Michigan Department of Environmental Quality
Water Bureau
August 2005

Total Maximum Daily Load for Dissolved Oxygen for Paint Creek Washtenaw County, Michigan

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources (NPS) to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources of dissolved oxygen (D.O.) standard nonattainment in Paint Creek near Ypsilanti, and to quantify reductions in oxygen-demanding substances for attainment of the standard. Paint Creek is designated as a coldwater stream with a D.O. standard of 7 milligrams per liter (mg/l) as a minimum.

This TMDL follows the phased approach due to inherent uncertainties in deriving numeric targets and estimating loadings from both point and NPS. Under the phased approach, load allocations (LAs) and waste load allocations (WLAs) are calculated using the best available data and information, recognizing the potential need for additional monitoring data to determine if the load reductions required by the TMDL lead to attainment of WQS. The phased approach provides for the implementation of the TMDL while additional data are collected to reduce uncertainty.

PROBLEM STATEMENT

The Paint Creek TMDL reach is listed in the 2004 Section 303(d) list (Wolf and Wuycheck, 2004) as:

PAINT CREEK WBID#: 061201D
County: Washtenaw Size: 4.6 Miles
Location: R6E, T3S, Sec.12 at Ypsilanti, stations are located just above and just below the detention basin 1600 feet S. of I-94
HUC: 4100001 RF3rchID: 4100001 18
Problem: D.O.; Fish kills, Pathogens (Rule100).
TMDL Year(s): 2005

The basis for the listing was a continuous D.O. survey (multiple readings taken over a 24-hour period for one month) completed in July 1991, that found Paint Creek was not attaining the WQS of 7 mg/l as a daily minimum for D.O. approximately 0.5 miles upstream and immediately downstream of an in-stream detention basin (Figure 1). The D.O. standard was not met during both dry and wet weather conditions, but wet weather conditions appeared to exacerbate the nonattainment (Lamrouex, 1991). Paint Creek upstream of the detention basin is named Upper Paint Creek Drain and is a designated county drain.

Three sites were continuously monitored for D.O., conductivity, pH, and temperature in September 2003 (Brunsen, 2005 draft) (Figure 2). The stations were located 50 feet downstream of the detention basin (STA 102), at Merritt Road two miles downstream of the detention basin, and at Judd Road five miles downstream of the detention basin. The study found STA 102 was not attaining the WQS of 7 mg/l as a daily minimum for D.O. in a coldwater system, primarily in response to wet weather events. The other sites met or exceeded the WQS for D.O. except in response to one wet weather event in excess of 1.5 inches.

The 2003 study demonstrated that improvements in stream D.O. appear to have occurred between the 1991 and 2003 studies. Stream D.O. concentrations in 1991 routinely fell below the 7 mg/l minimum both upstream and downstream of the detention basin during all weather conditions, while the 2003 study showed downstream concentrations immediately below the basin falling below 7 mg/l generally in response to wet weather events. It can be concluded from the 2003 data that the wet weather D.O. exceedances are likely caused by a combination of D.O.-demanding substances (e.g., total suspended solids (TSS)) in the storm water and the oxygen demand generated by conditions within the detention basin (e.g. Sediment Oxygen Demand (SOD)).

This TMDL only addresses the D.O. standard nonattainment portion of Paint Creek. The TMDLs for biota and pathogens will be addressed separately by the Michigan Department of Environmental Quality (MDEQ).

NUMERIC TARGETS

Rule 100 (designated uses) of the Part 4 rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended, requires Paint Creek to be protected for coldwater fish, other indigenous aquatic life and wildlife, agriculture, navigation, industrial water supply, public water supply at the point of intake, partial body contact recreation, and total body contact recreation from May 1 to October 31. The impaired designated use for Paint Creek addressed by this TMDL is coldwater fish. Attainment of the coldwater standard of 7 mg/l as a daily minimum is the target for this TMDL. The D.O. WQS is defined by Rule 64 of the WQS as:

> R 323.1064 Dissolved oxygen in Great Lakes, connecting waters, and inland streams.
> Rule 64. (1) A minimum of 7 milligrams per liter of dissolved oxygen in all Great Lakes and connecting waterways shall be maintained, and, except for inland lakes as prescribed in R 323.1065, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained at all times in all inland waters designated by these rules to be protected for coldwater fish. In all other waters, except for inland lakes as prescribed by R 323.1065, a minimum of 5 milligrams per liter of dissolved oxygen shall be maintained. These standards do not apply for a limited warmwater fishery use subcategory or limited coldwater fishery use subcategory established pursuant to R 323.1100(10) or during those periods when the standards specified in subrule (2) of this rule apply.
>
> (2) Waters of the state which do not meet the standards set forth in subrule (1) of this rule shall be upgraded to meet those standards. For existing point source discharges to these waters, the commission may issue permits pursuant to R 323.2145 which establish schedules to achieve the standards set forth in subrule (1) of this rule. If existing point source dischargers demonstrate to the commission that the dissolved oxygen standards specified in subrule (1) of this rule are not attainable through further feasible and prudent reductions in their discharges or that the diurnal variation between the daily average and daily minimum dissolved oxygen concentrations in those waters exceeds 1 milligram per liter, further reductions in oxygen-consuming substances from

such discharges will not be required, except as necessary to meet the interim standards specified in this subrule, until comprehensive plans to upgrade these waters to the standards specified in subrule (1) of this rule have been approved by the commission and orders, permits, or other actions necessary to implement the approved plans have been issued by the commission. In the interim, all of the following standards apply:

(a) For waters of the state designated for use for coldwater fish, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below a minimum of 6 milligrams per liter at the design flow during the warm weather season in accordance with R 323.1090(3) and (4). At the design flows during other seasonal periods, as provided in R 323.1090(4), a minimum of 7 milligrams per liter shall be maintained. At flows greater than the design flows, dissolved oxygen shall be higher than the respective minimum values specified in this subdivision.

…(3) The commission may cause a comprehensive plan to be prepared to upgrade waters to the standards specified in subrule (1) of this rule taking into consideration all factors affecting dissolved oxygen in these waters and the cost effectiveness of control measures to upgrade these waters and, after notice and hearing, approve the plan. After notice and hearing, the commission may amend a comprehensive plan for cause. In undertaking the comprehensive planning effort the commission shall provide for and encourage participation by interested and impacted persons in the affected area. Persons directly or indirectly discharging substances which contribute towards these waters not meeting the standards specified in subrule (1) of this rule may be required after notice and order to provide necessary information to assist in the development or amendment of the comprehensive plan. Upon notice and order, permit, or other action of the commission, persons directly or indirectly or indirectly discharging substances which contribute toward these waters not meeting the standards specified in subrule (1) of this rule shall take the necessary actions consistent with the approved comprehensive plan to control these discharges to upgrade these waters to the standards specified in subrule (1) of this rule.

This TMDL will be considered the Comprehensive Plan for this water body referred to in R 323.1064(3) of the WQS.

SOURCE ASSESSMENT

The listed reach for Paint Creek is approximately 4.6 miles in the vicinity of Ypsilanti in Washtenaw County. The municipalities making up the largest portion of the TMDL watershed are Ypsilanti (52 percent) and Pittsfield Townships (38 percent) (Table 1).

Table 1. Distribution of land for each municipality in the Paint Creek TMDL reach (Purdue, 2005).

Municipality	County	Square Miles	Percent
Ypsilanti Township	Washtenaw	2.9	52
Pittsfield Township	Washtenaw	2.1	38
City of Ypsilanti	Washtenaw	0.42	8
City of Ann Arbor	Washtenaw	0.1	2
TOTAL		**5.52**	**100**

Land use categories within this rapidly urbanizing watershed are presented in Table 2. Potential NPS of pollutants were evaluated based on these data.

Table 2. Upper Paint Creek Drain basin land use categories as percentages (Purdue, 2005).

Land Use Category	Percent of Total
Water*	1.6
Commercial**	8.9
Agriculture*	8.9
High Density - Residential**	7.0
Low Density - Residential**	35.0
Grass/Pasture*	17.5
Forest*	18.0
Industrial**	3.1

* Considered in the LA
** Considered in the WLA

There are no Combined Sewer Overflows or Concentrated Animal Feeding Operations in the Paint Creek watershed.

There are 14 National Pollutant Discharge Elimination System (NPDES)-permitted discharges to Paint Creek in the TMDL reach (Table 3).

Table 3. NPDES-permitted discharges to the upper Paint Creek watershed (NMS, 2005).

Permit Name	Permit Number	Permit Type	Receiving Water
Industrial Storm Water:			
Corrigan Moving Systems	MIS510181	Industrial General	Paint Creek
Doan Companies-Ypsilanti	MIS510459	Industrial General	Stony Creek
Doan Construction-Ypsilanti	MIS510178	Industrial General	Paint Creek
Engineered Plastic Products	MIS510588	Industrial General	Paint Creek
Huron Advertising Company	MIS510180	Industrial General	Paint Creek
London Aggregate-Ypsilanti	MIS510576	Industrial General	Paint Creek
Pollard Banknote Ltd-Ypsilanti	MIS510497	Industrial General	Paint Creek
United Parcel Service	MIS410015	Industrial General	Paint Creek
MS4 Storm Water:			
Ypsilanti MS4-Washtenaw	MIS040015	Jurisdiction General	Paint Creek
Ypsilanti Township MS4	MIG610037	Watershed General	Paint Creek
Pittsfield Township MS4	MIS040021	Jurisdiction General	Paint Creek
Washtenaw CDC MS4	MIG610039	Watershed General	Paint Creek
Washtenaw CRC MS4	MIG610314	Watershed General	Paint Creek
MDOT – Statewide MS4	MI0057364	Statewide Individual Permit	Paint Creek

Runoff and storm water discharges from the city of Ypsilanti, and urbanized areas in the vicinity, flow to Upper Paint Creek Drain and then to the in-line detention basin. The detention basin, initially completed in 1974, consists of a 44-acre wetland surrounded by a levee with an emergency spillway. A retrofit in 1996 added a sediment forebay with flow diversion infrastructure and a micropool at the outlet (Wojcik, 2005). The Paint Creek Drain flows through the detention basin to the micropool on the south end and is discharged to Paint Creek through a 36-inch outfall pipe fitted with an adjustable gate valve. The outfall gate is set to release all

dry weather flow. The basin retains the runoff during a rain event for controlled release after allowing the suspended material to settle. The detention basin, depending on the amount of runoff received, is usually emptied within a 24-hour period.

The water impounded in the detention basin during wet weather events covers the decomposing organic material resulting in an oxygen demand. The opportunity for reaeration in the basin is limited due to reduced velocity in the basin. The combined result of the contribution of suspended solids during wet weather events and the quiescent conditions in the basin during and following wet weather events is an oxygen deficit in the water exiting the basin to Paint Creek.

LINKAGE ANALYSIS

The oxygen deficit causing the D.O. nonattainment status in Paint Creek can be attributed primarily to wet weather events and the associated TSS in the discharges and runoff to Paint Creek. As described under the Source Assessment section, solids deposited in the detention basin during wet weather events exert an oxygen demand on the overlying water. This reaction is known as SOD. Potential sources of TSS include both point and NPS. Low atmospheric reaeration, as described below, further contributes to D.O. nonattainment in Paint Creek.

Yearly point and nonpoint loadings to Paint Creek for TSS, as calculated using the L-THIA model (Purdue, 2005), are shown in Table 4.

Table 4. Estimated Upper Paint Creek Drain TSS loads, pounds/year.

Parameter	Point Source Loadings (from land use data)*	Nonpoint Source Loadings (from land use data)**	Total Loadings
TSS	97,769	21,259	119,028

* These figures include the commercial, industrial, and high and low density residential development land use categories described in Table 2 as it is assumed these categories would fall under the Municipal Separate Storm Sewer System (MS4) permit categories.

** These figures include the water, agricultural, grass/pasture, and forest categories described in Table 2.

SOD

Solids present in the water column of a flowing water body can settle to the stream bed, forming layers of sediments with variable depths and compositions. Organic solids on the surface layer of the substrate in direct contact with the water can undergo aerobic decomposition. This decomposition causes diffusion of D.O. from the water column into the sediment layer in a process called SOD, depleting D.O. levels in the overlying river water. High levels of TSS in a water body can contribute to high SOD rates if the solids settle to the bottom and decompose.

The solids in the Paint Creek system settle out of the water column within the detention basin, which was designed to attenuate excessive flows from the city of Ypsilanti. During a storm event, the detention basin fills with storm water, covering the settled solids creating an oxygen demand in Paint Creek.

Atmospheric Reaeration

Because much of the water in Paint Creek is of groundwater origin and therefore low in D.O., atmospheric reaeration is a major source of D.O. in this system. The rate at which oxygen diffuses across the air-water interface depends on the water surface area exposed to the

atmosphere through flow turbulence. Turbulence is increased by either an increase in flow velocity or by obstructions breaking up flow lines.

Indicators of low atmospheric reaeration include low in-stream velocity and a lack of substrate to create turbulence. Flow measurements and field observations made by MDEQ staff in 2003, were used to assess the atmospheric reaeration capabilities in Paint Creek (Brunsen, 2005 draft). The detention basin is designed to slow the flow of water to allow for the settling of solids. In addition, the stream channel within and upstream of the detention basin has been straightened and there are no obstacles such as rooted plants, woody debris, or stone to increase the flow turbulence. Reaeration in this type of stream flow regime is low. Reaeration is most efficient in riffle zones where the flow is forced around or over obstacles such as stone or woody debris. The characteristics observed in the detention basin and Upper Paint Creek Drain contribute to the reduced ability of Paint Creek to reaerate low D.O. levels resulting from storm water runoff and discharges and the effects of the detention basin.

TMDL DEVELOPMENT

The TMDL represents the maximum loading of TSS that can be assimilated by the water body while still achieving the D.O. standard of 7 mg/l as a daily minimum for a coldwater system as stated in the Numeric Targets section. This TMDL is based on reducing TSS to Paint Creek and increasing the amount of oxygen in the water column using natural reaeration processes. Reaeration is needed to offset the natural oxygen demand from the decomposition of organic material found in the detention basin during wet weather events.

The TMDL development also defines the environmental conditions that will be used when defining allowable levels. The “critical condition” is defined as the set of conditions which, if controls are designed to protect, attainment of the WQS is achieved under all other conditions. The critical condition for Paint Creek occurs during wet weather events. Even relatively minor wet weather events produce D.O. exceedances in the discharge from the detention basin, e.g., a 0.2-inch rainfall on September 15-16, 2003, resulted in a minimum D.O. of 6.5 mg/l (Figure 2). Storm water from the Upper Paint Creek Drain enters the detention basin at a low velocity to facilitate settling of sediment. Flow in excess of the hydraulic capacity of the outfall pipe to Paint Creek is temporarily stored for later discharge and submerges organic material accumulated in the detention basin. The critical condition occurs as natural decomposition of organic material in the detention basin exerts an oxygen demand and reaeration is minimized due to quiescent conditions. The TMDL is developed to address the results of the critical condition.

The once in ten-year wet weather event level for the Paint Creek region in Michigan, using the Steel Formula coefficients, is 1.5-inches (Lindeberg, 1998). TSS loading reductions for Paint Creek were determined based on the observed D.O. concentrations following a September 23, 2003, rain event greater than the ten-year recurrence storm of 1.5 inches (actual storm total was 1.65-inches) when D.O. was depressed to a minimum of 4.6 mg/l. Therefore, the proposed loading reductions are expected to be protective of all rain events up to and including the once in ten-year storm event of 1.5 inches.

ALLOCATIONS

TMDLs are comprised of the sum of individual WLAs for point sources and LAs for NPS and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for NPS, and the MOS.

A completely mixed reactor (CMR) model was used to determine the reduction of oxygen demanding pollutants required to reach the target D.O. standard of 7 mg/l as a daily minimum in Paint Creek. The CMR model was developed by the Michigan Department of Natural Resources (now MDEQ) based on Thomann's Finite Cell Approach (Argiroff, 1990). This model uses a steady state and time-variable approach to calculate the effects of pollutant loads on a standing body of water based on the mass balance equations for decay, SOD, and reaeration. The model was calibrated and verified using data collected in September 2003 (DO, stage, rainfall) and construction drawings (slope, volume, topography) provided by the Washtenaw County Drain Commission (CDC) under both dry and wet weather conditions. Predictive simulations were run with the calibrated and verified model to determine the load reductions required to meet the WQS of 7 mg/l as a daily minimum in Paint Creek under the design conditions.

This phased-approach D.O. TMDL targets a 50 percent reduction in TSS loads to Paint Creek from point sources and NPS. The 50 percent TSS load reduction was chosen due to the results of D.O. modeling using the data collected during the 1.65-inch rainfall event observed during the September 2003 study. The model indicates that oxygen demanding pollutants contributed to the creek and detention basin should be reduced 50 percent to ensure WQS are met within the impaired reach of Paint Creek and Upper Paint Creek Drain.

WLA

The WLA for the impaired reach of the Paint Creek watershed (Table 5) is allocated to the NPDES permitted facilities identified in Table 3. These NPDES permits are assumed to address the commercial, industrial, and high and low density residential development land uses described in Table 2. Discharges covered under the MS4 and industrial storm water permits in the watershed will be allocated 42,850 pounds of the TSS load after subtracting the MOS.

LA

TSS inputs resulting from land use-related sediment loads will be targets for reduction in this TMDL. These land uses include agricultural, grass/pasture, and forest. These sources in the watershed will be allocated 10,713 pounds of the TSS load after subtracting the MOS.

MOS

The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into the TMDL analysis thorough conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an explicit MOS of 10 percent, or 5,951 pounds of TSS. The use of 10 percent as an MOS reflects the uncertainty between the modeled allowable loadings and actual loadings that will assure attainment of WQS.

Table 5. Annual TSS load source allocations and numeric targets for Paint Creek.

Water Body	Current Annual TSS	Load Capacity TSS Numeric Target	WLA Annual TSS Load	LA Annual TSS	MOS (lbs)

	Load (lbs)	(lbs)	(lbs)	Load (lbs)	
Industrial/Municipal Storm Water Permitted Outfalls*	97,769	42,850	42,850	-	-
Other Land Use Related Sources**	21,259	10,713	-	10,713	-
Paint Creek Total Annual Loads	119,028	59,514	42,850	10,713	5,951

* These figures include the commercial, industrial, and high and low density residential development land use categories described in Table 2 as it is assumed these categories would fall under the MS4 and industrial permit categories.

** These figures include the water, agricultural, grass/pasture, and forest categories described in Table 2.

SEASONALITY

The summer and early fall seasons represent the critical conditions for D.O. attainment in Paint Creek. The inability to meet the coldwater daily minimum D.O. standard of 7 mg/l is greatest in the summer and early fall periods due to elevated air and water temperatures, which require a higher degree of saturation to maintain the 7 mg/l daily minimum D.O. concentration. Therefore, the reduction in TSS loads and associated oxygen demanding substances based on observed summer conditions should result in decreased D.O. diurnal variations and attainment of WQS in the Paint Creek during all seasons.

MONITORING

Monitoring of Paint Creek to determine its attainment status will be conducted following: (1) the installation of best management practices (BMPs) in the watershed to reduce sources of TSS loadings, and (2) a remedy to the effects of the detention basin on D.O. following wet weather events, e.g., installation of a riffle zone or some other form of reaeration.

REASONABLE ASSURANCE ACTIVITIES

There are several measures in the NPDES permits identified in Table 3 that will contribute to attaining WQS in the affected reaches of the Paint Creek watershed.

The discharges authorized by industrial storm water general permits identified in Table 3 require that if there is a TMDL established by the MDEQ for the receiving water that restricts a material that could impair or degrade water quality, then the required storm water pollution prevention plan shall identify the level of control for those materials necessary to comply with the TMDL and an estimate of the current annual load of those materials via storm water discharges to the receiving stream.

The Ypsilanti MS4-Washtenaw and Pittsfield Township MS4 jurisdictional permits require that the permittee implement BMPs to comply with six minimum measures and any corrective action plans for TMDLs. The six minimum measures include education and outreach, public involvement and participation, illicit discharge elimination, post construction storm water management for new development and redevelopment projects, construction storm water runoff control, and pollution prevention/good housekeeping.

The Ypsilanti Township, Washtenaw CDC, and Washtenaw County Road Commission (CRC) MS4 watershed permits and certificates of coverage require that the permittees submit to the MDEQ approvable illicit discharge elimination plans, public education plans, public participation

plans, and storm water pollution prevention initiatives (SWPPI). The objective of a SWPPI is to reduce the discharge of pollutants to the maximum extent practicable. Specifically, the SWPPI requires, at a minimum, an evaluation and implementation of pollution prevention and good housekeeping practices, a description of storm water structural controls to reduce pollutants, development and implementation of a storm water management program for areas of development, and a requirement to implement BMPs to prevent or minimize water quality impacts.

Eastern Michigan University acquired a Clean Water Act Section 319 grant in 2003, to develop a WMP for the Stony Creek watershed, which includes Paint Creek. The WMP was completed in May 2005, and was submitted to the MDEQ for approval. The objectives of the plan were to identify, document, and prioritize all NPS within the watershed. The MDEQ approved the plan on June 7, 2005, with respect to criteria specified in the Administrative Rules for the Clean Michigan Initiative NPS Pollution Control Grants promulgated pursuant to Part 88, Water Pollution and Environmental Protection Act, of the NREPA, effective October 27, 1999. As an outgrowth of the Stony Creek watershed planning project, a watershed council for Stony Creek is under formation.

The Michigan Department of Transportation (MDOT) statewide permit requires the permittee to reduce the discharge of pollutants to the maximum extent practicable and employ BMPs to comply with TMDL requirements.

Lastly, discussions are underway with the MDEQ, Water Bureau, district staff and the Washtenaw CDC to determine what projects are still pending in the detention basin and what future modifications can be made to the detention basin to insure that Paint Creek will attain the WQS of 7 mg/l as a daily minimum in the future.

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Figure 1. Paint Creek Watershed

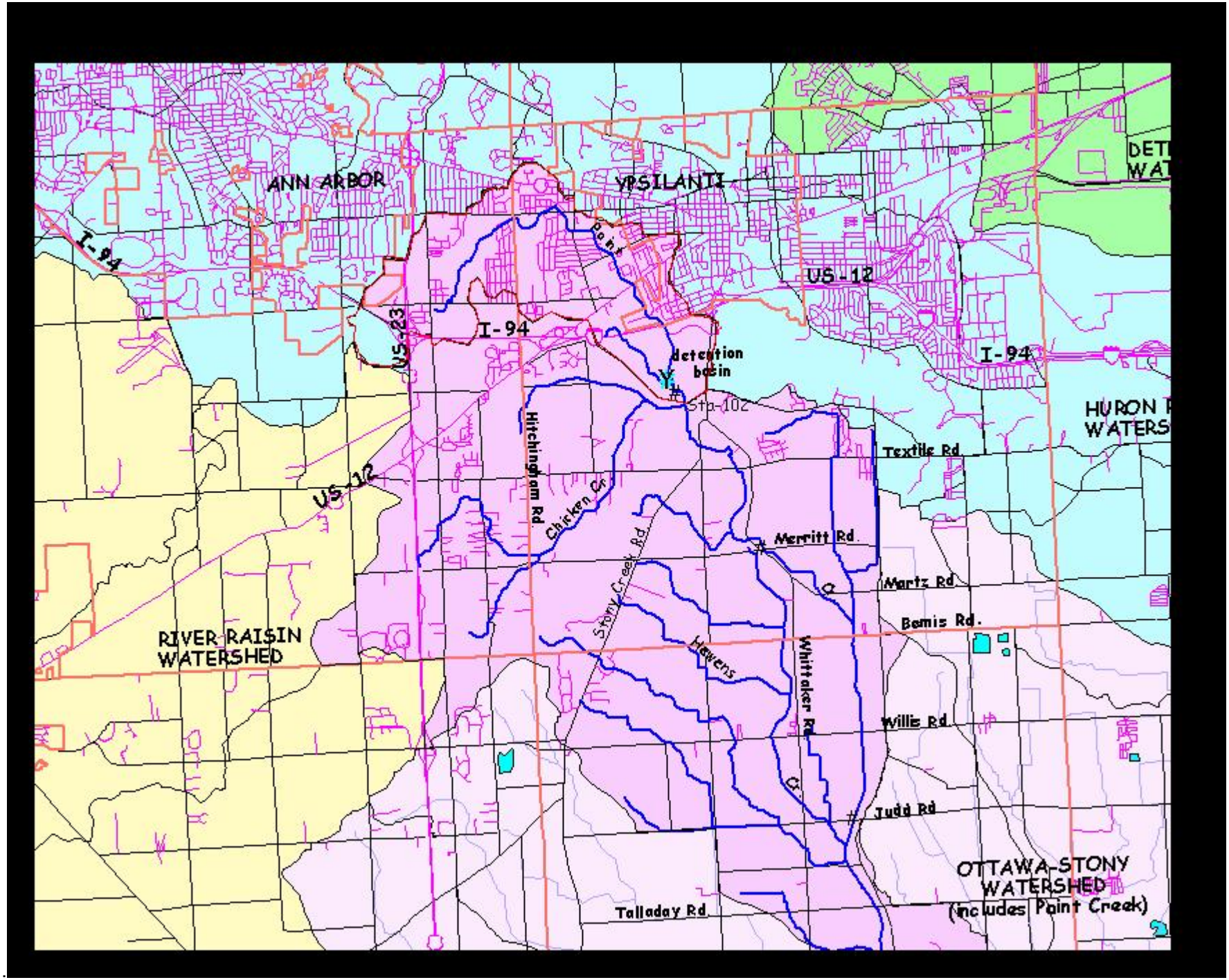

FIGURE 2
PAINT CREEK MINIMUM DISSOLVED OXYGEN