Appendix B
Wasteload Assimilative Capacity Analysis

WASTELOAD ASSIMILATIVE CAPACITY (WAC) ANALYSIS FOR LEGACY RIDGE

1.0 Introduction

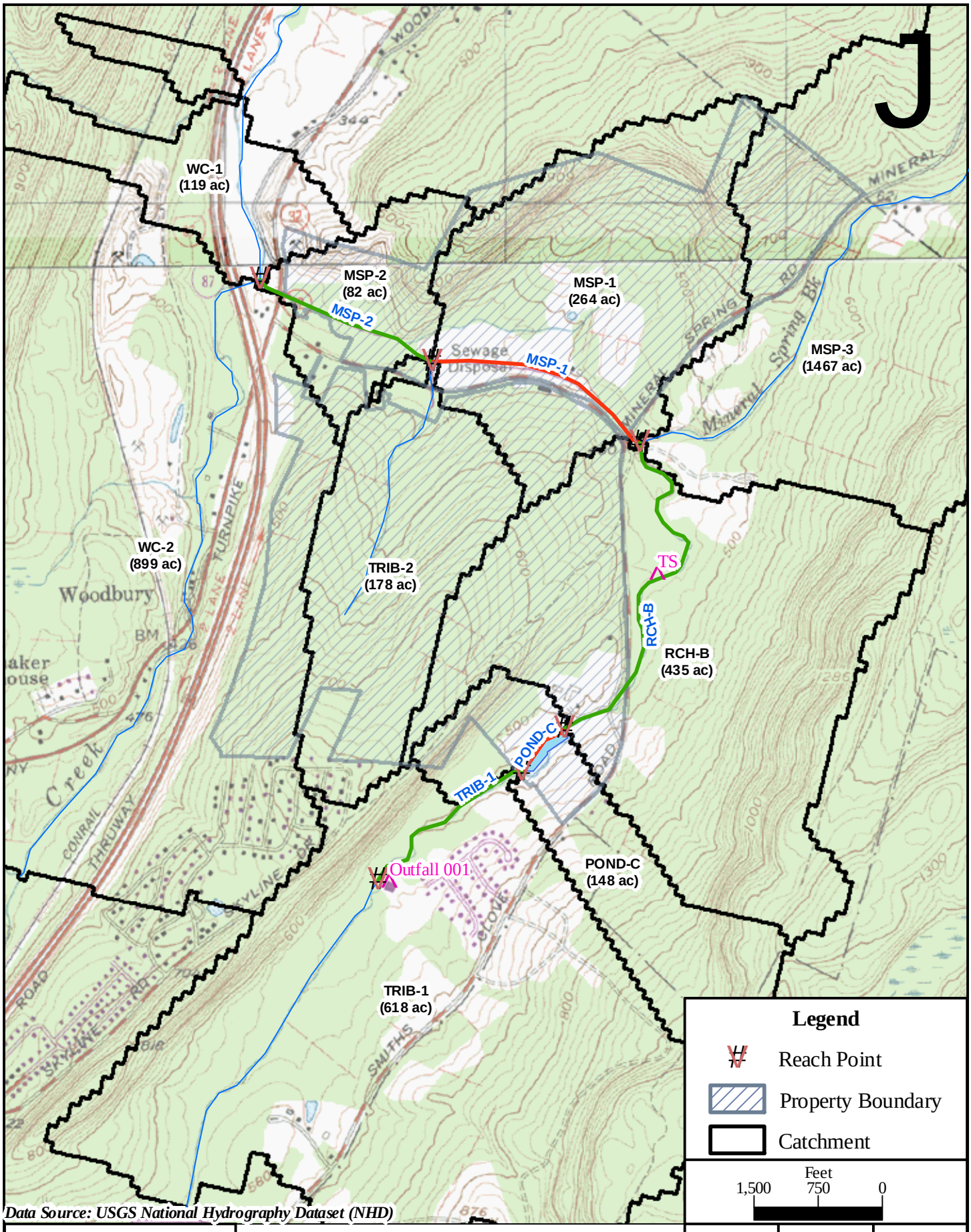
The Legacy Ridge development will generate wastewater that will be treated at the Valley Forge WWTP. The treatment plant will be completely rebuilt to an advanced facility designed to treat a design flow of 225,000 GPD, which was determined based on existing permit requirements, proposed flow from Legacy Ridge development, and 15% additional capacity to improve the plant's reliability and to serve future connections, if so desired by the Town.

The objective of the WAC analysis is to evaluate the effects of the proposed WWTP on water quality and determine the effluent limits that will result in compliance with water quality standards. The effluent limits will then determine the level of treatment required for the Valley Forge WWTP. The water quality constituents of concern are dissolved oxygen and ammonia, which have numerical criteria as specified in the Surface Water and Groundwater Classifications and Standards New York State Codes, Rules and Regulations Title 6, Chapter X Parts 700-706 (NYSDEC 1999).

The methodology for the WAC analysis is described in New York State Department of Environmental Conservation (NYSDEC) Division of Water Technical and Operational Guidance Series (TOGS 1.3.1D) TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY-BASED EFFLUENT LIMITS AMENDMENT - WASTE ASSIMILATION CAPACITY DETERMINATIONS FOR ISOLATED WASTEWATER DISCHARGES IN FRESH WATER STREAMS.

The upgraded WWTP will discharge to unnamed Tributary 1 of Mineral Springs Brook (water index number H-89-7-4-1). Mineral Springs Brook flows into Woodbury Creek in the Town of Woodbury and Woodbury Creek flows into Moodna Creek. Tributary 1 of Mineral Springs Brook is an intermittent stream, which means that it has no natural flow during the critical conditions appropriate for a WAC analysis. (The flow specified in the TOGS is referred to as the minimum average 7-day flow with a 10-year recurrence period, which in our case is less than 0.1 cfs.) Therefore, the only flow in the tributary during critical conditions is the WWTP flow of 225,000 GPD. Although the flow from the WWTP will vary from day to day and year to year, the WAC analysis is based on the full 225,000 GPD design flow, as a conservative assumption.

The ammonia criterion is addressed first in the WAC analysis. As ammonia exerts a nitrogenous biochemical oxygen demand (BOD), it is included along with the carbonaceous BOD in the analysis of the dissolved oxygen (DO). Section 2 summarizes the effluent limit for ammonia and Section 3 describes the development of the effluent limits for CBOD and DO. Another constituent that will be a discharge permit limit is phosphorus as explained in Section 4.



Data Source: USGS National Hydrography Dataset (NHD)

HDR | LMS

WAC ANALYSIS
LEGACY RIDGE

Job No.	Date	Figure No.
201916	05/30/07	x

FILE: \\PRL-SRV2\Projects\201916_MILLENNIUM HOMES\0063000_MILLHOMES-SB-LEGACY RIDGE FEIS\Temporary\GIS\map_docs\mxd\WAC_Analysis.mxd

2.0 Ammonia

The unnamed tributary into which the Valley Forge WWTP discharges is Class C at the point of discharge. NYSDEC criteria are specified in terms of the un-ionized ammonia and vary according to pH and temperature. According to TOGS 1.3.1, the water temperature for non-trout waters is 25^{o}C. A neutral pH of 7.0 is generally assumed when site-specific stream data are not available. For a temperature of 25^{o}C and a pH of 7.0, the in-stream unionized ammonia criterion is 8.3 ug/l. The percent of the total ammonia concentration that is un-ionized at this temperature and pH is 0.57%. Therefore, the total ammonia concentration, which includes the ionized and un-ionized fractions, shall not exceed 1.5 mg/l in the receiving water at the point of discharge. The WWTP discharge permit limit for total ammonia is 1.5 mg/l.

3.0 Dissolved Oxygen

The Streeter-Phelps equation is used to model the DO in a stream. The equation describes the sinks of DO attributable to the degradation of CBOD and NBOD and the source of DO attributable to atmospheric reaeration. The model is applied by first segmenting the receiving water into reaches that have similar physical characteristics such as water depth and velocity. Model parameters are then evaluated for each reach. The model was programmed in an Excel spreadsheet by HDR|LMS and validated for a "test case". The wasteload or discharge data that are set as input to the model are:

- Flow
- $CBOD_5$ (5-day CBOD)
- Total Ammonia
- Organic Nitrogen
- Dissolved Oxygen
- Temperature

The WWTP flow (225,000 GPD), total ammonia (1.5 mg/l), CBOD5 (5 mg/l) and temperature (25^{o}C) were constant in all model runs whereas the organic nitrogen and DO were varied to determine effluent limits that would comply with the water quality standards for DO. NBOD is the sum of the organic nitrogen and total ammonia concentrations multiplied by a factor of 4.5 as nitrification takes 4.5 mg of oxygen to react 1 mg of ammonia and the organic nitrogen is hydrolyzed into ammonia.

3.1 Water Quality Classifications and Model Reaches

The unnamed tributary at the point where the WWTP discharges is Class C, which requires a daily average DO of 5 mg/l and a minimum at any time of 4 mg/l. The pond, which is 0.43 mile downstream of the WWTP outfall is also Class C. The classification changes to Class B downstream of the pond. NYSDEC found trout spawning in the unnamed Tributary 1 approximately 1.07 miles downstream of the WWTP outfall. As NYSDEC is required to protect water quality for this observed use, Class C trout spawning (TS) criteria are applied starting at this point and continuing downstream to Mineral Spring Brook and its confluence with

Woodbury Creek. The minimum DO for Class C(TS) is 7.0 mg/l and the maximum temperature is 24 ^{o}C.

Five reaches are designated to capture the physical features of the streams and model the processes affecting DO (Figure 1). The first reach (TRIB-1) starts at Outfall 001 as shown on the map (Figure 1). The pond is modeled as a separate reach (POND-C) because it is deeper than the stream on either side of it. The third reach (RCH-B) covers the Class B (current classification pre-dates TS finding) portion of the unnamed tributary from the pond to the confluence with Mineral Spring Brook (MSB). The red star labeled "TS" in Figure 1 shows the approximate location where NYSDEC found trout spawning and the DO criteria changes at this point. Two reaches (MSP-1 and MSP-2) are designated to model MSB.

USGS' National Hydrography Dataset (NHD) was accessed using Geographical Information System (GIS) software to estimate the reach lengths and the stream elevations at the upstream and downstream boundaries of each reach. The length, elevation and slope of the reaches are shown in Table 1.

Table 1 Model Reach Length and Slope Data

					Elevation (ft)		
WAC_RCH	RCH_ID	RCHLENFT	Length (mi)	Cum Len (mi)	Upstrm	Dwnstrm	Slope
TRIB-1	1	2258	0.428	0.428	506.16	494.49	0.00517
POND-C	2	736	0.139	0.567	494.49	491.24	0.00442
RCH-B	3	4553	0.862	1.429	491.24	416.55	0.01640
MSP-1	4	2769	0.524	1.954	416.55	356.32	0.02176
MSP-2	5	2241	0.424	2.378	356.32	337.73	0.00829
Total			2.378				

3.2 Travel Time

The velocity of pool and riffle streams is estimated using the Boning equation which relates velocity to the flow and slope of the reach.

$V=0.38Q^{0.40}S^{0.20}$ (Boning, 1974)

Where:

V is velocity (ft/s)
Q is flow (cu ft/s)
S is slope (ft/ft)

The travel time is calculated as the reach length divided by the velocity as shown in Table 2. It takes a total of 34.3 hours for effluent to travel 2.4 miles from the outfall to the confluence with Woodbury Creek, which is the downstream boundary of the model.

Table 2 Model Reach Travel Time Data

Reach	Length (mi)	Vel (fps)	Travel Time (hr)
TRIB-1	0.428	0.087	7.19
TSPOND-C	0.139	0.084	2.43
RCH-B	0.862	0.110	11.55
MSP-1	0.524	0.116	6.64
MSP-2	0.424	0.096	6.52
Total	2.378		34.31

3.3 Reaction Rate Coefficients

The decay of CBOD and NBOD is modeled as a first order reaction with a deoxygenation rate coefficient referred to as K1. The deoxygenation rate coefficient is generally higher in shallow streams than in deeper ponds (USEPA 1985). The value of K1 at 20^{o}C was estimated to be 1.2 /day in all reaches except the pond where the value was estimated to be 0.3 /day. The K1 is adjusted to the temperature of the reach using the Arhenius equation with theta equal to 1.04 for CBOD and 1.06 for NBOD (USEPA 1985).

Reaeration rate coefficients (K2) were calculated using Owen's equation for the stream reaches and O'Connor-Dobbins equation for the pond reach (USEPA 1985). The assimilation factor is defined as the ratio of K2:K1 and is indicative of the capacity of a reach to decay BOD while maintaining a given DO concentration through reaeration. The K2 is adjusted to the temperature of the reach using the Arhenius equation with theta equal to 1.02 (USEPA 1985). Model reaction rates are shown in Table 3.

Table 3 Model Reach Reaeration and Deoxygenation Rate Coefficients at 20 ^{o}C and Assimilation Factor

Reach	Vel (fps)	Depth (ft)	K2 Formula	K2 (1/day)	K1 (1/day)	Assimilation Factor f
TRIB-1	0.0873	0.80	Owens	6.43	1.2	5.36
TSPOND-C	0.0842	2.00	O'Connor-Dobbins	1.32	0.3	4.41
RCH-B	0.1095	0.64	Owens	11.40	1.2	9.50
MSP-1	0.1159	0.60	Owens	13.14	1.2	10.95
MSP-2	0.0955	0.73	Owens	8.08	1.2	6.73

3.4 Model Results – DO profile

The model was run iteratively for different organic nitrogen and DO concentrations in the Valley Forge WWTP effluent to calculate DO in the unnamed tributary and MSB. The DO decreases within the first two model reaches and then the DO increases downstream of the pond. Calculated DO is compared with the water quality criteria for Class C, B and C(TS) waters as they apply to the streams modeled. The point that controls the wasteload allocation is in Reach RCH-B where the minimum DO criterion changes from 4 to 7 mg/l, which is 1.07 miles downstream of the WWTP outfall (Figure 2). The discharge concentrations for the Valley Forge WWTP that yield compliance with the water quality criteria are:

- Organic Nitrogen =1.0 mg/l
- Dissolved Oxygen = 7.0 mg/l
- $CBOD_5$ (5-day CBOD) = 5 mg/l
- Total Ammonia =1.5 mg/l

4.0 Permit Limit for Other Water Quality Constituents

4.1 Phosphorus

There will be a SPDES limit on total phosphorus as there are P-waters (ponds, lakes) downstream of the WWTP discharge. The total phosphorus limit will be 0.5 mg/l according to Mr. Chuck St. Lucia of NYSDEC Bureau of Monitoring and Assessment.

4.2 Other Permit Limits

Effluent discharges to streams where little or no streamflow is available for dilution are subject to intermittent stream effluent limits (TOGS 1.3.1). The limit on total suspended solids is 10 mg/l as a maximum daily concentration. Fecal and/or total coliform concentration may be limited for discharge to a Class C water. Chlorine residual may be limited if chlorination is used for disinfection. A range in pH is normally specified appropriate for the receiving water. Other pollutants or whole effluent toxicity (WET) testing may be included in the monitoring requirements in the SPDES permit.

Permit limits may be less stringent in the winter season than the summer because chemical properties and reaction rates vary with temperature. Total ammonia concentrations in NYSDEC's water quality standards are higher at a water temperature of 15 ^{o}C than 25 ^{o}C. Water can hold more dissolved oxygen in a saturated state at a colder temperature than a higher temperature. Reaction rates decrease as temperature decreases. These seasonal variations provide the technical basis for the NYSDEC to set seasonal permit limits that will comply with water quality standards throughout the year.

Table 3 summarizes the anticipated SPDES permit limits that will be imposed by the NYSDEC.

Table 3 Anticipated SPDES Permit Limits

Parameter	Limitation (mg/l, unless otherwise noted)
flow (GPD)	225,000*
BOD5	5
BOD5 (% removal)	85
TSS	10
TSS (% removal)	85
total ammonia - summer	1.5
total ammonia - winter	2.2
temperature (^{O}C)	25
dissolved oxygen	7
total phosphorus	0.5
residual chlorine	**
fecal coliform – average (#/100 mL)	200
fecal coliform – maximum (#/100mL)	400
pH – minimum (S.U.)	6.5
pH – maximum (S.U.)	8.5

* SPDES permits typically limit flows on the basis of 30-day average.

** No limit anticipated (disinfection with ultraviolet light, rather than chlorine).

References

Boning, Charles W., 1974. Generalization of Stream Travel Rates and Dispersion Characteristics from Time-Of-Travel Measurements. Jour. Research U.S. Geol. Survey Vol. 2, No. 4, July-Aug 1974, p 495-499.

U.S. Environmental Protection Agency. 1985. Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition) EPA/600/3-85/040.

Figure 2 D.O. Profile - WAC for Valley Forge WWTP Expansion and Upgrade Legacy Ridge

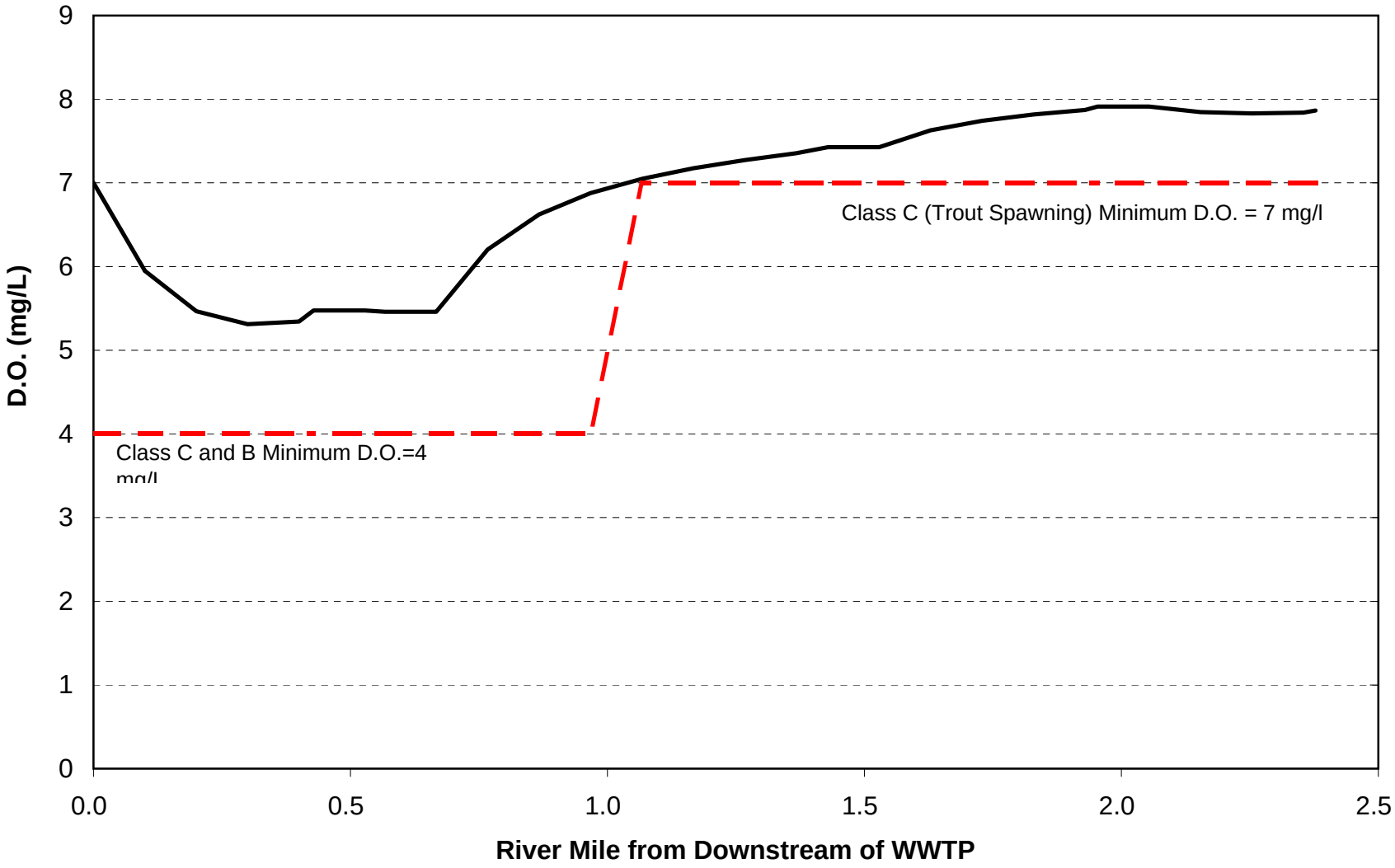


Figure 2 D.O. Profile - WAC for Valley Forge WWTP Expansion and Upgrade Legacy Ridge