Upper Peace River SEFA Modeling Report

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4/16/2025

Introduction

Instream habitat is included in the ten environmental values in the water resource implementation rule (62-40.473, Florida Administration Code) as “fish and wildlife habitats and the passage of fish”. Fish, including game fish, non-game fish, and the invertebrates that support the ecosystem have specific requirements for water depth, velocity, and qualitative aspects of the environment including substrate type (e.g. sand, mud), and presence of cover such as large woody debris. Instream habitat modeling combines field measurements with hydraulic equations to predict changes to habitat under modified flow regimes.

Habitat is the resources and conditions present in an area that produce occupancy, including survival and reproduction, by a given organism (Hall et al. 1997). The resources and conditions present include various physical, chemical, and biological aspects which can vary continuously across a wide range of quantifiable values, and/or be discrete or qualitative in nature. Water depth and velocity are continuous, quantifiable metrics that can be measured in the field and modeled as part of alternative flow regimes. In addition, qualitative habitat variables including fallen logs, vertical and overhanging banks, and vegetated shorelines are differentially inundated as flows advance and recede along the streambed and floodplain.

The System for Environmental Flows Analysis (SEFA) software package offers a flexible modeling framework for quantifying changes to the habitat of fish and other stream life in response to changing flow regimes (Jowett et al. 2020, Aquatic Habitat Analysts, Inc. 2021). The SEFA software is capable of analysis identical to PHABSIM or Physical Habitat Simulation (Milhous and Waddle 2012), which was commonly used in past minimum flows analysis by the District, and offers options for analysis in addition to PHABSIM methods. SEFA models the effects of flow on depth, velocity, and inundation of qualitative habitat features to predict overall habitat suitability under varying flow regimes.

Because habitat includes all the conditions present, it can be characterized in a stream by measuring water depths and velocities and reporting presence of qualitative habitat aspects in cross-sections perpendicular to flow (Figure 1). Habitat suitability is quantified individually for species, life history stages, and habitat use guilds as indices where suitability is scaled from zero (unsuitable) to one (most suitable) (Nestler et al. 2019). The Florida Handbook of Habitat Suitability Indices provides a list of habitat suitability indices appropriate for use in Florida and describes the history of their development (Nagid 2022). These indices relate water depth, velocity, and qualitative aspects - presence of wood, sediment characteristics, and other discrete characteristics - to relative suitability for occupancy (Figure 2). SEFA uses habitat

suitability indices, along with depth, velocity and inundation of qualitative aspects to calculate habitat suitability at discrete intervals in a cross section as a combined suitability index (i.e., the combination of depth, velocity, and qualitative aspects). Furthermore, those combined suitability indices at each interval are weighted by the area of the cross section they represent and averaged to create an area-weighted suitability index (AWS). The AWS can be summed across numerous cross sections to provide a metric of total habitat suitability for a species within a reach of a stream. The ultimate output of SEFA is an AWS-flow relationship for each species (or life history stage or habitat guild) that relates a combined, area-weighted, average index of habitat suitability (AWS) to flow, where each value of flow has a corresponding habitat suitability (AWS) value. These habitat suitability (AWS) flow relationships can then be used to convert time series of flows into time series of habitat suitabilities and compared between alternative flow regimes.

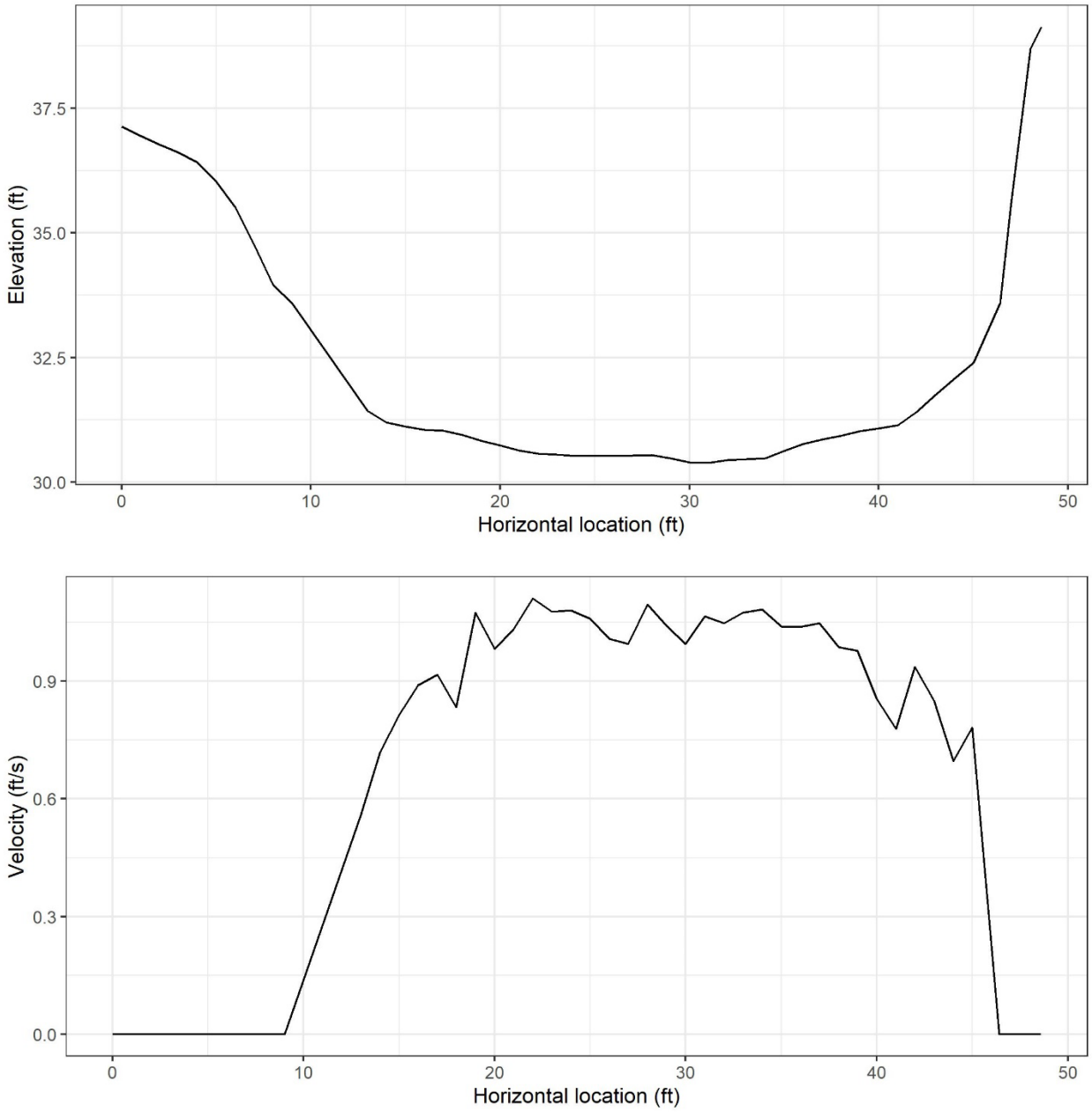

Figure 1. Example cross section profile of depth and velocity from field observations.

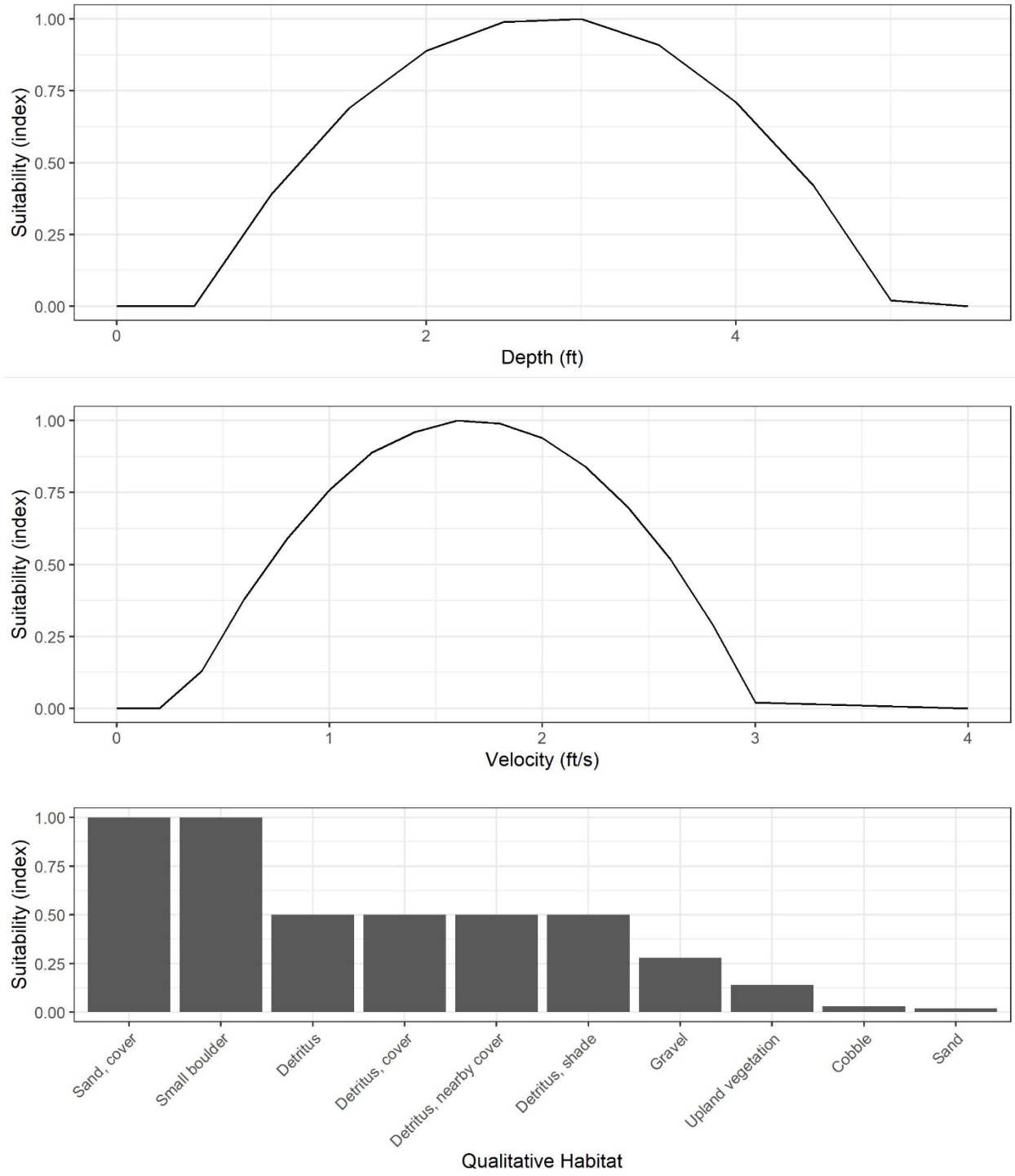

Figure 2. Example of habitat suitability curves for net-spinning caddisflies (Hydropsychidae).

Site Selection and Data Collection

Data collection was performed by HSW-Verdantas (2021) at a subset of sites selected by District Staff based on known locations of shallow shoals. Data collection occurred at 9 sites, dispersed between the USGS gage at Bartow at the upstream end and the USGS gage at Zolfo Springs at the downstream end of the Upper Peace River (Figure 3). Each site consisted of three transects: a shallow shoal, a deep pool, and a run with intermediate depth.

Sites were selected to evenly represent three main river reaches: Bartow to Fort Meade (Figure 4), Fort Meade to Bowling Green (Figure 5), and Bowling Green to Zolfo Springs (Figure 6) (Table 1). Data were collected on 25 dates from 9/1/2021 through 2/1/2023 (Table 2). These data collection events were chosen to represent low, medium and high flows which are used to create stage-flow rating curves for each cross section.

Data included substrate and cover descriptions, relative elevations of sediment surface, water surface elevations at left bank and right bank looking downstream, and depth-averaged velocity at a minimum of 20 wetted intervals and on dry land from top of left bank to top of right bank. In smaller channels and at edges of larger channels, velocity was measured with a handheld acoustic doppler velocimeter at six-tenths depth when depths are less than 1.5 ft or at two-tenths and eight-tenths depth when depths are greater than or equal to 1.5 feet (Turnipseed & Sauer, 2010). Where feasible, velocity was measured with ADCP and depth average velocity calculated with RiverSurveyor Live software.

This analysis uses all 32 species, life history stages, and guilds recommended for use in the Peace River basin by the Florida Handbook of Habitat Suitability Indices (Table 3) (Nagid 2022).

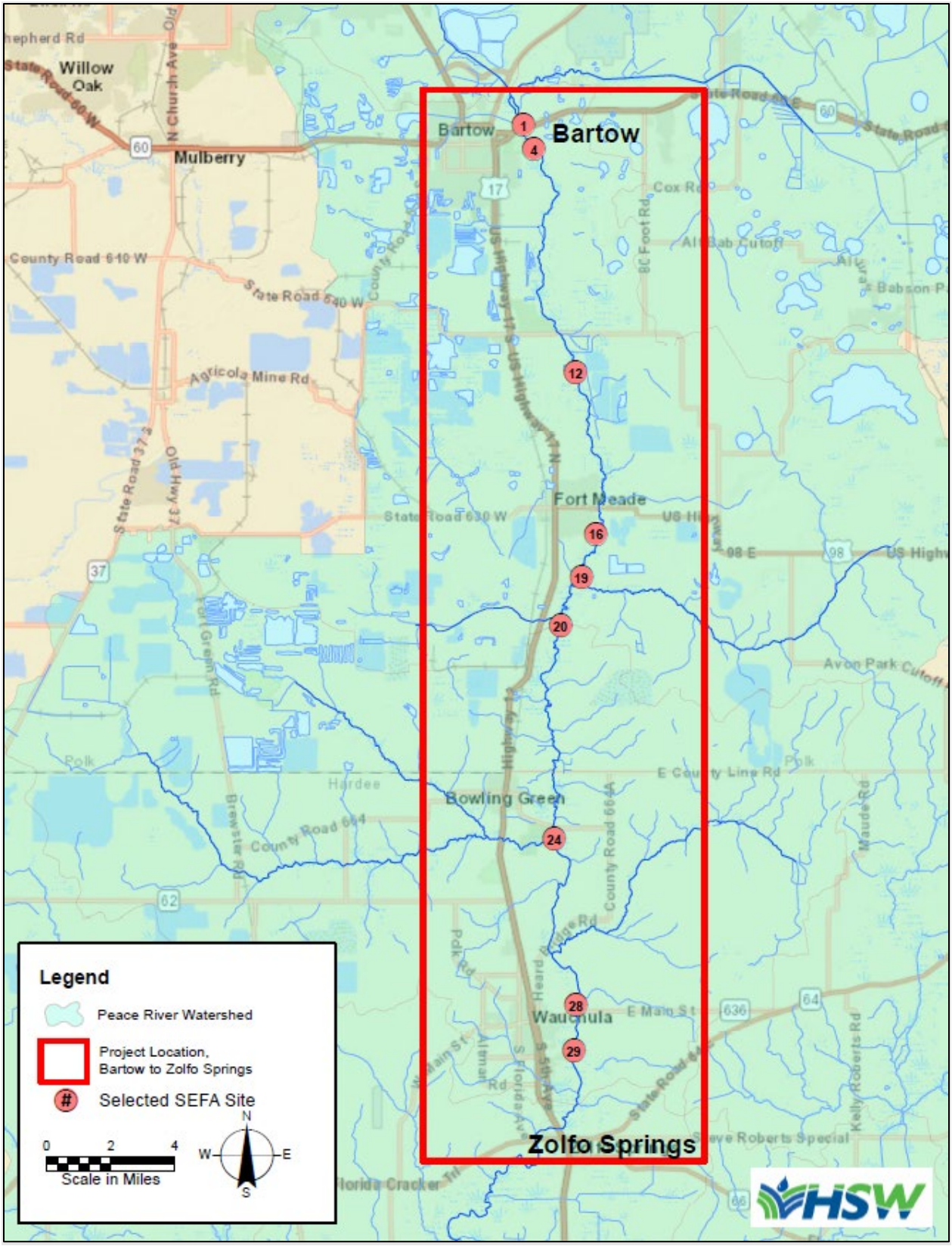

Figure 3. Locations of nine SEFA data collection sites in the Upper Peace River.

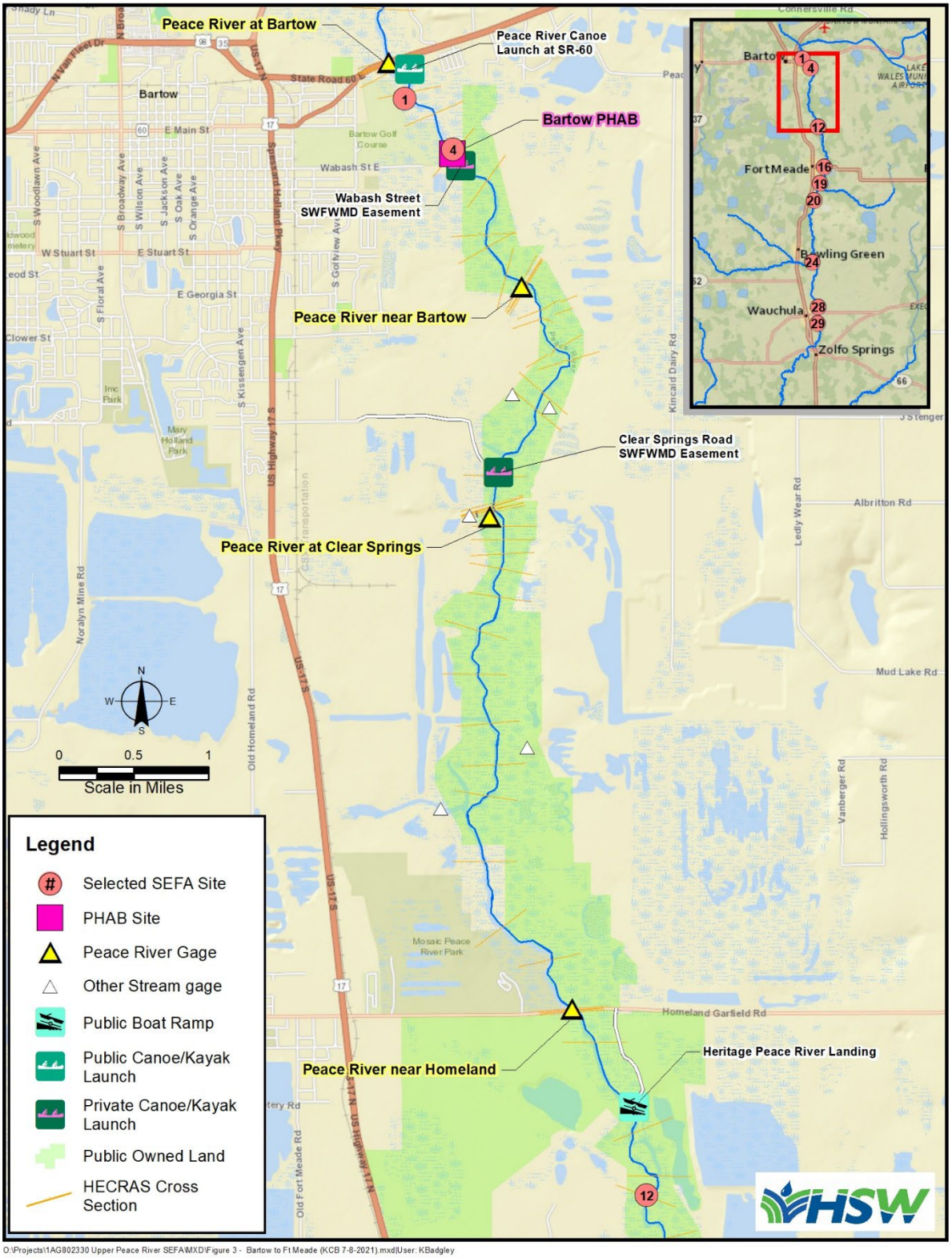

Figure 4. Locations of three SEFA data collection sites from Bartow to Fort Meade

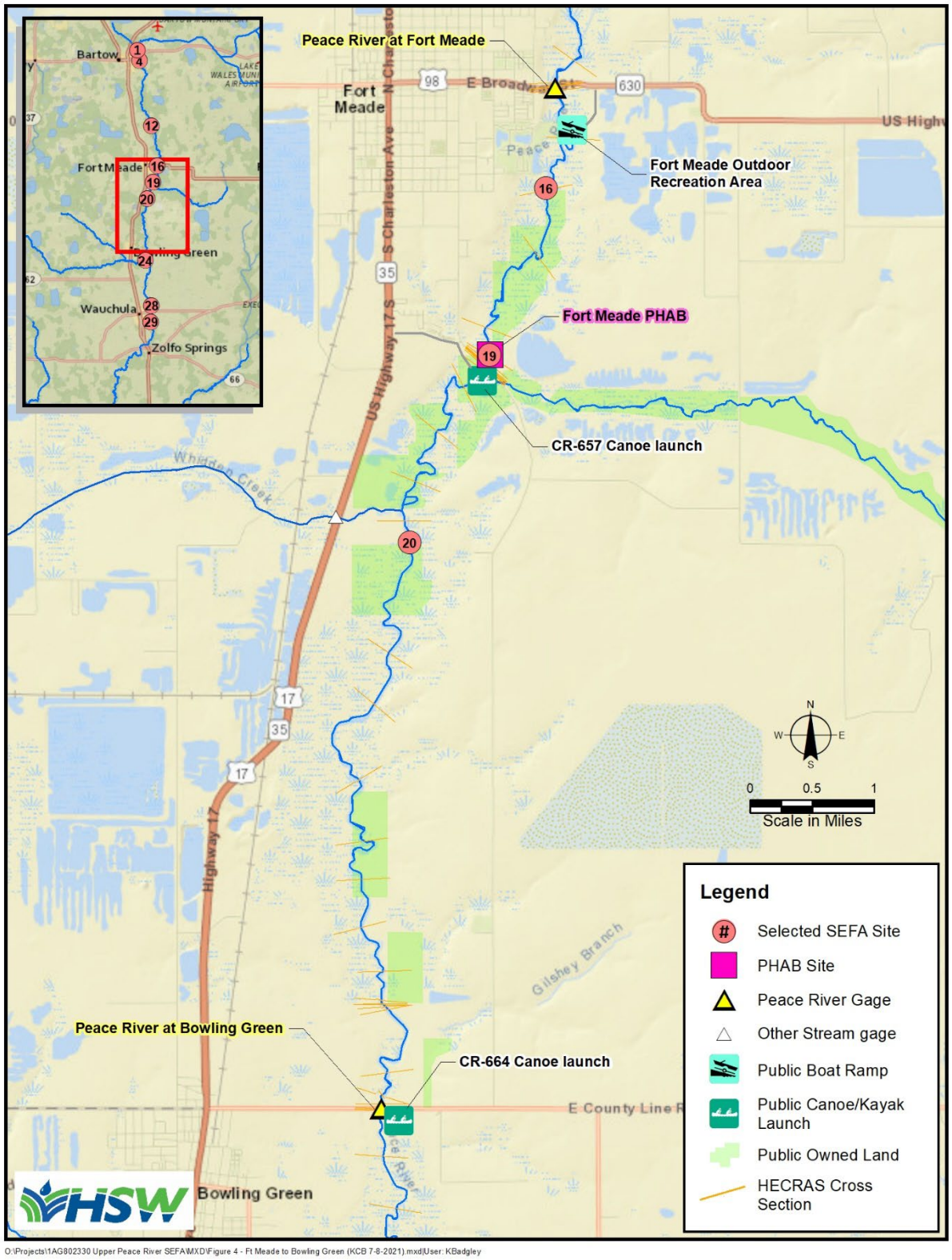

Figure 5. Locations of three SEFA data collection sites from Fort Meade to Bowling Green

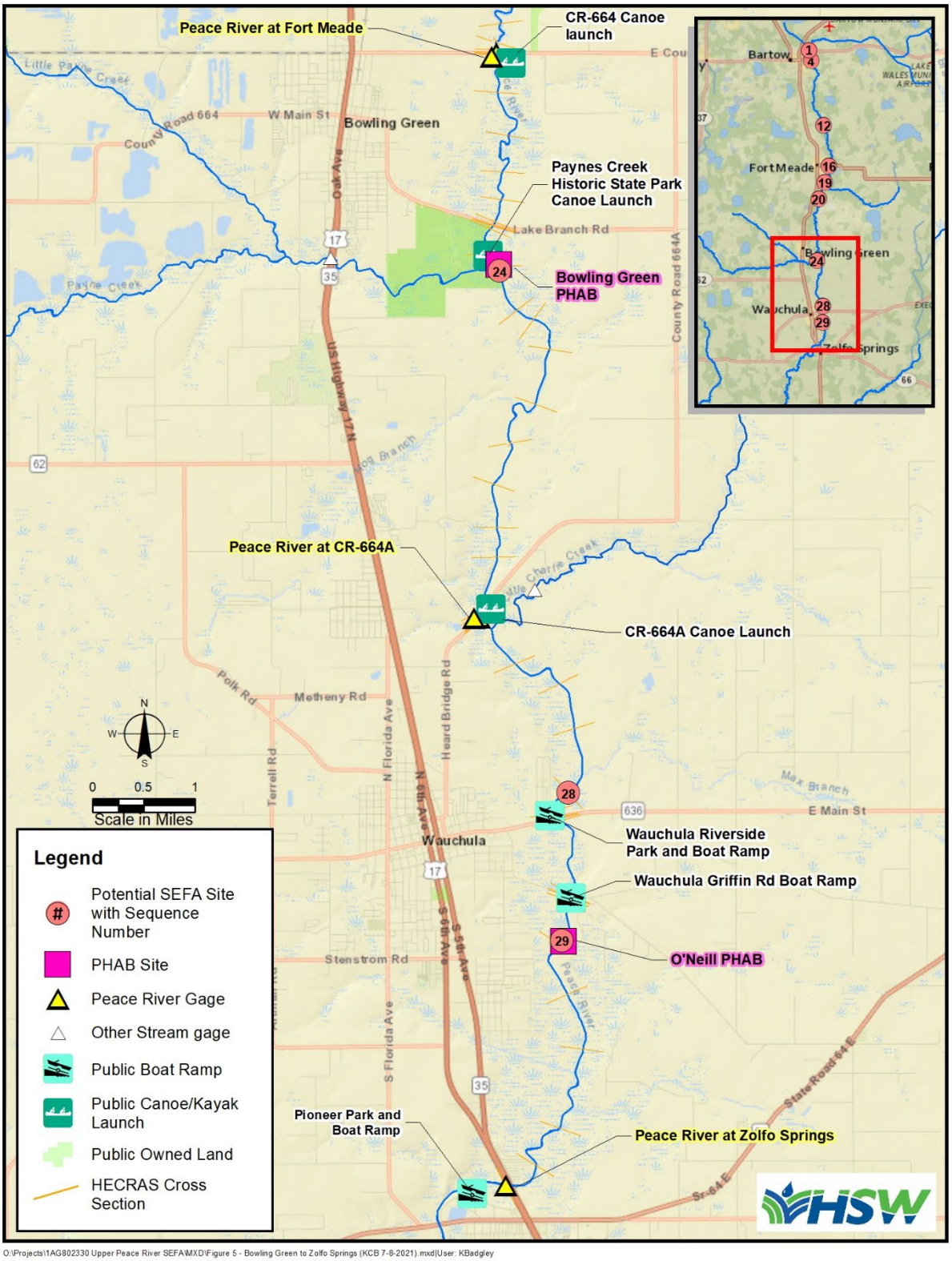

Figure 6. Locations of three SEFA data collection sites from Bowling Green to Zolfo Springs

Table 1. Locations of SEFA data collection sites.

Site No.	Selected Site	Latitude/Longitude
Bartow to Ft. Meade		
1	Site 1	27.899072/-81.815720
2	Site 4 (Bartow PHAB)	27.894444/-81.811028
3	Site 12	27.805658/-81.791195
Ft. Meade to Bowling Green		
4	Site 16	27.741000/-81.783083
5	Site 19 (Ft. Meade PHAB)	27.723779/-81.789653
6	Site 20	27.704472/-81.798972
Bowling Green to Zolfo Springs		
7	Site 24 (Bowling Green PHAB)	27.619555/-81.801789
8	Site 28	27.553510/-81.792060
9	Site 29 (O'Neill PHAB)	27.535078/-81.792942

Table 2. Data collection dates for high, medium and low flow events.

site	high	med	low
R1	8/24/2022	10/8/2021	1/12/2022
P1	8/24/2022	10/8/2021	1/12/2022
S1	8/24/2022	10/8/2021	1/12/2022
R4	8/25/2022	10/7/2021	1/12/2022
S4	8/25/2022	10/7/2021	1/12/2022
P4	8/25/2022	10/7/2021	1/12/2022
S12	12/14/2022	10/6/2021	1/13/2022
P12	12/14/2022	10/6/2021	1/13/2022
R12	12/14/2022	10/6/2021	1/13/2022
R16	12/15/2022	10/13/2021	2/10/2022
S16	12/15/2022	10/13/2021	2/10/2022
P16	12/15/2022	10/13/2021	2/10/2022
P19	12/16/2022	10/15/2021	2/11/2022
S19	12/15/2022	10/15/2021	2/11/2022
R19	12/16/2022	10/15/2021	2/11/2022
S20	2/1/2023	10/14/2021	2/11/2022
P20	2/1/2023	10/14/2021	2/11/2022
R20	2/1/2023	10/14/2021	2/11/2022
P24	9/3/2021	12/9/2021	1/7/2022
S24	9/3/2021	12/9/2021	1/7/2022
R24	9/3/2021	12/9/2021	1/7/2022
R28	9/1/2021	12/7/2021	1/21/2022
P28	9/1/2021	12/7/2021	1/21/2022
S28	9/1/2021	12/7/2021	1/21/2022
S29	9/2/2021	12/8/2021	1/6/2022
P29	9/2/2021	12/8/2021	1/6/2022

site	high	med	low
R29	9/2/2021	12/8/2021	1/6/2022

Table 3. Habitat suitability indices used for the Upper Peace River

Name from Nagid 2022	Name in this report	Descriptor 1	Descriptor 2	H Code[1]
AMEE	AMEE	American Eel	Yellow	W
BLUE	BLUA	Bluegill	Adult	G
BLUE	BLUF	Bluegill Fry	Fry	G
BLUE	BLUJ	Bluegill Juvenile	Juvenile	G
BLUE	BLUS	Bluegill Spawning	Spawning	G
CHCA	CATA	Channel Catfish	Adult	G
CHCA	CATF	Channel Catfish	Fry	G
CHCA	CATJ	Channel Catfish	Juvenile	G
CHCA	CATS	Channel Catfish	Spawning	G
COSN	COSA	Common Snook	Adult	E
COSN	COSJ	Common Snook	Juvenil	E
EPHE	EPHE	Ephemeroptera	Richness	G
Habitat Guilds	HGDF	Deep	Fast	G
Habitat Guilds	HGDS	Deep	Slow	G
Habitat Guilds	HGSF	Shallow	Fast	G
Habitat Guilds	HGSS	Shallow	Slow	G
HYDR	HYDR	Hydropsychidae	Naiad	G
IRSH	IRSH	Ironcolor Shiner	Adult	D
LMB	LMBA	Largemouth Bass	Adult	G
LMB	LMBF	Largemouth Bass	Fry	G
LMB	LMBJ	Largemouth Bass	Juvenile	G
LMB	LMBS	Largemouth Bass	Spawning	G
MCD	MACD	Macroinvertebrate	Community Diversity	G
MESH	MESH	Metallic Shiner	Adult	A
PIPE	PIPE	Pirate Perch	Adult	D
PSEP	PSEP	Pseudocloeon Ephippiatum	Naiad	G
SPSU	SPSA	Spotted Sunfish	Adult	G
SPSU	SPSF	Spotted Sunfish	Fry	G
SPSU	SPSJ	Spotted Sunfish	Juvenile	G
SPSU	SPSS	Spotted Sunfish	Spawning	G
TORG	TINV	Invertebrates	Total	G
TRIC	TRIC	Trichoptera	Naiad	G

[1]Habitat codes defined in Nagid (2022): W = Warren and Nagid 2008, G = Jim Gore (unpublished), A = Nagid et al. 2014, and D = Nagid 2022.

Upper Segment Habitat

The cross-sectional geometry and water levels varied among individual transects (Figure 8). Water surface elevation data was collected at three events representing low, medium, and high flows.

Site 1 is around 25 feet wide bank to bank with pool, run, and shoal habitats closely spaced (Figure 9). At the medium flow data collection event, the pool and run were around 4 feet deep, and the shoal is around 2 feet deep. The site has sand substrate with cover near the banks (HSW 2021).

Site 4 is around 30 to 45 feet wide bank to bank (Figure 8). The run and shoal have maximum depths under 2 feet, while the pool reaches a maximum depth between 3 and 4 feet at medium flow. The shoal is sandy, located in between the upstream run and downstream pool (Figure 10).

Site 12 is 50 to 60 feet wide bank to bank (Figure 8). The shoal has a maximum depth between 2 and 3 feet at medium flow, while the run and pool are approximately 5 feet deep. Site 12 is downstream of the Heritage Peace River boat ramp and is dominated by bare sand, sand with cover, and terrestrial vegetation at the banks (Figure 11).

Habitat-flow curves show how the average habitat across all nine cross sections varies with changes in flow (Figure 12). Many species show habitat increases as flow increases, often in a nonlinear manner.

The baseline flow record at Bartow was bounded at 0 and 71 cfs to represent the instream portion of the flow regime. The baseline flow record was then reduced up to 25% in 1% intervals and matched to the habitat-flow curves. These alternative time series of habitat were then averaged across all dates to create a single habitat value for each flow scenario between 100% (baseline) and 75%.

Some species lose habitat as flow is reduced, while others gain habitat. The most sensitive have the potential to lose at least 15% of their habitat as flows decrease to 75% of the daily flow over the period of record (Figure 13). The most sensitive habitat in the upper segment is for the net-spinning caddisflies of the family Hydropsychidae, which loses 15% of its habitat when flows are reduced to under 88% of the unimpacted (baseline) flow record (Table 4).

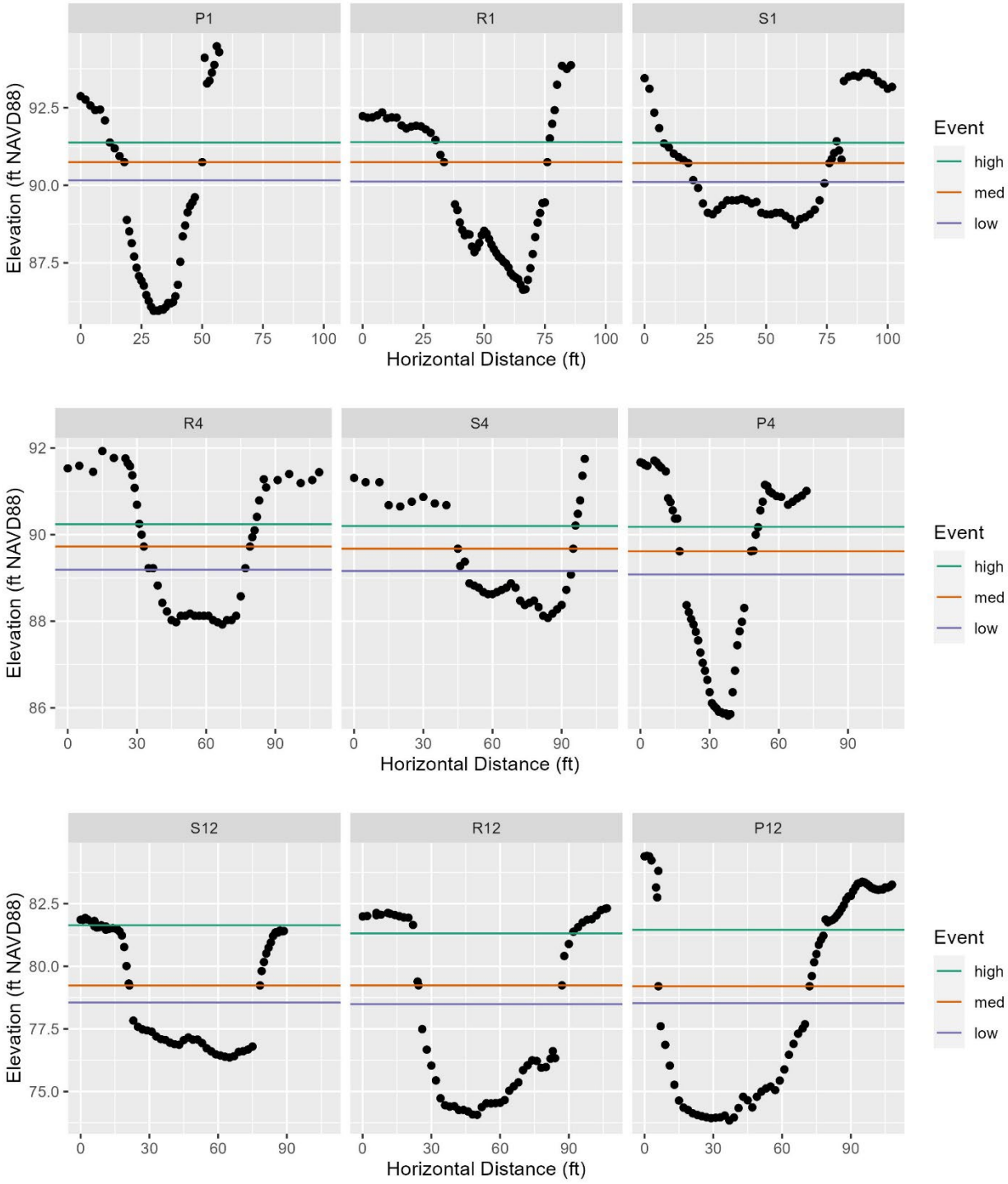

Figure 7. Cross section elevations in the upper segment. Horizontal lines are water surface elevations at high, medium, and low flow events. P, R and S indicate the pool, run and shoal transects, respectively at each site. Within each numbered site, cross sections are arranged from left to right, upstream to downstream.

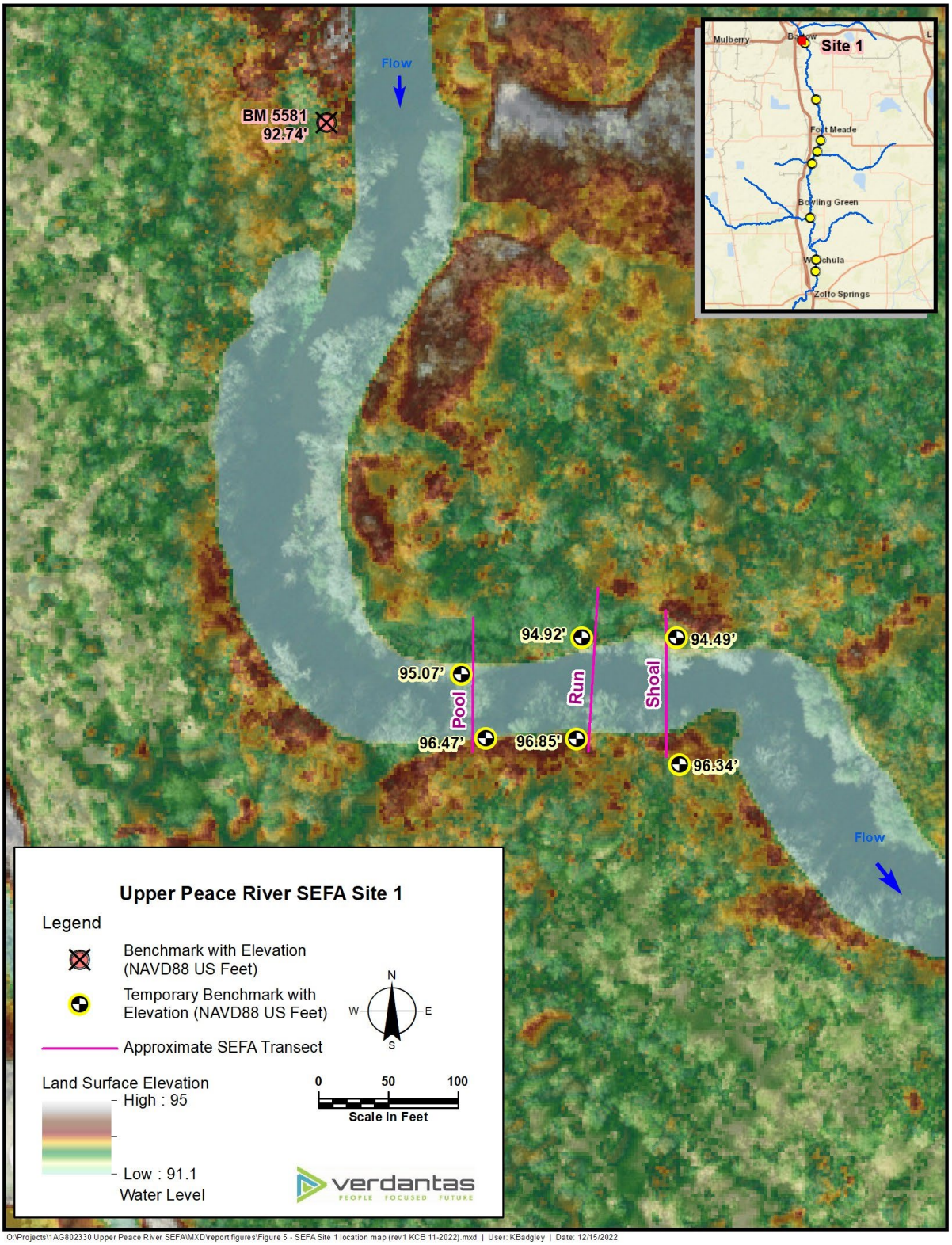

Figure 8. Approximate locations of SEFA transects in site 1

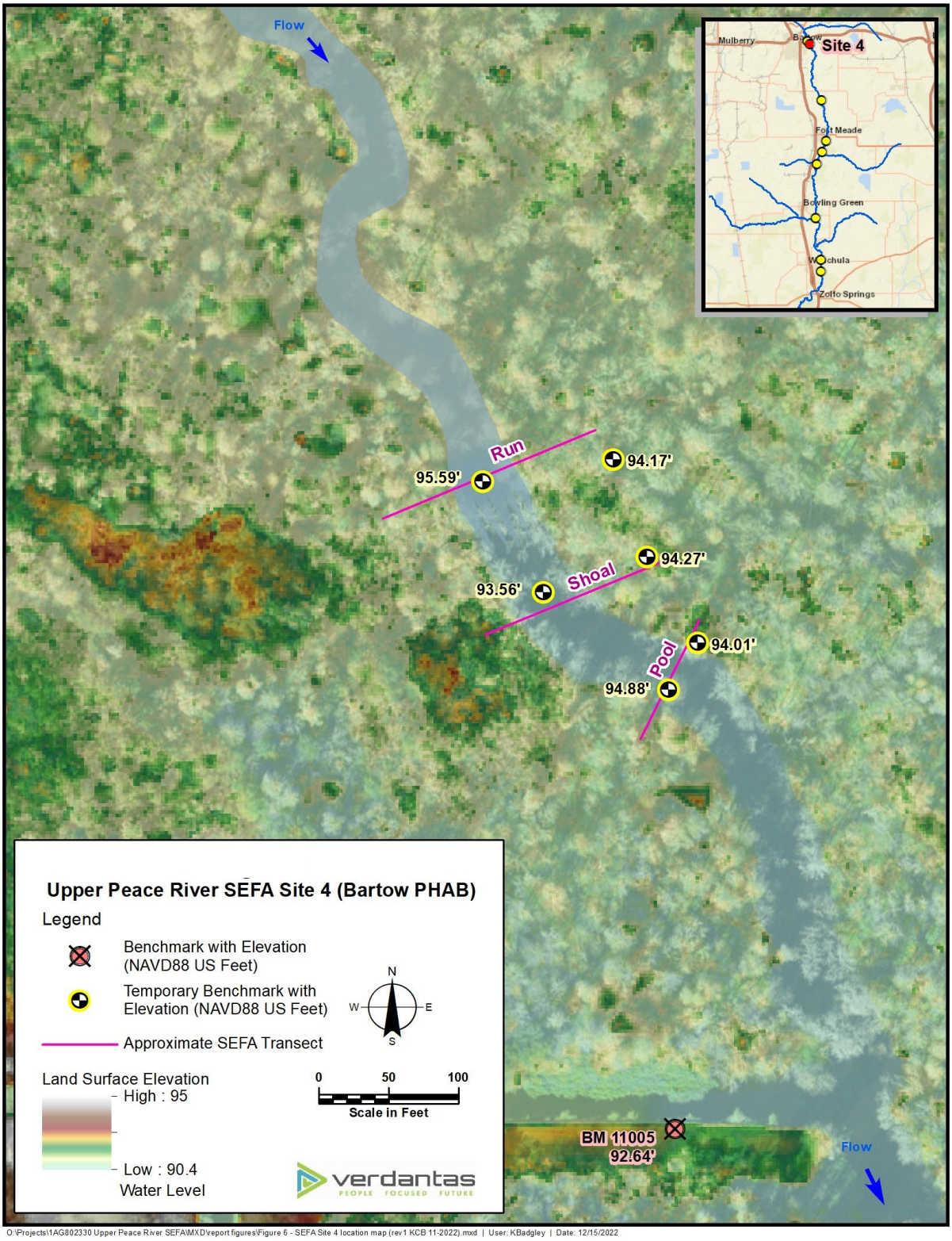

Figure 9. Approximate locations of SEFA transects in site 4.

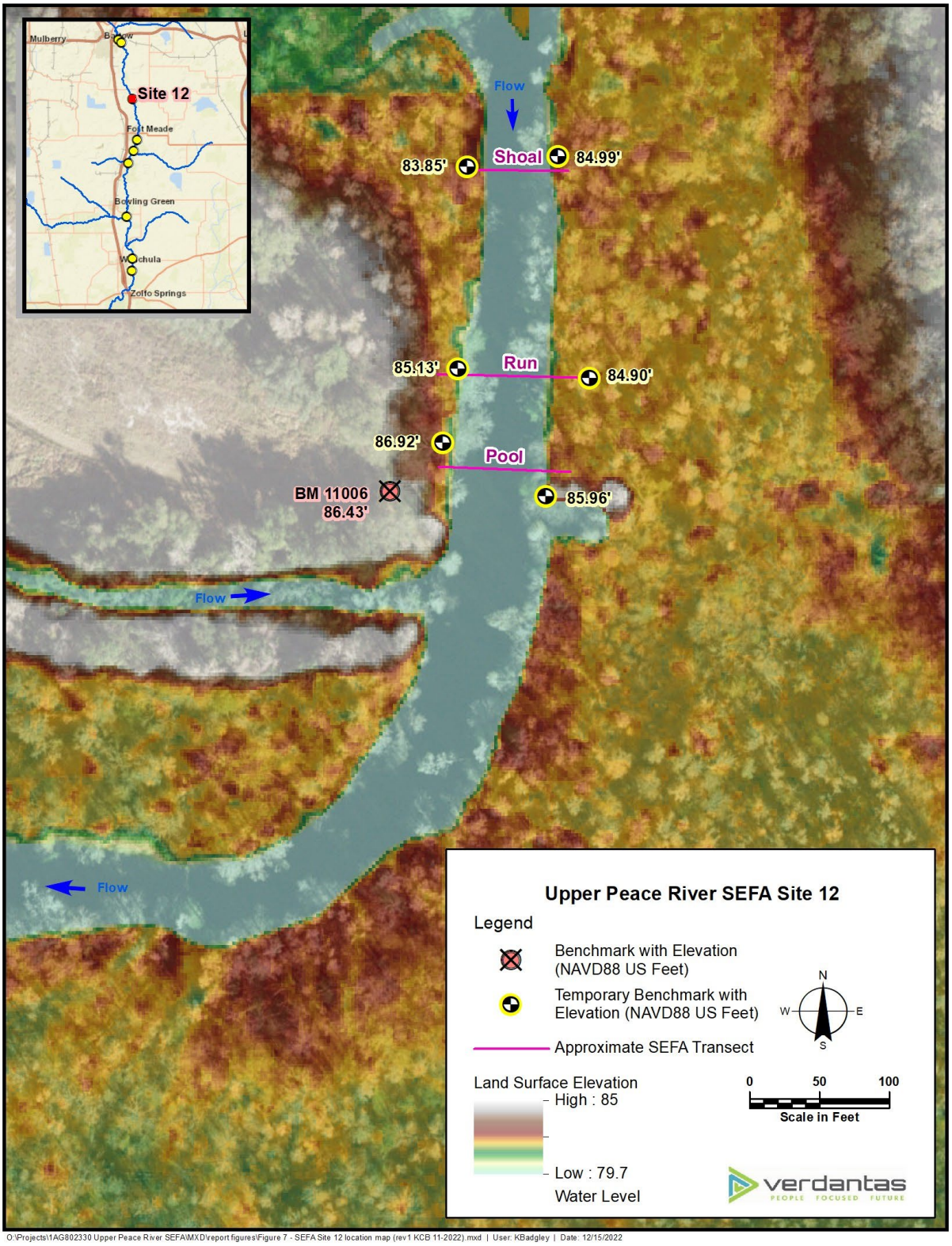

Figure 10. Approximate locations of SEFA transects in site 12

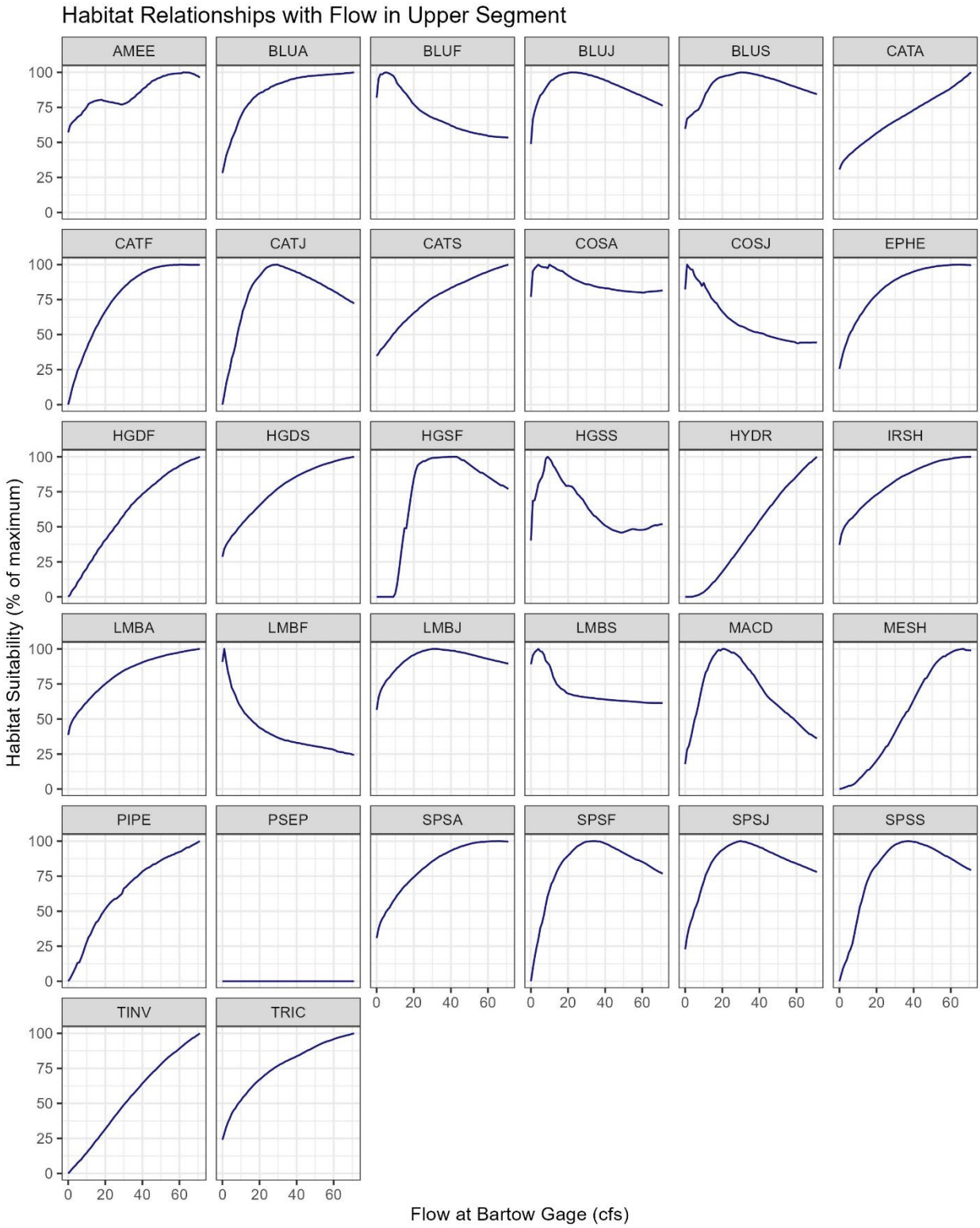

Figure 11. Average habitat – flow relationships in the upper segment. Habitat suitability is relative to the maximum for each species, thus all species with any habitat reach a maximum of 100% at some flow. This illustrates the shape of the response of habitat to flow changes. PSEP has no habitat at any flow.

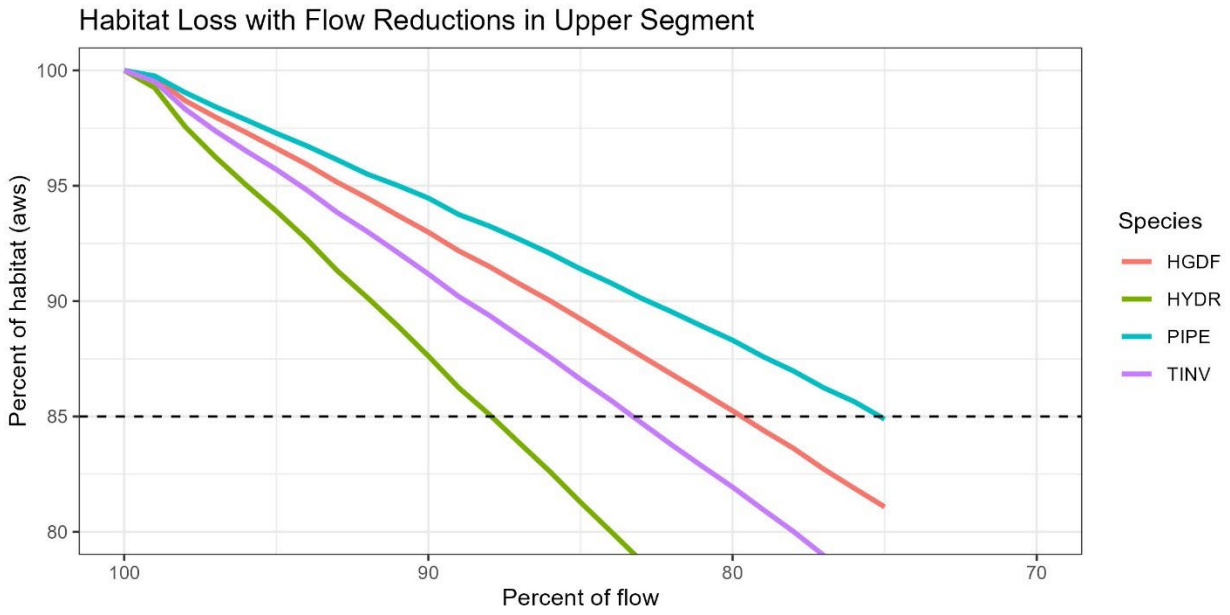

Figure 12. Habitat loss for the most sensitive species in the upper segment between Bartow and Fort Meade USGS gages.

Table 4. Minimum flow percentages necessary to maintain 85% of area-weighted habitat suitability (AWS) in the upper segment using a baseline flow record at the Bartow gage for all days with flows between 0 and 71 cfs, inclusive.

Species	Minimum Flow (%)
HYDR	88
TINV	84
HGDF	80

Middle Segment Habitat

The cross-sectional geometry and water levels varied among individual transects (Figure 14). Water surface elevation data was collected at three events representing low, medium, and high flows.

Site 16 has wetted widths of around 50 feet with flat sandy floodplains on both sides (Figure 15). During medium flow ranges, the run and shoal are around 2 feet deep, and the pool reaches around 5 feet deep (Figure 14). The site has sand substrate with cover near the banks (HSW 2021).

Site 19 is around 100 feet wide (Figure 14). This location is hydrologically complex, with meandering pattern between the pool and the shoal, artificial berms, a bridge for Mt. Pisgah Road, and bowlegs creek entering near the three cross sections (Figure 16). This was the site of a previous PHABSIM data collection effort, chosen for ease of acces rather than ideal hydrologic or habitat conditions.

Cross sections at Site 20 vary from the pool which is around 75 feet wide to the shoal which is around 125 feet wide (Figure 14). These cross sections are in a straight section of the river (Figure 17).

Habitat-flow curves show how the average habitat across all nine cross sections varies with changes in flow (Figure 18). Many species show habitat increases as flow increases, often in a nonlinear manner.

The baseline flow record at Ft. Meade was bounded at 120 cfs to represent the instream portion of the flow regime. The baseline flow record was then reduced up to 25% in 1% intervals and matched to the habitat-flow curves. These alternative time series of habitat were then averaged across all dates to create a single habitat value for each flow scenario between 100% (baseline) and 75%.

Some species lose habitat as flow is reduced, while others gain habitat. The most sensitive have the potential to lose at least 15% of their habitat as flows decrease up to 75% of the daily flow over the period of record (Figure 19). The most sensitive habitat in the upper segment is for the net-spinning caddisflies of the family Hydropsychidae, which loses 15% of its habitat when flows are reduced to under 88% of the unimpacted (baseline) flow record (Table 5).

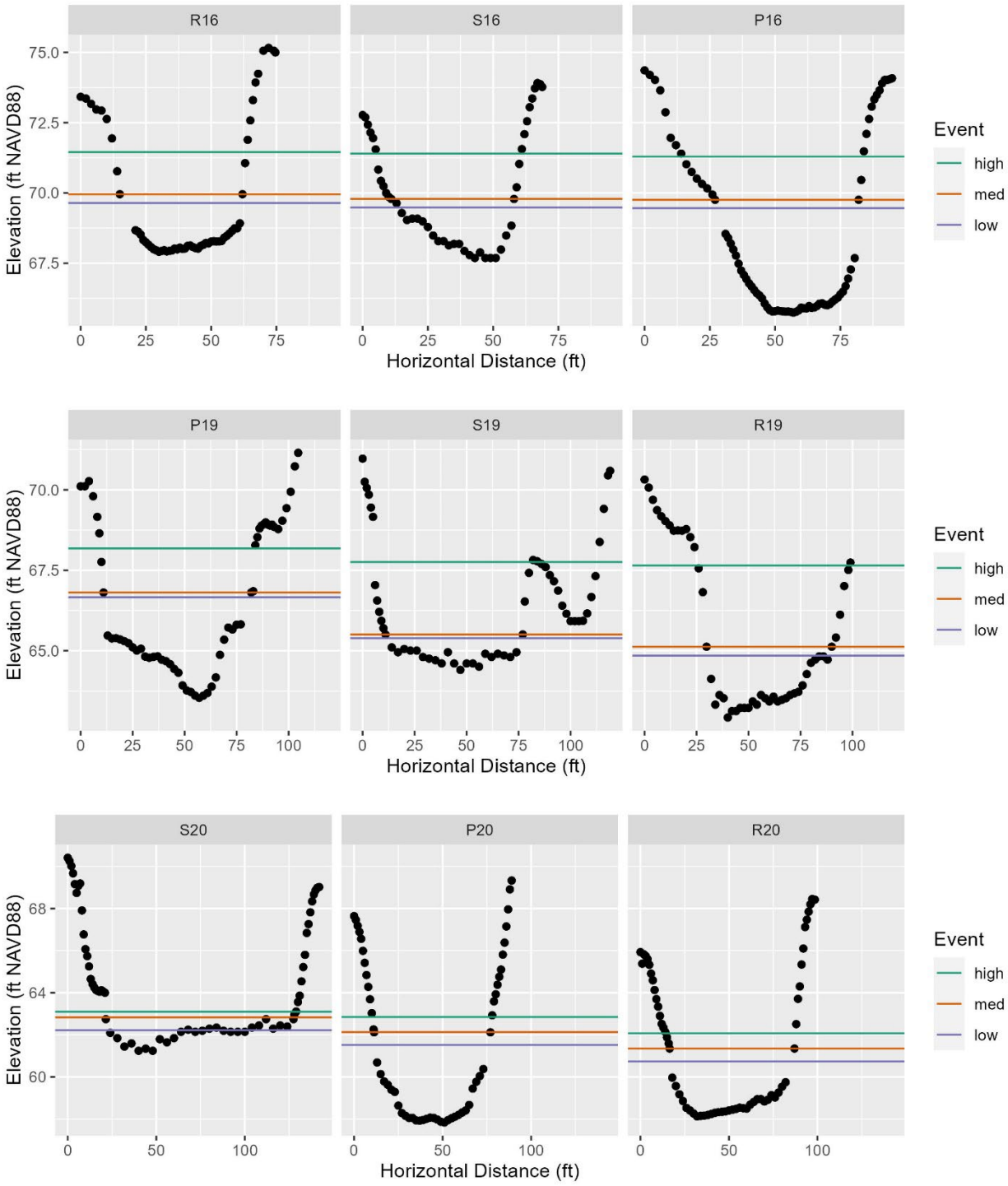

Figure 13. Cross section elevations in the middle segment. Horizontal lines are water surface elevation at high, medium, and low flow events. P, R, and S indicate the pool, run and shoal transects, respectively at

each site. Within each numbered site, cross sections are arranged from left to right, upstream to downstream.

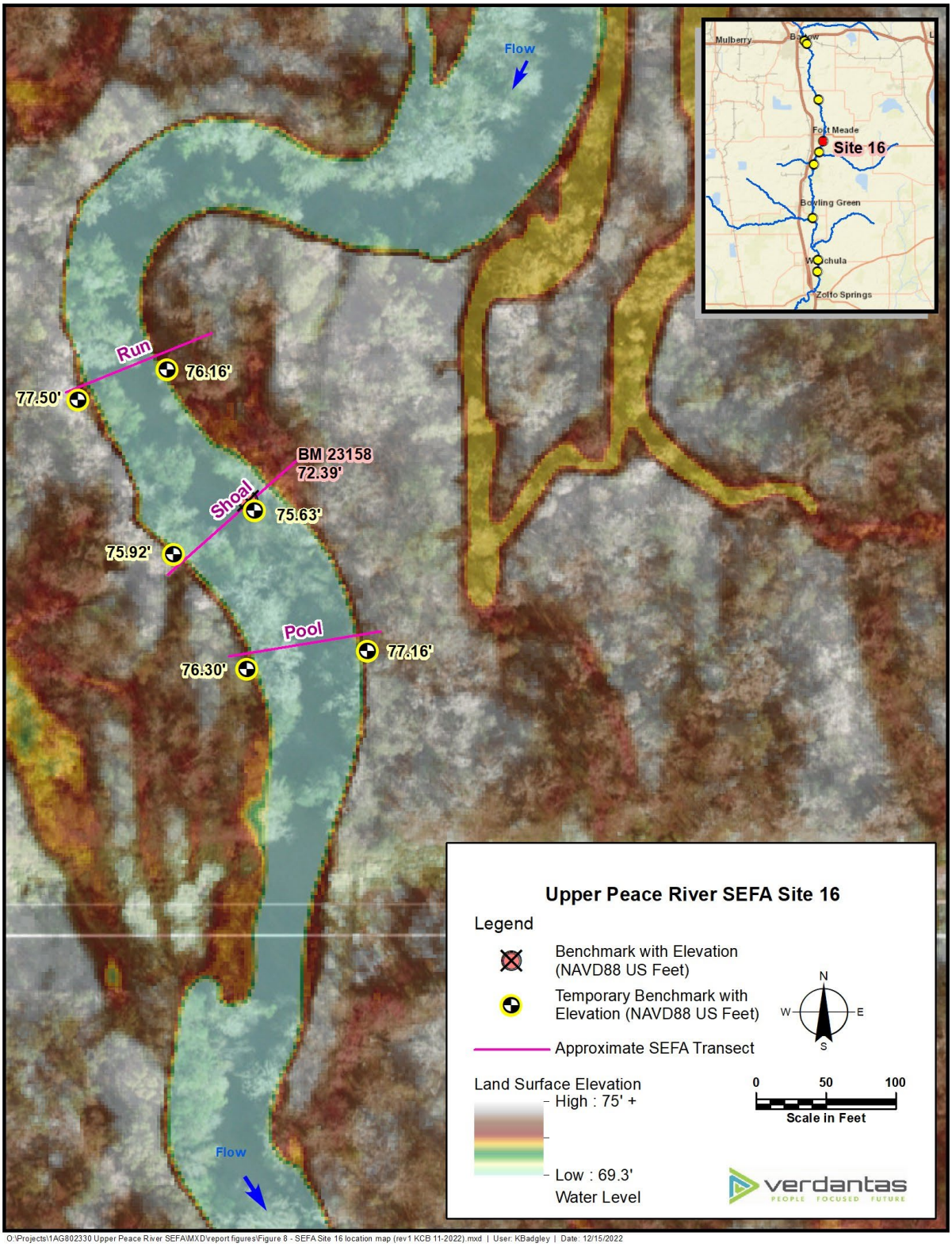

Figure 14. Approximate locations of SEFA transects in Site 16

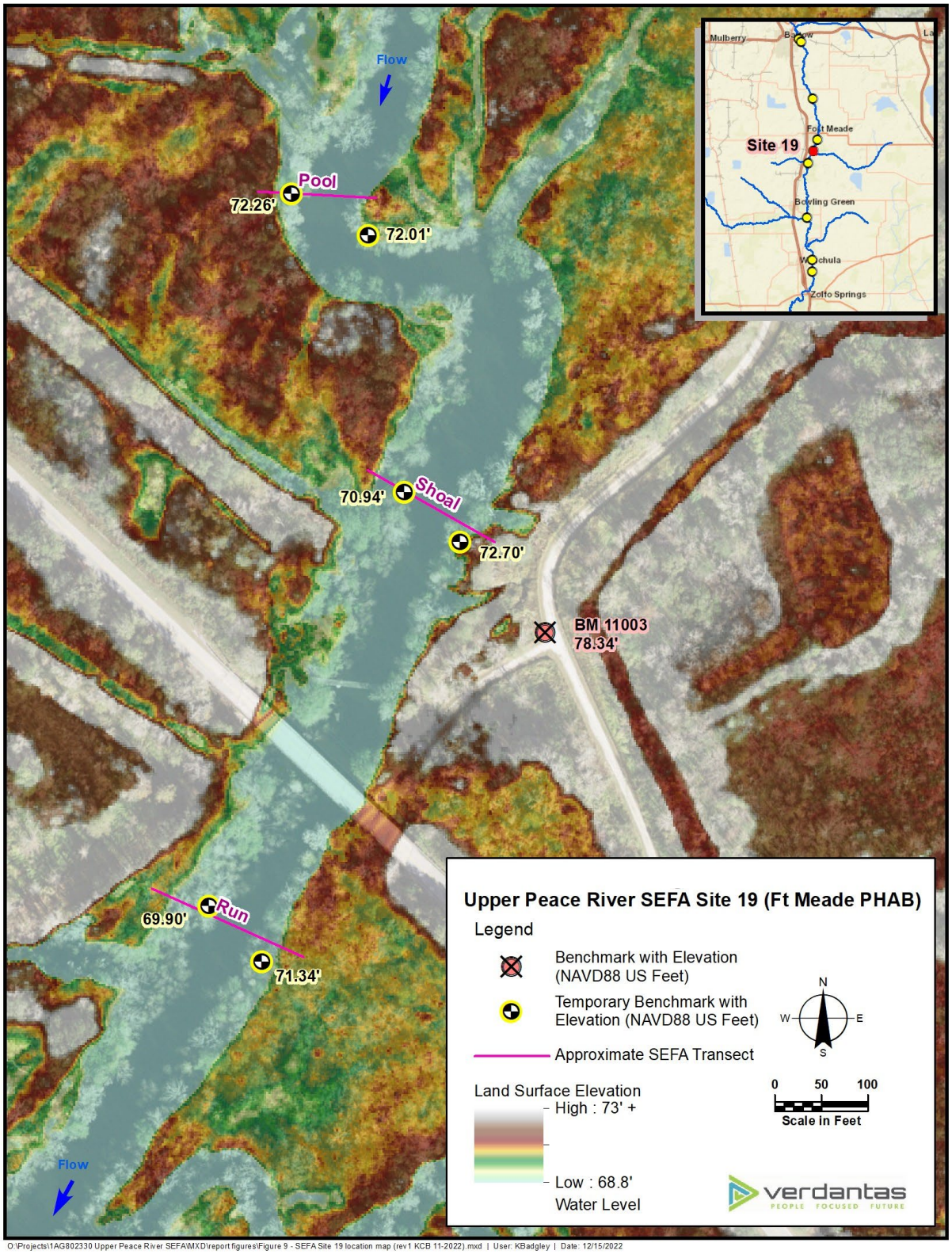

Figure 15. Approximate locations of SEFA transects in Site 19

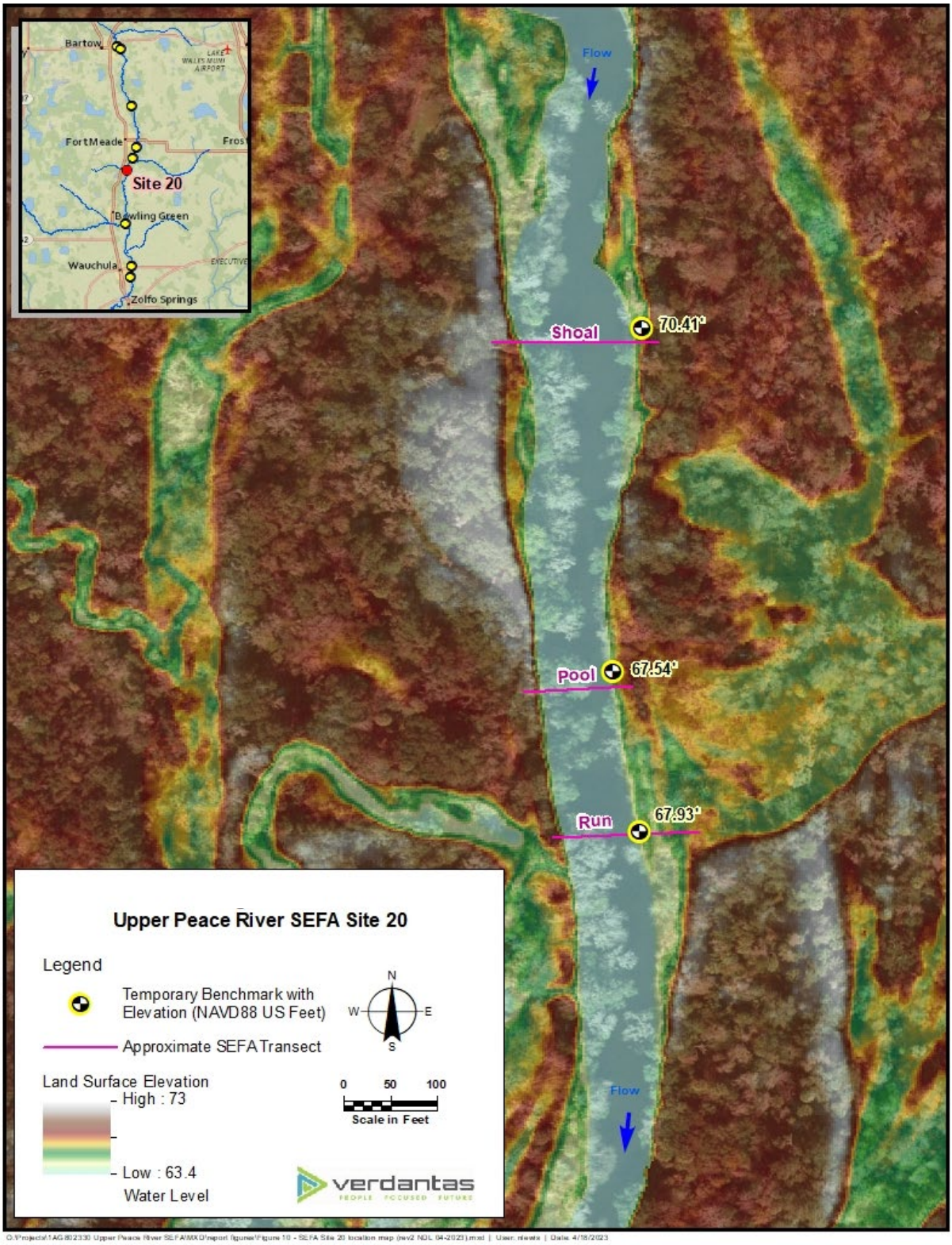

Figure 16. Approximate locations of SEFA transects in Site 20

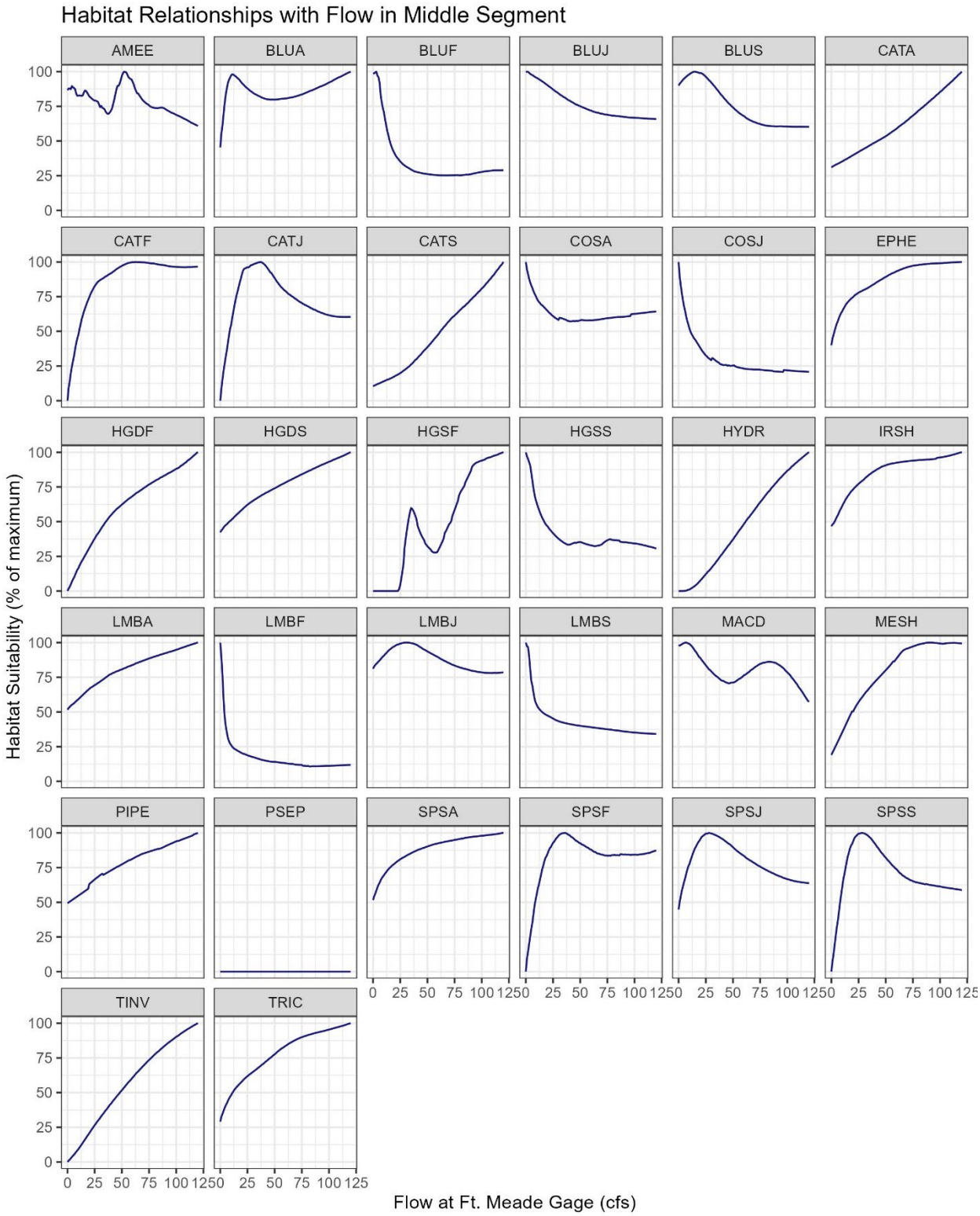

Figure 17. Average habitat – flow relationships in the middle segment. Habitat suitability is relative to the maximum for each species, thus all species with any habitat reach a maximum of 100% at some flow. This illustrates the shape of the response of habitat to flow changes. PSEP has no habitat at any flow.

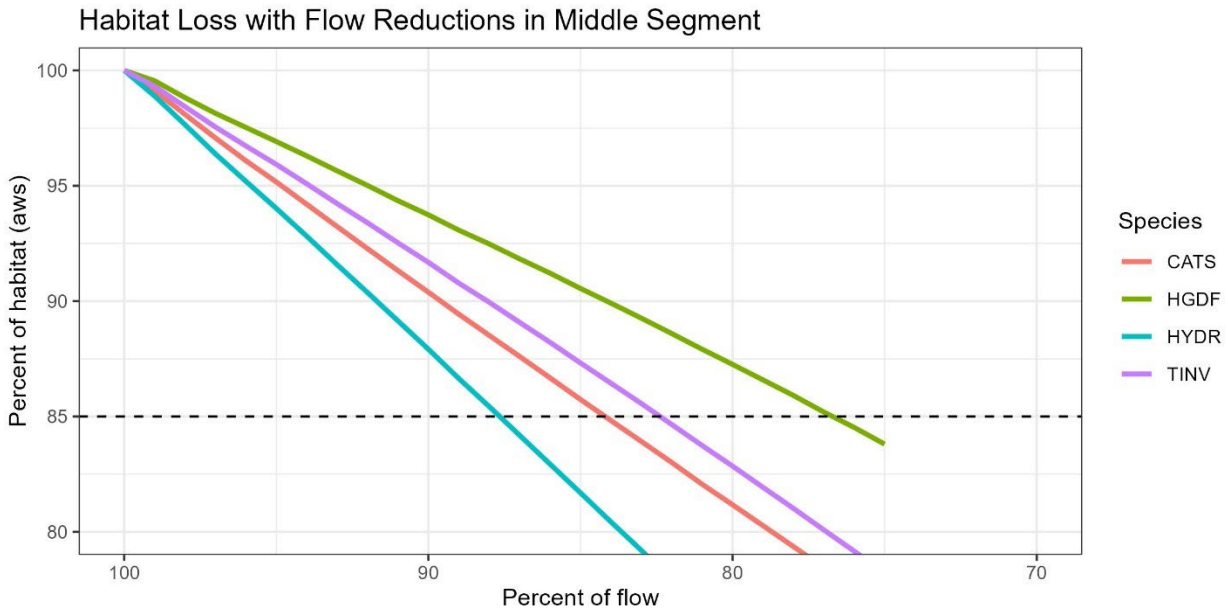

Figure 18. Habitat loss for the most sensitive species in the middle segment between Fort Meade and Bowling Green USGS gages

Table 5. Recommended minimum flow percentages in the middle segment when the baseline flow at Fort Meade gage is less than or equal to 120 cfs.

Species	Minimum Flow %
HYDR	88
CATS	85
TINV	83
HGDF	77

Lower Segment Habitat

The cross-sectional geometry and water levels varied among individual transects (Figure 20).

The run at site 24 is around 45 feet wide, while the pool and shoal are 60 to 70 feet wide during medium flows. During medium flow, the shoal is around 2 feet deep, the run around 4 feet deep, and the pool reaches depths around 6 feet (Figure 20). These three cross sections are located near a bend in the river (Figure 21). This was the site of a previous PHABSIM data collection effort.

The three cross sections of site 28 are in a relatively straight section of the river (Figure 22). All three cross ections are around 75 feet wide (Figure 20). The run is 3-4 feet deep, the shoal under 2 feet deep, and the pool around 6 feet deep at medium flows.

The shoal at site 29 is around 60 feet wide and 2 feet deep, the run 75 feet wide and 2.5 feet deep and the pool 85 feet wide and nearly 5 feet deep (Figure 20). These cross sections are in a broad curve near the Zolfo Springs boat ramp (Figure 23).

Habitat-flow curves show how the average habitat across all nine cross sections varies with changes in flow (Figure 24). Many species show habitat increases as flow increases, often in a nonlinear manner.

The baseline flow record at Zolfo Springs was bounded at 0 and 274 cfs to represent the instream portion of the flow regime. The baseline flow record was then reduced up to 25% in 1% intervals and matched to the habitat-flow curves. These alternative time series of habitat were then averaged across all dates to create a single habitat value for each flow scenario between 100% (baseline) and 75%.

Some species lose habitat as flow is reduced, while others gain habitat. The most sensitive have the potential to lose at least 15% of their habitat as flows decrease to 75% of the daily flow over the period of record (Figure 25). The most sensitive habitat in the upper segment is for the net-spinning caddisflies of the family Hydropsychidae, which loses 15% of its habitat when flows are reduced to under 87% of the unimpacted (baseline) flow record (Table 6).

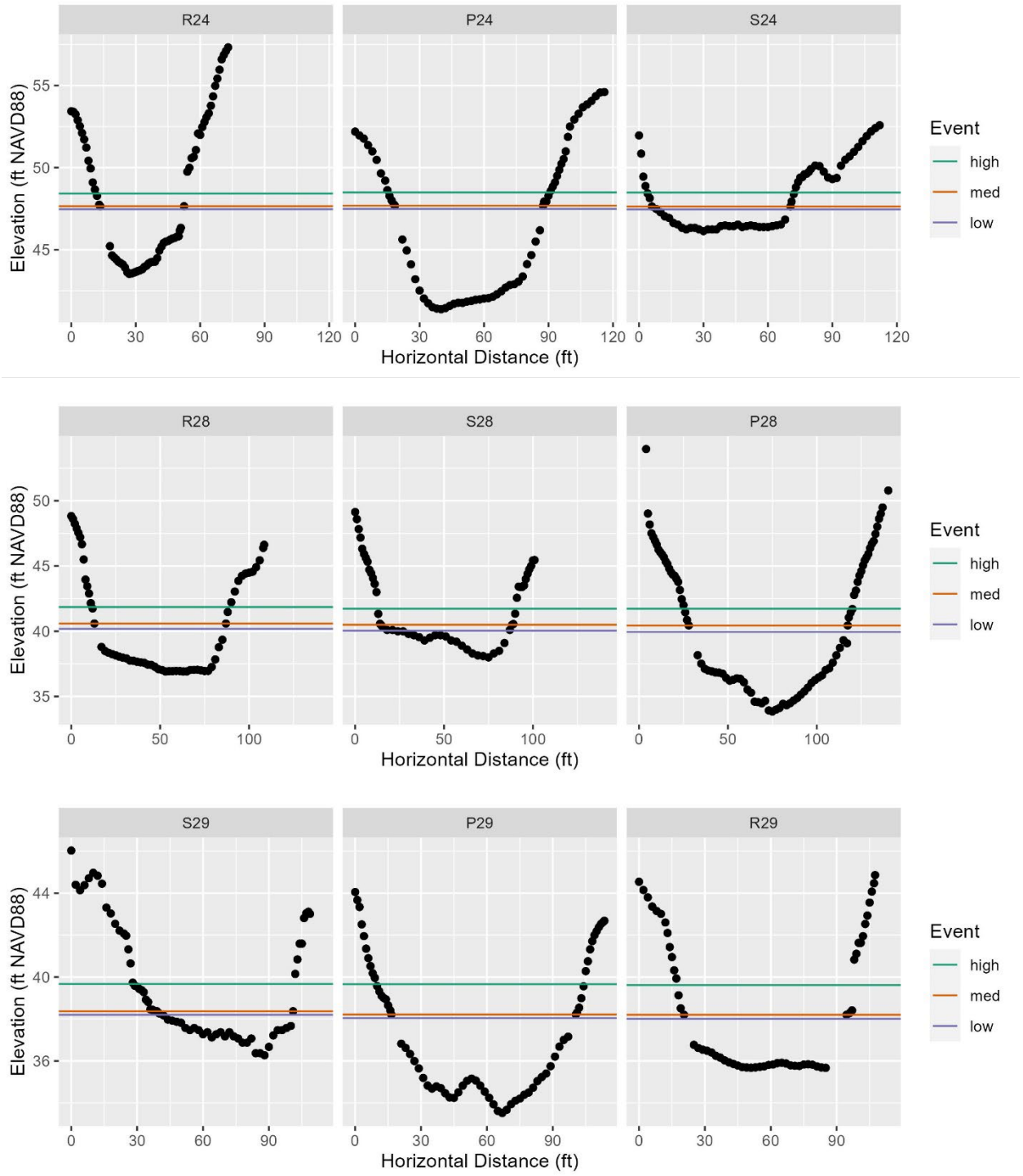

Figure 19. Cross section elevations in the lower segment. Horizontal lines are water surface elevation at high, medium and low flow events. P, R, and S indicate the pool, run, and shoal transects, respectively at each site. Within each numbered site, cross sections are arranged from left to right, upstream to downstream.

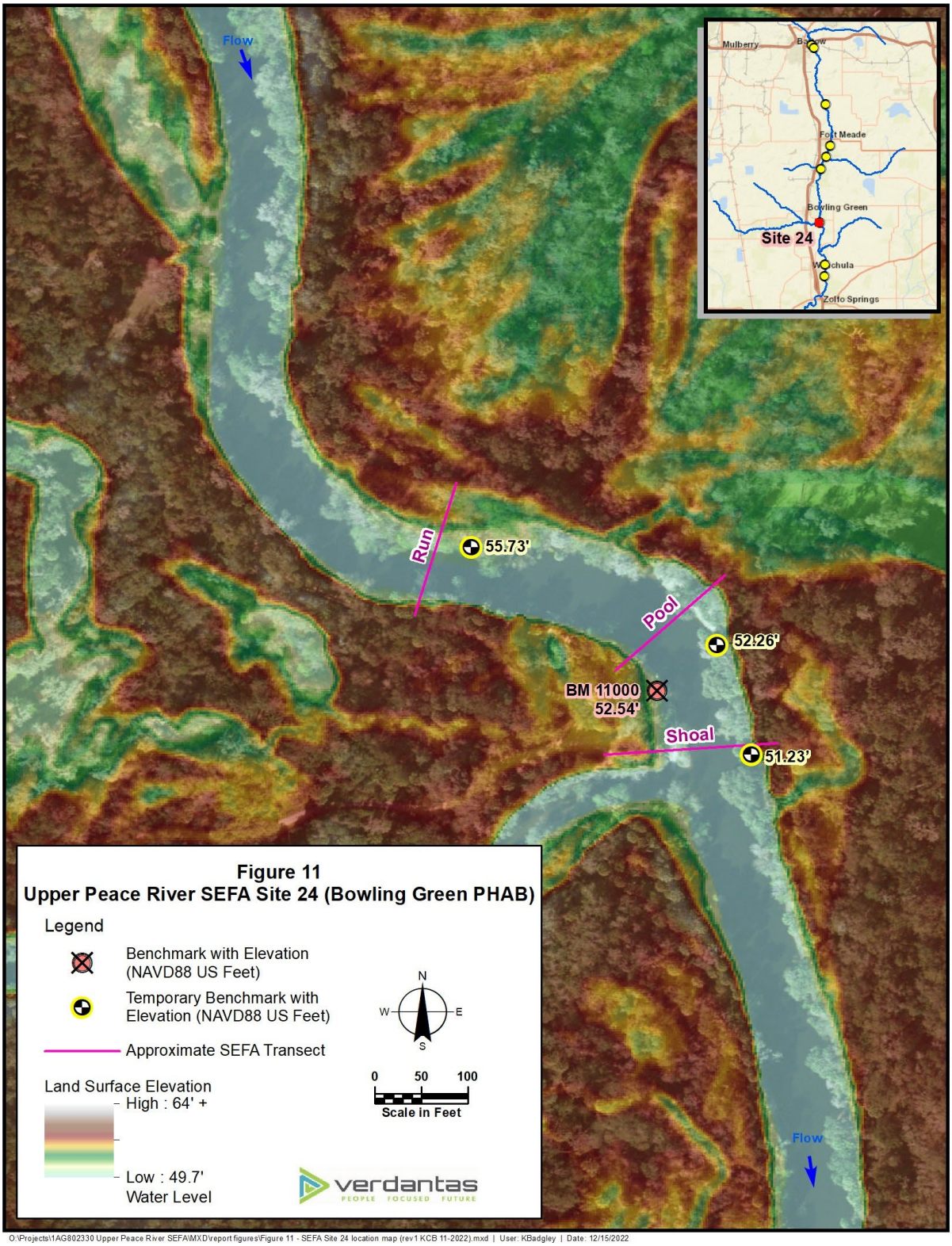

Figure 20. Approximate locations of SEFA transects in site 24

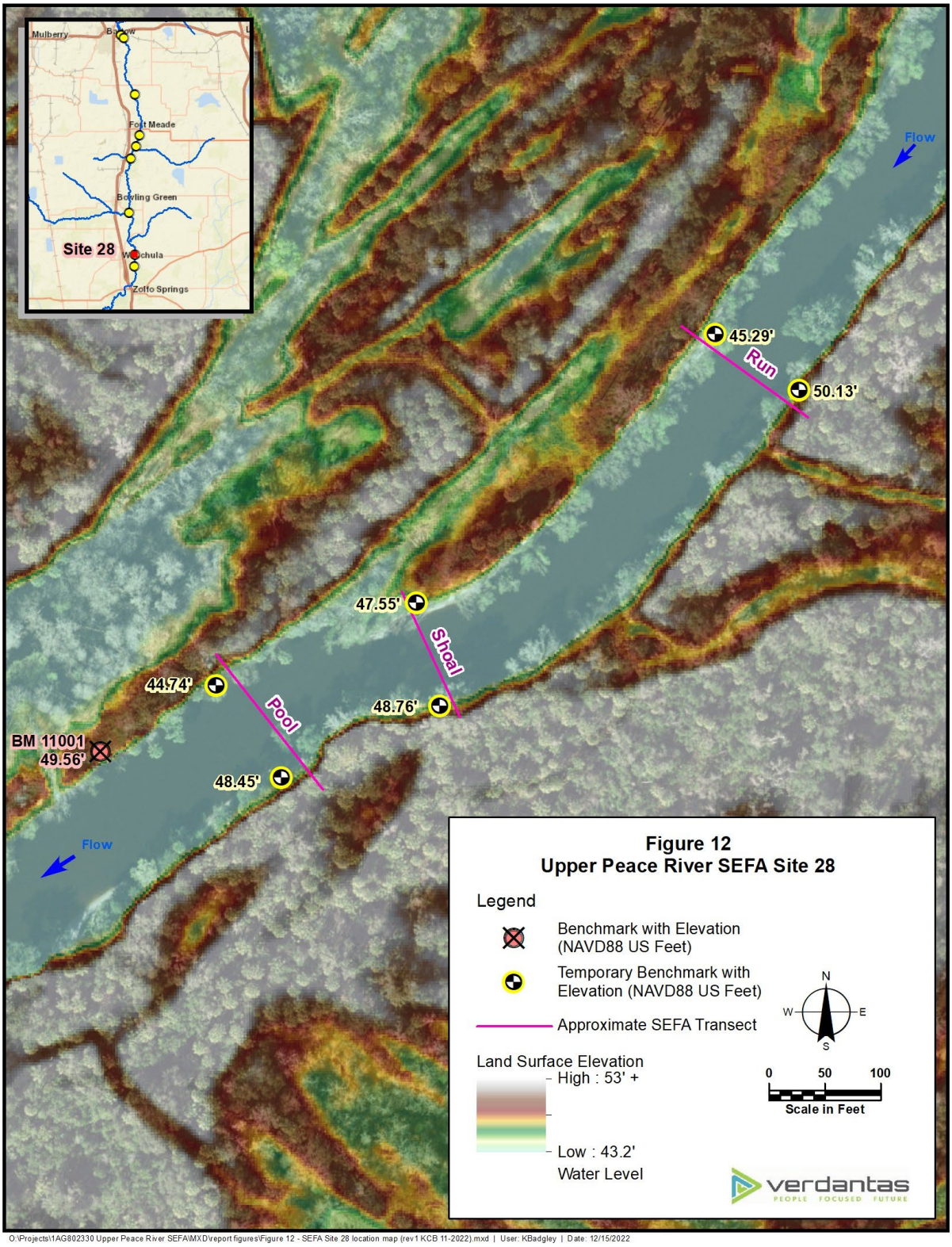

Figure 21. Approximate locations of SEFA transects in site 28

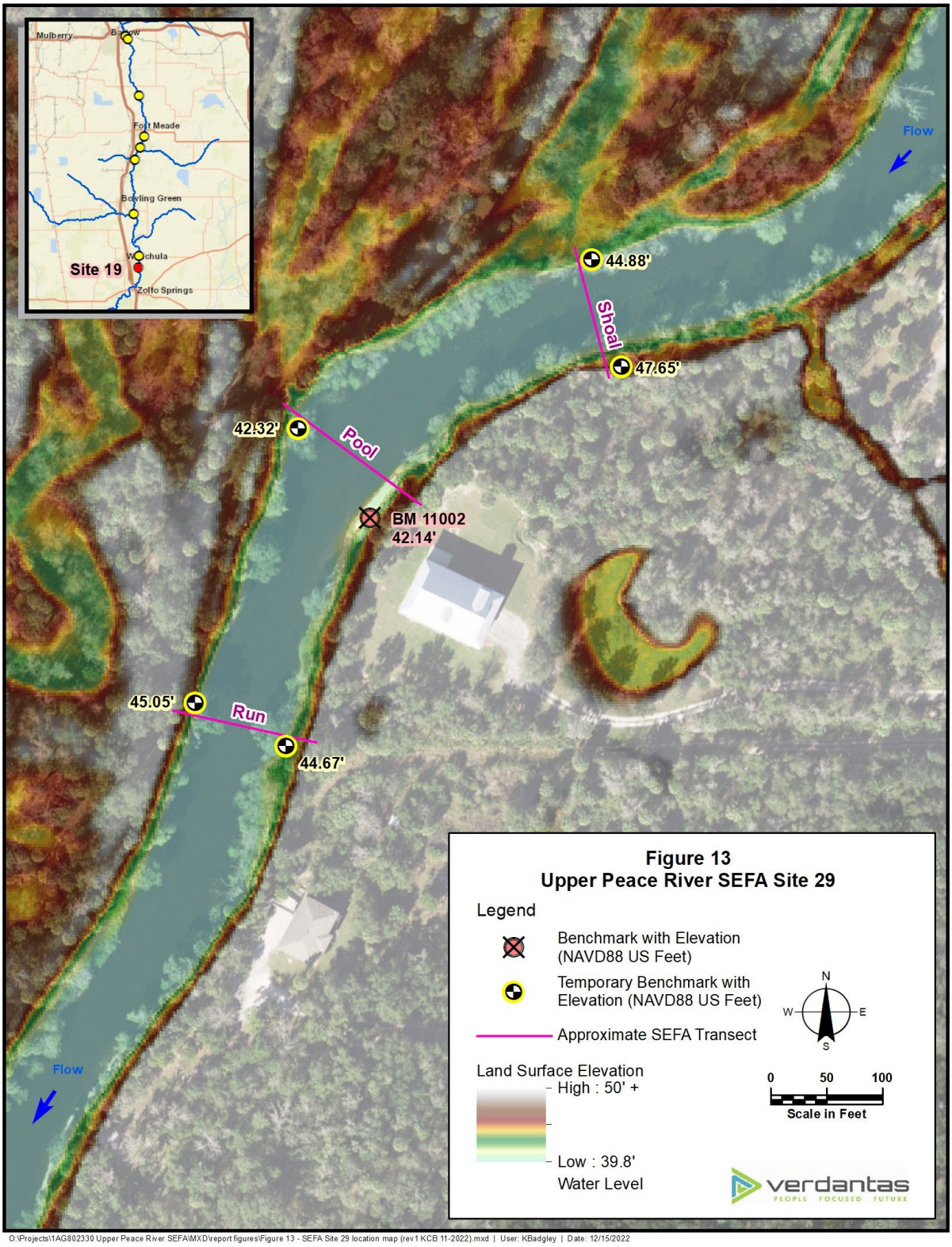

Figure 22. Approximate locations of SEFA transects in site 29

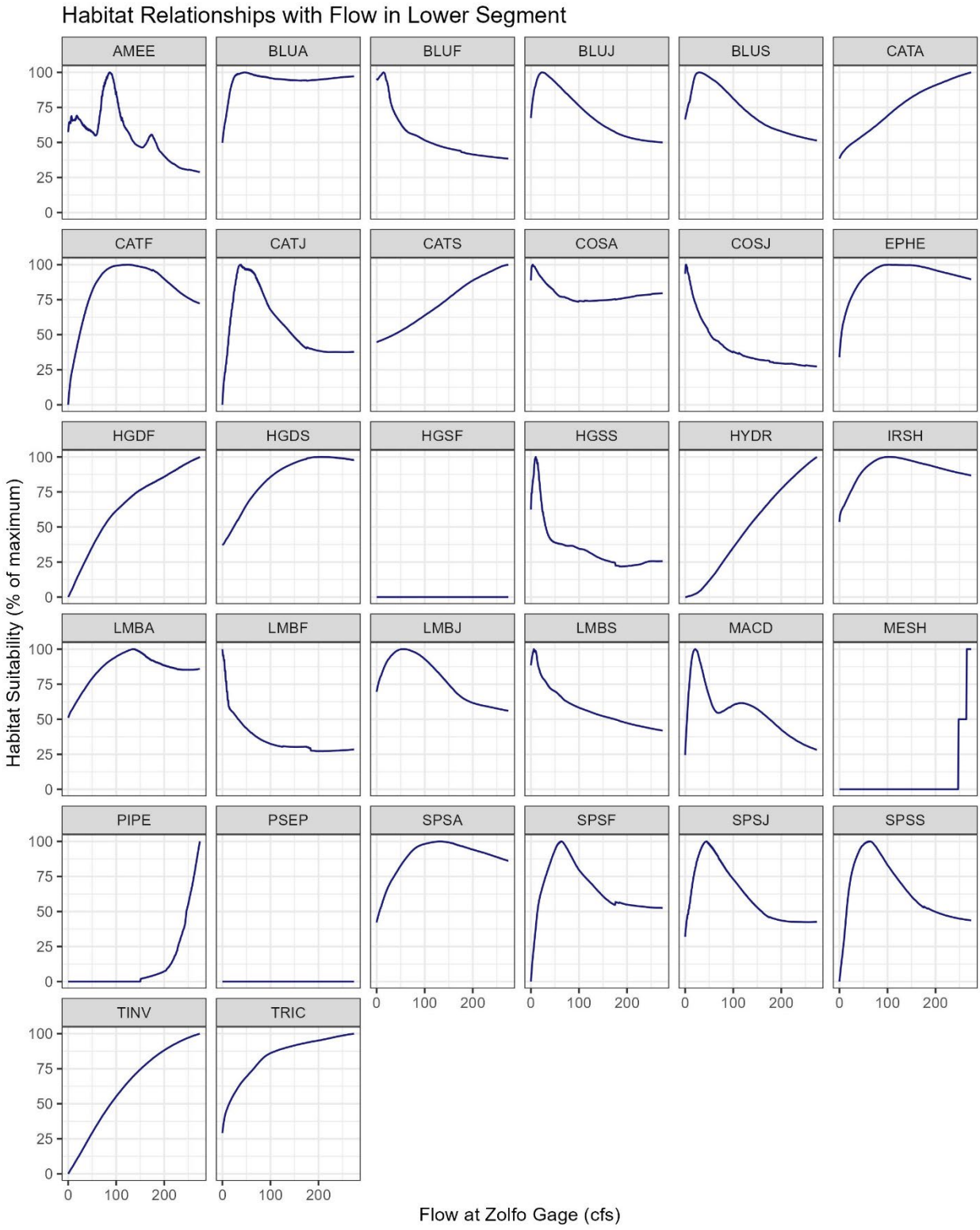

Figure 23. Average habitat – flow relationships in the lower segment. Habitat suitability is relative to the maximum for each species, thus all species with any habitat reach a maximum of 100% at some flow. This illustrates the shape of the response of habitat to flow changes. PSEP has no habitat at any flow.

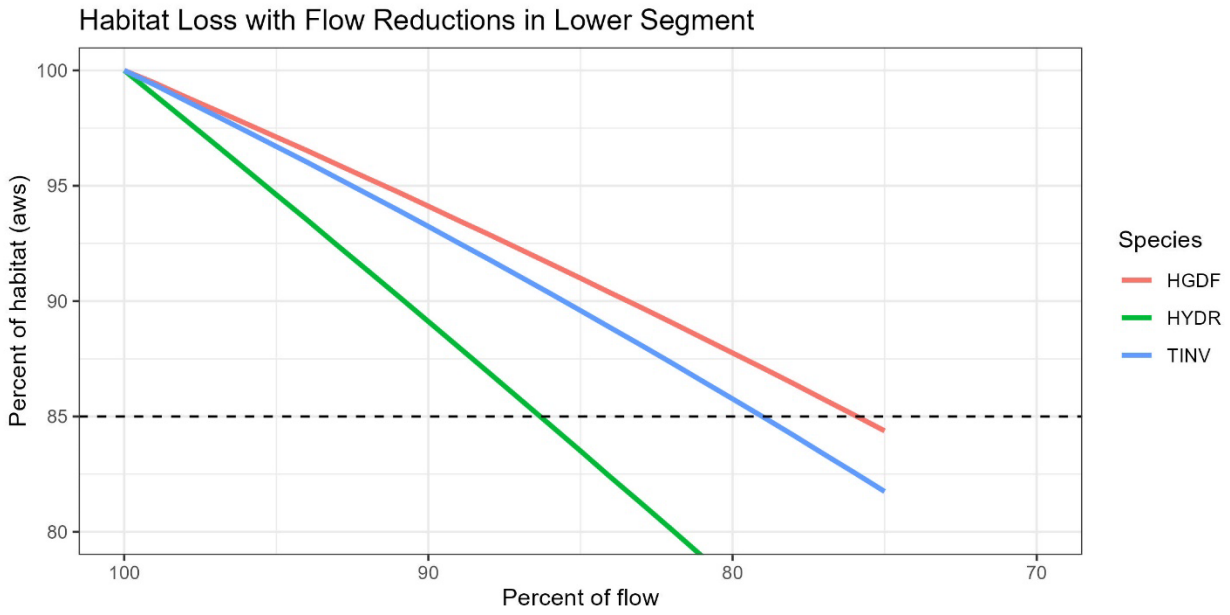

Figure 24. Habitat loss for the most sensitive species in the lower segment between Bowling Green and Zoflo Springs USGS gages.

Table 6. Recommended minimum flow percentages in the lower segment when the baseline flow at the Zolfo Springs gage is less than or equal to 274 cfs.

Species	Minimum Flow %
HYDR	87
TINV	80
HGDF	76

Summary

Minimum flow results are 88 percent of baseline flow in the upper segment, 88 percent of baseline flow in the middle segment, and 87 percent of baseline flow in the lower segment. These are the minimum flow percentages below which significant harm would occur, where significant harm is defined as a 15% loss in habitat for Hydropsychidae. The habitat suitability curves for Hydropsychidae are based on data and analysis documented in Warren and Nagid (2008) and the Florida Handbook of Habitat Suitability Indices (Nagid 2022).

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