

APPENDIX E STREAMFLOW ALTERATION ANALYSIS

As part of assessment planning, relationships between streamflow alteration and stream biological condition were examined in order to guide the selection of watershed health metrics. The objective of this effort was to identify ecologically-relevant measures of streamflow alteration that could be included as hydrologic condition metrics. This appendix outlines the methods, results, and conclusions of the streamflow alteration analysis for Alabama streams.

The method applied to analyze relationships between streamflow alteration and stream biological condition consisted of four general steps:

1. Estimate present-day values of streamflow metrics;
2. Estimate reference values of streamflow metrics (i.e., expected values under reference watershed conditions);
3. Quantify streamflow alteration as the difference between present-day and reference values of streamflow metrics; and
4. Evaluate the strength of correlation between streamflow alteration and biological condition at sites with paired streamflow-biological data.

Streamflow metrics considered for analysis are flood magnitudes for 2, 5, 10, 25, 50, 100, 200, and 500 year return intervals. These metrics were selected because present-day values for 36 Alabama streams with biological monitoring data are reported by the USGS (Hedgecock, 2004; Hedgecock & Feaster, 2007; Hedgecock & Lee, 2010) and because reference values can be calculated from regression equations reported in Hedgecock (2004) and Hedgecock and Feaster (2007). The following paragraphs provide a summary of analysis steps.

Estimate Present-Day Values of Streamflow Metrics – Flood frequency statistics have been quantified by the USGS for several Alabama streams from long-term gaging station data (Hedgecock, 2004; Hedgecock & Feaster, 2007; Hedgecock & Lee, 2010). Gaging station locations with reported flood frequency statistics were mapped in conjunction with ADEM/GSA fish monitoring site locations. 36 gaging stations were determined to be located on the same reach as a fish monitoring site or within one mile of a fish monitoring site. Flood magnitudes for these gaging stations were recorded from USGS reports and were used as estimates of present-day values of 2, 5, 10, 25, 50, 100, 200, and 500 year flood magnitude.

Estimate Reference Values of Streamflow Metrics – The USGS has developed regression equations to estimate flood frequency statistics for small (Hedgecock, 2004) and large (Hedgecock & Feaster, 2007) streams in Alabama. These equations describe the statistical relationship between the magnitude of floods with 2, 5, 10, 25, 50, 100, 200, and 500 year return intervals and a stream's contributing drainage area. Equations were developed from peak flow data collected through 2003 at gaging stations that have not been affected by flow regulation, channelization, or urbanization. These equations therefore provide an estimate of flood magnitudes under reference conditions.

Reference values of flood magnitudes were quantified for 36 stream gaging stations with fish monitoring data using the regression equations described above. Equations reported in Hedgecock (2004) were used for streams with contributing drainage areas less than 15 square miles. For streams with contributing drainage areas greater than 15 square miles, equations reported in Hedgecock and Feaster (2007) were applied.

Quantify Streamflow Alteration – Streamflow alteration at each of the 36 study sites was quantified from estimates of present-day and reference flood magnitudes. Flow alteration was calculated as:

$$Q_{Altered} = \frac{Q_{Present} - Q_{Reference}}{Q_{Reference}}$$

where $Q_{Altered}$ is the flood alteration ratio, $Q_{Present}$ is the present-day flood magnitude, and $Q_{Reference}$ is the reference flood magnitude. Flood alteration ratios were calculated for 2, 5, 10, 25, 50, 100, 200, and 500 year flood magnitudes.

Evaluate Relationships between Streamflow Alteration and Biological Condition – Relationships between streamflow alteration and biological condition were reviewed using calculated flood alteration ratios and fish Index of Biotic Integrity (IBI) scores acquired from GSA. Correlation coefficients were calculated for each flood return interval to describe the strength and directionality of the relationship between changes in flood magnitude and fish IBI score.

Correlation coefficients for fish IBI score and flood alteration ratios for 2, 5, 10, 25, 50, 100, 200, and 500 year floods are shown in Table E-1. Correlations are negative for all flood return intervals, indicating that higher flow alteration corresponds to lower fish IBI scores. However, the relationship between flow alteration and fish IBI is weak, with coefficient magnitudes ranging from -0.01 to -0.17.

Because fish communities may be negatively impacted by a large increase *or* decrease in flood magnitudes, correlation coefficients were also calculated using the absolute value of flood alteration ratios (Table E-1). Correlations are negative for 7 of the 8 return intervals (the exception is 25 year flood magnitude) and are slightly stronger than those generated from unadjusted flood alteration ratios (correlation coefficients range from -0.16 to -0.31).

TABLE E-1. CORRELATION COEFFICIENT BETWEEN FISH IBI SCORE AND ALTERATION OF FLOOD MAGNITUDE.

| Streamflow Alteration Metric | Correlation Coefficient |
|---|-------------------------|
| Alteration of 2 year flood magnitude | -0.08 |
| Alteration of 5 year flood magnitude | -0.06 |
| Alteration of 10 year flood magnitude | -0.05 |
| Alteration of 25 year flood magnitude | -0.17 |
| Alteration of 50 year flood magnitude | -0.04 |
| Alteration of 100 year flood magnitude | -0.04 |
| Alteration of 200 year flood magnitude | -0.03 |
| Alteration of 500 year flood magnitude | -0.01 |
| Alteration of 2 year flood magnitude (Absolute Value) | -0.26 |
| Alteration of 5 year flood magnitude (Absolute Value) | -0.16 |
| Alteration of 10 year flood magnitude (Absolute Value) | -0.18 |
| Alteration of 25 year flood magnitude (Absolute Value) | 0.15 |
| Alteration of 50 year flood magnitude (Absolute Value) | -0.23 |
| Alteration of 100 year flood magnitude (Absolute Value) | -0.25 |
| Alteration of 200 year flood magnitude (Absolute Value) | -0.27 |
| Alteration of 500 year flood magnitude (Absolute Value) | -0.31 |

Overall, flow and biological data for the 36 stream sites included in this analysis do not point to a strong relationship between altered flood magnitude and stream biological condition. For this reason, none of the flood alteration metrics reviewed as part of this analysis were included as hydrologic condition metrics for the *Alabama and Mobile Bay Basin Integrated Assessment of Watershed Health*.

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