Total Maximum Daily Loads of Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD) for the Little Youghiogheny River

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7Q10	7-day consecutive lowest flow expected to occur every 10 years
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CWA	Clean Water Act
DNR	Department of Natural Resources
EPA	Environmental Protection Agency
LA	Load Allocation
LYR-INPRG	Little Youghiogheny River INPRG Water Quality Model
MDE	Maryland Department of the Environment
MOS	Margin of Safety
NBOD	Nitrogenous Biochemical Oxygen Demand
NPDES	National Pollutant Discharge Elimination System
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Waste Load Allocation
WQLS	Water Quality Limited Segment
WWTP	Waste Water Treatment Plant

PREFACE

Section 303(d) of the federal Clean Water Act directs States to identify and list waters, known as water quality limited segments (WQLS), in which currently required pollution controls are inadequate to achieve water quality standards. For each WQLS, the State is to establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards.

The Little Youghiogheny River was identified on the State's 1996 list of WQLSs because of nutrients. However, the actual impairment in the Little Youghiogheny River was the occurrence of occasional low dissolved oxygen which was believed to be due to nutrients. Although recent data shows that the dissolved oxygen standard violations in the Little Youghiogheny River are minor and infrequent, it is suspected that the violations could increase in both severity and frequency if the Trout Run Wastewater Treatment Plant and Deer Park Spring Water Company discharges and nonpoint source loads are not carefully regulated. While the cause of these violations was initially suspected to be nutrients, subsequent investigation determined that biochemical oxygen demand (BOD) is the dominant cause of the low dissolved oxygen concentrations. This report documents the proposed establishment of a TMDL for the Little Youghiogheny River to maintain and improve dissolved oxygen concentrations. MDE anticipates that these CBOD and NBOD TMDLs will completely address the original 303(d) listing for nutrients.

Once approved by the United States Environmental Protection Agency (EPA), the TMDL will be reflected in the State's Continuing Planning Process. In the future, the established TMDL will support regulatory and voluntary measures needed to protect water quality in the Little Youghiogheny River.

EXECUTIVE SUMMARY

This document establishes a Total Maximum Daily Load (TMDL) that addresses low dissolved oxygen concentrations in the Little Youghiogheny River. The low dissolved oxygen concentrations are due to biochemical oxygen demand (BOD) in the effluent of the Trout Run Wastewater Treatment Plant (WWTP), the Deer Park Spring Water Company discharge and nonpoint sources. BOD reflects the amount of oxygen consumed through two processes: carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). The water quality goal of the TMDL is to establish allowable CBOD and NBOD inputs at a level that will ensure the maintenance of the dissolved oxygen standard.

The TMDL was developed using a mathematical model for free-flowing streams. The model was used to determine allowable CBOD and NBOD loadings which would result in the maintenance of the receiving stream dissolved oxygen standard. The model was also used to investigate seasonal variations in stream conditions and to establish margins of safety that are environmentally conservative. Load allocations were determined for distributing allowable loads between point and nonpoint sources.

The allocation of CBOD and NBOD for nonpoint sources was based on observed field values and the implementation of nutrient management plans which will also achieve a commensurate reduction in CBOD and NBOD loads. The point source allocation was based on the future maximum National Pollutant Discharge Elimination System (NPDES) permit limits at the Trout Run WWTP and the Deer Park Spring Water Company. The TMDL for 7Q10 low-flow conditions in the Little Youghiogheny River for CBOD is 423 lbs/month and 413 lbs/month for NBOD. This TMDL is seasonal and applies during the period from June 1 to October 31.

Several factors provide assurance that this TMDL will be implemented. First, NPDES permits will be written to be consistent with the load allocations in the TMDL. Second, Maryland has adopted a watershed cycling strategy, which will ensure that future water quality monitoring and TMDL evaluations are routinely conducted. In addition the certainty of implementation of the nonpoint source CBOD and NBOD reductions in this watershed will be enhanced by two specific programs; the Water Quality Improvement Act of 1998 (WQIA), and the EPA-sponsored Clean Water Action Plan of 1998 (CWAP).

1.0 INTRODUCTION

The Clean Water Act (CWA) Section 303(d)(1)(C) and federal regulation 40 CFR §130.7(c)(1) direct each State to develop Total Maximum Daily Loads (TMDL) for all impaired waters on the Section 303(d) list. States must consider seasonal variations and must include a margin of safety to account for uncertainty in the monitoring and modeling processes. A TMDL reflects the total pollutant loading of an impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Little Youghiogheny River was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment (MDE). It was listed as being impaired by nutrients. The actual impairment consisted of low dissolved oxygen concentrations found near the confluence of the Little Youghiogheny River and the Youghiogheny River. The Little Youghiogheny River is designated as a Use III-P, natural trout water according to the Code of Maryland Regulations 26.08.02. The dissolved oxygen standard for a Use III-P water is a minimum daily average of 6.0 mg/l and 5.0 mg/l at any time. The Department's analysis, as discussed in detail in Section 4.0, demonstrates that the impairment is principally due to biochemical oxygen demand (BOD) in the stream, instead of nutrients, and describes the development of TMDLs for CBOD and NBOD in the Little Youghiogheny River. MDE anticipates that these TMDLs will completely address the original 303(d) listing for nutrients.

2.0 DESCRIPTION OF THE WATERSHED

The Little Youghiogheny River is a tributary of the Youghiogheny River, located in Garrett County, Maryland (Figure 1). The Youghiogheny River flows northward into Pennsylvania, joining the Monongahela and Allegheny Rivers to form the Ohio River. The mainstem of the river is approximately 11 miles long. The watershed of the Little Youghiogheny River has an area of approximately 26,214 acres. As shown in Figure 2, the predominant land uses in the watershed, based on 1997 Maryland Office of Planning land cover data, are mixed agriculture comprising 11,129 acres or 43% of the total area, forest at 11,027 acres or 42%, and urban at 3,837 acres or 15%. The upper portion of the Little Youghiogheny River traverses both agricultural and forest lands. The lower portion traverses the watershed's urban areas of Loch Lynn Heights, Mountain Lake Park, and Oakland.

The Little Youghiogheny River watershed lies in the Allegheny Plateau. The geological strata include shale and sandstone of the Devonian Chemung and Hampshire formations (Maryland Geological Survey, Geologic Map of Maryland, 1968). Soils in the watershed are primarily Calvin-Gilpin association, gently sloping to steep, moderately deep, well-drained soils; formed over acid, red to gray shale and sandstone (U.S. Department of Agriculture, Soil Survey of Garrett County, 1974).

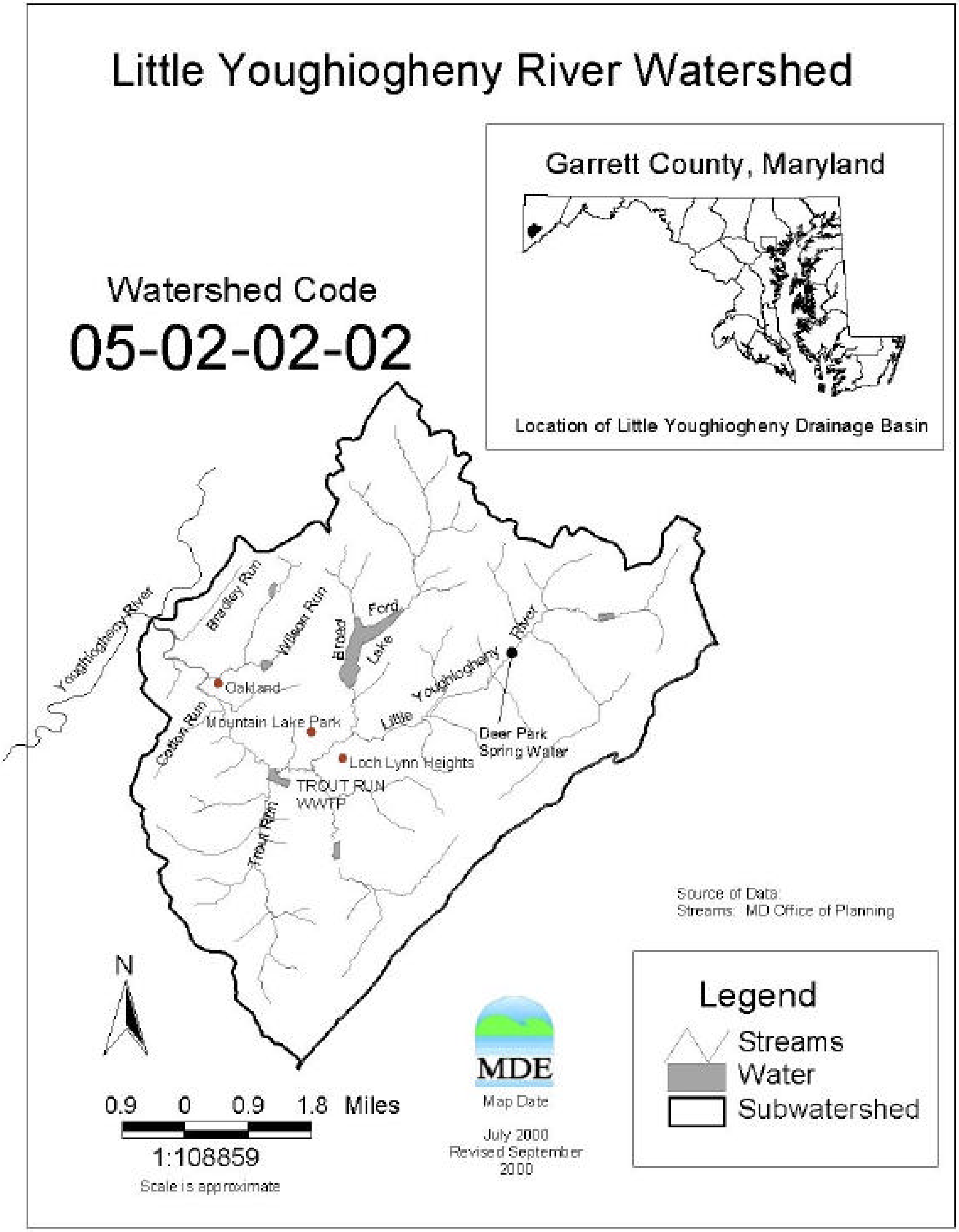

Figure 1: Location of the Little Youghiogheny River Drainage Basin, within Garrett County, Maryland

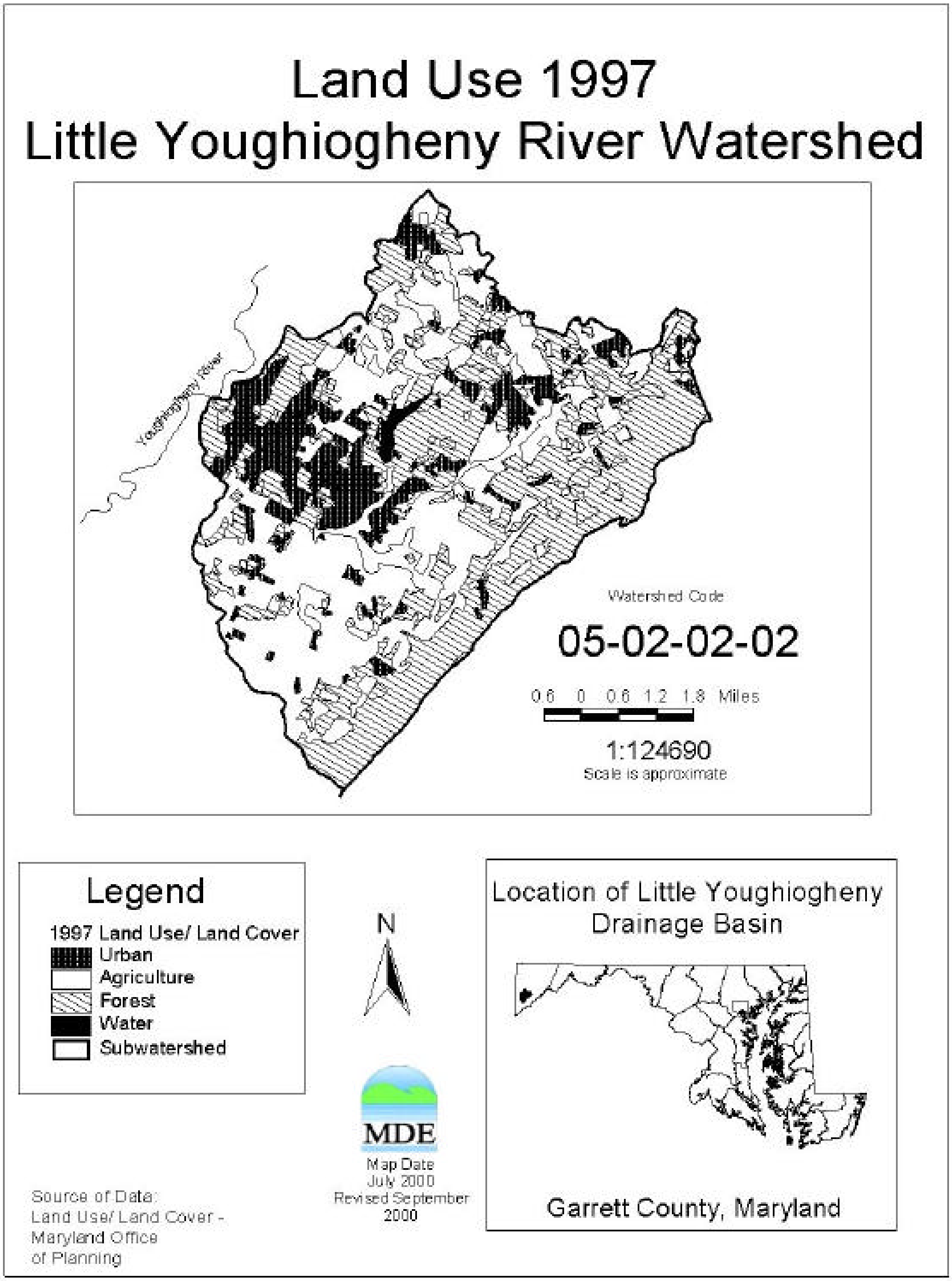

Figure 2: Land use in the Little Youghiogheny River Drainage Basin, Garrett County, Maryland

The hydrology of the Little Youghiogheny differs from typical Appalachian streams, due to relatively little elevation change along its river channel. The sluggish, meandering river is more depositional than erosional (Maryland Department of the Environment, Hydrologic Transport In The Little Youghiogheny River, 1997). During a low-flow stream survey of the Little Youghiogheny River from the Trout Run WWTP to the confluence with the Youghiogheny River, velocities averaged 0.13 feet per second and depths averaged about 1 to 1.5 feet.

3.0 WATER QUALITY CHARACTERIZATION

3.1 Little Youghiogheny River Water Quality

Only one long-term historical water quality sampling station, LYO0004, is located in the Little Youghiogheny River watershed. LYO0004 is located in the portion of the Little Youghiogheny River where the observed impairment is located and it was used to characterize the existing water quality. Figure 3 shows the location of water quality sampling sites, a United States Geological Survey (USGS) flow gage, and other geographic points of interest. Water chemistry data has been collected approximately on a monthly basis by the Maryland Department of Natural Resources (DNR) and the Maryland Department of the Environment (MDE) since July 1968 at station LYO0004. The water quality of three parameters, dissolved oxygen, total nitrogen, and total phosphorus collected at the station were examined, for the period between January 1990 and October 1998.

The important issues for the Little Youghiogheny River are the amount of nutrients and BOD entering the system and the dissolved oxygen concentrations immediately upstream of the confluence with the Youghiogheny River. Figure 4 shows the measured dissolved oxygen concentrations at station LYO0004, four tenths of a mile upstream of the confluence with the Youghiogheny River. Although the problem is not currently severe, the data show that dissolved oxygen levels were 0.1 mg/l below the numeric criteria of 5 mg/l minimum at any time in September 1991and were 0.1 mg/l below the 6 mg/l minimum daily average numeric criteria as recently as July 1997. Figure 5 shows the total nitrogen concentrations observed at station LYO0004, they averaged 1.765 mg/l and peaked at 3.636 mg/l in September 1998. Figure 6 shows the total phosphorus concentrations averaged 0.0948 mg/l and peaked at 0.401 mg/l in February 1996 at station LYO0004.

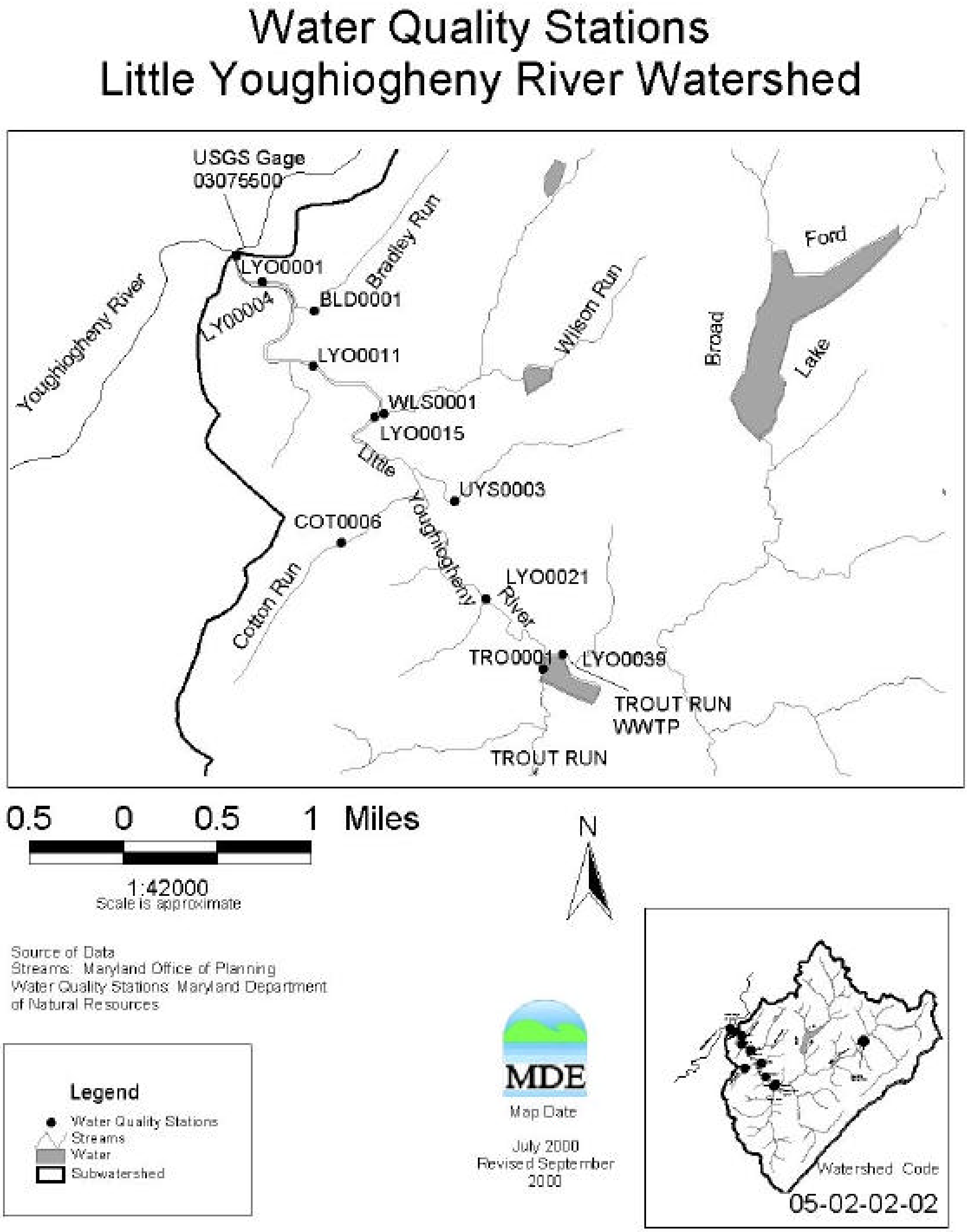

Figure 3: Location of Water Quality Monitoring Stations, and Other Points of Interest

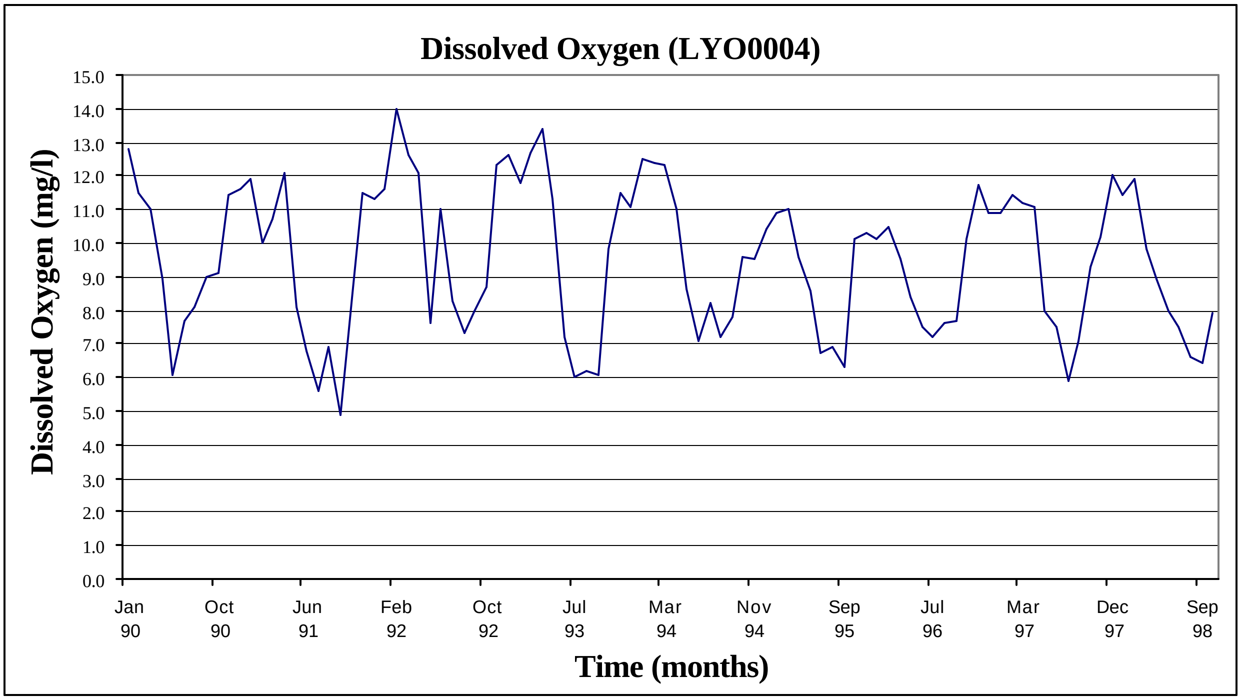

Figure 4: Dissolved Oxygen Concentrations at Water Quality Station LYO0004

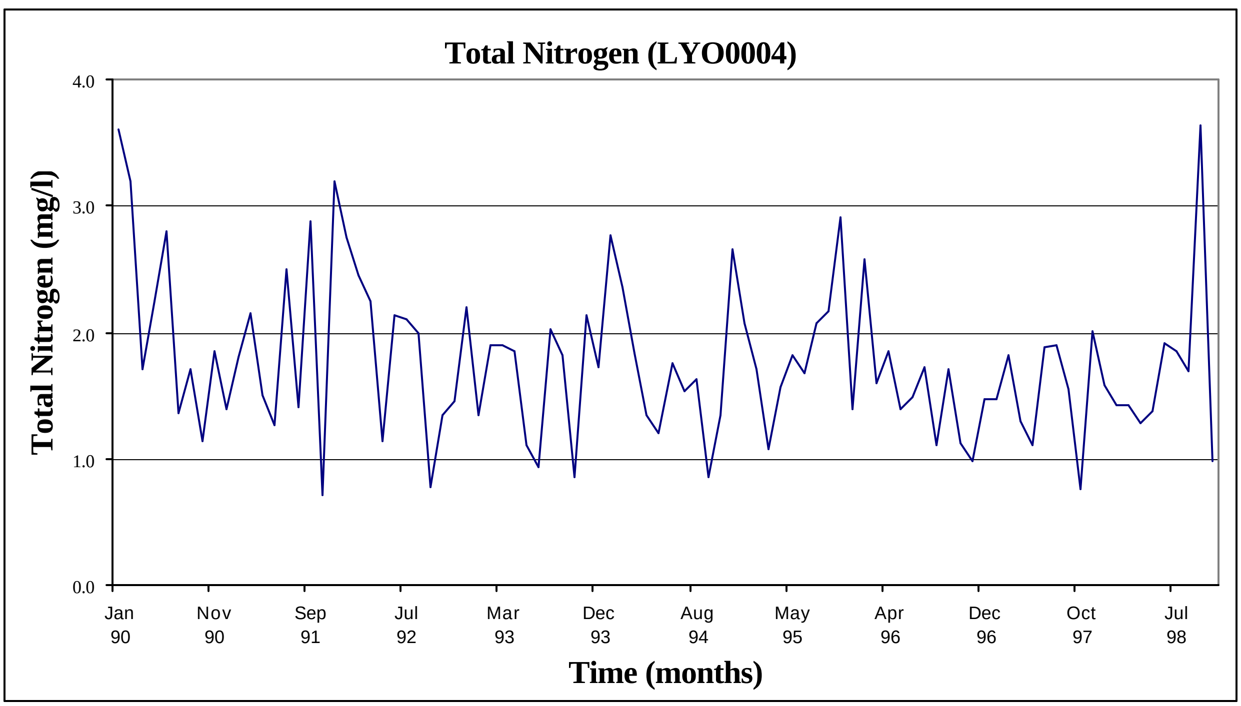

Figure 5: Total Nitrogen Concentrations at Water Quality Station LYO0004

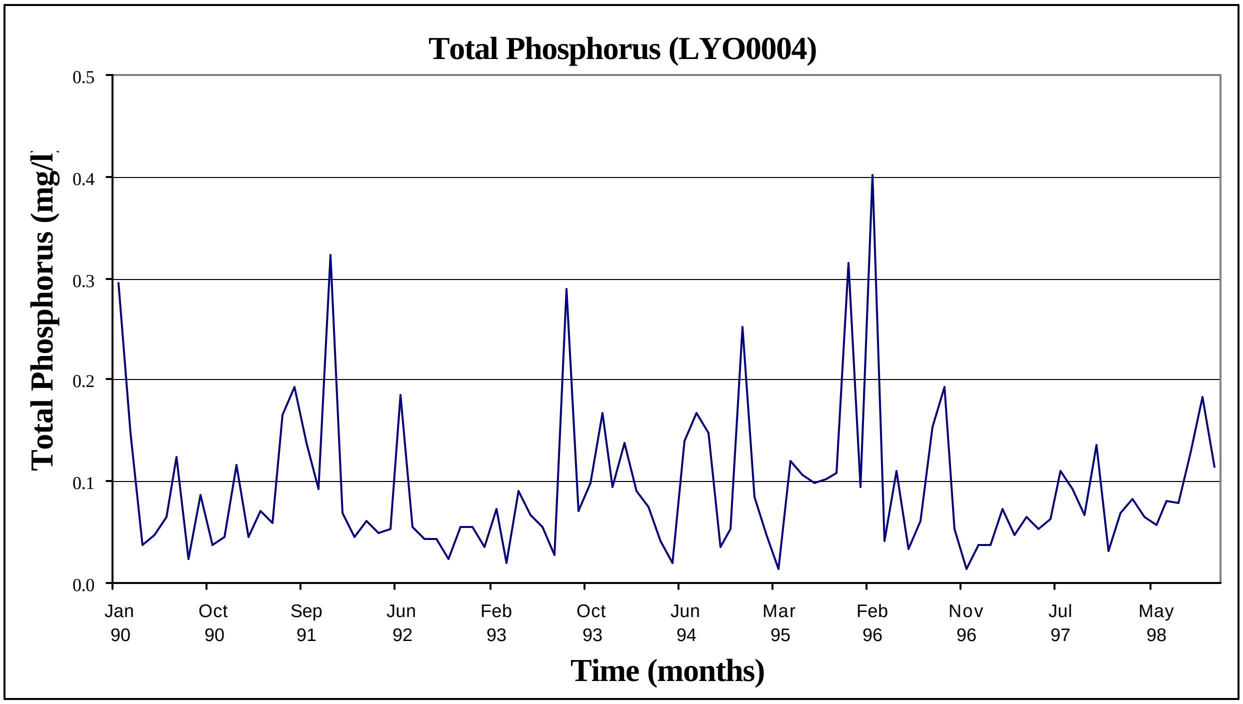

Figure 6: Total Phosphorus Concentrations at Water Quality Station LYO0004

3.2 Sources of the Impairing Substance

The primary substances of concern in this watershed are nutrients and BOD. Nutrients can stimulate the growth of algae, which in turn die and start decaying in the sediment layer, and consume oxygen. BOD is a composite term that describes the consumption of oxygen through the oxidation of carbon and nitrogen by bacteria in the water. The sources of nutrients and BOD include both point and nonpoint source loads. There are two significant point sources in the Little Youghiogheny River watershed, the Trout Run WWTP, and the Deer Park Spring Water Company. During low flow and average summer flow conditions, both point and nonpoint sources contribute significant nutrient and BOD loads to the system. The point source values used in this document come from the NPDES discharge permits for each of the WWTPs.

The majority of the nonpoint source loads of nutrients and BOD enter the system at the upstream boundary located at water quality model station 1 and from Trout Run at water quality model station 10. Cotton Run, Wilson Run, Bradley Run and several unnamed tributaries also contribute loads to the system. The nonpoint source loads are based on in-stream water quality monitoring data. Because the low flow loading estimations are based on observed data, they account for all human and natural sources. While this document addresses both nutrients and BOD, the TMDL reflects limits on BOD only, because BOD is the dominant impairing substance. MDE anticipates that the CBOD and NBOD TMDLs will completely address the original 303(d) listing for nutrients.

In addition to accounting for the sources of the substances of concern, the processes that deplete dissolved oxygen should also be considered. These processes include those that consume oxygen (sinks) as well as those that generate oxygen (sources). These processes and some additional factors are presented in Figure 7. As mentioned before, BOD reflects the amount of oxygen consumed through two processes: carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). CBOD is the reduction of organic carbon material to its lowest energy state, CO_2, through the metabolic action of microorganisms (principally bacteria). NBOD is the term for the oxygen required for nitrification, which is the biological oxidation of ammonia to nitrate. The BOD values seen throughout this document represent the amount of oxygen consumed by the oxidation of carbonaceous and nitrogenous waste materials over a 5-day period, at 20 ^{o}C. This is referred to as a 5-day, 20 ^{o}C BOD and is the standard reference value utilized internationally by both design engineers and regulatory agencies. The 5-day BOD represents primarily consumption of carbonaceous material and minimal nitrogenous material. The ultimate BOD represents the total oxygen consumed by carbonaceous and nitrogenous material, over an unlimited length of time.

Another factor influencing dissolved oxygen concentrations is the sediment oxygen demand (SOD). As with BOD, SOD is a combination of several processes. Primarily it is the aerobic decay of organic materials that settle to the bottom of the stream. However, SOD is usually considered negligible in free flowing streams like the Little Youghiogheny River because frequent scouring during storm events usually prevents long-term accumulation of organic materials. All of the dissolved oxygen sources and sinks make up the dissolved oxygen balance. For more information, see Appendix A.

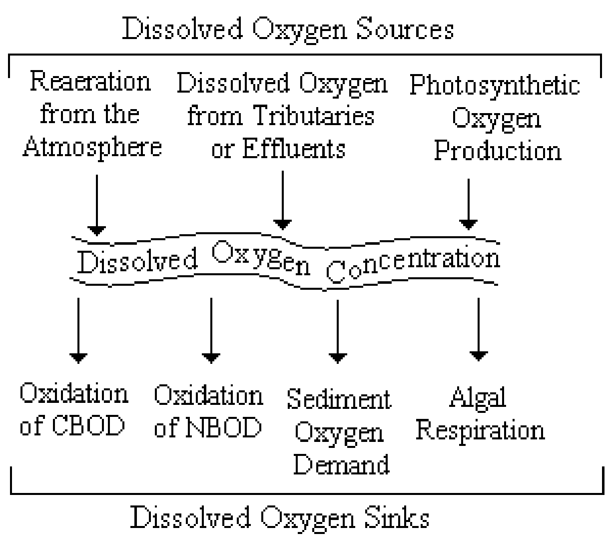

Figure 7: Sources and Sinks for Dissolved Oxygen in the River

4.0 WATER QUALITY IMPAIRMENT

The Little Youghiogheny River impairment consists of infrequent violations in the 5.0 mg/l minimum at any time dissolved oxygen standard for Use III-P waters and slightly more frequent low dissolved oxygen levels below the 6.0 mg/l daily average standard at station LYO0004, as indicated by monitoring data shown in Figure 4. As it currently stands, these minor and infrequent dissolved oxygen standard violations would not be a major cause of concern. However, the allowable rate of wastewater release from the Trout Run WWTP is dependent upon the flow rate of the Little Youghiogheny River above the wastewater treatment plant. If the wastewater release rate from the Trout Run WWTP is not carefully controlled, it is likely that dissolved oxygen violations in the Little Youghiogheny River will increase in both severity and frequency. In addition, below standard dissolved oxygen levels are predicted by the water quality model in the upper portions of the Little Youghiogheny River during low flow conditions. The predicted low dissolved oxygen levels in the upper portions of the Little Youghiogheny River are due to the Deer Park Spring Water Company and nonpoint source BOD loads. Development of a TMDL at this point will protect the receiving stream dissolved oxygen in the upper portions of the Little Youghiogheny River and minimize further degradation of the lower portions of the waterbody.

In the 1996 303(d) list, the cause of the impairment was presumed to be nutrients. The total nitrogen and total phosphorus are averaging 1.765 mg/l and 0.0948 mg/l respectively at station LYO0004 as shown in Figures 5 and 6. Generally, nutrient levels are of concern in slow moving waterbodies such as lakes and estuaries having low velocities and long travel times. Low velocities and excess nutrients can encourage the growth of undesirable levels of algae. Algal growth can be a significant factor in dissolved oxygen levels due to photosynthetic oxygen production and oxygen consumption through respiration by the algae. Evidence of undesirable levels of algae is normally supported by large diurnal variations in dissolved oxygen concentrations. Careful examination of the chlorophyll-a and dissolved oxygen data and subsequent modeling has determined that BOD, and not nutrients, is the dominant cause of the low dissolved oxygen impairment. Chlorophyll-a concentrations in the Little Youghiogheny River averaged less than 8.5 ug/l and ranged between 1.8 ug/l and 14.5 ug/l as shown in Figure 8 below. These low levels of algae support the conclusion that algae is not a significant factor influencing dissolved oxygen concentrations in the Little Youghiogheny River. The conclusion is further supported by the lack of a significant diurnal variation in dissolved oxygen. Early morning and late afternoon dissolved oxygen measurements were collected at several locations on the Little Youghiogheny River to assess the diurnal variation in dissolved oxygen. As shown in Figures 9 through 11 below the diurnal variation of dissolved oxygen in the Little Youghiogheny River ranged from 0.2 mg/l at station LYO0039 on August 9, 1994 to 2.8 mg/l at the same station on August 11, 1997. The diurnal variation in dissolved oxygen averaged 1.6 mg/l during the recorded period. Therefore, it is also not necessary to consider the diurnal variations of dissolved oxygen due to algae in the model scenarios since one half of the observed diurnal variation is 0.8 mg/l. Attainment of dissolved oxygen concentrations above a minimum of 5.0 mg/l at any time will be assured since the model scenarios will have a daily average dissolved oxygen water quality goal greater than 6.0 mg/l in the Little Youghiogheny River.

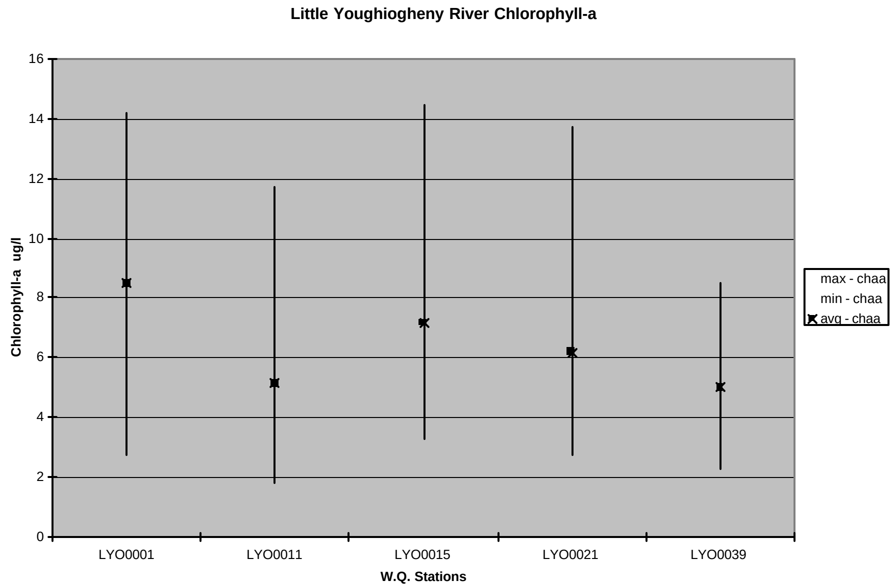

Figure 8: Little Youghiogheny River Chlorophyll-a

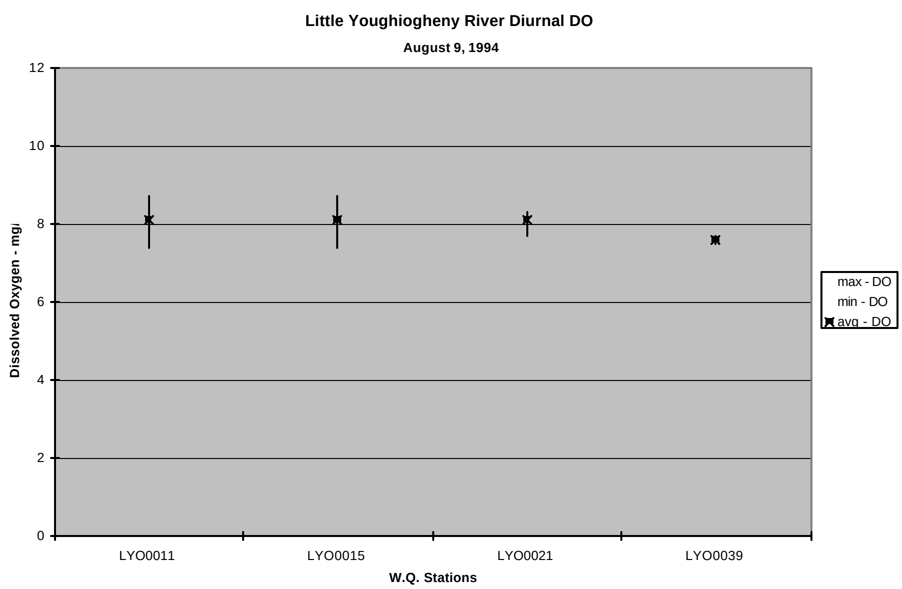

Figure 9: 8-9-94 Little Youghiogheny River Diurnal DO

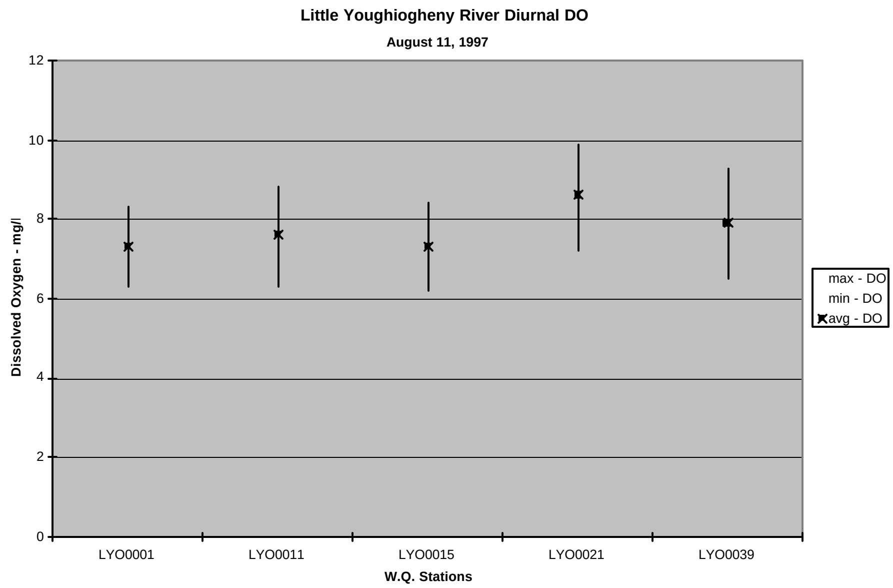

Figure 10: 8-11-97 Little Youghiogheny River Diurnal DO

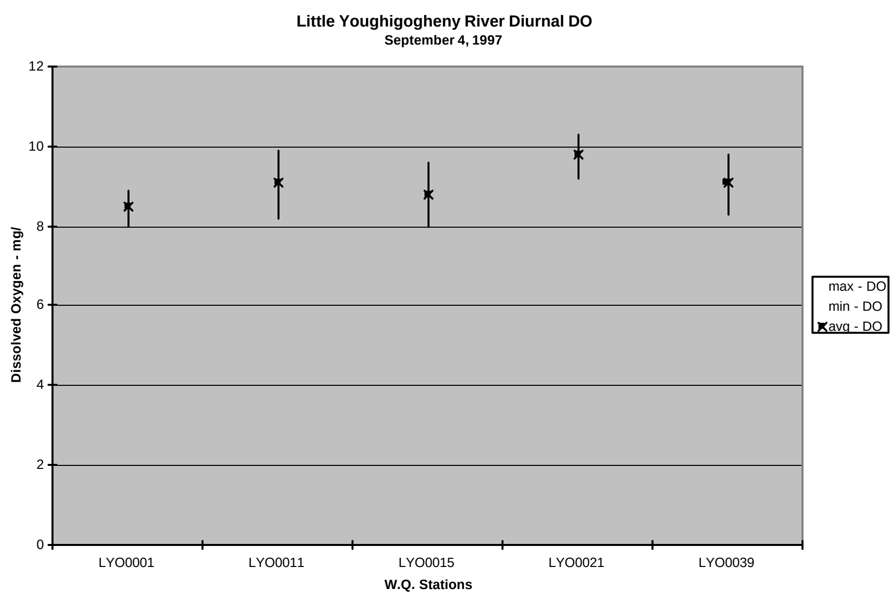

Figure 11: 9-4-97 Little Youghiogheny River Diurnal DO

5.0 TARGETED WATER QUALITY GOAL

The overall objective of the development of the TMDL for the Little Youghiogheny River is to determine the maximum allowable BOD inputs from point and nonpoint sources that will allow for the maintenance of dissolved oxygen standards. The development of the TMDL for the Little Youghiogheny River is intended to assure that dissolved oxygen concentrations remain above a minimum of 5.0 mg/l at any time and a minimum daily average of 6.0 mg/l in the Little Youghiogheny River. This dissolved oxygen goal is based on specific numeric criteria for Use III-P designated waters set forth in the Code of Maryland Regulations 26.08.02.

6.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

This section describes how the TMDL and load allocations for point and nonpoint sources were developed for the Little Youghiogheny River. The first section describes the modeling framework for simulating water quality constituent interactions and hydrology. The second and third sections summarize the scenarios that were explored using the model. The scenarios investigate water quality responses assuming different stream flow conditions and load allocations. The fourth and fifth sections present the modeling results in terms of TMDLs, and allocate the TMDL between point sources and nonpoint sources. The sixth section explains the rationale for the margin of safety. Finally, the pieces of the equation are combined in a summary accounting of the TMDL.

6.1 Analysis Framework

The computational framework, or model, chosen for determining the TMDL of the Little Youghiogheny River was the INPRG water quality model. INPRG is a steady state mathematical model, developed within MDE, for the impact assessment of point and nonpoint source load discharges of material which exert an oxygen demand in free flowing streams. The model prepares input data and runs a free flowing stream model based upon the Streeter Phelp's equation. The INPRG model predicts receiving stream CBOD, NBOD, and dissolved oxygen concentrations for selected stream input conditions. For more information on INPRG, see Appendix A.

The spatial domain represents the portion of the watershed that is included in the model. The Little Youghiogheny River INPRG water quality model (LYR-INPRG) spatial domain extends from the confluence of the Little Youghiogheny River and the Youghiogheny River for approximately 7.6 miles upstream along the mainstem of the Little Youghiogheny River to the discharge from the Deer Park Spring Water Company at LYR-INPRG model station 1 (see Figure 12). Station 1 is the upper boundary of the model's spatial domain, and the confluence with the Youghiogheny River is the lower boundary. The model's spatial domain does not include the entire length of the Little Youghiogheny River; rather, it focuses on the area where the localized dissolved oxygen impairment occurs. Figure 12 also includes the location of several other key inputs to the model as well as the model segmentation.

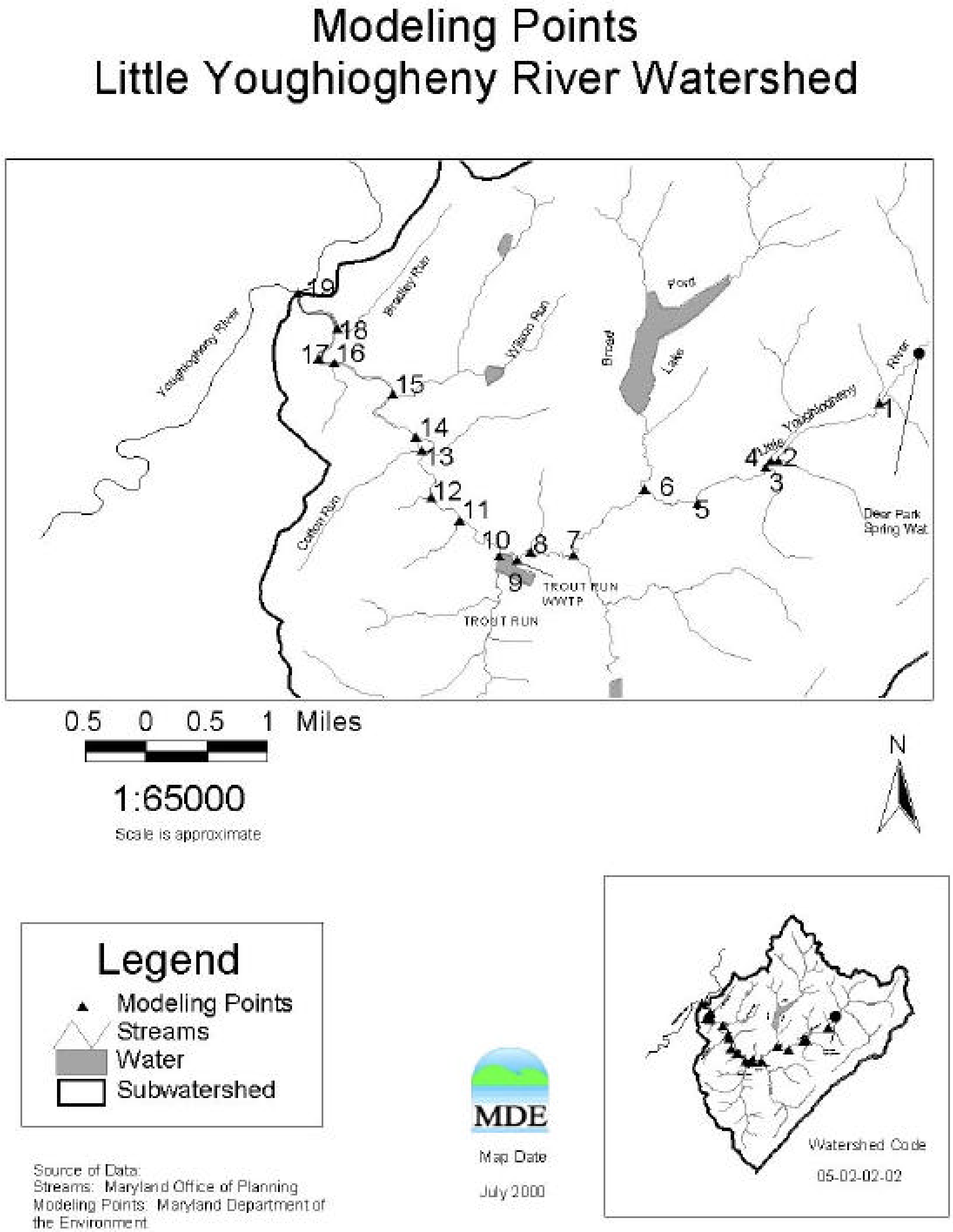

Figure 12: Representation of Modeling Domain, Segmentation, Point and Nonpoint Source location.

Each model station identified in Figure 12 (with exception of stations 1, 5, 9, and 17) is located at the confluence of a tributary of the Little Youghiogheny River with the mainstem. Each tributary station and the drainage area above station 1 has an associated nonpoint source load entering the system. The majority of the nonpoint source loads enter the system at the upstream boundary located at water quality model station 1 and from Trout Run (station 10). Other significant nonpoint source loads enter the system at Cotton Run (station 13), Wilson Run (station 15), Bradley Run (station 18), and at several unnamed tributaries (stations 3, 4, 7, 8, and 14). The nonpoint source loads are based on in-stream water quality monitoring data. The in-stream data accounts for atmospheric deposition to the land, nonpoint source runoff from urban development, agriculture, and forest land, and infiltration from septic tanks. The freshwater flows used in the model were estimated based on proportional drainage areas and calibration with observed streamflow data. Seven-day, 10-year, low-flow conditions were estimated using the USGS gage located on the Youghiogheny River near Oakland (03075500).

There are six NPDES permitted point sources in the Little Youghiogheny River watershed. These are Peters Fuel Corporation, which has two discharge permits authorizing the discharge of treated garage floor drainage and storm water runoff, Garrett County Sanitary District, Inc., Trout Run WWTP which is authorized to discharge treated municipal wastewater, Deer Park Spring Water Company, which is authorized to discharge bottle washing rinse water, distillation unit blowdown, water storage tank overflow, excess spring water, and storm water runoff, Wood Products, Inc., which is authorized to discharge boiler blowdown to groundwaters and storm water to surface waters, and Fairfax Concrete Products, Inc., which is authorized to discharge truck wash water, boiler blowdown, block plant drainage, garage drainage, storm water, and water softener backwash. Only two of the point sources discharge BOD or significant amounts of nutrient loads into the system. The two point sources, Trout Run WWTP and Deer Park Spring Water Company, discharge directly to in the Little Youghiogheny River. The Deer Park Spring Water Company load is treated as a distinct load entering the Little Youghiogheny River at LYR-INPRG model station 1. The Trout Run WWTP load is treated as a distinct load entering at LYR-INPRG model station 9.

The existing Trout Run WWTP treatment process and wastewater discharge method was factored into the development of the Little Youghiogheny River TMDL. The Trout Run WWTP is a lagoon treatment system with hydrographic controlled wastewater release. Effluent flows are restricted during the summer period and are dependent upon the Little Youghiogheny River stream flow conditions above the wastewater treatment plant. A wastewater release rate relationship for the facility was developed in 1983 using an earlier uncalibrated version of the LYR-INPRG model and became a discharge permit condition. During low-flow periods, when the wastewater release rate is restricted, wastewater storage is necessary until flow conditions in the Little Youghiogheny River increase and greater wastewater releases are permissible. The LYR-INPRG model was calibrated with September 1997 data and verified with August 1997 data collected by MDE's Field Operations Program staff. The calibrated version of the LYR-INPRG model was utilized to develop a new hydrographic release relationship for the Trout Run WWTP. Calibration and verification of the model, and the development of a new hydrographic release relationship can be seen in Appendix A

6.2 Scenario Descriptions

To project the water quality response of the system the model was applied to several different scenarios under selected stream flow conditions. By modeling several stream flow conditions, the scenarios simulate seasonality, which is a necessary element of the TMDL development process.

The scenarios are grouped into three categories according to *beginning condition scenarios, intermediate condition scenarios,* and *final condition scenarios*. The *beginning condition scenarios* represent the future conditions of the system with no reductions in point or nonpoint source loads. The *intermediate condition scenarios* represent the future conditions of the system with some reductions in point and some or no reduction in nonpoint source loads. The *final condition scenarios* represent the projected maximum point and nonpoint source loads.

Beginning Condition Scenarios

The first scenario represents the system during summer low-flow conditions. At the upper boundary of the Little Youghiogheny River, a flow of 0.4 cfs was used, which represents the 7-day consecutive lowest flow expected to occur every 10 years, known as the 7Q10 flow. As described above in "Analysis Framework", the flows entering at the upstream boundary and from tributaries were estimated based on proportional drainage areas, calibration with observed stream flow data, and gage data from the USGS gage located on the Youghiogheny River near Oakland (03075500). The nonpoint source loads reflect observed water quality concentrations in the Little Youghiogheny River watershed during the summer stream surveys of 1994 and 1997. The point source loads were computed under the assumption that the Trout Run WWTP and Deer Park Spring Water Company would be discharging at their current monthly maximum National Pollutant Discharge Elimination System (NPDES) permit limits. Because this scenario represents summer conditions, summer limits were used where applicable.

The LYR-INPRG model calculates the daily average dissolved oxygen concentrations in the stream. Since the Little Youghiogheny River has low concentrations of chlorophyll-a, the diurnal dissolved oxygen variations due to algal photosynthesis and respiration would be minimal and are not included in the analysis. Also, due to the lack of long-term accumulation of organic materials, the sediment oxygen demand would be minimal and is not included in the analysis. The model runs required an input of CBOD and NBOD to incorporate the total BOD (biochemical oxygen demand) loads. The CBOD and NBOD values were calculated by multiplying BOD_5 by 1.5 and TKN by 4.6 respectively. The model calculates dissolved oxygen by considering the oxidation of CBOD and NBOD and reaeration only.

The second scenario represents the system during average summer conditions. Low dissolved oxygen concentrations were not expected to occur during average summer conditions. However, to confirm that the worst possible conditions occur in the summer low-flow period, average summer conditions were examined in this scenario. Average summer flow conditions were estimated using monthly mean flow data for the months of June through October at USGS gage 03075500 and proportional drainage areas. At the upper boundary of the Little Youghiogheny River, an average summer flow of 10.5 cfs was used. The nonpoint source loads reflect observed water quality concentrations in the Little Youghiogheny River watershed during the summer stream surveys of 1994 and 1997. The point source loads from the Trout Run WWTP and Deer Park Spring Water Company were computed under the same assumption as scenario one, except a maximum Trout Run WWTP summer wastewater discharge rate of 3.0 MGD was assumed based on inspection of the most recent three years of discharge monitoring reports. Although a flow of 3.0 MGD is less than the allowable Trout Run WWTP release rate relationship-based flow for an average Little Youghiogheny River summer flow of 28.9 cfs, it was considered a practical maximum wastewater flow during the summer period. The assumed Scenario 2 point source and nonpoint source conditions are conservative since they do not consider the implementation of future TMDL control strategies developed to achieve 7Q10 low-flow requirements. A finding of no impairment with the Scenario 2 assumed loading conditions would rule out the need to examine average summer conditions further, as discussed in *Beginning Condition Scenarios* in the Model Results section.

Intermediate Condition Scenarios

It is very important that the dissolved oxygen concentrations do not go below the minimum daily average standard of 6.0 mg/l and 5.0 mg/l at any time. The *intermediate condition scenarios* investigated point source and nonpoint source load reduction options with the intermediate goal of raising the dissolved oxygen up to the daily average standard of 6.0 mg/l and 5.0 mg/l at any time.

The third scenario determines the effects of the revised wastewater release rate relationship for the Trout Run WWTP and reduced CBOD and NBOD loads from Deer Park Spring Water Company. The nonpoint source loads were the same as for scenario one. The point source loads were reduced at the Trout Run WWTP as a result of the reduced allowable flow from 20,300 gpd to 3,100 gpd at 7Q10 stream flow conditions and Deer Park Spring Water Company CBOD and NBOD loads were reduced as a result of more restrictive BOD_5 and TKN limitations. The third scenario did not achieve the desired intermediate goal of the daily average dissolved oxygen standard of 6.0 mg/l since the model predicted a dissolved oxygen concentration of 5.4 mg/l at model station 2.

The fourth scenario shows the effects of reducing the nonpoint source loads from the third scenario by 40% and further adjustment of the Deer Park Spring Water Company CBOD and NBOD loads to bring the predicted dissolved oxygen up to 6.0 mg/l. The Trout Run WWTP load is the same as scenario three.

The fifth scenario shows the effects if Deer Park Spring Water Company connects to the Trout Run WWTP and nonpoint sources are reduced by 10%. The Trout Run WWTP load is the same as scenario three and no load from Deer Park Spring Water Company is included. The nonpoint source loads were reduced from the third scenario by 10% to bring the predicted dissolved oxygen up to 6.0 mg/l.

Final Condition Scenarios

For the *final condition scenarios*, load reduction options were investigated which would reserve some of the stream assimilative capacity to provide for a margin of safety. The *final condition scenarios* provide a margin of safety by having the average daily dissolved oxygen concentrations remain above 6.0 mg/l for the entire length of the Little Youghiogheny River.

The sixth scenario shows the effects of a proposed final solution by reducing the scenario four Deer Park Spring Water Company CBOD load with the same Trout Run WWTP loads as scenario three and the nonpoint source loads were reduced from scenario three by 40%. The sixth scenario brings the minimum average daily dissolved oxygen up to 6.1 mg/l.

The seventh scenario shows the effects of a proposed final solution if Deer Park Spring Water Company connects to the Trout Run WWTP and nonpoint sources are reduced by 20%. The Trout Run WWTP load is the same as scenario three and no load from Deer Park Spring Water Company is included. The nonpoint source loads were reduced from the third scenario by 20% to bring the predicted dissolved oxygen above 6.0 mg/l. The seventh scenario brings the minimum average daily dissolved oxygen up to 6.2 mg/l. The point and nonpoint source loads for all scenarios can be seen in Table 1.

Scenario		1	2	3	4	5	6	7
Nonpoint Source Loads								
CBOD	*lbs/day*	16.3	512.7	16.3	9.8	14.7	9.8	13.1
NBOD	*lbs/day*	17.6	548.5	17.6	10.6	15.9	10.6	14.1
Flow	*cfs*	1.38	43.18	1.38	1.38	1.38	1.38	1.38
Point Source Loads								
CBOD	*lbs/day*	21.2	1139.7	5.7	4.3	1.2	3.4	1.2
NBOD	*lbs/da*	46.3	1761.3	1.8	3.2	1.8	3.2	1.8
Flow	*mgd*	0.056	3.0366	0.039	0.039	0.003	0.039	0.003
CBOD MOS	*lbs/day*	0.0	0.0	0.0	0.0	0.0	0.9	1.6
NBOD MOS	*lbs/day*	0.0	0.0	0.0	0.0	0.0	0.0	1.8

Table 1: Point and Nonpoint Source Flows and Loads used in the Model Scenario Runs

6.3 Model Results

Beginning Condition Scenarios

1. *Summer Flow*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes average summer nonpoint source concentrations. Assumes current monthly summertime NPDES permitted flows and concentrations at both of the WWTPs. A wastewater flow of 20,350 gpd was assumed for the Trout Run WWTP with CBOD and NBOD loads based on BOD_5 = 30 mg/l and TKN = 15 mg/l. A wastewater flow of 36,000 gpd with CBOD and NBOD loads based on BOD_5 = 30 mg/l and TKN = 25 mg/l was assumed for Deer Park Spring Water Company.

2. *Average Summer Flow*: Assumes average summer stream flow conditions. Assumes average summer nonpoint source concentrations. Assumes current monthly summer NPDES permitted concentrations at both of the WWTPs. A practical maximum summer wastewater flow of 3.0 MGD was assumed for the Trout Run WWTP and a wastewater flow of 36,000 gpd was assumed for Deer Park Spring Water Company.

The first scenario represents the critical conditions of the system during summer low stream flow. As seen in Figure 13, the dissolved oxygen level goes below the water quality standard of 6.0 mg/l. The results of the second scenario, also seen in Figure 13, show the stream system to have dissolved oxygen concentrations well above 7.0 mg/l during average summer flow conditions. Further examination of average summer flow conditions is not necessary since the assumed Scenario 2 point source and nonpoint source conditions are conservative as discussed in the *Beginning Condition Scenarios* section. The dissolved oxygen concentrations plotted for all scenarios are the average daily dissolved oxygen concentrations, as calculated by the model.

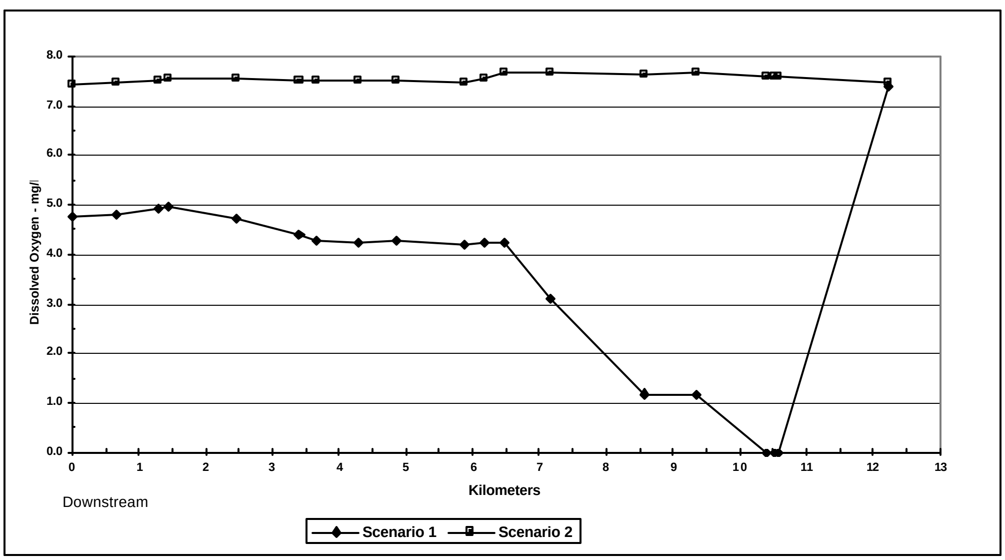

Figure 13: Results of Model Scenario Runs 1 and 2 for Dissolved Oxygen

Intermediate Condition Scenarios

3. *Revised Trout Run WWTP Release Rate Relationship and Reduced Deer Park Spring Water Company CBOD and NBOD Loads*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes average summer nonpoint source concentrations. Assumes a reduced allowable Trout Run WWTP flow of 3,100 gpd with CBOD and NBOD loads based on BOD_5 = 30 mg/l and TKN = 15 mg/l and reduced CBOD and NBOD loads from Deer Park Spring Water Company corresponding to a wastewater flow of 36,000 gpd with the more restrictive limitations of BOD_5 = 10 mg/l and TKN = 0 mg/l.

4. *Revised Trout Run WWTP Release Rate Relationship, Reduced Deer Park Spring Water Company CBOD and NBOD Loads, and 40% Nonpoint Source Load Reduction*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes a 40% reduction in average summer nonpoint source concentrations. Assumes scenario three point source loads for the Trout Run WWTP and CBOD and NBOD loads from Deer Park Spring Water Company corresponding to a wastewater flow of 36,000 gpd with limitations of BOD_5 = 7 mg/l and TKN = 1 mg/l.

5. *Revised Trout Run WWTP Release Rate Relationship, No Deer Park Spring Water Company CBOD and NBOD Loads, and 10% Nonpoint Source Load Reduction*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes a 10% reduction in average summer nonpoint source concentrations. Assumes scenario three point source loads for the Trout Run WWTP and no wastewater discharge from Deer Park Spring Water Company.

As can be seen from the results for Scenario 3 in Figure 14, the Little Youghiogheny River dissolved oxygen level falls below the minimum average daily dissolved oxygen standard of 6.0 mg/l when the point source loads are reduced without reduction in nonpoint sources.

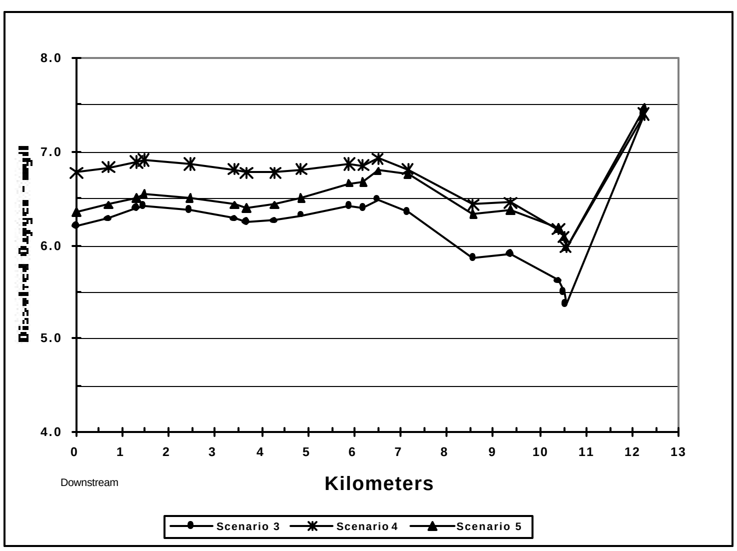

Figure 14: Results of Model Scenario Runs 3, 4 and 5 for Dissolved Oxygen

A 40% reduction of nonpoint source loads and alternative Deer Park Spring Water Company loads were investigated in Scenario 4, since the dissolved oxygen standard of 6.0 mg/l was not met in Scenario 3. As shown in Figure 14, the results of Scenario 4 indicate that the water quality standard for dissolved oxygen is just barely met at the location of the critical dissolved oxygen sag. The dissolved oxygen standard is also just barely met with the assumed Scenario 5 conditions which included the Trout Run loads of Scenario 3, the connection of Deer Park Spring Water Company to the Trout Run WWTP and a 10% reduction in nonpoint source loads.

Final Solution Scenarios

6. *Revised Trout Run WWTP Release Rate Relationship, Reduced Deer Park Spring Water Company CBOD and NBOD Loads, and 40% Nonpoint Source Load Reduction*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes a 40% reduction in average summer nonpoint source concentrations. Assumes scenario three point source loads for the Trout Run WWTP and reduced CBOD and NBOD loads from Deer Park Spring Water Company corresponding to a wastewater flow of 36,000 gpd with the more restrictive limitations of BOD_5 = 5 mg/l and TKN = 1 mg/l.

7. *Revised Trout Run WWTP Release Rate Relationship, No Deer Park Spring Water Company CBOD and NBOD Loads, and 20% Nonpoint Source Load Reduction*: Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes a 20% reduction in average summer nonpoint source concentrations. Assumes scenario three point source loads for the Trout Run WWTP and no wastewater discharge from Deer Park Spring Water Company.

As shown in Figure 15 the results of Scenario 6 indicates a critical sag dissolved oxygen of 6.1 mg/l if the Trout Run WWTP loads of Scenario 3 are assumed with a reduction of the Deer Park Spring Water Company Scenario 3 loads and nonpoint sources are reduced by 40%.

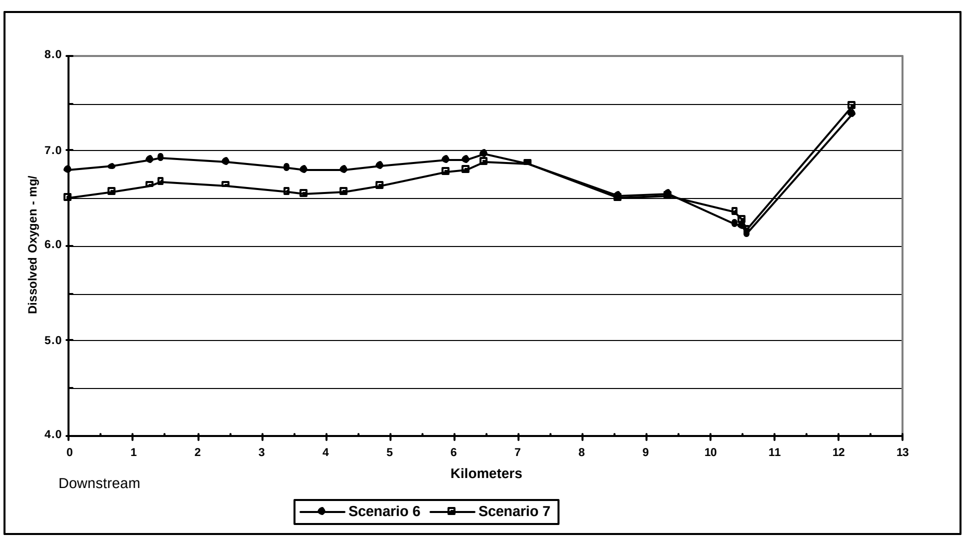

Figure 15: Results of Model Scenario Runs 6 and 7 for Dissolved Oxygen

The results of Scenario 7 indicate a critical dissolved oxygen sag of 6.2 mg/l if the Trout Run WWTP loads of Scenario 3 are assumed, Deer Park Spring Water Company connects to the Trout Run WWTP, and nonpoint sources are reduced by 20%. Scenarios 6 and 7, therefore, provide waste load allocations for a margin of safety and future growth. For further analysis of the model scenario runs, see Appendix A.

6.4 TMDL Loading Cap

The first model scenario showed that the dissolved oxygen standard in the Little Youghiogheny River is violated during low stream flow conditions in the summer, when the water temperatures are warmer and there is less water flowing in the system. The second model run indicated that no dissolved oxygen violations are expected during average summer conditions. Thus, summer low stream flow conditions are the critical period for which a TMDL is necessary. The third, fourth and fifth model scenarios examined the sensitivity of the system to CBOD and NBOD from the point sources and nonpoint sources. The sixth and seventh model scenarios show that the dissolved oxygen standard is met with a margin of safety. Thus, the modeling analyses indicate that, under future projected conditions with the proposed CBOD and NBOD TMDLs, water quality standards are maintained for all flow conditions. The TMDL was calculated for only 7Q10 conditions. Because 7Q10 conditions are only likely to occur during summer months, this TMDL only applies from June 1 to October 31. Due to the uncertainty of the feasibility of the connection of Deer Park Spring Water Company to the Trout Run WWTP model scenario six represents the final TMDL loading scenario. The resultant TMDL loading for CBOD and NBOD is:

CBOD TMDL (June 1 to October 31) **423 *lbs/month***

NBOD TMDL (June 1 to October 31) **413 *lbs/month***

6.5 Load Allocations Between Point Sources and Nonpoint Sources

The point source load allocation for CBOD and NBOD are represented as future monthly summer loads (based on future NPDES permits) from the Trout Run WWTP and Deer Park Spring Water Company, assuming the revised wastewater release rate relationship for the Trout Run WWTP and reduced CBOD and NBOD loads from Deer Park Spring Water Company. The total monthly load allocation was calculated directly from future monthly average permit limits multiplied by 30 days. To implement the point source allocations, permit limits will continue to be expressed as monthly average limits and will be calculated by dividing the allocated TMDL monthly load by 30. To ensure that sampling variability issues are addressed, the limits will also require, as a minimum, the same minimum sampling frequencies which are associated with the current permit limits.

This load allocation is also based on the understanding that, in addition to the revised wastewater release rate relationship for the Trout Run WWTP and reduced CBOD and NBOD loads from Deer

Park Spring Water Company, both facilities will continue to discharge at a minimum daily average dissolved oxygen concentration of no less than 6.0 mg/l. NPDES permit limits for BOD_5 and TKN at the two WWTPs were developed to be protective of dissolved oxygen standards of the Youghiogheny River. The future summer limits at the Trout Run (6/1 – 10/31) are a monthly average of 30 mg/l of BOD_5 and 15 mg/l TKN over a month, in addition to the revised wastewater release rate relationship. The future summer limits at Deer Park Spring Water Company (6/1 – 10/31) are an average of 5.0 mg/l of BOD_5 and 1 mg/l TKN over a month.[1]

The current in-stream concentrations of CBOD from nonpoint sources were estimated to range from 1.5 to 2.25 mg/l and NBOD from 1.47 to 3.1 mg/l. These are representative values obtained from summer sampling and data analysis in the Little Youghiogheny River watershed during the period 1994 to 1997. The CBOD and NBOD concentrations for the final TMDL loading scenario were reduced by 40% and then multiplied by the 7Q10 flow (0.4 cfs) at Station 1, the upper boundary of the model's spatial domain, and by each tributary's 7Q10 flow to produce the nonpoint source load allocations for the TMDL. The low-flow nonpoint source loads are attributable to base-flow contributions. The nonpoint source loads that were assumed in the model account for both "natural" and human-induced components. The load allocation for nonpoint source CBOD is 294 lbs/month and 318 lbs/month for NBOD (91 lbs/month CBOD and 93 lbs/month NBOD at Station 1, 203 lbs/month CBOD and 225 lbs/month NBOD from tributaries). The point source and nonpoint source allocations for CBOD and NBOD are summarized in Table 2. Appendix A provides more detailed computations of these loads. It should be noted that various other point source allocations are feasible within the bounds of the TMDL. The loadings, concentrations, and flow represented in scenarios six and seven are for illustrative purposes only. Actual effluent limits and related permit conditions will be established at the time of permit issuance or renewal and will be based upon conditions present at that time, as reflected in population projections, infrastructure needs, and appropriate concentrations and loadings needed to assure the maintenance of water quality standards.

	Nonpoint Source	**Point Source**
CBOD	**294**	**102**
NBOD	**318**	**95**

Table 2: Point Source and Nonpoint Source Load Allocations (lbs/month)

The nonpoint source load allocations were calculated for 7Q10 flow. This produced a very small load allocation for nonpoint sources. It must be made clear that the above load allocations assume no runoff loads due to rainfall. Scenario 2 showed that when the flows in the river were increased and the Trout Run WWTP was discharging a practical maximum wastewater flow during the summer period, there were no water quality violations within the modeling domain. Figure 13, showed that when the river

[1] A TKN of 1 mg/l was selected based on available information indicating that the Deer Park Spring Water Company effluent ammonia is less than 0.1 mg/l. A slight adjustment in the NBOD and/or CBOD load allocations may be necessary after planned effluent monitoring is completed.

flows were increased and the point and nonpoint source concentrations remained unchanged, the water quality in the river was maintained. The assumption of constant concentrations was an approximation made to double check that the 7Q10 allocations would not violate water quality standards at higher flows. To allocate loads at higher flows a more detailed analysis of the instream concentrations of water quality constituents would have to be performed. This document only allocates loads during 7Q10 conditions. The nonpoint source load allocations may increase above those stated in the TMDL for flows higher than the 7Q10 flow.

6.6 Margin of Safety

The TMDL must include a margin of safety (MOS) in recognition of the uncertainties in our scientific and technical understanding of water quality in natural systems. Specifically, we cannot know the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex natural waterbodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of protection of the environment. Based on EPA guidance, the MOS can be achieved through one of two approaches: (1) reserve a portion of the loading capacity as a separate term in the TMDL, or (2) incorporate the MOS as part of the design conditions for the waste load allocations (WLA) and the load allocations (LA) computations (EPA, April 1991).

The CBOD TMDL for the Little Youghiogheny River employs both of these approaches. The sixth model scenario incorporated a MOS for CBOD at the upper boundary of the model. In the TMDL, 27 lbs/mo. of loading capacity was set aside for a margin of safety for CBOD. The MOS for CBOD of 27 lbs/mo. is based on the MOS for CBOD of 0.9 lbs/day as shown in Table 1 which is the difference in point source CBOD loads between Scenario 4 and Scenario 6.

A set-aside NBOD MOS is not provided. It was concluded that the fourth scenario point and nonpoint source controls for NBOD in conjunction with the CBOD point source reductions of the sixth scenario will provide an acceptable MOS for BOD.

In addition to the set-aside CBOD MOS, the design conditions for the WLA and the LA computations include two implicit MOSs. First, the critical condition of the consecutive 7-day low-flow expected to occur once every 10 years was used to determine the final TMDL load allocations. Because the 7Q10 flow constitutes a worst case scenario, its use builds a conservative assumption into the TMDL. Second, the sixth modeling scenario was done using the NPDES monthly permit limits for the Trout Run WWTP and future NPDES monthly permit limits for Deer Park Spring Water Company for effluent concentrations. The monthly limits are conservative because they represent an upper limit which the WWTPs will strive not to exceed to avoid paying a fine. The MOS can be seen in Table 3.

	Margin of Safety
CBOD	**27**

Table 3: Margin of Safety (lbs/month)

6.7 Summary of Total Maximum Daily Load

The low-flow TMDLs, applicable from June 1 – October 31, for the Little Youghiogheny River, equated with illustrative allocations are:

For CBOD (lbs/month)

TMDL	=	LA	+	WLA	+	MOS
423	=	**294**	+	**102**	+	**27**

For NBOD (lbs/month)

TMDL	=	LA	+	WLA	+	MOS
413	=	**318**	+	**95**	+	**0**

Where:

LA = Load Allocation or Nonpoint Source
WLA = Waste Load Allocation or Point Source
MOS = Margin of Safety

7.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the CBOD and NBOD TMDLs will be achieved and maintained. The certainty of implementation of the CBOD and NBOD reduction plan in this watershed will be enhanced by two specific programs; the Water Quality Improvement Act of 1998 (WQIA), and the EPA-sponsored Clean Water Action Plan of 1998 (CWAP) and through enforceable NPDES permits for the wastewater dischargers in the basin.
Also, Maryland has adopted procedures to assure that future evaluations are conducted for all TMDLs that are established.

Maryland's WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that these nutrient management plans be developed and implemented for nitrogen by 2002. Maryland's CWAP has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in Maryland's Unified Watershed Assessment process are totally coincident with the impaired waters list for 1996 and 1998 approved by EPA. The State has given a high-priority for funding assessment and restoration activities to these watersheds.

Assurances that CBOD and NBOD reductions can be implemented are associated with the same plans that will be relied upon for nutrients. The nutrient management plans implemented through the WQIA will also help to control CBOD and NBOD. Best management practices such as conservation tillage, buffer strips, and treatment of highly erodible land will reduce the amount of CBOD and NBOD entering the stream. Animal waste accounts for large loads of CBOD and NBOD to the stream. Nutrient management plans also address the proper management, storage, and use of animal waste, which will assure a reduction of CBOD and NBOD loads to the stream.

It is reasonable to expect that nonpoint source loads can be reduced during low-flow conditions. While the low-flow loads cannot be partitioned specifically into contributing sources, the sources themselves can be identified. These sources include dissolved forms of the impairing substances from groundwater, the effects of agricultural ditching and animals in the stream, and deposition of nutrients and organic matter to the stream bed from higher flow events. When these sources are controlled in combination, it is reasonable to achieve nonpoint source reductions of the magnitude identified by this TMDL allocation.

Finally, Maryland has recently adopted a five-year watershed cycling strategy to manage its waters. Pursuant to this strategy, the State is divided into five regions, and management activities will cycle through those regions over a five-year period. The cycle begins with intensive monitoring, followed by computer modeling, TMDL development, implementation activities, and follow-up evaluation. The choice of a five-year cycle is motivated by the five-year federal NPDES permit cycle. This continuing cycle ensures that, within five years of establishing a TMDL, intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability. Enforceable NPDES permits that will be written for the wastewater dischargers in this basin provide confidence in assuring implementation of this TMDL. The implementation of point source CBOD and NBOD controls will be executed through the use of NPDES permits. The NPDES permits for the Trout Run WWTP and Deer Park Spring Water Company will require implementation of the TMDL CBOD and NBOD load reductions.

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