# Appendix E:

## Evaluation of Turbidity Criteria Applicable to the Recreational and Aesthetic Designated Uses vs. Secchi Depth in the TMDL Scenario

In *Anacostia Riverkeeper v. Jackson,* 798 F. Supp. 2d 210 (D.D.C. 2011), the U.S. District Court for the District of Columbia upheld the EPA's approval of the 2007 TSS TMDL for the Anacostia River in all respects, except that the court remanded the approval to EPA because the court held that there was insufficient information in the record to support EPA's approval of the TMDL as sufficient to achieve all applicable designated uses. While the court agreed that the TMDL was sufficient to achieve the designated aquatic life use, the court held that the record was insufficient to support EPA's assertion that the TMDL also is sufficient to achieve the water contact and aesthetic designated uses. This appendix provides data and analysis demonstrating that implementation of the 2007 TMDL will also achieve applicable turbidity criteria in Maryland (MD) and the District of Columbia (DC) that protect the recreational and aesthetic designated uses.

Both DC and MD have numeric turbidity criteria, which if achieved, will protect recreational, aquatic life and aesthetic uses of their waters. An analysis correlating the TMDL allocations to turbidity levels in the tidal Anacostia shows a good correspondence between attainment of the Secchi depth criterion, designed to protect aquatic life through the support of SAV growth and propagation, and attainment of the numeric turbidity standards that are applicable to the recreational and aesthetic uses. Attainment of the year-round turbidity standards in the Anacostia River through the reduction of sediment loads to levels that achieve the seasonal DC Secchi depth criterion is further demonstrated through an evaluation of a model simulation of turbidity levels under the TMDL allocations, which require an 85% reduction in sediment loads from baseline conditions. To comply with the Anacostia River Sediment/TSS TMDL, sediment loads discharged to the Anacostia must be consistent with all of the stated loading limits in the TMDL—annual average, seasonal, and maximum daily. This means that even if the allowed highest flow maximum daily load were to occur, the seasonal and average annual maximum allowable loads must still be met.

A detailed description of the analysis of turbidity under the TMDL scenario is provided in this appendix. The results may be summarized as follows:

- In MD, under the TMDL scenario, the 30-day average turbidity values never exceed the 50 NTU monthly average standard and less than 0.1% of the daily values exceed the maximum value standard of 150 NTU, thereby demonstrating attainment of MD's numeric turbidity criteria applicable for protection of Use I-P (water contact recreation, protection of non-tidal warmwater aquatic life, drinking water supply).

- DC's turbidity water quality criterion applicable for the protection of, among other uses, Class A: "Primary Contact Recreation," Class B: "Secondary Contact Recreation and aesthetic enjoyment," and Class C: "Protection and propagation of fish, shellfish, and wildlife," is defined as no more than 20 NTU above ambient levels. The most environmentally conservative assumption is to assume that ambient or background is zero. In this scenario, the TMDL model results indicate that less than 10% of the daily NTU values are greater than 20 NTU. If it is assumed that background is 20 NTU, then less than 3% of the daily NTU values are greater than 40 NTU.

The analysis described in this appendix demonstrates that, by achieving the sediment reductions required by the TMDL in order to meet DC's seasonal Secchi depth criterion, all applicable sediment-related water quality standards in the tidal and non-tidal portions of the Anacostia watershed will also be met, including the MD and DC turbidity standards which apply year-round to protect recreation and aesthetic uses. The results of the analysis confirm that the DC Secchi depth criterion remains the most stringent of the applicable numeric criteria.

**Applicable Designated Uses**

In MD, the Anacostia River ("the Anacostia") and its tributaries have been variously designated as Use I-P (water contact recreation, protection of non-tidal warmwater aquatic life, public drinking supply); Use II (support of estuarine and marine aquatic life and shellfish harvesting – seasonal shallow water SAV category); Use III (non-tidal cold water (supporting self-sustaining trout populations); and Use IV waters (recreational trout waters) [Code of Maryland Regulations (COMAR) 26.08.02.08 O]. The Maryland Department of the Environment (MDE) has identified the Anacostia on the State's 303(d) List as impaired by the following (listing years in parentheses): nutrients (1996); sediments (1996); fecal bacteria (non-tidal waters in 2002, tidal waters in 2004); impacts to biological communities (2002); and toxics (polychlorinated biphenyls [PCBs] and heptachlor epoxide) in 2002. Fecal bacteria TMDLs for MD tidal and non-tidal areas were submitted to EPA for approval in 2006. TMDLs for PCBs were approved in 2007 (MD tidal waters) and 2011 (MD non-tidal waters). A MD and DC TMDL for nutrients/BOD was approved in 2008. A MD and DC TMDL for trash was approved in 2010. The TMDLs developed in this report address the sediments impairment. All other impairments in MD's tidal and non-tidal portions of the Anacostia will be addressed at a future date.

DC has classified the Anacostia for current and designated uses including Class A: "Primary Contact Recreation," Class B: "Secondary Contact Recreation and aesthetic enjoyment," Class C: "Protection & Propagation of fish, shellfish and wildlife, Class D: "Protection of human health related to consumption of fish and shellfish," and Class E: "Navigation." [Title 21 of the District of Columbia Municipal Regulations (DCMR) §1101.1]. DC's 303(d) List divides the Anacostia River within the District's borders into two segments. The lower Anacostia is identified as that portion of the river extending

from the mouth of the river to the John Philip Sousa Bridge on Pennsylvania Avenue and the upper Anacostia from the bridge to the MD border. The upper and lower segments of the Anacostia were listed on DC's 1998 Section 303(d) List as impaired by biochemical oxygen demand (BOD), bacteria, organics, metals, total suspended solids (TSS), and oil and grease. DC has already developed TMDLs addressing these impairments in the Anacostia. A MD and DC TMDL for nutrients/BOD was approved in 2008. A MD and DC TMDL for trash was approved in 2010. A TSS TMDL was established for the tidal Anacostia in DC in 2002. The watershed-wide TMDLs developed in this report replace the 2002 DC TSS TMDLs.

### Effects of Sedimentation

Excessive sediment has been identified by the EPA as the leading cause of impairment of our nation's waters, and as contributing to the decline of populations of aquatic life in North America.[1] Suspended sediment in streams may reduce visibility and prevent fish from seeing their prey, and may clog gills and filter feeding mechanisms of fish and benthic (bottom-dwelling) organisms. Excessive deposition of sediment on streambeds may bury eggs or larvae of fish and benthic macroinvertebrates, or degrade habitat by clogging the interstitial spaces between sand and gravel particles. Suspended sediment also reduces the amount of light reaching aquatic plants and can cause a decline or disappearance of communities of submerged aquatic vegetation (SAV), an important component of tidal ecosystems. As noted in EPA's Gold Book (Quality Criteria for Water, EPA 440/5-86001 (May 1, 1986), turbid water can pose hazards to swimmers due to low visibility and the possibility of unseen objects; other types of recreational contact, such as boating and fishing, generally will be protected when the aquatic life use is protected. Lastly, excessive suspended solids in the water column can create an unpleasant appearance due to degraded water color and clarity.

### Numeric Water Quality Criteria for Turbidity (applicable to achieve aesthetic and recreational designated uses)

MD and DC both have numeric turbidity standards to achieve the applicable designated uses (recreation and/or aesthetic), as well as aquatic life protection, applicable in both tidal and non-tidal waters of the Anacostia River.[2] Both DC's and MD's water quality

[1] U. S. Environmental Protection Agency. *Developing water quality criteria for suspended and bedded sediments (SABS) – Potential Approaches – DRAFT*. USEPA Science Advisory Board Consultation, EPA Office of Water, Office of Science and Technology, August 2003.

[2] Both jurisdictions also have general narrative criteria prohibiting substances at levels that are "objectionable" or cause a "nuisance" (COMAR 26.08.02.03B; DCMR 21-1104.1). Such terms presuppose a common aesthetic sensibility, although this is a highly subjective area of valuation. DC's narrative criteria for the aesthetic use states that the "aesthetic qualities of Class B waters shall be maintained." The remainder of the narrative prohibits "construction, placement or mooring of facilities not primarily and directly water oriented" with certain specified exceptions (DCMR 21-1104.4). In terms of water quality, turbidity is an appropriate measure of sediment-related impairments to aesthetic enjoyment of the

standards (WQSs) make clear that achievement of the applicable numeric water quality standards for water clarity and turbidity will achieve the applicable designated uses.

MD's WQSs include numeric turbidity criteria applicable to Use I, III and IV waters (Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life): Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time or 50 units as a monthly average. Units shall be measured in NTU. The same criteria apply in Use II waters (Support of estuarine and marine aquatic life and shellfish harvesting – seasonal shallow water SAV subcategory) (COMAR 26.08.02.03-3).

DC's WQSs include a numeric turbidity criterion for Class A, B and C waters of no more than 20 Nephelometer Turbidity Units (NTU) above ambient levels that will attain and maintain the designated uses. Class A waters are designated for primary contact recreation use, Class B for secondary contact recreation and aesthetic enjoyment, and Class C for protection and propagation of fish, shellfish, and wildlife (21 DCMR 1104).

The following table summarizes the water quality criteria applicable to sediment in various portions of the Anacostia River:

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Anacostia River, degrading water color and clarity due to excessive suspended solids in the water column, causing in turn an appearance that some might interpret as unpleasant and a disincentive to contact recreation. These qualities, consistent with the terms "objectionable," "nuisance," etc. set forth in the jurisdictions' narrative water quality criterion, vary within the minds of individuals who encounter the waterbody and, consequently, are difficult to quantify to a generally applicable numeric value. For that reason, EPA's Gold Book defers to the best professional judgment of the agencies making a determination in the public good. Both jurisdictions' water quality standards reflect the best professional judgment of MDE and DC Department of the Environment that the "aesthetic enjoyment" use and recreation use are attained by maintaining MD's and DC's numeric turbidity criteria. This appendix demonstrates that MD's and DC's numeric turbidity criteria will be achieved through implementation of the sediment load reductions required by this TMDL to meet the most stringent applicable water clarity standard in the Anacostia River, DC's seasonal Secchi depth criterion of 0.8 meters

**Table E-1. Designated Uses and Sediment-Related Water Quality Standards for the Anacostia Watershed**

| | Designated Use | Waterbody | Water Quality Standards |
|---|---|---|---|
| **MD non-tidal** | Use I-P: Water contact recreation, protection of non-tidal warmwater aquatic life, public drinking supply | All non-tidal MD streams except those designated Use III and IV | Turbidity criterion: ≤ 150 NTU / 50 NTU monthly average; narrative criteria |
| | Use III: Non-tidal cold water (supporting self-sustaining trout populations) | Paint Branch above Interstate 495 (Capital beltway) | Turbidity criterion: ≤ 150 NTU / 50 NTU monthly average; narrative criteria |
| | Use IV: Recreational trout waters | NWB above highway 410 | Turbidity criterion: ≤ 150 NTU / 50 NTU monthly average; narrative criteria |
| **MD tidal** | Use II: Support of estuarine and marine aquatic life and shellfish harvesting – seasonal shallow water SAV subcategory | MD portion of tidal Anacostia | Secchi depth criterion: ≥ 0.4 meters throughout growing season (Apr 1 - Oct 1) based on application depth of 0.5 meters; Turbidity criterion: ≤ 150 NTU / 50 NTU monthly average |
| **DC non-tidal** | Class A: Primary Contact Recreation | All non-tidal DC streams | Turbidity criterion: ≤ 20 NTU above background; narrative criteria |
| **DC non-tidal** | Class B: Secondary Contact Recreation; aesthetic enjoyment | All non-tidal DC streams | Turbidity criterion: ≤ 20 NTU above background; narrative criteria |
| **DC non-tidal** | Class C: Protection & propagation of fish, shellfish and wildlife | All non-tidal DC streams | Turbidity criterion: ≤ 20 NTU above background; narrative criteria |
| **DC tidal** | Class C: Protection & propagation of fish, shellfish and wildlife | DC portion of tidal Anacostia | Secchi depth criterion: seasonal segment average ≥ 0.8 meters (Apr 1 - Oct 31); Turbidity criterion: ≤ 20 NTU above background |

## Relationship of Turbidity and Secchi Depth Water Clarity

Figure E-1 shows an analysis of the relationship between the daily average Secchi depth values and turbidity (NTU) values in the tidal Anacostia, based on DC water quality monitoring data from 1995-2002[3]. For example, the results show that a numeric turbidity value of approximately 10 NTU corresponds to a Secchi depth measure of 0.8 meters (m).

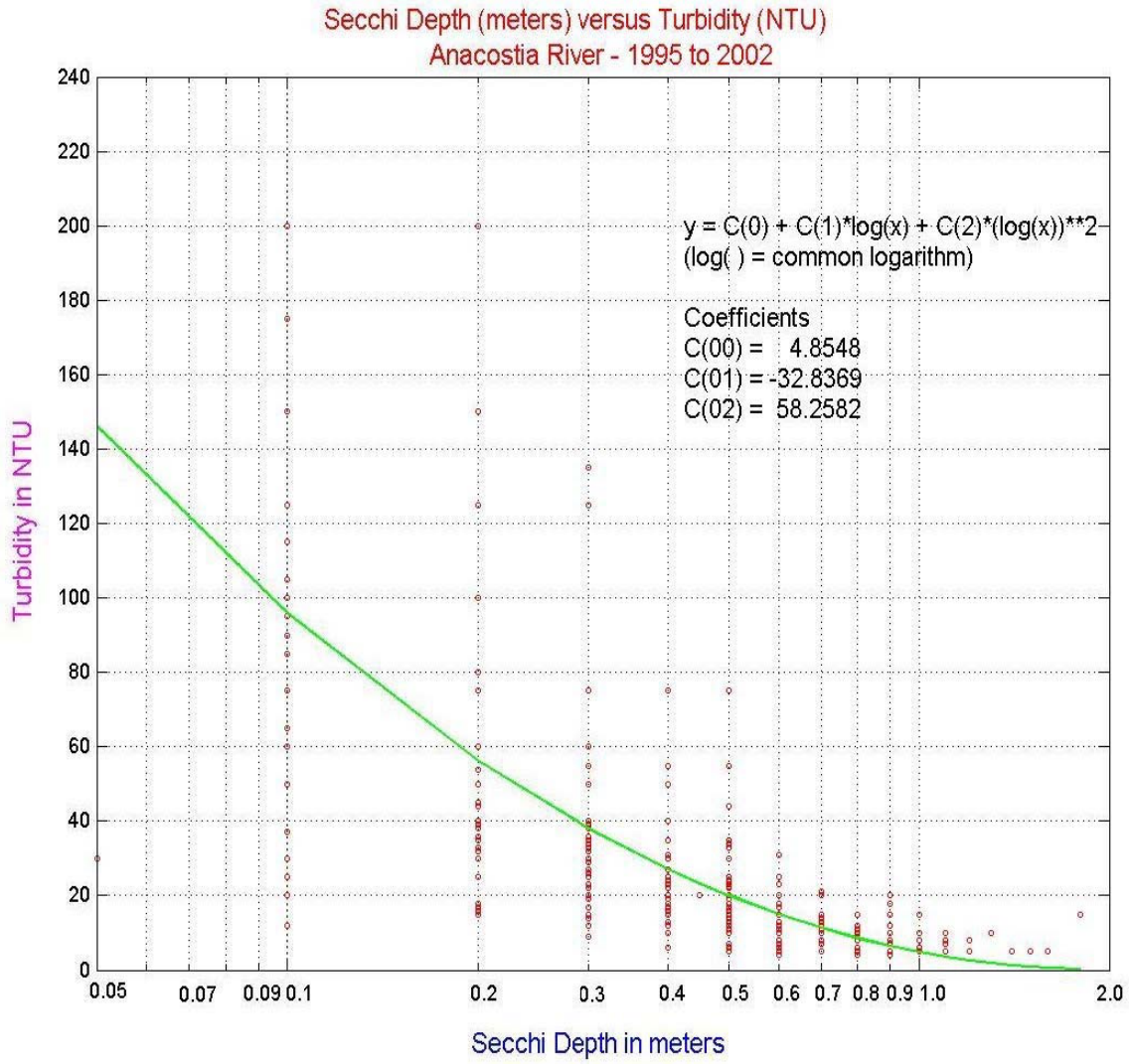


**Figure E-1. Secchi Depth vs. Turbidity in the Anacostia River, 1995-2002**

### Attainment of Turbidity Standards under the TMDL Scenario

Attainment of the year-round turbidity standards in the Anacostia River by reducing sediment loads as necessary to meet the seasonal DC Secchi depth criterion is

[3] The data used in the analysis is available from the "Data Hub" on the Chesapeake Bay Program web site at: www.chesapeakebay.net

demonstrated through an evaluation of a model simulation of three years of turbidity levels under the TMDL allocations, which require an 85% reduction in sediment loads from baseline conditions. Predicted turbidity levels under the TMDL allocation were calculated based on simulated Secchi depths from the TAM/WASP Model's TMDL Scenario and the empirical model of the relation between turbidity and Secchi depth depicted in Figure E-1. The TAM/WASP Model was used in the Anacostia Sediment TMDL to determine the allocation of sediment loads that would meet the Secchi depth criteria for protecting SAV. (See Section 4.0 of the TMDL main report for a detailed description of the modeling and analytical framework used. The predicted daily Secchi depths were generated for each model segment for each day of the three-year simulation period. Secchi depths were converted to turbidity levels based on the following empirical equation:

$$\text{Turbidity} = C_0 + C_1 * \log_{10}(\text{Secchi depth}) + C_2 * \log_{10}(\text{Secchi depth})^2$$

where Secchi depths are measured in meters, turbidity is measured in NTU, and
$C_0 = 4.8548$,
$C_1 = -32.8369$, and
$C_2 = 58.2582$.

This equation was developed from simultaneous observations of daily average turbidity values and Secchi depth in the Anacostia River between 1995 and 2002, as described above and shown in Figure E-1.

A daily turbidity value was determined by jurisdiction by averaging over the MD or DC segments. A 30-day moving average of the daily average turbidity values was also calculated for comparison to MD's monthly average criterion. The highest percentiles (>90th) of each time series are summarized in Table E-2 below. The "percent exceedance" indicates the percentage of the total data values that exceed the NTU levels indicated in each row of the table. For example, as illustrated in Table E-2 only 5% of all the data samples had daily NTU levels equal to or greater than 29.0 in MD. This means that 95% of the monitored data samples measured less than 29 NTUs.

**Table E-2: 90th Percentile of Daily and 30-Day Average Modeled Turbidity Levels Under the TMDL Scenario in the Anacostia River**

| Percent (%) Exceedance | Daily Turbidity Values (NTU) | | 30-day Average Turbidity Values (NTU) |
|---|---|---|---|
| | MD | DC | MD |
| 0.1 | 142.1 | 114.0 | 17.8 |
| 1.0 | 88.8 | 61.2 | 17.7 |
| 2.0 | 64.9 | 47.8 | 16.1 |
| 3.0 | 44.4 | 39.2 | 14.9 |
| 4.0 | 36.0 | 34.7 | 14.0 |
| 5.0 | 29.0 | 29.1 | 13.3 |
| 6.0 | 23.0 | 26.7 | 13.3 |
| 7.0 | 19.0 | 24.3 | 12.8 |
| 8.0 | 16.0 | 22.9 | 12.4 |
| 9.0 | 13.4 | 21.3 | 11.5 |
| 10.0 | 11.8 | 19.6 | 11.4 |

Both the daily average and 30-day moving average time series of predicted turbidity levels were then compared to the applicable MD and DC turbidity standards.

DC's turbidity water quality criterion is defined as no more than 20 NTU above ambient levels. The most environmentally conservative assumption is to assume that ambient or background is zero. In this scenario, the TMDL model results indicate that less than 10% of the daily NTU values are greater than 20 NTU. If it is assumed that background is 20 NTU, then approximately less than 3% of the daily NTU values are greater than 39 NTU in DC (see Table E-2). These conservative assumptions (background = 0 and background = 20) contribute to the margin of safety.

In MD, under the TMDL scenario, the 30-day average turbidity values never exceed 50 NTU and less than 0.1% of the daily values exceed a level of 150 NTU, thereby demonstrating complete attainment of MD's numeric criterion of 50 NTU monthly average and 99.9% attainment of the criterion of 150 NTU at any time (see Table E-2).

EPA's guidance has recommended making non-attainment decisions with respect to conventional pollutants, including Total Suspended Solids, when more than 10% of measurements exceed the water quality criterion. *See* Memorandum from Diane Regas, Director, Office of Wetlands, Oceans and Watersheds, to Water Division Directors, Regions I-X re *Guidance for 2006 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act* (July 29, 2005).

Both MD and DC make non-attainment decisions for conventional pollutants for their Section 303(d) lists based generally upon whether more than 10% of measurements exceed the water quality criterion. Accordingly, under the TMDL scenario when implemented, neither MD nor DC would consider the Anacostia River as impaired for sediment.

The analysis described above demonstrates that, by achieving the sediment reductions required by the TMDL in order to meet DC's seasonal Secchi depth criterion, all applicable sediment-related water quality standards in the tidal and non-tidal portions of the Anacostia watershed will also be met, including the MD and DC turbidity standards which apply year-round.[4]

[4] As noted in EPA's Gold Book (*Quality Criteria for Water*, EPA 440/5-86001 (May 1, 1986), turbid water can pose hazards to swimmers due to low visibility and the possibility of unseen objects; other types of recreational contact, such as boating and fishing, generally will be protected when the aquatic life use is protected. Although the TMDL is based on meeting a seasonal average of Secchi depths (April 1-October 31), this period (i.e., the warm weather months) generally coincides with the time when primary and secondary contact recreation in the Anacostia, particularly swimming, would be expected to be at its greatest frequency. The TMDL also includes annual loads and allocates loads to the non-growing season, as well as the growing season. Finally, as stated above and explained in Appendix E, the year-round turbidity standards are met when the sediment load reductions needed to meet the seasonal Secchi depth criterion are achieved.