

Habitat Modeling Analysis Notes

Habitat Modeling

Over the past 25-30 years, the NC Division of Water Resources (DWR) has conducted or been involved in numerous site specific studies to evaluate the effect of water resource projects on stream flows and aquatic habitat. The types of project proposals have included federal hydropower relicensing, water supply reservoirs, new or expanded water supply withdrawals, and water resource planning studies.

Each study involved the collection of site specific data for the stream channel: cross-section profiles, depths, velocities, and bottom substrate and cover objects. Individual cross-sections (transects) were selected to represent the range of habitat types available at each site. Data was collected under at least three different stream flow conditions, and a series of models (known as PHABSIM – Physical Habitat Simulation) was calibrated using this data to allow simulation of the physical conditions over a wide range of flows.

Each guild or species being modeled has a set of habitat suitability indices that represents how that organism responds to different stream velocities, depths, bottom substrates, and cover objects. These suitability indices are sometimes referred to as preference curves. When the preference curves are applied to the physical conditions the PHABSIM model simulates at different flows, the habitat model produces a relationship between the amount of habitat and stream flow (cubic feet per second) – with each guild or species having its own habitat vs. flow relationship for each study site.

A map of existing habitat studies performed in North Carolina can be seen [here](#). A more detailed presentation on habitat modeling studies can be seen [here](#).

Time Series Analysis

This entails converting a record of daily stream flows into a record of daily habitat amounts. The river basin hydrologic models being developed by DWR can be used to produce an 80-year record of daily stream flows at the site of interest under unaltered or various “with-project” conditions. The habitat versus flow relationships modeled at that site are then used to convert cubic feet per second (cfs) into weighted usable area (WUA) units of habitat. The record of daily WUA can then be analyzed to compare the effects of various alternate flow regimes, in contrast to the unaltered flows.

Index B

This is a metric calculated during time series analysis to quantify and compare the effects of different flow regimes on aquatic habitat. It is calculated as the average of all daily habitat values between the 10% and 90% exceedance levels. For example, 100 daily values would be rank ordered and the lowest and highest 10 would be dropped before calculating the average.

Index B values are calculated for each guild or species on a monthly basis and for each different flow scenario. The ratio of a particular flow scenario's Index B value to the Index B determined for the unaltered flow record is used to compare alternatives. DWR has used 80% of the unaltered habitat index as a target level of aquatic habitat to maintain when evaluating flow alternatives. The Ecological Flows Science Advisory Board decided to use the 80% of unregulated Index B value as a lower threshold for the ratio, but was also interested in evaluating what flow scenarios resulted in an Index B ratio that was greater than 120% of the unregulated value. The reasoning was that "enhancing" habitat levels for a particular guild or species by more than 20% above unaltered conditions represented a significant change and might also have unknown or unintended consequences for the overall aquatic ecosystem.

Index B ratios that are less than 80% or more than 120% of the value calculated for unaltered flows are tallied separately and presented in separate graphs and tables. In addition, the output graphs also indicate separate results that are noted as "small" or "low" WUA. These represent a separate tally of those guilds or species for which the unregulated Index B values are less than 1000. In general, this is a relatively low value for the habitat index compared to the values for other guilds or species. While not wanting to ignore or totally discount the guilds/species with low Index B values, we do want to be aware of them. Since it is the denominator used in calculating percentages, relatively small changes in habitat amounts resulting from an alternative flow scenario can result in disproportionately large percentage differences when the unregulated Index B value is small. Note that on the graphs the solid and striped bars of the same color represent the tally for guilds/species with Index B values for unaltered flows that are greater than or less than 1000, respectively.

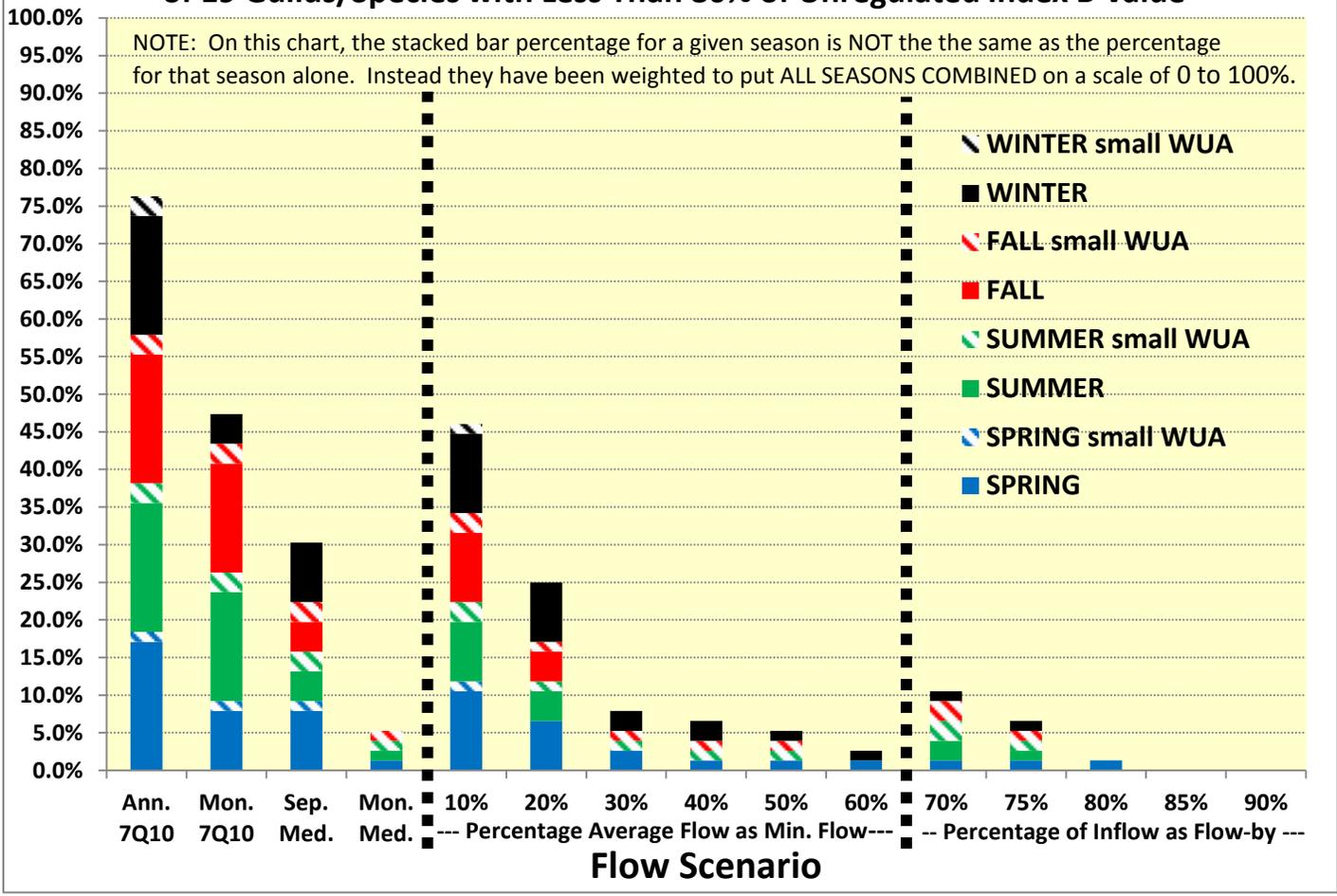
Calculations and Graphs

The Index B ratio is calculated as Index B for an alternate flow scenario divided by the Index B value for the unaltered flow scenario. If the ratio is <80% or >120% for a guild/species, it goes into a separate tally for each of the two thresholds.

Individual study site results (see example graph below):

1. First, the tally of guilds/species that are above or below the 80% and 120% thresholds is divided by the total number of guilds/species evaluated to determine the percentage affected. In this case the total number of guilds or species is 19, and this is the denominator in the percentage calculation. This is done separately for each of the four seasons.
2. To combine results for all four seasons onto a single graph, the percentage for each season is divided by 4 – giving each season equal weight – and all four seasons are shown on a stacked bar graph with a different color for each season.
3. Each individual season result is further broken down on the stacked bar graph into: the percentage that represents guilds with relatively low amounts of available habitat – Index B values < 1000 for the unaltered flow regime (the striped portions of the bar); and those with Index B values \geq 1000 for the unaltered flow regime (the solid portions of the bar).

Tar River, Louisburg site - Percentage (weighted equally for each season) of 19 Guilds/Species with Less Than 80% of Unregulated Index B Value



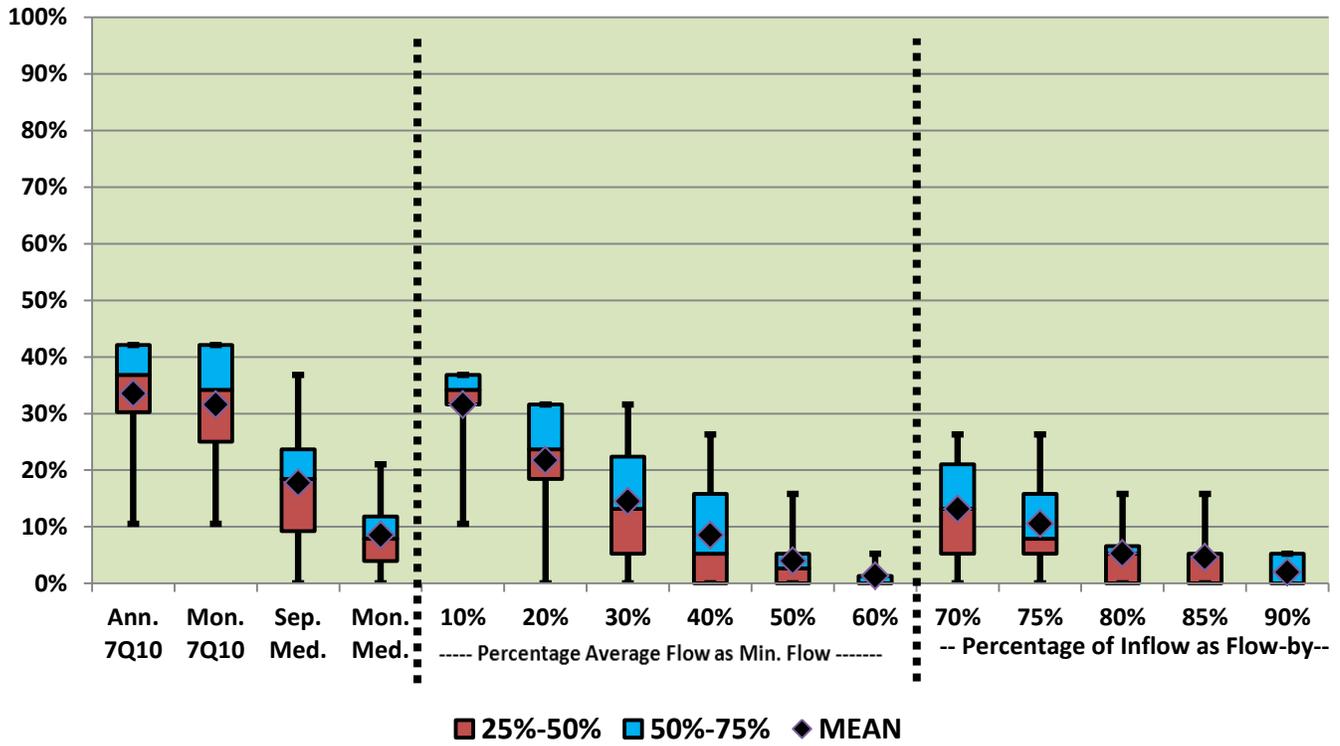
Study Sites Combined:

A description of the different study sites included in this analysis is included in a separate document.

Box Plots

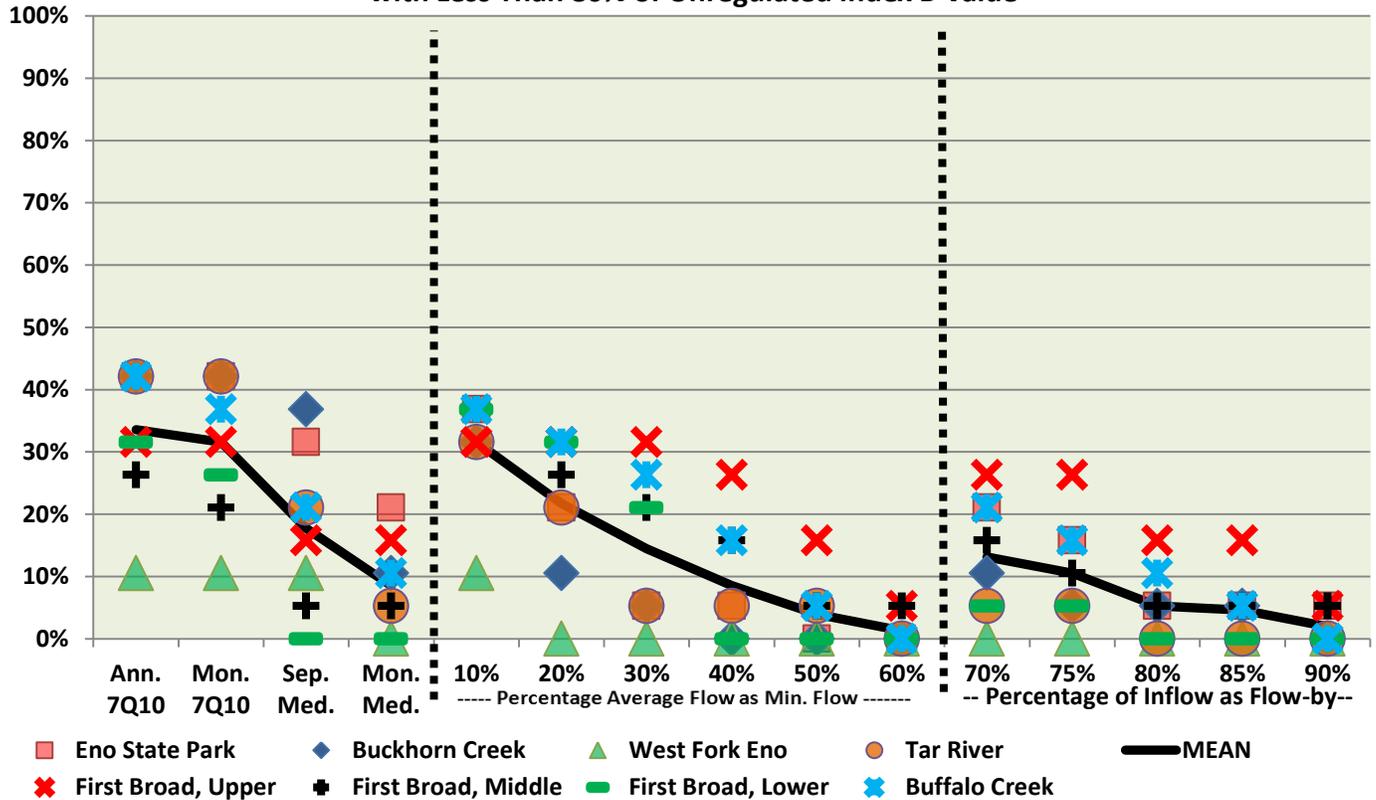
1. The results are divided into 8 guilds that are deep/slow, deep/fast or golden redhorse; and 11 guilds that are shallow/slow, shallow/fast, or benthic macro-invertebrates (mayflies, stoneflies, and caddis flies).
2. Tallies of guilds and species for which the Index B ratio is < 80% or > 120% of the value for the unaltered flow regime are determined separately for each site, and further subdivided into the group of 8 or 11 guilds. Percentages are recalculated using either 8 or 11 as the denominator, instead of the total of 19 guilds/species.
3. The results for all sites are shown as box/whisker plots showing the entire range (whisker), quartiles (blue and red boxes) and mean (black diamonds). See the example below.

FALL - Percentage of 8 Deep Guilds & Golden Redhorse with Less Than 80% of Unregulated Index B Value



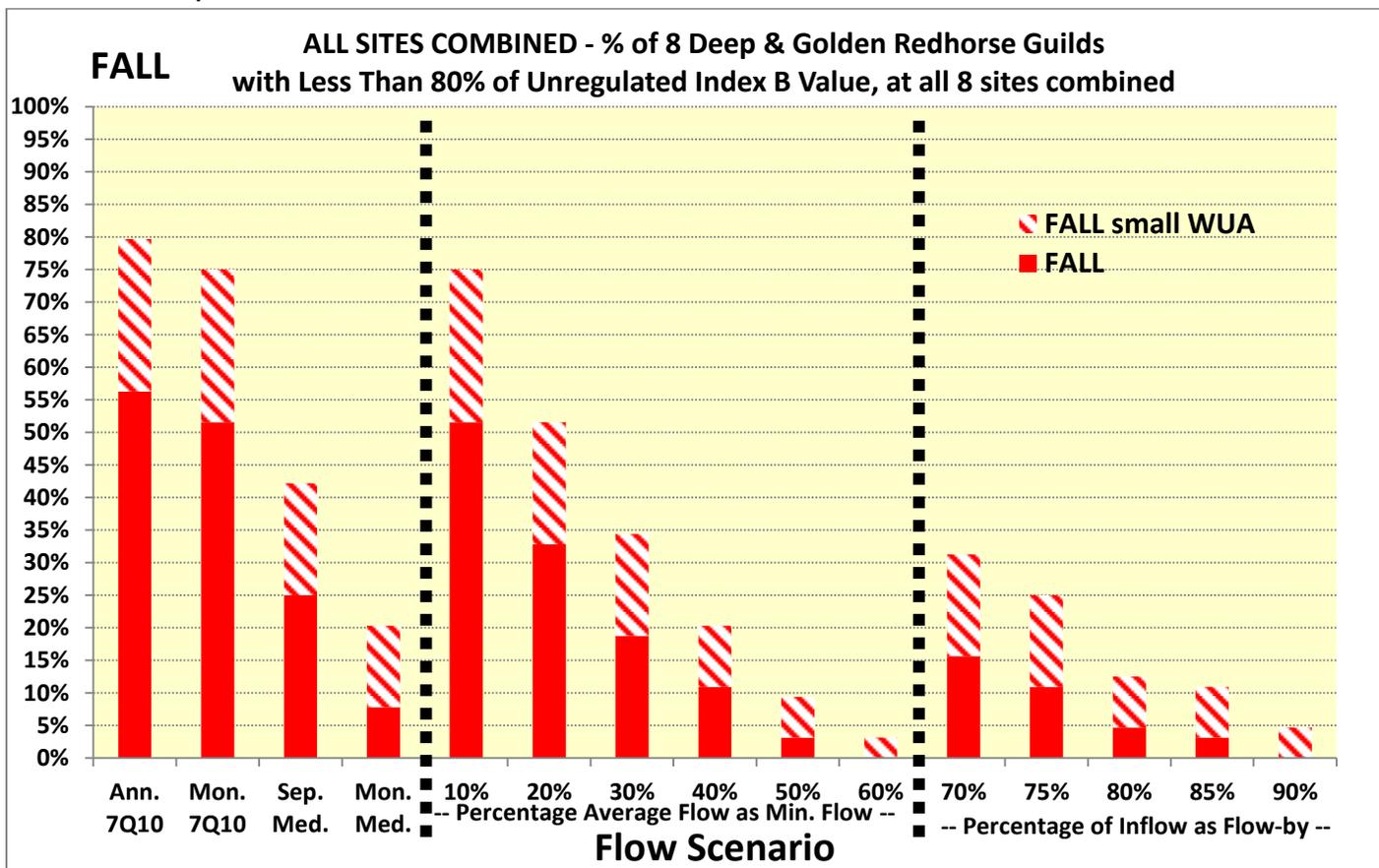
Results are also depicted with separate symbols for each study site, plus the mean (see below)

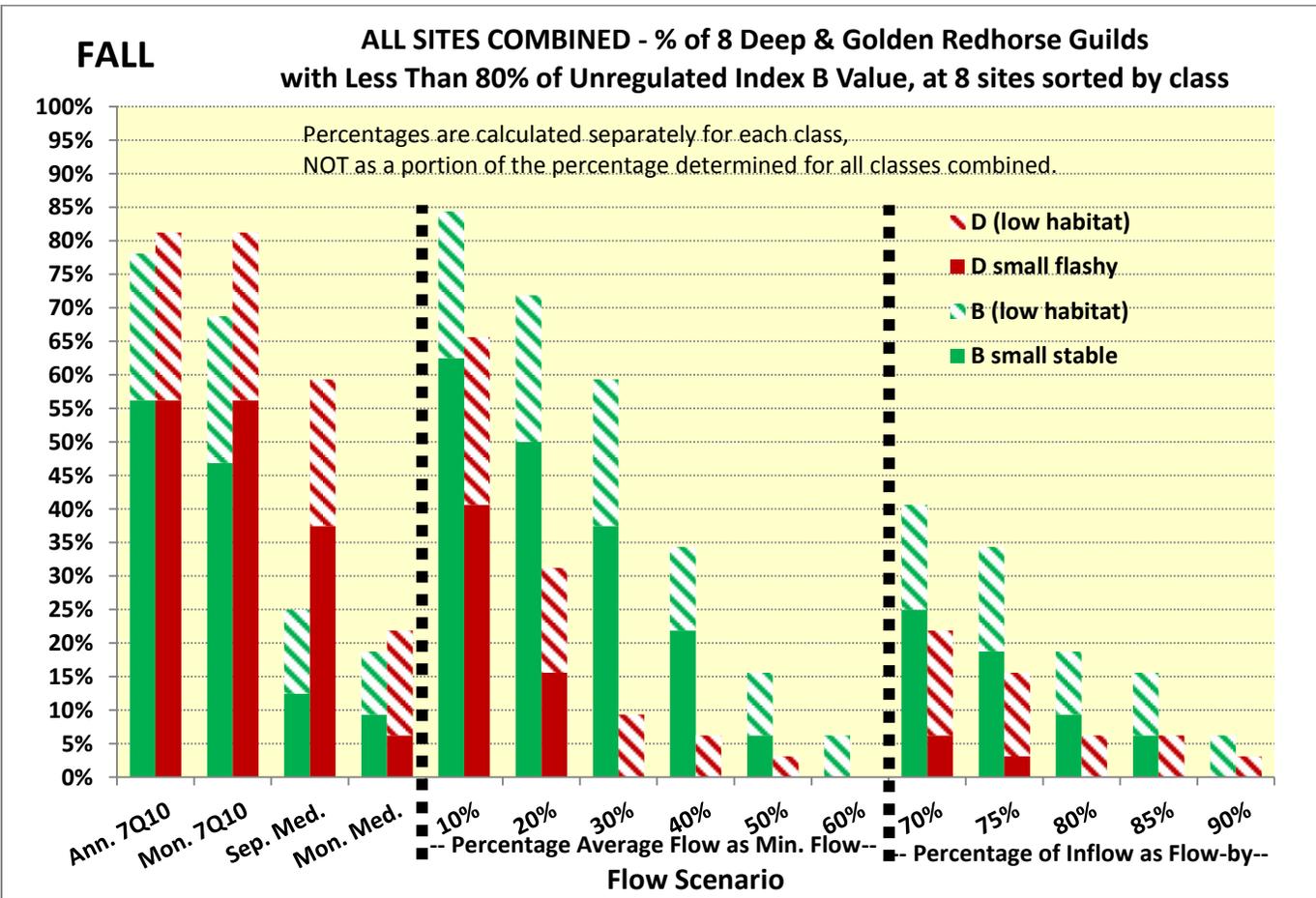
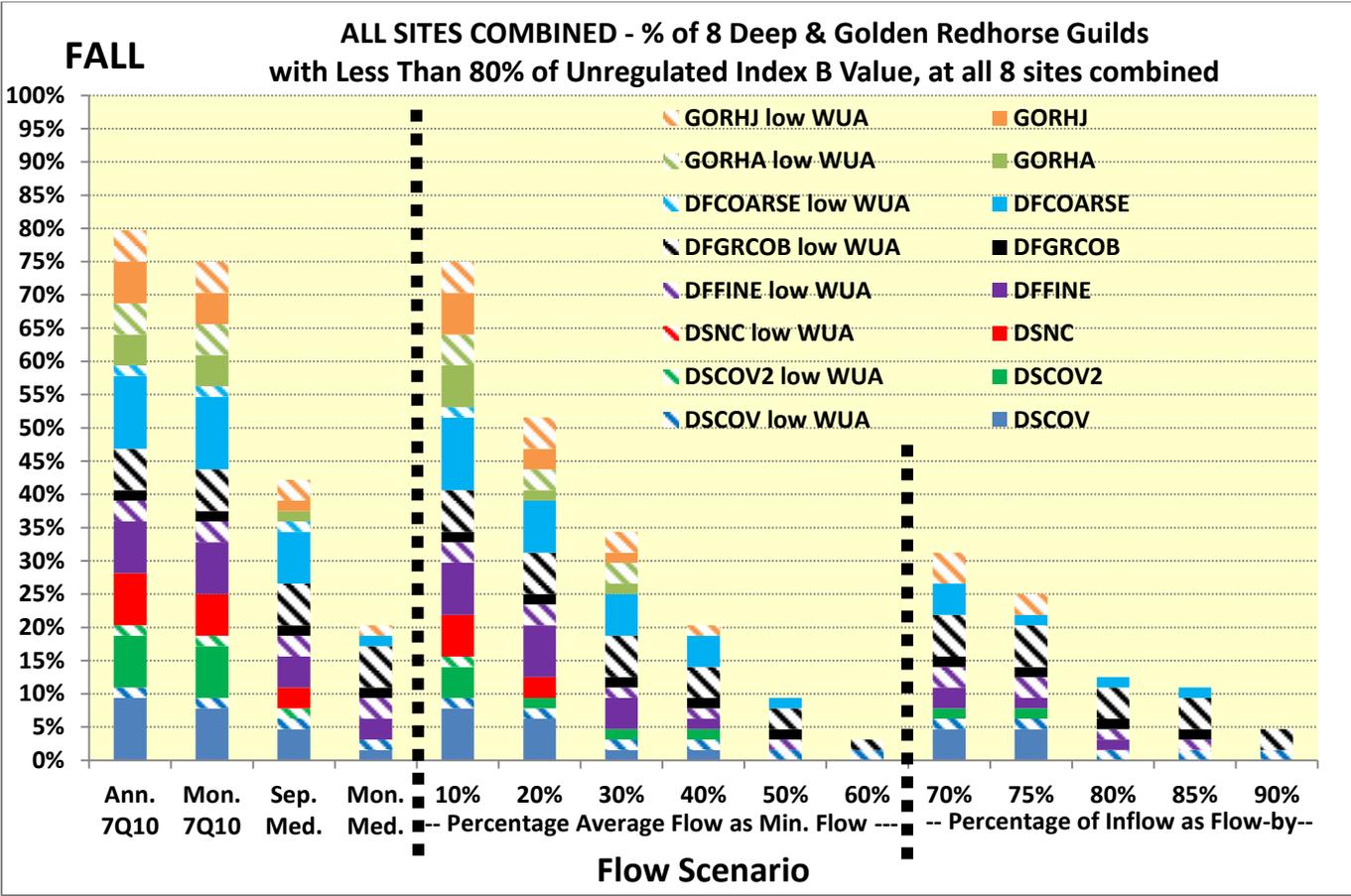
FALL - Percentage of 8 Deep Guilds & Golden Redhorse with Less Than 80% of Unregulated Index B Value



Seasonal Results for All Sites Combined

1. The tallies of species/guilds for which the Index B ratio is < 80% of the unaltered flow Index B value are added together for all sites.
2. The tally for the Index B ratio >120% was not evaluated, because other results indicated that this was less valuable for differentiating between flow alternatives.
3. As before, results were divided into two groups of guilds/species representing 8 deep and 11 shallow types.
4. As before, all graphs also use stacked solid and striped bars to differentiate between relatively low amounts of available habitat – Index B values < 1000 for the unaltered flow regime (the striped portion of the bar); and those with Index B values \geq 1000 for the unaltered flow regime (the solid portion of the bar).
5. Percentages were calculated by dividing the total tally for each season by the total number of guilds/species multiplied by the number of sites. For example, in the first graph below of all sites combined, the denominator is 64 – 8 deep guilds x 8 sites.
6. The second graph below shows the same results as the first, but further divided into the portions of the total tally represented by each of the guilds/species. As with the first graph, the denominator in this example is 64.
7. Another analysis and graph were completed which further subdivides the results by stream classification of the sites. Four of the sites were small flashy and four were small stable. For the last graph below, the percentages are calculated with a denominator of 32 – 8 deep guilds x 4 sites of each type. Because the percentages are calculated separately for each class, adding the percentages for the two classes together does not produce the same result as the single percentage for all classes combined





Guilds and Species Modeled

A table of abbreviations and descriptions of the guilds and species modeled is shown below. The 11 highlighted in yellow are the shallow guilds/species and the 8 highlighted in pale orange are the deep guilds/species. Those that are not highlighted may have been originally modeled for some sites but are not included in the consistent set of 19 guilds and species being used to analyze all sites.

abbreviation	organism	based on
SSYOY	shallow slow, young of year guild	bluehead chub YOY
SSVEG	shallow slow, aquatic vegetation cover guild	notch lip (formerly silver) redhorse YOY, veg cover
SSWOOD	shallow slow, woody debris cover guild	notch lip (formerly silver) redhorse YOY, woody cover
SSCOARSE	shallow slow, coarse substrate	generic
SSFINENC	shallow slow, fine substrate, no cover guild	redbreast sunfish spawning
SFLOWVEL	shallow fast lower velocity guild	marginated madtom adult
SFMODVEL	shallow fast moderate velocity guild	generic
SFHIVEL	shallow fast higher velocity guild	fantail darter adult
DSCOV	deep slow, cover guild	generic
DSCOV2	deep slow, cover guild version 2	redbreast sunfish adult
DSNC	deep slow, no cover guild	generic
DFFINE	deep fast, fine substrate guild	notch lip (formerly silver) redhorse adult
DFGRCOB	deep fast, gravel/cobble substrate guild	white bass spawning
DFCOARSE	deep fast, coarse substrate guild	shorthead redhorse adult
AMSS2	American shad spawning 2	Stier & Crance 1985
ROBRHS	Robust redhorse spawning	
GORHA	Golden redhorse adult	surrogate for Carolina redhorse
GORHJ	golden redhorse juvenile	surrogate for Carolina redhorse
AMSS4	American shad spawning 4	Hightower et al 2011
EPHEM	Mayfly nymph	Jim Gore
PLECO	stonefly nymph	Jim Gore
TRIC1	caddis fly larvae	Jim Gore
MACLR	Macro-invertebrate diversity, large river	Jim Gore