Safe Yield in the Upper Saluda Watershed – Is It Really Safe?

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ABSTRACT. Safe yield (SY) is generally presumed to be the upper threshold of water available for withdrawal without causing adverse impacts. United States Geological Survey (USGS) gaging station data in the Upper Saluda Watershed were used to compare calculated regulatory SY levels to measured streamflow. Regulatory SY levels were determined in accordance with the South Carolina Surface Water Withdrawal, Permitting, Use and Reporting Act and implementing regulations. The percentage of average daily streamflow readings that occurred below regulatory SY levels was determined for each gaging station location and ranged from 50 to 68 percent. These data indicate that SY flow, as defined by the South Carolina law, is not present in streams and rivers for more than half the time. Therefore, use of this regulatory definition of SY as an upper threshold for registration and permitting decisions could lead to over-allocation and impairment of South Carolina's surface water resources.

INTRODUCTION

Safe yield is a term used to describe the amount of water theoretically available for withdrawal at a given location in a watershed. It has commonly been used in water resources planning and management as a measure of the reliability of surface and groundwater supply systems for human use. South Carolina's regulatory approach to this concept has led to conflicting definitions that risk over-allocation of available surface water in our state (River Network, 2016). This paper compares the regulatory definition of SY as applied in the Upper Saluda River Watershed to measured flows to demonstrate the fallacy of SY as defined in the South Carolina water withdrawal law.

BACKGROUND

The concept of SY originated from water supply engineering studies that define SY as the maximum quantity of water that can be supplied from a surface water reservoir during a critical drought period. In groundwater applications, safe yield has traditionally been defined as the attainment and maintenance of a long-term balance between the amount of groundwater withdrawn annually and the annual amount of natural recharge. More recently, this concept of SY has been widely discredited as it ignores discharge from the system, and has therefore led to continued groundwater depletion, stream dewatering, and loss of wetland and riparian ecosystems (Sophocleous, 1997).

SY has evolved towards the idea of sustainable yield, to mean the amount of water that can be withdrawn regularly and permanently without dangerous depletion of the storage reserve or without producing undesired effects. Undesired effects can include long-term declines of groundwater levels or ecological impacts to surface waters and wetlands. Other definitions of SY have also considered additional risk factors such as economic feasibility, degradation of water quality, and water rights (Alley and Leake, 2004).

Climate variability can also have significant bearing on long-term SY. If droughts become more frequent or severe, previous estimates of SY may no longer be reliable and may need to be revised according to the appropriately selected critical drought period. Osborne et al. (2009) demonstrated this for a reservoir system in the Upstate of South Carolina where the observed downward trend and 10% drop of SY from previous estimates was attributed to the recent drought conditions.

Similarly, watershed land use changes can affect SY, particularly near urbanized areas where the high degree of impervious surface area impedes recharge to surface and groundwater systems. This effect has been observed in the highly urbanized Upper Reedy River Watershed where studies show an increasing trend in peak flow and a downward trend in baseflow (North Wind, 2007).

SY is not static, but fluctuates with changing hydrologic and land use conditions. It may be constrained by other variables such as storage characteristics of the source and source facilities, upstream and downstream withdrawals, and minimum in-stream flow requirements to maintain biological, chemical, and physical integrity of the stream/river.

Regulatory definitions of SY are variable from state to state. The South Carolina Surface Water Withdrawal, Permitting, Use and Reporting Act (herein after referred to as the SC water withdrawal law, or the SC law), generally defines SY as the amount of water available for withdrawal from a particular surface water source in excess of the minimum instream flow or minimum water level for that surface water source.[1] It is determined, according to the SC law, by comparing the natural and artificial replenishment of the surface water to existing or planned consumptive and nonconsumptive uses.

SY is more explicitly defined in the implementing regulations and conflicts with the SC water withdrawal law. For withdrawals from stream segments not influenced by impoundments, SY is defined by the regulation as eighty percent of mean annual daily flow. For withdrawals from impoundments, SY is the maximum amount that would not cause a reservoir water level to drop below its minimum water level or to be able to release the lowest minimum flow specified in the license. For withdrawals from stream segments materially influenced by impoundments, SY is the difference between mean annual daily flow and the lowest designated flow in the license specified for normal conditions. SY must be considered when determining whether a proposed withdrawal is reasonable, with the exception of agricultural withdrawals[2].

The following hydrologic analysis was conducted to determine the relative frequency of occurrence of regulatory SY levels in the Upper Saluda Watershed.

UPPER SALUDA WATERSHED CASE STUDY

The Upper Saluda Watershed, as defined for this study, is situated largely in the Upper Piedmont region of South Carolina with headwaters in the Blue Ridge region near the South Carolina-North Carolina border. It includes both the Saluda and Reedy River watersheds and terminates at Lake Greenwood.

The Saluda River originates from its headwaters in the South Saluda River above Table Rock Reservoir, in the Middle Saluda River near Caesar's Head and Jones Gap, and in the North Saluda River above Poinsett Reservoir. The three branches join above Saluda Lake near Greenville and flow south to the Piedmont dam and the Upper and Lower Pelzer dams, then southeast to the Lee Steam Plant Weir, Holiday dam, and finally to Lake Greenwood. The Reedy River Watershed is a major tributary of the Saluda River. Originating near Travelers Rest, the Reedy flows southeast through the City of Greenville to the Lake Conestee, Cedar Falls, Boyd Mill Pond, and finally to Lake Greenwood.

Data from thirteen active and historic USGS gaging stations in the Upper Saluda Watershed were used to calculate and compare regulatory SY levels, as defined by the regulation, to recorded flow levels. Mean annual flow (MAF), median flow, SY, and the percentage of average daily streamflow readings below computed SY levels was determined for each gaging station location. Two gaging station sites, Saluda River near Williamston (2163001) and Saluda River near Ware Shoals (2163500), are located immediately below licensed impoundments. Alternate SY levels were calculated for these sites using methods outlined in the regulation for stream segments materially influenced by impoundments.

The period of record for gaged sites varied between four and 76 years. Five stations had greater than 30 years of flow data. Drainage areas vary between 1.6 and 580 square miles and mean annual flows range from 3 to 953 cfs (Table 1).

The percentage of average daily streamflow readings below corresponding computed SY levels ranged from 50 to 68 percent across sites. Measured median flows were lower than calculated regulatory SY levels for ten of the thirteen gaging station sites (77%). Three sites had similar median and SY levels (Table 1). Figure 1 shows measured streamflow data in comparison to the computed SY level for a long-term gaging station. For this site, average daily flows were below SY levels for 50 percent of days across the period of record.

DISCUSSION

The SC water withdrawal law and implementing regulations effectively establish numeric flow standards for surface waters across the state. Analysis of historic streamflow data in the Upper Saluda Watershed shows that SY flow levels as defined by the SC law are not present in streams and rivers for more than half of the time. These findings indicate that the standard for SY is flawed. Its use as upper threshold for registration and permitting decisions could lead to over-allocation, hydrologic impairment, and depletion of South Carolina's surface water resources by overestimating the amount of water that can be safely withdrawn without adversely impacting ecological health and sustainability, water quality, and flows needed to support designated uses.

Accordingly, SY should be redefined in the regulations in a way that is consistent with the law, that realistically represents the amount of water that would be available for withdrawal (without causing adverse water

[1] Agricultural uses are not subject to minimum flow requirements under the SC law.
[2] Agricultural uses are presumed reasonable and users may withdraw up to the SY level.

Table 1. Safe yield flows in the Upper Saluda Watershed compared to average daily flows.

Location	Drainage Area	Period of Record	Mean Annual Flow (MAF)	Median Flow	Safe Yield (SY)	% Avg Daily Flow < SY
	mi^2	yrs	cfs	cfs	cfs	%
South Saluda near Cleveland (2162290)	18	8.5	32	12	25	**68**
Middle Saluda near Cleveland (2162350)	21	26	58	45	47	**52**
Saluda near Greenville (2162500)	298	63	609	489	487	**50**
North Saluda near Slater (21623975)	44	4.4	49	30	40	**63**
Hamilton Ck near Easley (2162525)	1.6	5.7	3	2	2	**50**
Grove Ck near Piedmont (21630967)	19	14	22	13	17	**64**
Saluda near Pelzer (2163000)	405	42	783	608	626	**52**
Saluda near Williamston (2163001)[1]	414	21	671	487	537	**55**
Saluda near Ware Shoals (2163500)[2]	580	76	953	717	762	**53**
Reedy near Greenville (2164000)	49	74	79	50	63	**63**
Reedy above Fork Shoals (216410)	110	22	194	134	155	**61**
Reedy near Waterloo (21650905)	251	11	265	201	212	**54**
Rabon near Gray Court (2165200)	30	49	33	22	26	**58**

[1] Below Lower Pelzer dam; alternate SY calculated as MAF - FERC minimum flow (140) = 531 cfs; 54% flows < SY)
[2] Below Ware Shoals dam; alternate SY calculated as MAF - FERC minimum flows (200-800) = 753-153 cfs; 2-53% flows < SY)

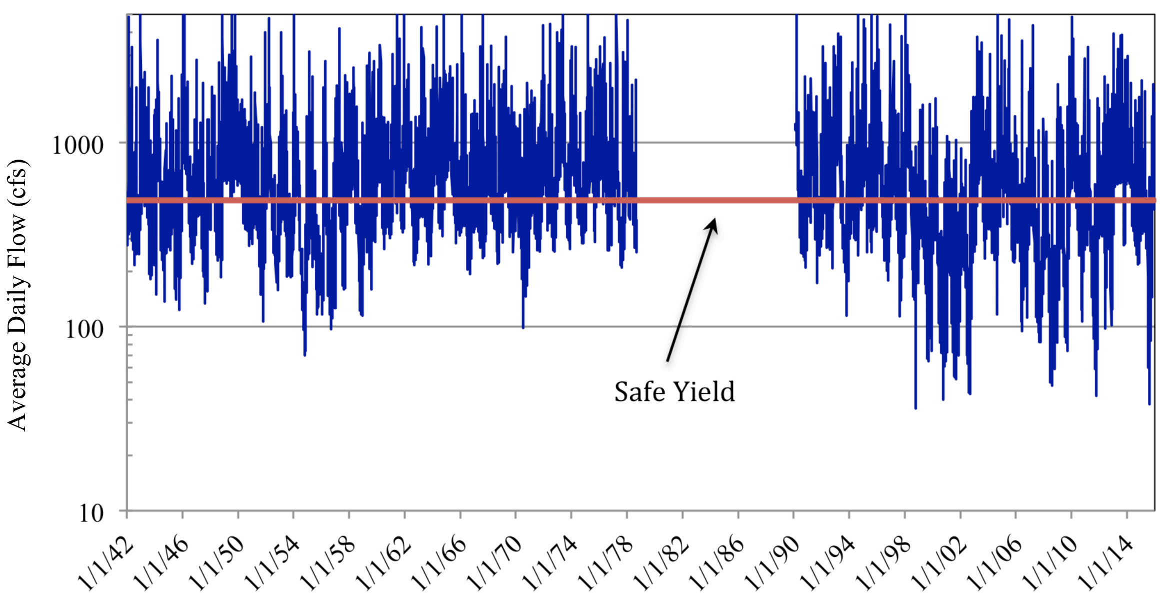

Figure 1. Measured streamflow vs regulatory safe yield in the Saluda River near Greenville, SC.

quality and ecological impacts) during the duration of an appropriately selected critical drought period, that maintains the variability of the natural flow regime, and that can be updated as climatic and land use conditions change.

The regulations also stipulate that the amount of water not returned to a water source from a water withdrawal point should not cause other than minimal changes in water quantity and should not "significantly reduce the safe yield at the withdrawal point." Because SY is based on the entire period of record, large changes in a flow regime may not become statistically significant (apparent) for many years. Therefore, criteria for determining the level of significance in the change in SY that constitutes other than a minimal change in water quantity should be clearly established in the regulation.

There is considerable concern regarding agricultural registrations. The SC law allows water withdrawers not subject to minimum flows[3] (i.e. agricultural users) to decrease streamflows to zero or near zero for significant periods of time throughout the growing season. Through the law, these uses are presumed reasonable, are not subject to minimum flow requirements, are permitted to withdraw water quantities up to the SY level with no legal restrictions, and are granted such right to do so in perpetuity without public notice and without requirements for drought contingency plans.

Furthermore, because industrial-scale agricultural uses, like all agricultural uses, can withdraw all of the water up to the defined regulatory SY level, they have the potential to significantly impact flow in streams and rivers because of their need for larger amounts of water for consumptive use. Therefore, they should be subject to the same thresholds and requirements for permitting, public notice, minimum flows, and drought contingency planning as other industrial uses.

Until it is changed, the fallacy of SY as currently defined in the SC law and implementing regulations should be factored into all permitting and registration decisions, including decisions regarding the test for reasonable use.

[3] The SC law and regulations establish minimum instream flow requirements based on a percentage of mean annual daily flow that varies seasonally, but not according to physiographic region, as was recommended by the South Carolina Water Plan: http://www.dnr.sc.gov/water/hydro/HydroPubs/assessment/SCWA_Ch_9.pdf

LITERATURE CITED

Alley, W.M. and S.A. Leake, 2004. "The journey from safe yield to sustainability." *Ground Water* 42(1):12-16.

North Wind, Inc., 2007. "Factors contributing to flooding in the Upper Reedy River Watershed." Archive Site for the Saluda-Reedy Watershed Consortium Reports. http://www.saludareedy.org/resInDepth.html, Access Date 10.2.16.

River Network, 2016. "Protecting and restoring flows in our southeastern rivers: a synthesis of state policies for water security and sustainability." written by Katherine Baer and April Ingle, River Network.

Sophocleous, M.,1997. "Managing Water Resources Systems: Why "safe yield" is not sustainable." *Ground Water* 35(4): 561.