Appendix H

Instream Habitat Modeling in the Little Manatee River

Update using System for Environmental Flow Analysis (SEFA)

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DEFINITIONS

AWS – Area Weighted Suitability is an index of suitability in units of ft^2/ft. Although AWS is expressed in units of ft^2/ft, it is a weighted measure of habitat suitability, and not an area. The AWS is calculated by multiplying the CSI at each point by the proportion of the reach area represented by that point (i.e., the width and cross-section weight) and summing over the reach.

CSI – Combined Suitability Index. The suitability of the value of each variable is determined from the selected habitat suitability curves. The suitability varies between 0 (unsuitable) and 1 (ideal). The overall suitability of a point (CSI) is the product of the suitability of depth, velocity, and substrate (if applied). This means that if any suitability is zero then the point is unsuitable for that habitat use.

Habitat Suitability Group - These are taxonomic, functional, and life history groupings which each have their own habitat suitability curves for velocity, depth, and substrate/cover. Examples include Largemouth Bass spawning, which is a combination of species and a life history even, and the Slow-Shallow Habitat Guild, which describes a set of habitat characteristics shared by many species and life history stages.

Reach – Reaches consist of multiple sections.

Reach Habitat Curves – Curves relating Area Weighted Suitability on the y-axis to flow on the x-axis. The Reach Habitat Curve is the main outcome of the model, showing how the area weighted suitability (AWS) varies as a function of flow.

Section - A section is an individual transect run perpendicular to the direction of flow. Sections are subdivided into offsets, each with a depth, velocity, and calculated flow value. May also be referred to as cross-sections.

Site - Sites may consist of multiple sections. Sites may be considered individual “reaches” in SEFA.

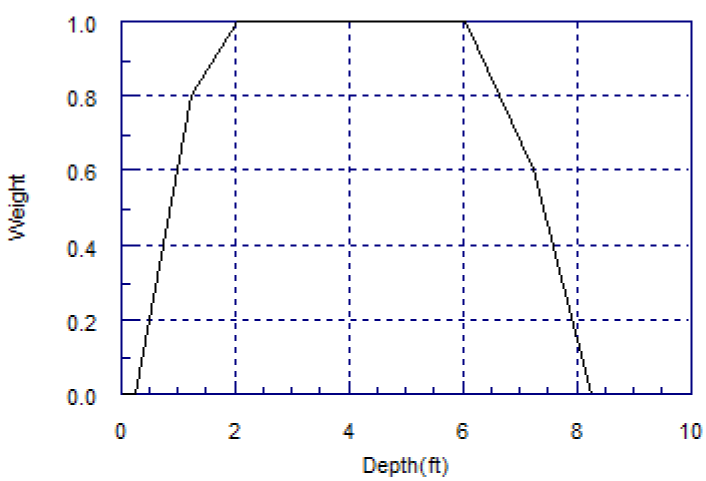
SEFA – System for Environmental Flow Analysis

INTRODUCTION

The objective of this analysis is to characterize the potential effects of flow reductions on a suitability index for instream habitat in the Little Manatee River. The District collected physical habitat data on substrate and cover and combined this with depth and velocity from HEC-RAS modeling to develop an area-weighted habitat index using the System for Environmental Flow Analysis (SEFA).

HABITAT SUITABILITY CURVES

Habitat suitability curves describe relative habitat suitability for species and life history stages (Figure 1). We used a set of 26 habitat suitability curves corresponding to species, life history stages, larger taxonomic groups of fish and arthropods, and habitat guilds (Table 1). These habitat suitability groups were selected based on known habitat use within the Little Manatee River (Nagid and Tuten 2020).



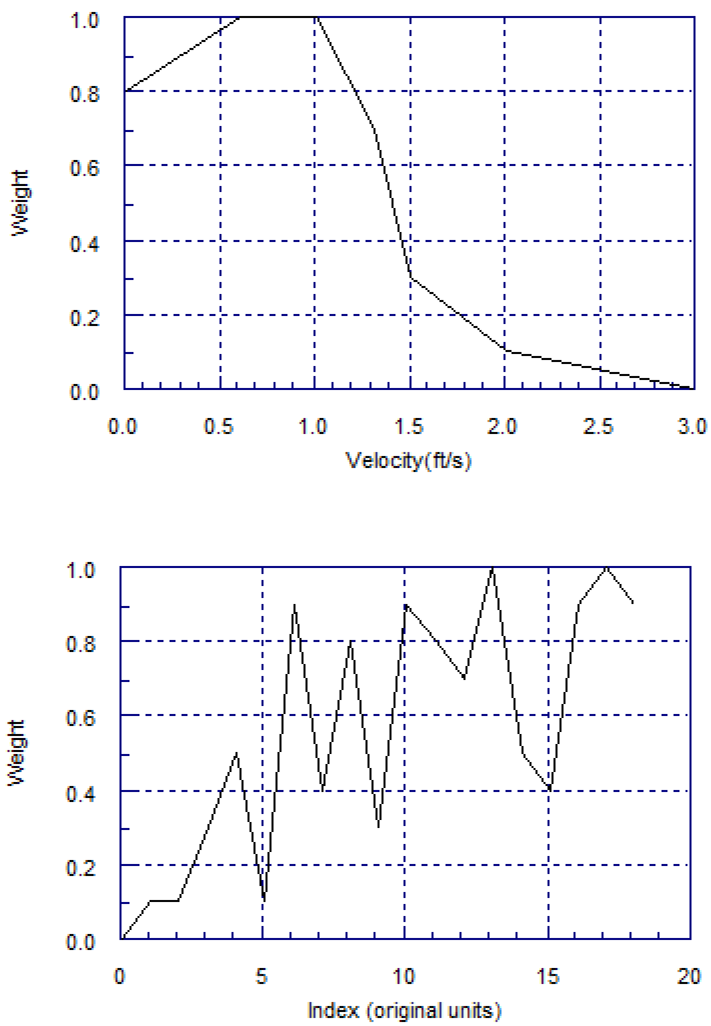


Figure 1. Habitat Suitability Curve examples from Redbreast Sunfish (*Lepomis auritus*) Adults. The bottom x-axis labled “Index (original units)” is substrate and cover coding.

Table 1. Habitat suitability group AWS curves used in this analysis with 4-letter abbreviations.

Taxonomy, life history, or functional group	ABV
Redbreast Sunfish - adult	RBSA
Redbreast Sunfish - juvenile	RBSJ
Redbreast Sunfish - spawning	RBSS
Redbreast Sunfish - fry	RBSF
Habitat Guilds - Shallow/Slow	HGSS
Habitat Guilds - Shallow/Fast	HGSF
Habitat Guilds -Deep/Slow	HGDS
Habitat Guilds -Deep/Fast	HGDF
Generic Darters - adult	GDAA
Ephemeroptera	EPHM
Plecoptera	PLEC
Tricoptera	TRIC
EPT Total	EPTT
Largemouth Bass - adult	LMBA
Largemouth Bass - juvenile	LMBJ
Largemouth Bass - spawning	LMBS
Largemouth Bass - fry	LMBF
Bluegill - adult	BLGA
Bluegill - juvenile	BLGJ
Bluegill - spawning	BLGS
Bluegill - fry	BLGF
Spotted Sunfish - adult	SPSA
Spotted Sunfish - juvenile	SPSJ
Spotted Sunfish - spawning	SPSS
Spotted Sunfish - fry	SPSF
Cyprinidae - adult	CYPA

DATA COLLECTION

Substrate and cover observations were made at 21 transects grouped into 7 sites on 7/29/2020 and 7/31/2020 (Table 2). Twenty-one (21) nearby sections were selected from the HEC-RAS model (Figure 2). Substrate and cover data were collected and recorded on field data sheets, which were then transcribed to electronic format (Figure 3). Substrate and cover were coded to match habitat suitability curve categories (Table 3). Velocities and elevations from HEC-RAS sections were matched to substrate and cover to generate SEFA input files. Input files were made for each site, which consisted of three sections each. Input files include: horizontal location along the transect -variously called “offset”, “interval”, and “station”; elevation or depth; velocity; and substrate/cover coding. In addition, input files contain information about each cross section including: rating curves, weighting, and stage at zero flow. See Jowet et al. (2017) for more information about options and general SEFA modeling methods.

Table 2. Locations of substrate/cover data collection. GPS coordinates are in degrees/minutes/seconds. Since water levels were at average/below average on survey days, water edge-to-edge widths were shorter than bank-to-bank widths above

Site	Section	Lat /N	Long/W	GPS Accuracy	Width (ft)
1	Upstream	27 39 52.2'	-82 17 59.4'	10'	32
1	Middle	27 39 52.0'	-82 17 59.5'	13'	37
1	Lower	27 39 51.4'	-82 18 00.0'	9'	40
2	Upstream	27 39 44.3'	-82 18 04.6'	10'	36
2	Middle	27 39 44.0'	-82 18 04.9'	7.5'	31
2	Lower	27 39 43.6'	-82 18 05.4'	8.5'	42
3	Upstream	27 39 42.4'	-82 18 13.1'	11.5'	41
3	Middle	27 39 42.0'	-82 18 13.5'	10'	51
3	Lower	27 39 41.8'	-82 18 13.9'	9'	42
4	Upstream	27 39 36.1'	-82 18 16.5'	15.5	42
4	Middle	27 39 35.7'	-82 18 17.0'	14'	45
4	Lower	27 39 35.6'	-82 18 17.6'	7	42
5	Upstream	27 39 34.7'	-82 20 45.2'	17	48
5	Middle	27 39 35.3'	-82 20 45.7'	10	55
5	Lower	27 39 35.4'	-82 20 46.1'	11	53
6	Upstream	27 39 48.8'	-82 21 00.2'	17	67
6	Middle	27 39 49.2'	-82 21 00.4'	12	60
6	Lower	27 39 49.5'	-82 21 07.7'	14	52
7	Upstream	27 39 58.7'	-82 20 59.1'	7	56
7	Middle	27 39 59.1'	-82 20 59.3'	8.5	64
7	Lower	27 40 00.0'	-82 20 59.0'	7.5	60

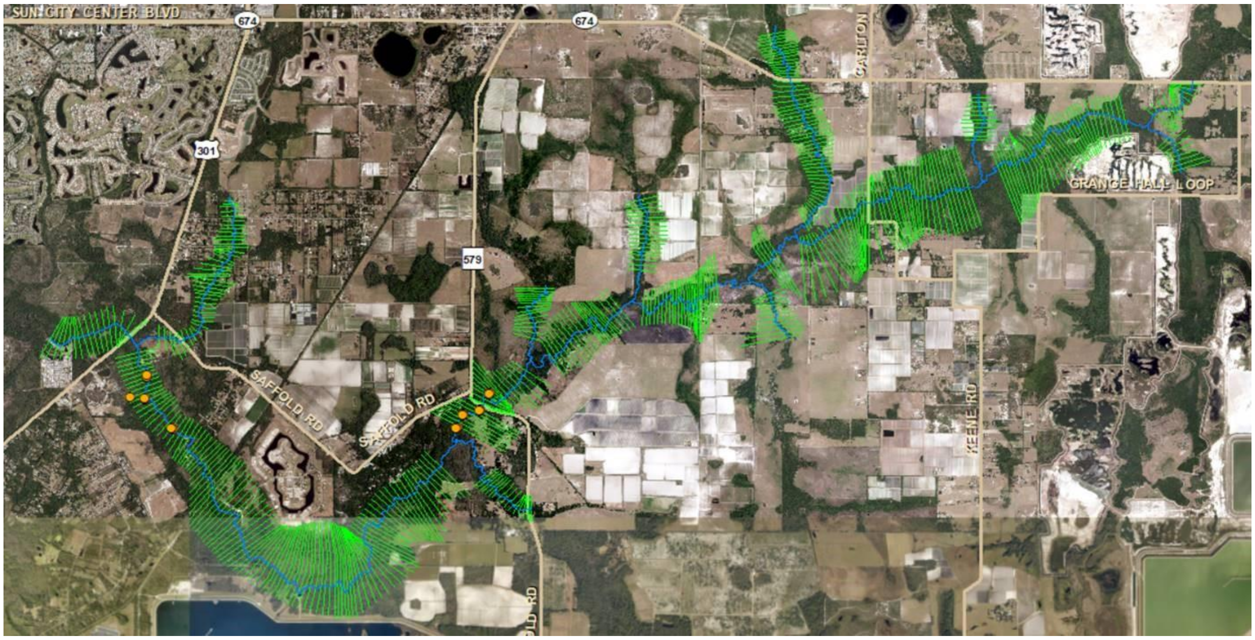


Figure 2. Location of substrate/cover sites (yellow circles) and HEC-RAS sections (green lines) along the Little Manatee River.

SEFA Field Data

Date:	7/29/2020	**Project**	Little Manatee River System
Time:	13:15	Page:	
Habitat Type:		TBM Used:	NA
Transect:	1 Lower	B.S. :	NA
		B.S.(2) :	NA
		Staff	KRH, GH, LY, JM
WS:	RB NA MID NA LB NA		
Slope:	WS up NA	Distance	NA
	WS dn NA	Distance	NA
Distance to next upstream transect	NA	Weight	NA
Comments:	Upstream of 579 Bridge, each transect ~50' apart		

		Substrate						Leaves/Wood				Vegetation						Cover		Comment	Substrate/Cover Code KRH	GH	LY	JDM	Group Consensus
INTERVAL(ft)	**F.S. (ft)**	**S**	**M**	**CL**	**R**	**GR**	**SH**	**LL**	**LP**	**ER**	**WD**	**TV**	**WV**	**SAV**	**FAV**	**AL**	**EV**	**OHC**	**PROX**						
0-3	Left Bank	X										X						X			8	8	8	8	**8**
3-9		X																X			17	17	17	17	**17**
9-15	9': Edge of Water	X																X			17	17	17	17	**17**
15-18		X									X							X			11	11	11	11	**11**
18-25		X																X			17	17	17	17	**17**
25-29		X									X							X			11	11	11	11	**11**
29-32		X																X			17	17	17	17	**17**
32-34	34': Edge of Water	X								X								X			11	17	11	11	**17**
34-36	Right Bank	X																X			17	17	17	17	**17**
36-40		X										X						X			8	8	8	8	**8**

Figure 3. Field substrate – cover data sheet example.

Table 3. Coding for habitat suitability of substrate and cover.

CODE	DESCRIPTION
0	**Delimiter**
1	No cover and silt **or** terrestrial vegetation
2	No cover and sand

3	No cover and gravel
4	No cover and cobble
5	No cover and small boulder
6	No cover and boulder, angled bedrock, or woody debris
7	No cover and mud or flat bedrock
8	Overhead vegetation and terrestrial vegetation
9	Overhead vegetation and gravel
10	Overhead vegetation and cobble
11	Overhead vegetation and small boulder, boulder, angled bedrock, or woody debris
12	Instream cover and cobble
13	Instream cover and small boulder, boulder, angled bedrock, or woody debris
14	Proximal instream cover and cobble
15	Proximal instream cover and small boulder, boulder, angled bedrock, or woody debris
16	Instream cover or proximal instream cover and gravel
17	Overhead vegetation or instream cover or proximal instream cover and silt or sand
18	Aquatic Vegetation – macrophytes
100	**Delimiter**

REACH HABITAT CURVES

Each site was treated as a sub-reach in SEFA, generating SEFA (*.rhbx) files for each, and then combined to model as a single reach with a single set of {*m*} reach habitat curves where {*m*} is the number of habitat suitability groups (Table 1). Methods for modeling multiple reaches is described in Jowett et al. (2017; section 5.4.2, p. 61; section 19.3.1, p. 117; section 19.5, pp. 121-123).

Site 1 was used as the reference reach, which means that flow values in the resulting reach habitat curves correspond to flows at the four upstream sites but internally account for higher flows at downstream sites (Figure 4). The AWS values in the combined reach habitat curves represent averages across all sites, with each site weighted evenly.

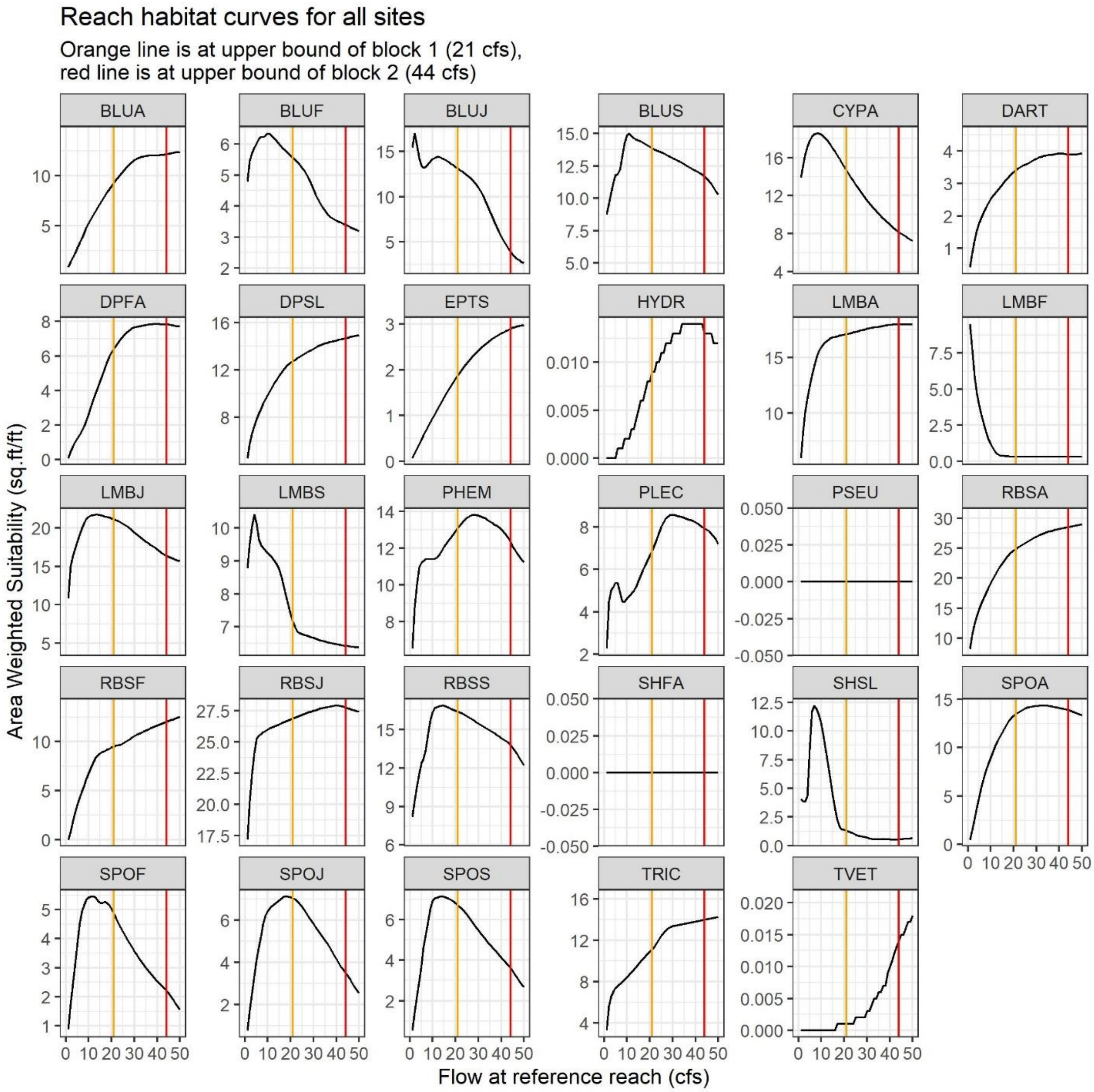


Figure 4. Reach Habitat Curves for all sites combined.

TIME SERIES ANALYSIS

Methods and Results

Flow percentiles were extracted from HEC-RAS model. Percentile values of flows at the downstream gage reach in HEC-RAS match those given in the 2017 draft report Table 5-1; these percentiles also match the daily flow record for the unimpacted flow scenario at the Wimauma gage (60th percentile at 72 cfs, 80th percentile at 174 cfs) (Table 4, Figure 5). Sites 5-

7 are located in the same HEC-RAS reach, and receive the same flow durations as the Wimauma gage. Sites 1-4 are in an upstream HEC-RAS reach, and all receive the same flow durations.

Percentile flows at the Wimauma gage and the reference reach were correlated in order to create a daily record of flows at the reference reach (Table 5, Figure 6). Flow timeseries were developed by JEI in 2017 and includes dates between 1939-04-01 and 2014-12-31 (Figure 7). The linear model in Table 5 was used to predict daily flows at the reference reach from the daily flow record at the Wimauma gage.

SEFA analysis was done within flow-based blocks. SEFA block 1 flows cover the 0 to 33rd percentile, which equals flows 1 to 21 cfs at the reference reach and 1 to 35 cfs at the gage reach (Table 4). SEFA block 2 flows cover 34th to 60th percentile flows, equaling >21 cfs to 44 cfs at the reference reach and >35 to 72 cfs at the Wimauma gage reach (Table 4). Flows above the 60th percentile were not included in SEFA analysis. Blocks were assigned to dates based on the baseline, unimpacted flow timeseries. In this way, each flow reduction scenario included the same set of dates in each block.

Reach habitat curves were imported to R from SEFA (Figure 4). Reach habitat curves were joined to flow timeseries to create reach habitat timeseries for each flow reduction scenario. Life-history stages dependent upon month of year had their timeseries filtered accordingly (Table 6).

Timeseries of AWS were condensed into median values for each habitat suitability group. Scenarios were compared, and maximum flow reduction scenarios were found corresponding to reductions in median values of less than 15% loss compared to the unimpacted scenario (Table 7). Medians are considered more appropriate than means as measures of central tendency when the distribution of values is skewed (Figure 8) (Zar 1999). Skewness (non-normality) can be observed in these density plots. Example results for Shapiro-Wilks test for DPFA habitat suitability from 2005 to 2014 ($W = 0.88818$, $p\text{-value} < 2.2e\text{-}16$) indicate statistically significant non-normality (Royston 1995).

Key Results

In block 1, the most sensitive habitat suitability group is the deep-fast habitat guild (DPFA) which experiences a 15% loss in median habitat associated with flow reductions greater than 10% (Table 7). In block 2, the most sensitive habitat suitability group is the ephemeroptera, plecoptera, and tricoptera (EPTS) which experiences a 15% loss in median habitat associated with flow reductions greater than 20%. The minimum flow recommendation based on this SEFA analysis is 10% for block 1 and 20% block 2, expressed as maximum allowable reductions from unimpacted flows.

Table 4. Percentile flows at the Wimauma gage (sites 5-7) and at the reference reach (sites 1-4).

Percentile	Wimauma Gage (cfs)	Reference Reach (cfs)	Block
0	1	1	1
10	17	10	1

20	25	15	1
30	32	19	1
33	35	21	1
40	40	24	2
50	53	32	2
60	72	44	2
70	105	64	--
80	174	105	--

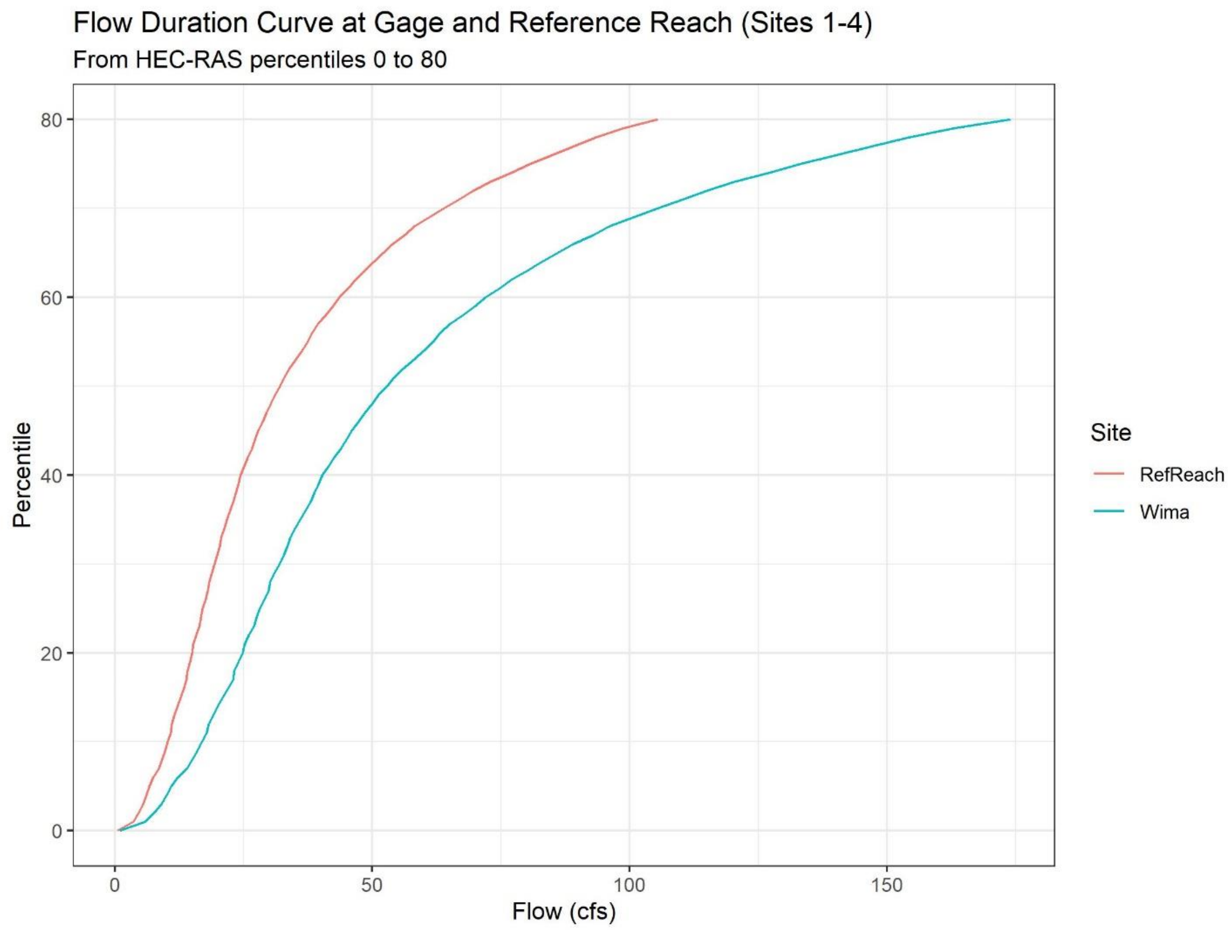


Figure 5. Flow duration curve for percentile flows at Wimauma gage and reference reach.

Table 5. Regression results for percentile flows at Wimauma gage and reference reach.

Call:
lm(formula = RepReach ~ Wima, data = Perc80)

```
Residuals:
      Min        1Q     Median        3Q       Max
-0.0004304 -0.0003835 -0.0002139  0.0002169  0.0020322

Coefficients:
            Estimate Std. Error   t value Pr(>|t|)
(Intercept) -2.142e-03  9.671e-05    -22.14   <2e-16 ***
Wima         6.062e-01  1.442e-06 420360.70   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0005217 on 79 degrees of freedom
Multiple R-squared:      1,      Adjusted R-squared:      1
F-statistic: 1.767e+11 on 1 and 79 DF,  p-value: < 2.2e-16
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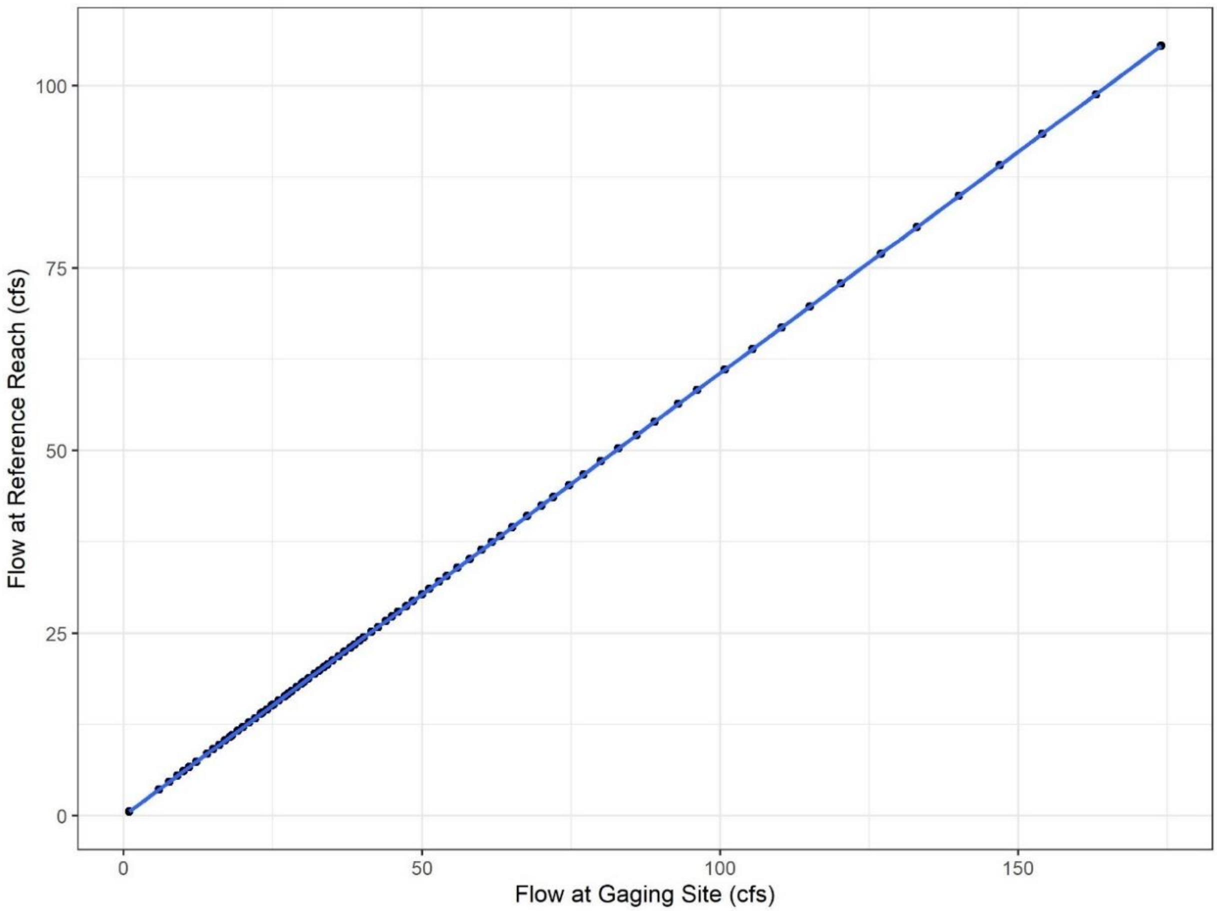

Figure 6. Regression results between flows at the Wimauma gage and at the reference reach (sites 1 through 4).

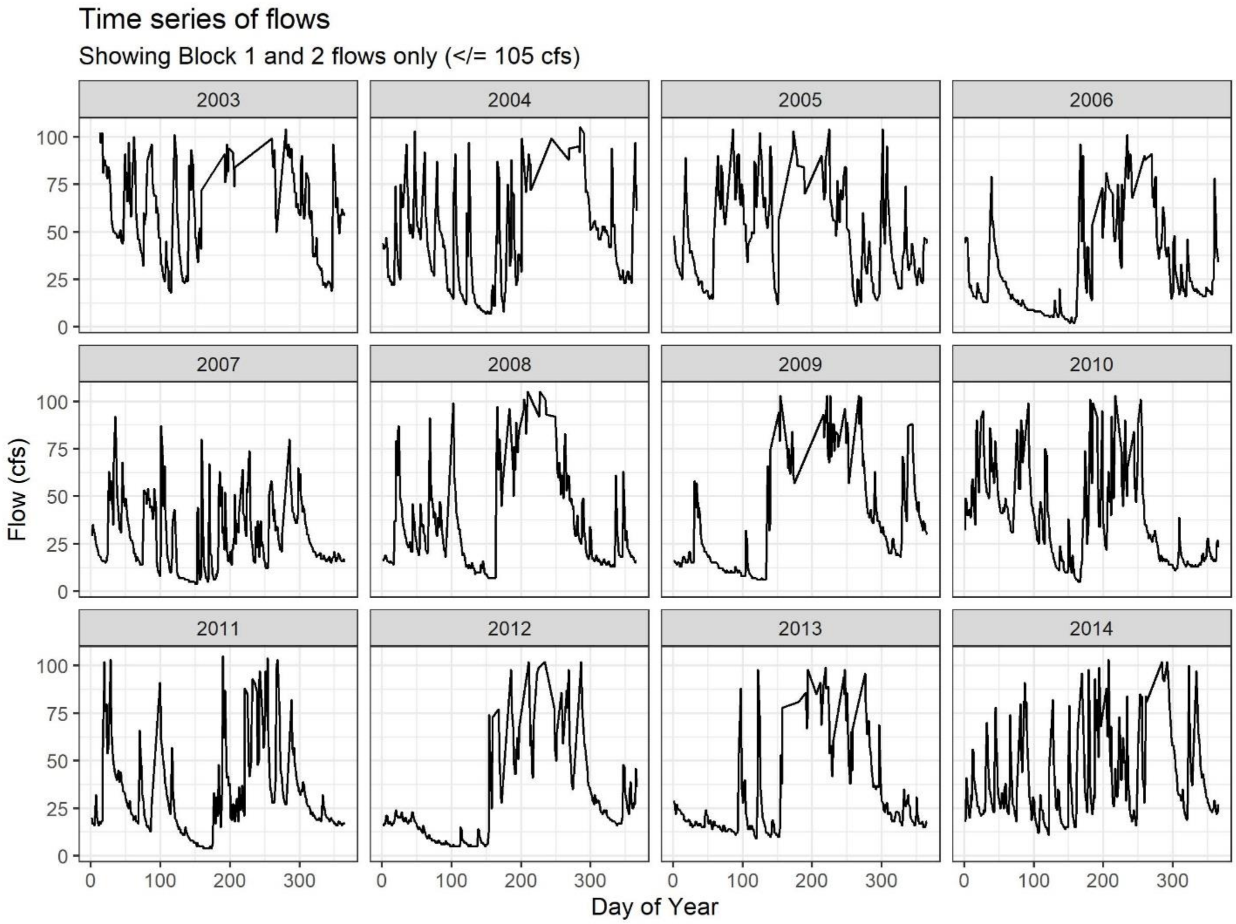

Figure 7. Timeseries of flows from 2003 to 2014. Baseline (unimpacted) record shown as developed in 2017. Shown is only a subset of full period of record. Blocks 1 and 2 are included here, all flows greater than 105 cfs are excluded from SEFA analysis and not shown in these plots. 105 cfs at reference reach equals 174 cfs at Wimauma gage.

Table 6. Months where each habitat suitability group is applied. Values = 1 indicate habitat is used during that month. Values = “NA” indicate habitat does not apply during that month for that group.

month	1	2	3	4	5	6	7	8	9	10	11	12
RBSA	1	1	1	1	1	1	1	1	1	1	1	1
RBSJ	1	1	1	1	1	1	1	1	1	1	1	1
RBSS	NA	NA	NA	1	1	1	1	1	1	1	1	NA
RBSF	NA	NA	NA	NA	1	1	1	1	1	1	1	1
SHSL	1	1	1	1	1	1	1	1	1	1	1	1
SHFA	1	1	1	1	1	1	1	1	1	1	1	1
DPSL	1	1	1	1	1	1	1	1	1	1	1	1
DPFA	1	1	1	1	1	1	1	1	1	1	1	1
DART	1	1	1	1	1	1	1	1	1	1	1	1
PHEM	1	1	1	1	1	1	1	1	1	1	1	1
PLEC	1	1	1	1	1	1	1	1	1	1	1	1
TRIC	1	1	1	1	1	1	1	1	1	1	1	1
EPTS	1	1	1	1	1	1	1	1	1	1	1	1
PSEU	1	1	1	1	1	1	1	1	1	1	1	1
HYDR	1	1	1	1	1	1	1	1	1	1	1	1
TVET	1	1	1	1	1	1	1	1	1	1	1	1
LMBA	1	1	1	1	1	1	1	1	1	1	1	1
LMBJ	1	1	1	1	1	1	1	1	1	1	1	1
LMBS	NA	NA	NA	1	1	1	NA	NA	NA	NA	NA	NA
LMBF	NA	NA	NA	1	1	1	1	NA	NA	NA	NA	NA
BLUA	1	1	1	1	1	1	1	1	1	1	1	1
BLUJ	1	1	1	1	1	1	1	1	1	1	1	1
BLUS	NA	NA	NA	1	1	1	1	1	1	NA	NA	NA
BLUF	NA	NA	NA	1	1	1	1	1	1	1	NA	NA
SPOA	1	1	1	1	1	1	1	1	1	1	1	1
SPOJ	1	1	1	1	1	1	1	1	1	1	1	1
SPOS	NA	NA	NA	1	1	1	1	1	1	1	1	NA
SPOF	NA	NA	NA	NA	1	1	1	1	1	1	1	1
CYPA	1	1	1	1	1	1	1	1	1	1	1	1

Table 7. Key results of SEFA analysis in blocks 1 and 2. Maximum allowable flow reductions are based on flow scenarios corresponding to greatest loss of habitat less than the threshold of 15%. positive change = net positive changes in habitat with flow reductions.

Habitat Suitability Group	Maximum allowable flow reduction (%)	
	Block 1	**Block 2**
DPFA	10	≥ 25
BLUA	17	24
EPTS	17	20
RBSF	22	≥ 40
SPOA	24	≥ 40
SPOS	≥ 25	positive change
DART	≥ 30	≥ 40
RBSA	≥ 30	≥ 40
BLUS	≥ 35	positive change
DPSL	≥ 35	≥ 40
RBSS	≥ 35	positive change
SPOJ	≥ 35	positive change
TRIC	≥ 35	≥ 25
LMBA	≥ 40	≥ 40
LMBJ	≥ 40	positive change
PLEC	≥ 40	≥ 25
PHEM	≥ 40	≥ 40
RBSJ	≥ 40	≥ 40
SPOF	≥ 40	positive change
BLUF, BLUJ, CYPA, LMBF, LMBS, SHSL	positive change	
HYDR, PSEU, SHFA, TVET	Excluded from analysis because there is less than 1 ft^2/ft AWS under unimpacted conditions	

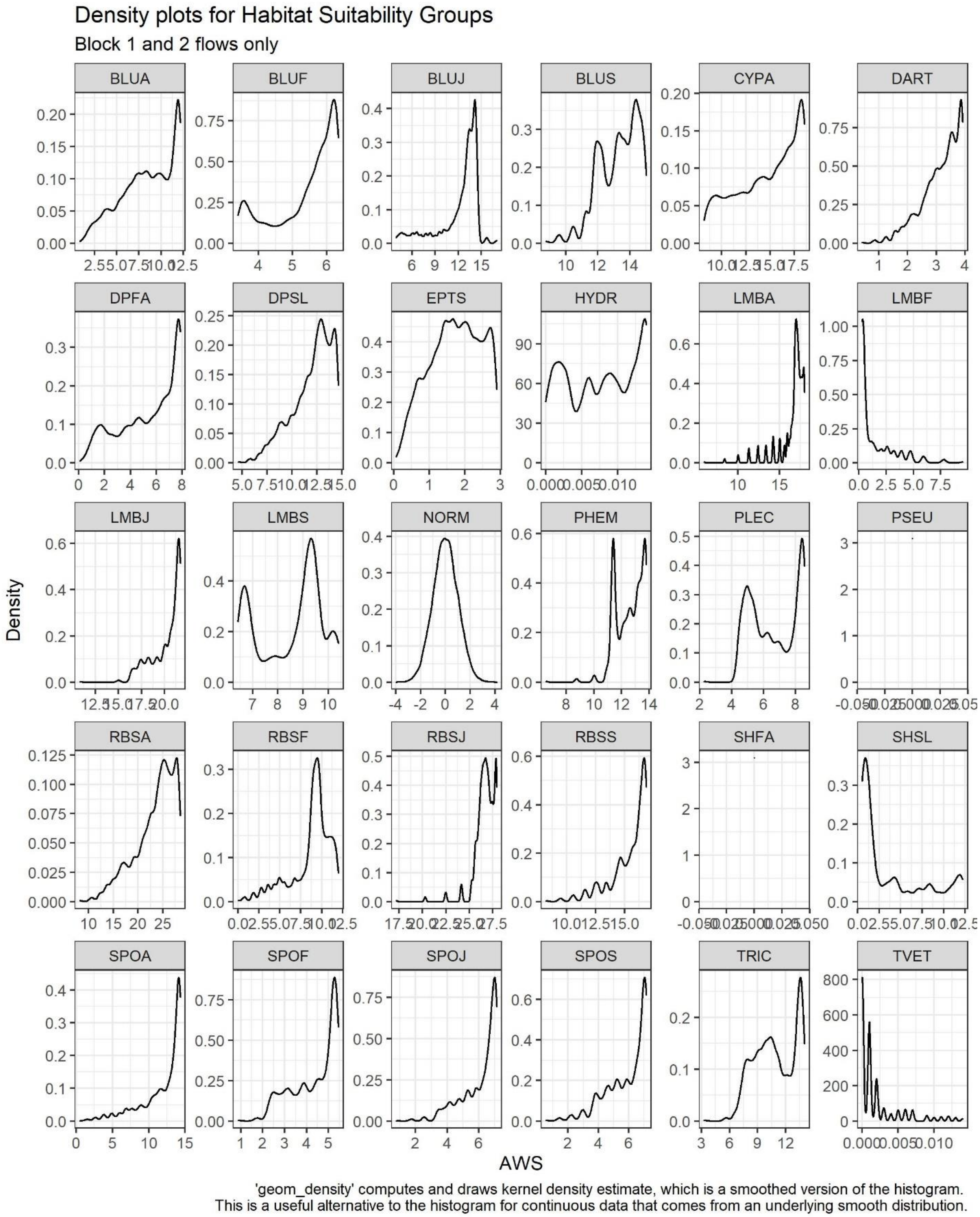

Figure 8. Density plots for habitat suitability groups show skewness in distribution of AWS over timeseries within block 1. NORM shows normal distribution for comparison. Skewness indicates medians are better metrics for central tendency than means.

DISCUSSION

Block 1 DPFA response

In block 1, the most sensitive habitat suitability group is the deep-fast habitat guild (DPFA) (Table 7). We might reasonably ask what is it about DPFA that causes it to be the most sensitive habitat suitability group in block 1? If we look at the reach habitat curve for DPFA in block 1, we can see a distinct decrease in AWS as flow decreases (Figure 4). A closer look at the DPFA response to depth and velocity shows peak suitability at 2.2 to 3.3 ft depth and 0.83 to 1.22 ft/s velocity (Figure 9).

To see how depth, velocity, and substrate/cover at individual cross sections varied in block 1, and how that variation matches the response of DPFA to flows, we can look at cross-section 1M, the middle of three cross sections at site 1, as an example. This cross section was chosen at random, not because it has any particular characteristics that make it more or less suitable for DPFA. A plot of depth at flows within block 1 shows depths of 1.33 ft at 21 cfs (lime green line) which is the upper limit of block 1 flows (Figure 10). The DPFA suitability curve for depth decreases from a peak at 2.2 ft to zero at 0.99 ft (Figure 9) which occurs at this cross section when flows drop below 14 cfs. This steep decline in suitability over the range of depths occuring within block 1 flows at this particular section (1M) help illustrate how the DPFA response to flow is sensitive within this block.

Likewise, we can look at velocity response of DPFA, which experiences a steep decline in suitability below 0.83 ft/s (Figure 9). Velocities in this cross-section peak at 0.182 ft/s (Figure 11), at which the suitability index is already below 0.25, but suitability does not fully reach zero until velocity reaches zero. The steep decrease in suitability in this part of the curve allows for sharp reductions in suitability along the cross section as flows decrease within block 1.

Of the 18 substrate/cover combinations described in the index corresponding to habitat suitability curves used (Table 3), seven were observed in the channel at the 21 sites surveyed (Table 8). The most important thing to look for are zero values because the three criteria (depth, velocity, and substrate/cover) are multiplied at each point to create a composite suitability index. Any zero values will automatically reduce composite suitability to zero. There are no zero values for DPFA among the 7 substrate/cover types seen. Although DPFA has a relatively low suitability at index 17, it is fairly suitable at index 2 (observed in 19% of points along all transects) and highly suitable at 15, 11, 6, and 18, which sum to 29% of all points.

Substrate and cover do not change directly with flow in the same way that depth and velocity will. However, depth and velocity can change at points with critical substrate and cover values, which makes it important that suitable substrate and cover types are well represented throughout the transects sampled. We see that this is the case for the DPFA substrate/cover coding.

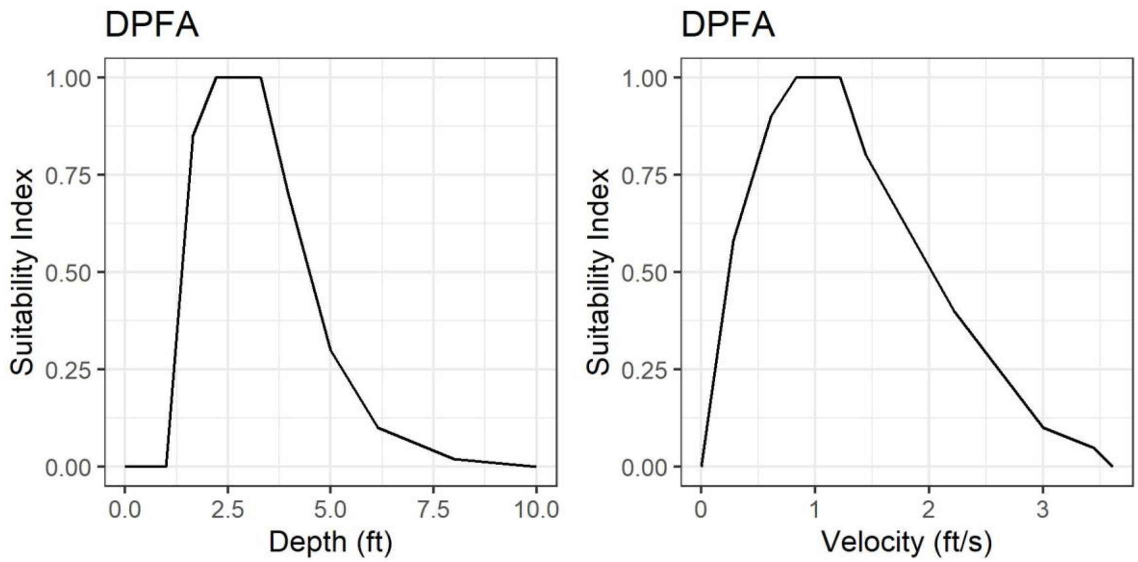

Figure 9. Depth and velocity suitability curves for DPFA show peak suitability at 2.2 to 3.3 ft depth and 0.83 to 1.22 ft/s velocity.

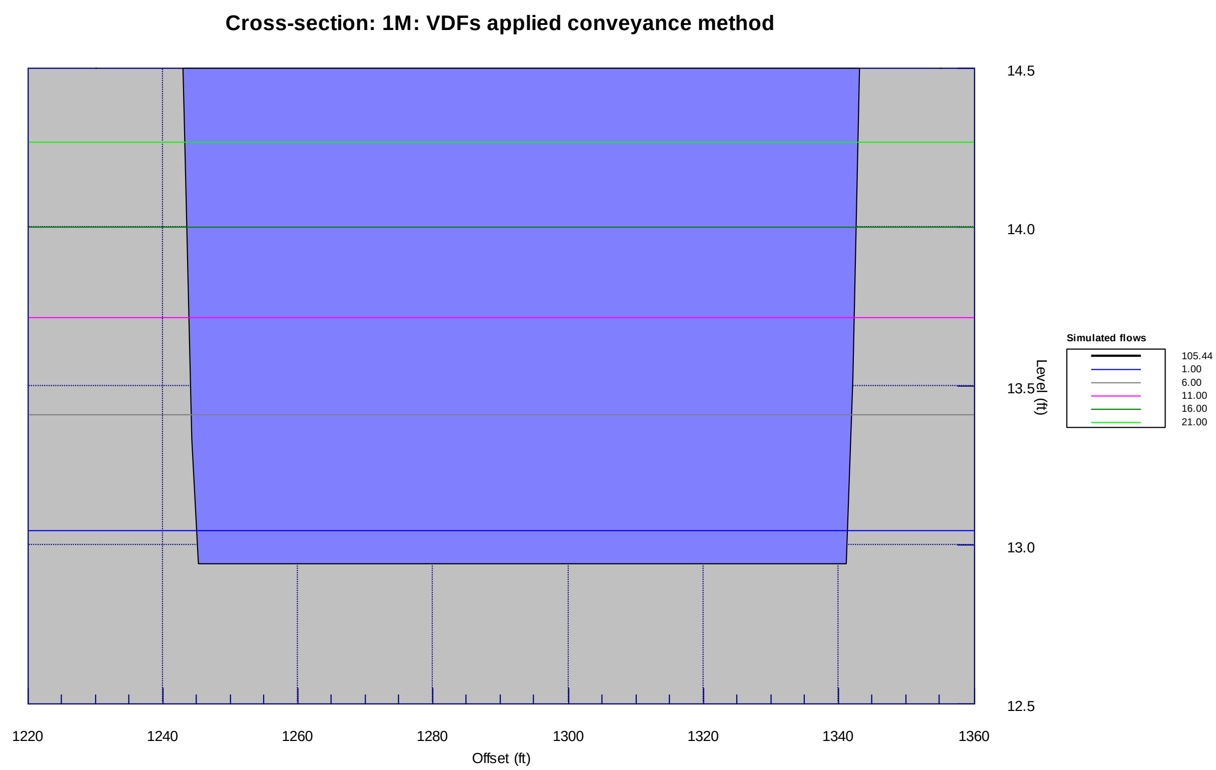

Figure 10. Depth response to flow change in block 1 at cross-section 1M.

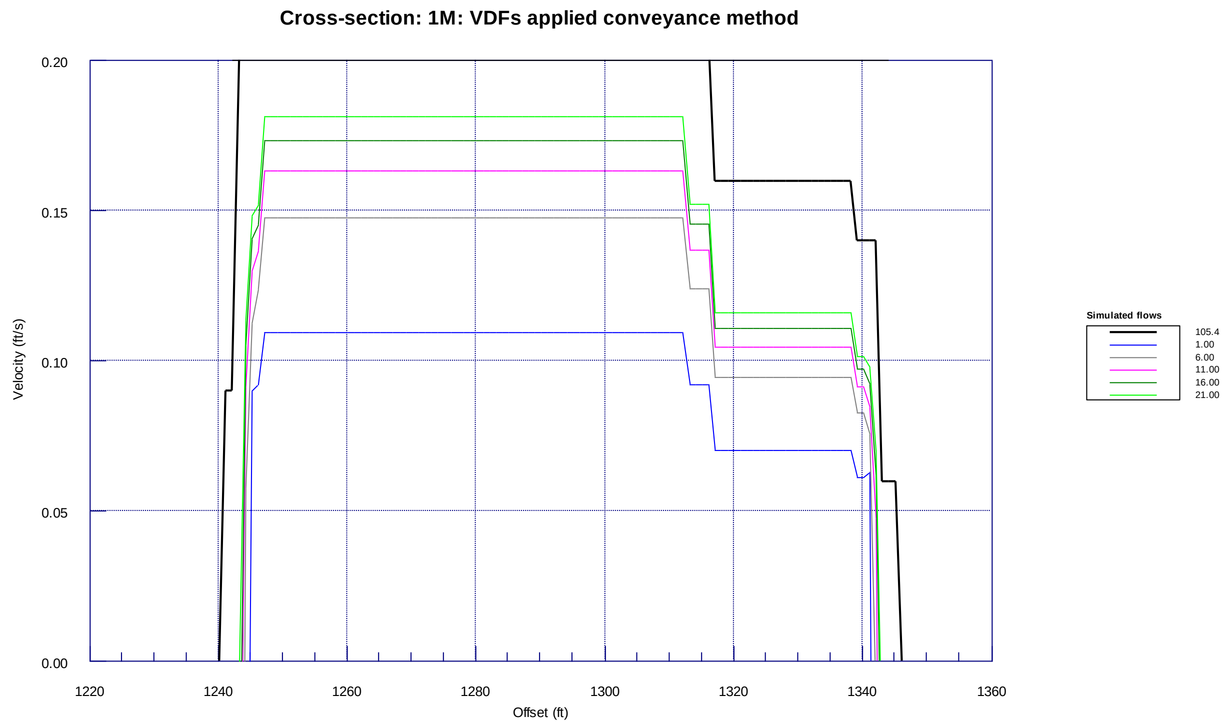

Figure 11. Velocity profile at section 1M for block 1.

Table 8. Frequency of substrate/cover index values within channel across all transects. Substrate and cover were observed at 1ft intervals across all transects. Frequency represents the frequency of all 1ft intervals where each substrate/cover index was observed.

Index	Frequency	Cumulative Frequency	DPFA Suitability	EPTS Suitability
17	0.50	0.50	0.1	0.34
2	0.19	0.69	0.3	0.34
15	0.13	0.82	1	0.48
11	0.12	0.94	1	0.25
6	0.04	0.98	1	0.05
18	0.02	> 0.99	1	0.8
8	< 0.01	1.00	0.5	0.1

Block 2 EPTS response

Within block 2, the most sensitive habitat suitabilty group is the combined ephemeroptera, tricoptera and plecoptera group (EPTS) (Table 7). As with DPFA above, we might reasonably ask what is it about EPTS that causes it to be the most sensitive habitat suitability group in block 2? If we look at the reach habitat curves, we can see that AWS continues to rise through block 2 for EPTS, while for DPFA, AWS peaks and levels out (Figure 4). A closer look at the EPTS response to depth and velocity shows peak suitability at 3 ft depth and 2 ft/s velocity with steady declines as each approach zero (Figure 12).

As above, we will look at cross section 1M during block 2 flows to see how depths and velocities in this example cross-section vary over the range of flows experienced within block 2 (22 to 44 cfs). At the high end of block 2 (44 cfs), depths are 2.46 ft, while at the low end of block 2 at 22 cfs, depth is 1.38 ft (Figure 13). Both of these values occur along the part of the EPTS depth curve that shows a steep deline in suitability as depth decreases from 2.46 ft to 1.38 ft (Figure 12). Therefore, it makes sense that reductions in flows across this range results in reductions in AWS for this habitat suitability group based on this depth habitat suitability curve.

Likewise, peak velocity at 44 cfs is 0.204, and at 22 cfs it is 0.183 (Figure 14). Both of these values are well below the peak suitabilty for EPTS, but nontheless there is a decline in suitability assocated with a decrease from 0.204 to 0.183 (Figure 12). This steep slope in the velocity habitat suitability curve is consistent with the sensitive response for AWS over this flow range.

Lastly, looking at substrate and cover, we see the suitability index for EPTS shows moderate values across the board, with intermediate values for 17, 2, 15, and 11, which account for 94% of all points surveyed (Table 8). Of particular note is the habitat code 15, which represents woody debris: this is the most favored habitat for EPTS and is the third most common habitat type, occupying 13% of all transect points. Therefore, the substrate and cover requirements of EPTS are widely available across sites, and therefore the decreases in velocity and depth associated with reduced flows will take place in habitats that are suitable for EPTS.

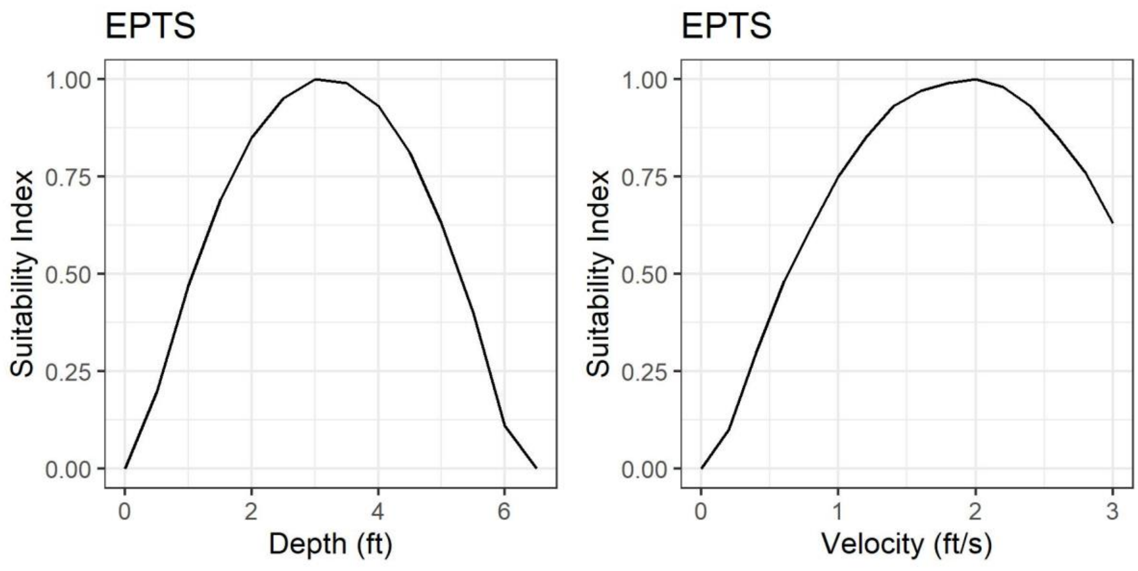

Figure 12. Depth and velocity suitability curves for EPTS shows peak suitability at 3 ft depth and 2 ft/s velocity with steady declines as each approach zero.

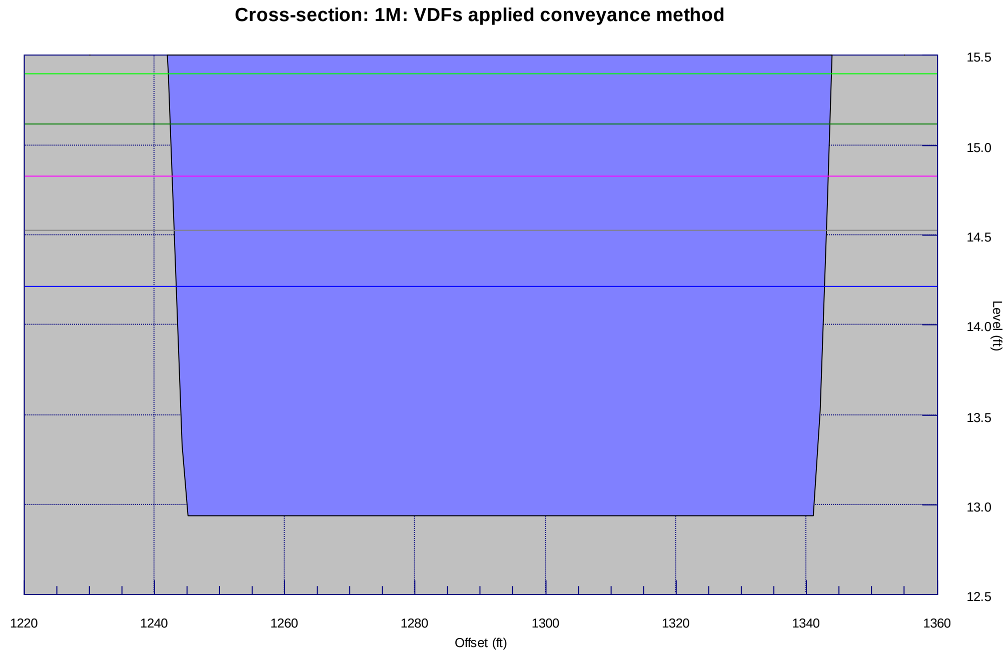

Figure 13. Depth response to flow change in block 2 at section 1M. Horizontal lines indicate simulated flows at reference reach: blue = 20 cfs, gray = 26 cfs, magenta = 32 cfs, dark green = 38 cfs, light green = 44 cfs.

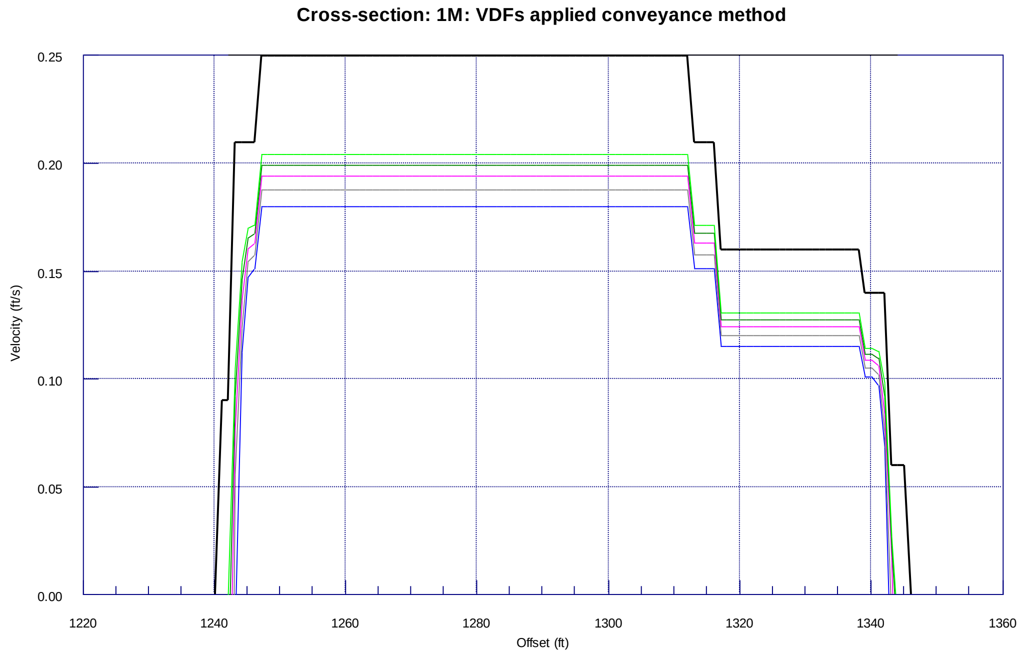

Figure 14. Velocity response to flow change during block 2 at section 1M. Velocity profiles are shown at variable simulated flows: blue = 20 cfs, gray = 26 cfs, magenta = 32 cfs, dark green = 38 cfs, light green = 44 cfs.

Synthesis

Upon further review of reach habitat curves, which describe the area weighted suitability response across all seven sites; the habitat suitability curves, which describe the response of the most sensitive habitat suitability groups (DPFA in block 1 and EPTS in block 2); and the range of depths and velocities at 1M as an example cross-section; we can see how the physical habitat characteristics of this river vary with flows, and how those variations in turn affect the habitat suitability for these most sensitive groups. This reasoning provides an intuitive explanation for how the DPFA and EPTS habitat suiatiliby groups respond to changes in flow.

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