Guidance for evaluating ecological indicators in water planning

Developed as part of the EPD Seed Grant: Evaluating Options for Improving Drought Resilience of the Upper Flint River System

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Introduction

Freshwater species are adapted to, and depend on, the full range of flows that a river system naturally experiences across seasons and among years to complete their life cycles and sustain populations. For this reason, managers and stakeholders need information on flow levels that support a range of ecosystem functions when assessing future water availability for river ecosystems.

Evaluating water availability to support river ecosystems requires a different approach than is currently used to evaluate gaps in water availability for other demands in Georgia's water planning process. During each 5-year cycle in Georgia's water planning process, planners compare a forecast of future water demand to current water availability. Gaps are expressed as the proportion of time during a model period (80 years) that a demand is not met, or that streamflow falls below the wastewater assimilation threshold. Ecological indicators, or attainment of functional flows, can be assessed using the same framework of current and future flow projections, however evaluation requires shifting from averaging over the entire model period to examining the occurrence and severity of ecologically stressful events.

Evaluating and Interpreting Ecological Indicators

The ecological outcome of an exceptional flow condition (such as an extreme low flow) will partly depend on how low (magnitude), how long (duration), and how often (frequency) stressful events occur. Therefore, it is most useful to evaluate flow thresholds (magnitudes) in the context of how long and how often they are exceeded with respect to current and future conditions.

For example, supporting survival of aquatic organisms is a key streamflow function that will be affected when flow falls below a 'dry-season threshold.' To evaluate whether future flows during the dry season are likely to compromise organism survival, it would be useful to compare the annual frequency and duration of flow events below the dry season threshold (e.g., during June-October) for the current and future scenarios. We show an example of this evaluation process below for the Upper Flint Regional Water Council.

Deciding how much change is too much may depend on a variety of factors, including risk tolerance (e.g., of utilities and resource managers), the availability of current or future options to minimize the change, and the ecological function of the flow being evaluated (e.g., flows necessary for survival across many groups of organisms versus seasonal connectivity to floodplain habitats for a subset of organisms). If the consequences of crossing a flow threshold in a future scenario are too great, the next step is to investigate management alternatives to prevent this outcome.

Example for the Upper Flint River Water Council

In the 2023 Upper Flint Regional Water Plan, the Council requested that metrics for recreation and ecological indicators be evaluated, based on flows levels provided in "Guidance on Drought Resilience for People and Nature in the Upper Flint River Basin" (Upper Flint River Working Group 2021). The streamflow metrics were evaluated at the Carsonville gage (Flint River at US 19, near Carsonville, USGS gage 02347500; USGS 2025) and comprised two flow levels: 100 cfs, representing a drying threshold where the river shoals were "more rocks than water," and 600 cfs, which is a generally accepted minimum flow for floating a kayak or canoe down Flint River shoals. This "paddling flow" is similar to a flow level (500 cfs) estimated to sustain swift-water habitat in Flint River shoal ecosystems and can be used to evaluate outcomes for both recreation and shoal ecosystems.

The metrics were evaluated in the Regional Water Plan (RWP) as the total proportion of the 80-year model period during which flow at the Carsonville gage was below metric thresholds for the baseline demand (average demand from 2010-2018) and the baseline drought demand (2011; RWP, pages 3.6-3.10). The baselines were compared with future water availability to meet these metrics based on data from agricultural demand forecasts through 2060; results showed minimal differences between current and future conditions for either metric, since most agricultural growth was projected to occur downstream of the Carsonville gage.

Table 3-5: Surface Water Availability Streamflow Results

Carsonville Flow Summary	Streamflow Metric *cfs*	Scenario	
		Baseline	Baseline Drought
% Time Below Streamflow Metric	100	0.91%	1.02%
	600	23.6%	23.9%
**% Time is calculated as a proportion of the full model period (1939-2018).*			

*Results table from the 2023 Upper Flint RWP.

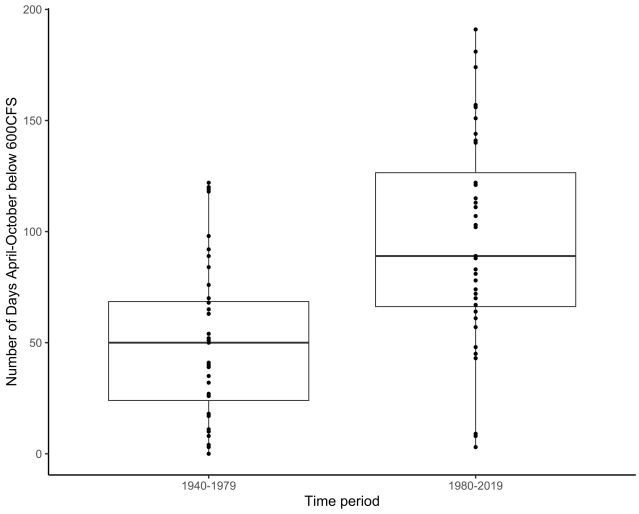
Interpreting these metrics as percent of total time exceeded presents a challenge. For example, 1% of time below 100 cfs ("more rocks than water" condition) could reflect annual events of 3-4 days each year of the 80-year period, or events lasting over a month once every 10 years. The ecological consequences of these scenarios could be substantially different, depending on an organism's ability to withstand stagnant water or emersion. Similarly, the effect of flows below the river-recreation threshold may depend on whether those low flows occur as one "poor boating" year out of every four or represent three months of lost recreation during the period of highest demand every year. Thus, to interpret the ecological consequences or the impact on recreation of flows under a given scenario, it is relevant to consider the seasonality, duration and frequency of individual flow excursions below ecological and recreational thresholds. Recreational paddling (best-supported when flows exceed 600 cfs) is concentrated between April and October, which overlaps with the seasonally low flows that impact shoal habitat for

aquatic organisms (Flint River flows are generally higher in winter and spring and lowest during summer and fall). Extreme low flows that lead to riverbed drying ("more rocks than water" condition; 100 cfs) are most likely to occur and overlap with potentially stressful, elevated water temperatures from June to October.

One can use the record for the Carsonville gage to evaluate the historic annual occurrences of seasonal flows below the thresholds for recreational boating (and shoal habitat) and river drying. Because we did not have the forecasted demand data available to compare historic and future scenarios, we split the historical record at the Carsonville gage into two 40-year periods to illustrate how one could evaluate changes in recreation and ecological metrics between time periods. In the context of water planning, one would compare the agreed-upon baseline or current conditions to a future scenario.

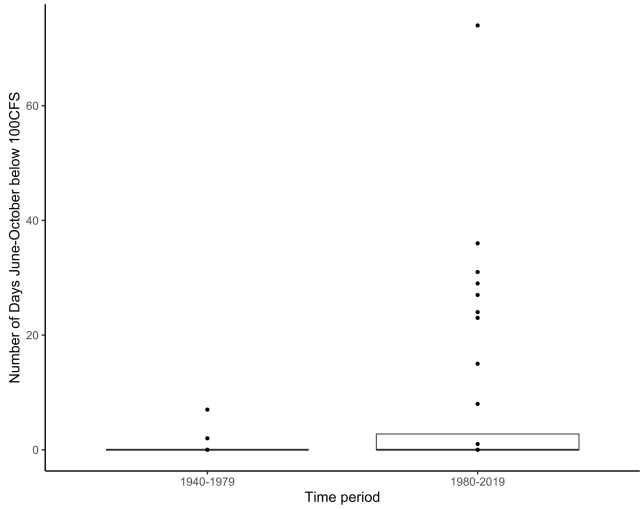
River flows recorded at the Carsonville gage were below 600 cfs and 100 cfs more often and for more days in the years 1980-2019 than in the earlier period, 1940-1979. These changes could be consequential. In the 1980-2019 period, the time that the river was below the paddling threshold almost doubled compared to the prior 40-year period, with nearly half of the years having unsuitable recreational flows for much or most of the season (Figure 1). Flows below 100 cfs rarely occurred between 1940-1979, but in the period 1980-2019 they occurred in about 25% of years and for up to 74 days (Figure 2).

Observing a shift like this in the summer and fall baseflow thresholds would raise a flag that river flows are trending lower for longer during the months evaluated. If these trends were to appear for a water planning scenario, it would be relevant to consider potential causes or evaluate alternative management actions that could mitigate the occurrence or duration of these events.



	1940-1979	1980-2019
# YEARS	40	40
% OF TIME BELOW 600 (APRIL-OCTOBER)	23.4	44.8
# YEARS WITH OCCURRENCE OF FLOWS BELOW: 600 CFS	38	40
MEDIAN # DAYS APRIL-OCTOBER WITH FLOWS BELOW: 600 CFS	50	89
MAX # DAYS APRIL-OCTOBER WITH FLOWS BELOW: 600 CFS	122	191

Figure 1. Boxplot of the annual number of days between April and October that flows were below 600 cfs at the Carsonville gage on the Flint River. In the boxes, 25 percent of the data fall below the lower line, the middle line is the median, and 75 percent of the data are below the upper black line. This type of figure helps visualize the spread of the occurrence and duration of events below the 600 cfs threshold. The table summarizes the total percent of time and the median number of days each year, and the maximum number of days in one year, below 600 cfs during the recreational season.



	1940-1979	1980-2019
# YEARS	40	40
% OF TIME BELOW 100 (JUNE-OCTOBER)	0.15	4.8
# YEARS WITH OCCURRENCE OF FLOWS BELOW: 100 cfs	2	11
MAX # DAYS JUNE-OCTOBER WITH FLOWS BELOW: 100 cfs	7	74

Figure 2. Boxplot of the annual number of days between June and October that flows were below 100 cfs at the Carsonville gage on the Flint River. In the boxes, 25 percent of the data fall below the lower line, the middle line is the median, and 75 percent of the data are below the upper black line. This type of figure helps visualize the spread of the occurrence and duration of events below the 100 cfs “more rocks than water” threshold. The table summarizes the total percent of time, the number of years with occurrence (i.e., at least one day), and the maximum number of days in a single year with flows below 100 cfs during each time period.