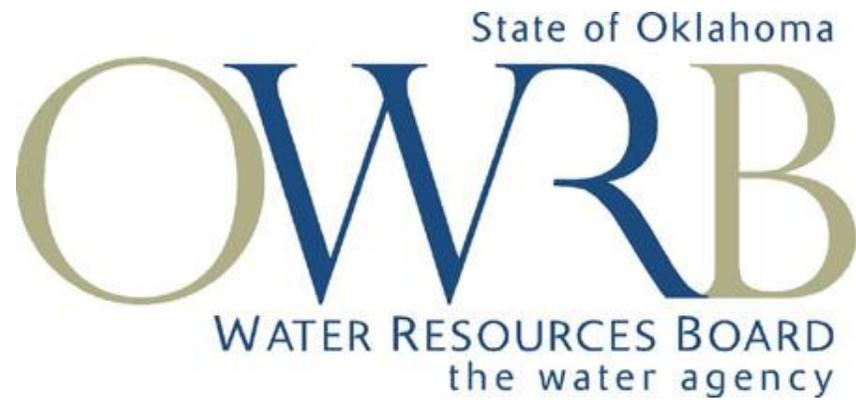


Proposed Dissolved Oxygen Revisions



October 8, 2014

Dissolved Oxygen Revisions

Introduction

The Oklahoma Water Resources Board (OWRB) is proposing to amend various provisions of Oklahoma Administrative Code (OAC) 785:45 and OAC 785:46 to address Water Quality Standards and Implementation regarding dissolved oxygen. The need for these amendments is to clarify the existing dissolved oxygen provisions. In 2010, the OWRB made several amendments to the OAC 785:45 and OAC 785:46 in response to EPA's interpretation of the CWA and CFR, based on recent court decisions, which required that assessments must strictly follow the State's approved water quality standards and the interpretation that aspects of the assessment rules in 785:46-15, which were being used for assessment, constituted unapproved waters quality standards. Now that these changes have been made and approved by EPA, there has been some confusion related to the approach that was used which included the duplication of assessment protocols from OAC 785:46 into the standards document in OAC 785:45.

The revisions proposed here include:

- Removing the assessment language from OAC 785:45 which is a duplication of language found in OAC 785:46.
- Retaining the necessary components that were added in 2010 which were previously considered unapproved water quality standards. These components are proposed to be relocated and expressed in a clarified manner to reduce potential confusion. These components include the provisions that prohibit the hypolimnion from exhibiting hypoxic conditions (defined as <2 mg/L DO), provisions that prohibit acute (<2 mg/L) dissolved oxygen occurrences in streams, and application of the 10% exceedance rate to the criteria magnitude as assessed across all life stages.
- Clarifying that the Warm Water Aquatic Community dissolved oxygen criteria apply to the surface waters of the lake.
- Modifying the lake dissolved oxygen provision from applying separately to two different conditions ('stratified' and 'non-stratified') to one single provision that applies at all times.

The bulk of the modifications proposed are clarifications to existing language, minor language modifications, and/or reformatting with the intent to increase clarity. As such, most of these changes are considered to be non-substantive changes. However, the clarifications that are being proposed for the lake provisions (applying the volumetric hypoxia criteria to the entire year instead of only during periods of stratification, and clarifying where the WWAC DO criteria apply in lakes) could be viewed as substantive changes.

In EPA's approval of the 2010 provision changes, it was determined that the 50% volume threshold for subsurface DO to be above 2 mg/L was protective of the Warm Water Aquatic Community. The most critical season for dissolved oxygen in lakes is typically in the warm summer months, particularly when there is strong stratification. The subsurface provisions were considered to be protective of the most extreme critical time period. These stratification

events typically happen during the late summer months and can cause a reduction in available habitat for the aquatic communities. Application of the volumetric hypoxia provision to the entire year would continue to remain protective. One reason that this would remain protective is due to the decreased likelihood of a strong stratification event occurring during the cooler seasons. Currently, the subsurface provisions apply only when there is stratification. So, conversely, when there is no stratification, then the surface criteria has been interpreted to apply throughout the entire water column. Using the term “stratification” as the determining factor for when different D.O provisions apply, can be troublesome. Stratification is based on a thermal process involving differing densities of water. There can be both strong and weak stratification. While strong stratification is not likely to occur in the cooler seasons, weak stratification, as well as sediment oxygen demand, can lead to low dissolved oxygen levels just above the sediment surface. While this typically does not create any issues during routine use support determination, it has proven troublesome when modeled data has been used in TMDL development. Under some scenarios, using modeled data, the application of the 10% exceedance frequency has proven troublesome to implement. By applying the subsurface provisions year around, the intent of our modifications will be more clear and easier to implement in various programs.

To clarify that the WWAC D.O. criteria apply to the surface waters or mixed surface layer, a footnote is proposed to be added to Appendix G, table 1. This footnote clarifies that the WWAC D.O. criteria are intended to apply to the surface waters. The addition of language in OAC 785:46 clarifies that “surface, when used in this section means surface waters or mixed surface layer, typically represented by a sample taken at least 0.5 m below the surface”. This language gives flexibility to the agencies when performing water quality assessments. Under most scenarios, the mixed surface layer is well represented by taking a sample just below the surface. In fact, many protocols for dissolved oxygen sampling in lakes call for the sample to be taken somewhere within the first meter of depth. A common protocol in Oklahoma has been to take the sample at around 0.5 meters from the surface. Continuation of this approach should provide a representative sample in most situations. If the person making a water quality assesement determines that the surface sample does not represent the mixed layer, then another sample, or aggregation of samples, that better represents the mixed layer could be used.

Another term for “surface waters” or “mixed surface layer” would be the term “epilimnion”. The following are various definitions of the term epilimnion:

- That part of a lake that is well-mixed by wind action and can be expected to have relatively homogenous physical and chemical conditions.
- An upper stratum of less dense, more or less uniformly warm, circulating, and fairly turbulent water. (Wetzel 1983)
- The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed throughout at least some portion of the day and because of its exposure, can freely exchange dissolved gases (such as O₂ and CO₂) with the atmosphere. (waterontheweb.org)

- The warm upper layer of a body of water with thermal stratification, which extends down from the surface to the Thermocline, which forms the boundary between the warmer upper layers of the epilimnion and the colder waters of the lower depths, or Hypolimnion. The epilimnion is less dense than the lower waters and is wind-circulated and essentially homothermous. (ecologydictionary.org)
- Uppermost, warmest, well-mixed layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline. (EPA-841-R-93-002. Fish and Fisheries Management in Reservoirs, May 1993)

As noted above, by its very definition, the epilimnion is a well-mixed layer of water. The properties of the density of this warmer layer and the result of wind and wave action work to keep the upper most layer of water mixed. Circulation occurs within the epilimnion to keep the layer mixed. Appendix 1 of this document has been included to provide examples of dissolved oxygen profiles from OWRB's Beneficial Use Monitoring Program. These example profiles are informative to provide supporting evidence that a single measurement taken just below the surface is representative of the mixed upper layer.

DRAFT PROPOSED LANGUAGE CHANGES

Chapter 45

(1) Dissolved oxygen.

(A) Dissolved oxygen (DO) criteria are designed to protect the diverse aquatic communities of Oklahoma.

(B) Allowable loadings designed to attain these dissolved oxygen criteria are provided as follows:

(i) For streams with sufficient historical data, the allowable load shall be based on meeting the dissolved oxygen concentration standard at the seven-day, two-year low flow and the appropriate seasonal temperatures.

(ii) For streams lacking sufficient historical data, or when the appropriate flow is less than one (1) cubic foot per second (cfs), the allowable load shall be based on meeting the dissolved oxygen concentration standard at one (1) cfs and the appropriate seasonal temperature.

(iii) Provided, for streams designated in OAC 785:45 Appendix A as HLAC or WWAC which have sufficient historical data as determined by the permitting authority, the allowable BOD load may be based upon meeting the dissolved oxygen concentration standard at the applicable seasonal temperature and corresponding seasonal seven-day, two-year low flow.

(iv) Provided further, in stream segments where dams or other structures have substantially affected the historic flow regime of the stream segment, including but not limited to the portions of the Verdigris and Arkansas Rivers constituting the McClellan-Kerr Arkansas River Navigation System, a properly designed and implemented site-specific hydrologic study approved by the permitting authority and the Board may be used to determine the appropriate regulatory low flow. In such circumstances, the allowable BOD load may be based upon meeting the dissolved oxygen concentration standard at the applicable seasonal temperature and the site-specific regulatory low flow.

(C) Except for naturally occurring conditions ~~and as modified in (D) of this paragraph~~, the dissolved oxygen criteria are as set forth in Table 1 of Appendix G of this Chapter. Additionally;

(i) For streams, no more than two DO samples shall exhibit a DO concentration of less than 2.0 mg/L in any given year.

(ii) For lakes, no more than 50% of the water volume shall exhibit a DO concentration less than 2.0 mg/L. If no volumetric data is available, then no more than 70% of the water column at any given sample site shall exhibit a DO concentration less than 2.0 mg/L. If a lake specific study including historical analysis demonstrates that a different percent volume or percent water column than described above is protective of the WWAC use, then that lake specific result takes precedence.

~~(D) For purposes of assessment, listing and reporting under sections 303(d) and 305(b) of the federal Clean Water Act as amended, the procedure for determining use support of the Fish and Wildlife Propagation beneficial use or any subcategory thereof with respect to dissolved oxygen shall be as follows:~~

~~(i) **General support test for all streams.** If more than two concentrations of DO in a stream are observed to be below 2.0 mg/L in any given year, the Fish and Wildlife Propagation beneficial use shall be deemed to be not supported.~~

~~(ii) **Support tests for HLAC streams.**~~

~~(I) The HLAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples from the stream are less than 4.0 mg/L from April 1 through June 15 and less than 3.0 mg/L during the remainder of the year.~~

~~(II) The HLAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples from the stream are less than 4.0 mg/L from April 1 through June 15 or less than 3.0 mg/L during the remainder of the year due to other than naturally occurring conditions.~~

~~(iii) **Support tests for WWAC streams.**~~

~~(I) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples from the stream are less than 6.0 mg/L from April 1 through June 15 and less than 5.0 mg/L during the remainder of the year.~~

~~(II) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the samples from the stream are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from April 1 through June 15, or more than 10% of the samples are less than 5.0 mg/L and 10% or less of the samples are less than 4.0 mg/L from June 16 through October 15.~~

~~(III) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples from the stream are less than 5.0 mg/L from April 1 through June 15, or less than 4.0 mg/L from June 16 through October 15, or less than 5.0 mg/L from October 16 through March 31, due to other than naturally occurring conditions.~~

~~(iv) **Support tests for CWAC and Trout streams.**~~

~~(I) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples from the stream are less than 7.0 mg/L from March 1 through May 31 and less than 6.0 mg/L during the remainder of the year.~~

~~(II) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the samples from the stream are less than 7.0 mg/L and 10% or less of the samples are less than 6.0 mg/L from March 1 through May 31, or more than 10% of the samples are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from June 1 through October 15.~~

~~(III) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples from the stream are less than 6.0 mg/L from March 1 through May 31, or less than 5.0 mg/L from June 1 through October 15, or less than 6.0 mg/L from October 16 through the last day of February, due to other than naturally occurring conditions.~~

~~(v) **Support tests for WWAC lakes.** The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported with respect to the DO criterion if both the Surface and Water Column criteria prescribed in (vi)(I) and (vii)(I) of this subparagraph (D) are satisfied. If either of the Surface or Water Column criteria prescribed in (vi)(II) or (vii)(II) produce a result of undetermined, then the WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined with respect to the DO criterion; provided, if either of the Surface or Water Column criteria prescribed in (vi)(III) or (vii)(III) produce a result of not supported, then the WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported with respect to the DO criterion.~~

~~(vi) **Surface criteria for WWAC lakes.**~~

~~(I) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no~~

stratification is present, are less than 6.0 mg/L from April 1 through June 15 and less than 5.0 mg/L during the remainder of the year.

~~(II) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 5.0 mg/L and 10% or less of the samples are less than 4 mg/L from June 16 through October 15, or more than 10% of the samples from the surface are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from April 1 through June 15.~~

~~(III) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 5.0 mg/L from April 1 through June 15 or less than 4.0 mg/L from June 16 through October 15, or less than 5.0 mg/L from October 16 through March 31, due to other than naturally occurring conditions.~~

~~(vii) **Water Column criteria for WWAC lakes.**~~

~~(I) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported during periods of thermal stratification with respect to the DO criterion if less than 50% of the volume (if volumetric data is available) or 50% or less of the water column (if no volumetric data is available) of all sample sites in the lake are less than 2.0 mg/L.~~

~~(II) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined during periods of thermal stratification with respect to the DO criterion if 50% or more, but not greater than 70%, of the water column at any given sample site in the lake is less than 2.0 mg/L due to other than naturally occurring conditions.~~

~~(III) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported during periods of thermal stratification with respect to the DO criterion if 50% or more of the water volume (if volumetric data is available) or more than 70% of the water column (if no volumetric data is available) at any given sample site is less than 2.0 mg/L.~~

~~(IV) If a lake specific study including historical analysis produces a support status which is contrary to an assessment obtained from the application of (I), (II) or (III) of (D)(vii) of this section, then that lake specific result will control.~~

~~(viii) Additional application/exercise when support undetermined. In instances where application of the tests in this subparagraph (D) initially produce a result that the pertinent subcategory is undetermined with respect to the DO criterion, such shall be subject to additional investigation that considers diurnal data for further application of such tests in order to resolve the determination of use support.~~

TABLE 1.

**Dissolved Oxygen Criteria to Protect Fish and Wildlife Propagation
and All Subcategories Thereof ¹**

SUBCATEGORY OF FISH AND WILDLIFE PROPAGATION (FISHERY CLASS)	DATES APPLICABLE	D.O. CRITERIA (MINIMUM) (mg/L) ⁴	SEASONAL TEMPERATURE (°C)
Habitat Limited Aquatic Community			
Early Life Stages	4/1 - 6/15	4.0	25 ³
Other Life Stages			
Summer Conditions	6/16 - 10/15	3.0	32
Winter Conditions	10/16 - 3/31	3.0	18
Warm Water Aquatic Community ⁵			
Early Life Stages	4/1 - 6/15	6.0 ²	25 ³
Other Life Stages			
Summer Conditions	6/16 - 10/15	5.0 ²	32
Winter Conditions	10/16 - 3/31	5.0	18
Cool Water Aquatic Community & Trout			
Early Life Stages	3/1 - 5/31	7.0 ²	22
Other Life Stages			
Summer Conditions	6/1 - 10/15	6.0 ²	29

¹ For use in calculation of the allowable load.

² Because of natural diurnal dissolved oxygen fluctuation, a 1.0 mg/l dissolved oxygen concentration deficit shall be allowed for not more than eight (8) hours during any twenty-four (24) hour period.

³ Discharge limits necessary to meet summer conditions will apply from June 1 of each year. However, where discharge limits based on Early Life Stage (spring) conditions are more restrictive, those limits may be extended to July 1.

⁴ [DO shall not exhibit concentrations less than the criteria magnitudes expressed above in greater than 10% of the samples as assessed across all life stages and seasons.](#)

⁵ [For Lakes, the warm water aquatic community dissolved oxygen criteria expressed above are applicable to the surface waters.](#)

Chapter 46

785:46-15-5. Assessment of Fish and Wildlife Propagation support

- (a) **Scope.** The provisions of this Section shall be used to determine whether the beneficial use of Fish and Wildlife Propagation or any subcategory thereof designated in OAC 785:45 for a waterbody is supported.
- (b) **Dissolved oxygen.** For purposes of assessment, listing and reporting under sections 303(d) and 305(b) of the federal Clean Water Act as amended, the procedure for determining use support of the Fish and Wildlife Propagation beneficial use or any subcategory thereof with respect to dissolved oxygen shall be as follows:

(1) Support tests for HLAC streams.

(A) The HLAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples ~~from the stream are less than 4.0 mg/L from April 1 through June 15 and less than 3.0 mg/L during the remainder of the year.~~ across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds:

(i) April 1 through June 15: 4.0 mg/L

(ii) June 16 through March 31: 3.0 mg/L

(B) The HLAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples ~~from the stream are less than 4.0 mg/L from April 1 through June 15 or less than 3.0 mg/L during the remainder of the year due to other than naturally occurring conditions.~~ across all seasons exhibit DO concentrations below the following season-specific thresholds due to other than naturally occurring conditions:

(i) April 1 through June 15: 4.0 mg/L

(ii) June 16 through March 31: 3.0 mg/L

(2) Support tests for WWAC streams.

(A) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples ~~from the stream are less than 6.0 mg/L from April 1 through June 15 and less than 5.0 mg/L during the remainder of the year.~~ across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds:

(i) April 1 through June 15: 6.0 mg/L

(ii) June 16 through March 31: 5.0 mg/L

(B) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the samples ~~from the stream are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from April 1 through June 15, or more than 10% of the samples are less than 5.0 mg/L and 10% or less of the samples are less than 4.0 mg/L from June 16 through October 15.~~ across all life stages and seasons exhibit DO concentrations below the upper DO threshold and 10% or less of the samples across all seasons exhibit DO concentrations below the lower DO threshold considering the following season-specific ranges:

(i) April 1 through June 15: 5.0 mg/L to 6.0 mg/L

(ii) June 16 through October 15: 4.0 mg/L to 5.0 mg/L

(C) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples ~~from the stream are less than 5.0 mg/L from April 1 through June 15, or less than 4.0 mg/L from June 16 through October 15, or less than 5.0 mg/L from October 16 through March 31, due to other than naturally occurring conditions.~~ across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds due to other than naturally occurring conditions:

(i) April 1 through June 15: 5.0 mg/L

(ii) June 16 through October 15: 4.0 mg/L

(iii) October 16 through March 31: 5.0 mg/L

(3) Support tests for CWAC and Trout streams.

(A) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the samples ~~from the stream are less than 7.0 mg/L from March 1 through May 31 and less than 6.0 mg/L during the remainder of the year.~~ across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds:

(i) March 1 through May 31: 7.0 mg/L

(ii) June 1 through last day of February: 6.0 mg/L

(B) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the samples ~~from the stream are less than 7.0 mg/L and 10% or less of the samples are less than 6.0 mg/L from March 1 through May 31, or more than 10% of the samples are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from June 1 through October 15.~~ across all life stages and seasons exhibit DO concentrations below the upper DO threshold and 10% or less of the samples across all seasons exhibit DO concentrations below the lower DO threshold considering the following season-specific ranges:

(i) March 1 through May 31: 7.0 mg/L to 6.0 mg/L

(ii) June 1 through October 15: 6.0 mg/L to 5.0 mg/L

(C) The CWAC or Trout subcategory of the Fish and Wildlife Propagation beneficial use designated for a stream shall be deemed to be not supported with respect to the DO criterion if more than 10% of the samples ~~from the stream are less than 6.0 mg/L from March 1 through May 31, or less than 5.0 mg/L from June 1 through October 15, or less than 6.0 mg/L from October 16 through the last day of February, due to other than naturally occurring conditions.~~ across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds due to other than naturally occurring conditions:

(i) March 1 through May 31: 6.0 mg/L

(ii) June 1 through October 15: 5.0 mg/L

(iii) October 16 through the last day of February: 6.0 mg/L

(4) Support tests for WWAC lakes. The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported with respect to the DO criterion if both the Surface and Water Column criteria prescribed in (5)(A) and (6)(A) of this subparagraph (b) are satisfied. If either of the Surface or Water Column criteria prescribed in (5)(B) or (6)(B) produce a result of undetermined, then the WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined with respect to the DO criterion; provided, if either of the Surface or Water Column criteria prescribed in (5)(C) or (6)(C) produce a result of not supported, then the WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported with respect to the DO criterion.

(5) Surface criteria for WWAC lakes.

(A) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported with respect to the DO criterion if 10% or less of the ~~samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 6.0 mg/L from April 1 through June 15 and less than 5.0 mg/L during the remainder of the year.~~ surface samples across life stages and all seasons exhibit DO concentrations below the following season-specific thresholds:

(i) April 1 through June 15: 6.0 mg/L

(ii) June 16 through March 31: 5.0 mg/L

(B) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined with respect to the DO criterion if more than 10% of the ~~samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 5.0 mg/L and 10% or less of the samples are less than 4 mg/L from June 16 through October 15, or more than 10% of the samples from the surface are less than 6.0 mg/L and 10% or less of the samples are less than 5.0 mg/L from April 1 through June 15.~~ surface samples across all life stages and seasons exhibit DO concentrations below the upper DO

threshold and 10% or less of the surface samples across all seasons exhibit DO concentrations below the lower DO threshold considering the following season-specific ranges:

(i) April 1 through June 15: 5.0 mg/L to 6.0 mg/L

(ii) June 16 through October 15: 4.0 mg/L to 5.0 mg/L

(C) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported with respect to the DO criterion if more than 10% of the ~~samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 5.0 mg/L from April 1 through June 15 or less than 4.0 mg/L from June 16 through October 15, or less than 5.0 mg/L from October 16 through March 31, due to other than naturally occurring conditions.~~ surface samples across all life stages and seasons exhibit DO concentrations below the following season-specific thresholds due to other than naturally occurring conditions:

(i) April 1 through June 15: 5.0 mg/L

(ii) June 16 through October 15: 4.0 mg/L

(iii) October 16 through March 31: 5.0 mg/L

(D) "Surface," when used in this Section, means surface waters or the mixed surface layer, typically represented by a sample taken at least 0.5 m below the surface.

(6) Water Column criteria for WWAC lakes.

(A) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be fully supported ~~during periods of thermal stratification~~ with respect to the DO criterion if less than 50% of the volume (if volumetric data is available) or 50% or less of the water column (if no volumetric data is available) of all sample sites in the lake are less than 2.0 mg/L.

(B) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be undetermined ~~during periods of thermal stratification~~ with respect to the DO criterion (if no volumetric data is available) if 50% or more, but not greater than 70%, of the water column at any given sample site in the lake is less than 2.0 mg/L due to other than naturally occurring conditions.

(C) The WWAC subcategory of the Fish and Wildlife Propagation beneficial use designated for a lake shall be deemed to be not supported ~~during periods of thermal stratification~~ with respect to the DO criterion if 50% or more of the water volume (if volumetric data is available) or more than 70% of the water column (if no volumetric data is available) at any given sample site is less than 2.0 mg/L.

(D) If a lake specific study including historical analysis produces a support status which is contrary to an assessment obtained from the application of (A), (B) or (C) of (b)(6) of this section, then that lake specific result will control.

(7) Additional application/exercise when support undetermined. In instances where application of the tests in this subsection (b) initially produce a result that the pertinent subcategory is undetermined with respect to the DO criterion, such shall be subject to additional investigation that considers diurnal data for further application of such tests in order to resolve the determination of use support.

Appendix 1. Dissolved Oxygen Profiles from OWRB's BUMP Monitoring Program

Oolagah Reservoir when not stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
11/29/2011	14:04:47	1	0.439	9.98	10.52	93.2
11/29/2011	14:04:26	1	1	9.98	10.51	93.2
11/29/2011	14:04:01	1	2	9.98	10.5	93
11/29/2011	14:03:37	1	3	9.97	10.48	92.9
11/29/2011	14:03:08	1	4	9.95	10.46	92.6
11/29/2011	14:02:42	1	5	9.95	10.44	92.5
11/29/2011	14:02:12	1	6	9.94	10.43	92.4
11/29/2011	14:01:39	1	7	9.93	10.42	92.3
11/29/2011	14:01:07	1	8	9.93	10.41	92.2
11/29/2011	14:00:36	1	9	9.93	10.4	92.1
11/29/2011	14:00:08	1	10	9.93	10.38	91.9
11/29/2011	13:59:43	1	11	9.93	10.37	91.8
11/29/2011	13:59:15	1	12	9.93	10.36	91.7
11/29/2011	13:58:46	1	13	9.93	10.36	91.7
11/29/2011	13:58:12	1	14	9.93	10.34	91.6
11/29/2011	13:57:29	1	15	9.92	10.31	91.3
11/29/2011	13:57:01	1	16	9.92	10.27	90.9
11/29/2011	13:56:27	1	16.338	9.93	10.29	91.1

Oolagah Reservoir when stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
7/22/2013	18:00:14	1	0.157	28.63	8.97	116.8
7/22/2013	18:03:40	1	1.053	28.46	8.69	112.8
7/22/2013	18:05:17	1	2.059	26.65	4.3	54
7/22/2013	18:07:26	1	3.062	26.29	3.94	49.2
7/22/2013	18:09:56	1	4.015	26.03	1.88	23.3
7/22/2013	18:12:00	1	5.06	25.9	0.39	4.9
7/22/2013	18:13:04	1	6.065	25.68	0.32	3.9
7/22/2013	18:15:03	1	7.014	25.57	0.29	3.6

Durant Reservoir when not stratified

Date	Time	Dep100	Temp	LDO	LDO%
MMDDYY	HHMMSS	meters	øC	mg/l	Sat
Annotation at 121510 133604 : ST1					
12/15/2010	13:37:34	0.1	8.61	11.31	101.3
12/15/2010	13:38:24	1	8.58	11.23	100.5
12/15/2010	13:39:24	2	8.57	11.23	100.5
12/15/2010	13:40:36	3.1	8.5	11.23	100.4
12/15/2010	13:41:30	3.9	8.47	11.23	100.3
12/15/2010	13:42:36	5.1	8.49	11.2	100.1
12/15/2010	13:43:32	5.8	8.5	11.19	99.9
12/15/2010	13:44:50	7.1	8.45	11.19	99.9
12/15/2010	13:46:03	8.2	8.44	11.21	100
12/15/2010	13:46:40	9.1	8.43	11.2	99.9
12/15/2010	13:48:10	8.9	8.43	11.17	99.6
12/15/2010	13:48:52	9.3	8.43	11.04	98.4

Duran Reservoir during when stratified

Date	Time	Dep100	Temp	LDO	LDO%
MMDDYY	HHMMSS	meters	øC	mg/l	Sat
Annotation at 062811 101740 : ST1					
062811	102405	0.1	29.12	7.95	109.1
062811	102507	1	29.14	7.91	108.6
062811	102555	2	29.07	7.81	107.2
062811	102641	3	29.05	7.76	106.5
062811	102729	4	29.05	7.64	104.8
062811	102837	5	28.71	5.96	81.2
062811	102923	6	25.91	0.34	4.5
062811	102955	7	21.26	0.04	0.5
062811	103029	8	16.74	0	0
062811	103106	9	15.86	0	0
062811	103135	10	14.91	0	0

Tenkiller Reservoir when not stratified.

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
11/14/2011	13:18:10	1	0.175	17.15	6.72	69.8
11/14/2011	13:19:48	1	1	17.12	6.65	69
11/14/2011	13:20:39	1	2	17.01	6.57	68.1
11/14/2011	13:22:09	1	3	17	6.53	67.6
11/14/2011	13:23:07	1	4	16.99	6.56	67.9
11/14/2011	13:24:07	1	5	16.99	6.53	67.6
11/14/2011	13:25:01	1	6	16.98	6.48	67.1
11/14/2011	13:25:58	1	7	16.98	6.42	66.4
11/14/2011	13:27:06	1	8	16.98	6.43	66.5
11/14/2011	13:27:51	1	9	16.98	6.39	66.2
11/14/2011	13:28:50	1	10	16.98	6.36	65.8
11/14/2011	13:29:54	1	11	16.98	6.32	65.4
11/14/2011	13:30:58	1	12	16.98	6.31	65.3
11/14/2011	13:32:02	1	13	16.98	6.3	65.2
11/14/2011	13:33:04	1	14	16.97	6.3	65.1
11/14/2011	13:34:13	1	15	16.97	6.29	65.1
11/14/2011	13:35:25	1	16	16.96	6.4	66.2
11/14/2011	13:36:12	1	17	16.96	6.44	66.6
11/14/2011	13:37:28	1	18	16.96	6.63	68.6
11/14/2011	13:38:42	1	19	16.94	6.86	70.9
11/14/2011	13:40:06	1	20	16.92	6.95	71.9
11/14/2011	13:40:52	1	21	16.92	6.96	72
11/14/2011	13:41:49	1	22	16.92	6.97	72
11/14/2011	13:42:53	1	23	16.91	6.97	72.1
11/14/2011	13:44:14	1	24	16.91	6.97	72
11/14/2011	13:45:20	1	25	16.91	6.98	72.1
11/14/2011	13:46:24	1	26	16.91	6.98	72.2
11/14/2011	13:47:14	1	27	16.9	6.99	72.2
11/14/2011	13:48:18	1	28	16.9	6.97	72
11/14/2011	13:49:32	1	29	16.9	6.91	71.4
11/14/2011	13:50:46	1	30	16.89	6.89	71.1
11/14/2011	13:51:36	1	31	16.89	6.92	71.5
11/14/2011	13:52:34	1	32	16.88	6.96	71.8
11/14/2011	13:53:52	1	33	16.87	7.01	72.4
11/14/2011	13:54:51	1	34	16.86	7	72.2
11/14/2011	13:56:00	1	35	16.83	6.99	72.1
11/14/2011	13:57:25	1	36	16.83	6.99	72.1
11/14/2011	13:58:19	1	37	16.82	6.99	72
11/14/2011	13:59:01	1	38	16.82	6.98	72
11/14/2011	14:00:00	1	38.613	16.82	6.85	70.7

Tenkiller Reservoir when stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
8/14/2012	10:53:15	1	0.162	28.84	7.49	97.1
8/14/2012	10:55:04	1	1	28.83	7.46	96.7
8/14/2012	10:56:28	1	2	28.83	7.44	96.5
8/14/2012	10:57:27	1	3	28.82	7.4	95.9
8/14/2012	10:58:34	1	4	28.82	7.35	95.3
8/14/2012	10:59:18	1	5	28.82	7.36	95.4
8/14/2012	11:00:18	1	6	28.82	7.28	94.3
8/14/2012	11:02:04	1	7	28.82	7.27	94.2
8/14/2012	11:04:07	1	8	28.81	7.2	93.4
8/14/2012	11:07:07	1	9	28.81	7.21	93.5
8/14/2012	11:08:03	1	10	28.77	7.05	91.3
8/14/2012	11:10:07	1	11	26.46	0.68	8.4
8/14/2012	11:10:50	1	12	24.44	0.61	7.3
8/14/2012	11:11:57	1	13	22.58	0.58	6.7
8/14/2012	11:13:40	1	14	21.42	0.58	6.6
8/14/2012	11:15:50	1	15	20.44	0.57	6.4
8/14/2012	11:18:02	1	16	19.65	0.58	6.3
8/14/2012	11:19:38	1	17	18.48	0.59	6.3
8/14/2012	11:21:02	1	18	17.28	0.59	6.1
8/14/2012	11:23:00	1	19	16.39	0.61	6.2
8/14/2012	11:24:05	1	20	15.61	0.62	6.2
8/14/2012	11:25:43	1	21	15.18	0.62	6.2
8/14/2012	11:27:23	1	22	14.61	0.63	6.2
8/14/2012	11:28:11	1	23	14.05	0.63	6.2
8/14/2012	11:28:57	1	24	13.8	0.64	6.2
8/14/2012	11:29:56	1	25	13.5	0.65	6.2
8/14/2012	11:30:37	1	26	13.19	0.65	6.2
8/14/2012	11:31:50	1	27	12.93	0.65	6.2
8/14/2012	11:32:36	1	28	12.79	0.66	6.2
8/14/2012	11:33:17	1	29	12.65	0.66	6.2
8/14/2012	11:33:41	1	30	12.52	0.66	6.2
8/14/2012	11:34:02	1	31	12.42	0.66	6.2
8/14/2012	11:35:03	1	32	12.34	0.66	6.2
8/14/2012	11:35:37	1	33	12.25	0.66	6.2
8/14/2012	11:36:22	1	34	12	0.66	6.1
8/14/2012	11:36:58	1	35	11.83	0.66	6.1
8/14/2012	11:37:40	1	36	11.67	0.67	6.2
8/14/2012	11:38:23	1	37	11.57	0.67	6.2
8/14/2012	11:39:01	1	38	11.53	0.67	6.2
8/14/2012	11:39:59	1	39	11.5	0.68	6.2
8/14/2012	11:40:25	1	39.291	11.46	0.67	6.2

Skiatook Reservoir when not stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
10/11/2011	11:39:18	1	0.107	21.76	7.08	80.7
10/11/2011	11:42:00	1	1	21.45	6.95	78.7
10/11/2011	11:43:52	1	2	21.3	6.85	77.3
10/11/2011	11:45:07	1	3	21.28	6.77	76.4
10/11/2011	11:46:48	1	4	21.27	6.76	76.2
10/11/2011	11:47:51	1	5	21.26	6.61	74.6
10/11/2011	11:50:57	1	6	21.24	6.25	70.5
10/11/2011	11:52:16	1	7	21.23	6.54	73.8
10/11/2011	11:53:49	1	8	21.22	6.09	68.6
10/11/2011	11:55:04	1	9	21.22	5.96	67.2
10/11/2011	11:56:32	1	10	21.2	5.84	65.8
10/11/2011	11:57:53	1	11	21.17	5.76	64.9
10/11/2011	11:59:30	1	12.016	21.12	5.48	61.7

Skiatook Reservoir when stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%
M/D/Y	hh:mm:ss		m	C	mg/L	%
7/16/2012	10:08:34	1	0.296	29.21	9.02	117.8
7/16/2012	10:11:18	1	1	29.23	9.03	117.9
7/16/2012	10:12:34	1	2	29.22	9.03	117.9
7/16/2012	10:13:34	1	3	29.18	9.02	117.7
7/16/2012	10:14:29	1	4	29.17	8.96	116.9
7/16/2012	10:15:21	1	5	29.12	8.91	116.2
7/16/2012	10:16:07	1	6	28.89	8.6	111.7
7/16/2012	10:18:31	1	7	27.88	5.62	71.7
7/16/2012	10:20:32	1	8	26.62	3.47	43.3
7/16/2012	10:21:38	1	9	25.39	1.78	21.7
7/16/2012	10:23:22	1	10	24.21	0.3	3.6
7/16/2012	10:24:14	1	11	23.12	0.23	2.7
7/16/2012	10:25:05	1	12	20.87	0.2	2.2
7/16/2012	10:25:57	1	13	19.85	0.17	1.9
7/16/2012	10:26:43	1	14	19.04	0.16	1.7
7/16/2012	10:27:33	1	15	18.54	0.15	1.6
7/16/2012	10:28:47	1	16	18.07	0.13	1.4
7/16/2012	10:29:21	1	17	17.55	0.13	1.4
7/16/2012	10:31:00	1	17.665	16.98	0.12	1.2

Chickasha Reservoir when not stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%	
M/D/Y	hh:mm:ss		m	C	mg/L	%	
10/22/2012	8:29:51		1	0.145	18.12	8.39	89.6
10/22/2012	8:30:52		1	0.984	18.11	8.37	89.4
10/22/2012	8:31:44		1	1.9	18.11	8.33	88.9
10/22/2012	8:32:20		1	2.914	18.11	8.33	88.9
10/22/2012	8:33:06		1	4.106	18.1	8.29	88.6
10/22/2012	8:33:58		1	4.981	18.09	8.29	88.5
10/22/2012	8:34:40		1	6.025	18.08	8.23	87.9
10/22/2012	8:35:53		1	6.458	17.7	7.2	76.2
10/22/2012	8:57:24		2	0.15	19.41	8.56	93.8
10/22/2012	8:58:11		2	0.981	19.41	8.55	93.8
10/22/2012	8:58:56		2	1.289	19.41	8.55	93.7
10/22/2012	9:17:37		3	0.095	19.33	8.56	93.7
10/22/2012	9:18:13		3	1.02	19.32	8.55	93.6
10/22/2012	9:19:00		3	2.069	19.31	8.53	93.3
10/22/2012	9:19:48		3	2.278	19.31	8.52	93.2

Chickasha Reservoir when stratified

Date	Time	Site	Depth	Temp	ODO Conc	ODO%	
M/D/Y	hh:mm:ss		m	C	mg/L	%	
7/22/2013	18:00:14		1	0.157	28.63	8.97	116.8
7/22/2013	18:03:40		1	1.053	28.46	8.69	112.8
7/22/2013	18:05:17		1	2.059	26.65	4.3	54
7/22/2013	18:07:26		1	3.062	26.29	3.94	49.2
7/22/2013	18:09:56		1	4.015	26.03	1.88	23.3
7/22/2013	18:12:00		1	5.06	25.9	0.39	4.9
7/22/2013	18:13:04		1	6.065	25.68	0.32	3.9
7/22/2013	18:15:03		1	7.014	25.57	0.29	3.6

Broken Bow Reservoir when stratified

Date	Time	Dep100	Temp	LDO	LDO%
MMDDYY	HHMMSS	meters	øC	mg/l	Sat
Annotation at 071911 071627 : STE 1					
071911	71754	0.1	30.12	7.62	106.1
071911	71942	2	30.28	7.63	106.4
071911	72007	3	30.28	7.61	106.2
071911	72035	4	30.28	7.63	106.4
071911	72115	5	30.13	7.53	104.8
071911	72143	6	29.19	7.16	98
071911	72217	7	27.43	6.52	86.5
071911	72248	8	24.78	4.58	57.9
071911	72343	9	21.86	2.36	28.2
071911	72418	10	20.09	2.12	24.4
071911	72556	11	18.1	2.47	27.3
071911	72648	12	16.8	2.92	31.5
071911	72744	13	15.32	3.95	41.3
071911	72855	14	14.74	4.43	45.7
071911	72935	15	13.75	4.87	49.2
071911	73115	16	12.68	5.44	53.7
071911	73210	17	11.84	5.88	57
071911	73249	18	11.33	6.12	58.6
071911	73344	19	10.62	6.47	60.9
071911	73431	20	9.8	6.9	63.7
071911	73521	21	9.19	7.13	64.9
071911	73556	22	8.79	7.29	65.8
071911	73650	23	8.35	7.41	66
071911	73719	24	8.09	7.42	65.8
071911	73754	25	7.83	7.56	66.6
071911	73833	26	7.64	7.7	67.5
071911	73908	27	7.48	7.82	68.3
071911	73941	28	7.33	7.9	68.8
071911	74019	29	7.21	8	69.3
071911	74128	30	7.08	8.07	69.7
071911	74150	31	6.99	8.07	69.6
071911	74243	32	6.95	8.13	70.1
071911	74326	33	6.89	8.19	70.4
071911	74403	34	6.83	8.22	70.6
071911	74446	35	6.75	8.02	68.7
071911	74520	36	6.69	7.99	68.4
071911	74607	37	6.67	8.09	69.2
071911	74637	38	6.64	8.2	70.1
071911	74735	39	6.62	8.25	70.5
071911	74756	40	6.6	8.24	70.4
071911	74842	41	6.59	7.79	66.5
071911	74908	42	6.59	7.76	66.2
071911	75116	43	6.54	7.69	65.6
071911	75135	44	6.53	7.74	66
071911	75218	45	6.52	7.54	64.3
071911	75248	46	6.49	7.49	63.8
071911	75339	47	6.48	7.37	62.7
071911	75353	48	6.47	7.33	62.4
071911	75449	49	6.46	7.29	62
071911	75526	50	6.46	7.25	61.7
071911	75606	51	6.47	6.8	57.9
071911	75618	51.5	6.5	6.71	57.1

Broken Bow Reservoir when stratified

Date	Time	Dep100	Temp	LDO	LDO%
MMDDYY	HHMMSS	meters	øC	mg/l	Sat
Annotation at 113010 093341 : ST 1					
11/30/2010	9:34:18	0.1	13.45	9.16	92.7
11/30/2010	9:35:40	1	13.5	9.12	92.4
11/30/2010	9:36:39	2	13.53	9.11	92.3
11/30/2010	9:38:06	3	13.55	9.07	92
11/30/2010	9:40:08	4	13.55	9.06	91.8
11/30/2010	9:41:58	5	13.55	9.04	91.7
11/30/2010	9:43:06	6	13.55	9.05	91.7
11/30/2010	9:43:54	7	13.55	9.05	91.7
11/30/2010	9:44:52	8	13.55	9.02	91.4
11/30/2010	9:45:57	9	13.56	9.03	91.5
11/30/2010	9:47:05	10	13.55	9.01	91.4
11/30/2010	9:48:02	11	13.56	8.99	91.2
11/30/2010	9:49:46	12	13.56	8.97	90.9
11/30/2010	9:50:48	13	13.56	8.97	90.9
11/30/2010	9:51:57	14	13.56	8.95	90.8
11/30/2010	9:53:01	15	13.56	8.96	90.9
11/30/2010	9:54:06	16	13.56	8.95	90.8
11/30/2010	9:55:09	17	13.55	8.94	90.7
11/30/2010	9:56:35	18	13.55	8.93	90.6
11/30/2010	9:57:49	19	13.55	8.92	90.4
11/30/2010	9:58:45	20	13.54	8.88	90
11/30/2010	9:59:53	21	13.38	8.67	87.6
11/30/2010	10:02:03	22	11.79	4.17	40.6
11/30/2010	10:03:27	23	9.36	4.09	37.6
11/30/2010	10:04:33	24	8.58	4.79	43.2
11/30/2010	10:05:54	25	8.24	4.9	43.9
11/30/2010	10:07:13	26	8.05	5.35	47.7
11/30/2010	10:09:05	27	7.79	5.68	50.4
11/30/2010	10:11:03	28	7.63	5.94	52.5
11/30/2010	10:12:02	29	7.57	6.06	53.4
11/30/2010	10:13:33	30	7.48	6.27	55.2
11/30/2010	10:14:46	31	7.42	6.14	53.9
11/30/2010	10:15:46	32	7.37	6.24	54.7
11/30/2010	10:17:02	33	7.33	6.28	55
11/30/2010	10:19:32	34	7.29	6.36	55.7
11/30/2010	10:21:12	35	7.25	6.32	55.3
11/30/2010	10:22:13	36	7.24	6.31	55.1
11/30/2010	10:23:18	37	7.22	6.28	54.9
11/30/2010	10:24:43	38	7.19	6.07	53
11/30/2010	10:25:40	39	7.17	6.04	52.7
11/30/2010	10:26:23	40	7.16	6	52.4
11/30/2010	10:27:16	41	7.13	5.95	51.9
11/30/2010	10:29:06	42	7.1	5.16	44.9
11/30/2010	10:29:50	43	7.08	4.33	37.7
11/30/2010	10:30:53	44	7.07	4.02	35
11/30/2010	10:31:46	45	7.05	3.9	34
11/30/2010	10:32:44	46	7.05	3.59	31.3
11/30/2010	10:33:26	46.4	7.06	3.2	27.9