Response to EPA comments (in Bold) and Additional Staff-Identified Changes

Letter from EPA dated January 3, 2013

Areas Requiring Further Discussion

Comment #1- Please include the priority ranking of the waterbodies in question as part of the executive summary

Response #1: The following text has been added to the Executive Summary in the sub-section Problem Identification and Water Quality Targets.

"Lake Thunderbird is designated as a Category 5a lake on the Oklahoma 303(d) list with a Priority 1 ranking. Category 5 defines a waterbody where, since the water quality standard is not attained, the waterbody is impaired or threatened for one or more designated uses by a pollutant(s), and the water body requires a TMDL. "

Comment #2- While seasonality is addressed, the temporal issues related to spawning are not discussed. Since the lake does not support its warm water aquatic community designated use, an explanation discussing any impacts on spawning should be included. If there are no spawning related impacts, please indicate that in the report.

Response #2: The following text has been added to the Executive Summary in the sub-section TMDL, Waste Load Allocation, Load Allocation and Margin of Safety. The same text has also been added to Section 5.3, Seasonal Variability.

"Seasonal variation was accounted for in the TMDL determination for Lake Thunderbird in two ways: (1) water quality standards, and (2) the time period represented by the watershed and lake models. Oklahoma's water quality standards for dissolved oxygen for lakes are developed on a seasonal basis to be protective of fish and wildlife propagation for a warm water aquatic community at all life stages, including spawning. Within the surface layer, dissolved oxygen standards specify that DO levels shall be no less than 6 mg/L from April 1 to June 15 to be protective of early life stages and no less than 5 mg/L for the remainder of the year (June 16 to March 31). Under summer stratified conditions during the period from mid-May to October, the hypoxic volume of the lake, defined by a DO target of 2 mg/L, is not to be greater than 50% of the lake volume. Seasonality was also accounted for in the TMDL analysis by developing the watershed and lake models based on one full year of water quality data collected as part of a special study of Lake Thunderbird from April 2008-April 2009."

Comment #3- Please provide a description of any important assumptions made in developing the TMDL within the TMDL document. Material found in Appendix B could be used to formulate a concise summary of the assumptions.

Response #3: Based on a discussion on January 17, 2013 between Mark Derichsweiler (Oklahoma DEQ) and Taimur Shaikh (EPA Region 6), EPA clarified that its request was for a discussion of the overall approach used for calibration of the HSPF and EFDC models. In particular, EPA requested a discussion detailing the sequence used for calibration of state variables. This new information is presented for the

HSPF watershed model in Appendix A (Section A.3, HSPF Model Calibration) and the EFDC lake model in Appendix B (Section B.3, EFDC Model Calibration).

The following text was added to Appendix A (Section A.3, HSPF Model Calibration):

"Water quality constituents or pollutants were simulated using HSPF's PQUAL module with simple accumulation and washoff relationships with water and sediment yield (Bicknell et al., 2001). Existing land management practices, including pollutant reducing best management practices for urban and agricultural land uses, were implicitly simulated with this approach.

Based on model structure and their physicochemical properties, water quality constituents were calibrated in the following order--stream flow, water temperature, total suspended sediment, total organic carbon, nitrogen, phosphorus and finally dissolved oxygen. After the initial calibration, fine tuning was conducted to further calibrate individual constituents without following that order."

The following text was added to Appendix B (Section B.3, EFDC Model Calibration):

"Calibration of the Lake Thunderbird model was performed using the following sequence of steps:

- Compile observed data required for lake model setup and comparison of model results with observed data at OWRB station locations;
- Develop computational grid to represent the spatial domain, bathymetry of the lake, and lake level vs. volume relationship;
- Assign grid cell locations for boundary inflows and develop linkage of flow and load data for input to EFDC model from water withdrawals, flow release over the dam and streamflow and water quality data from HSPF model results;
- Develop hydrodynamic model water balance to calibrate lake volume and stage height;
- Add linkage of atmospheric forcing data and water temperature from watershed model to test ability of hydrodynamic model to simulate density effects, onset and erosion of lake stratification, and seasonal variation of water temperature;
- Add linkage of sediment loading from watershed model and setup in-lake sediment transport model with cohesive parameters for critical shear stress, deposition velocity and resuspension rate;
- Add linkage of algae, organic carbon, and nutrient loading from watershed model, assign splits for dissolved and particulate forms of organic carbon and nutrients, and setup in-lake water quality model with water quality kinetics;
- Compile sediment bed observation data and add linkage of sediment diagenesis model with sediment flux kinetics to internally couple organic matter deposition from the water column to the sediment bed for simulation of sediment oxygen demand and benthic recycle of inorganic nutrients back to the water column.

Kinetic coefficients for the sediment transport, water quality model and the sediment flux model were initially assigned from the literature for hydrodynamic, sediment transport, water quality models and the sediment flux model. Based on model performance statistics and visual comparisons of model-data plots, selected model kinetic coefficients were adjusted, within the range of literature values, to achieve an acceptable calibration of the Lake Thunderbird model with the observed data sets for water temperature, TSS and water quality constituents.

Calibration of the lake model was accomplished by comparison of model results to observed data extracted from specific grid cells matching OWRB station locations in Lake Thunderbird. Model-data comparisons were evaluated for water temperature, TSS, dissolved oxygen, nutrients, algae biomass as chlorophyll-a and organic carbon. Model results were extracted and compiled with observed data to prepare (a) time series plots of surface layer and bottom layer results; and (b) vertical profiles as time snapshots of model results that match sampling dates. In addition to a visual inspection of model-data plots, model performance statistics were computed for the Root Mean Square (RMS) Error and the Relative RMS Error."

Comment #4- A discussion of the strengths and weaknesses of the turbidity to TSS relationship should be included. In particular, an analysis of the synergistic and antagonistic nature of different interferences would be appropriate.

Response #4: The following text has been added to Section 4.3, EFDC Model Calibration, TSS and Turbidity. The same text is also added to Appendix B, Section B.3.2, Total Suspended Solids (TSS) and Turbidity

"Water clarity is an issue for impairment of Lake Thunderbird and turbidity is the water quality parameter used to determine if the lake fully supports designated uses. Oklahoma water quality criteria states that no more than 10% of samples collected over the most recent 10 year period shall be greater than 25 NTU. Turbidity is a measure of the optical properties of water that causes light to be scattered and absorbed by particles in the water sample. Turbidity, as measured with a Nephelometer and reported with units of Nephelometric Turbidity Units (NTU), however, accounts only for the scattering of light. Since turbidity is not a mass-based concentration, a surrogate indicator of water quality must be used to develop a TMDL that addresses compliance with water quality criteria for turbidity. Total suspended solids (TSS) is a common water quality measurement that can be used as a surrogate indicator for turbidity. Although turbidity and TSS measure very different properties of water samples, both measurements do provide information about water clarity. TSS vs. turbidity relationships can therefore be developed and applied for TMDL determinations. The TSS vs. turbidity relationship must, however, be developed using site-specific paired data since inconsistencies and interferences in the relationship can result from site-specific properties of a water sample including water color, size, shape and refractive index of sediment particles, the organic and inorganic composition of sediment particles, and the inconsistency of instruments used for the turbidity measurement itself (Thackston and Palermo, 2000; Bash, Berman and Bolton, 2001). For the Lake Thunderbird study, paired TSS and turbidity measurements from the 8 lake stations were used to develop a whole lake linear regression relationship. As described in Appendix B, the relationship was considered acceptable to apply a site-specific correlation to compute simulated turbidity from modeled TSS for Lake Thunderbird."

New References Cited

Bash, J. , C. Berman, and S. Bolton. 2001. EFFECTS OF TURBIDITY AND SUSPENDED SOLIDS ON SALMONIDS. Final Research Report, Research Project T1803, Task 42, Effects of Turbidity on Salmon, Report Prepared for Washington State Transportation Commission, Department of Transportation in cooperation with U.S. Department of Transportation, Federal Highway Administration, November. http://www.wsdot.wa.gov/research/reports/fullreports/526.1.pdf

Thackston, E. L. and M.LR. Palermo. 2000. "Improved methods for correlating turbidity and suspended solids for monitoring," DOER Tech. Notes Collection (ERDC TN-DOER-E8), U.S. Army Engineers Research and Development Center, Vicksburg, MS, www.wes.army.mil.el/dots/doer

Technical Aspects

Comment #5- The document and associated appendices do not contain the input and associated files for the HSPF and the EFDC models. Please submit the associated electronic files to the agency for review. Additionally, any proprietary pre- or post-processors used in the development of the TMDL should be included to facilitate the modeling review.

Response #5: Input files for the HSPF watershed model and the EFDC lake model were uploaded to the Dynamic Solutions FTP site setup for the Lake Thunderbird project on December 13, 2012. Oklahoma DEQ was notified in an e-mail dated December 13, 2012 that Dynamic Solutions had uploaded the HSPF and EFDC input files to the project FTP site. Oklahoma DEQ then notified EPA Region 6 that the files were available for download on the Dynamic Solutions FTP site.

EFDC_Explorer7 is the proprietary pre- and post-processor for EFDC developed by Dynamic Solutions International. The URL link for downloading a 30-day free trial version was provided to EPA Region 6 and Oklahoma DEQ in an e-mail dated January 3, 2013 to Paul Yue, Oklahoma DEQ. Oklahoma DEQ then notified EPA Region 6 that a trial version of EFDC_Explorer7 was available from the Dynamic Solutions International website.

Comment #6- Page 68 of the TMDL document states, "*The maximum daily load (MDL) is computed from the LTA and the statistics of the loading data by the following equations for a lognormal distribution…*" Please include a substantiation of the lognormal nature of the flow and the pollutants of concern.

Response #6: The following text has been added to Section 5.5, TMDL Calculations

"The equations used for calculating the Maximum Daily Load (MDL) from the Long Term Average (LTA) load are based on the assumption that streamflow, water quality concentration and watershed loading data are lognormally distributed. It is well documented in numerous studies that a two-parameter lognormal distribution defined by the mean and variance of the log transformed data set provides a very useful approximation to the probabilistic distribution of streamflow (Nash, 1994; Limbrunner et al., 2000; Vogel et al., 2005). In addition, Van Buren et al., (1997) and Di Toro (1984) determined that water quality analyses based on an assumption of the lognormal probability distribution for both streamflow and water quality concentration are quite realistic for many streams and rivers, including waterbodies investigated in the United States.

Although it is well documented, data is presented to show that the assumption of a lognormal distribution for watershed loading data holds true for Lake Thunderbird. Total Phosphorus (TP) loading data derived from the watershed model is used as an example to demonstrate that (a) log transformed TP data follows a normal distribution and (b) a lognormal distribution for loading data is an appropriate assumption for TMDL determinations for Lake Thunderbird. As shown in Figure 5-1, a typical bell shaped curve is produced from the log transformed TP load data, indicating a normal distribution of the

transformed data set. The probability plot for the log transformed time series of TP data is presented as the natural log of the TP load against the Z-score statistic computed from the percentile ranking of the TP load data (Figure 5-2). The log transformed TP loading data shown in Figure 5-2 shows an almost linear relationship with the Z-score statistic (r^2 of 0.96) also indicating a lognormal distribution. Since streamflow is common to all loads derived from the watershed model, suspended sediment, TN and CBOD loads also have similar lognormal distributions as demonstrated with r^2 of 0.99, 0.975, and 0.94 for sediment, TN and CBOD, respectively."

New figures developed and presented in Section 5.5

Figure 5-1 presents a histogram of the log transformed load data for Total Phosphorus (TP)

Figure 5-2 presents a probability plot of log transformed Total Phosphorus load from the watershed to Lake Thunderbird

New References Cited

Di Toro, D. M. 1984. Probablility model of stream quality due to runoff. *J. Environ. Eng.*,110(3), :607–628.

Limbrunner, J. F., Vogel, R. M., and Brown, L. C. 2000. Estimation of harmonic mean of lognormal variable. *J. Hydrologic Eng.*, 5(1),59–66.

Nash, D. B. 1994. Effective sediment-transporting discharge from magnitude-frequency analysis. *J. Geol.*, 102,79–95.

Van Buren, M A., Watt, W. E., and Marsalek, J. 1997. Application of the lognormal and normal distributions to stormwater quality parameters. *Water Res.*, 31(1), 95–104.

Vogel, R.M., Rudolph, B., and R.P. Hooper, 2005. The Probabilistic Behavior of Water Quality Loads, *Journal of Environmental Engineering*, 131 (7): 1081-1089.

General Aspects

Comment #7- Please provide reference(s) for the following comment found on page 36 of the TMDL document.

Response #7: *In many coastal and inland watersheds, atmospheric deposition of nitrogen derived primarily from burning fossil fuels, can account for 25-30 percent, or more, of the total nitrogen loading to a waterbody.*

The text given above has been revised in Section 3.2.1, Atmospheric Deposition as follows:

"In many coastal and inland watersheds atmospheric deposition of nitrogen, derived primarily from burning of fossil fuels, can account for a significant fraction of the total nitrogen loading to a waterbody. Atmospheric deposition, for example, accounts for 10-40% of nitrogen loading to estuaries along the East coast of the USA and eastern Gulf of Mexico (Paerl et al., 2002) and 25-28% in Chesapeake Bay (EPA, 2010). Atmospheric deposition of nitrogen is therefore a potentially significant component of nitrogen loading to a waterbody."

New References Cited

Paerl, H.W., R.L. Dennis, and D.R. Whitall .2002. Atmospheric Deposition of Nitrogen: Implications for Nutrient Over-Enrichment of Coastal Waters. Estuaries, 25(4B) 677-693.

USEPA. 2010. Chesapeake Bay TMDL, Section 4, Sources of Nutrients and Sediment to the Chesapeake Bay, Chesapeake Bay Program, Annapolis, MD.

Comment #8- Please correct the web link found on page 37 of the TMDL document.

Response #8: URL link typo is corrected as follows:
The URL for HSPF is http://www.epa.gov/ceampubl/swater/hspf/index.htm

Comment #9-Please address the incorrect page numbers in the report starting at page 75.

Response #9: Footer for page numbering in section of document has been corrected.

Email from EPA received January 16, 2013

Comment #1- Do the Noble and Midwest City MS4s discharge to the study area?

Response #1: Small portions of the Noble and Midwest City MS4s are located in the Thunderbird watershed, however these areas are negligible. The MS4s are discussed in Parts 3.1.3 and 5.1.3 of the report. The attached map shows the MS4 areas within the watershed. Noble comprises 0.26% of the watershed and Midwest City comprises 0.05%. These discharges are considered *de minimis* and no wasteload allocations are proposed for them. The watershed percentages were added to the report in Parts 3.1.3 and 5.1.3.

Letter from EPA dated April 25, 2013

Comment #1 – Please address the technical basis and any assumptions relating to the underlined portion of the standard (dissolved oxygen criteria for the water column under non-stratified conditions) **in regards to the TMDL.**

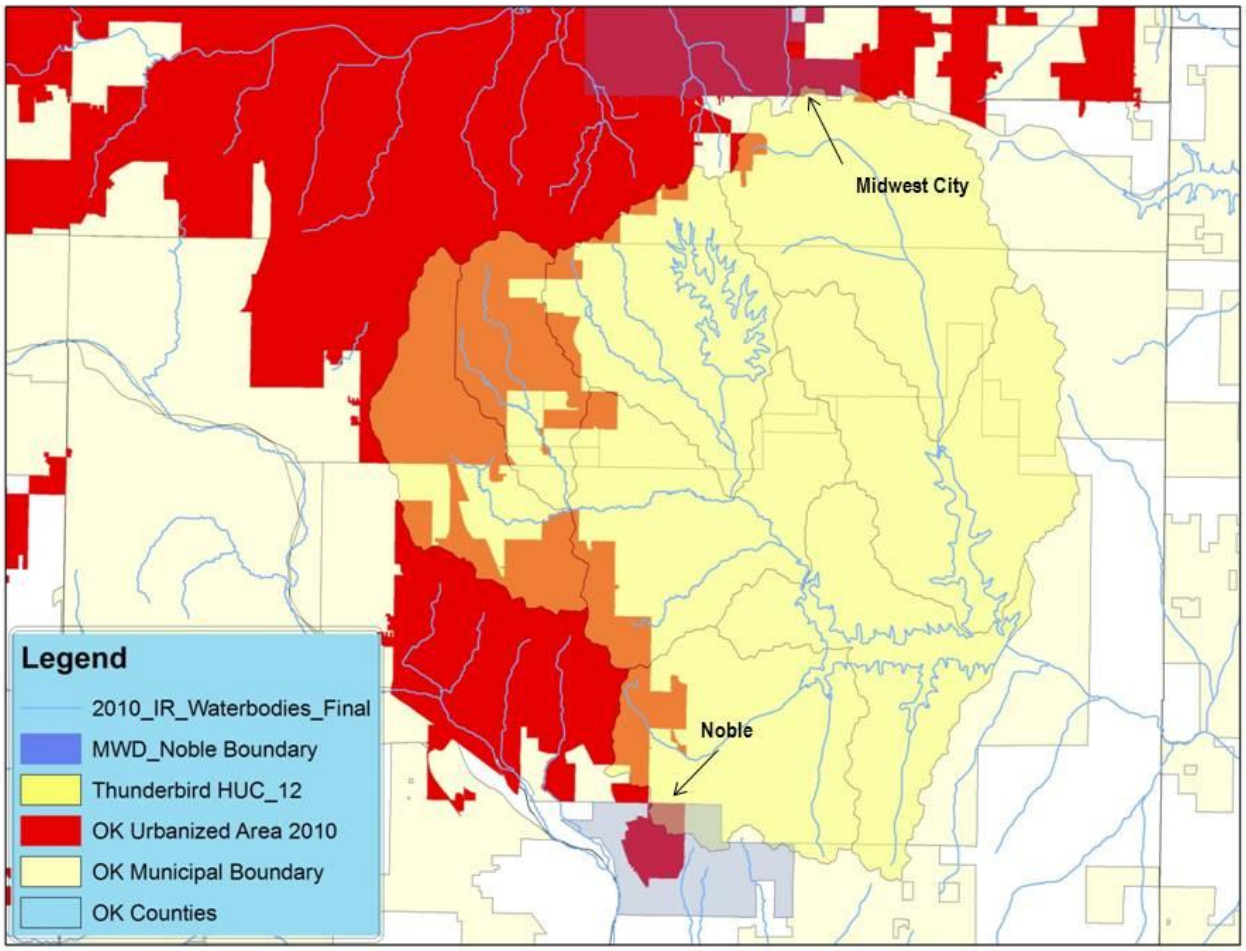
Response #1: This particular section of the Water Quality Standards was only recently approved by EPA. The descriptions of relevant water quality standards were revised in the Problem Identification section of the Executive Summary and in Sections 2.3 and 4.3. Section 4.5 of the report was revised to include an analysis of the dates of stratification and dissolved oxygen concentrations under non-stratified conditions. The previously-recommended pollutant reductions were shown to be sufficient to comply with the new standards.

Additional Staff-Identified Changes

1. Various typographical corrections were made in the report and Appendix E.
2. The following paragraph was added to Appendix E to clarify the geographic scope of MS4 permit coverage:
   The Phase I permit under which Oklahoma City and its co-permittees operate covers all areas located within the corporate boundary of the City of Oklahoma City. The Phase II permit under which the cities of Moore and Norman operate requires implementation of the storm water program only in the portions of the city located within the urbanized area. Since the wasteload allocations developed in this TMDL are based

on the pollutant loadings generated within the entire corporate boundaries of all three cities, Moore and Norman will be required to operate their storm water programs throughout their entire corporate boundaries within the Lake Thunderbird watershed in order to comply with this TMDL. This designation authority is found at 40 CFR 122.26(a)(9)(i)(C).

3. A new Section 5.6.3 regarding Section 404 permits and certification conditions was added to the report.



MS4 Urbanized Areas Within The Lake Thunderbird Watershed