physically use most of the ridiculous allowance the proposal would grant them. Under the IEPA proposal, one could have a daily maximum of 88.7 ° F in January without violating the standard as long as the monthly average was met. While heating the water to 89 ° F in January may be impossible without use of multiple nuclear warheads, it would seem that this proposal allows temperature to rise for a few days to substantially more than the proposed 54.4 ° F period average. Because fish are acclimated to lower temps in the non-summer months when fish reproduction also occurs, Yoder testified that he would be more worried about the effects of very high temperatures in March on fish growth and reproduction than he would be in July. (Tr. 1/31/08 at 86.) In its letter of January 29, 2010 (PC 286), U.S. EPA questioned the basis for allowing the same acute value all year and suggested a seasonally adjusted Daily Maximum. Seasonally-adjusted daily maximum temperatures were also proposed by the Yoder Report. (Ex. 15 at 15-19.) Yet IEPA has declined to propose more reasonable Daily Maximum temperatures for the non-summer months.

U.S. EPA recommended "that Illinois consider deriving seasonally-based daily minimum criteria based upon the information provided in Option E [in the Yoder Report, Table 5] or other adequately-justified and scientifically-defensible methods." (PC 286 at 6.) Following that recommendation, we recommend that the daily maximum values be revised as shown in red in Figure 1 below.

Growth and Avoidance Temperatures Should have been Used

As discussed above, growth endpoints are those that allow fish to maintain their normal reproductive cycles and maintain the general health of the fishery. Avoidance endpoints also maintain the health of the fishery, because the avoidance temperature is the point at which a large decrease in population for that species is observed in the assemblage.

IEPA's proposal neither protects fish growth nor prevents fish avoidance for the species on the RAS.

IEPA Proposed summer monthly average	Avoidance: Emerald Shiner	Avoidance: White Sucker	Growth: White Sucker	Growth: Emerald Shiner
85.1°F	85.6°F	83.7°F	82.0°F	78.3°F

Even the ExxonMobil expert agreed that it does not make sense to adopt a temperature standard that allows temperatures in which the fish were driven out of the system. (Tr. 12/17/13 at 36.) U.S. EPA Region 5 specifically commented that IEPA should explain "why the period average criteria [were] derived from survival endpoints when available information was presented to show that these temperatures may lead to avoidance or reduced growth." (PC 286 at 1-2.)

As mentioned, the IEPA developed the summer period average temperature limit for the UDIP, 85.1 °F, by subtracting 2 °C from the UILT for the White Sucker. If IEPA had instead used the avoidance temperature for White Sucker, the period average would be 83.7 °F, (Ex. 15 at 42), and use of the Growth threshold for White Sucker would have brought the number down to 82 °F. (Ex. 15 at 66). The growth and avoidance figures for the Emerald Shiner are 78.3 °F and 85.6 °F respectively. (Ex. 15 at 66.)

V. CONCLUSION

The voluminous record in this case contains all the data needed to set protective standards for the Brandon Pool, the UDIP, and Aquatic Life Use A waters. Below we propose a method to do so, while accounting for the unique nature of these waterways.

1. The Board should delete the 3.6 °F excursion allowance for all Aquatic Life Uses.
2. The Board should include IEPA's proposed cold shock provision in all three use designations.
3. The Board should adopt the thermal criteria in the table below for the UDIP.
    a. The summer daily maximum temperature is based on the UILT (i.e. short-term survival) endpoint from the Yoder Report, (SR Attach. HH), including the USEPA-recommended safety factor of 2°C.
    b. The summer period average temperature is based on the concept proposed by Yoder and Twait that a thermal standard is protective of long-term survival by subtracting 2°C from the daily maximum. (*See*, Tr. 1/30/08 at 154-55; Tr. 2/1/08 at 157.) The resulting value addresses USEPA's concern that IEPA's standard does not protect for growth or avoidance, as 81.5°F is below the avoidance threshold for all representative aquatic species for this use, and is below the growth endpoints for all RAS except Northern Pike, Emerald Shiner and Walleye. (See, Ex. 15 at 66.)
    c. The non-summer daily maximum and period average criteria are taken from Table 5 of the Yoder Report (Ex. 15 at 18), using Option E as recommended by USEPA in its January 29, 2010 comments on IEPA's proposed rules. (PC 286.) These values are consistent with prevailing temperatures that are uninfluenced by thermal discharges, but are not likely to cause compliance problems for sewage treatment plants.

d) Water temperature for the Upper Dresden Island Pool, as defined in 35 Ill.
Adm. Code 303.237, shall not exceed the period average limits in the
following table during any period on an average basis.

Months-dates	Period Average (F)	Daily Maximum (F)
January 1-31	~~54.3~~ 38.4	~~88.7~~ 46.6
February 1-28	~~53.6~~ 41.7	~~88.7~~ 51.7
March 1-31	~~57.2~~ 47.0	~~88.7~~ 57.3
April 1-15	~~60.8~~ 54.0	~~88.7~~ 59.9
April 16-30	~~62.1~~ 57.3	~~88.7~~ 67.7
May 1-15	~~69.2~~ 63.7	~~88.7~~ 71.6
May 16-31	~~71.4~~ 65.1	~~88.7~~ 71.2
June 1-15	~~74.2~~69.8	~~88.7~~ 77.8
June 16-30	~~85.1~~ 81.5	~~88.7~~ 85.1
July 1-31	~~85.1~~ 81.5	~~88.7~~ 85.1
August 1-31	~~85.1~~ 81.5	~~88.7~~ 85.1
September 1-15	~~85.1~~ 81.5	~~88.7~~ 85.1
September 16-30	~~77.0~~69.9	~~88.7~~ 75.7
October 1-15	~~73.2~~ 63.7	~~88.7~~ 71.2
October 15-31	~~69.6~~ 59.8	~~88.7~~ 68.0
November 1-30	~~66.2~~ 53.0	~~88.7~~ 63.6
December 1-31	~~59.9~~ 43.4	~~88.7~~ 56.9

4. The Board should adopt the thermal criteria in the table below for the ALU B Brandon Pool waters:
    a. The summer daily maximum temperature is based on the UILT (i.e. short-term survival) endpoint from the Yoder Report, (SR Attach. HH), including the USEPA-recommended safety factor of 2°C.
    b. The summer period average temperature is based on the concept proposed by Yoder and Twait that a thermal standard is protective of long-term survival by subtracting 2°C from the daily maximum. (*See*, Tr. 1/30/08 at 154-55; Tr. 2/1/08 at 157.) The resulting value addresses USEPA's concern that IEPA's standard does not protect for growth or avoidance, as 83.1°F is protective of growth and avoidance for the 8 highly tolerant species from the RAS used to define this use. (*See*, Ex. 15 at 72.)
    c. Taking a cue from the Illinois general use thermal standards, and recognizing that requiring cooling of sewage effluent may not be the best use of resources, we propose non-summer daily maximum criteria that are 5.0 °F above the period average criteria proposed by IEPA.

c) Water temperature in the Chicago Area Waterway System and Brandon Pool Aquatic Life Use B waters listed in 303.325, shall not exceed the period average limits in the following table during any period on an average basis.

Months-dates	Period Average (F)	Daily Maximum (F)
January 1-31	54.3	~~90.3~~ 59.3
February 1-28	53.6	~~90.3~~ 58.6
March 1-31	57.2	~~90.3~~ 62.2
April 1-15	60.8	~~90.3~~ 65.8
April 16-30	62.1	~~90.3~~ 67.1
May 1-15	69.2	~~90.3~~ 74.2
May 16-31	71.4	~~90.3~~ 76.4
June 1-15	74.2	~~90.3~~ 79.2
June 16-30	~~86.7~~ 83.1	~~90.3~~ 86.7
July 1-31	~~86.7~~ 83.1	~~90.3~~ 86.7
August 1-31	~~86.7~~ 83.1	~~90.3~~ 86.7
September 1-15	~~86.7~~ 83.1	~~90.3~~ 86.7
September 16-30	77.0	~~90.3~~ 82.0
October 1-15	73.2	~~90.3~~ 78.2
October 15-31	69.6	~~90.3~~ 74.6
November 1-30	66.2	~~90.3~~ 71.2
December 1-31	59.9	~~90.3~~ 74.9

5. The Board should adopt the thermal criteria in the table below for the ALU A waters:
    d. The summer daily maximum temperature is based on the UILT (i.e. short-term survival) endpoint from the Yoder Report, (SR Attach. HH), including the USEPA-recommended safety factor of 2°C.
    a. The summer period average temperature is based on the concept proposed by Yoder and Twait that a thermal standard is protective of long-term survival by subtracting 2°C from the daily maximum. (*See*, Tr. 1/30/08 at 154-55; Tr. 2/1/08 at 157.) The resulting value addresses USEPA's concern that IEPA's standard does not protect for growth or avoidance, as 81.5°F is below the avoidance threshold for all representative aquatic species for this use, and is below the growth endpoints for all RAS except Northern Pike, Emerald Shiner and Walleye. (See, Ex. 15 at 66.)
    e. Taking a cue from the Illinois general use thermal standards, and recognizing that requiring cooling of sewage effluent may not be the best use of resources, we propose non-summer daily maximum criteria that are 5.0 °F above the period average criteria proposed by IEPA.

b) Water temperature in the Chicago Area Waterway System Aquatic Life Use A waters listed in 35 Ill. Adm. Code 303.230 shall not exceed the period average limits in the following table during any period on an average basis.

Months-dates	Period Average (F)	Daily Maximum (F)
January 1-31	54.3	~~88.7~~ 59.3
February 1-28	53.6	~~88.7~~ 58.6
March 1-31	57.2	~~88.7~~ 62.2
April 1-15	60.8	~~88.7~~ 65.8
April 16-30	62.1	~~88.7~~ 67.1
May 1-15	69.2	~~88.7~~ 74.2
May 16-31	71.4	~~88.7~~ 76.4
June 1-15	74.2	~~88.7~~ 79.2
June 16-30	~~85.1~~ 81.5	~~88.7~~ 85.1
July 1-31	~~85.1~~ 81.5	~~88.7~~ 85.1
August 1-31	~~85.1~~ 81.5	~~88.7~~ 85.1
September 1-15	~~85.1~~ 81.5	~~88.7~~ 85.1
September 16-30	77.0	~~88.7~~ 82.0
October 1-15	73.2	~~88.7~~ 78.2
October 15-31	69.6	~~88.7~~ 74.6
November 1-30	66.2	~~88.7~~ 71.2
December 1-31	59.9	~~88.7~~ 64.9

Dated: April 30, 2014

Respectfully submitted,

ENVIRONMENTAL LAW & POLICY CENTER

FRIENDS OF THE CHICAGO RIVER

NATURAL RESOURCES DEFENSE COUNCIL

OPENLANDS

PRAIRIE RIVERS NETWORK

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CERTIFICATE OF SERVICE

I, Jessica Dexter, hereby certify that I have served the attached ENVIRONMENTAL GROUPS' POST HEARING COMMENTS ON SUBDOCKET D upon the below service list via the United States Mail, postage prepaid, in Chicago, Illinois on April 30, 2014.

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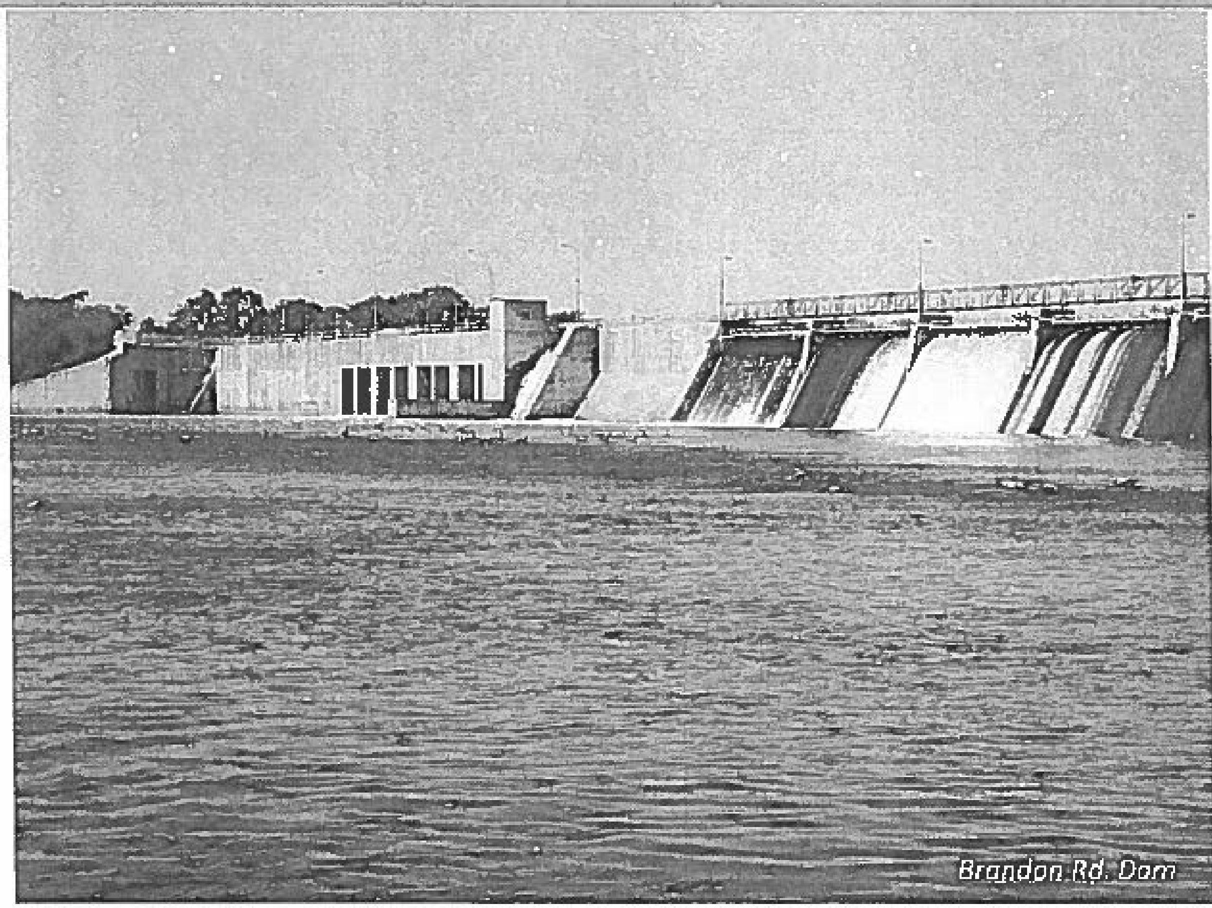
Illinois Pollution Control Board
R2008-09
Environmental Groups' Post Hearing Comments on Subdocket D
Attachments

Attachment 1: "Evaluation of Potential Biological Impacts of Adding Hydroelectric Power Units to Two Dams on the Upper Illinois Waterway"

C-0405-08

Evaluation of Potential Biological Impacts of Adding Hydroelectric Power Units to Two Dams on the Upper Illinois Waterway



Midwest Biodiversity Institute

Peter A. Precario, Executive Director
David J. Horn, Board President

Evaluation of Potential Biological Impacts of Adding Hydroelectric Power Units to Two Dams on the Upper Illinois Waterway

MBI Technical Report MBI/2011-10-8

October 14, 2011

Third Party Review prepared at the request of:

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Executive Summary

The Midwest Biodiversity Institute (MBI) was requested by Northern Illinois Hydroelectric (NIH) at the recommendation of the Illinois Environmental Protection Agency (IEPA) to conduct a third party review of two proposed hydroelectric projects to be constructed and operated by NIH. While some interaction with NIH and their consultant Kleinschmidt Associates was necessary to learn about the specific technical details of the proposed projects, all analyses conducted and conclusions stated herein are solely those of MBI. Furthermore, MBI has conducted prior biological and habitat assessments (2004-7) in the Chicago Area Waterway System (CAWS) and Upper Illinois Waterway (UIW) system, which includes the Lower Des Plaines and Illinois Rivers, in support of the ongoing Use Attainability Analysis (UAA) process conducted by Illinois EPA and in support of the development and testing of biological assessments of large rivers under grants from U.S. EPA. In addition, MBI developed temperature criteria recommendations for the Lower Des Plaines River in 2006-7 on behalf of both U.S. EPA and Illinois EPA. As such, this prior familiarity with the UIW system was also used to support our analyses and conclusions presented and stated herein.

Given the permanently altered nature of the UIW (Illinois and Lower Des Plaines Rivers) in the vicinity of the proposed hydroelectric projects and the permanence of the navigational structures and impoundments, the data we examined and analyses that were conducted indicate that potential impacts on the biological assemblages in these reaches will be nominal and that some of the anticipated changes in the flow regime downstream of the power stations could actually improve habitat for key fluvial dependent and fluvial specialist fish species. We expect that ongoing improvements in the control of combined sewer overflows (CSOs), wastewater discharges, and other water quality issues in the CAWS and UIW via the implementation of the Tunnel and Reservoir Project (TARP) should further reduce nutrient levels and organic enrichment resulting in an improved D.O. regime over time. While there is the potential for some entrainment mortality, the impounded habitats at the intakes of each proposed facility will most likely minimize the probability of mortality to sensitive fish species (e.g., fluvial dependents and specialists) and would have little or no effect on measures of assemblage condition (e.g., Index of Biotic Integrity) used to measure assemblage health and attainment of Illinois aquatic life use endpoints for these rivers. As such, the proposed projects should have a nominal impact on either the water quality or biological quality of the UIW system.

Site Description

Brandon Road Lock & Dam Powerhouse

Northern Illinois Hydropower (NIH) is pursuing licensing and permitting for the development of a new hydropower facility at the Brandon Road Lock & Dam (RM 286) on the Lower Des Plaines River (Figure 1). This operation will replace four existing headgates within the guide and ice walls near the north end of the dam. This is a run-of-the-river design and importantly for

Figure 1. Aerial view of the Brandon Road Lock and Dam with the location of the proposed powerhouse and attendant structures (from NIH 2011).

biological assemblages it is integral to the dam and does not require any diversion or re-routing of river flows.

areas between the intake point and where flow is returned to the river. The Brandon and Dresden Island powerhouses are integral to the existing dams and as such would not create extended areas subject to dewatering or reduced flows. The passage of flows though the turbines, rather than over the headgates and tainter gates alone, will result in changes to depth and flow characteristics of the habitat immediately downstream of each dam. The question is whether these changes will be reflected in any biologically significant "loss" of useable habitat compared to existing conditions.

Potential Downstream Geomorphic and Habitat Impacts from the Hydropower Stations

One of the issues raised by the Federal Energy Regulatory Commission (FERC 2011) was related to potential impacts to biological assemblages from changes in downstream habitat and flow alterations compared to existing conditions (Kleinschmidt 2010). Essentially much of the flow that is currently distributed among the multiple side and tainter gates of these dams will become more concentrated through the hydropower stations. The concern is with the loss of marginal and shallow water habitats along the length of the dams and altered velocity distributions compared to existing conditions.

The tailwater areas of the Brandon Road and Dresden Island dams already reflect a flow altered system and in many ways an "unnaturally" stable system in relation to habitat features. Depending on the geology and lithology of natural rivers, habitat is typically dynamic with the locations of various features (e.g., runs, riffles, pools, shallows, margins, etc.) changing in relation to high flows and storm events of varying magnitudes.

The existing biological quality of the Lower Des Plaines River reflects a recovering system that is also limited by the extensive physical alterations compared to a more natural riverine condition (i.e., free flowing), specifically the extensive impoundments for navigation. The areas immediately downstream from the dams provide the "best" areas of physical habitat and are the closest to natural in form relative to the impoundments that characterize most of the UIW. A question arises as to whether the change in flow characteristics due to the concentration of flows through the powerhouses will result in the significant alteration or loss of important habitat for the biological assemblages that both presently occur in the river or that are expected to as conditions improve. Although the UIW has been permanently modified for navigation, a more diverse assemblage of fish and other aquatic life is expected to result from ongoing pollution controls aimed at improving water quality in the UIW. As such we included the anticipation of these improvements to approach and even attain conditions consistent with the current Illinois General Use downstream from each dam.

Table 1. List of fish species collected by MBI in the Des Plaines River upstream and downstream of the Brandon Road dam and in the Illinois River upstream and downstream of the Dresden Dam. Numbers are relative abundances per 1 km of distance sampled. Species are identified as to their tolerance: I – Intolerant, M – Moderately Intolerant, P – Moderately Tolerant, T – Tolerant and fluvial classification: FS – Fluvial Specialist; FD – Fluvial Dependent; HG – Habitat Generalist.

Species Code		Common Name	Toler -ance	Fluv -ial	Brandon Rd. Dam		Dresden Is. Dam	
					Upstream RM 287.9	Tailwater RM 285.8	Upstream RM 273.3	Tailwater RM 271.1
10	004	Longnose Gar		FD		20	6	24
20	001	Skipjack Herring		FD				16
20	003	Gizzard Shad		HG	108	158	98	216
40	003	Black Buffalo		HG		14		24
40	004	Smallmouth Buffalo		HG		54	16	122
40	005	Quillback Carpsucker		HG				4
40	006	River Carpsucker		HG		2	8	4
40	007	Highfin Carpsucker		FD				2
40	008	Silver Redhorse	M	FD				2
40	009	Black Redhorse	I	FS				4
40	010	Golden Redhorse	M	FD			8	44
40	011	Shorthead Redhorse	M	FD		58	2	106
40	013	River Redhorse	I	FD				6
40	015	Northern Hog Sucker	M	FS				2
40	016	White Sucker	T	FD		4		
43	001	Common Carp	T	HG		116	8	22
43	002	Goldfish	T	HG		4		
43	015	Suckermouth Minnow		FD		2		
43	020	Emerald Shiner		HG	60	114	6	994
43	025	Striped Shiner		FS		6		
43	028	Spottail Shiner	P	HG		38		2
43	032	Spotfin Shiner		FD	2	22		40
43	034	Sand Shiner	M	FS		36		8
43	041	Bullhead Minnow		HG				4
43	042	Fathead Minnow	T	HG				2
43	043	Bluntnose Minnow	T	HG	4	122		12
43	044	Central Stoneroller		FS		2		
47	002	Channel Catfish		HG		48	14	50
47	004	Yellow Bullhead	T	HG		10		
47	007	Flathead Catfish		FD			2	
47	013	Tadpole Madtom		HG		2		
74	001	White Bass		FD				16
74	003	White Perch		HG				2
77	002	Black Crappie		HG				4
77	003	Rock Bass		FD		10		
77	004	Smallmouth Bass	M	FD		16	22	30
77	005	Spotted Bass		FD			2	
77	006	Largemouth Bass		HG		30	30	110
77	008	Green Sunfish	T	HG	2	8		28

Data Analyses

For our analyses we used attributes of the Qualitative Habitat Evaluation Index (QHEI; Rankin 1989, 1995; Ohio EPA 2006) including the overall QHEI score, QHEI riffle metric, and the HydroQHEI current metric as the physical habitat measures that would reflect changes in velocity distributions below the dams. We used an extensive Ohio dataset (≈25 years; circa 1980-2005) to estimate the probability of occurrence of each of these species along these habitat gradients. The use of Ohio data as applied to Illinois is relevant as the fish species are in common being distributed widely throughout the upper Ohio and upper Mississippi River basins and at similar latitudes. Furthermore, there is prior precedent for applying Ohio calibrated measures to the Lower Des Plaines River as the Ohio fish IBI was used in the analyses that supported the Illinois EPA sponsored Use Attainability Analysis (UAA).

We chose the habitat metrics used in our analyses because they are correlated with the occurrence of flow sensitive fish species associated with variations in depth and current velocity attributes and these reflect the principal changes that are likely to occur from the operation of the hydroelectric projects. Each habitat measure was divided into 20 bins of data of approximately equal sample size with the midpoint of the bin used as the x-axis point and the probability of occurrence of the species as the response variable. We excluded the lower 10th and upper 90th percentiles of the drainage area distributions of each species as being at the edge of the species stream or river size preference and only included a species as "absent" if it occurred elsewhere in the same Huc-11 watershed. We then fit a smoothing curve to the probability of occurrence vs. metric or index score relationship to help visualize trends with each habitat gradient. Thus for each of these species in Ohio, within the core of their distribution in Ohio, these curves represent their preferred or avoided habitat types. We also reassert here that for these purposes conditions in Ohio are sufficiently similar to Illinois.

Clearly, the tailwaters of the Brandon Road and Dresden dams provide habitat for fluvial specialist and dependent species that does not exist within the more extensive impounded habitats of the UIW. The modeling of the flows and depths below each dam indicates that the hydropower stations will increase the duration of higher velocities downstream of the powerhouse discharges. Shallow, lower velocity and river edge habitats will still persist under the various scenarios. These shallow, low-velocity habitats are also common in margins of the downstream impounded areas of the Illinois River and are not likely to be habitat types that limit sensitive or fluvial dependent fish species populations. Although flows may decrease immediately downstream of some tainter or other gates where flow is currently directed, this should be compensated for by faster and deeper flows of longer duration downstream of the power stations.

eventually realized. Again, the longer duration of high velocity habitats should provide more essential habitat for these species compared to existing conditions. The impounded character of the river and the limitations that the current operation of the navigational locks and dams have on the rivers will continue to be the most limiting to the biological assemblages compared to a more natural riverine flow regime. However, the proposed hydropower project operations should have a nominal effect on the immediate downstream habitat conditions and may, in fact, enhance these conditions for fluvial dependent and specialist fish species.

Issue 2: Dissolved Oxygen and Water Quality Standards

One concern about the proposed hydroelectric facilities is the potential impact on the Illinois WQS in the rivers, particularly compliance with the D.O. criterion. Kleinschmidt (2009b) estimated that water spilling over the existing dams can add 1 mg/l to D.O. levels during the summer (Kleinschmidt 2009b). The turbines may enhance D.O. levels, but, without modification would not achieve the 1 mg/l boost provided by the current operation. NIH assessed the cost effectiveness, issues and efficacy of installing auto-venting devices to enhance D.O. from the turbine operation and concluded that reducing operation to increase spill (to enhance D.O.) was the most cost effective and practical option to avoid adverse impacts to the D.O. regime. This will be tracked by an automated D.O. monitoring system that will be used to adjust operations in response to ambient D.O. levels. NIH proposes to cease operations when D.O. levels approach the WQS criteria so as to avoid any exceedences.

The fact that the power stations are proposed only to be operated when D.O. would not violate WQS indicates that their operation will not impact water quality. D.O. levels in the lower Des Plaines and Illinois Rivers reached their nadir when wastewater from Chicago was reversed in 1900 and discharged into the Upper Illinois Waterway system to carry it away from Chicago and Lake Michigan, which is the drinking water source for Chicago (Forbes and Richardson 1913). According to Forbes and Richardson (1913) the first 26 miles of the Illinois River from the confluence of the Kankakee River with the lower Des Plaines River were "septic" and low D.O. continued for another 60 miles downstream. CWA initiated improvements gradually improved these conditions and the implementation of the Chicago Tunnel and Reservoir Plan (TARP), which started in 1975 to further protect the CAWS and Upper Illinois Waterway systems from combined sewer overflows (Groschen 2004). The current D.O. conditions, which only occasionally decline to levels of concern, have been substantially improved compared to the historical near anoxic conditions and with only partial implementation of TARP. Planned implementation of newer phases of TARP should further improve D.O. levels by controlling nutrient and organic enrichment from CSOs.

Issue 3: Potential Entrainment and Impingement Impacts from Hydropower Operation

The operation of hydropower facilities on natural rivers has been documented to have important consequences for biological assemblages such fish, macroinvertebrates, and freshwater mussels. Many of the impacts are related to the effects of impounding habitat and impeding flows as compared to the "natural flow regime" (Poff et al. 1997). At the proposed Dresden and Brandon Road hydropower stations these impacts are already present as part of the U.S. Army Corp of Engineers system of navigation locks and dams. Upstream migration of fish through these existing structures is largely dependent on movement through the locks, although organisms can also move downstream through the various dam overflow structures. The addition of the hydropower projects could potentially change downstream movements and induce added mortality to fish and other aquatic organisms; however, there will virtually be no effect on upstream movements from these proposed projects.

Potential impacts from the hydropower facilities on fisheries can be due to "impingment" (trapping fish on screens) or "entrainment" (mortality from passing through the turbines). FERC (1995) summarized the data about these issues in a detailed review with the important issues summarized in Table 2. As previously indicated, the current conditions in the Des Plaines/Illinois River system reflect a partial recovery of a once a severely polluted and limited resource. Table 1 lists fish species collected during a 2006 study of the Des Plaines and Illinois River which included the reaches that encompasses both dams. The most diverse sites were immediately downstream of each of the Brandon Road and Dresden dams.

Kleinschmidt (2009) conducted a desktop study to estimate entrainment mortality that might occur from the Brandon Road and Dresden hydroelectric projects based on a methodology developed by EPRI (1992) and using a database of fish mortality studies reported by FERC (1995). These methodologies allow estimates based on geographic location, turbine and operation type (run-of-river), flow, water quality issues, species, etc. The Kleinschmidt (2009) study estimated the number of fish entrained annually at the Brandon Road operation would be ~81,750 fish and at the Dresden operation ~53,400. NIH proposed to install trash racks over the powerhouse intake with 2" bar spacing and approach velocities of 1.5 feet per second to minimize fish entrainment (Kleinschmidt 2009). This should allow most adult fish to avoid entrainment.

Fish in the pool habitats above each dam tend to be more tolerant than the species occurring in the tailwater areas. It is likely that the relatively small number of fish entrained and the species of fish likely to occur in the vicinity of the intake would have little effect on the assemblages in the downstream tailwater areas. Because the condition of the Des Plaines and Illinois Rivers is one of recovering through time and the full implementation of the TARP project should further

Table 2. FERC Review Summary of Findings Related to Fish Passage and Entrainment (BOX 1-2: Chapter 2 Findings)

- The need for entrainment protection and passage for riverine fish is very controversial. There is a growing body of evidence that some riverine fish make significant movements that could be impeded by some hydropower facilities. The need for passage for riverine fish is most likely species- and site-specific and should be tied to habitat needs for target fish populations. This will be difficult to determine without establishing goals for target species.
- The acceptability of turbine passage for anadromous fish is site-specific and controversial. There is major concern when anadromous fish must pass through multiple dams, creating the potential for significant cumulative impacts. Passage of adult repeat spawners is also a major concern for most Atlantic Coast species.
- The effects of turbine passage on fish depend on the size of the fish; their sensitivity to mechanical contact with equipment and pressure changes; and whether fish happen to be in an area near cavitation or where shearing forces are strong. Smaller fish are more likely to survive turbine passage than larger fish. Survival is generally higher where the turbines are operating with higher efficiency.
- Riverine fish are entrained to some extent at virtually every site tested. Entrainment rates are variable among sites and at a single site. Entrainment rates for different species and sizes of fish change daily and seasonally. Entrainment rates of different turbines at a site can be significant.
- Turbine mortality studies must be interpreted with caution. Studies show a wide range of results, probably related to diversity of turbine designs and operating conditions, river conditions, and fish species and sizes. Turbine mortality study design is likely to affect results. Different methods may yield different results.
- Methods for turbine mortality study include: mark-recapture studies with netting or balloon tags, and observations of net-caught naturally entrained fish, and telemetry. Methods for entrainment studies include: netting, hydroacoustic technology (used especially in the West), and telemetry tagging. These methods have advantages and disadvantages depending on target species and site conditions. Hydroacoustic technology and telemetry tagging can provide fish behavior information (e.g., tracking swimming location) useful for designing passage systems and evaluating performance.\
- Early agreement on study design would help minimize controversies between resource agencies and hydropower operators. Lack of reporting of all relevant information makes it difficult to interpret results. Standardized guidelines to determine the need, conduct, and reporting of studies could help overcome this limitation.
- Mitigation by financial compensation is very controversial. The degree of precision necessary for evaluation studies and how fish should be valued are items of debate.

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Illinois Pollution Control Board
R2008-09
Environmental Groups' Post Hearing Comments on Subdocket D
Attachments

Attachment 2: Ohio Admin. Code 3745-1-32

3745-1-32 Ohio river standards.

(A) The Ohio river is designated warmwater habitat, public water supply, agricultural water supply, industrial water supply and bathing waters, and will meet the most stringent criteria set forth in, or derived in accordance with, this rule, rules 3745-1-01 to 3745-1-07 of the Administrative Code, and rules 3745-1-34 to 3745-1-36 of the Administrative Code.

Table 32-1. Water quality criteria for the Ohio river.

Chemical	Form[1]	Units[2]	IMZM[3]	OMZM[3]	OMZA[3]
Bacteria (fecal coliform)	T		--	b	b
Cyanide	free	µg/l	44	22	5.2
Dissolved oxygen[4]	T	mg/l	--	4.0[c]	5.0
Radionuclides	T		--	d	d
Temperature	--	ºF	--	Table 32-3	Table 32-3

[1] T = total.

[2] mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion); ºF = degrees fahrenheit.

[3] IMZM = inside mixing zone maximum; OMZM = outside mixing zone maximum; OMZA = outside mixing zone average.

[4] For dissolved oxygen, OMZM means outside mixing zone minimum at any time and OMZA means outside mixing zone minimum daily average.

[a] See rule 3745-1-07 of the Administrative Code.

[b] For the months of May to October, the maximum allowable level of fecal coliform bacteria shall not exceed two hundred per one hundred ml as a monthly geometric mean based on not less than five samples per month; nor exceed four hundred per one hundred ml in more than ten per cent of all samples taken during the month. For the months of May to October, measurements of Escherichia coli bacteria may be substituted for fecal coliform. Content shall not exceed one hundred thirty per one hundred ml as a monthly geometric mean, based on not less than five samples per month, nor exceed two hundred forty per one hundred ml in any sample. For the months of November to April, the maximum allowable level of fecal coliform bacteria shall not exceed two thousand per one hundred ml as a geometric mean based on not less than five samples per month.

[c] A minimum of 5.0 mg/l at any time shall be maintained during the April fifteen to June fifteen spawning season.

[d] Gross total alpha particle activity (including radium-226, but excluding radon and uranium) shall not exceed fifteen picocuries per liter (pci/l) and combined radium-226 and radium-228 shall not exceed four pci/l. The concentration of total gross beta particle activity shall not exceed fifty pci/l. The concentration of total strontium-90 shall not exceed eight pci/l.

Table 32-2. Ohio river water quality criteria for the protection of human health.

Chemical	Form[1]	Units[2]	OMZA[3] Intakes	Elsewhere
Acenaphthene	T	µg/l	1,200	1,200
Acrolein	T	µg/l	320	320
Acrylonitrile[5]	T	µg/l	0.59	0.59
Alachlor	T	µg/l	2.0[a]	--
Aldicarb[6]	T	µg/l	7.0[a]	--
Aldicarb sulfone[6]	T	µg/l	7.0[a]	--
Aldicarb sulfoxide[6]	T	µg/l	7.0[a]	--
Aldrin[5]	T	µg/l	0.0013	0.0013
Anthracene	T	µg/l	9,600	9,600
Antimony	TR	µg/l	6.0[a]	14
Arsenic	TR	µg/l	10[a]	50
Asbestos	T	Mf/l	7.0[a]	--
Atrazine	T	µg/l	3.0[a]	--
Barium	TR	µg/l	2,000[a]	--
Benzene[5]	T	µg/l	5.0[a]	12
Benzidine[5]	T	µg/l	0.0012	0.0012
Benzo(a)anthracene[5]	T	µg/l	0.044	0.044
Benzo(a)pyrene[5]	T	µg/l	0.044	0.044
Benzo(b)fluoranthene[5]	T	µg/l	0.044	0.044
Benzo(k)fluoranthene[5]	T	µg/l	0.044	0.044
Beryllium	TR	µg/l	4.0[a]	16
Bromate	T	µg/l	10[a]	--
Bromoform[5]	T	µg/l	43	43
Butylbenzyl phthalate	T	µg/l	3,000	3,000
Cadmium	TR	µg/l	5.0[a]	--
Carbofuran	T	µg/l	40[a]	--
Carbon tetrachloride[5]	T	µg/l	2.5	2.5
Chloramine	T	µg/l	4,000[a]	--
Chlordane[5]	T	µg/l	0.021	0.021
Chlorides	T	mg/l	250[a]	250
Chlorine	T	µg/l	4,000[a]	--
Chlorine dioxide	T	µg/l	800[a]	--
Chlorite	T	µg/l	1,000[a]	--
Chloroacetic acid[7]	T	µg/l	60[a]	--
Chlorobenzene	T	µg/l	100[a]	680
Chlorodibromomethane[5]	T	µg/l	4.1	4.1

Table 32-2. Ohio river water quality criteria for the protection of human health.

Chemical	Form[1]	Units[2]	OMZA[3] Intakes	Elsewhere
Bis(2-Chloroethyl)ether[5]	T	µg/l	0.31	0.31
Chloroform[5]	T	µg/l	57	57
bis(2-Chloroisopropyl)ether	T	µg/l	1,400	1,400
bis(2-Chloromethyl)ether[5]	T	µg/l	0.0013	0.0013
2-Chloronaphthalene	T	µg/l	1,700	1,700
2-Chlorophenol	T	µg/l	120	120
Chromium	TR	µg/l	100[a]	--
Chrysene[5]	T	µg/l	0.044	0.044
Copper	TR	µg/l	--	--
Cyanide	free	µg/l	200[a]	700
2,4-D (2,4-Dichlorophenoxy-acetic acid)	T	µg/l	70[a]	100
Dalapon	T	µg/l	200[a]	--
4,4'-DDD[5]	T	µg/l	0.0083	0.0083
4,4'-DDE[5]	T	µg/l	0.0059	0.0059
4,4'-DDT[5]	T	µg/l	0.0059	0.0059
Dibenzo(a,h)anthracene[5]	T	µg/l	0.044	0.044
Dibromochloropropane	T	µg/l	0.2[a]	--
Di-n-butyl phthalate	T	µg/l	2,700	2,700
Dichloroacetic acid[7]	T	µg/l	60[a]	--
1,2-Dichlorobenzene	T	µg/l	600[a]	2,700
1,3-Dichlorobenzene	T	µg/l	400	400
1,4-Dichlorobenzene	T	µg/l	75[a]	400
3,3'-Dichlorobenzidine[5]	T	µg/l	0.40	0.40
Dichlorobromomethane[5]	T	µg/l	5.6	5.6
1,2-Dichloroethane[5]	T	µg/l	3.8	3.8
1,1-Dichloroethylene[5]	T	µg/l	0.57	0.57
cis-1,2-Dichloroethylene	T	µg/l	70[a]	--
trans-1,2-Dichloroethylene	T	µg/l	100[a]	700
2,4-Dichlorophenol	T	µg/l	93	93
1,2-Dichloropropane[5]	T	µg/l	5.0[a]	5.2
1,3-Dichloropropene	T	µg/l	10	10
Dieldrin[5]	T	µg/l	0.0014	0.0014
Di(2-ethylhexyl)adipate	T	µg/l	400[a]	--
Diethyl phthalate	T	µg/l	23,000	23,000
2,4-Dimethylphenol	T	µg/l	540	540

Table 32-2. Ohio river water quality criteria for the protection of human health.

			OMZA[3]	
Chemical	Form[1]	Units[2]	Intakes	Elsewhere
Dimethyl phthalate	T	µg/l	310,000	310,000
4,6-Dinitro-o-cresol				
(4,6-Dinitro-2-methylphenol)T	µg/l	13	13	
Dinitrophenols[4]	T	µg/l	70	70
2,4-Dinitrotoluene[5]	T	µg/l	1.1	1.1
Dinoseb	T	µg/l	7.0[a]	--
1,2-Diphenylhydrazine[5]	T	µg/l	0.40	0.40
Diquat	T	µg/l	20[a]	--
Dissolved solids	T	mg/l	750/500[a,b]	--
alpha-Endosulfan[8]	T	µg/l	110	110
beta-Endosulfan[8]	T	µg/l	110	110
Endosulfan sulfate[8]	T	µg/l	110	110
Endothall	T	µg/l	100[a]	--
Endrin[9]	T	µg/l	0.76	0.76
Endrin aldehyde[9]	T	µg/l	0.76	0.76
Ethylbenzene	T	µg/l	700[a]	3,100
Ethylene dibromide (EDB)	T	µg/l	0.050[a]	--
bis(2-Ethylhexyl)phthalate[5]	T	µg/l	6.0[a]	18
Fluoranthene	T	µg/l	300	300
Fluorene	T	µg/l	1,300	1,300
Fluoride	T	µg/l	1,000	1,000
Glyphosate	T	µg/l	700[a]	--
Heptachlor[5]	T	µg/l	0.0021	0.0021
Heptachlor epoxide[5]	T	µg/l	0.0010	0.0010
Hexachlorobenzene[5]	T	µg/l	0.0075	0.0075
Hexachlorobutadiene[5]	T	µg/l	4.4	4.4
alpha-Hexachlorocyclohexane[5]	T	µg/l	0.039	0.039
beta-Hexachlorocyclohexane[5]	T	µg/l	0.14	0.14
gamma-Hexachlorocyclohexane (Lindane)[5]	T	µg/l	0.19	0.19
Hexachlorocyclohexane-technical grade[5]	T	µg/l	0.12	0.12
Hexachlorocyclopentadiene	T	µg/l	50[a]	240
Hexachloroethane[5]	T	µg/l	19	19
Indeno(1,2,3-c,d)pyrene[5]	T	µg/l	0.044	0.044
Iron	S	µg/l	300[a]	--

Table 32-2. Ohio river water quality criteria for the protection of human health.

			OMZA[3]	
Chemical	Form[1]	Units[2]	Intakes	Elsewhere
Isophorone[5]	T	µg/l	360	360
Mercury	TR	µg/l	0.012	0.012
Methoxychlor	T	µg/l	40[a]	100
Methyl bromide	T	µg/l	48	48
Methylene chloride[5]	T	µg/l	5.0[a]	47
Nickel	TR	µg/l	610	610
Nitrate-N + Nitrite-N	T	µg/l	10,000[a]	10,000
Nitrite-N	T	µg/l	1,000[a]	1,000
Nitrobenzene	T	µg/l	17	17
Nitrosoamines[5]	T	µg/l	0.0080	0.0080
N-Nitrosodibutylamine[5]	T	µg/l	0.064	0.064
N-Nitrosodiethylamine[5]	T	µg/l	0.0080	0.0080
N-Nitrosodimethylamine[5]	T	µg/l	0.0069	0.0069
N-Nitrosodi-n-propylamine[5]	T	µg/l	0.050	0.050
N-Nitrosodiphenylamine[5]	T	µg/l	50	50
N-Nitrosodipyrrolidine[5]	T	µg/l	0.16	0.16
Oxamyl (Vydate)	T	µg/l	200[a]	--
Pentachlorobenzene	T	µg/l	3.5	3.5
Pentachlorophenol[5]	T	mg/l	1.0[a]	82
Phenol	T	µg/l	21,000	21,000
Phenolics	T	µg/l	5.0	5.0
Picloram	T	µg/l	500[a]	--
Polychlorinated biphenyls[5]	T	µg/l	0.0017	0.0017
Pyrene	T	µg/l	960	960
Selenium	TR	µg/l	50[a]	170
Silver	T	µg/l	50	50
Silvex (2,4,5-TP, 2-[2,4,5-Trichlorophenoxy]propionic acid	T	µg/l	10	10
Simazine	T	µg/l	4.0[a]	--
Styrene	T	µg/l	100[a]	--
Sulfates	T	mg/l	250[a]	250
1,2,4,5-Tetrachlorobenzene	T	µg/l	2.3	2.3
2,3,7,8-Tetrachlorodibenzo-p-dioxin[5]	T	pg/l	0.13	0.13
1,1,2,2-Tetrachloroethane[5]	T	µg/l	1.7	1.7

Table 32-2. Ohio river water quality criteria for the protection of human health.
Page 5 of 5

Chemical	Form[1]	Units[2]	OMZA[3] Intakes	OMZA[3] Elsewhere
Tetrachloroethylene[5]	T	µg/l	5.0[a]	8.0
Thallium	TR	µg/l	1.7	1.7
Toluene	T	µg/l	1,000[a]	6,800
Toxaphene[5]	T	µg/l	0.0073	0.0073
Trichloroacetic acid[7]	T	µg/l	60[a]	--
1,2,4-Trichlorobenzene	T	µg/l	70[a]	260
1,1,1-Trichloroethane	T	µg/l	200[a]	--
1,1,2-Trichloroethane[5]	T	µg/l	5.0[a]	6.0
Trichloroethylene[5]	T	µg/l	5.0[a]	27
2,4,5-Trichlorophenol	T	µg/l	2,600	2,600
2,4,6-Trichlorophenol[5]	T	µg/l	21	21
Vinyl chloride[5]	T	µg/l	2.0[a]	20
Xylenes	T	µg/l	10,000[a]	--
Zinc	T	µg/l	9,100	9,100

[1] S = soluble; T = total; TR = total recoverable.
[2] mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion); ng/l = nanograms per liter (parts per trillion); pg/l = picograms per liter (parts per quadrillion); Mf/l = million fibers per liter.
[3] OMZA = outside mixing zone average. Criteria in the “Intakes” column apply within five hundred yards of drinking water intakes. Criteria in the “Elsewhere” column apply at all other locations.
[4] The criteria for this chemical apply to the sum of all dinitrophenols.
[5] Criteria for this chemical are based on a carcinogenic endpoint.
[6] The criterion for this chemical applies to the sum of aldicarb, aldicarb sulfone and aldicarb sulfoxide.
[7] The criterion for this chemical applies to the sum of chloroacetic acid, dichloroacetic acid and trichloroacetic acid.
[8] The criteria for this chemical apply to the sum of alpha-endosulfan, beta-endosulfan and endosulfan sulfate.
[9] The criteria for this chemical apply to the sum of endrin and endrin aldehyde.
[a] This criterion is the maximum contaminant level (MCL) developed under the “Safe Drinking Water Act”.
[b] Equivalent 25°C specific conductance values are 1200 micromhos/cm as a maximum and 800 micromhos/cm as a thirty-day average.

Table 32-3. Ohio river temperature criteria.

Month/date	Period Average (°F)	Instantaneous Maximum (°F)
January 1-31	45	50
February 1-29	45	50
March 1-15	51	56
March 16-31	54	59
April 1-15	58	64
April 16-30	64	69
May 1-15	68	73
May 16-31	75	80
June 1-15	80	85
June 16-30	83	87
July 1-31	84	89
August 1-31	84	89
September 1-15	84	87
September 16-30	82	86
October 1-15	77	82
October 16-31	72	77
November 1-30	67	72
December 1-31	52	57

Effective: 12/30/2002

R.C. Section 119.032 review dates: 3/25/2002 and 12/30/2007

Promulgated under: R.C. Section 119.03
Rule authorized by: R.C. Section 6111.041
Rule amplifies: R.C. Section 6111.041
Prior effective dates: 4/4/1985, 8/19/1985, 5/1/1990, 10/31/1997

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Illinois Pollution Control Board
R2008-09
Environmental Groups' Post Hearing Comments on Subdocket D
Attachments

Attachment 3: Colorado Water Quality Forum, "Temperature-Margin of Safety"

Margin of Safety

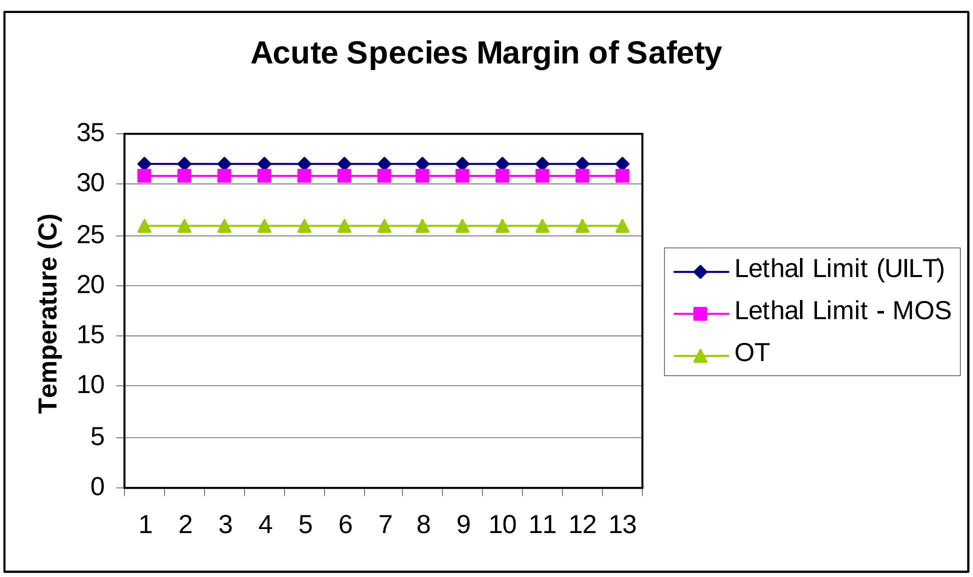
Acute Temperature Criterion:
"Acute" has been defined as "having a sudden onset, lasting a short time; of a stimulus, severe enough to induce a response rapidly" (Rand and Petrocelli, 1985). Short duration, acute numeric criteria are useful for addressing short duration changes in ambient temperature (e.g., associated with an intermittent discharge) and also daily high temperatures due to seasonal warming. Acute numeric standards are also useful where monitoring is intermittent, and the available ambient data are not sufficient to compare to a chronic standard.

This criterion uses the upper incipient lethal temperature (UILT) data derived using acclimation temperatures typical of summertime in Colorado above the lower optimum temperature for all species that are expected to be present. This includes all ultimate upper incipient lethal temperature (UUILT) data. The calculation uses only species for which there are data.

Since the UILT end point results in death for 50% of the organisms, a margin of safety (MOS) is subtracted from the species values to change the acute criterion from an "effect" level to a "no-effect" level.

Typically, laboratory-derived upper incipient lethal temperature (UILT) values are used to estimate acute exposure maxima. UILTs are based on 50% mortality of test organisms, but are adjusted by subtracting a 2°C "safety factor" to estimate a temperature that is protective of 100% of organisms (U.S. EPA, 1986; Armour, 1991).

This is done because in a laboratory it is difficult to tell where the threshold is that 100% of the organisms survive. UILT studies are common and report 50% mortality.



EPA based the 2°C safety margin on studies by Black (1953) that demonstrated that 100% survival typically occurred at temperatures 2°C less than the UILT. Subsequently, studies of field distributions of salmonids in relation to water temperature have shown that the upper field distribution limit is typically 2-4 °C below the UILT, adding further support for the use of a safety factor (Eaton et al., 1995; McCullough, 1999; McCullough et al., 2001).

The study conducted by Black in 1953, looked at the upper lethal temperatures for freshwater fish in the Summerlan Trout Hatchery. The temperature for which all, 50% and 100% of the fish survived in a 24-hour period are listed in the table below. The idea of the margin of safety is to develop a metric where 100% of the fish survive, by using data that is reported for temperatures where only 50% of the fish survive.

Table II. Summary of upper lethal; temperature data for freshwater fishes studied at the Summerland Trout Hatchery from May to July 1951. The data are arranged in groups according to the approximate acclimation temperatures. The values marked * are actual readings for 50 per cent mortality. (Black, 1953)

Species	Approximate Acclimation Temperature	Upper Temperatures at which fish survive 24 hours		
		All	50%	None
Kamloops trout	11	22.4	24	25.7
Fine scaled sucker	14	26.4	26.9*	28.3
Chub	14	24.4	27.1	28.3
Silver-grey minnow	25.2	28.3	28.3	28.3-31.1
Redside shiner	14	22.8	27.6	30.3
Prickly sculpin	18-19	22.8	24.1	26.5
Coarse-scaled sucker	19	25.7	29.4	32.2
Largemouth Bass	20-21	25.2	28.9*	30.4
Squawfish	19-22	26.4	29.3	32
Northern black catfish	23	34.4	35	36.7
Yellow perch	22-24	28.9	29.2	29.1-29.8
Pumpkinseed	24	29.2	30.2	31
Carp	26	34.4	35.7	36.9

The Commission has decided that a margin of safety is important to assure that the acute criterion protects aquatic species rather than allows a 50% mortality. In the April 2006 AAH, there was some disagreement as to whether or not the 2°C safety margin is appropriate for Colorado.

The Division investigated the appropriateness of the 2°C safety margin.

Why 2°C margin of safety may be appropriate for Colorado?
This method is established and has been used to develop temperature criteria in the past.

The Gold Book states the 2° C factor in the above equation is a margin of safety:

> To provide a safety factor so that none or only a few organisms will perish, it has been found experimentally that a criterion of 2° C below maximum temperature is usually sufficient (Black, 1953; Coutant, 1970; Fry et al. 1942).

Why 2°C margin of safety may not be appropriate?
A constant 2°C safety margin may not be appropriate for Colorado for two reasons:

1. Some warm water species in Colorado see a rate of decline from non-lethal effect to lethal effects well within two degrees. For this reason, it is not practical to universally apply a 2°C safety margin to all species, as it will result in acute species a criterion that is colder than the chronic criteria for certain species.
2. The 2°C safety margin was derived experimentally from 13 species, some of which do not reside in Colorado. "Several studies have indicated that a 2°C reduction of an upper stress temperature results in no deaths within equivalent exposure duration. Further research may determine that safety factors, as well as tolerance limits, have to be decided independently for each species, each life stage, and each water quality situation. As of now, however, 2°C appears to be an adequate safety factor." (Coutant, 1977)

What margin of safety is appropriate?
The Division investigated species that reside in Colorado for which we have data, and were similar to those species which were used to derive the 2°C safety margin by Black in 1953. In this investigation, the Division estimated that a margin of safety for these "equivalent" species could also be arrived at by looking at the average thermal distance from the median upper optimum (OT_{up}) and the median upper incipient lethal temperatures (UILT). On average the 2°C safety margin equates to 1/5 (approximately the same as a fraction of 0.18) of the thermal distance from the UILT and the OT_{up}.

Margin of Safety for Acute Species Temperature Criteria
(for Species comparable to those used to derive the 2°C safety margin by Black in 1953)

Species	UILT	UILT-2	OT_{up}	Fraction	Fractions Used for Calculation	Species comparable to Black, 1953
Rainbow Trout	25.9	23.9	18	0.246861925	0.24686192	*Kamloops Trout*
Mottled sculpin[1]	*0*	*-2*	*16.7*	*9.35*		*Prickly Sculpin*
Longnose sucker	27	25	16	0.36	0.36	*Fine scaled sucker*
Pumpkinseed[2]	*30.2*	*28.2*	*31.5*	*-0.11702128*		*Pumpkinseed*
Yellow perch	29.7	27.7	21.9	0.209386282	0.20938628	*Yellow perch*
Golden shiner	33.5	31.5	30	0.047619048	0.04761905	*Redside shiner*
Largemouth bass	36.2	34.2	30.2	0.116959064	0.11695906	*Largemouth bass*
Fathead minnow	33.1	31.1	27.6	0.112540193	0.11254019	*Silver-grey minnow*
Creek chub	31.5	29.5	21	0.288135593	0.28813559	*Chub*

Margin of Safety for Acute Species Temperature Criteria (for Species comparable to those used to derive the 2°C safety margin by Black in 1953)						
Species	**UILT**	**UILT-2**	**OT_{up}**	**Fraction**	**Fractions Used for Calculation**	**Species comparable to Black, 1953**
Common carp	36	34	32	0.058823529	0.05882353	*Carp*
Common shiner[2]	*32.8*	*30.8*	*31*	*-0.00649351*		*Redside shiner*
Spottail shiner	33.6	31.6	26	0.17721519	0.17721519	*Redside shiner*
Red shiner[1]	*0*	*-2*	*0*	*1*		*Redside shiner*
Sand shiner[1]	*0*	*-2*	*0*	*1*		*Redside shiner*
				Average:	**0.17973**	
Note 1: Mottled sculpin, Red shiner and Sand shiner not used in the calculation because there was no UILT data available.						
Note 2: Pumpkinseed and Common shiner were not sued in the calculation because the UILT minus 2 is less than the median of the upper optimum temperatures. These species are an example of why the constant 2°C in not appropriate for all species in Colorado.						

The Division also validated these results by looking at all species for which there was data in Colorado from the last rulemaking hearing in June 2005. The following table shows similar results of a margin of safety equal to subtracting 1/5 the thermal distance between the median UILT and the OT_{up}.

Division Recommendations:
The Division recommends that we use a proportional margin of safety for the species acute, instead of a constant 2°C. The Division believes that a 1/5 Rule would be appropriate in for the wide variety of species in Colorado.

This would be calculated as follows:

$$\mathbf{UILT - 1/5\ (UILT\text{-}OT_{up}) = Species\ Acute\ Value}$$

Attachment 4: Colorado Department of Public Health and Environment

Water Quality Control Commission

Temperature Criteria Methodology: Policy Statement 06-1

Temperature Criteria Methodology

Policy Statement 06-1

Colorado Department of Public Health and Environment
Water Quality Control Commission
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Approved: August 8, 2011
Expires: December 31, 2014

I. INTRODUCTION

This policy addresses the Water Quality Control Commission's methodology and rationale for developing water temperature criteria and standards for the protection of aquatic life in Colorado's surface waters. Colorado's temperature criteria were revised in January 2007 and in June 2010, and this policy records the incremental progress towards the current criteria. The Commission believes that it is appropriate to adopt this policy statement due to the importance of temperature criteria and the need for guidance on their development. This policy is intended as a general informational guide of the Commission's approach to the adoption of these criteria and standards.

The contents of this document have no regulatory effect, but rather summarize the Commission's thinking. Moreover, this policy is not intended and should not be interpreted to limit any options that may be considered, or adopted by the Commission in future rulemaking proceedings. Therefore, this policy statement can, and will, be modified over time as warranted by future rulemaking proceedings.

II. BACKGROUND

Water temperature directly governs the metabolic rate of fish and influences their behavior. Water temperature also can have a dramatic influence on the diversity and health of the aquatic community. Fish and macroinvertebrates are cold blooded organisms that have evolved with specific thermal requirements, and changes from the natural patterns or ranges can have deleterious effects on the individuals and the communities. Water temperatures are affected by various factors including solar radiation, ambient air temperature, stream shade, channel morphology, stream flows, ground water inflows, and various anthropogenic activities. The intent of Colorado's temperature standard is to protect aquatic life from adverse warming and cooling caused by anthropogenic activities from both point and nonpoint sources.

The Basic Standards and Methodologies for Surface Waters (Regulation No. 31, 5 CCR 1002-31) provides a framework for implementing water quality standards throughout the State of Colorado. Temperature criteria have been adopted in the Basic Standards. Temperature criteria provide protection for the aquatic community from both lethal and sublethal effects. The narrative temperature criteria also provide protection against abrupt or unseasonal changes in water temperatures, which may lead to thermal shock, a condition that can have lethal effects.

The Colorado temperature standard was first adopted by the Commission in 1978, and remained intact for over 25 years. The Division reviewed historic files from both the Division and Commission to determine the basis of these criteria. The Commission hearing files from that time are scarce and incomplete and no records were found regarding adoption of the temperature criteria. Likewise, the Division's files lacked any background information for the temperature criteria adoption. Thus, there was no clear guidance regarding the intent of the adopted criteria.

To address these issues, several references, including US EPA criteria documents, were reviewed to understand the historical background for Colorado's temperature criteria and to shed light on the scientific basis for their development.

A. Colorado Temperature Criteria Adopted in the Late 1970s

Colorado Temperature Standard Adopted in the Late 1970s		
PARAMETER	**CLASS 1 COLD WATER BIOTA**	**CLASS 1 WARM WATER BIOTA**
Temperature (°C)	Max 20°C, with 3 °C Increase (5)(G)	Max 30°C, with 3 °C increase (5)(G)

(5) Temperature shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall have no increase in temperature of a magnitude, rate and duration deemed deleterious to the resident aquatic life. Generally, a maximum 3 degrees Celsius increase over a minimum of a four-hour period, lasting 12 hours maximum is deemed acceptable for discharges fluctuating in volume or temperature. Where temperature increases cannot be maintained within this range using BMP, BATEA and BPWTT control measures, the Division will determine whether the resulting temperature increases preclude an aquatic life classification.
(G) Recommendations based on review of all available information by the Committee on Water Quality Standards and Stream Classification.

The temperature criteria consisted of two parts: 1) the 20 °C and 30 °C "numerics"; and 2) the narrative contained in the footnote, which includes language on the "normal pattern of diurnal and seasonal fluctuations" and reference to the maximum 3 °C increase. Further explanations of the averaging period for criteria evaluation were not provided. For instance, most criteria are for the protection of acute (1-day) or chronic (30-day) exposures. The duration for which the temperature criteria should be assessed was not described in a similar manner.

Historically, the Division generally did not assess whether waterbodies were in attainment with the temperature standard; therefore, the issue of the appropriate averaging period (1-day, 30-day, etc.) had not been critically considered. The Division has issued CDPS permits for many years to dischargers of heated effluent to receiving waterbodies. When developing permit limits, the Division included the appropriate 20 °C and 30 °C values as explicit, not-to-exceed effluent limits in the permits for coldwater and warmwater classified waterbodies, respectively. This past practice was questioned in the year 2000 as to whether it was protective of the 3 °C increase portion of the temperature standard.

B. What was the problem with the former criteria?

The three problems with the 1970's version of the criteria were that they were inconsistently applied in permits, Footnote 5 was unclear, and there were disagreements about how the attainment of this standard should be assessed in the context of the 303(d) List.

A workgroup convened in the fall of 2001 to discuss the interpretation of the temperature criteria for the purpose of assessing ambient water quality and its implementation in CDPS permits. Efforts towards understanding the criteria increased in preparation for the 2005 Regulation No. 31 Basic Standards rulemaking hearing. The Division proposed new temperature standards in the June 2005 Basic Standards Rulemaking.

C. Commission's Action in June 2005

The temperature workgroup was far from consensus for the June 2005 Basic Standards Rulemaking. In response, the Commission adopted revised temperature standards with an effective date of December 31, 2007. This delay was provided to enable the Division and stakeholders to continue to work on refining the methodology and the data quality protocols for developing revised temperature criteria.

D. Preparation for January 2007 Rulemaking Hearing

In 2005 and 2006, the Division and stakeholders continued to work on the methodology and data quality protocols through various venues. A Temperature Technical Advisory Committee (TAC) was formed to discuss temperature issues through a series of four technical memos and conference calls. The TAC consisted of six members from a wide range of disciplines: academia, government, dischargers, and environmental consultants. The Division reported back to the stakeholders through monthly temperature stakeholder meetings where stakeholders had the opportunity to comment on the work the TAC was doing.

The TAC addressed the following:

- Identification of metrics useful for assessing fish species tolerance of lethal and long-term effects of temperature (see section VIII.D.)
- Screening criteria and important metadata for creating a database that would contain all known acceptable scientific data on the thermal tolerance and optima for Colorado fish species (see section IX.)
- The appropriate averaging periods for assessing chronic and acute in-stream temperatures (see section VI.)
- The importance of protecting against thermal shock (see section IV.C.2.)
- The importance of protecting spawning (see section IV.C.1.)
- The importance of protecting early life stages (see section IV.C.1.)
- The importance of protecting normal diel and seasonal variation (see section IV.C.3.)
- The importance of protecting normal patterns of spatial variability (see section IV.C.3.)

Following the TAC's recommendations, the WQCD and stakeholders identified the appropriate fish species, metrics, and specific studies (see section IX.) that were used for criteria development. The result was the Colorado Temperature Database v3.1 (see section X.) which was used to develop the summer criteria adopted in the January 2007 rulemaking hearing (see sections VII & VIII.).

In addition to addressing the TAC's recommendations, the WQCD and stakeholders defined circumstances where exceedances would be allowable including exclusions for air temperature, low-flow, and adequate refuge in lakes and reservoirs (section V). Some specific aspects of implementing temperature standards into permits, such as the exemption for discharges from natural hot springs, were adopted into section 31.14(14)(b). But rather than exempting a wide range of dischargers in the Basic Standards Regulation, the Commission directed the WQCD to include appropriate exemptions as part of the reasonable potential guidance (31.45).

III. CENTRAL CONCEPTS

It is the policy of the Commission to establish temperature standards to protect against negative effects to aquatic life. These include a range of effects from lethality to decreased rates of growth and reproduction.

A combination of criteria that can protect from adverse effects of temperature include:

- an acute or maximum temperature criterion (lethality),
- a chronic criterion for a longer duration average (growth, etc.),
- a season/location/species specific spawning criteria (sensitive life stages),
- a criterion to maintain a normal temperature pattern (upstream/downstream, normal spatial variability),
- a criterion to avoid effects due to sudden temporary changes (thermal shock).
- a criterion to maintain normal seasonal and diel temperature patterns.

Establishing limits on both maximum (acute) and average (chronic) temperatures offers the best opportunity to protect aquatic life, and is appropriate to address the variety of temperature regimes found in Colorado. This approach also allows for the use of both lethal and non-lethal effects data in deriving acute and chronic criteria as described below.

A. Elements of Criterion

The three elements of criterion are magnitude, duration, and frequency. Criterion magnitude specifies acceptable ambient levels of a pollutant or other parameter. Criterion duration is the period of time over which data are averaged for comparison with a criterion-magnitude. Criterion frequency is the element of a numeric water quality criterion describing how often waterbody conditions can surpass the combined magnitude and duration components (i.e., specifying the allowed number of excursions that can occur within a certain period of time (i.e., the acceptable rate of excursions). All three elements of criterion will be addressed in this policy document.

B. Acute Temperature Criterion

The acute temperature criterion provides protection against lethal effects that elevated temperature can cause. Short duration, acute numeric criteria are useful for addressing short duration changes in ambient temperature (e.g., associated with an intermittent discharge) and also daily high temperatures due to seasonal warming. Acute numeric criterion is also useful where monitoring is intermittent, and the available ambient data are not sufficient to compare to a chronic criteria.

C. Chronic Temperature Criterion

The chronic temperature criterion provides protection against sublethal effects on behavior, metabolism, growth, and reproduction.

D. Protection for Sensitive Life Stages Criterion

Sensitive life-stages (e.g., eggs and fry) and critical activities (e.g., migrations, spawning) related to reproduction need to be considered when developing temperature criteria. The temperatures during spawning seasons must be protective of the offspring (i.e., eggs, fry, early life stages).

E. Protection of Normal Temperature Pattern

Attainment of the acute and chronic numeric table values may not be sufficient alone to protect the aquatic community if the seasonal and diel temperature patterns are not maintained. Variations from the normal temperature pattern can have biological consequences, such as shifts in migration timing, incubation rates, and spawning timing as well as interfere with essential rearing periods.

F. Protection Against Thermal Shock Provision

Thermal shock provisions provide another way to address short duration changes attributable to discharges. "Thermal shock" can result from sudden releases of very hot water, and can result in serious sublethal or lethal conditions for fish (Parker and Krenkel, 1969). Sudden discharges of hot water can overwhelm a fish's heat tolerance range, its ability to acclimate to changes in ambient water temperatures, and its avoidance reactions. Likewise, sudden discharges of cold water can have similar effects. Thermal shock can lead to increased susceptibility to predation, increased avoidance energy costs, increased metabolism and resultant oxygen and food requirements that may be difficult to meet, and other negative effects (McCullough, 1999; McCullough et. al., 2001).

G. Community Composition

This concept refers to how species are grouped to protect the biological community that is expected to occur in the area. Aquatic life cold and warm use classifications are too general to capture the natural temporal and spatial variability associated with temperature in the state of Colorado.

H. Adoption of Criteria into Standards

Standards protect the uses of a waterbody. The temperature standards adopted in 2007 and revised in 2010 are designed to protect the Aquatic Life use.

IV. CRITERIA - MAGNITUDE

The Commission adopted two criteria based on a literature review of temperature effects data for fish species present in Colorado. The acute criterion protects against lethality, and the chronic criterion protects against adverse effects that could include reduction of growth or reproduction. The Commission also chose to create special provisions for protection against thermal shock and to protect sensitive life stages.

The acute and chronic criteria chosen by the Commission are defined in Sections A and B below:

A. Acute Criteria

The acute criterion for the fish community that is expected to be present is calculated using the 95th percentile of species-specific acute values. Species-specific values were based on the lethal temperature for that species minus a margin of safety (MOS).

This criterion uses the upper incipient lethal temperature (UILT) and ultimate upper incipient lethal temperature (UUILT) data derived using acclimation temperatures typical of summertime water temperatures in Colorado (see VIII. D. 1. for definitions). In some cases, lethal data from critical thermal maximum (CTM) studies were used for species that lacked UILT/UUILT data.

A MOS is subtracted from the species-specific lethal values to take the acute criterion from a lethal level to a sub-lethal level. These species-specific acute values are ranked and the value for the 95th percentile of species in the community is chosen as the overall acute criterion (e.g., if there are 100 species, this would generally equate to the value that protects 95 of the 100 species). The 95th percentile is not appropriate where a more protective approach is deemed necessary to protect a commercially, recreationally, or environmentally important species (e.g. cutthroat trout).

The details of how species-specific acute criteria were calculated are discussed in section VIII. F. 1. of this document. Details of how community acute criteria were calculated are discussed in section VIII. G. 1. of this document.

B. Chronic Criteria

The chronic criterion for the fish community that is expected to be present is calculated using the 95th percentile of species-specific chronic values. Species-specific values were based on the upper optimum temperature for that species, or surrogate data if upper optimum data were not available.

The chronic species criteria data were ranked and the value for the 95th percentile was chosen (e.g. if there are 100 species, this would generally equate to the value that protects 95 of the 100 species). This criterion is intended to protect 95 percent of the species present (provided that commercially, recreationally or environmentally important species are protected) at the upper bound of their optimal levels. The 95th percentile was determined not appropriate to protect commercially, recreationally or environmentally important species. In these situations, the chronic criterion was set to the species specific chronic value to fully protect the species of interest (e.g., cutthroat trout).

The details of how species-specific chronic criteria were calculated are discussed in section VIII. F. 2. of this document. The details of how community chronic criteria were calculated are discussed in section VIII. G. 1. of this document.

C. Special Provisions

In 2007, special provisions were adopted to protect spawning, thermal shock, normal seasonal fluctuations, normal diel fluctuations, and normal spatial variability. Commission policies and the efforts to protect these functions are described below.

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1. Reproduction

It is the policy of the Commission that protection of spawning/reproduction from anthropogenic thermal effects is appropriate.

In preparation for the 2007 hearing, the WQCD investigated the possibility of compiling a database of spawning temperatures and dates, but found that such data were not available. Instead, spawning numbers from the EPA "Gold book" were used as a basis to set seasonal temperature standards for cold waters (streams, lakes, and reservoirs).

This approach not only protects the thermal regime needed for spawning and survival of embryos, but also helps ensure that normal seasonal temperature patterns are maintained by requiring that winter temperatures be substantially cooler than summer temperatures. The chronic cold-water winter temperature standard is 9 ^{o}C based on the spawning temperature requirements of brook trout and rainbow trout (31.16(3) Table 1). The acute cold-water winter temperature standard is 13 ^{o}C based on the maximum temperature for successful incubation and hatching of embryos for all Salmonids listed. It was noted that the cold-water winter temperature criteria were about 50% of the summer criteria and this relationship was applied to warm waters, where spawning data was not as readily available.

The winter standards for coldwater streams apply from October through May. This duration is based on the typical timing of fall and spring spawning for Salmonids, and on broad attainability of these standards. The seasonal duration can be extended or shortened on a site-specific basis. For all lakes and reservoirs, the winter criteria apply from January through March. This adjustment was based on empirical temperature data from lakes and reservoirs, which have large water volumes that cool slowly in the fall.

For warm waters, the winter chronic and acute values are 50% of the summer values. A halving of the summer values set the criteria below the threshold that triggers spawning in warm-water fish. This should ensure that fish are not being induced to spawn in the winter by anthropogenic warming, when food is scarce and/or the appropriate habitat, such as floodplains, may not be available. The warm-water winter criteria for streams apply December through February.

The following table shows the default assumptions for when ELS are present for each species and temperature tier associated with those species.

Colorado Fishes, Early Life Stage Expectation and Temperature Criteria Tiers
Shaded cells indicate ELS default assumption.

Species	Temp. Tier	J	F	M	A	M	J	J	A	S	O	N	D
Cutthroat Trout	CS-I				S	S	S	S,I	I,E				
Brook Trout	CS-I	I	I	E	E	E				S	S	I	I
Mountain Whitefish	CS-II	I	I	I						S	S	S	I
Mottled Sculpin	CS-II					S	S						
Brown Trout	CS-II	S,I	I	I	I,E					S	S	S	S
Golden Trout	CS-II						S	S	I,E				
Longnose Sucker	CS-II			S	S	S	S	S					
Rainbow Trout	CS-II			S	S	S	S	I	E				
Mountain Sucker	CS-II						S	S					
Lake Trout	CL	I	I	I	I						S	S	S,I
Kokanee	CL	I	I	I						S	S	S	I
A. Grayling	CL				S	S	S	S,I					
White Sucker	WS-II				S	S	S	S	S				
Brook Stickleback	WS-II						S	S					
Longnose Dace	WS-II					S	S	S					
Creek Chub	WS-II				S	S	S	S	S				
N. Redbelly Dace	WS-II					S	S	S					
Flathead Chub	WS-III					S	S	S	S				
Lake Chub	WS-III					S	S						
Spottail Shiner	WS-III						S	S	S				
Sand Shiner	WS-III					S	S	S	S				
Brassy Minnow	WS-III					S	S						
Plains Minnow	WS-III				S	S	S	S	S				
Fathead Minnow	WS-III					S	S	S	S				
N. Pike Minnow	WS-III					S	S	S					
Redside Shiner	WS-III					S	S	S	S				
River Carpsucker	WS-III					S	S						
Bluehead Sucker	WS-III				S	S	S						
Carp	WS-III					S	S	S					
Golden Shiner	WS-III					S	S	S					
Iowa Darter	WS-III					S	S	S					
Black Bullhead	WS-III					S	S	S					
Channel Catfish	WS-III					S	S	S					
Green Sunfish	WS-III					S	S	S	S				
Pumpkinseed	WL					S	S						
Bluegill	WL					S	S	S					
Northern Pike	WL				S	S							
White Crappie	WL					S	S	S					

Black Crappie	WL					S	S						
Yellow Perch	WL				S	S	S						
Sauger	WL				S	S							
Walleye	WL				S	S							
Smallmouth Bass	WL					S	S						
Largemouth Bass	WL					S	S	S					
S=Spawning Period, I=Incubation period for eggs, E=Time period in which sac-fry are in the gravels.													

2. Thermal Shock Provision

It is the policy of the Commission that a provision against an in-stream or in-lake temperature change that could result in thermal shock is warranted, but that it may be difficult to implement.

Thermal shock proved to be one of the most difficult aspects of temperature criteria development. In the 2007 hearing, a spatial or temporal limitation of temperature change could not be agreed upon, therefore a narrative standard to protect against thermal shock was adopted by the Commission, as follows:

> "Temperature shall maintain a normal pattern of diel and seasonal fluctuations and spatial diversity *with no abrupt changes* and shall have no increase in temperature of magnitude, rate, and duration deleterious to aquatic life." (italics added) 31.16(3) Table 1, footnote (5)

The 2007 Statement of Basis and Purpose indicates that the WQCD will impose permit conditions where best professional judgment indicates protection is necessary to protect the use from abrupt thermal changes. In preparation for the 2010 hearing, the Division reviewed new information, but did not find data that would support a proposal for additional regulatory provisions to protect against thermal shock. The WQCD will also continue to explore means to protect aquatic life from anthropogenic thermal shock, with particular emphasis on an implementation strategy that is straightforward (31.45).

3. Seasonal/Diel Fluctuations and Spatial Diversity

It is the policy of the Commission to maintain normal seasonal/diel temperature fluctuations as well as normal variability in the temperature of the stream or lake.

In the 2007 hearing, the Commission chose to adopt the following narrative standard to ensure that seasonal/diel fluctuations and spatial diversity are maintained:

> "Temperature shall maintain a *normal pattern of diel and seasonal fluctuations and spatial diversity* with no abrupt changes and shall have no increase in temperature of magnitude, rate, and duration deleterious to aquatic life." (italics added) 31.16(3) Table 1, footnote (5)

With respect to seasonal and diel fluctuations, the Commission decided that a single value to protect summertime diel fluctuation would not address the myriad of site-specific conditions, and so is relying on the narrative standard. The 2007 Statement of Basis and Purpose indicates that the WQCD will impose permit conditions where best professional judgment indicates such protection is necessary to protect the use, as directed by the Commission (31.45).

With respect to spatial variability, the Commission does not see a way to quantify spatial diversity in regulation at this time. The 2007 Statement of Basis and Purpose indicates that the WQCD will use its discretion to implement the narrative requirement for spatial diversity in situations where there is evidence that an activity does or will create spatial uniformity that will threaten or impair aquatic life, as directed by the Commission (31.45).

V. CRITERIA – FREQUENCY

In 2007, the Commission determined the Maximum Weekly Average Temperature (MWAT) or the Daily Max (DM) (see section VI for definitions) should not be exceeded more than once every three years, unless one of three exemptions were applicable (31.16(3) Table 1, footnote (5)(c)).

In 2010, the Commission changed the air temperature exclusion from an annual maximum air temperature to a monthly maximum air temperature, and added a fourth exemption for the winter shoulder-seasons in cold-water streams (31.16(3) Table 1, footnote (5)(c)(iv).

These exemptions are:

(1). An air temperature exemption that allows for the standard to be exceeded when the air temperature exceeds the 90th percentile value of the monthly maximum air temperatures calculated using at least 10 years of air temperature data.

In 2010, the Commission changed the annual maximum air temperature to a monthly maximum air temperature, so it is possible to exclude data from any extraordinarily warm day for any time of year and not just in summer when the maximum annual temperature occurs.

(2). A low flow exemption that allows for the standard to be exceeded when the daily stream flow falls below the acute critical low flow or monthly average stream flow falls below the chronic critical low flow, calculated pursuant to Regulation 31.9(1).

(3). A lake and reservoir exemption that allows temperature exceedances in the mixed layer of a stratified lake if an adequate refuge is present below the mixed layer. Adequate refuge depends on the concurrent attainment of the applicable dissolved oxygen standard and applicable temperature standard.

(4). A winter shoulder-season exemption that allows temperature exceedances in cold-water streams for 30-days before the winter/summer transition, and 30-days after the summer/winter transition, provided that the natural seasonal progression of temperature is maintained and those exceedances are not the result of anthropogenic activities in the watershed.

This exemption does not change the underlying winter standard, and has no effect on permit limits. This exclusion was not applied to lakes or warm-water streams because there was no evidence that spring or fall temperature fluctuations occur naturally outside of the regulatory "summer" season in these systems.

VI. CRITERIA – DURATION

In 2007 the Commission defined the implementation statistics for temperature as follows:

1. Maximum Weekly Average Temperature (MWAT): The MWAT is the largest mathematical mean of multiple, equally spaced, daily temperatures over a seven-day consecutive period, with a minimum of three data points spaced equally throughout the day. For lakes and reservoirs, the MWAT is assumed to be equivalent to the maximum WAT from at least three profiles distributed throughout the growing season (31.5(25).)

2. Daily Maximum Temperature (DM): The DM is the highest two-hour average water temperature recorded during a 24-hour period (31.5(13)).

3. Weekly Average Temperature (WAT): The WAT is a mathematical mean of multiple, equally spaced, daily temperatures over a seven-day consecutive period, with a minimum of three data points spaced equally throughout the day. For lakes and reservoirs, the WAT is assumed to be equivalent to the average temperature of the mixed layer. The average temperature of the mixed layer is determined from a vertical profile of equally-spaced temperature measurements, separated by not more than one meter (31.5(49)).

In 2010, the Commission slightly revised the definition of the MWAT.

The word "daily" was removed from the definition to clarify that the standard is assessed as a rolling average; no intermediate daily-statistic needs to be calculated. The word "summertime" was added to clarify that seasonal summer and winter standards also apply to lakes (31.5(25)). Therefore, winter temperature measurements would not be compared to the summer MWAT.

VII. COMMUNITY COMPOSITION

In 2007, the Commission adopted temperature 'tiers' within the cold and warm categories. The fish within a 'tier' have similar thermal requirements, and the criteria in the first 'tier' of both the warm and cold communities have the coolest thermal requirements, while subsequent tiers are less thermally sensitive. For cold streams, two temperature 'tiers' were adopted. The criteria for the first tier were based upon the thermal requirements of the most thermally sensitive cold-water species: cutthroats and brook trout. The criteria for the second cold tier were based on 'not-sensitive' species, including brown and rainbow trout and the remaining cold-water species.

For warm-water streams, four temperature 'tiers' were adopted in 2007. The criteria for the first tier were based upon the most thermally sensitive warm-water species: common shiner, Johnny darter, and orangethroat darter. The criteria for the second tier were based upon 'other sensitive species' including brook stickleback, central stoneroller, creek chub, longnose dace, Northern redbelly dace, finescale dace, and white sucker. The criteria for the third tier were based upon the razorback sucker, which is a federally listed endangered species. Finally, the criteria for the fourth tier were based upon all the remaining warm-water fishes in the database, which all had less stringent thermal requirements than fish in the first three tiers.

In 2010, the Commission deleted one warm tier, which was based upon the thermal requirements of the razorback sucker only. The Commission deleted this tier because it would not apply to any segment. DOW has found that the white sucker, which is more thermally sensitive than the razorback sucker, exists everywhere the razorback sucker is expected to occur. The razorback sucker was incorporated into warm tier two, which also includes the white sucker.

In 2007, the Commission also adopted separate criteria for lakes and reservoirs in recognition of their distinct assemblage of fishes. For cold waters, separate criteria were adopted for small lakes (less than 100 acres surface area) and large lakes (100 acres or greater surface area). The 100 acre threshold is based on CDOW's lake management criteria for fish. Large lakes generally do not have cutthroat or brook trout, which are the most sensitive to temperature, therefore the criteria for large lakes are not based upon those species. The Commission intends to adopt site-specific criteria for the few large lakes that do contain, or are managed for, those sensitive cold-water species. Size distinctions play a less significant and consistent role in dictating warm-water lakes species assemblages, thus warm-water lake criteria apply to all warm lakes regardless of size.

VIII. METHODOLOGY TO DEVELOP CRITERIA

The Commission endorsed the following methodology to develop temperature table values in Colorado. This section includes recommended methods on the overall process to determine temperature standards, how to screen the data, the use of lab and field data, how to calculate acute and chronic species criteria, and how to calculate community criteria.

A. General Data Collection Process

These are the general guidelines for all data included in the Colorado Temperature Database. The Commission recommends the following methodology to determine water quality criteria for temperature:

1. Data Screening

The studies are screened for applicability to Colorado temperature criteria. Data screening guidelines are included Section IX, Data Quality Screening Guidelines below.

2. Database Compilation

All data that passes the initial data screening should be added to the database. All appropriate information should be included. It is important to cast a wide net to capture all types of information. Any additional information that may influence the results must be noted in the "Notes" field.

3. Species Specific Criteria Calculations

Species-specific temperature criteria are calculated (both acute and chronic). See subsection F. 1. in this section below for acute and chronic methodology.

4. Community Composition Analysis

An analysis of fish thermal sensitivity and community composition is used to determine where separate categories or subcategories (tiers) of temperature standards are needed in the table values. Various categories and subcategories should be investigated to see if they have thermal requirements that deserve a distinct table value. If the data shows no difference from the subcategory community criteria and the overall table value, then there would be no need to make that distinction. If a significant difference was noted then it may be appropriate to have separate table values for a subcategory of the use. This could alleviate an overly conservative temperature value for some circumstances or offer more protection for more sensitive species. Table values will be calculated for the existing use classifications and for the following subcategories:

- East Slope versus West Slope
- West Slope T&E Species
- Aquatic Life Cold Streams
- Aquatic Life Cold, Lakes and Reservoir
- Aquatic Life Warm Streams
- Aquatic Life Warm Lakes and Reservoir
- Transition Zone

- Cutthroat Trout
- Varying Elevation Zones
- Small versus Large Lakes and Reservoirs
- Thermal 'tier' groupings

The Commission intends the following actions to occur in regard to the subcategories listed above:

a. The Division will compile data for the subcategory in question.

b. From the database, calculate a subcategory-specific table value for both acute and chronic. These table values will be calculated using the same procedures as temperature table values, but only using data for the specific species present.

c. Determine whether this subcategory-specific table value is significantly lower or higher than the table value for the appropriate use. If it is, the Division will recommend a subcategory-specific table value.

d. The Commission will consider adoption of this subcategory-specific table value to be applied to streams where this specific community is present or expected to be present on a case-by-case basis.

B. Data Screening

Data screening guidelines are included Section IX, Data Quality Screening Guidelines below.

C. The role/use of lab data

The Commission intends laboratory-derived temperature tolerance data to be used to develop the criteria. Data from primary scientific literature should be collected, reviewed and compiled into a database. Data screening guidelines are included in Section IX, Data Quality Screening Guidelines, in this Policy document. Field data are used to validate lab data when available.

The following excerpt of Sullivan et al, 2000[1] discusses the use of field and lab data by the Environmental Protection Agency (EPA):

> The Environmental Protection Agency (EPA) and other agencies have conducted water quality research over the years to accomplish two major objectives: 1) develop cause–and effect relationships between water quality conditions and

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[1] Sullivan K., D. Martin, R. Cardwell, J. Toll, and S. Duke. 2000. *An analysis of the Effects of Temperature on Salmonids of the Pacific Northwest With Implications for Selecting Temperature Criteria*. Sustainable Ecosystems Institute, Portland OR

biological response, and 2) develop repeatable methodologies that use research findings to craft regulatory water quality criteria grounded in sound science. A primary technique used by researchers is to subject fish and other aquatic organisms to pollutants in a controlled laboratory setting to determine the relationship between dosage, length of exposure and biological responses such as growth loss, stress, altered behavior, disease, or death. Such laboratory-based research has been a cornerstone of fisheries science during this century and its validity has been confirmed in field-based studies (Brett 1971, Shuter et al. 1980, Baker et al. 1995, Filbert and Hawkins 1995). Conversely field observations alone are often not reliable for deriving water quality criteria because of variability in the natural environment and the complexity of factors controlling natural systems and habitat response. Brett (1971) observed that "it is inherently difficult to examine existing conditions and deduce the important biological factors which have occurred in the past to explain the present". Laboratory studies were the basis for EPA recommended temperature criteria (U.S. EPA 1977) and field studies have been used mainly for validating the appropriateness of water quality criteria (Hansen 1989, Mount et al. 1984).

D. Data that should be used

All thermal tolerance data should be recorded in the database in case there is a need to use it in the future should the methodologies in this policy document change. The following data are preferred:

1. Acute Thermal Endpoints:

a. Ultimate Upper Incipient Lethal Temperature (UUILT): UUILT is the highest Upper Incipient Lethal Temperature (UILT) that can be produced by selection of an acclimation temperature. Further increases in acclimation temperatures do not result in higher UILT values.

b. Upper Incipient Lethal Temperature (UILT): UILT is an estimate of acute exposure maximum temperature relative to a previous acclimation temperature. It is the temperature at which 50% of the test organisms die within a 1- or 7-day exposure period, given a previous acclimation to a constant lower temperature that is within the zone of tolerance of the organism. Generally, the higher the acclimation temperature, the higher will be the UILT, until the UUILT is reached. At this point, further increases in acclimation temperature do not result in any further increase in UILT.

In most UILT studies fish are transferred from the acclimation tank to the experimental tank, so the temperature change experienced by the fish is instantaneous. However, it should be noted that there are deviations from this method.

c. Critical Thermal Maximum (CTM) Data: CTM is an estimate of the median temperature reached in a quickly increasing temperature environment (usually 3^{o}C/min) that produces loss of equilibrium, spasms, or death of test organisms. Important factors in CTM studies include the rate of temperature change and the initial acclimation temperature. CTM studies typically give higher values than do UILT studies, probably because the temperature change is more gradual than the instantaneous temperature change that is typically used in UILT studies.

In the January 2007 hearing, a conversion factor may be used to estimate median UILT/UUILT from the median CTM. While UILT /UUILT are the preferred metrics for use in calculating acute values for each species in Colorado, this type of data was unavailable for many Colorado fish species as of 2007. The critical thermal maximum (CTM) is a more common experimental method for determining lethal values for fish, but generally gives higher lethal values than UILT/UUILT. For species that did not have UILT/UUILT, but did have CTM data, the CTM value minus a conversion factor was used as a surrogate for UILT/UUILT data. For warm-water species a conversion factor of 0.8 was used. This value was calculated from the 2005 temperature database, and is the median value of the median CTM minus the median UILT for all warm-water species where both metrics were available. For cold-water species, the conversion factor was calculated the same way, but instead of taking the mean of all the species values, the conversion factor was used on a species-specific basis. Thus, a different conversion factor was used for each cold-water species.

Values used to convert CTM values to UILT values. CTM-conversion factor=UILT	
Species	**conversion factor ^{o}C**
all warm-water	0.8
cutthroat trout	4.4
brook trout	1.3
brown trout	1.3
rainbow trout	0.8

2. Chronic Thermal Endpoints:

a. Optimum Temperature (OT): The optimum temperature is derived from the species-specific performance over a range of temperatures and includes parameters such as growth rate, digestion rate, gross conversion efficiency, swimming performance, metabolic rate, cardiac rate, etc.

Optimum temperature data from various studies are combined by taking the median of all reported optima data including lower and upper optima. This results in one central tendency OT value for a given species.

Growth optimum is the most common measure of optimum temperature. In these studies, groups of fish are raised over a range of experimental temperatures, and the size of the fish in each group is measured over a period of time. Each group is held at a constant temperature for the period of study, and the fish are typically fed as much as they can eat during that time. The growth over the period of study is usually measured as wet-weight, or length. The temperature at which the fish grow the most is the optimum temperature.

In growth optimum studies, the experimental temperatures should not be confused with acclimation temperature. The acclimation temperature is the temperature the fish were held at *before* the study began, and is usually not relevant since the studies are run for a longer period of time.

b. Final Preferred Temperature/Preferred Temperature: Final preferred temperature for fish given a wide range of thermal choices and enough time to select the temperature (multiple days) is also an appropriate surrogate for OT data. Acclimation temperature should not play a role in final preferred temperature selection, because studies of preference should be long enough that any prior acclimation effect is superseded by the exposure to the experimental temperature; in thermal preference studies where the fish are given enough time to select their final preferred temperature, the same thing should happen.

Preferred temperature for fish given a wide range of thermal choices and enough time to select the temperature can be an appropriate surrogate for OT data. For preferred temperature, acclimation temperature does play a role in temperature selection, but this effect can be offset by using only data obtained from acclimation temperatures within the range of normal summertime water temperatures in Colorado.

Preference and final preference may be measured in vertical gradients, horizontal gradients, or shuttleboxes that allow fish to move between compartments of varying temperature.

c. Avoided High: Avoided high is typically measured in shuttleboxes where the temperature in the occupied box is raised until the fish decides to exit the box for a cooler environment.

3. Other data that should be recorded:

a. Acclimation temperature and duration: the temperature within a species' tolerance zone that test fish are experimentally exposed to for several days (usually at least 14 days) before a tolerance test (Armour, 1991). Acclimation temperature affects the temperature range that a fish can tolerate.

b. Life stage: The life stage of the test organism at the time of the study is important to record.

c. Full reference: The full citation of the study will be recorded in the database.

d. Location: Whether the experiment took place in a lab, semi-natural conditions (such as outdoor ponds), or in the field will be recorded in the database.

e. Number of replicates and sample size: The number of replicates and/or the global sample size shall be recorded where appropriate.

f. Origin of fish: The origin of the fish used in the study will be recorded in the database (wild caught, hatchery, pet store, etc).

g. Endpoint of CTM studied: The endpoint used for CTM studies will be recorded in the database (loss of equilibrium, spasms, or death)

h. Relevant experimental procedures: Rates of temperature change for CTM studies, or other important details will be recorded in the database.

E. The role/use of field data

The Commission intends field data to be used as validation of the calculated standards. In other words, field observations should be used to ground truth the values derived from laboratory test results.

Where field observations indicate that a species thought to be sensitive (based on laboratory data) thrives in conditions that are warmer than predicted by the laboratory data, such information should be considered in determining whether the criteria or standards need to be adjusted. Likewise, where field observations indicate that unacceptable effects occur at temperatures thought to be protective (based on lab data) such information should be considered in determining whether the criteria or standards need to be adjusted.

F. Species Criteria were developed based on the following steps:

1. Acute Species Criterion:

a. Acute Species Criterion: It is the policy of the commission to protect aquatic species from lethal effects due to temperature. A margin of safety (MOS) is subtracted from the temperature that causes death in order to obtain a sub-lethal criterion.

b. Data Collection: Query all thermal tolerance data with lethal (or near lethal endpoints) from the most current version of Colorado Temperature Database. This includes ultimate upper incipient lethal temperature (UUILT), upper incipient lethal temperature (UILT), and critical thermal maximum (CTM) data for each species.

c. Data Consolidation: Compile all UUILT/UILT (or CTM if UUILT/UILT are not available) data derived using acclimation temperatures typical of summertime temperatures in Colorado. For cold water, normal summertime temperatures fall between 7 and 23 ^{o}C, unless the lowest CTM for that cold-water species is less than 23 ^{o}C. In that case, use the lowest CTM as the upper limit for screening data. For warm water, normal summertime temperatures are between 15 and 30 ^{o}C, unless the lowest CTM for that warm-water species is less than 30 ^{o}C. In that case, use the lowest CTM as the upper limit for screening data. Any data with acclimation temperatures outside the normal range of summer temperatures should be excluded from the calculations. Field studies should also be excluded from the calculations as well as studies using eggs, embryos, and larvae.

If UILT/UUILT data are not available for a given species a conversion factor can be used to convert the median CTM to an estimate of the median UILT/UUILT.

Median CTM – conversion factor = median UILT/UUILT

For cold water species, use the following conversion factors: cutthroat trout 4.4, brook trout 1.3, brown trout 1.3, and rainbow trout 0.8. For all warm-water fishes use a conversion factor of 0.8. A more scientifically valid conversion factor should be used if a better method of conversion becomes available.

d. Data Selection: Select the median of the. UILT/UUILT data, or use the estimate of median UILT/UUILT derived from the converted median CTM.

e. Determination of MOS: Calculate the MOS using the 1/5 rule if appropriate data are available, or a default 2 ^{o}C MOS will be used. The 1/5 rule is that the MOS is equal to 1/5 the distance between the median UILT/UUILT and the Upper Optimum.

1/5 * (Median UILT/UUILT – Upper Optimum) = MOS

The converted median CTM may be used as a surrogate for median UILT/UULIT. Three metrics are possible surrogates for Upper Optimum. In order of preference they are: median Optimum, median Preferred Average, or the Avoided High with an acclimation temperature closest to the inferred optimum. In this case, the optimum is inferred from the preferred average with the smallest difference between the acclimation temperature and the preferred average.

f. Include Safety Factor: Subtract a MOS.

Median UILT/UUILT – MOS = species acute value

g. Record Species Acute Criteria: This value is then used as the species acute criteria. This value can then be used to determine a community acute criterion, or can be used for any site-specific criteria that focuses on this particular species as the most sensitive species.

2. Chronic Species Specific Criterion

It is the policy of the commission to protect aquatic species from sub-lethal effects due to temperature.

a. Data Collection: Collect all thermal tolerance data with optimal endpoints. This includes OT, GO, preference, and final preferrenda. Record upper and lower optima where published. For cold water, normal summertime temperatures fall between 7 and 23 ^{o}C, unless the lowest CTM for that cold-water species is less than 23 ^{o}C. In that case, use the lowest CTM as the upper limit for screening data. For warm water, normal summertime temperatures are between 15 and 30 ^{o}C, unless the lowest CTM for that warm-water species is less than 30 ^{o}C. In that case, use the lowest CTM as the upper limit for screening data. Any data with acclimation temperatures outside the normal range of summer temperatures should be excluded from the calculations. Field studies should also be excluded from the calculations as well as studies using eggs, embryos, and larvae.

b. "Upper Range of Optimum" Calculation: Select the median of the Upper Optimum temperatures reported for growth and reproduction.

If Upper Optimum data are not available, proceed to step c and use the 1/3 Rule to estimate the median Upper Optimum. If there was sufficient data for the Upper Optimum for a species – proceed to step d.

c. "1/3 Rule" Calculation (where data are not available for the Upper Optimum):

i. Select the median of all the optimum temperature (OT) data. If Optimum data are not available, two other metrics may be used as surrogates. In order of preference these are median Preferred

Average, or Avoided High with an acclimation temperature closest to the inferred optimum. If using Avoided High, the optimum is inferred from the preferred average with the smallest difference between the acclimation temperature and the preferred average.

ii. Select the median of the UUILT/UILT temperatures from the data collected. If UILT/UUILT data is not available for a given species the converted CTM (described above in the acute procedure) may be used instead.

iii. Calculate the Chronic Species Criterion: Using the two temperatures calculated above**,** calculate the species chronic standard with the following equation:

Criterion = median OT + 1/3 * (median UUILT/UILT – median OT)

d. Record Species Chronic Criterion: This value is then used as the species chronic criteria. This value can then be used to determine a community chronic criterion, or can be used for any site-specific criteria that focuses on this particular species as the most sensitive species.

G. Community Criteria were developed based on the following steps:

1. Acute/Chronic Community Criterion

The Commission determined that community criteria for acute temperature standards should be determined following the same methodology as the chronic temperature criteria. Therefore, there is a need to identify only one methodology for the community criteria. The steps are as follows:

a. Determine the species that are expected to be present in the specific community.

b. Compile and rank the species data (acute or chronic) that are available for the expected community.

c. Calculate the 95th percentile of the species values. (e.g. if there are 100 species, this would generally equate to the value that protects 95 of the 100 species).

d. Determine if there are commercially, recreationally, or environmentally important species that would not be protected with the criteria developed using the 95th percentile approach. If there are species that are economically or ecologically important that will not be protected using the 95th percentile approach, determine the value that would be protective of that species.

e. The more protective value (from Step c or Step d) becomes the community criterion (acute or chronic).

IX. DATA QUALITY SCREENING GUIDELINES

A. Initial Data Screening Objectives

The following table outlines elements of a good study, or the data quality objectives, that must be considered when choosing data to be entered in the Colorado Temperature database:

Initial Data Screening Objectives	
Element	**A good study includes…**
Replications	An adequate number of replications.
Endpoint of the Study	The intent to study thermal tolerances and clearly stated biological endpoint that was used.
Acclimation History	Sufficient time for acclimation.
Acclimation Rate	The acclimation rate (this applies to Critical Thermal Maximum (CTM), preference, avoidance, performance optimum, and UILT studies).
Life Stage	The life stage of the test organism.
Appropriate Methods Employ appropriate controls Size of Fish	Same size fish are used throughout the study.
Appropriate Methods Employ appropriate controls Feeding State	Well documented Nutritional Status. (Noted that fasted fish prefer colder waters, fed fish prefer warm water, and animals should not be fed within 24 hours of the study to decrease the stress due to digestion.)
Appropriate Methods Employ appropriate controls Standard environment	A standard environment should be used.
Peer Reviewed Study	Evidence that it has been Peer reviewed (Any grey literature should be noted.) Study present in a published scientific journal. Data are from the original study. (although secondary citation may be necessary if the original study is not available)
Quality of Animals	Good quality Animals. Limit the stress on the animals – limited handling, not abnormally stressed, not subject to prior disease.

Initial Data Screening Objectives	
Element	**A good study includes…**
Field Conditions (where appropriate)	Collection under known conditions. Collection from known regions Lab Studies should have light similar to that season.
For field studies…	A natural environment during testing including competitors and predators. Normal physical environmental conditions/natural substrate, current speed and habitat complexity.
From hatchery	Information of known origin and history.
Number of Tanks for Critical Thermal Maximum (CTM) Studies	Information on how many fish per tank. Will not be run with more than one fish per tank.

B. Data Screening Process

Only primary, peer-reviewed scientific literature can be considered for inclusion in the database. No data from compilations or references from other studies are allowed. Papers published in scientific journals, dissertations, and theses, are all considered to be peer-reviewed literature. Section X contains details about the decision process for including or excluding papers from the database. The following steps should be considered in the initial data quality screening.

1. Determine if the intent of the study was to investigate how fish respond to changes/differences in temperature (for lab and field studies).

A few studies included in the database studied other variables in addition to temperatures. Those additional variables were noted in the database. However, only the results from treatment groups where temperature was the only treatment applied were added to the database (usually the control groups).

2. Determine if the data make sense.

Studies must consist of measurements taken over a range of experimental (laboratory) or field conditions to quantitatively define a thermal tolerance, optima, or preference value. Where such values are not defined, but the details are present to allow determination of their equivalents, the equivalents are calculated. Assuming all other criteria are met, the equivalents should be included in the database with a note to indicate how the value was calculated or determined (e.g., read from a figure, calculated from a reported regression equation, etc.).

Specifically excluded are values cited from other studies, and values from anecdotal observations (e.g., temperature of a drying pool that a researcher happens across that contains some dead fish).

The experimental design of each study should be evaluated as to whether the experimental design gives clear thermal tolerance and/or optimum thresholds, particularly if the design deviations from standard procedures. An example of an inadequate experimental design would be a growth study where maximum growth occurred at the highest experimental temperature because it cannot be known if the fish might have grown even more at higher temperatures. Another example of inadequate experimental design would include any study where the fish were stressed or otherwise altered in a way that might affect the outcome of the test (as occurred in one study where the fish were subjected to brain surgery before testing).

Where a tolerance, preference, or optimum is reported, whether these are medians, modes, or averages was recorded in the notes. Where they were reported as a range, a median value was recorded in the database with an appropriate note, in addition to the upper and lower values reported.

3. Was the replication adequate?

Replication means that a study was repeated. For CTM studies, each separate and simultaneous run of a fish, or group of fish is a replicate, but few studies met the suggested requirement of 10 replicates suggested by the TAC. Despite this, most studies produced results that were similar to those studies that did have 10 replicates (when those studies were available for comparison for a given species).

For UILT studies, tests of survival rates over time for fish exposed to a given temperature do not represent an individual replicate. In order to replicate a study, one would need to repeat the whole set of lethal temperature exposures. This wasn’t done in any UILT study reviewed. The sample sizes of fish treated at each temperature in UILT studies (n), as well as the global sample size or the total number of fish used (N), were recorded in the database for UILT studies in most cases.

Those UILT studies that were conducted with an average of less than 5 fish per temperature exposure, generally also had a low global sample size that would be detrimental to the precision or accuracy of the results. Studies with per-treatment sample sizes less than 5 were included in the database only when there were little or no other UILT data for a species. The samples sizes n and N were noted in the database, allowing database users to make a determination on whether these values should be included in the calculations.

4. If it is a laboratory study, are the design criteria met?

Check to see that the study did not deviate substantially from typical test procedures for upper incipient lethal and/or critical thermal maximum described in question 2. Data included in the database from experiments that deviated from standard procedures was recorded in the 'notes' fields. Some of the studies included in the database deviated from the standard experimental design, but the results were otherwise reasonable compared to similar studies. Variations on the standard designs for UILT, CTM, and Preference studies were noted in the 'experimental design' field. For example, the rate of temperature change used in CTM studies, and whether the UILT study involved a transfer of fish to a new temperature, or an increase of temperatures within the tanks to the various final lethal temperature treatment levels. Preference studies were generally conducted by one three means (horizontal gradients, vertical gradients, or shuttlebox), and the method was recorded in the database.

5. **Verify that field studies have appropriate experimental designs and do not have confounding stressors that may have altered the results. (e.g. in metals impacted streams)**

   'Preference' studies from the field, which used either observation of fish in combination with temperature measurements, or temperature-sensitive telemetry devices were not reported as preferences in the database, but instead as water temperature occupied by fish. Field studies that did not present a reliable method of estimating or measuring water temperature at the site of fish observations or captures were not included in the database. Additional qualifiers and details of the study design were reported in the notes and experimental design fields. Sample sizes were reported in the replicates/sample size column.

6. **Does the study return a set of useable, numeric values?**

   Qualifiers should be examined at this stage in the process.

The results of the data screening process will result in three sets of studies:

1. **USE –**These studies have met the quality requirements and have been included in the Colorado Temperature Database. Additionally, these studies have met the requirements for appropriate acclimation temperature, appropriate life stage, and are lab studies.

2. **SAVE –**These studies are of good quality and will be included in the Colorado Temperature Database, but should not necessarily be used in calculations. It is up to the user to eliminate unacceptable studies (such as field data, embryos, data with acclimation temperatures outside the range of summertime values, etc.) from the calculations. By including all good quality data in the database, users can decide what data to include or excluded from calculations. Also, the appropriateness of the data to be included in the calculations can be reevaluated in the future.

3. **DISCARD –**These studies are not recommended for any use, and will not be entered into the database.

A list of all studies considered for inclusion in the database will be kept by the WQCD so that rejected studies need not be evaluated repeatedly.

C. Data Rich Scenario

The policy of the Commission is that all studies are equal after the study/data quality screening is completed – no study should have more weight than another. Likewise, no studies should be discounted if it passes the initial data screening. In a rulemaking hearing the Commission may choose to exclude some data if a good rationale is presented.

D. Data Poor Scenario

The policy of the Commission is only use good quality data. Data that does not pass the initial data screening should not be used. In a rulemaking hearing, if there are no data for a species, the Commission may choose to include data from a surrogate species if a good rationale is presented.

E. Data Qualifiers

Qualifiers (such as less than, or more than) should be recorded and then some level of professional judgment will have to be applied as to how to handle that data. There may be many types of qualifiers that need to be recorded along with any numeric value. It is important for the compiler/analyst to recognize all the kinds of experimental conditions that could have a bearing on the results so that the results can be compared and contrasted. Some qualifiers might cause some numeric values to be discounted somewhat in importance if the conditions producing the result were somehow anomalous, unusual, or not typical of natural conditions or likely to elicit abnormal responses.

Regardless, significant qualifiers or caveats that are associated with experimental results should be collected and included in the dataset.

In many cases the temperature tolerance data are presented with the “less than” and/or “greater than." The Commission recommends that these are handled in the following manner:

1. For optimum temperatures and UILT, the value X in a “ > X” situation should be entered as the lower optimum or as an unadjusted UILT (that is, do not adjust with the 2 °C safety factor). This is a conservative/protective approach, and allows the data to be used.

2. <u>Do not use “X” temperature in an “< X” scenario</u> for optimum and UILT temperature.

It could overestimate the value. For example using UILT data, the study reported a UILT of <17 °C but the study was conducted between 17-21 °C. If the species OT is actually 15 °C then using 17 °C does not reflect the optimum. Where possible, the data qualifiers should be interpreted in the most conservative fashion. Where the range of temperatures was not sufficient to establish a discrete UILT, the study was not included in the database

3. These data should be evaluated on a case-by-case basis.

X. DATABASE

A. Location

The temperature database will be housed at the Water Quality Control Division. The Commission recommends that the most current version of the Colorado Temperature Database be made available on the WQCD's website, or that contact information be made readily available to the public for accessing the database.

B. Updates

The database will be updated when a recalculation procedure has occurred. Recalculations must involve a literature search for any new data. The database can also be updated with new studies as they are found.

C. Papers Considered for Inclusion in the Database

It is important that the data included in the Colorado Temperature Database are scientifically sound. As additional references become available, the Division will review the data to ensure that the scientific integrity of the Colorado Temperature Database is maintained. All studies included in the database in the future should meet the guidelines outlined in section IX.

If a dispute arises between the WQCD and a stakeholder about the inclusion or exclusion of a study in the Colorado Temperature Database, the WQCD may solicit an external review of the study. The reviewer(s) should comment on the scientific merit of the study, and recommend the paper for inclusion or exclusion in the database.

XI. IMPLEMENTATION INTO REGULATIONS

In 2008 and 2009 the Commission adopted temperature standards for the segments in Regulations 33, 37, and 38, which cover the Colorado, North Platte, and South Platte river basins. Temperature implementation guidance for developing permit effluent limits is available through the WQCD Permits section. Guidance for determining attainment of temperature standards is contained in the 303(d) Listing Methodology.

A. Numeric Temperature Criteria

In the January 2007 hearing, the revised numeric and narrative temperature criteria were incorporated into Table 1 of the Basic Standards. The table value standards recognized two cold-water tiers for streams, four warm-water tiers for streams, cold-water lakes and reservoirs, large cold-water lakes and reservoirs, warm-water lakes and reservoirs, and seasonal winter values for all subcategories. The table values will be used as a basis for adopting segment-specific temperature standards in conjunction with expected fish species distributions, unless evidence establishes that a site-specific numeric standard is appropriate.

Temperature standards are assigned to segments based on available information about the expected fish community, existing temperature data, and any other relevant factors. The appropriate temperature standard for a given segment is based on the temperature tier associated with the most thermally sensitive species expected to be present, unless there are data to support a site-specific standard.

The Commission has adopted temperature standards for segments with aquatic life, but no fish, despite the fact that the temperature criteria are based only on thermal data for fish at this time. Generally, the least restrictive cold or warm temperature tier is applied in these cases. The temperature criteria are intended to protect the aquatic life use classification in general, including other forms of aquatic life for which there are very limited thermal tolerance data.

Where there is uncertainty about the appropriate temperature tier, the Commission adopts temperature standards based upon the available information, and the uncertainty should be recorded in the Statement of Basis and Purpose. The Division, DOW, and/or stakeholders will work to resolve the uncertainty for those segments. Where there is uncertainty about the underlying standard AND data to show that a permitted discharger will have a compliance problem with the adopted temperature standard, a temporary modification may be adopted in accordance with 31.7(3).

In some cases, species in intermediate tiers are not present or expected to be present in transitional segments. Thus, cold stream tier one segments can abut warm stream tier three segments if species in intermediate tiers are not expected to be present.

In transition areas, where cold and warm aquatic species coexist or are expected to be present on a seasonal basis, it may be appropriate to adopt site-specific standards that reflect the seasonal presence of cold-water species.

B. Changes in Segmentation

In some cases, changes to the existing segmentation are needed to facilitate the adoption of appropriate temperature standards. Four general scenarios warrant re-segmentation: (1) separating lakes and streams, (2) separating cold large lakes from cold lakes, (3) separating stream segments, and (4) combining segments.

1. Separating Lakes and Streams

Lakes and streams may be separated into different segments since different temperature tiers have been developed for lakes and streams.

2. Separating Cold Large Lakes from Cold Lakes

Large cold-water lakes (greater than 100 acres surface area) may be separated from small lakes. The assemblage of fish species in large cold-water lakes differs from the assemblage that occurs in small cold-water lakes and, as a result, there are different temperature standards for large versus small cold-water lakes.

3. Separating Stream Segments

Segments may be split into two or more segments where information shows that the aquatic community is not homogenous throughout a segment. For instance, the Commission may split a segment if brook trout or cutthroat trout (cold stream tier 1) are present in the upper portion of a segment, and only rainbow trout or brown trout (cold stream tier 2) are present in the lower portion of the segment.

4. Combining Stream Segments

Segments may be combined where two or more contiguous segments have the same expected aquatic community, anti-degradation designation, use classifications, and similar water-quality.

C. Assessing Attainability of Proposed Standards

The Commission considers the attainability of temperature standards by evaluating water temperature in combination with the published thermal requirements in the Colorado Temperature Database for the expected aquatic community, and the anthropogenic influences on stream temperature. Footnote (5)(c) of Table 1 in 31.16 outlines four cases where high temperatures are not considered exceedances of the standard. Attainability is assessed considering the factors set forth in Regulation 31.6(2)(b)

D. Changes to Aquatic Life Use Classifications

A change in use classification may be warranted where segments with cold-water species have been misclassified as Aquatic Life Warm, or where segments with only warm-water species have been misclassified as Aquatic Life Cold. Errors in classification may be remedied by adjusting segment boundaries, creating new segments, developing site-specific standards, or reclassifying existing segments.

Sufficient data are necessary to support a change to the Aquatic Life use classification, particularly when the change is a downgrade from Cold to Warm. A Use Attainability Analysis (UAA) is required by EPA in these cases because the change from Cold to

Warm is associated with less stringent dissolved oxygen and is therefore a downgrade of the use (40 CFR 131.3(g), 40 CFR 1311.0(j)(2), 31.5, and 31.6(2)(b)).

Where sufficient data are not available to support a reclassification, the uncertainty concerning the classification of the segment must be identified in the Statement of Basis and purpose, and additional data should be collected.

1. **Warm to Cold:** A change in the Aquatic Life use classification from Warm to Cold must be supported by adequate data about the expected aquatic community as well as actual temperature data showing the attainability of cold-water temperature standards.

2. **Cold to Warm:** A change in the Aquatic Life use classification from Cold to Warm relaxes the standard for dissolved oxygen. Therefore, a UAA and sufficient supporting data are required. A change from a Cold to Warm use classification can only be adopted where both biological and temperature data support such a change. The thermal effects of both point and non-point sources also need to be addressed including the effects of diversions and water storage projects.

a. Considerations and Data Sources

The following information has been considered in temperature UAAs.

1. Thermal preference of the aquatic community including species expected to be present

2. Critical habitat for endangered fishes

3. Available water temperature data

4. Exemptions due to low-flow, air temperature, or adequate refuge (refuge applies to lakes only), or winter shoulder-season.

5. Flow removed by diversions

6. Precipitation

7. Elevation

8. Upstream reservoirs and their release structures (top or bottom release)

9. Land cover and land use

10. Natural hot springs

11. Point sources and non-point sources of anthropogenic thermal load

b. Practical Effects of Changing from Cold to Warm Sub-classification

Beyond the obvious change in temperature criteria, the practical effect of changing the Aquatic Life use classification from a cold to a warm sub-classification is that the numeric standards for dissolved oxygen are relaxed.

i. Dissolved Oxygen: The dissolved oxygen criterion is relaxed from 6.0 mg/L to the Aquatic Life Warm value of 5.0 mg/L, and the spawning dissolved oxygen standard of 7.0 mg/L does not apply.

E. Development of Site-Specific Standards for Individual Segments

As noted above, the numerical temperature table values will be used as the starting point for developing site-specific numerical standards for individual segments. Site-specific temperature standards may be appropriate where the ambient temperatures are adequate to protect the expected community, but the corresponding table value standard is not attained. Site-specific temperature standards may alter the seasons when summer and winter standards apply, and/or change the numeric values. Site-specific standards must be supported with adequate data to characterize the thermal regime, the aquatic community, and the extent of anthropogenic temperature alterations from both point and non-point sources (see subsection D.2.a above). The existing and expected aquatic life use must be protected by site-specific standards.

As outlined in the Basic Standards at 31.7(1)(b) Ambient Quality-Based or Site-Specific Criteria Based Standards may be adopted by the Commission. These situations include:

1. Ambient Based Standards may be established where evidence has been presented.

31.7(1)(b)(ii) Ambient Quality-Based Standards

For state surface waters where the natural or irreversible man-induced ambient water quality levels are higher than specific numeric levels contained in tables I, II, and III, but are determined adequate to protect classified uses, the Commission may adopt site-specific chronic standards equal to the 85th percentile of the available representative data. Acute standards shall be based on table values or site-specific-criteria-based standards, and in no case may an ambient chronic standard be more lenient than the acute standard.

2. Site-Specific Alternatives that do not Require a Rulemaking Hearing

The Commission adopted provisions at 31.14(14)(d) and (e) to allow alternative site-specific criteria to be developed at the time of permit development without the need for rulemaking. A site-specific recalculation following the procedures set forth in section XII of this document can be used to support variation from the table value standards. When conducted as part of a permit renewal, the recalculated criterion should then be considered for formal adoption in the appropriate segment as part of the next basin review and rulemaking hearing.

XII. THE RECALCULATION PROCEDURE

The Recalculation Procedure is intended to result in a site-specific temperature criterion that differs from the aquatic life table value criterion if justified by differences between the aquatic species that are expected to be present and those that were used in the derivation of the table value.

The phrase “expected to be present” includes the species, genera, families, orders, classes, and phyla that:

1) are usually present at the site.
2) are present at the site only seasonally due to migration.
3) are present intermittently because they periodically return to or extend their ranges into the site.
4) were present at the site in the past, are not currently present at the site due to degraded conditions, and are expected to return to the site when conditions improve.
5) are present in nearby bodies of water, are not currently present at the site due to degraded conditions, and are expected to be present at the site when conditions improve.

The taxa that are “expected to be present” cannot be determined merely by sampling downstream and/or upstream of the site at one point in time. Additionally, “expected to be present” does not include taxa that were once present at the site but cannot exist at the site now due to permanent physical alteration of the habitat at the site resulting from dams, etc.

The definition of the “site” can be extremely important when using the Recalculation Procedure. For example, the number of taxa that occur at the site will generally decrease as the size of the site decreases. Also, if the site is defined to be very small, the permit limit might be controlled by a criterion that applies outside (e.g., downstream of) the site.

The concept of the Recalculation Procedure is to create a dataset that is appropriate for deriving a site-specific criterion. Whenever a Recalculation is done, the literature for thermal preference and tolerances of the species expected to be present must be searched for new studies or studies that might have been missed when the Colorado Temperature Database was created. New studies that meet the guidelines outlined in sections IX and X of this document should be added to the Colorado Temperature Database, and this effort will help the keep the database current.

The acute and chronic species calculations, and community criteria calculations, must follow the guidelines outlined in section VIII of this document. This includes appropriate screening of data (appropriate acclimation temperature, removal of embryos, removal of field data, etc.) from the Colorado Temperature Database, unless an appropriate justification is provided.

- Correction of data that are in the statewide dataset.

- Addition of data to the statewide dataset.
- Deletion of data that are in the dataset.

Each step is discussed in more detail below.

A. Corrections

1. Only corrections approved by the Water Quality Control Division may be made.

2. The concept of "correction" includes removal of data that should not have been in the dataset in the first place. The concept of "correction" does not include removal of a datum from the dataset just because the quality of the datum is claimed to be suspect.

3. Two kinds of corrections are possible.

    a. The first includes those corrections that are known to and have been approved by the Water Quality Control Division; a list of these will be available from the Water Quality Control Division.

    b. The second includes those corrections that are submitted to the Water Quality Control Division for approval. If approved, these will be added to Water Quality Control Divisions list of approved corrections.

4. Selective corrections are not allowed. All corrections on Water Quality Control Divisions newest list <u>must</u> be made.

B. Additions

1. Only additions approved by the Water Quality Control Division may be made.

2. Two kinds of additions are possible:

    a. The first includes those additions that are known to and have been approved by the Water Quality Control Division; a list of these will be available from the Water Quality Control Division.

    b. The second includes those additions that are submitted to the Water Quality Control Division for approval. If approved, these will be added to Water Quality Control Divisions list of approved additions.

3. Selective additions are not allowed. All additions on Water Quality Control Divisions newest list <u>must</u> be made.

C. The Deletion Process

The basic principles are:

1. Additions or corrections must be made as per steps A and B above, before the deletion process is performed.

2. Selective deletions are not allowed.

   If any species is to be deleted, the deletion process described below **must** be applied to all species in the statewide dataset, after any necessary corrections and additions have been made to the statewide dataset. The deletion process specifies which species **must** be deleted and which species **must not** be deleted. Use of the deletion process is optional, but no deletions are optional when the deletion process is used.

Comprehensive information **must** be available concerning what species occur at the site; a species cannot be deleted based on incomplete information concerning the species that do and do not satisfy the definition of “occur at the site”.