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Minimum Flow Rules for South Carolina Rivers

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Letter Report

to

Senator Daniel B. Verdin III
Chairman
Committee on Agriculture and Natural Resources
South Carolina Senate

from

South Carolina Independent Science Review Panel for Minimum Instream Flows

Center for Humans and Nature

January 15, 2009

Center for Humans and Nature
South Carolina Lowcountry
School of the Environment
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Senator Daniel B. Verdin III
Chairman
Committee on Agriculture and Natural Resources
South Carolina Senate
404 Gressette Building
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January 15, 2009

Dear Senator Verdin,

We were most pleased to have Senator Ronnie W. Cromer attend the meeting of the "South Carolina Independent Science Review Panel for Minimum Instream Flows" held on December 3, 2008 in Columbia; we hope he has briefed you on the discussions at that meeting. This report outlining our conclusions is the document we promised to provide your Committee. We present our independent assessment of each of the proposed minimum flow rules that are likely to be considered by you and your committee in the near future, and provide some general principles from a science perspective that might assist in decision making. We do not advocate for any one rule. Rather, we provide science background and then evaluate each proposed rule, pointing out the likely results of the adoption of each. Our comments on minimum flow rules are of a general nature not specific to any one rule.

The letter contains the following sections:

1. Executive Summary
2. Preamble and Statement of Purpose
3. Process
4. Economic and Environmental Significance of Low Flows
5. Experiences with Minimum Flow Rules
6. Assessment of Proposed Rules
7. General Comments on Minimum Flow Rules
8. Conclusions

The letter concludes with a list of its authors. For further information, contact either the sponsor of this effort, Dr. Bruce Coull (Director, Center for Humans and Nature) at bccoull@environ.sc.edu) or the lead author, Dr. Will Graf (Professor, University of South Carolina) at graf@sc.edu.

1. Executive Summary

On December 3, 2008, a group of more than 20 independent volunteer scientists and engineers from universities in South Carolina met in Columbia to take testimony and to assess the likely outcomes of adopting various rules for minimum instream flows in the state. The group recognized that water is a highly variable resource that fluctuates through time and varies across space. Water resources are susceptible to change as a result of the adjustments to land cover resulting from land management, urbanization, and population growth. The group concluded the rule that is ultimately adopted should be able to account for seasonal (within years) and annual (from one year to another) variability as well as geographic variation in river and stream behavior, be simple and easily understood and used, and that it be scientifically valid. The group also concluded that the economic and environmental needs of the state are not well served by a minimum flow rule that is a single number or one that relies solely on annual data. An effective rule is likely to be one defined by a formula that produces minimum flow requirements that vary seasonally and geographically. The group recognizes that a key component of any successful rule is the selection of a reference time period, because climate conditions vary across different multi-year time periods.

2. Preamble and Statement of Purpose

Surface water and stream flow are finite, strategic resources in South Carolina. Continued population growth and economic development along with water required to sustain valued environmental resources and services are likely to create surface water demands that exceed supply, particularly during low flow periods. Furthermore, the ecosystem needs variable flows for sustainability, while an increasing human population needs consistent and generally increasing flows. It is therefore prudent that the State define a minimum stream flow rule to specify the amount of water that must be left in river and stream channels to maintain economic and environmental integrity.

In 2008 the South Carolina legislature considered a proposed state law defining minimum instream flows for the state's rivers. When flows are at or below these minimums, water withdrawals would be curtailed. After considerable debate the legislation did not emerge from committee consideration. In 2009 there will likely be a renewed effort to establish minimum stream flow legislation because minimum flows play an important role in any subsequent general permitting system. A permitting system will eventually be needed for the state to negotiate interstate water compacts.

The intersection of science and public policy is often difficult to negotiate. The purpose of the panel's letter report is to provide decision makers with unbiased information about minimum stream flows and the methods for establishing them.

This panel consists entirely of independent scientists and engineers who conduct research, teaching, and public service related to water. The panel will not recommend the single "right" answer to the question of what the state's minimum stream flow rule should be. Rather the panel can describe the general characteristics of a minimum flow rule that are most likely to meet the wide-ranging (and sometimes competing) needs of water uses. The panel can assess through professional judgment the likely outcomes of some proposed rules. The ultimate objective of the panel is to insure that whatever decision is ultimately taken in the matter is an informed decision.

Little published scientific or engineering research is available to assist in fashioning a minimum instream rule for South Carolina. For that reason, it is necessary to rely on scientific experience and judgment in assessing the likely outcomes of proposed rules. In a more general sense, a great deal is known and published about the state's water supply, water quality, ecosystems, and salt water dynamics, and much of that knowledge can help inform discussions about minimum flows.

3. Process

To meet the challenges of exploring minimum flows, the Center for Humans and Nature (www.humansandnature.org) convened a panel of experts to hear testimony, discuss the wide range of possibilities for minimum flow rules, and generate general conclusions. The Center for Humans and Nature is a privately funded organization that facilitates efforts to aid communication among scientists, decision makers, and the public. The Center, a non-profit organization, is prohibited by its charter from lobbying or engaging in political activities in any way. It is not an advocacy organization, but rather its mission is to integrate research, education, and regional civic responsibility. In this case, the center contacted South Carolina experts in the academic community of the state, and invited them to a one-day meeting in Columbia to consider the various options for a minimum flow rule for the state. About 20 experts agreed to participate on a volunteer basis, without pay. The Center provided logistical support and reimbursed travel costs. The organizers were Dr. Bruce Coull (Director of the SC Initiative of the Center), Dr. David Cowen (Carolina Distinguished Professor Emeritus at the University of South Carolina, and Dr. William L. Graf (University Foundation Distinguished Professor at the University of South Carolina).

Prior to the panel meeting, Dr. Cowen assembled a variety of data in different formats to illustrate the data record for South Carolina rivers and streams. He provided the panel with example data sets plotted to show how the various minimum flow rules would play out at particular sites in a variety of regions within the state. He also shared plots of stream flow at various sites with various percentiles of flow compared to actual flows as derived from the U.S. Geological Survey. The panel reviewed these data in formulating their assessments of

different minimum flow rules. These data are available to anyone at http://www.cas.sc.edu/gis/HAN.

The panel met in two sessions, an initial open public session for testimony about minimum flows, followed by a closed committee session for assessment of proposed minimum flow rules. The panel invited a range of guests who provided input to the deliberations:

Agriculture interests, represented by South Carolina Farm Bureau, Russell Ott
Urban water supply interests, represented by Beaufort/Jasper Water and Sewer Authority, Charles Sexton
Hydropower interests, represented by South Carolina Electric and Gas, Bill Argentieri and Ray Ammarell
South Carolina Manufacturers Association, invited, chose not to attend
South Carolina Chamber of Commerce, invited, chose not to attend
Conservation Non-Profit Organizations, represented by American Rivers, Inc., Gerrit Jobsis
U.S. Geological Survey, John Shelton
South Carolina Department of Natural Resources, Bud Badr and Jim Bulak
South Carolina Department of Health and Environmental Control, David Baize

This report is a distillation of observations and conclusions drawn from testimony by interest groups, literature, and (most importantly) the collective experiences of engineers and scientists in South Carolina. Dr. Will Graf wrote numerous drafts of the report and circulated them for comment in revision to the experts who attended the meeting and who are listed at the end of this document. Independent scientists from outside South Carolina reviewed the penultimate draft, and made several suggestions for improvement that were included in the final report.

4. Economic and Environmental Significance of Low Flows

Water is a vital natural resource for the State of South Carolina. It is a ***strategic resource*** in the sense that it is required for human and environmental survival, for industrial and agricultural production, for production of electrical power, navigation, recreation, and for river ecosystems that are the natural heritage of the State. Water is also a renewable but ***finite resource***, with practical limits. It is entirely possible that in the coming decades population growth in the state will exhaust the readily available supply of fresh water, particularly from surface water sources. In order to protect existing users and ecosystem integrity, it is prudent to insure that during periods of low flows, users do not completely deplete flows. Water is also a ***legally defined resource***, subject to adjudication in courts of law and distribution according to agreements among states.

In considering minimum flow rules, the Independent Panel took into account the need to protect four primary services rendered by the State's streams: water

supply, water quality, ecosystem functions, and defense against salt water intrusion.

Water supply for environmental services and support, urban, industrial, and agricultural use and flow for hydropower generation is essential for the citizens of the state. Maintaining minimum stream flows, usually in late summer and early autumn, are sometimes a challenge for such users. When flow is unavailable, such users must rely on expensive groundwater pumping or off-stream storage in tanks or reservoirs. Hydropower generators associated with dams require through-flow to generate electricity, with heavy demands or emergency requirements that sometimes coincide with low flows.

Water quality protects human and environmental health, and clean water is required for many users as well as wildlife. Although the state has water treatment facilities to remove contaminants from water before it is returned to rivers after use, stream flow is vital to dilute and disperse harmful substances including some bacteria. Minimum flows insure that these materials can be diluted and dispersed to reduced concentrations within limits defined by federal and state agencies.

Ecosystem health, including species abundance and diversity, depends on water that is abundant and clean, two characteristics that are difficult to maintain during low-flow conditions. The maintenance of aquatic habitats for mussels, fish, and other organisms relies in part on flows during drier periods of the year.

Prevention of saltwater intrusion into surface bodies of water and groundwater systems is of considerable concern in coastal regions of the State. If stream flows are inadequate, lakes, wetlands, and groundwater aquifers receive too little fresh water input. In coastal areas, these freshwater inputs counterbalance inflows of salt water from the ocean, so that if fresh flows are too low, increasingly salty conditions prevail. Municipal wells in coastal areas are increasingly at risk from this salt-water intrusion, a resource management problem that is likely to become more acute as coastal development progresses and population increases there.

5. Experiences with Minimum Flow Rules

There is relatively little scientific research available from South Carolina that addresses the effects of low flows in rivers and streams. Scientific experience and judgment therefore play important roles in evaluating minimum flow rules. Many jurisdictions outside South Carolina, however, have extensive experiences from which this state can learn. Such rules are common in the drier western states in the United States, but some states in the more humid eastern part of the country also have experience that can be helpful to South Carolina. For example, Florida, Arkansas, Michigan, and Maine have administrative and research experiences related to minimum flows. Research in Georgia (some on the

Savannah River that is shared with South Carolina) has demonstrated the detrimental effects of excessively low flows on culturally and economically important fish populations. The European Union, South Africa, and Australia also deal with minimum flow rules in humid-region settings somewhat similar to South Carolina.

6. Assessment of Proposed Rules

Below are the panel's comments on four potential minimum low flow rules. *In each case, the rule is applied to a particular site or river reach*, and uses data from stream flow measurements that are presently available.

Rule: 7Q10

General Definition: Low flows must be at least equal to the lowest seven-day average encountered in the stream gage record of the last ten years.
Data Used for Calculation: Measured mean annual flow from the last 10 years.
Existing Mandate in South Carolina: Used in water quality regulations
Seasonal Variation: Not included in the rule. A single rule or formula serves for the entire year.
Geographic Variation: Not included in the rule. A single rule or formula serves for the entire state, with individual values calculated at specific places.
Comments: General application would result in allowing users on some streams to withdraw so much water that flows could decline to zero; does not account for important variation from one season to another; rule is advantaged because it already is in use for water quality work; likely to damage ecosystem health and not protect the rights of existing users; often uses only 10 years of data, a period that is too short to account for climatic variation; simplistic, easily understood by stakeholders, and easily applied by regulators; in general, application would be likely to result in the greatest withdrawals from streams; lack of seasonal variation greatly limits use of this rule.

Rule: 20 Percent of Mean Annual Flow

General Definition: Low flows must be at least equal to 20 percent of the mean annual flow
Data Used for Calculation: Measured mean annual flow from the entire record
Existing Mandate in South Carolina: None
Seasonal Variation: Not included in the rule. A single rule or formula serves for the entire year.
Geographic Variation: Not included in the rule. A single rule or formula serves for the entire state, with individual values calculated at specific places.
Comments: General application would insure that allowable flows would not decline to zero, but does not account for those river reaches that

"naturally" decline to zero; data show that because this method does not vary by month, it may be too low in winter months for realistic application. Because the rule is based on a mean value from the *entire* record, the rule is insensitive to normal climatic variations with dry, average, and wet periods of several years duration. All streams do not have records of the same length, so that the reliability of the rule (which is sensitive to length of record) is likely to be highly variable. Simple idea behind the rule, so it is easily understood by stakeholders and easily implemented by regulators; robust as possible because the rule uses the entire flow record. Rule does not consider seasonal effects such as needs for higher flows in winter months. Rule may require more instream flow than necessary in some summer low flow months. Lack of seasonal variation in the rule limits its use.

Rule: 5 Percentile-Monthly

General Definition: Stream flow is equal to or greater than the prescribed value 95 percent of the time; or stated differently, stream flow is less than this value only 5 percent of the time.
Data Used for Calculation: Measured monthly mean flows from entire record
Existing Mandate in South Carolina: Specified in drought regulations
Seasonal Variation: Included because of the use of monthly data, and flows are specified on a monthly basis.
Geographic Variation: Not included in the rule. A single rule or formula serves for the entire state, with individual values calculated at specific places.
Comments: General application would result in low flows that follow "naturally" defined seasonal flows because of the use of a monthly calculation; would always result in a prescription that is greater than zero except where "natural" flows have always been zero in the record; application would be advantaged because the rule already exists in drought regulations; seasonality is an advantage in protecting rights of existing users and ecosystem health. Rule is robust as possible because it uses the entire flow record; reasonably understandable for stakeholders and use by regulators; generally would be most protective of instream flows among alternative rules; more demanding of stakeholders and regulators in terms of data and calculations than rules using only annual data.

Rule: Variable, 20/30/40 Piedmont and 20/40/60 Coastal Plain

General Definition: In the Piedmont region of the state, flows in winter months must not be less than a flow equal to 20 percent of July-November flows in the record; May, June, and December flows equal no lower than 30 percent of average flow; and January-April flows no lower than 40 percent of the average The same definition is used for streams in the Coastal Plain, except the respective are 20, 40, and 60 percent.
Data Used for Calculation: Measured monthly mean flows from entire record

Existing Mandate in South Carolina: None
Seasonal Variation: Included in the calculation that uses monthly data
Geographic Variation: Included by definition
Comments: May be difficult to implement. General application results in summer low flows that in most streams are higher than those generated by the 5-percentile-monthly method, but not always; in the majority of cases provides maximum protection for existing users and ecosystem health; considers natural seasonal flows, but less so than the 5-percentile monthly rule; robust in using entire stream flow record; reasonably understandable by stakeholders; provides a balance among the needs of users and ecosystem needs; because the rule simplifies natural seasonal flows in streams by using season-long averages, certain stream may have minimum flows set too high, and others too low; geographical component of the rule may not be at an appropriate scale—flows might be best specified for the eight separate hydrologic basins in the state. In some formulations, the percentiles used in this rule are calculated using mean annual flows, but use of annual base data would obscure important seasonal variation.

It is possible to combine some minimum flow rules, such as specifying that flow must "equal or exceed the 5 percentile flow or the Regional-Seasonal Rule, which ever is greater," and there are many other potentially useful minimum flow rules that South Carolina might adopt. The rules outlined above as examples are primarily oriented to deal with drought conditions rather than the maintenance of the long-term health of aquatic and riparian ecosystems, and they may not be sufficient to avoid damage to the state's aquatic resources. This damage is likely to be in the form of the loss of habitats resulting from periods of low flow that are extended by withdrawals and that occur more frequently. Summer flows across the entire state and winter flows in piedmont streams are particularly at risk in this regard.

7. General Comments on Minimum Flow Rules

During discussions of minimum flow rules in both the open public session and the closed committee session, the panel identified the following points that decision-makers should take into account in establishing a formal system for minimum flow rules.

a. *Stream Flow Data.* The U.S. Geological Survey should be the single authoritative source for stream flow data. Their system of stream gages (technical term for "gauges") is maintained cooperatively between the state and federal government, and their data are viewed by regulators as the national standard. USGS or other generally accepted formulas should be used for estimating flows on ungaged streams.

b. *Measurement Network.* A minimum flow rule will likely require some state funds to support some stream gages, analysis of data, and monitoring to support and test the utility of the designated minimum flows. The gage network of the state is relatively sparse and has declined over the past several decades. Some of the funds from permitting fees might reasonably be dedicated to the installation and operation of additional gages under cooperative agreements whereby the federal government shares costs – a standard arrangement.

c. *Adaptive Management.* A minimum stream flow law should allow for re-opener mechanisms to account for special cases and to make adjustments in the rule to reflect experience. This is a form of adaptive management; it requires the monitoring of the system and rule performance followed by adjustments in the rule if deemed appropriate by decision makers. An adaptive management approach will enable appropriate action when unexpected events (such as rapid population growth or unusual climatic conditions) occur that influence withdrawals from streams.

d. *Dam Licensing Agreements.* Minimum flows defined by any state law should yield deference to minimum flows previously established under dam relicensing agreements negotiated through the Federal Energy Regulatory Commission (FERC). State minimum flows should be met for all new FERC licenses.

e. *Users.* A minimum stream flow law should consider all users within a watershed. If a minimum stream flow is lower at a downstream location than at an upstream location, then the downstream flow should take priority at the upstream location.

f. *Geographic Scale.* The geographic scale for defining a minimum stream flow should be similar to hydrology and precipitation patterns. This may include areas in which no USGS gage exists.

g. *Land Use and Minimum Flows.* Changes in land use and land cover will impact minimum stream flow requirements, and will alter the connections among precipitation, runoff, and stream flow. The minimum flow rule should include the provision that once a minimum stream flow is set, counties and cities should assess zoning plans and regulations in order to avoid detrimental impacts on future minimum flows. To alleviate pressure on surface water use and to maintain minimum stream flow recommendations, any new rules should stress the importance of rain catchment and storage mechanisms.

h. *Length of Record for Rule Making.* Decision makers should use the longest record possible in calculating minimum flows because climate variability creates decades of dry, moist, or average water availability and stream flow. In general hydro-climatic applications, “normal” is determined to be the average of a 30-year period. The “present” conditions should be characterized as dry, moist, or average when considered in light of the long record of at least 30 years, with

some adaptive-management style adjustments if they are in order as more data become available over time. If users select a particular limited part of the record, the last ten years for example, that short period may not reflect reasonable expectations for the next ten years.

i. *Lack of Knowledge.* Scientific knowledge about linkages among low flows and ecosystem responses is not strong, so that scientific judgment plays an important role in choosing the best rule for South Carolina. The state should support efforts to improve knowledge about the effects of low flows on organisms, physical and chemical river and stream processes, salt water intrusion, waste dispersal, and water supply. More knowledge is required for those times when low flows become pervasive as in long-term droughts.

j. *Minimum Flows are Thresholds, not Targets.* Although there is a clear need to set minimum instream flows in South Carolina, continuous flow maintained at the minimum is clearly not desirable. Because so little is known about ecosystem requirements, responses to low flows, and tipping points for catastrophic ecosystem changes, the goal for the state should be to keep as much water as possible in the state's rivers, estuaries, and lakes.

k. *Initial levels.* If the minimum flow rule adopted by the state is very low, it will likely be very difficult to raise the level if future experience shows unexceptional damage to aquatic resources. On the other hand, a more conservative approach to protecting aquatic resources is to set higher minimum levels that can be adjusted downward if needed to meet emergency needs.

l. *Groundwater – Surface Water Connections.* Groundwater and surface water systems are connected to each other by exchanges of water, but our knowledge about the nature of the connection and the magnitudes of exchanges is limited. Relying completely on groundwater as a backup to increasingly stressed surface water may not be possible, especially in drought conditions. After droughts are replaced by more moist conditions, groundwater systems may require years to recover their previous volumes. As a result, minimum flows that depend on groundwater inputs may also be slow to recover.

m. *Non-reporting Users.* An effective minimum flow rule and permitting system will depend on a clear understanding of all uses of surface water and groundwater. If non-reporting uses are large in comparison to regulated uses, the rule and permitting system will not be effective. For example, at present regulations for wells cover only those users who withdraw 3 million gallons per month, but a large number of smaller consumers might have equal or greater impacts in localized areas.

8. Conclusions

Based on our knowledge and experience, we conclude that the national trends identified by the National Academy of Sciences' National Research Council are useful in South Carolina. Their review of a state-wide system (National Research Council, 2005, *The Science of Instream Flows: A Review of the Texas Instream Flow Program*) identified the following increasingly common principles that apply in South Carolina:

- Avoid single numbers applied statewide, develop a formula instead
- Include protection of wetlands and flood plains
- For environmental health, focus on ecosystems rather than individual species
- Employ a wide range of considerations: water supply and quality, and water rights, as well as hydrology, biology, and geomorphology

An effective minimum stream flow rule for South Carolina will protect the economic and environmental quality interests of the State's citizens and their environment. It will also protect present users from potentially inappropriate overuse by future users, and will strengthen the State's hand in negotiating with neighboring states. An effective minimum flow rule will lead to wise management for one the State's most strategic, yet finite resources, its water.

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