KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

BUREAU OF WATER

WATER QUALITY STANDARDS WHITE PAPER

ALLOWANCES FOR LOW DISSOLVED OXYGEN LEVELS FOR AQUATIC LIFE USE

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ISSUE

Should Kansas explicitly define conditions where low dissolved oxygen is acceptable?

It is the mission of the Kansas Department of Health and Environment (KDHE) to protect the health and environment of all Kansans by promoting responsible choices. One facet of this mission is the setting of water quality standards based on the best science available.

CURRENT CRITERIA

Currently, the Kansas Water Quality Standards (KSWQS) define the water quality criterion (5 mg/l) for dissolved oxygen in Table 1g of the KANSAS SURFACE WATER QUALITY STANDARDS: Tables of Numeric Criteria**. K.A.R. 28-16-28e (d)** states: *The numeric criteria for the designated uses of classified surface waters shall be the numeric criteria specified in the department's "Kansas surface water quality standards: tables of numeric criteria," dated December 6, 2004, which is hereby adopted by reference.* Table 1g includes the following condition for dissolved oxygen: *The concentration of dissolved oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution.*

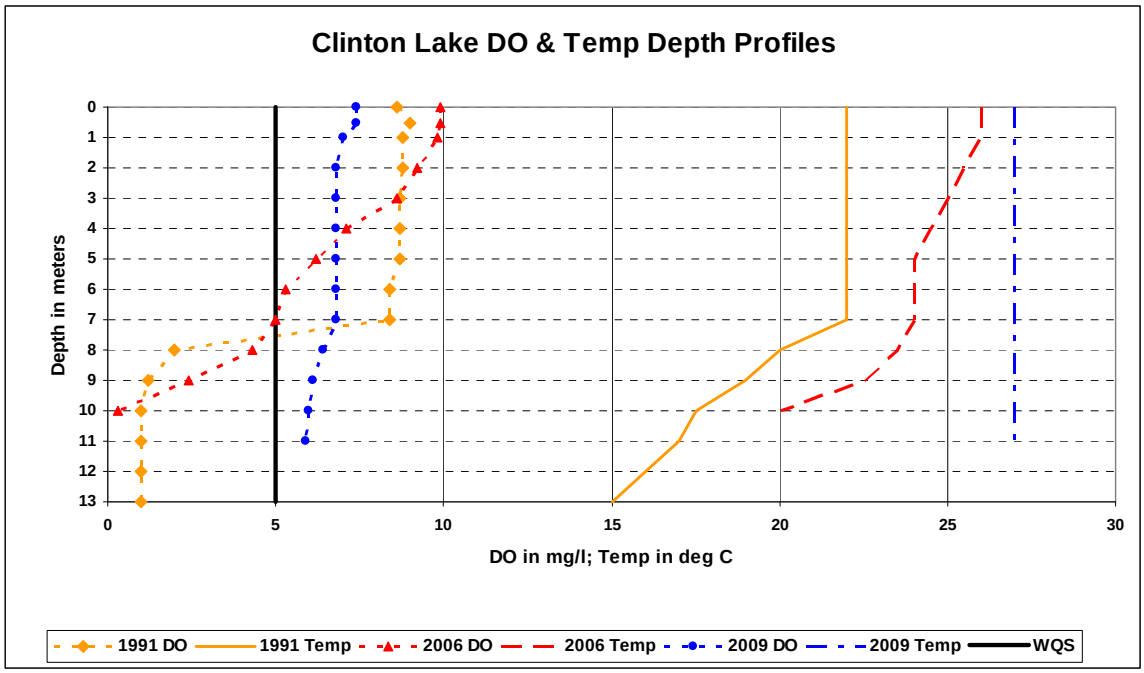
BACKGROUND

Dissolved oxygen is critical to maintaining a robust aquatic life community in Kansas waters. Dissolved oxygen (DO) is the concentration of oxygen dissolved in water and is necessary for the support of oxygen-demanding aquatic organisms such as fish, crawfish, snails; etc For the warm water streams and lakes of the state, a universal criterion of 5 mg/l of dissolved oxygen has been applied for decades. To date, there have been no exceptions to this value nor site-specific criteria derived for any Kansas stream, lake or wetland. The listing methodology for developing the 303(d) list of impaired waters assesses dissolved oxygen as an acute impairment. Therefore, the frequency of dissolved oxygen levels falling below 5 mg/l on any Kansas water cannot be more than once every three years. A number of streams have been identified as impaired by low dissolved oxygen. Typically, the incidence of low dissolved oxygen occurs in the summer when water temperatures are high (reducing the ability of water to retain dissolved oxygen) and streamflows are low (reducing the

ability of the stream to re-aerate itself or flush or dilute any oxygen-demanding substances present in the water). At times, the introduction of organic material is natural, such as during periods of leaf fall. Additionally, ground water reaching the surface through springs and seeps may not have 5 mg/l of dissolved oxygen.

Lakes have also been listed for deficient dissolved oxygen, oftentimes in conjunction with eutrophication impairments. However, lakes with moderate levels of nutrient or algal content have sufficient levels of dissolved oxygen, but see dissolved oxygen diminish at their lower depths. This condition occurs particularly during times when the lake or reservoir thermally stratifies with warmer water lying above cooler, denser water. In Kansas lakes with moderate to high turbidity, light penetration into the water column is limited and organic material tends to accumulate in the lower depths (hypolimnion). Thus aerated water is thermally blocked from the hypolimnion and primary productivity to create dissolved oxygen is minimal at depth. Conversely, decomposition of organic matter and respiration by the aquatic life present near the lake bottoms consume what dissolved oxygen exists.

As an example, depth profiles for Clinton Lake are presented for 1991, 2006 and 2009. The lake showed stratification in 1991 and 2006, marked by the rapid decrease in temperature with depth. At the same time, the dissolved oxygen levels in the lower portions of the lake fell below 5 mg/l. In 2009, the lake was thoroughly mixed with uniform temperature throughout its profile. Dissolved oxygen levels in 2009 remained above the water quality standard.



The existing water quality standards expect dissolved oxygen to not be lowered by artificial sources of pollution. Secondary treatment by permitted wastewater facilities removes Biochemical Oxygen Demand (BOD) sufficiently so that the stream (or lake) receiving the wastewater does not see its dissolved oxygen levels sag below 5 mg/l. Kansas streams typically see a diel[1] pattern for dissolved

[1] Diel – a chronological 24-hour day

oxygen, with the highest levels during daytime oxygen production by plant photosynthesis and the lowest concentrations seen during dark periods of respiration and decomposition. However, the language of the water quality standards implies that natural causation of low dissolved oxygen may occur and would be acceptable. Nonetheless, no allowance for naturally diminished dissolved oxygen has been made through the impaired waters [303(d)] listing process. Dissolved oxygen below 5 mg/l at a frequency more often than once every three years is cause for listing, with no regard to cause.

OTHER STATES' APPROACH

Within Region VII, Iowa maintains a criterion of 5 mg/l for warm water aquatic life, but does restrict its application in lakes to their upper layer. Missouri is similar to Kansas stating water contaminants will not cause dissolved oxygen to fall below standards, but with no explicit allowances for natural conditions. Missouri does use a binomial approach in listing waters for dissolved oxygen and that analysis may discount some infrequent, naturally occurring episodes of low dissolved oxygen. Nebraska does not identify exceptions to its criteria, but applies a 1-day minimum of 5 mg/l and a 7-day average of 6 mg/l during the early life stage period of April through September. Nebraska also has criteria of 3, 4 and 5.5 mg/l during October thru March as 1, 7 and 30 day averages. Thus, while not having a provision accounting for natural causes of low dissolved oxygen, the use of averages allow for such causes to be discounted.

For the other two surrounding states, Oklahoma has a criterion of 5 mg/l for warm water aquatic communities, but decreases that to 4 mg/l during June 16 to October 15. Impairment is cited if more than 10% of the samples are below the criterion or if more than 2 samples are below 2 mg/l. For lakes, impairment is claimed if more than 50% of the lake water column has a dissolved oxygen concentration less than 2 mg/l or if 10% of the surface samples are below the 5/4 mg/l criteria.

In Colorado, stream dissolved oxygen is deemed impaired if the 15th percentile falls below the applicable criterion of 6 mg/l (7 mg/l during spawning season). Furthermore, Colorado states: *Where dissolved oxygen levels are less than these levels occur naturally, a discharge shall not cause a further reduction in dissolved oxygen in receiving water.* So there is a more overt recognition of naturally deficient conditions. For lakes, Colorado asserts: *The dissolved oxygen criteria is intended to apply to the epilimnion and metalimnion strata of lakes and reservoirs. Dissolved oxygen in the hypolimnion may, due to the natural condition, be less than the table criterion. No reduction in dissolved oxygen levels due to controllable sources is allowed.*

Elsewhere, Tennessee claims within their listing methodology: *If the source of the low DO is a natural condition such as ground water, spring, or wetland, then the low DO is considered a natural condition and not pollution.* North Carolina applies a daily average of 5 mg/l for non-trout waters, with a minimum instantaneous value of 4 mg/l and notes: *swamp waters, lake coves or backwaters and lake bottom waters may have lower values if caused by natural conditions.* Ohio and Pennsylvania have criteria for warm water fisheries of a 5 mg/l average and 4 mg/l minimum and applies its criteria only to the epilimnion (upper) layer of lakes. Minnesota applies a daily minimum of 5 mg/l to its cool and warm water fisheries and splits the year into two seasons; May through September and October through April. The assessment for dissolved oxygen requires no more than ten percent of the measurements taken in either period violate the standard. Furthermore, measurements must be taken before 9:00 am to

be representative of minimal conditions. Finally, dissolved oxygen in wetlands is expected to be maintained at background concentrations, indicating that wetlands have a propensity for low dissolved oxygen.

OPTIONS

There are a number of options that Kansas could adopt as an exception to the current water quality standard pertaining to dissolved oxygen. These options may be considered individually or as a combination to address situations in lakes and/or streams where dissolved oxygen levels fall below 5 mg/l.

1. Lower the dissolved oxygen criterion to 4 mg/l as an instantaneous minimum.
2. Assess dissolved oxygen similarly as a chronic impairment (binomial; 10%)
3. Explicitly state allowances for dissolved oxygen lower than 5 mg/l when caused by documented natural conditions.
4. Explicitly exclude applying dissolved oxygen criteria to the lowest portions of a lake (i.e. the hypolimnion)

Impact Considerations: Continuation of the status quo could allow some waters to remain perpetually listed as impaired when the cause of dissolved oxygen (DO) depression is the result of naturally occurring conditions. The consequence of listing waters as impaired include the implication that certain waters are polluted, thus lessening its value and potential uses that could be made of that water. Providing an allowance for naturally occurring conditions would allow waters to be assessed as unimpaired based on their natural state. Such a provision would direct state and federal resources toward true impairment issues, increasing the efficacy of water quality restoration efforts.

REFERENCES

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