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DEPARTMENT OF NATURAL RESOURCES

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MEMORANDUM

DATE: **DEC 30 2009**

TO: Leanne Tippet Mosby, Acting Director
Division of Environmental Quality

THROUGH: Scott B. Totten, Acting Director *SBT*
Water Protection Program, DEQ

FROM: Refaat Mefrakis, P.E., Chief, Permits and Engineering Section *RMM*
Water Protection Program, DEQ

SUBJECT: DO Modeling & BOD Effluent Limit Development Administrative Guidance for the Purpose of Conducting Water Quality Assistance Reviews.

One of the central tenants of the Clean Water Act is an evaluation of applicable technology-based effluent limits to ensure that the State's water quality goals are achieved. To that end, to ensure that dissolved oxygen (DO) standards are met with the discharge of biochemical oxygen demand (BOD) effluent, we require that certain National Pollutant Discharge Elimination System (NPDES) dischargers (as defined within this guidance) evaluate the potential effects of BOD on DO in the receiving stream via DO modeling. The Missouri Department of Natural Resources (Department) currently does not have a procedure to evaluate DO for permitting purposes.

The attached guidance document establishes administrative procedures for DO modeling and BOD effluent limit development. Its intention is to provide staff and applicants with guidelines for establishing a need to conduct DO modeling, which models to use, BOD and DO effluent limit development, and model submittal requirements.

The guidance is not intended as technical guide for model inputs. The guidance document cannot encompass all situations encountered when developing limits; applicants are encouraged to contact the central office with site-specific questions.

This guidance supersedes any previous DO modeling guidance, effective on the date of this memorandum. The Department will use this guidance when developing BOD effluent limitations as part of water quality and antidegradation review assistance. For renewals, BOD effluent limitations will be based upon effluent regulation 10 CSR 20-7.015. This guidance will be incorporated in the appendix of the draft Guidance for Water Quality and Antidegradation Review Assistance.

RM:tbs

c: Water Pollution Control Branch Staff
Regional Directors and Water Pollution Staff

**DEPARTMENT OF NATURAL RESOURCES
WATER PROTECTION PROGRAM**

**Dissolved Oxygen Modeling and Biochemical Oxygen Demand
Effluent Limit Development
Administrative Guidance**

December 2009

Background

Dissolved oxygen modeling is required to demonstrate that waste load allocations (WLA) for 5-day biochemical oxygen demand (BOD₅) are protective of water quality standards for dissolved oxygen (DO). The WLA may be a regulatory technology-based effluent limit (TBEL), alternative analysis-based effluent concentration (based on treatment capacity), or any BOD₅ concentration decided upon by applicant. Because BOD₅ does not have an instream standard and does affect DO, modeling is a useful decision-making tool for establishing BOD₅ limits. This analysis documents that the waste water treatment facility's discharge, after considering as appropriate the allowable Missouri State regulatory mixing zone [10 CSR 20-7.031 (4)(A)], will not cause the receiving stream's DO level after the mixing zone to drop below Missouri's minimum water quality standard for DO [10 CSR 20-7.031 (4)(J)]. If the WLA will cause a downstream DO sag below the Missouri minimum water quality standard, the Clean Water Act and its implementing regulations require the development of water quality-based effluent limits (WQBEL) to ensure that beneficial uses are met.

Intent

The intent of this guidance is to establish an administrative procedure for DO modeling and BOD₅ effluent limit determinations and to supersede any previous DO modeling guidance. This guidance supplements the *Water Quality Review Assistance (WQRA) Request* form instructions. The guidance will explain 1) when DO modeling is needed, 2) which models to use, 3) how to develop effluent limits for BOD₅ and DO, and 4) documentation and submittal requirements, including facility performance exemptions. We expect the applicant to have technical understanding of DO modeling; therefore, technical details on modeling processes and inputs are not included in this guidance.

The Need for Dissolved Oxygen Modeling

This requirement applies to applicants who will be expanding their discharge or proposing a new discharge. Expansions are defined as discharge from a facility that is increasing their dry-weather design flow. New discharge is defined as the construction of a facility that does not currently possess a National Pollutant Discharge Elimination System (NPDES) permit or the addition of BOD₅ as a new pollutant of concern in a current NPDES permit. Facility performance exemptions from the required DO modeling are possible provided the applicant can demonstrate the requirements described in the *Document and Submittal Requirements*. Applicants, in compliance with terms and conditions of their permit who are seeking renewal, will not be required to complete DO modeling provided the stream does not have a WLA from a Total Maximum Daily Load (TMDL) or impairment listing for low DO.

Models to Use

For new or expanding treatment facilities, applicants must submit DO analysis indicating that the WLA and limit for BOD₅ is protective of Missouri’s water quality standard for DO. The DO analysis must use Missouri Department of Natural Resources (Department) approved models such as Streeter Phelps or QUAL2K/QUAL2E (QUAL2) stream water quality study.

The Streeter-Phelps modeling method is documented in the Environmental Protection Agency (EPA)/600/6-85/002a (*Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water*). Situations when the Streeter-Phelps model is not useful include: 1) significant tributaries in flow segment, 2) discharge to a losing stream segment, 3) groundwater inflow from springs, 4) other pollutant loading sources before predicted critical DO sag point, or 5) water body impairment for DO. In these situations, a more sophisticated model such as QUAL2 should be used.

If applicant is conducting an alternatives analysis or demonstration of insignificant degradation as part of an antidegradation review, the applicant must use the modeling process to evaluate BOD₅ effluent concentrations (WLA) described in the attached flow chart (*Decision Diagram for Choosing the Appropriate Level of Dissolved Oxygen Modeling*) and Table 1. If the water body

Table 1. Model Effort Levels for Dissolved Oxygen Analysis

Analysis	Model	Site-Specific Data Requirements
Level 1	Streeter-Phelps (spreadsheet)	Default assumptions from literature and predictive equations
Level 2	Streeter-Phelps (spreadsheet)	Stream geometry, time of travel using geometry only
		Stream geometry, time of travel using tracers
Level 3	QUAL2 or equivalent*	Stream geometry, time of travel using tracers , One (1) **48-hour water quality study
Level 4	QUAL2 or equivalent*	Stream geometry, time of travel using tracers, Two (2) **48-hour water quality studies

*Must be a Department-approved model. Two water quality studies should target the low-flow condition at slightly different temperatures and/or discharge conditions. A third study conducted during a cooler season may be needed to establish seasonal WLA and permit limits.

**See *Water Quality Monitoring in Support of Missouri Antidegradation Review* for parameter monitoring

is impaired for DO, the Department requires a calibrated and verified QUAL2 model (contact the Department before commencing). All QUAL2 studies must have a Quality Assurance Project Plans (QAPP) that is approved by the Water Protection Program’s Water Quality Monitoring and Assessment Section.

From the flow chart below, an applicant may begin analysis with Level 1 screening level model (applicant has option of starting at Level 1, 2, 3 or 4). Applicants should setup the model for compliance with the appropriate DO criteria in the first classified stream to ensure that the discharge protects water quality standards. Site-specific data requirements are briefly summarized in the table above. When the Streeter-Phelps modeling indicates that DO concentrations fall below the appropriate water quality standard at the downstream regulatory

point of compliance, *then a less degrading BOD₅ concentration (WLA) must be chosen and evaluated, thus repeat Level 1 as needed*; otherwise, proceed to Level 2 for further evaluation. If water quality standards are met, proceed to effluent limit determination and/or submittal details. Streeter-Phelps modeling is only a screening tool for DO water quality analysis. If, as a result of Level 2 analysis, the WLA produces a critical DO concentration that is not in compliance with WQS, a more sophisticated model such as QUAL2 should be used to derive an appropriate WLA.

Level 3 and 4 analyses involve the use of the QUAL2 model to determine the appropriate BOD₅ and ammonia WLA (See flow chart below) that is protective of the WQS. Site-specific data requirements are briefly summarized in the table above. If, as a result of Level 3 or 4 analysis, the WLA produces a critical DO concentration that is not in compliance with the DO WQS, *a less degrading BOD₅ and/or ammonia concentration (WLA) must be chosen and evaluated; this analysis must be repeated until the WLA can be demonstrated to be protective of the DO WQS*. The applicant should then proceed to effluent limit determination and/or submittal details.

Effluent Limit Determination

For Level 1 or 2 modeling with WLA for BOD₅ that is protective of WQS, effluent limits may be derived using the following scenarios:

Model Scenario #1: The average monthly limit (AML) may be the treatment capacity of preferred treatment alternative, and the model's BOD₅ input must be the average weekly limit (AWL) as the WLA. In this case, the AML is calculated by dividing the AWL by 1.5. The maximum BOD effluent concentration of the treatment technology must be the model input in order to prevent excursions below DO WQS minimum.

Model Scenario #2: If applicant uses the secondary treatment technology-based weekly average BOD₅ effluent limit as the model input, the state's secondary treatment regulatory limit shall apply, provided model demonstrates that the limit is protective of WQS.

For the Level 3 or 4, the BOD₅ WLA shall be applied as AML and 1.5 times that AML shall be the AWL.

DO effluent limits may be applied to the discharge if the DO in the discharge is needed to maintain the receiving stream critical DO concentration above water quality standards. DO permit limits will include a daily minimum permit limit as determined by the results of the model and a monthly average minimum permit limit of 5.0 mg/L, respectively. Water Pollution Control Branch will not assign DO permit limits unless a WLA study or DO modeling has been completed and approved.

If a Level 3 or 4 analysis was completed, the WLA for ammonia is obtained from the model. For guidance on deriving ammonia permit limits, refer to the Department's *Total Ammonia Nitrogen Criteria Implementation Guidance*, August 2007.

Documentation and Submittal Requirements

The Water Protection Program's Permits and Engineering Section is responsible for reviewing and approving the submitted documentation as part of the WQRA request. The applicant has the option to submit documentation that demonstrates the performance of the new or expanded facility in lieu of the DO modeling requirement. Facility performance exemptions from the required DO modeling are possible for new and expanded facilities:

- less than 100,000 gallons per day¹ (gpd) and proposing advanced BOD₅ treatment less than or equal to an average monthly of 10 mg/L and average weekly of 15 mg/L as demonstrated by
 - 1) performance specifications from manufacturer and/or
 - 2) effluent sampling of a existing facility with the same treatment system (applicable to new facilities only), or
- greater than 100,000 gpd and proposing advanced BOD₅ treatment less than or equal to average monthly of 10 mg/L and average weekly of 15 mg/L as demonstrated by
 - 1) performance specifications from manufacturer and/or
 - 2) effluent sampling of existing facility with the same treatment system (applicable to new facilities only). Facility has the option of 1) instream monitoring to demonstrate that water quality standards will be protected (location of the point of compliance will be established on site-specific basis²), or 2) dissolved oxygen screening analysis using the process outlined in the *Models to Use* section. If option one is selected, facility will be required to have receiving water chemistry monitoring for a period of three years. At a minimum, temperature and dissolved oxygen should be sampled. A quality assurance project plan (QAPP) must be submitted to the Water Quality Assessment and Monitoring (WQAM) Section of the Department. The QAPP will be reviewed and approved by WQAM. The sampling frequency must be approved by the WQAM Section. At the end of three years, facility will be required to submit a report evaluating the facilities contribution to the receiving stream. If the facility causes or contributes to exceedence of the dissolved oxygen minimum, then the 5-day biological oxygen demand loading to the receiving stream must be reduced by an amount to restore dissolved oxygen above standards.

The Water Protection Program's Permits and Engineering Section will review the Streeter-Phelps DO modeling data for each proposed discharge. However, if more involved modeling is needed such as a calibrated QUAL2 model involving the collection of water quality data, a QAPP will be required. Water Quality Monitoring and Assessment Section will review and approve all QUAL2 models (Please contact the Water Quality Monitoring and Assessment Section for more information).

For Streeter-Phelps modeling, model inputs and outputs must be submitted to the Department with a brief description of the model scenarios. All model scenarios should be clearly identified on the output. Identification of the critical DO concentration, critical DO deficit, and distance to critical DO concentration (feet or miles) are important. The critical DO concentration must be no less than Missouri's DO water quality criteria. Plots of distance versus BOD₅ and DO concentrations should be provided.

¹ Small municipalities are typically less than 100,000 gpd. This process encourages better effluent limitations because many facilities less than 100,000 gpd have equivalent-to-secondary limitations.

² Point of compliance—P-streams-immediately after ¼ mile mixing zone; C-streams-end of pipe; U-streams-first classified waterbody; Lakes-lesser of 100' or ¼ of lake width

For QUAL2 modeling, a complete model and data documentation should include a discussion of the conceptual and technical approach, parameter estimation, error and uncertainty, and the modeling results. At a minimum, the Department requires submittal of the following items:

- 48-hour WLA study data
 - Field data
 - Laboratory data
 - Location map and coordinates of all study sites
 - Quality assurance summary
- Model inputs
 - Significant assumptions
 - Rationale for estimates in absence of data
 - Data used for parameter estimation
- Model input and output files
 - Calibrated model (based upon first 48-hour WLA study)
 - Verified model (based upon all 48-hour WLA study data)
 - Model performance and accuracy summary
 - Effluent limit derivation model
 - Submit files with brief description of model scenario
- Model results
 - Critical DO concentration
 - Critical DO deficit
 - Distance to critical DO concentration
 - Plots of distance versus BOD₅ and DO concentrations
- Uncertainty analysis

The Department records all information and data used in determining WLAs for facilities having site-specific operating permits. A synopsis of WLA information is provided within Water Quality and Antidegradation Review (WQAR) documents developed by the Department. WQARs are typically issued in conjunction with new or expanded site-specific operating permits. A complete record of all WLA information is contained in the administrative record of decisions for each site-specific permit. In general, items within this record include:

- Final WLAs expressed as a concentration or load and tiered by parameter, season, flow regime or other category as deemed appropriate the reviewer;
- Documentation of water quality modeling or similar analysis that support final WLA values;
- Water quality criteria that were effective at the time the WLA was finalized; and
- Antidegradation review.

Decision Diagram for Choosing the Appropriate Level of Dissolved Oxygen Modeling

