THE NEED FOR CUMULATIVE IMPACT ASSESSMENT FOR RESERVOIRS

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Abstract. The natural functions provided by Georgia's streams and rivers, such as providing healthy aquatic habitats, have been impaired by the more than 68,000 reservoirs in the state. In light of renewed interest in reservoir construction, improved cumulative ecological impact assessments are necessary to better understand the impacts and manage the state's water resources. The federal agencies should convene state water resource experts to develop science-based guidance to perform these important and complex assessments.

INTRODUCTION

We make many demands on our streams and rivers that conflict with the maintenance of fully functional natural ecosystems (Table 1). While often necessary, water consumption, diversions, and storage in reservoirs disrupt the natural stream flows on which riverine ecosystems rely (Davis et al. 2002). River channels are now eroding. Poor water quality threatens human health. Too many fish species are going extinct. Effects are felt far beyond project sites and are pervasive, with many reservoirs having been built over the past 80 years throughout every watershed in the state. The projected increased demands for water from our streams and rivers (GDNR 2001) have raised important concerns about how well the impacts to stream flow are understood and managed.

ASSESSMENT REQUIREMENTS

There is little oversight or assessment required by federal or state law of the cumulative ecological impacts to streams and rivers. Impacts to streams and rivers are usually assessed for individual projects, not in terms of other sources of impacts to the same water body. Only those impacts to waters of the nation (e.g., wetlands, streams, rivers) that require federal permits, often under Section 404 of the Clean Water Act or the Rivers and Harbors Act, are subject to a cumulative impact assessment under the National Environmental Policy Act.

Most types of projects that impact stream flow do not undergo cumulative ecological impact assessments. For example, agricultural and silvicultural activities in waters of the nation are exempt from such assessments. Small projects that only require federal Section 404 nationwide and regional permits do not in practice undergo cumulative impact assessments. Georgia's programs for water withdrawal permits, wastewater discharge permits, stormwater runoff, wildlife management practices, and other activities also are not assessed for cumulative ecological impacts.

Only large projects that discharge dredged or fill material into waters of the nation, such as dam construction, are subject to cumulative impact assessments. These assessments are expensive, and data are not always available. Furthermore, specific, science-based guidance to perform these complicated analyses does not exist (See Section 404(b)1 Guidelines in 40 CFR Part 230.11). The cumulative ecological impact assessments that are performed, therefore, are

Table 1. Example Functions of Natural Rivers and Impacts of Reservoirs (Davis et al. 2002)

Natural water level fluctuations, including floods and low water events, are often reduced with reservoir releases.
Evaporative loss of water is increased from warm, large reservoir surfaces in comparison with river surfaces.
Temperature, turbidity, and other qualities of water leaving a reservoir are different that the water entering the reservoir from upstream and often less hospitable for native fauna.
Continuous flows from headwaters to the sea are broken into disconnected segments of streams by placement of dams across rivers, which limits migration of fish.
Native fish that depend on flowing water habitats are not able to live in reservoirs.
Fish stocked in reservoirs for sport prey on native species that have no defenses against predators.

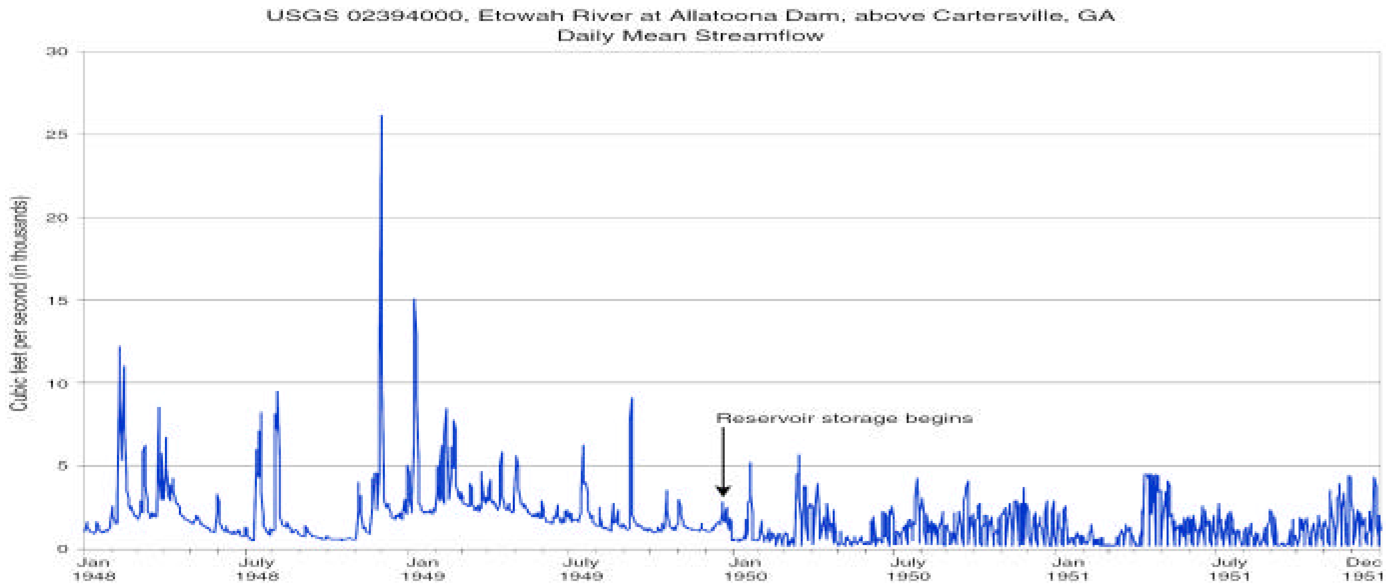

Figure 1. Streamflow fluctuations before and after construction of Allatoona Dam on the Etowah River.

qualitative and often inadequate. These hurdles are particularly significant for projects with large impacts, such as water supply reservoirs.

An important opportunity to perform cumulative ecological impact assessments and thereby more clearly understand impacts to Georgia's streams and rivers is during the permitting process for reservoir construction. Reservoirs (defined for the purposes of this paper as artificial lakes created by impounding streams and rivers) and associate activities are permitted under several federal and state regulatory programs (e.g., Sections 401 and 404 of the Clean Water Act and state water withdrawal permits). Reservoirs are particularly detrimental to streams and rivers, because they simultaneously alter stream flow and fragment watersheds (Davis et al. 2002). A surge in reservoir construction is expected in Georgia due to the drought of the past few years and projected population demands. Guidance for cumulative ecological impact assessments of reservoirs must be improved to better understand and manage Georgia's water resources.

ECOLOGICAL EFFECTS OF RESERVOIRS

A stream's flow regime is a critical "master variable" that controls many natural hydrological, physical, chemical, and biological services (Poff et al. 1997). Flow regimes are described in terms of rate of flow, range of variation, duration of flow, rate of change, and season of flow (Richter et al. 1997). In addition, continuity of flow from headwaters to estuaries is a key factor for fully functioning stream ecosystems (Vannote et al. 1980). Alterations of flow regimes negatively impact the natural functions and services provided by streams and rivers.

Reservoirs alter flow regimes by reducing water level variability (Figure 1) and quantity of flow, as well as fragmenting stream flow (Davis et al. 2002). These changes in flow regime disrupt natural services upstream and downstream, as well as in the impounded area. For example, reservoirs alter natural patterns of channel maintenance and block sediment transport. Waste assimilation capacity of downstream portions of the river can be reduced. Aquatic fauna that are adapted to flowing water habitats are often intolerant of lake conditions as well as the predatory sport fish species which are stocked for sport.

The physical barrier of one or more dams across a stream or river breaks the continuity of the ecosystem, creating fragments of disconnected stream segments (Figure 2, Merrill 2001). Water, energy, food, and biota are blocked from movement along their natural pathways. The ability of organisms to move between habitats and populations becomes increasingly limited with additional reservoirs. This is a significant factor in the large number of threatened and endangered aquatic species in Georgia (Folkerts 1997).

Effects of multiple reservoirs in a watershed can be more than additive in space and time. The spatial scale or extent of an ecological effect of reservoirs depends on several factors, such as the position in the stream network, size and type of the reservoirs, proximity to other reservoirs, as well as the type of ecological effect under consideration. For example, many species of darters live for a portion of their lives in small streams where they can escape predators. Reservoirs on streams isolate individual darter populations where they are likely to become locally extinct. A species may tolerate one or a few blockages, but the population in the watershed may eventually be lost when the availability of small stream habitats becomes inadequate (Mary Freeman, USGS, personal communication, 2002).

Effects of reservoirs on natural functions of streams and rivers are not always immediate. It takes decades after the loss of flood events, for example, for tree species composition of floodplain forests below dams to be replaced by to less flood tolerant species (Light et al. 1998). A fish population that has been isolated in a small portion of a watershed by a reservoir may survive for long periods of time until an event, such as a discharge of toxins, eliminates the species there. Few effects are reversible unless the reservoir is removed.

Figure 2. Multiple reservoirs on streams in south Georgia. Arrows indicate location of reservoirs.

RESERVOIRS IN GEORGIA

Georgia has few natural lakes and an estimated 68,000 – 70,000 reservoirs (Davis et al. 2002). Natural lakes occur primarily along the coast and in karst regions near the Florida border. Reservoirs are distributed throughout every watershed in the state, with few in the karst Doherty Plain of southwest Georgia and along the coast where there is little topographic relief (US EPA 1998).

Several reservoirs that still exist in the state were constructed in the late 1800's; however, most reservoirs were constructed beginning in the 1920's and 1930's for hydropower, flood control, and navigation (US EPA 1998). Most reservoirs serve several functions, with recreation being most common (US EPA 1998). Due to a severe drought in the 1950's, the US Department of Agriculture began a program to assist farmers in securing dependable water supplies by constructing ponds for irrigation and watering stock (USDA NRCS 1990). This program accounts for over 50,000 of the reservoirs in the state. The Georgia Soil and Water Conservation Commission continues to build many reservoirs each year. The more recent population growth in metro Atlanta created a large demand for water supply reservoirs that have become ecological and regulatory issues.

Reservoirs in Georgia range in size from 0.1 ha to over 7,000 ha (Davis et al. 2002), with the vast majority being small and relatively shallow. For example, there are over 24,000 reservoirs in the Chattahoochee and Flint River watersheds, with the 11 largest being on the main rivers (GDOT 1999). The balance are small reservoirs on tributaries and streams, however, their surface area totals the surface area of the main river reservoirs.

ASSESSMENT METHODOLOGY

Cumulative impact assessments differ from assessments of individual project impacts, because they take into account the impacts from past, current and foreseeable projects (Council on Environmental Quality, 40 CFR Part 1508.7)). This requires a holistic approach to determine the resources that are impacted (e.g., for reservoirs these include hydrology, geomorphology, water quality, and aquatic, wetland, and riparian biota), spatial and temporal extent of the impacts, and assessment tools that can be integrated into the process. Extensive data are required across long time frames at a resolution that is meaningful to the resource. In addition, results of cumulative impact assessments for regulatory purposes must indicate the significance of the impact relative to ecological thresholds for each resource to determine whether the impact is acceptable. General guidance for performing these assessments exists, but no specific guidance is available for reservoirs due to the complexity of resources and potential extent of the ecological impacts throughout watersheds and regions.

Determination of spatial and temporal extents of impacts is an important part of cumulative impact assessments. Spatially these assessments are performed beyond the project area to the extent that impacts occur. The extent depends on the resource being assessed

(Table 1) and is often determined using models. In the case of reservoirs, for example, this could mean a portion of the watershed for hydrologic impacts, but extend to a physiographic region for endangered species.

Temporally, impacts are considered that occur well before and after the impacts of construction. Pre-impact conditions must be determined for comparison with current and predicted impacts. Even with complete data sets and intensive modeling, conditions are often difficult to predict. For example, the number of years is site-specific for downcutting of riverbeds and increased bank erosion below reservoirs or species composition of adjacent floodplain forests to stabilize.

Determination of ecological thresholds beyond which further impacts are unacceptable is difficult. This is due in large part to the complexity of spatial and temporal scales of ecological effects of reservoirs and uncertainty about facts and direct relationships. Furthermore, many ecological responses to impacts are of such a nature that determination of a threshold is subjective. For example, by decreasing flood stage, there is a decrease in floodplain wetland acreage. Further reductions in flooding result in more impacted acreage. How much is too much? The answer must take into consideration the ecology as well as the public interest in the project.

CONCLUSIONS

Despite the lack of science-based guidance, the regulatory agencies routinely perform cumulative ecological impact assessments and determine significant impacts for all types of projects that impact waters of the nation, including reservoirs. Due to the presence of reservoirs throughout most of Georgia's watersheds, their pervasive effects, and projected increases in reservoir construction, guidance for cumulative ecological impact assessments is more critical than ever.

The federal agencies should convene state water resource experts, regulators, water supply authorities, and others involved with reservoir construction to answer key questions about cumulative ecological impact assessments. What resources must be assessed? What spatial and temporal factors must be considered? What tools, such as models or analyses, should be used? What data are required? Given limited resources, what parameters should have priority for analyses? Can thresholds be set for significant impacts? Once consensus is achieved, effective assessments can be performed. Cumulative ecological impacts to Georgia's streams and rivers will then be more clearly understood and better managed.

LITERATURE CITED

Davis M., S. Holmbeck-Pelham, B. Freeman, M. Freeman, K. Hatcher,R. Jackson, A. Miller-Keyes, M. Merrill, J. Meyer, E. Sutherland, and S. Wenger. 2002. Reservoirs in Georgia: Meeting Water Supply Needs while Minimizing Impacts. G. Cowie (ed.) White Paper for the UGA River Basin Science and Policy Center, Athens, GA.

Folkerts, G. W. 1997. State and fate of the world's aquatic fauna. In George W. Benz and David E. Collins (eds.). *Aquatic Fauna in Peril: The Southeastern Perspective.* Southeast Aquatic Research Institute Special Publication 1, Lenz Design and Communication, Decatur, GA. 554 pp.

Georgia Department of Natural Resources. 2001. *Water Issues White Paper.* Available at www.ganet.org/dnr/environ.

Georgia Department of Transportation. 1999. Lakes and Ponds Data from 1:24,000 USGS topographic maps. Available at www.clearinghouse.uga.edu.

Light, H. M., M. R. Darst, and J. W. Grubbs. 1998. *Aquatic Habitats in Relation to River Flow in the Apalachicola River Floodplain, Florida.* U.S. Geological Survey Professional Paper 1594, Tallahassee, Florida.

Merrill, M., M. C. Freeman, B. J. Freeman, E. A. Kramer, and L.M. Hartle. 2001. Stream loss and fragmentation due to impoundments in the Upper Oconee watershed. Pp. 66-69 in *Proceedings of the 2001 Georgia Water Resources Conference*, held March 26-27, at The University of Georgia, Kathryn J. Hatcher, editor, Institute of Ecology, UGA, Athens, Georgia.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestgaard, B.D. Richter, R.E. Sparks and J.C. Stromberg. 1997. The natural flow regime. *Bioscience* 47: 769-784.

Richter, B.D., J.V. Baumgartner, R. Wigington, and D.P. Braun. 1997. How much water does a river really need? *Freshwater Biology* 37:231-249.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37: 130-137.

U.S. Environmental Protection Agency. 1998. *National Inventory of Dams in BASINS, Version 2.0*. Region 4 software for calculation of Total Maximum Daily Loads. EPA-823-C-98-006.