Florida Department of Environmental Protection Stream Condition Index Stressor Identification

Contents

1. Purpose of Document

The purpose of this document is to summarize the various efforts conducted by the Florida Department of Environmental Protection's (DEP or department) Division of Environmental Assessment and Restoration (DEAR)and others to determine the most likely causes of failures of the Stream Condition Index (SCI), and to describe DEP's current Stressor Identification (SI) process.

The SCI is a biological assessment tool that is currently used to determine attainment of the stream numeric nutrient standard, identify impaired waters, assess restoration success, and various other applications. Pursuant to the Impaired Waters Rule [Chapter 62-303, Florida Administrative Code (F.A.C.)], if a stream fails the SCI, a causative pollutant must be identified before placing a water on the Verified List of impaired waters (Category 5). If a stream fails the SCI but a causative pollutant cannot be identified, the stream falls under Category 4d (Impaired, but no causative pollutant identified). For Category 4d waters, a stressor identification (SI) study must be conducted to determine the cause of the SCI failure (Rule 62-303.390(4), F.A.C.). A SI study may also be used to justify a site-specific interpretation of the nutrient criteria where it can be demonstrated that an SCI failure is not due to nutrients (Rule 62-302.531(2)(a)(1)(d), F.A.C.).

Biological communities respond to a variety of natural and human stressors, including water quality pollution, watercourse and watershed alterations that impact stream hydrology, and physical disturbance within the watercourse. The SCI may fail even if no other water quality standards are exceeded; therefore, DEP needs a process to identify the most likely causes of SCI failures. The SI process is a multi-step approach to identify the cause(s) for failing SCI scores. It involves critically reviewing available information, forming possible stressor scenarios, testing the scenarios in the SI Statewide Model, and producing conclusions based on the model output. In some cases, additional data collection may be necessary to accurately confirm the stressor(s). The conclusions can be translated into management actions and the effectiveness of those management actions can be monitored.

2. Background

2.1. Stream Condition Index and Sampling Approach

The SCI is a multi-metric index of macroinvertebrate community health for Florida streams. It is used as a biological assessment tool and as part of the numeric nutrient standard for streams in Chapter 62-302, F.A.C. The current version of the SCI (SCI_2012) was calibrated along a human disturbance gradient (HDG) to ensure that index scores reflect changes in the macroinvertebrate community related to human-induced changes in streams. The HDG for Florida streams included components related to water quality, in-stream habitat, riparian zone character, hydrologic disturbance, and landscape development intensity.

2.2. Habitat Assessment

DEP's stream and river habitat assessment (HA) procedure evaluates the following habitat and hydrologic aspects of streams, with the focus on impacts to the macroinvertebrate community within a representative 100 meter (m) sampling stretch: habitat diversity and availability; water velocity; degree of smothering from sand, silt, or algae; artificial stream channelization; potential for stream banks to contribute sediment to the stream; and riparian buffer width and quality. DEP Standard Operating Procedure (SOP) FT 3100 contains instructions for conducting the HA.

2.3. Florida Stream Classification System

In 2010, Dr. John Kiefer, Ph.D. developed a hydrobiogeomorphic (HBG) classification system for peninsular Florida streams that embodies a broad combination of physical and biological factors known to greatly affect the structure and ecological function of natural systems (Kiefer 2010). The key variables in this system are strongly associated with sources of water, hydrologic regime, fluvial geomorphology and channel dimension, in-stream habitat substrates, and riparian corridor soils and vegetation. The system is hierarchical, requiring streams to first be segregated based on broad differences in regional climate and geology, then by the dominant pathways water reaches the stream and the magnitude of the drainage area (DA), followed the watershed soils and slope of valley, and finally by the dimension and habitats of the channel and floodplain corridor (Kiefer 2010).

In 2012, FDEP contracted with Dr. Kiefer (through AMEC) to classify numerous sites in peninsular Florida as well as apply the system to include the Northeast and Panhandle ecoregions. Dr. Kiefer identified three regions for stream classification purposes based on geology, rainfall and stream flow patterns, and fluvial geomorphology: Northwest Florida Coastal Plain (NWFCP), Northeast Florida Coastal Plain (NEFCP), and the Peninsula Florida Coastal Plain (PFCP). Florida's geology results in three distinctly different water delivery systems for Florida streams: 1) abundant and steady groundwater discharged through limestone springs under pressure (karst), 2) unconfined lateral groundwater seepage through thick columns of sand through relict dunes (highlands), and 3) surface water runoff seasonally coursing through and over combinations of flat, shallow, organic, and sandy soils (flatwoods). Highlands typically, have an abundance of lakes, relict sand dunes, well-drained soils, low water tables, rolling topography, and either few streams on the peninsula or high stream densities on the panhandle (AMEC 2013). Flatwoods generally have an abundance of wetlands, poorly-drained soils, high water tables, flat topography, and many streams, and are typically "flashier" systems than highlands streams. AMEC (2013) found large rivers with a drainage area (DA) greater than 500 mi^2 have confounding factors that make them difficult to classify.

The contract also included an evaluation of the minimum flow regime that can be expected to support rheophilic (flow-loving) organisms. DEP had previously acknowledged that the SCI was not a reliable indicator of water quality in non-perennial streams but did not have a flow-based definition for non-perennial. The expanded study concluded that drainage area is a valuable delineative variable for assessing the potential of flow regime suitable for the SCI, with different thresholds among physiographic regions and water delivery systems. Streams in the PFCP with a DA smaller than 4 mi^2 were inherently non-perennial, while those in the NWFCP and NEFCP regions achieved perenniality with a DA smaller than 4 mi^2 due to the greater volume of rainfall that is more evenly distributed throughout the year (AMEC 2013). PFCP flatwoods streams with DAs between 5 and 50 mi^2 were considered seasonally perennial and those larger than 50 mi^2 were considered perennial.

Because SCI metrics are dependent upon rheophilic organisms, the sampling SOP and Primer have tried to account for these natural variations in flow regime by requiring an adequate period of flow in a stream prior to sampling. However, DEP has recently conducted additional analyses using concepts derived from Dr. Kiefer's work to refine sampling guidance and SCI stressor evaluation. These efforts are described in this report.

3. Summary of Stressor Evaluation Studies

To provide the most relevant and up-to-date information, DEP has refined the SCI sampling procedures directly and indirectly. We have 1) examined the effects of specific conductance and revised dissolved oxygen (DO) criteria to better address biological community requirements, 2) identified potential stressors based on field observations and previous studies, and 3) examined watershed-level characteristics, such as DA size, that can influence biological community. These refinements, observations, and studies are discussed in detail below.

3.1. Effects of Specific Conductance on SCI

From its inception, the SCI was intended to evaluate freshwater macroinvertebrates, so DEP biologists knew that the SCI would not score well in marine influenced waters. However, more detailed statistical analyses revealed that SCI scores were negatively related to specific conductance at much lower levels than the dividing line between predominantly fresh and marine. In 2005 and 2008, DEP conducted statistical analysis of SCI and specific conductance data to evaluate the need to change Florida's conductivity standard. FDEP (2005) found that the number and proportion of sensitive taxa in SCI samples were negatively related to specific conductance, and that a twofold increase in specific conductance could reduce the sensitive taxa by up to 50%. For streams with specific conductance <200 µmhos/cm, there was a rapid decrease in the relative abundance of Florida sensitive taxa as specific conductance increased. The rate of decrease of sensitive taxa declined as specific conductance increased between 200-563 µmhos/cm. None of the least disturbed stream sites had specific conductance greater than an average of 563 µmhos/cm. DEP evaluated all existing data for the 2005 study, and there were no minimally disturbed sites (*i.e.*, LDI <2) with mean specific conductance greater than 600 µmhos/cm. In 2008, DEP staff analyzed responses of the overall SCI scores to specific conductance and found that the probability of failing the SCI increases consistently as specific conductance increases (FDEP 2008).

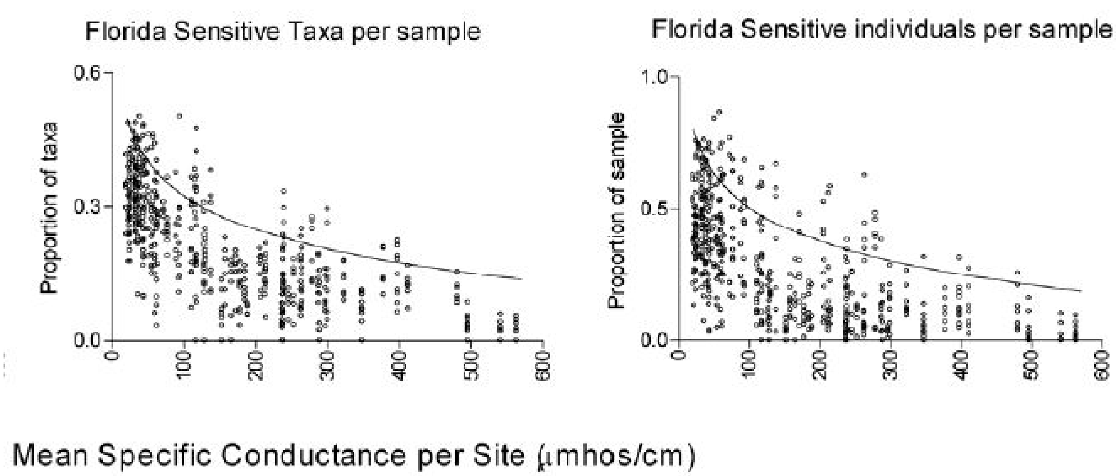


Figure 1. Proportion of taxa (left) and individuals (right) considered sensitive in SCI samples with increasing specific conductance (from DEP 2005).

3.2. Refinement of SCI Sampling Procedures to Prevent Failures due to Natural Hydrology

The SCI and its SOP (DEP SOP SCI 1000) have undergone several revisions since DEP began using it around 1992. The purpose of index revisions was to improve the relationship between the index and measures of human disturbance, while revisions in lab SOPs were to improve the precision of the method. Revisions in field SOPs were intended to ensure that the choice of the sampling site or conditions on the sampling date did not cause a healthy site to fail the SCI. In 2005, some DEP programs were noticing unexpected SCI failures, especially in large river and small stream sites that were relatively unknown to the samplers. Experienced samplers collected additional SCI data at 7 large river and small stream sites in 2006 and obtained significantly higher scores at 5 of the 7 sites (21-55 points higher). Bioassessment staff (previously of the Bureau of Laboratories) determined that some of the previous unexpected failures were due to SCI sample collection at times and locations at which natural hydrologic factors (recent water level change or very low water) or habitat limitation reduced the occurrence of healthy indicator organisms. Revisions were made to the SCI sampling SOP and training requirements to ensure that samplers only collect SCI samples during appropriate hydrologic conditions.

DEP SOP SCI 1000 and the associated *Sampling and Use of the Stream Condition Index for Assessing Flowing Waters: A Primer* (SCI Primer) stress the importance of minimizing impacts of natural hydrologic disturbance (*e.g*., major rain events) and habitat limitation on SCI results. Both documents instruct samplers to take antecedent water levels and habitat availability into account before collecting SCI samples if the purpose of the sampling is to evaluate water quality. It is also made clear that the SCI should not be conducted at “lake-like” sites in which flow-loving organisms likely would not be found. The purpose of these additional restrictions on sampling is to account for natural stressors that may confound impacts of human stressors.

Before a site is included on the 303(d) list for failing SCIs, DEP conducts a review to ensure that the SCI data were collected at appropriate sites under appropriate conditions, according to DEP SOP SCI 1000 and the SCI Primer. DEAR’s Aquatic Ecology and Quality Assurance section (AEQAS) has created a checklist for this review, which includes verification of the following: 1) samplers have maintained proficiency per SOP SCI 1200 and 1300 (http://fldeploc.dep.state.fl.us/sci/query.asp); 2) the waterbody is a flowing stream per SOP SCI 1100, section 2.1 and SCI Primer chapter 2; 3) the sampled site is representative of the waterbody; and 4) antecedent hydrologic conditions were appropriate for SCI sampling per SOP SCI 1100, sections 2.2 and 2.3, and SCI Primer Chapter 3.

3.3. Pollman Stressor Identification Contract

In 2009, DEP hired Dr. Curt Pollman to conduct a stressor identification (SI) analysis of all available SCI data (SCI_2004 and SCI_2007). The goal of this project was to identify the water quality, habitat, or land use factors responsible for SCI failures. Dr. Pollman conducted regression analysis, multiple regression analysis, principal components analysis, and other statistical analyses to best explain SCI failures. Pollman (2009) found that the SCI is likely to fail if specific conductance was greater than approximately 380 µmhos/cm. Pollman (2009) also found that DO was a major determinant of SCI status but focused on other variables for his model because DO is affected by so many other variables. Pollman (2013) found that SCI scores were strongly driven by water velocity, substrate diversity, riparian buffer width, and artificial channelization scores. His analysis showed that there was a high probability that the SCI would fail if the total HA score was less than 80 or the artificial channelization score was less than 10.

Dr. Pollman created two Excel Statewide SI Model spreadsheet models that predict SCI scores based on: 1) specific conductance, substrate diversity, DO, water velocity, excess Total Kjeldahl Nitrogen (TKN), riparian buffer width, and excess temperature (Riparian Buffer Width Model); and 2) specific conductance, substrate diversity, DO, water velocity, excess TKN, artificial channelization, and excess temperature (Artificial Channelization Model). These Statewide SI Models allow one to change the component variables and estimate how the SCI scores may change. For example, if the specific conductance of a stream is high and the SCI failed, one can see the predicted SCI score at that site under lower specific conductance conditions, all other factors staying the same. The models can only evaluate the factors that are included therein, but it is a useful tool for comparing the relative contribution of various stressors for a given site.

3.4. Revised Dissolved Oxygen Criteria

In 2013, DEP revised its DO criteria to better reflect the DO regime in Florida's healthy fresh and marine water systems (FDEP 2013). For freshwaters, the new criteria were derived from the relationship between the daily average DO percent saturation and SCI scores using data collected for a statewide DO study in 2005-2006 (Figure 2). With a set of sites that did not have other known stressors, DEP determined the DO saturation required to achieve passing SCI scores (average of 40) with 90 percent confidence; the revised DO criteria were set for each SCI region at that level. Dr. Pollman's work had shown that DO was a key stressor for the SCI, and the revised DO criteria provided specific DO levels to support stream macroinvertebrate communities in each region of Florida. If a sampling site fails the revised DO standard, then the SCI likely is negatively impacted by low DO.

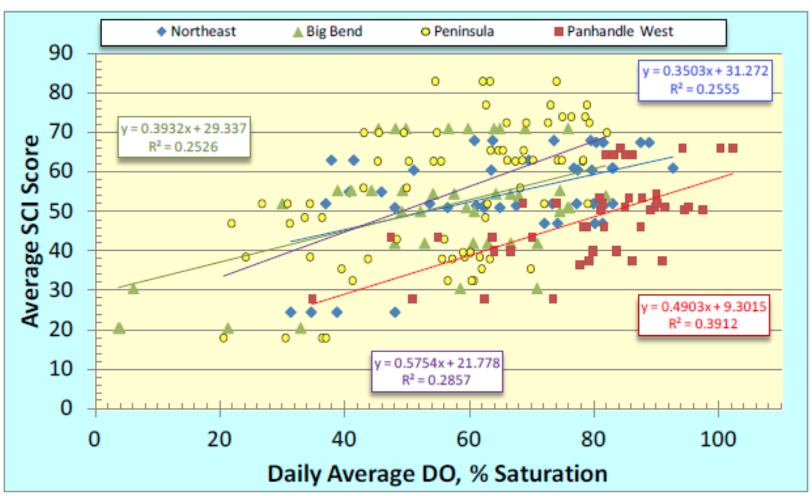


Figure 2. Regional relationships between average SCI score and average daily DO percent saturation for the Panhandle West, Big Bend, Northeast, and Peninsula bioregions. Based on data collected during 2005-2006 and 2010 DO studies screened to remove other potential influences on SCI scores (screening criteria included sites with LDI ≤ 2, conductivity ≤ 300, habitat assessment ≥110, NOx ≤ 0.35 mg/L). (Figure 18 reproduced from FDEP 2013)

3.5. Effects of Stream Classification on SCI Part 1: Dataset Overview

DEP Bioassessment Workgroup staff developed a Stream Classification Dataset to conduct additional analyses regarding SCI stressors. The dataset included the set of SCI metrics and ancillary metadata that was provided to AMEC as part of the 2013 study (n=408 samples representing 196 waterbodies), to which AMEC added a suite of HBG classification elements. Staff from DEAR's Geographic Information Systems (GIS) Section added additional sites to the data set (140 sites), and additional samples were added by DEP's Watershed Monitoring Section, bringing the complete data set to approximately 1,026 samples and 407 sites. Workgroup members filled as many gaps in the dataset as possible, which required classifying additional streams, matching SCI data with water quality, habitat assessment, and other companion data.

Bioassessment Workgroup staff from AEQAS used the Stream Classification Dataset as a launching point for the following study objectives:

1. Determine if some stream classes are more likely to fail the SCI than others.
2. Test the thresholds of perenniality developed by AMEC (2013) with SCI data.
3. Determine at what river size the SCI is no longer an appropriate biological assessment tool due to the overwhelming influence of other factors.

Evaluation of the Stream Classification Dataset showed that mean SCI scores were higher for highlands sites than for flatwoods or karst sites for all stream orders, and that mean SCI scores for sites of low stream order were lower than for mid-sized streams (Table 1). It was also notable that mean SCI scores were low for first order flatwoods and karst sites relative to second order sites of those types. The tendency for low order flatwoods streams to score poorly was further evaluated, and section 3.6 of this document contains those results. The tendency for SCI scores to decline as stream order increases to orders 6-8 was also further evaluated, and those results are presented later in this document.

Table 1. Mean SCI score (and sample size) for each stream order and water source (n=971 samples). Most unclassified sites are in urban areas.

Stream Order	Mean SCI Score Flatwoods	Mean SCI Score Highlands	Mean SCI Score Karst	Mean SCI Score Unclassified	Mean SCI Score by Stream Order
1	25 (10)	62 (35)	38 (31)	61 (13)	49 (89)
2	54 (50)	64 (18)	52 (11)	60 (36)	57 (115)
3	62 (50)	66 (28)	52 (2)	71 (51)	66 (131)
4	57 (72)	68 (47)	58 (2)	68 (91)	65 (212)
5	58 (53)	66 (68)	-	69 (28)	63 (149)
6	42 (51)	59 (62)	-	84 (13)	55 (126)
7	49 (43)	48 (38)	-	46 (26)	48 (107)
8	47 (10)	48 (28)	-	54 (4)	49 (42)
Overall Mean	**53**	**61**	**43**	**66**	**59**

An evaluation of the percent of SCI samples that failed showed that a higher percent of karst sites failed when compared with flatwoods and highlands sites (Figure 3). Fewer SCI samples have been collected in more recent years, especially at Karst sites. For flatwoods sites, 5-40% of samples scored less than 35 in recent years, while 10-30% of highlands samples scored below 35 (Figure 4).

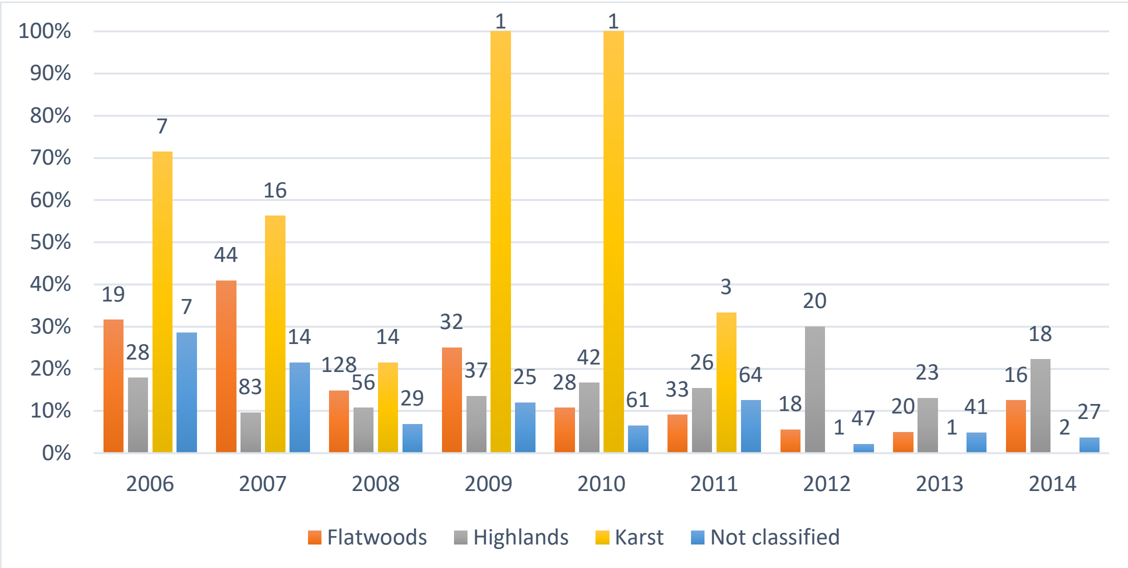


Figure 3. Percent of SCI samples within each physiographic stream type per year (2006-2014) that were less than 35 (failing) for 1,025 SCI samples in the 9/18/15 Stream Classification Master Datafile. Number shown on each column is the total number of samples for that stream type and year.

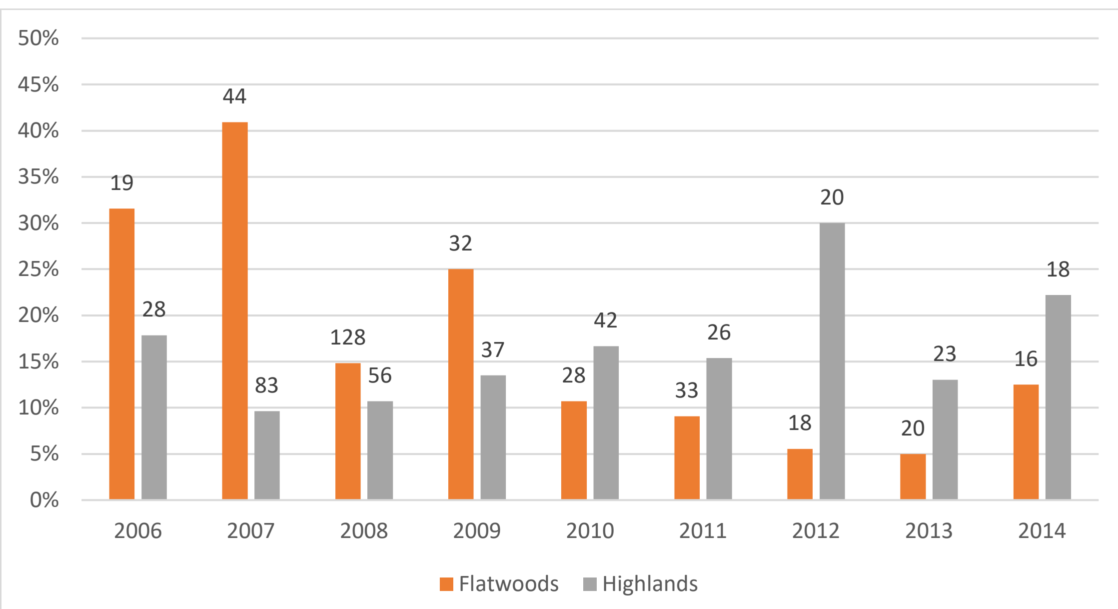


Figure 4. Percent of SCI samples within Flatwoods and Highlands physiographic stream type per year (2006-2014) that were less than 35 (failing) for SCI samples in the 9/18/15 Stream Classification Master Datafile. Number shown on each column is the total number of samples for that stream type and year. The data in this figure are a subset of data in the previous figure.

3.6. Effects of Stream Classification on SCI Part 2: Non-perennial Streams

Using stream gage information and flow duration curves, AMEC analyzed the relationships between DA and flow duration within each region to determine when sites within each region would achieve a 90-day, 180-day, and 360-day flow period per year (AMEC 2013). If a site had roughly 90% of years with 180-day flow periods or greater, AMEC considered these sites to be "reliably perennial." Streams with 50% of years with 180-day flow periods were "likely perennial," 75% of years with 90-day flow were "seasonally perennial," and sites with less than 50% of years with a 90-day flow regime were identified as "likely non-perennial." AMEC cautioned that the categories were conceptual and additional work was needed to confirm the thresholds and their relevance to SCI sampling. To test the relevance of these categories to SCI scores, DEP compared mean SCI scores for "likely non-perennial" and "likely-perennial," and SCI scores were significantly lower for "likely non-perennial" streams (48 ± 23) than for "likely perennial" (58 ± 17) (two sample t-test, $n=59$, $p<0.05$). In addition, "likely non-perennial" sites had a 25% failure rate (SCI <35), compared to 8% for "likely-perennial" sites.

DEP used a dataset of 1,011 SCI samples from 407 sites (karst and unclassified sites not included) that were assigned as either Flatwoods or Highlands to evaluate the likelihood for the SCI to fail at sites with small DAs (non-perennial streams) and very large DAs (large rivers, operating differently from wadeable streams). Most of the sites in the dataset have minimal human disturbance (sixty-four percent of sampling sites in the data set had stream corridor Landscape Development Intensity (LDI) values less than 2.5, while only 20% had values greater than 2.5 and 16% did not have LDI values assigned). .

Regardless of stream type, sites with DA less than 5 m^2 fail at a much higher rate than other size classes (Figure 5). Looking at highlands versus flatwoods streams provides additional insight into potential seasonal impacts on SCI scores. Mean SCI scores are typically five points higher in highlands streams than flatwoods streams, and the range of scores is generally wider for flatwoods streams (Figure 6). This pattern is likely related to greater flow variability in flatwoods streams compared to highlands streams, where more consistent base flow leads to stable conditions for aquatic macroinvertebrates. For flatwoods systems, sites with drainage areas less than 20 sq. miles have lower and more variable SCI scores than those with drainage areas greater than 20 sq. miles (Figure 7). These results suggest that SCI scores are lower, more likely to fail, and are more variable in streams with smaller DAs, particularly those with flashy hydroperiods as is typical in flatwoods systems. More samples are needed to confirm this pattern.

Based on these analyses, DEP has developed some preliminary guidance for SCI sampling in flatwoods or highlands streams of varying DAs. Table 2 identifies watershed-based attributes that further define biological expectations of streams of varying size. The objective is to *a priori* identify systems that are not likely to be appropriate for SCI sampling, which will help prevent sites from being listed for biological impairment due to misapplication of assessment tools. Table 2 makes recommendations for SCI sampling in systems of varying sizes to help reduce the SCI being used at sites and under conditions for which it was not intended.

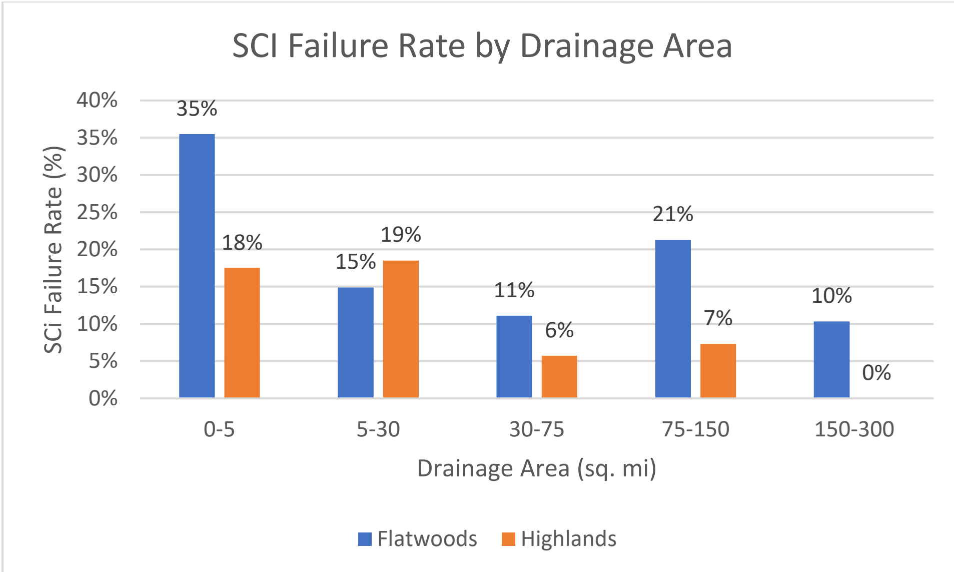


Figure 5. SCI failure rate for DAs of increasing size by water source. Individual sample results were used to obtain minimum sample size (n≥30) for each range of DAs.

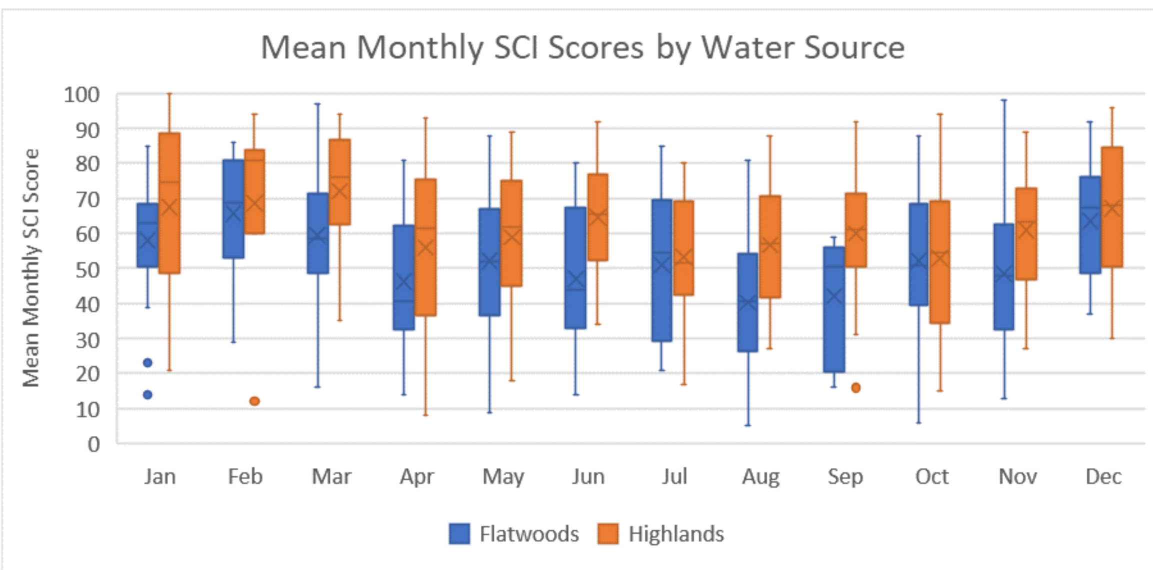


Figure 6. Mean monthly SCI scores by water source.

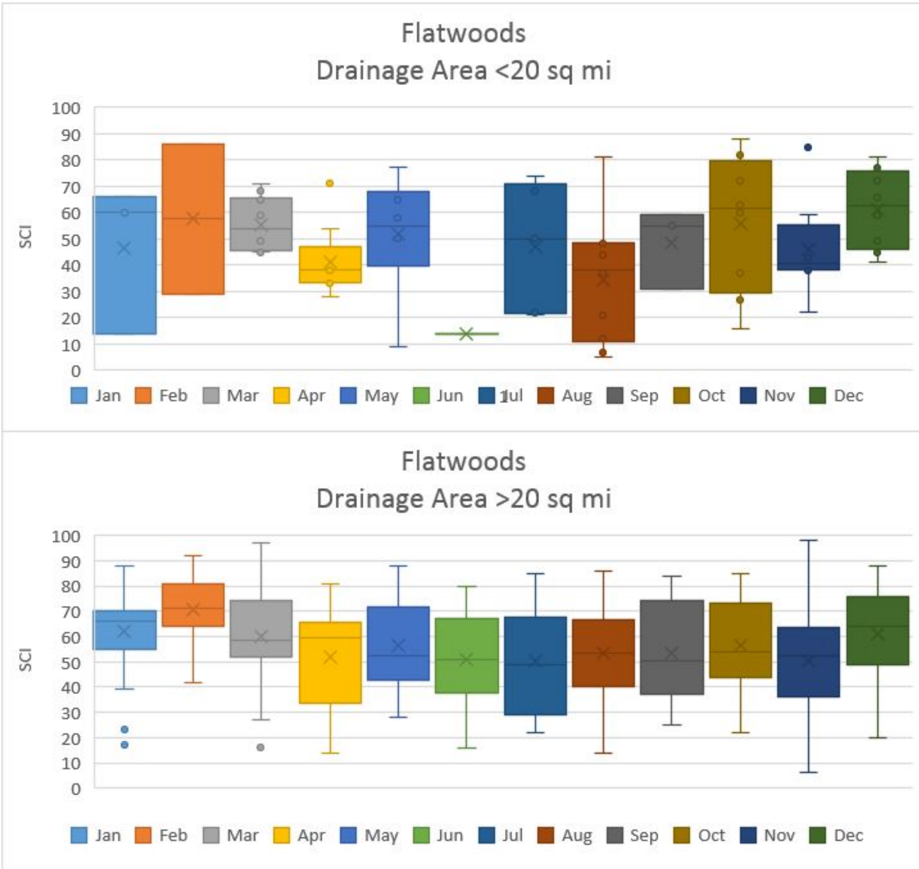


Figure 7. Monthly SCI scores for samples collected in flatwoods sites with drainage areas less than and greater than 20 sq. miles.

Table 2. Summary of draft SCI recommendations based on region, water source, and drainage area.

Region	Water Source	DA sq. miles	Perenniality	SCI Sampling Guidance
Peninsula	Flatwoods	DA <5	Non-perennial	SCI not appropriate.
		≥5 DA <20	Seasonally Perennial	Use caution after prolonged drought or onset of rainy season.
		≥20 DA <50	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥50	Perennial	Follow SCI primer. No additional restrictions.
	Highlands	DA <1	Non-perennial	SCI not appropriate.
		≥1 DA ≤5	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥ 5	Perennial	Follow SCI primer. No additional restrictions.
Northeast	Flatwoods	DA <1	Non-perennial	SCI not appropriate.
		≥1 DA <5	Seasonally Perennial	Use caution after prolonged drought or onset of rainy season.
		≥5 DA <20	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥20	Perennial	Follow SCI primer. No additional restrictions.
	Highlands	DA <3	Seasonally perennial	Use caution after prolonged drought or onset of rainy season.
		3 ≥DA ≥5	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥5	Perennial	Follow SCI primer. No additional restrictions.
Northwest	Flatwoods	DA <1	Non-perennial	SCI not appropriate.
		≥1 DA <5	Seasonally Perennial	Use caution after prolonged drought or onset of rainy season.
		≥5 DA <10	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥10	Perennial	Follow SCI primer. No additional restrictions.
	Highlands	DA <1	Seasonally Perennial	Use caution after prolonged drought or onset of rainy season.
		≥1 DA <5	Likely Perennial	Follow SCI primer. No additional restrictions.
		DA ≥5	Perennial	Follow SCI primer. No additional restrictions.

3.7. Effects of Stream Classification on SCI Part 3: Large Rivers

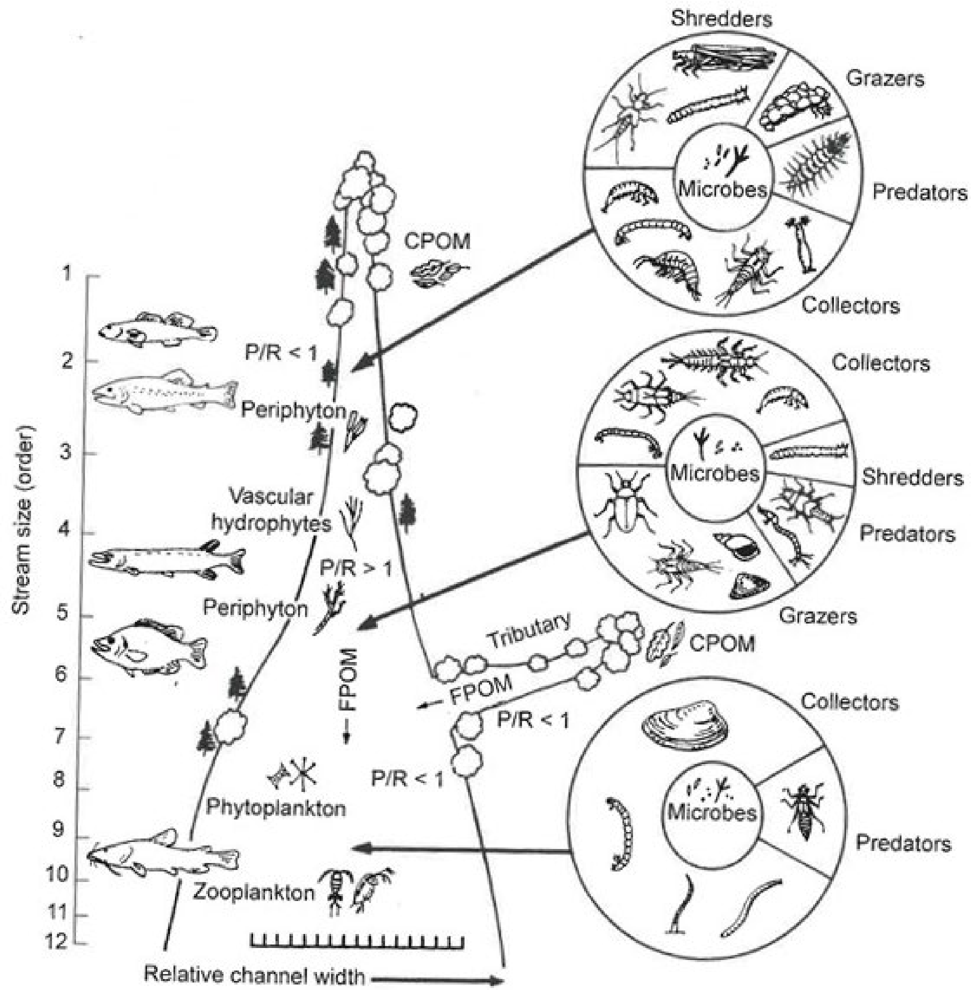


Figure 8. Allan JD, MM Castillo. 2007. Stream Ecology: structure and function of running water. Second Edition. Netherlands: Springer Publishing.

For the purpose of this study, DEP defined large rivers as those systems having a drainage basin greater than 500 mi^2 based on AMEC's guidance (2013). Based on ecological theory, large rivers should not have the same expectations as for headwater streams because flowing systems change from allochthonous (using external food material) to autochthonous (creating food within the waterbody) as the size of the river allows sunlight to drive productivity (Figure 8). However, it is not clear at what size the SCI would not be appropriate for rivers. Data were available for 218 large rivers throughout Florida for a total of 528 samples: 103 sites were classified as flatwoods (254 samples), and 115 sites were classified as highlands (274 samples). The smallest drainage area (DA) was 512 mi^2 (site on the Chipola River), and the largest was 17,851 mi^2 (site on the Apalachicola River). All SCI scores were calculated using the most recent 2012 version. The SCI failure rate for all samples was 29%, and that rate varied based on region and classification (Table 3).

Table 3. Summary of SCI samples and failures for all, flatwoods (FW), and highlands (HL) river sites with drainage area (DA) greater than 500 mi^2 within the northeast (NEFCP), northwest (NWFCP), and peninsular Florida Coastal Plain (PFCP) regions.

Region	Physiography	# of sites	# of samples	# SCI failures	% SCI failures	Min. DA	Avg. DA	Max. DA
All	**All sites**	**218**	**528**	**152**	**29**	**512**	**2,839**	**17,851**
All	**FW**	103	254	80	31	550	2,588	17,851
All	**HL**	115	274	72	26	512	3,071	17,178
NEFCP	**All sites**	**75**	**206**	**56**	**27**	**552**	**2,772**	**9,663**
NEFCP	**FW**	41	108	19	18	575	2,051	7,031
NEFCP	**HL**	34	98	37	38	552	3,567	9,663
NWFCP	**All sites**	**85**	**179**	**53**	**30**	**512**	**4,070**	**17,851**
NWFCP	**FW**	15	34	19	56	1309	7,969	17,851
NWFCP	**HL**	70	145	34	23	512	3,156	17,178
PFCP	**All sites**	**58**	**143**	**43**	**30**	**520**	**1,393**	**3,331**
PFCP	**FW**	47	112	42	38	550	1,472	3,331
PFCP	**HL**	11	31	1	3	520	1,106	2,004

Initially, SCI scores were plotted versus DA to determine if there was any obvious trend between SCI score and DA. One would expect SCI scores to decrease with increasing DA, potentially due to limited habitat availability and habitat diversity. However, a significant trend was not observed, $R^2 = 0.06$ (Figure 9). There was also no significant trend when Flatwoods and Highlands sites were evaluated separately.

As there were no significant trends when examining individual SCI scores versus DA, DA bins were created, and the percentage of SCI failures were compared in each bin range. The bin combination with the highest R^2 consisted of 8 bins with about 60 samples per bin ($R^2 = 0.64$). The goal was to keep the bin sample size equal; however, sites with multiples samples were not divided between two bins, which led to slightly unequal bin sample size. For the analysis, a DA bin with an SCI failure rate greater than 35% (1 in 3) was considered unacceptable (inappropriate for routine SCI sampling), and DA bins with an SCI failure rate between 25-34% were flagged for site-specific assessment prior to sampling.

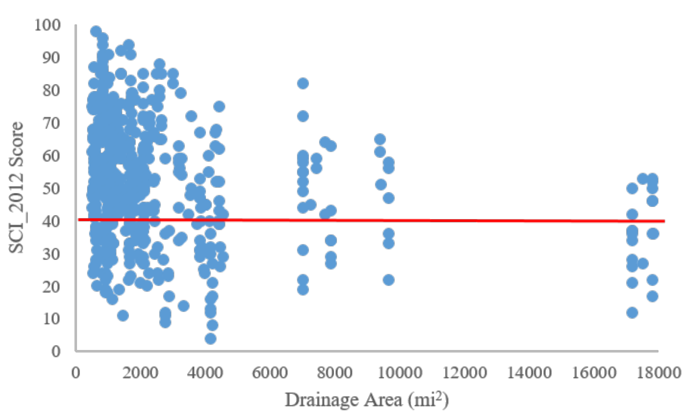


Figure 9. SCI score versus drainage area (mi^2) for all samples (218 sites, 528 samples), R^2=0.06. 152 samples fail the SCI for an overall SCI failure rate of 29%. Red line indicates passing SCI threshold.

After examining samples within the different regions and physiographies, several of the smaller large drainage basins (500-2,000 mi^2) had a higher than expected percentage of SCI failures. Some of the samples within the dataset had potential stressors, other than drainage size, that were identifiable based on previous studies. Samples failing the SCI with one or more of these stressors identified were removed from the dataset so that the analysis would focus on the effects of drainage area size and not additional known stressors. The stressors identified and the basis for their exclusion from the dataset include:

1. **Sites with unsafe sampling conditions, likely tidally influenced, and canalized structure**. These stressors were identified by staff responsible for the DEP Temporal Variability (Trend) Network, which examines long-term changes in Florida's ambient water quality. Trend Network staff specifically avoid sampling sites with unsafe sampling conditions, that are likely tidally influenced, or have a canalized structure.

2. **Samples with an "X" qualifier for SCI score** were also removed from the Large River dataset. An "X" qualifier when reporting results from an SCI analysis indicates that insufficient individuals were present in the sample to achieve a minimum of 280 organisms for identification, suggesting either extreme environmental stress or a sampling error. As the data user is unable to distinguish between environmental stress or sampling error, all SCI results with an "X" qualifier were removed from the dataset.

3. **Sites with an overall Habitat Assessment score less than 80 or an Artificial Channelization score of less than 10.** As part of the Stressor Identification analysis (Stressor ID) that he conducted under contract with the Department, Dr. Curt Pollman found that samples are likely to fail the SCI if the overall Habitat Assessment (HA) score is less than 80 and are highly likely to fail the SCI if the Artificial Channelization score of the HA is less than 10.

4. **Sites with specific conductance greater than 380 µmhos/cm.** Dr. Pollman also found that when specific conductance values are greater than 380 µmhos/cm, SCI scores are likely to be less than 45. An additional study (DEP 2005) found when specific conductance values are greater than 600 µmhos/cm, sensitive taxa are impacted.

5. **Sites with DO levels less than 5.0 mg/L.** While the DO criteria are now expressed as percent saturation for streams, these data are lacking from the Large Rivers dataset, so the old DO threshold of 5.0 mg/L was used to signify inadequate DO to support aquatic organisms.

Once these samples (Table 4) were removed from the dataset, the department calculated the average SCI failure rate for each DA bin and plotted the results (Figures 10-14). When all remaining samples were combined, there is a clear increase in the percentage of failures with increasing bin size (Figures 9 and 10). For this analysis, drainage area bins with an SCI failure rate less than 24% are considered to be appropriate for use with the SCI, bins with an SCI failure rate between 25-34% must be considered on a case-by-case basis, and bins with an SCI failure rate greater than 35% are inappropriate for use with the SCI.

Table 4. Identified potential stressors and number of samples and SCI failures after stressors were removed from larger rivers dataset. SCI failure rate decreased from 27% to 20% among large river sites after removing all known stressors.

Stressor	# of samples	# of samples removed per stressor	# of SCI failures	% SCI failure
All samples	528	0	141	27
Trend sites	516	12	129	25
"X" Qualifier for SCI	509	7	129	25
Sp. Conductance > 380 µmhos/cm	493	16	113	23
DO < 5.0 mg/L	483	10	103	21
HA < 80	482	1	102	21
Artificial Channelization < 10	474	8	94	20

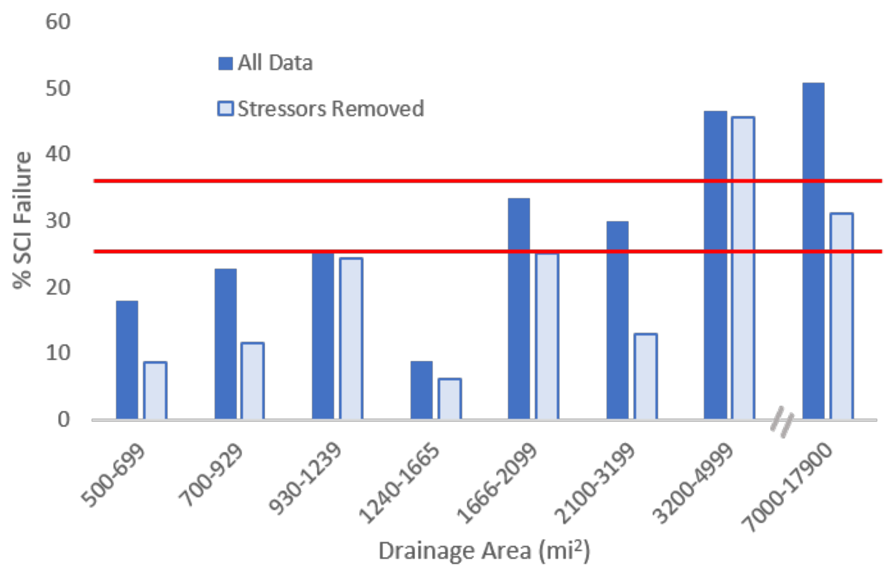


Figure 10. Percent SCI failure versus drainage area (mi²) for all samples after stressor removal (204 sites, 467 samples), R^2=0.46. Red lines indicate estimated thresholds of unacceptable SCI failure rates.

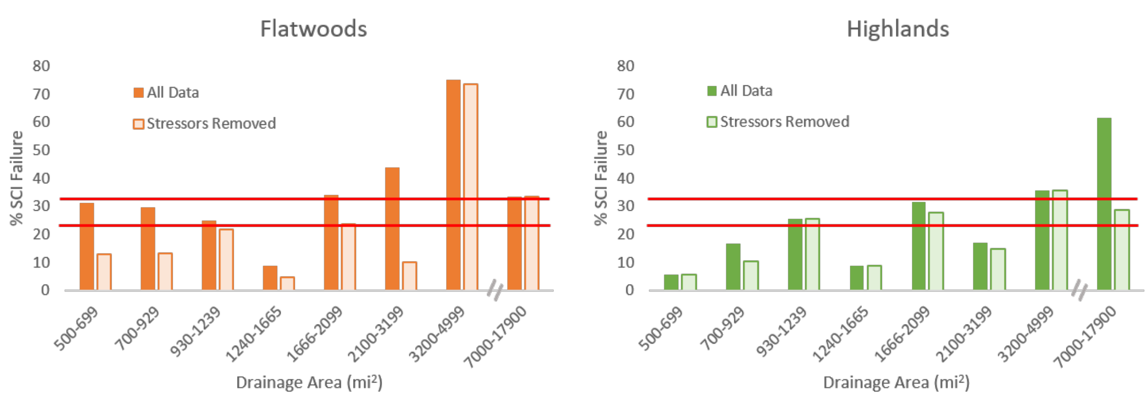


Figure 11. Percent SCI failure versus drainage area (mi²) for Flatwoods (left) and Highlands (right) after stressor removal. Red lines indicate estimated thresholds of unacceptable SCI failure rates.

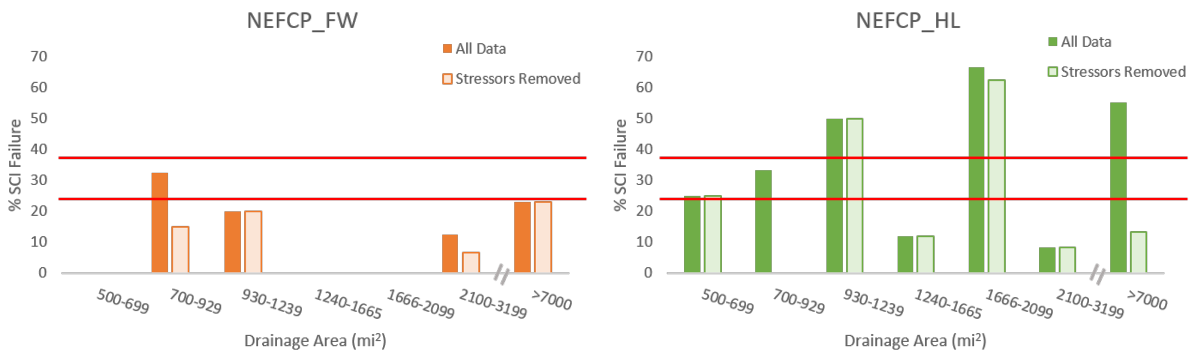


Figure 12. Percent SCI failure versus drainage area (mi^2) for NEFCP Flatwoods (left) and Highlands (right) after stressor removal. Red lines indicate estimated thresholds of unacceptable SCI failure rates.

However, there was no significant trend or pattern between SCI failure rate and DA in NEFCP Flatwoods or Highlands sites (Figure 12), which makes interpreting the results difficult. After removing potential stressors, Flatwoods had an overall SCI failure rate of 11% (11 out of 100 samples). Additional data are needed to make a recommendation for NEFCP Flatwoods sites; therefore, all NEFCP Flatwood sites should be considered on a case-by-case basis for use with the SCI.

For NEFCP Highlands sites, the SCI failure rate improved from 38% to 24% after stressor removal. NEFCP Highlands sites with a drainage area less than 930 mi^2 are appropriate for use with the SCI. Due to the variability of results for Highlands sites, those with a drainage area greater than 930 mi^2 should be considered on a case-by-case basis for use with the SCI.

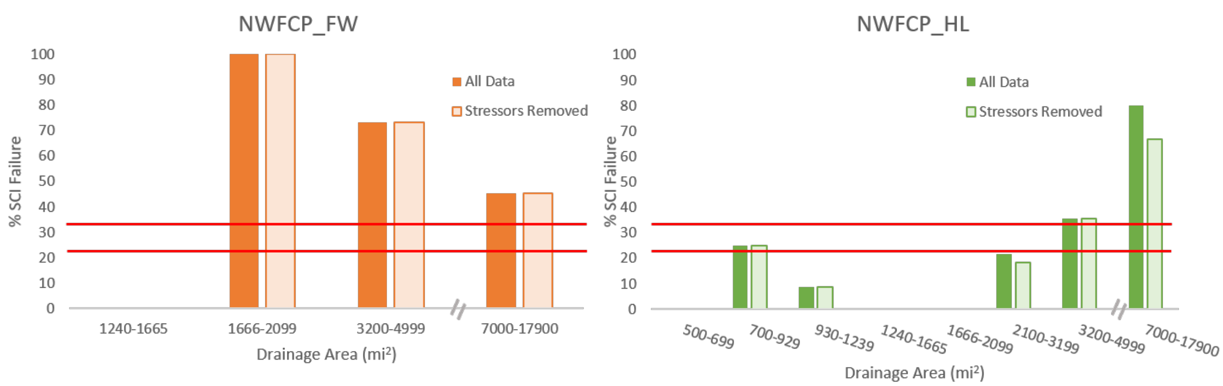


Figure 13. Percent of SCI Failure versus drainage area (mi^2) for NWFCP Flatwoods (left) and Highlands (right) after stressor removal. Red lines indicate estimated thresholds of unacceptable SCI failure rates.

After evaluating sites for potential stressors, no failing SCI samples were removed from the NWFCP Flatwoods dataset. NWFCP Flatwoods sites with a drainage area greater than 1,666 mi^2 are not appropriate for use with the SCI (Figure 13). Due to lack of data for Flatwoods sites with drainage area less than 1,309 mi^2, it is possible the drainage area requirements may be less for Flatwoods sites; however, additional data would be needed to make this determination. NWFCP Flatwoods sites with a drainage area less than 1,309 mi^2 should be considered on a case-by-case basis for use with the SCI; however, results from overall Flatwoods indicate sites with a drainage area between 500-1,665 mi^2 are appropriate for use with the SCI (Figure 11).

NWFCP Highland sites with a drainage area less than 2,100 mi^2 are appropriate for use with the SCI (Figure 13). Sites with a drainage area between 2,100-3,199 mi^2 should be sampled on a case-by-case basis. Sites in the NWFCP Highlands region with a drainage area greater than 3,200 mi^2 are not appropriate for use with the SCI.

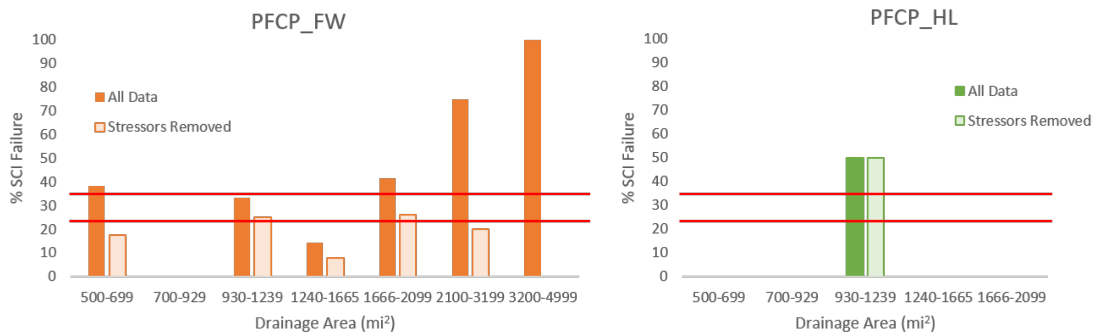


Figure 14. Percent of SCI Failure versus drainage area (mi^2) for PFCP Flatwoods (left) and Highlands (right) after stressor removal. Red lines indicate estimated thresholds of unacceptable SCI failure rates. Missing bars indicate there were no SCI failures for that bin.

The SCI failure rate for PFCP Flatwoods sites improved from 38% to 17% after removal of potential known stressors. Sites within the PFCP Flatwoods region with a DA less than 930 mi^2 are appropriate for use with the SCI (Figure 14). Sites with a drainage area greater than 930 mi^2 should be considered on a case-by-case basis for use with the SCI.

The rate of SCI failures (3%) did not change for sites in the PFCP Highlands region. There were too few data available for an appropriate analysis, and a conclusion cannot be determined about the drainage area bounds for appropriateness of the SCI in the PFCP Highlands. PFCP Highlands sites should be considered on a case-by-case basis for use with the SCI. Given overall results for Highlands sites, those with a drainage area less than 900 mi^2 are likely appropriate for use with the SCI (Figure 11).

Table 5. Draft recommendations for SCI for sites with drainage area ≥ 500 mi^2.

	Approximate Drainage Area (mi^2)	Recommendations for SCI
All**	500-1,665	OK
All**	1,666-3,199	Case-by-case
All**	>3,200	Not appropriate
Flatwoods	500-1,665	OK
Flatwoods	1,666-3,199	Case-by-case
Flatwoods	>3,200	Not appropriate
Highlands	500-929	OK
Highlands	930-3,199	Case-by-case
Highlands	>3,200	Not appropriate
NEFCP	500-929	OK

NEFCP	>930	Case-by-case
Flatwoods	>500	Case-by-case
Highlands	500-929	OK
Highlands	>930	Case-by-case
NWFCP	500-1,665	OK
NWFCP	1,666-3,199	Case-by-case
NWFCP	>3,200	Not appropriate
Flatwoods	500-1,665	Case-by-case
Flatwoods	>1,666	Not appropriate
Highlands	500-2,099	OK
Highlands	2,100-3,199	Case-by-case
Highlands	>3,200	Not appropriate
PFCP	500-929	OK
PFCP	>930	Case-by-case
Flatwoods	500-929	OK
Flatwoods	>930	Case-by-case
Highlands	>500	Case-by-case

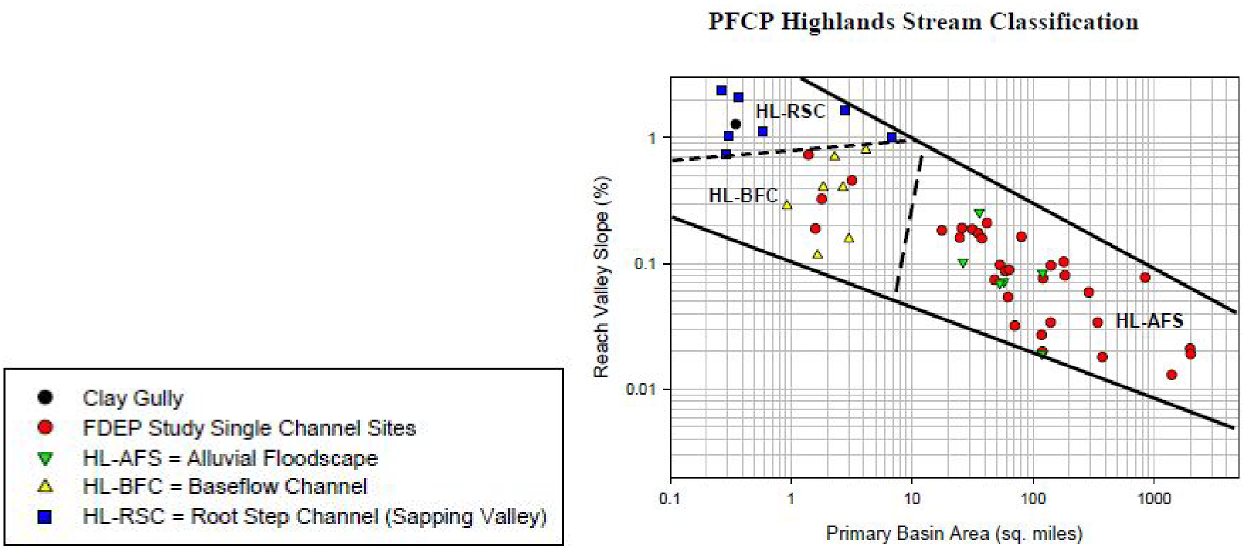
** If conditions are unsafe, do not sample regardless of drainage area size and/or recommendation. **

3.8 Effects of Stream Classification on SCI Part 4: Low-gradient systems

An additional feature of the landscape that can impact the SCI is the lack of a gradient or slope that can result in low-flow or even stagnant conditions for considerable periods of time. (Power is a stream's ability to move water and sediment downstream.) Dr. Kiefer's HBG stream types align along a gradient related to their size and power. Figures 15-20 show the relationship between slope and drainage area for Highlands and Flatwoods streams in the PFCP, NWFFCP, and NEFCP regions. Note that smaller systems typically have steeper slopes and more closed canopies and tend to widen and flatten as you move downstream. Individual HBG classes shown in the figures are more fully described in the 2013 report prepared by AMEC for the Department; what is important here is the overall relationship of slope to basin/drainage area for the different areas and water sources. The slope shown on the y-axis is the "reach valley slope," which is the difference in elevation from a section above the site/station of interest to a point below it divided by the distance between those points.

Before visiting a site, staff may want to determine the reach valley slope for the stream. The stream section used to calculate the slope should be relatively straight and representative of the waterbody in that area. Sites that fall outside the lower slope bounds of the depicted relationships tend to be too gradually sloped to have sufficient power to function as streams during typical hydrologic conditions, and the SCI may not be the appropriate assessment tool. It does not mean that these systems never have unidirectional flow or cannot support rheophilic taxa under ideal conditions, but that they are more likely to score poorly or fail the SCI due to a lack of adequate flow and the associated dissolved oxygen levels that result from such flow. They may function more as a chain of lakes (*e.g.*, parts of the St Johns River), a series of sloughs (*e.g.* systems in the Kissimmee River Basin), or anastomosing systems, all of which form under low energy conditions.

The graphs below should be used as a guide and alert samplers and data reviewers to the possibility of there being insufficient gradient to allow for continuous flow and dissolved oxygen for rheophilic organisms. Please note that Dr. Kiefer (AMEC 2013) did not provide a graph for Flatwoods basins in the Northwest Region because there were relatively few such systems. However, the two graphs provided below should help determine the expected slope for a given drainage area in this area.



Figures 15. Relationship between drainage area and valley slope for Highlands streams in the PFCP (Source: AMEC 2013).

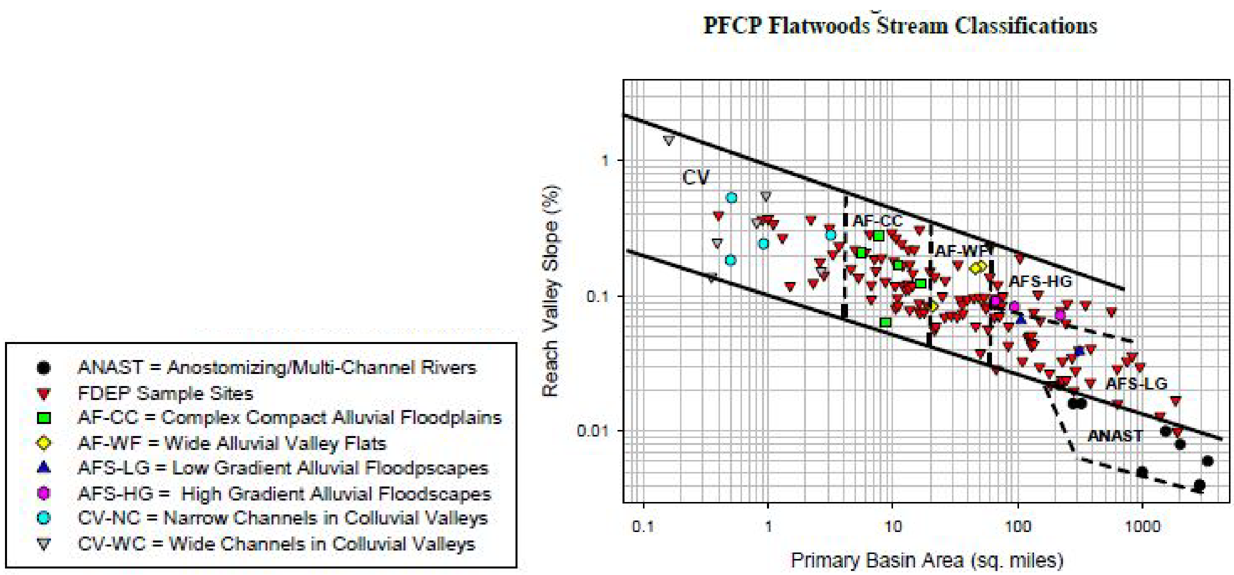


Figure 16. Relationship between drainage area and valley slope for Flatwoods streams in the PFCP (Source: AMEC 2013).

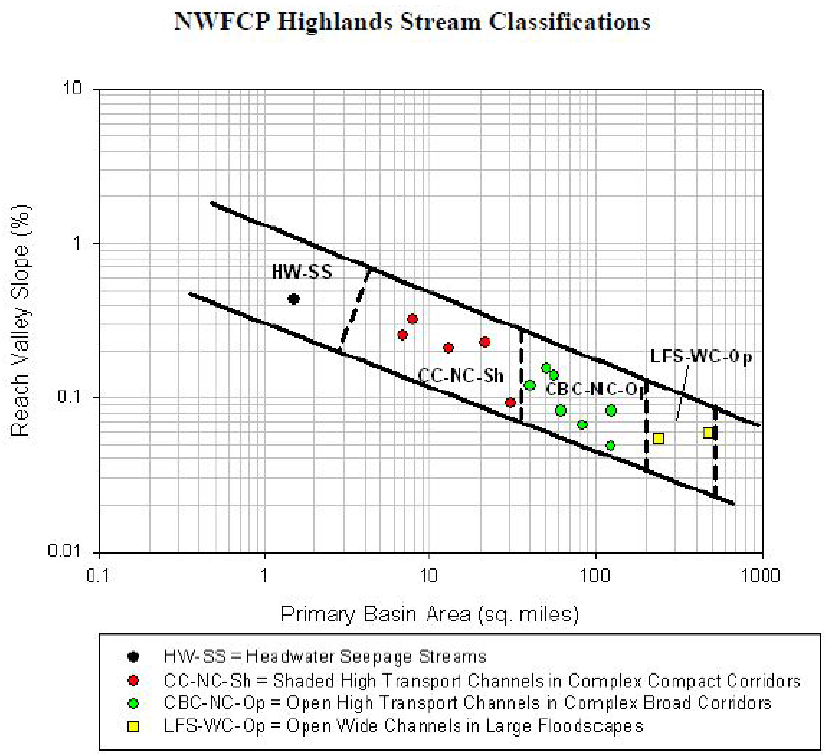


Figure 17. Relationship between drainage area and valley slope for Highlands streams in the NWFCP (Source: AMEC 2013).

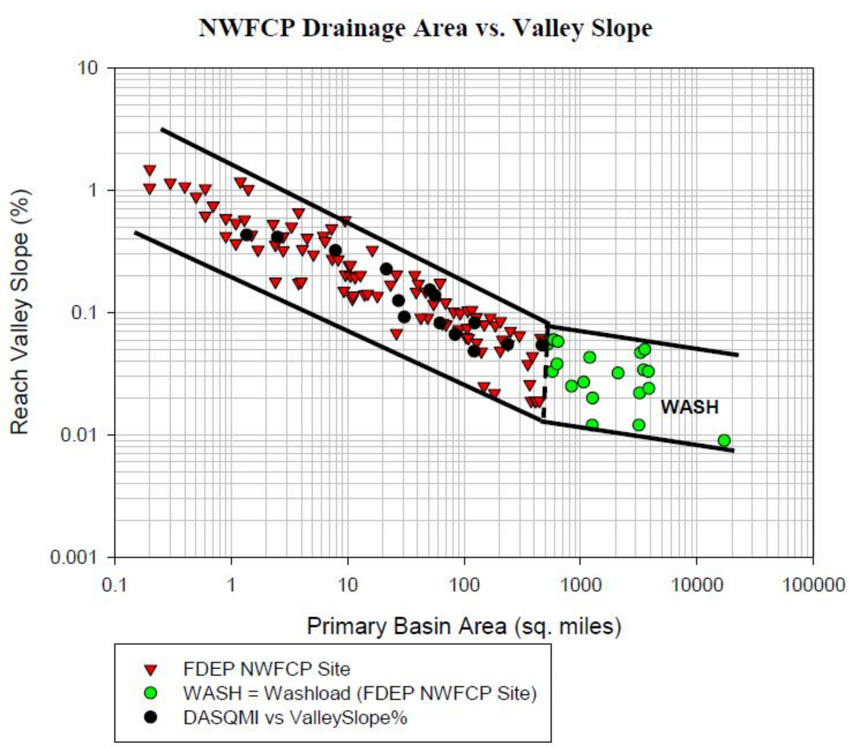


Figure 18. Relationship between drainage area and valley slope for Flatwoods streams in the NWFCP (Source: AMEC 2013).

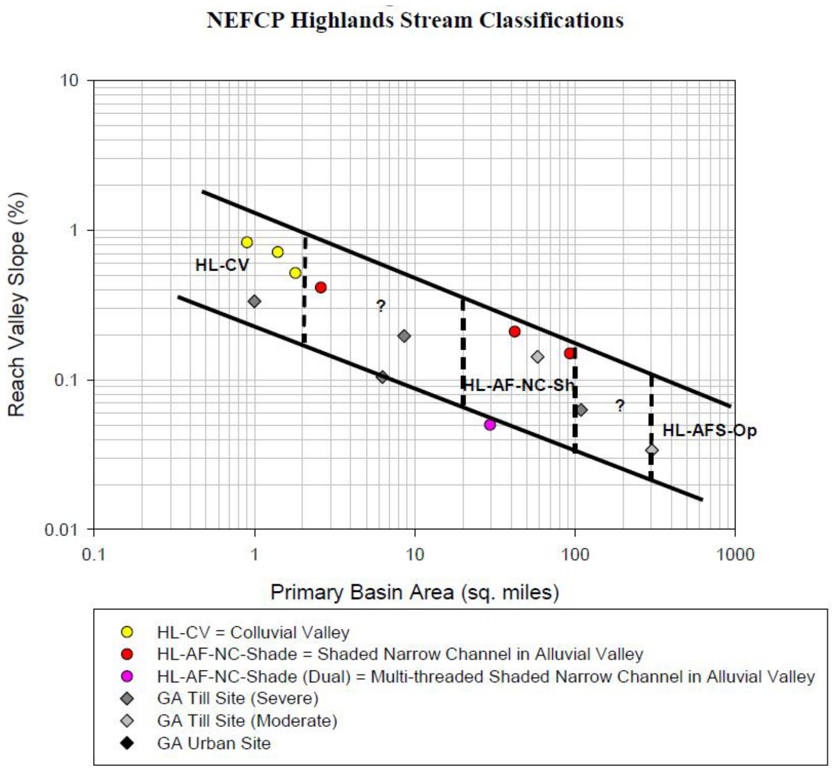


Figure 19. Relationship between drainage area and valley slope for Highlands streams in the NEFCP (Source: AMEC 2013).

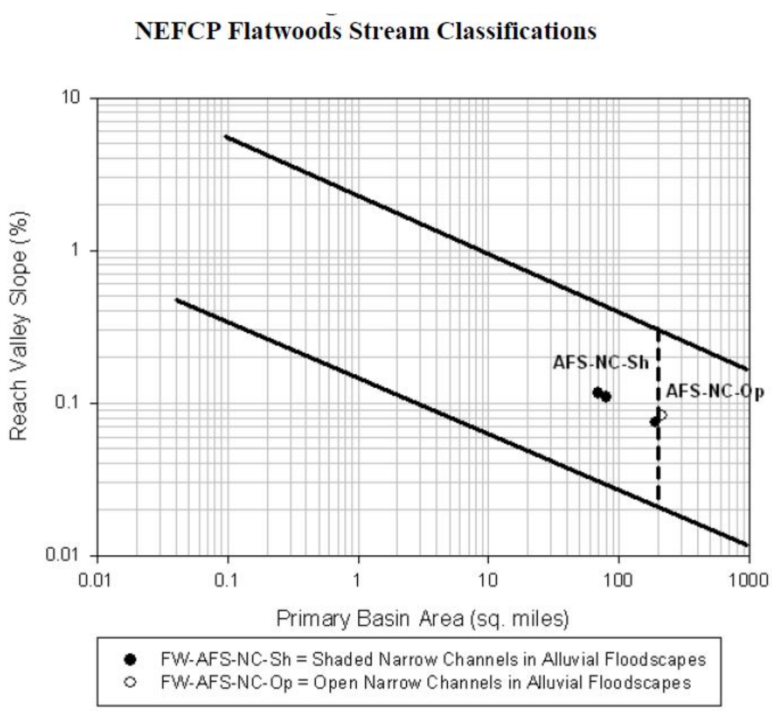


Figure 20. Relationship between drainage area and valley slope for Flatwoods streams in the NEFCP (Source: AMEC 2013).

3.9 Evaluation of SCI Failures in IWR Database

DEP summarized the effect levels of various stressors on the SCI as determined in past efforts (Table 6), and evaluated the relationship between SCI, HA, and water quality results from stream sampling events in the IWR database. As of 8/2/17, there were 2,598 SCI results with associated HA scores in the Impaired Waters Rule database, collected between 8/7/06 and 7/7/17. Of those samples, 1,911 (74%) had passing SCI scores (≥40) and optimal or suboptimal HA scores (>80, the HA score at which a site is likely to pass the SCI per Pollman 2009), and 127 (5%) samples failed the SCI and had poor or marginal HA scores. This is the population of samples with results expected to fail based on habitat alone. The remaining 560 samples had unexpected results that fall into 1 of 2 categories: 1) samples that passed the SCI with poor or marginal HA (54 samples, 2%), or 2) samples that failed the SCI with optimal or suboptimal HA (506 samples, 19%). The samples with failed SCIs but with optimal or suboptimal HA conditions require further attention and are a major focus of this effort. Of those 506 samples, 172 (34%) do not meet water quality criteria for DO, 28 (6%) have specific conductance greater than 380 (Table 6), and some additional streams are listed as impaired for ammonia or metals. The SI process described below is designed to help understand the varied reasons for the remaining failures, especially those not explained by water quality impairments.

Table 6. Summary of known Stressors, approximate thresholds that likely influence the SCI (typically pass vs. fail), the source of the threshold, and current DEP application.

Stressor	Threshold of Impact	Source of Threshold	In use? Where?
WQ: Specific conductance	600	FDEP 2005	DEP Status and Trend Networks and Strategic Monitoring Plan (SMP) do not sample if conductivity > 600 and marine source present; used to determine if marine-influenced sites appropriate for SCI in review checklist.
WQ: Specific conductance	~380	Pollman Stressor ID Task 1 (2009) – likely SCI < 45 if cond >~380	In final Stressor ID spreadsheet model
WQ: DO	New fresh DO criteria	FDEP 2013	Chapters 62-302 and 62-303, F.A.C.
HA: total	80	Pollman Stressor ID Task 1 (2009)– found highly likely to fail SCI if HA<80	Justification for artificial conveyance in NNC Implementation doc (poor or marginal score); SMP may not sample SCI if HA < 80
HA (hydrology): Artificial Channelization	10	Pollman Stressor ID Task 1 (2009)– found highly likely to fail SCI if channel < 10	Justification for artificial conveyance in NNC Implementation doc (poor or marginal score). In final Stressor ID spreadsheet model
WQ: TKN (shown as excess N when related to color)	0.38-1.38 mg/L	Pollman Stressor ID (Tasks 3 and 5, 2013) – SCI scores declined from TKN 0.38-1.38, no further declines above 1.38	In final Stressor ID spreadsheet model
HA (hydrology): water velocity	0.05 m/s	Best professional judgement. Velocities less than 0.05 do not provide appropriate conditions for rheophyllic organisms. Pollman Stressor ID (Tasks 3 and 5, 2013)	SCI SOP and Primer direct sampling not to sample if velocity <0.05 in past month. In final Stressor ID spreadsheet model
HA: substrate diversity HA: riparian buffer width (effects equal for riparian buffer veg quality)	No effect threshold in model	Pollman Stressor ID (Tasks 3 and 5, 2013)	In final Stressor ID spreadsheet model

WQ: Temperature (shown as excess temp when related to date) WQ: DO			
Hydrology: Perenniality	Non-perennial waters do not support passing SCI	BPJ and Kiefer 2010	SCI SOP and Primer require 6 months wetted condition and 3 months connected wetted for sampling; Implementation doc defines non-perennial streams as having wetland-like fauna
Hydrology: Perenniality	All streams Basin size < $1mi^2$, don't sample SCI; Flatwoods: Basin size < 5 mi^2 have 50% chance of failing SCI	AMEC 2013 and FDEP data confirmation	FDEP 2017
Hydrology: River drainage area size (square miles)	Lake-like rivers don't support passing SCI. Rivers with > 3,000 mi^2 basin size expected to be autochthonous and fail SCI	AMEC 2013 and FDEP data confirmation	FDEP 2018
Hydrology: % Impervious surfaces	No thresholds	Some from literature but none for FL	none

Using the Stream Classification Database, DEP used the known water quality stressors in Table 6 to quickly screen failing SCI sites to see if the failures not related to water quality could be explained by drainage area size or classification. More than half of Highlands failures were in large rivers (DA > 3,000 mi^2; Table 7). Approximately two thirds of samples with high HA scores and failing SCI scores were likely affected by other known stressors included in Table 6.

Table 7. Potential reasons for SCI failure for 76 samples in the Stream Classification database identified with high HA (> 80), failing SCI (< 40), and lacking the known levels of water quality stressors identified in Table 6. Some samples are associated with more than one potential reason for SCI failure (not noted in table). These determinations were based on rapid screening of potential stressors as specified.

Potential Failure	# of samples	% Explained	Flatwoods (%)	Highlands (%)
Site tidally influenced	6	7%	20%	0%
DA > 3,000 mi^2	31	36%	7%	64%
DA < 1.0 mi^2	5	6%	7%	7%
Percent Urban > 15%	8	9%	20%	4%
Kiefer note: Likely non-perennial	4	5%	7%	4%

Karst or likely karst	5	6%		
No potential failure identified	25			

3.10 SCI Metric Relationships with Water Quality and Habitat Components

Using the Stream Classification Dataset described in Section 3.5, DEP evaluated relationships between an expanded list of macroinvertebrate indicators (SCI metrics and other functional feeding groups or taxonomic groups) and both water quality and habitat indicators, using correlation analysis. All water quality variables were log-transformed to satisfy assumptions of normality, except dissolved oxygen which was already normally distributed.

Correlation analysis between macroinvertebrate metrics and HA components supported Pollman's earlier findings that velocity, riparian buffer and vegetation quality, and channelization were most correlated with the SCI (Table 8). Those HA components were most strongly correlated with the following SCI metrics: number of clinger taxa, number of Florida sensitive taxa, number of Trichoptera taxa, and percent very tolerant taxa. The additional macroinvertebrate indicators were not more strongly correlated with HA components than SCI metrics.

Correlation analysis between macroinvertebrate metrics and water quality variables supported Pollman's findings that values of specific conductance, dissolved oxygen, and TKN are related to macroinvertebrate community indicators; however, there were also some strong correlations with metals and other analytes (Table 9). These additional relationships suggest that there may be other chemical stressors that could be evaluated during the Stressor ID process.

Table 8. Correlation coefficients based on the pairwise method (JMP) for macroinvertebrate indicators and habitat assessment components. N = 1010 samples with SCI and HA data. Macroinvertebrate indicators without correlations ≥|0.2| not included. Correlation coefficients ≥|0.2| not shown. Habitat smothering, substrate availability, and substrate diversity were also tested, but no correlations were ≥|0.2|. *designates SCI metrics

	Water Velocity	**Riparian Veg Quality**	**Riparian Buffer Width**	**Artificial Channelization**	**Bank Stability**
EPT Taxa*	0.4371	0.2500	0.2092		
Long Lived Taxa*	0.2400				
Ephemeroptera Taxa*	0.3081				
Trichoptera Taxa*	0.4035	0.2559	0.2233		
Sensitive Taxa *	0.3591	0.3117	0.2843	0.2087	
Clinger Taxa *	0.4584	0.2687	0.2510	0.2003	
% Very Tolerant*	-0.2829	-0.2917	-0.2939	-0.2635	-0.2208
Pl Piercers	0.2175				
% Filterers *			0.2010		
Gastropod Taxa	-0.2540			-0.2037	
%Trichoptera	0.3666				

Table 9. Correlation coefficients based on the pairwise method (JMP) for macroinvertebrate indicators and water chemistry analytes (sample sizes in parentheses). Macroinvertebrate indicators without correlations ≥|0.2| not included. Correlation coefficients ≥|0.2| not shown. Nitrate+Nitrite and Turbidity were also tested, but no correlations were ≥|0.2|. *designates SCI metrics

	Cu (119)	Pb (119)	Al (14)	NH4 (907)	TKN (896)	Ca (469)	Cd (119)	Cr (107)	Sp. Cond. (996)	SO4 (544)	TOC (737)	TP (906)	DO (956)
% Amphipod			0.4079			0.3011			0.3623	0.2492			-0.2607
EPT Taxa	-0.2821	-0.3137	-0.2090	-0.3374	-0.3854	-0.5407			-0.5692	-0.4238	-0.3210	-0.3313	0.4488
%Dominant*			0.3335			0.2573			0.2609	0.2600			-0.2179
Long Lived Taxa*			-0.3623		-0.2607	-0.3570	0.2146		-0.4403	-0.3292		-0.2030	0.2777
Sensitive Taxa*	-0.2223			-0.3670	-0.3439	-0.6781			-0.7346	-0.6007	-0.2079	-0.4101	0.4256
Clinger Taxa*	-0.2958	-0.2495		-0.2674	-0.2760	-0.5646		-0.2209	-0.5873	-0.4492		-0.3028	0.4407
%Very Tolerant*	0.3560	0.2612		0.2562	0.2403	0.2938			0.3634	0.3928		0.3149	-0.2037
%Chironomid			-0.5018										
Chironomid Taxa			-0.4213			-0.2758			-0.2894	-0.2636			
%Diptera			-0.5349										
Ephemeroptera Taxa*	-0.2316	-0.2994	-0.2774	-0.2284	-0.2568	-0.2960			0.3501	-0.2710	-0.2363		0.3245
%Browsers/Grazers			-0.3731										
%Predator/Carnivore		0.2470				-0.4006			-0.4263	-0.3469			
%Shredders			-0.3257						0.2083				
%SubColDet	0.3817	0.3288											
%Filterers*			-0.4165										
%UnknownP			0.5379										
Gastropod Taxa			0.5223			0.3439			0.3736	0.2674			-0.2049
%Oligochaete	0.3826	0.3304											
%Trichoptera		-0.2006	-0.2862			-0.3555			-0.3218	-0.2147			0.2410
Trichoptera Taxa*	-0.2543	-0.2700		-0.3070	-0.3556	-0.4963			-0.4917	-0.3464	-0.2775		0.3856

4 The Stressor Identification Process

While the SCI was primarily developed to assess stream health and identify streams impaired by pollutants (water quality), streams may fail the SCI due to other causes, primarily poor habitat or hydrologic modification. Pursuant to the Impaired Waters Rule (Chapter 62-303, F.A.C.), if a stream fails the SCI, a causative pollutant must be identified before placing a water on the Verified List of impaired waters (Category 5). If a stream fails the SCI but a causative pollutant cannot be identified, the stream falls under Category 4d (Impaired, but no causative pollutant identified). Both categories are part of the 303(d) list submitted to EPA. For category 4d waters, a stressor identification (SI) study must be conducted to determine the cause of the SCI failure (Rule 62-303.390(4), F.A.C.). A SI study may also be used to justify a site-specific interpretation of the nutrient criteria where it can be demonstrated that an SCI failure is not due to nutrients (Rule 62-302.531(2)(a)(1)(d), F.A.C.).

The SI process is a multi-step approach to identifying the cause(s) for failing SCI scores in cases where a pollutant has yet to be identified. It involves critically reviewing available information, forming possible stressor scenarios, testing the scenarios in the SI Statewide Model, and producing conclusions based on the model output. In some cases, additional data collection may be necessary to accurately confirm the stressor(s). The conclusions can be translated into management actions, and the effectiveness of those management actions can be monitored. The overall process involves seven steps, which are described below and demonstrated with examples.

Step 1. Obtain information at the site level, including the waterbody name, WIN ID, site nickname, associated DEP Laboratory Information Management System (LIMS) Event ID, SCI Bioregion, and latitude and longitude. These components are helpful in obtaining the biological community attributes from SBIO.

Step 2. Obtain information about the watershed for the waterbody with the failing score. Elements to include are the Waterbody Identification (WBID) number, site Landscape Development Intensity Index (LDI), watershed LDI, watershed size, stream order, nearest stream gage, and the Kiefer water source classification (e.g. Flatwoods or Highlands). Some of these elements may be available in the Statewide Biological Database (SBIO), the Stream Classification Master Dataset, or the WBID History Database. If they are not readily available, and depending on the level of certainty required, they can either be estimated or calculated using various layers in ArcGIS. For example, if a LDI is not available, it can be estimated from the "Current Land Use LDI and LSI" layer in ArcGIS or it can be calculated using the DEP Laboratory SOP (BG-06-1.6). All the collected information is entered in an SI process template in Excel.

Step 3. Determine whether the stream is highlands, flatwoods, or karst, and its perenniality (Kiefer 2010 and AMEC 2013). (If the stream is karst, or fed by springs, it is most likely perennial.) First, delineate the drainage area, and then based on the predominant soil type in the basin, decide if the site is highlands or flatwoods. The NRCS GIS Soils Layer can be used to determine each waterbody segment's (WBID) soil characteristics, and then GIS can be used to calculate the percentage of soil type for each WBID in order to determine if the site is classified as Flatwoods or Highlands. For sites in the NEFCP and NWFCP, if A+B soils are less than 30%, the site is classified as Flatwoods; and if A+B soils are greater than 30%, the site is classified as Highlands. For sites in the PFCP, if A+C soils are less than 40%, the site is classified as Flatwoods; and if A+C soils are greater than 40%, the site is classified as Highlands (Kiefer). If the stream is flatwoods, it is likely not perennial if its DA is less than 5 mi^2 and seasonally perennial if its DA is less than 20 mi^2 (Table 1). If the stream is highlands, it is likely not perennial if its DA is less than 1 mi^2 (highlands are nearly always perennial). If the stream is not perennial, then the SCI may fail due to lack of consistent flow (FDEP 2017, Section 3.6 of this document). If a stream is flatwoods, flow can be flashy after rain events, so it is important to review antecedent flow conditions carefully (especially during rainy months). See Table 2 for guidance. For large streams and rivers (≥500 mi^2), determine if the DA of the stream is so large that it has a high probability of failing (FDEP 2018, Section 3.7 of this document). Once you have determined the region, water source, and drainage area, calculate and compare the valley slope to the appropriate figure in Section 3.8 (Figures 15-20) to rule out the possibility of it being a low-gradient system.

Step 4. Retrieve the macroinvertebrate community attributes for each sample from SBIO. If there is more than one failing score, enter the information for each sample separately. The information for this step includes the sample date, Visit ID, SCI score, number of sensitive taxa, number of long-lived taxa, percent of the dominant taxon, and the name of the dominant taxon. You can add and review additional attributes (e.g. number of Ephemeroptera taxa, number of clinger taxa), but the ones listed should give a good indication of why the SCI failed.

Step 5. Compile the water chemistry data for entry into the Statewide SI Model (Pollman 2013). The models were developed based on the water chemistry on the dates the SCI was collected, and this is preferred, but it may be necessary to use data collected from other dates with a preference for those collected as near to the SCI collection date as possible. Some of the elements are available directly from SBIO, while others will have to be obtained from LIMS, the Impaired Waters Rule (IWR) database, or Watershed Information Network (WIN). Some elements listed are required and others help confirm or refute suspected stressors. Variables in the model are color, specific conductance, TKN, DO, temperature, substrate diversity score, water velocity score, and riparian buffer width or artificial channelization score. Color and TKN are used to generate the excess TKN. Bioregion, month, and latitude are needed to calculate the excess temperature factor. A map of the WBID, photos of stations, and the IWR listing history for parameters assessed can be obtained from the latest version of the WBID History Database (DB) (obtain from Watershed Assessment Section and enter WBID number).

Step 6. Enter the habitat assessment components and final score into the template for each sample.

Step 7. The final step is to enter in the required variables into the model and test the suspected stressors individually and combined until the predicted SCI score is similar to the actual score.

A. If the predicted SCI score based on input data is similar to the actual SCI score, then the score can likely be explained by the combination of factors in the model. The input variables can be manually adjusted to evaluate which factors are most influential for that site (for example, decrease the specific conductance to determine how much the measured specific conductance values are predicted to limit the SCI).

B. If the predicted SCI score is lower than the actual score, this suggests there may be mitigating conditions for some of the stressors. For example, there may be very little available habitat but the habitat that is available is highly productive and sufficient in quantity to allow for a healthy macroinvertebrate assemblage.

C. If the predicted SCI score is greater than the actual score, then an additional stressor not included in the model is likely the cause of the SCI failure (e.g. altered hydrology) and can be surmised from the other information that was compiled. This can then be tested by deploying long-term monitoring devices in the stream of interest. Ideally, this would be done during conditions similar to those that created the failing SCI scores.

Stressor ID Model Outputs: The model initially over-predicted the SCI for both sampling periods based on the *in situ* values. However, DO values for the sampling events were high compared to other DO data in the IWR database. To explore the potential that DO is the stressor, the DO was lowered to 1.67 mg/L or 2.60 mg (actual values from WBID History DB), and the model then predicted SCI values of 36 and 39, which are closer to the measured SCI scores (26 and 38). Low DO, coupled with alterations in the watershed, and in-stream habitat, likely result in failing SCI scores.

Conclusion: Low DO as a result of altered hydrology in a highly developed watershed appear to be contributing to the failing SCI. A continuous sonde should be deployed to confirm whether fluctuating hydrology and low DO levels are the cause of the low SCIs.

Example: Mizner's Branch – WBID 2645

Description: According to the WBID History DB, Mizner's Branch is impaired for DO but no causative pollutant was identified (TN = 0.85 mg/L, TP = 0.1mg/L). Chl-a is not elevated.

SITE INFORMATION			(Source - SBIO)	Potential stressors are high LDIs and a small drainage area. Even though the site is Highlands, it is at the lower end of the size range making it more susceptible to widely fluctuating hydroperiods given the amount of development immediately adjacent to the stream and in the wateshed. Check hydrographs, photos, and habitat assessment for evidence of flashly hydroperiod.
	WATERBODY		Mizners Branch	
	STORET		27010068	
	NICKNAME		MIZNERBR	
	LIMS EVENT ID		CEN-DIST-2015-11-04-02	
	BIOREGION		PENINSULA	
	LATITUDE		29.26696	
	LONGITUDE		-81.08756	
	WBID		2645	
WATERSHED COMPONENTS			(Source - GIS)	
	SITE LDI (100m buffer)		8 (estimated)	
	WATERSHED LDI		7 (estimated)	
	WATERSHED SIZE		1.5	
	STREAM ORDER		2	
	NEAREST GAGE		Tomoka near Daytona	
	WATER SOURCE		Highlands	
SAMPLE INFORMATION			(Source - SBIO)	The lack of sensitive taxa and so few long-lived taxa suggest a combination of factors causing the failing scores, e.g. low dissolved oxygen as a result of excess nutrients and lack of continuous flow. A high percent of a single, tolerant, grazer suggests low flow, low DO conditions.
		SAMPLE 1	SAMPLE 2	
SAMPLE DATE		2/16/2010	11/3/2015	
VISIT ID		67853	75041	
SCI SCORE		26	38	
# SENSITIVE TAXA		0	0	
# LONG-LIVED		1	0	
% DOMINANT TAXON		52	20	
DOMINANT TAXON (NAME)		Gammarus	Gammarus/Hyalella	
WATER CHEMISTRY			(Source - LIMS, IWR, WIN)	Conductivity is slightly high as are some of the nutrients - may be acting as a secondary stressors.
COLOR		120	97	
SP COND Source: SBIO & LIMS		392	407	
TKN		0.97	0.78	
DISSOLVED OXYGEN (MG/L)		8.7	6.1	
TEMP		14.7	25.3	
DISSOLVED OXYGEN (%)		-	74	
PH		7.7	6.4	
NITRATE		0.31	0.2	
CHL-A		1.8	0.55 U	
HABITAT COMPONENTS			(Source - SBIO)	The secondary HA components are low which supports the idea that hydrology is being impacted by development immediately adjacent to the streams and in the watershed.
SUBSTRATE DIVERSITY		13	16	
SUBSTRATE AVAILABILITY		7	15	
WATER VELOCITY		15	12	
SMOTHERING		17	10	
CHANNELIZATION		10	10	
AVG. BANK STABILITY		3.5	6	
AVG. BUFFER WIDTH		5	4	
AVG. BUFFER QUALITY		4.5	4.5	
TOTAL HA SCORE		88	92	
STRESSOR MODEL OUTPUT			(Source - Stressor ID Model)	The results of the in situ variables do not adequately capture stressors. Lowering the DO improves model prediction.
Expected SCI with in situ values		52	48	
Expected SCI with lower DO values		39	36	

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