LOW FLOW STREAMS CONDITIONS IN GEORGIA

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ABSTRACT: In Georgia, there are low flow streams that receive high quality domestic treated wastewater due to the increasing urban development. Municipal and industrial water pollution control plants (WPCP) often request a waste load allocation (WLA) evaluation for a discharge of treated wastewater to low flow surface waters, under the National Pollutant Discharge Elimination Systems (NPDES) permit of the Clean Water Act[1]. A response to a WLA request requires an examination of whether or not there is enough water, in the context of 7Q10 and the physical, chemical and biological factors of the receiving stream. Other factors evaluated include the existing assimilative capacity, permitted upstream and downstream discharges, (305(b) and 303(d) lists, the overall headwater areas, critical temperature, total maximum daily loads issues, (TMDL) and the hydrology of the watershed. This paper discusses some of the considerations and challenges associated with determining whether a given stream, with low flow conditions, can assimilate the requested organic and nutrient waste loads.

The significance of this discussion is to assist industries and municipalities in factoring in the physical and chemical instream constraints in their planning for urban development and sitting of point source discharges. Information to consider includes low flow streams conditions in the context of 7Q10, and temperature used in developing water quality models for waste load allocation. This presentation will show how the headwater 7Q10, and the critical temperatures vary in the physiographic river basin regions of the mountains, Piedmont, upper coastal and lower coastal plains. Low flow conditions in the coastal plains present greater modeling challenges than in the mountains and Piedmont regions in terms of allocating the amount of organic and nutrient loads in treated waste water discharges to low flow stream.

INTRODUCTION

Waste Load Allocation (WLA) of organic and nutrients for water quality protection serves as a tool for documenting municipal and industrial effluents into streams and rivers. (Tables 1, 2 and 3). WLA information should not be perceived as barrier to urban development. There are inadequate stream flow records for most low flows streams in coastal areas. In Georgia, because of low (7Q10) flows impact, effluent wastewater is so highly treated that the wastewater quality appear to be that of a high quality domestic wastewater and better than the receiving stream in most instances.

Table 1.0 below shows the recommended typical effluent concentrations from most of the municipal treatment plants. Due to low 7Q10 flows, Table 1.0 is no longer applicable to many receiving streams particularly below the “Fall Line” of Georgia

Table 1.0 Typical Effluent Concentration From Municipal Treatment Plants

Treatment Process	CBOD (Mg/l)		NH_3 (mg/l)	NBOD (mg/l)		DO (mg/l)
	Range	Typical	Range	Range	Typical	Typical
Trickling Filter	30 - 100	45	15 - 40	60-180	80	2
Activated Sludge(AS)	20 - 70	30	15 - 40	60 - 80	80	5
AS/Nitrification	7 - 30	15	1 - 5	5 - 25	15	5
AS/Nitrification/Denitrification	7 - 30	15	0 - 3	0 - 15	5	5
AS/Nitrification/Denitrification/Alum	2 - 15	7	0 - 3	0 - 15	5	5
AS/Nitrif/Denitrif/Activ Carbon/Alum	1 - 8	5	0 - 3	0 - 15	5	5

Under normal situations, domestic plants would be discharging wastewater treated to secondary treatment standards of five-day biochemical oxygen demand (BOD_5) of 30 mg/l, ammonia (NH_3) of 17.4 mg/l, and dissolved oxygen (D.O.) of 5.0 mg/l for activated sludge treatment plants. This is not happening due to in most part the low 7Q10 flows.

As demonstrated in Tables 2 and 3, generally speaking, the notion of use of rivers and streams to dispose of effluent wastewater was based on the principals of: (1) There would be sufficient surface water flow available to assimilate the waste. (2) The water quality criteria will be maintained and protected during drought condition.

This paper describes some of the dilemmas and pertinent issues factored in the calculation of instream-dissolved oxygen for the allocation of waste, carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). The 7Q10 flow was not intended to define adequate base flows for aquatic habitat requirement or other instream uses. The purpose of 7Q10 flows was to

[1] Federal Water Pollution Control Act, popularly known as the Clean Water Act 1972 Amendments

protect aquatic life downstream from point source discharges during expected low flow conditions. (James W. Evans and Russell H. England et al).

Wasteload allocations (wla) above the fall line

TABLE 2.0 below, shows typical WLA's standards or criteria for the low 7Q10 flows located above the "Fall Line". Georgia has a diverse watershed. This includes the underground water and surface waters with varying physical, chemical, biological, geology and hydrology characteristics. For example, in Table 2.0, the surface waters above the "*Fall Line*" were found to be generally characterized by low 7Q10 flows and the groundwater is used very little for drinking water. Therefore, the source of effluent wastewater in most part is the surface water due to the geology and hydrology of river basins found above the "Fall Line".

Unlike in the Table 2 below, for the most part below the "Fall Line", the source of the effluent wastewater discharged to the streams is from ground water. Groundwater is the main source of drinking water for the most part below the "Fall Line". This explains why most low 7Q10 flows receive a higher amount of effluent wastewater than those streams above the Fall Line. WLA's for CBOD, NBOD and DO are catalogued in the river basins as shown in Tables 2 and 3 below.

Wasteload allocations in North Georgia

Effluent wastewater discharged in streams above the Fall Line includes the Metropolitan North Georgia Watershed Planning District. Based on the low 7Q10 flows , the receiving streams are predominately effluent wastestreams and are of high quality effluent. WLA considers special criteria standards or criteria for the protection of surface water quality. Urban development is the deriving force and it is likely to alter stream flows. The WLA recognized that growth may be a threat to water resources and ecological systems and so an adjustment has been made in WLA to protect water quality.

WASTE LOAD ALLOCATION PROCESS

In examining Tables 2 and 3, there has been significant increase in the request for point source discharges in the last five years. The process starts with a letter from the municipals or industry for a WLA evaluation as shown below. The Georgia Environmental Protection Division (GAEPD) engineers review the request from a WPCP's and issue a typical internal request letter, which reads as follows:

Example

"Please find attached request from the City of Griffin for a WLA from their existing Cabin Creek WPCP for an increased discharge to 2.1 MGD and 2.5 MGD of treated domestic wastewater into Cabin Creek in the Okmulgee River basin and for a WLA from their existing Potato Creek WPCP for an increased discharge to 2.5 MGD and 3.0 MGD of treated domestic wastewater into Potato Creek in the Flint River basin. A map showing the plants and discharge locations is attached. Please contact me if additional information is necessary".

Applications of 7Q10 flows[2]

Low flow information is widely used in the evaluation of the capacity of streams to permit surface water withdrawals, wasteload allocations and total maximum daily loads (TMDL) assessment. The U.S. Geological Survey has developed the techniques used in estimating 7Q10 profiles. As shown in Figure 1.0, low-flows are characteristics from continuous-record gagging stations. Fitting log-Pearson Type III distribution to low data developed the flows.

A dilemma arises when the estimation of 7Q10 for WLA is not readily available, as for ungaged reaches of streams. In those cases, low-flow rates for ungaged reaches of streams are estimated, with some confidence, from concurrent at gagged sites on the same stream. The yield flow (7Q10 flow divided by the drainage area) of a gagged station is calculated. The drainage area of the ungaged reaches multiplies the yield-factor derived from the gagged stream.

The product is the 7Q10 flow of the ungaged site used in the WLA development. The low 7Q10 flows in Tables 2 and 3 are mainly derived from ungaged stations method described above. The streams described in Tables 2 and 3 were mostly ungaged streams.

Table 2.0 Effects of Low 7Q10 on WLA Above Fall Line

EFFECTS OF LOW FLOWS ON WASTE LOAD ALLOCATIONS

LOW FLOW (< 2 CFS) 7Q10 IMPACT ON WASTE LOAD ALLOCATIONS

ABOVE THE FALL LINE MOUNTAINS AND PIEDMONTS PHYSIOGRAPHIC REGIONS OF GEORGIA

River Basins Receiving Streams/ Creeks	County	Upstream Area (mi^2)	Temp. (^oC)	BOD_5 (mg/l)	NH_3 (mg/l)	DO (mg/l)	7Q10 (cfs)	Effluent Flows (MGD)
Upper Chattahoochee								
Nickajack Creek	Cobb	1.8	26	10	2.3	6	0.3	1.5
Suwanee Creek	Gwinnett	12	24	18	2.8	6	0.6	2
Suwanee Creek	Gwinnett	12	25	2.9	0.3	6	0.2	4
Anneewakee Creek	Douglas	15	26	10	2	5	1.8	3.7
Upper Flint River								
Brantly Creek	Terrell	8	25	10	2	6	0.8	2.5
Pigeon Creek	Meriwether	17	29	7.8	2	5	1.2	2
Potato Creek	Spalding	10	25	9	0.7	6	0.6	3
White Oak Creek	Coweta	30	25	5	1	6	2	2
Ocmulgee								
Bush Creek	Henry	1.3	25	6	1.3	6	0.1	1.5
Panther Creek	Clayton	24	25	3.6	0.5	6	0.6	10
Sweetwater Creek	Gwinnett	46	27	10	2	6	1.8	4.5

[2] Carter, R.F, Thomson, M.T., Pulman, U.S. Geological Survey Water-Resources Investigations Report 83-4158

Jackson Creek	Gwinnett	26	10	10	2	6	1.2	3
Big Cotton Indian Creek	Henry	31	25	2.6	0.6	6	1.7	3.5
Upper Oconee								
Jackson Creek	Jackson	0.3	25	30	3.4	6	0.1	0.25
Little River	Walton	0.5	25	23	2	6	0.1	0.65
Wolf Creek	Jones	2	27	1.2	0.2	6	0.1	5
Indian Creek	Jackson	2	25	5	2	6	0.2	0.5
Barber Creek	Barrow	11	27	5	1.2	6	1	1.5
Upper Savannah								
Unawatti Creek	Franklin	8	27	20	5	6	1.7	1.3
Whites Creek	McDuffie	1	24	15	3.1	6	0	2.5
Rocky Creek	Wilkes	3	26	15	1.4	6	0.1	4
Crawford Creek	Columbia	4	25	12	1.2	5	0	1.5
Coosa								
Rubes Creek	Cheroke	12	26	7	2	6	0.9	1.25
Stone Branch	Whitfield	4	25	10	2	5	0.1	0.25
Town Creek	Walker	15	24	9	1.4	6	1.4	5
Weaver Creek	Paulding	2	24	10	2.5	6	0.1	2

7Q10 FLOW CALCULATIONS

The hydrologic information of the receiving stream is used to establish minimum flow and water level requirement for assimilative capacity of the waste. (U.S. Geological Survey Water –Resources Investigation Report 96-4308). Adequate data addressing the effects of low 7Q10 flows and climatic changes such as temperatures and precipitation on streams below the fall line are not readily available. There are few 7Q10 stream flows statistics data available for streams and rivers found in Table 2 and 3 discussed.

As stated earlier, the U.S. Geological Survey (USGS) has developed methods that can be used to estimate characteristics flows based on measured hydrologic and climate basin characteristics. The U.S. Geological Survey developed regression equations to estimate peak flows, annual, monthly mean and median streamflows at gagged and ungaged streams with drainage areas from one to 1,650 square miles. (Paker, 1978). The new equation took advantage of 25 years of additional flow data and basin characteristics calculated with a geographic information system (GIS) (Dudley, 2004). The example below is extracted Yellow River Low-Flow Frequency Analysis) (Annual, Monthly, Seasonal 7Q10 Flows) (See Figure 1)

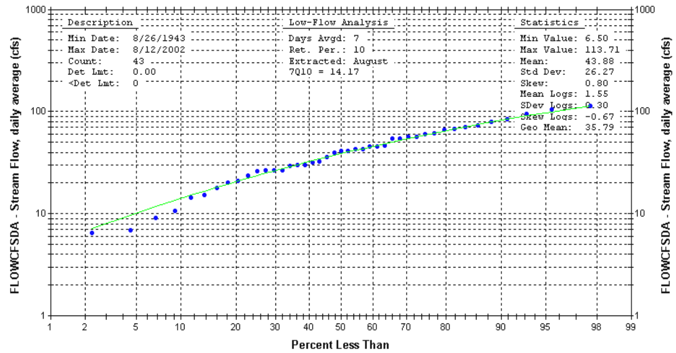


Figure 1.0 Regression Equation Graph to Estimate 7Q10 flows

Table 3.0: Effects of Low 7Q10 Flows Below the Fall Lines

EFFECTS OF LOW FLOWS ON WASTE LOAD ALLOCATIONS

LOW FLOW (< 2 CFS) 7Q10 IMPACT ON WASTE LOAD ALLOCATIONS

ABOVE THE FALL LINE MOUNTAINS AND PIEDMONTS Physiographic Regions of Georgia

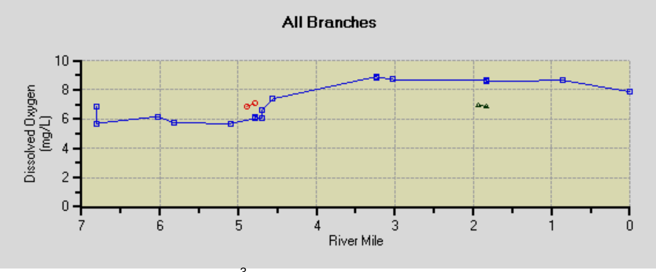
River Basins Receiving Streams / Creeks	County	Up-stream Area (mi^2)	Temp. (^0C)	BOD_5 (mg/l)	NH_3 (mg/l)	DO (mg/l)	7Q10 (cfs)	Effluent Flows (MGD)
Lower Flint								
Fish Pond Drain	Seminole	16	28	16	0.3	6	0	0.4
Gum Creek	Crips	21	25	11	2	6	1	5
Spring Creek	Macon	8	24	20	0	6	0.4	2
Baptist Branch	Early	2.9	28	17	1	6	0	2
Perry County	Early	0.4	26	10	0.6	6	0	0.25
Lower Ocmulgee								
Sugar Creek	Dodge	11	23	10	2	6	0.4	1.8
Bay Creek	Peach	2.9	26	15	5	6	0.4	2.2
Tanyard Branch	Washing-ton	1.7	26	11	0.5	6	0.1	3
Lower Savannah								
Whites Creek	McDuffie	0.97	24	15	3.1	6	0.01	2.5
Buck Creek	Screven	3	27	30	2	5	0	4
McCoys Creek	Richmond	3.3	25	30	Monitor	5	0.3	4
Lower Ogechee								
Little Lotts Creek	Bulloch	9	27	10	2	6	0.03	10
Peacock Creek	Liberty	30	30	1	0.6	6	0.3	4
Taylors Creek Tributary	Liberty	1.5	30	5	1	6	0	7
Suwannee River								
New River	Tift	10	29	10	2	6	0.1	8
Mud Creek	Lowndes	40	26	10	1.5	6	0.8	3.2
Saint Augustine	Chatham	2	27	5	3	5	0	3
Satilla / Saint Mary's								
North River	Camden	3	31	25	2.9	2	2.2	1.8
Trib. To. 17 MI River	Coffee	2	27	12	1	6	0	6
Dunbar Creek	Glyton	1	28	15	2	5	0.1	3
Ochlockonee	Thomas	6.5	28	10	2	6	0.02	6

Assimilative Capacity Calculation

Georgia uses a computer program called Georgia dissolved oxygen sag (GADOSAG) to calculate: (1) the Minimum Daily Available Assimilative Capacity (MDAAC) and (2) the Allowable Maximum Daily Load (AMDL). The MDAAC is a measure of the capacity of the stream to assimilate waste loads. (Georgia Modeling Procedures Manual 1978). The Georgia DOSAG model is a modified version of the Streeter-Phelps equation.

The Georgia DOSAG model input consists of (a) headwater input (b) number of reaches, (c) elevation, benthic demand, temperature, incremental loss, and etc. The GADOSAG calculates the dissolved oxygen sag curve below waste load discharge point of the stream segment. (Georgia DOSAG User's Manual). The model results from the GADOSAG are used to estimate basis for issuance of permits limiting wastewater discharges into the receiving surface waters of Georgia. (GA DOSAG User's Manual)

Figure 2.0: Typical GADOSAG Effects of CBOD & NBOD



In Figure 1, the August 7Q10[3] is 14.17 cubic feet per second (cfs).

[3] 7Q10 simply defined as the lowest average flow for seven consecutive days, which statistically occurs once every ten years. (USGS Georgia District)

CONCLUSION

This preliminary examination of the impact of low 7Q10 flows on the organic, nutrients and dissolved oxygen wasteload allocation for assimilative capacity of a stream indicates the need for high quality effluent wastewater discharges to surface water. (Figure 2.0). For most of the low 7Q10 flows below the "Fall Line" high quality effluent such as those presented in Table 3 have the potential in contributing and improving the ecology and aquatic lives of surface waters in coastal areas of Georgia, where groundwater is the source of wastewater and 7Q10 is zero. Similarly, above the "Fall Line" as urban development continues in North Georgia, high quality effluents would significantly become the major source of surface water.

If you are in the watershed area with low 7Q10 flows, then two viable discharge alternatives exist. (1) If you wish to discharge to a low 7Q10 flow stream high quality treated wastewater would be required. On the other hand, if you do not wish to discharge to low 7Q10 flow stream, the other choice would be to land application systems where high treated wastewater would not be required. The use of high quality effluent wastewater as a source of drinking water also requires further studies in some river basins of Georgia where the source of drinking water is scarce. In the future, there may be a potential for water and wastewater trading as urban sprawl continues and meeting the need for adequate source of drinking water becomes problematic.

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