Appendix K
Climate Change Assessment

1.0 CLIMATE CHANGE ASSESSMENT

The US Army Corps of Engineers (USACE) Civil Works Program and its water resources infrastructure – built and natural, structural and nonstructural – represent a tremendous Federal investment that supports regional and national economic development, public health and safety, and national ecosystem restoration goals.

The hydrologic and coastal processes underlying this water resources management infrastructure are very sensitive to changes in climate and weather. Therefore, USACE has a compelling need to understand and adapt to climate change and variability to continue providing authorized performance despite changing conditions.

Engineering Construction Bulletin (ECB) No. 2018-14 (USACE ECB 2018) provides guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaption policy. It calls for a qualitative analysis. The goal of a qualitative analysis of potential climate threats and impacts to USACE hydrology-related projects and operations is to describe the observed present and possible future climate threats, vulnerabilities, and impacts of climate change specific to the study goals or engineering designs. This includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant climatic and hydrologic variables.

For more information about climate change impacts to water resources, see the overview report, USGS Circular 1331 "Climate Change and Water Resources Management: A Federal Perspective," located at http://pubs.usgs.gov/circ/1331/, and also the USACE Responses to Climate Change web site at https://corpsclimate.us/.

The Savannah Harbor Expansion Project (SHEP), as authorized in Water Resources Reform and Development Act (WRRDA) 2014, would "likely adversely affect" the Atlantic and Short-nose sturgeon. As a result, the authorized project included a fish passage for mitigation of those impacts at the New Savannah Bluff Lock and Dam (NSBLD). Since 1937, the NSBLD blocked fish from migrating to the Augusta Shoals; the historical spawning grounds for sturgeon. Other fish species, including American shad and Striped bass are also impacted by the presence of the dam.

To understand the conditions in the project area along the Savannah River including the Augusta metropolitan area, the USACE conducted extensive hydraulic modeling of over 33 scenarios. Ultimately, the final array of action alternatives narrowed to seven. USACE conducted the following model runs to develop alternatives for further analysis. The initial array of alternatives uses the approved FEMA 2003 1D HEC-2 model to evaluate the 1 and 0.2 percent ACE (100- and 500-year) flood event (FEMA's model for potential flood impacts to development). After screening the initial array of alternative and refinements, a HEC-RAS 2D model was developed to provide increased resolution of flood impacts at the 50, 20, and 10 percent ACE events (2, 5, and 10-year flood events).

The final array of alternatives include the no action alternative and 4 action alternatives. One action alternative, Alternative 1-1, repairs the lock wall and dam gates and piers and allows fish to pass adjacent to the lock wall along the Georgia side while maintaining the functionality of the pool for navigation, recreation, and water supply. Three alternatives use a weir to create an in-channel fish passage and remove the lock and dam and partially demolish the dam foundation. One of those action alternatives, Alternative 2-3, includes a fixed crest weir with a rock ramp sloping upstream from the existing dam location. Another one of those action alternatives, Alternative 2-6, includes a fixed crest weir with a rock ramp sloping upstream from the existing dam location with a flood plain bench for high stage flood conditions. Alternative 2-6 includes four refinements to the weir height. This was done as a tradeoff analysis between water supply intakes and recreational impacts and high frequency flooding events. The other action alternative, Alternative 2-8, uses an in-channel fish passage with a fixed weir with a rock ramp at the existing dam location with a gated flood bypass channel.

The important hydrologic variables affecting the project include water surface elevation (stage) and river discharge, which is also affected by inflow from tributaries between Thurmond Dam and NSBLD. The gates at New Savannah Bluff Lock and Dam are used to help maintain a pool elevation between 111.2 and 114.2 NAVD88 upstream of the dam. Impacts to recreation and navigation appear to occur when inflows fall below 5,000 cfs. As a result of proposed project alternatives, variation in river flow will have a much larger impact on pool elevation as compared to existing conditions. Several of the proposed alternatives have the potential to cause increases in nuisance flooding and would create false attraction flows during high flow conditions that would prevent or delay endangered fish passage to upstream spawning grounds.

A significant water management structure is located upstream of the study area: J. Strom Thurmond Dam. Besides fluctuations in climate, stage and flow in the study area can be influenced by long-term geomorphic change, changes to J. Strom Thurmond Dam operating plans, and gage relocation. Discharge can be influenced by changes in upstream water storage due to dam construction, changes in land-use, and measurement techniques. These factors can make it difficult to determine the role of climate change in affecting the hydrologic signal at the project scale. The relevant question to answer at the project scale is whether there has been, or will be a change due to climate change that affects ecological conditions in the study area and how this change would impact the resilience of the proposed project in terms of its ability to meet operating objectives for recreation and water supply and improve fish passage. The project's potential to increase flooding during future conditions should also be assessed. Annual Peak Discharge was chosen as the primary hydrologic variable to analyze for this project.

Ecologically relevant components of river discharge include its magnitude, frequency, and duration, as well as the timing of particular discharges, rate of discharge change, and inter-annual (year-to-year) variability. More frequent or longer duration flood conditions can stress floodplain forest and aquatic communities in the Augusta Shoals area, which is the historic breeding grounds for Atlantic and Short-nose sturgeon just downstream of Stephen's Creek Dam. Long periods of high water can kill trees and plant habitat in the Augusta Shoals area or weaken the root zone creating conditions more conducive to erosion. Excessive inflows to aquatic areas increases sediment and nutrient loading affecting plant and fish communities. The occurrence of long duration low water conditions may affect dissolved oxygen making areas unsuitable for aquatic animal species, as well as create insufficient depths in the Augusta Shoals area for breeding.

1.1 Literature Review

According to the *Third National Climate Assessment,* Climate change is expected to intensify current climate trends of temperature and precipitation in the U.S., including the Southeast region (Carter et al, 2014). The NSBLD Fish Passage Project is located on Savannah River, on the border of Georgia and South Carolina, approximately 187 river miles upstream of Savannah, GA. The frequency and intensity of precipitation is projected to increase more across the northern portion of the region and show less of an increase in the southern part of the region. Seasonal differences in precipitation will have a significant effect on many hydrologic processes. Soil moisture, critical for vegetation and agriculture, is determined in part by precipitation and temperature, which drives evapotranspiration (ET). Soil moisture fluctuates seasonally and has been observed to be decreasing over time in the Southeast (Hay et al 2011, Zhang and Georgakakos 2011).

Over the last 100 years, the Southeast's observed, average annual temperatures have cycled between warm and cool periods, but since 1970, temperatures have increased an average of 2°F. In that time, the number of days above 95°F and nights above 75°F have been increasing, while extremely cold days have been decreasing (Kunkel et al 2013).

Warmer temperatures have effected seasonal cycles. In the Southeast, the frost-free season has already expanded on average by 6 days. Projections based on global climate models suggest the trend toward a longer frost-free season is likely to continue. The southern freeze-free zone will continue to move northward, displacing species requiring freezing (Walsh et al, 2014).

A positive, but mild, warming trend is identified within observed temperature records for most of the area in the spring and summer. For the fall months, the southern portion of the area is shown to be warming.

The Eastern portion of the Southeast has observed drier conditions whereas the rest of the region has experienced wetter conditions. Daily and five-day observed rainfall intensities have increased (Ingram et al 2013), but summers have been either increasingly dry or extremely wet, which is indicative of the variability of the climate in the Southeast (Kunkel et al 2013). Linear trends in observed annual precipitation indicate a -2 to -5% reduction in precipitation in the upper Savannah River Basin and a +2 to +5% increase in precipitation in the lower Savannah River Basin (McRoberts and Nielsen-Gammon, 2011). The Southeast has seen a 27% increase in heavy precipitation events (defined as the heaviest 1% of all daily events) since 1900 (Karl et al 2009) and is projected to see a varied increase in storm severity and in the frequency of severe storms in the future.

Temperatures across the southeast are projected to increase during this century as depicted in Figure 1. Major consequences of warming include significant increases in the number of hot days, 95°F and above (Carter et al, 2014). This increases evaporation and decreases freezing events. Increased evaporation correlates to overall less flow in the river, possibly exposing more shoaling areas and diminishes the amount of spawning areas available for fish. The NSBLD Fish Passage Project is located in the part of the region with a projected increase in number of days above 95°F of approximately 45-60 days. Further, climate change is expected to increase harmful algal blooms and several disease-causing agents in inland waters, not previously problems in the region (Carter et al, 2014). This could have detrimental effects on fish in the Savannah River, especially in the Augusta Shoals area.

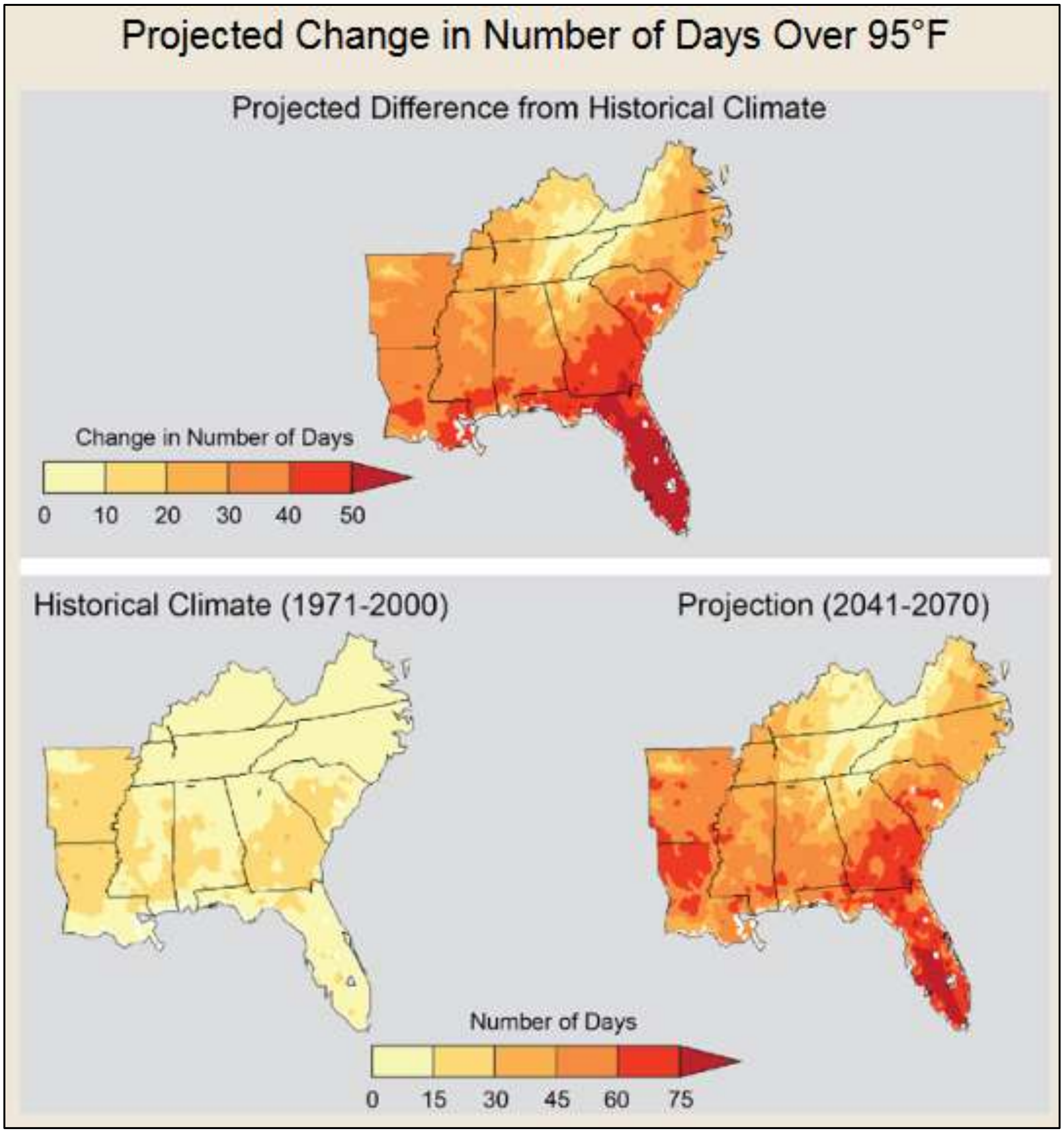


Figure 1: Projected Change in Number of Days over 95°F (Source: NOAA NCDC/CICS-NC)

The Southeast is also vulnerable to flooding caused by sea level rise. While sea-level rise is expected for the Southeast Region, the NSBLD Fish Passage Project is several hundred miles inland of the coast and therefore will not be impacted by the effects of sea level rise.

There is strong agreement in the literature that temperature for the Southeast region, and the entire country, will increase over the next century. The studies generally agree on an increase in mean annual air temperature of approximately 2 to 4 °C by the latter half of the 21st century for the South Atlantic-Gulf Region (USACE, 2015). Projections for precipitation events and hydrology are less certain than temperature projections for the Southeast Region. Figure 2 shows a summary matrix of observed and projected climate trends and projections for the HUC 03, which is the South Atlantic-Gulf Region, where the NSBLD Fish Passage Project is located.

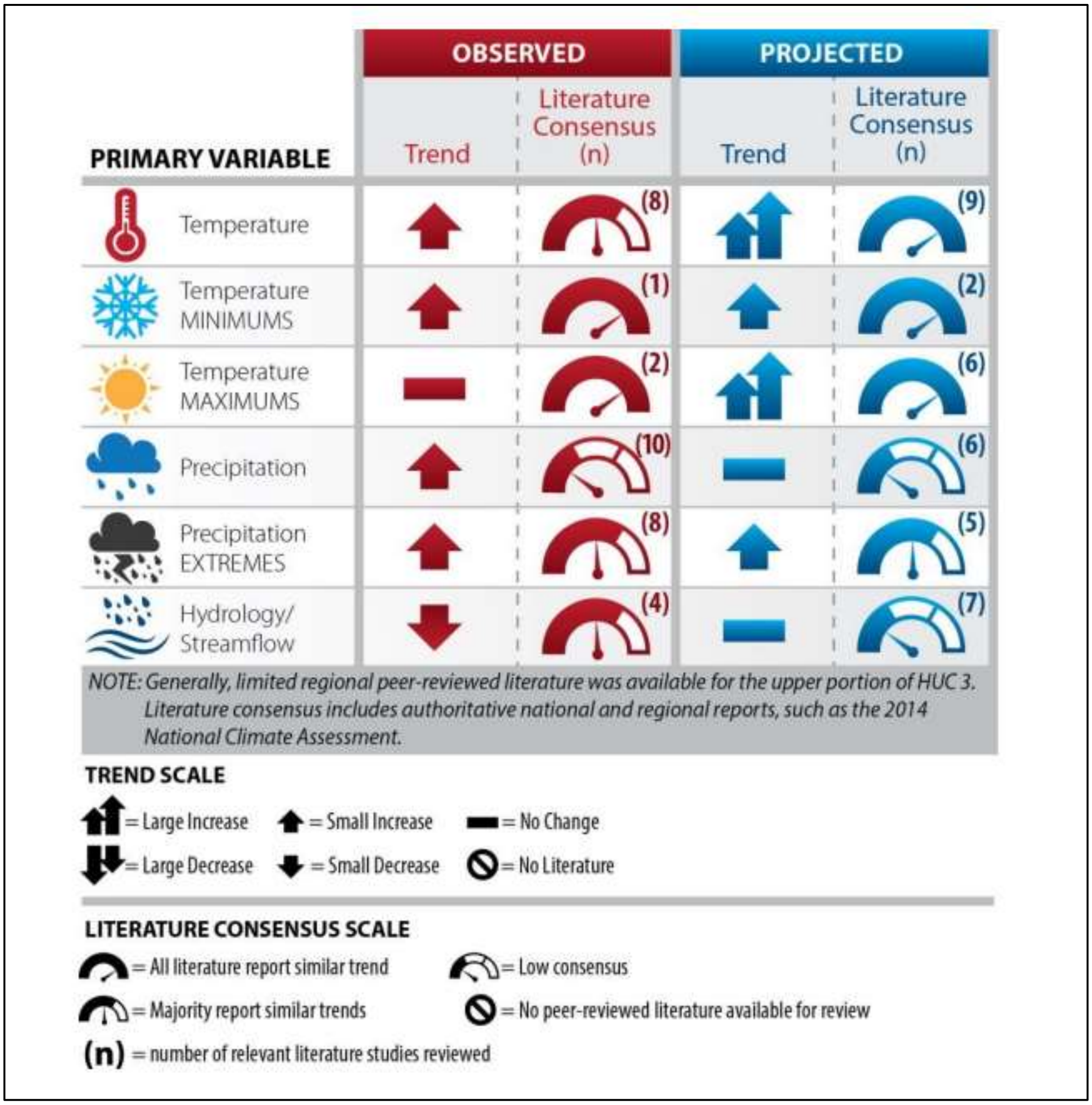


Figure 2: Summary Matrix of Observed and Projected Climate Trends and Literary Consensus (Source: USACE Climate Change Assessment for Water Resources Region 03).

Georgia's latitude and close proximity to the warm waters of the Gulf of Mexico and the Atlantic Ocean characterize the climate as long, hot, humid summers and short, mild winters. Georgia, like much of the southeastern United States, is in one of the few regions globally that has not exhibited an overall warming trend in surface temperatures over the 20th century (Figure 3) while the United States as a whole has warmed by about 1.5°F. (Frankson et al 2017)

Georgia receives frequent precipitation throughout the year, ranging from upwards of 80 inches in the mountainous northeastern corner of the state to around 45 inches in the eastern and central portions. Precipitation projections for Georgia are uncertain (Figure 4). Even if average annual precipitation remains constant, higher temperatures will increase evaporation rates and decrease soil moisture during dry spells, leading to greater drought intensity. This could increase competition for limited water resources, which currently support large population centers like the City of Augusta.

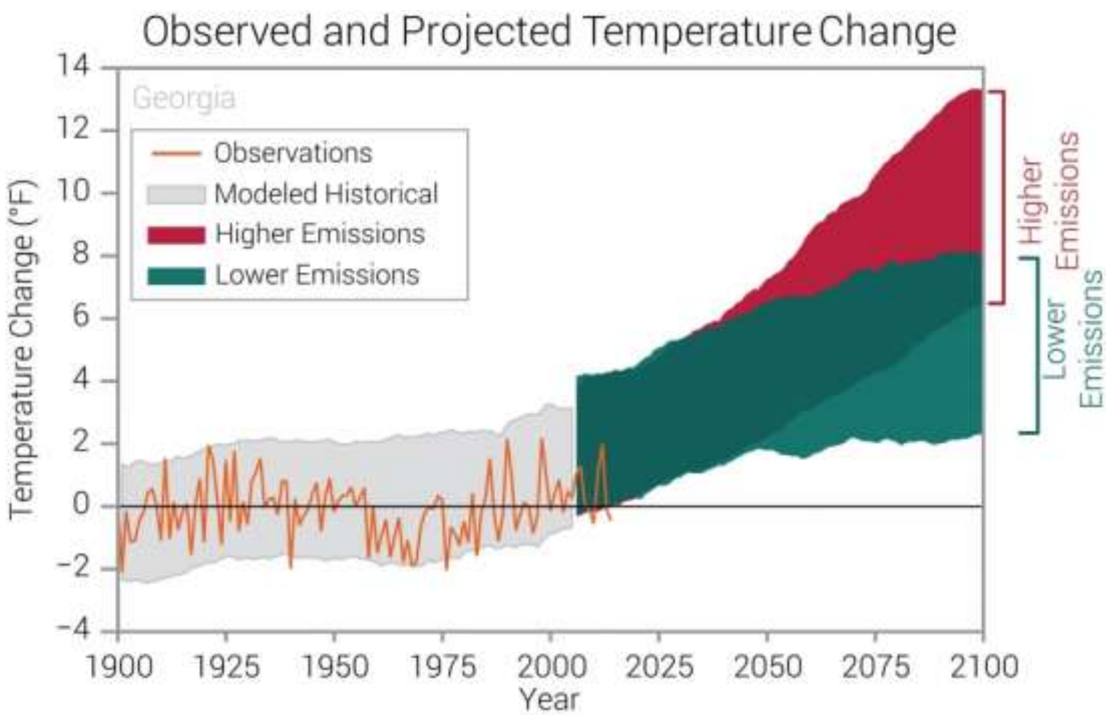


Figure 3: Georgia observed temperature change (orange line) Source: CICS-NC/NOAA NCEI

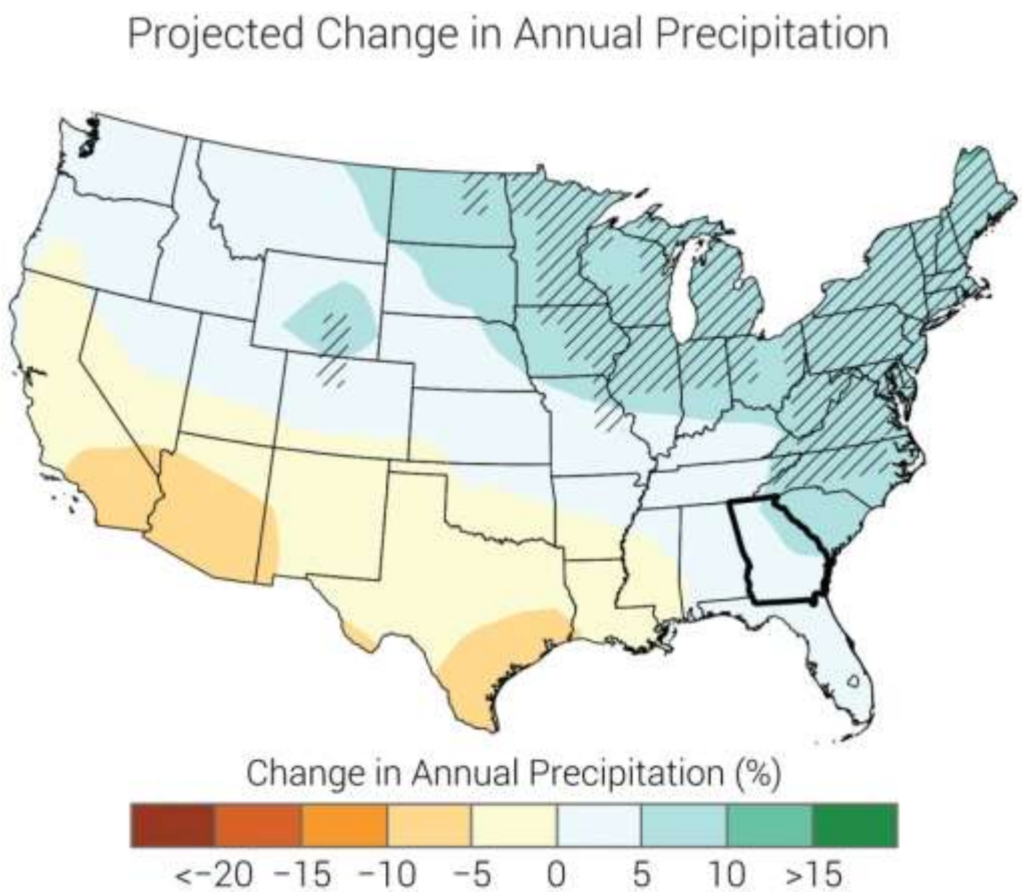


Figure 4: Climate model projections of changes (%) in annual precipitation for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Precipitation is projected to increase throughout Georgia, however, these changes are small relative to the natural variability in this region. Source: CICS-NC, NOAA NCEI, and NEMAC.

1.2 First Order Statistical Analysis: Trends in Streamflow & Climate Change at a Regional Scale

The USACE Climate Hydrology Assessment Tool was used to investigate potential future trends in streamflow for HUC 0306, the Ogeechee-Savannah watershed. Figure 5 below shows the location of the project area relative to the HUC04 watershed delineations.

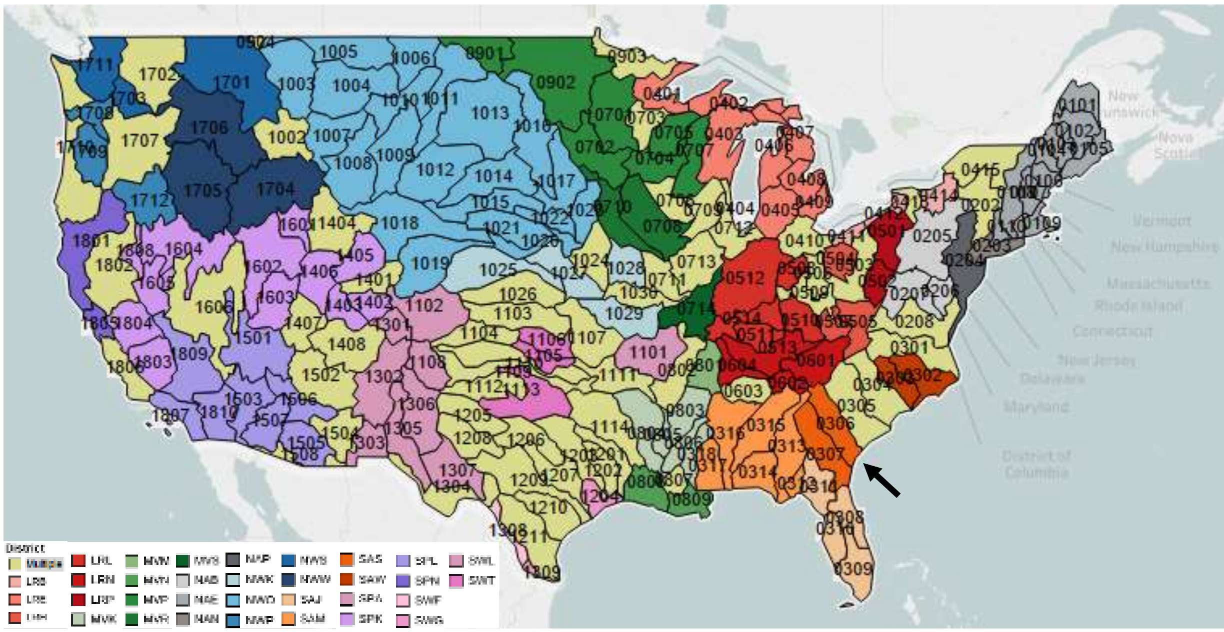


Figure 5: Reference Map of HUC 4 Watersheds by District. The Ogeechee-Savannah is highlighted by the black arrow.

Figure 6 displays the range of projected annual maximum monthly streamflows computed from 93 different climate changed hydrologic model runs for the period of 1952-2099. Climate Changed hydrology output is generated using various greenhouse gas emission scenarios (RCPs) and global circulation models (GCM) to project precipitation and temperature data into the future. These meteorological outputs are spatially downscaled using the BCSD statistical method and then inputted in the U.S. Bureau of Reclamation's Variable Infiltration Capacity (VIC) precipitation-runoff model to generate a streamflow response. The VIC model represents unregulated basin conditions. This is relevant because the Ogeechee-Savannah basin is impacted by regulation. As expected for this type of qualitative analysis, there is considerable, but consistent spread in the projected annual maximum monthly flows. The spread in the projected annual maximum monthly flows is indicative of the high degree of uncertainty associated with projected, climate changed hydrology.

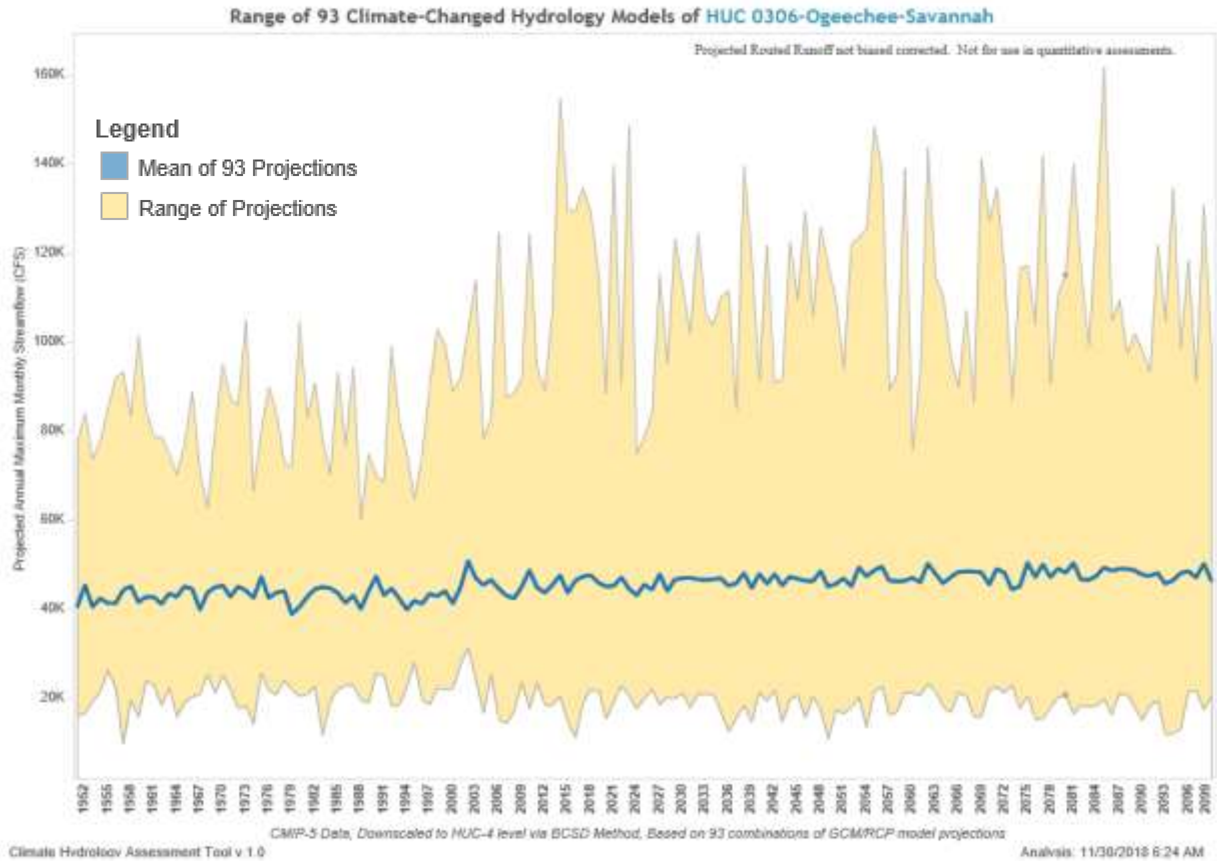


Figure 6: Range of Projected Annual Maximum Monthly Streamflow among Ensemble of 93 Climate-Changed Hydrology Models, HUC 306 Ogeechee-Savannah.

The overall trend in the mean projected annual maximum monthly streamflow (AMMS) is increasing over time (Figure 7). Earlier data shows no statistically significant trends. There is a statistically significant increasing later trend for the water basin (AMMS = 32.84 * [Water Year] – 20552.40; R^2 = 0.262933; P-value < 0.01). The p-value is for the linear regression fit drawn; a smaller p-value would indicate greater statistical significance. There is no recommended threshold for statistical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or a false positive. This finding suggests that there is potential for AMMS to increase in the future in the study area, relative to the current conditions.

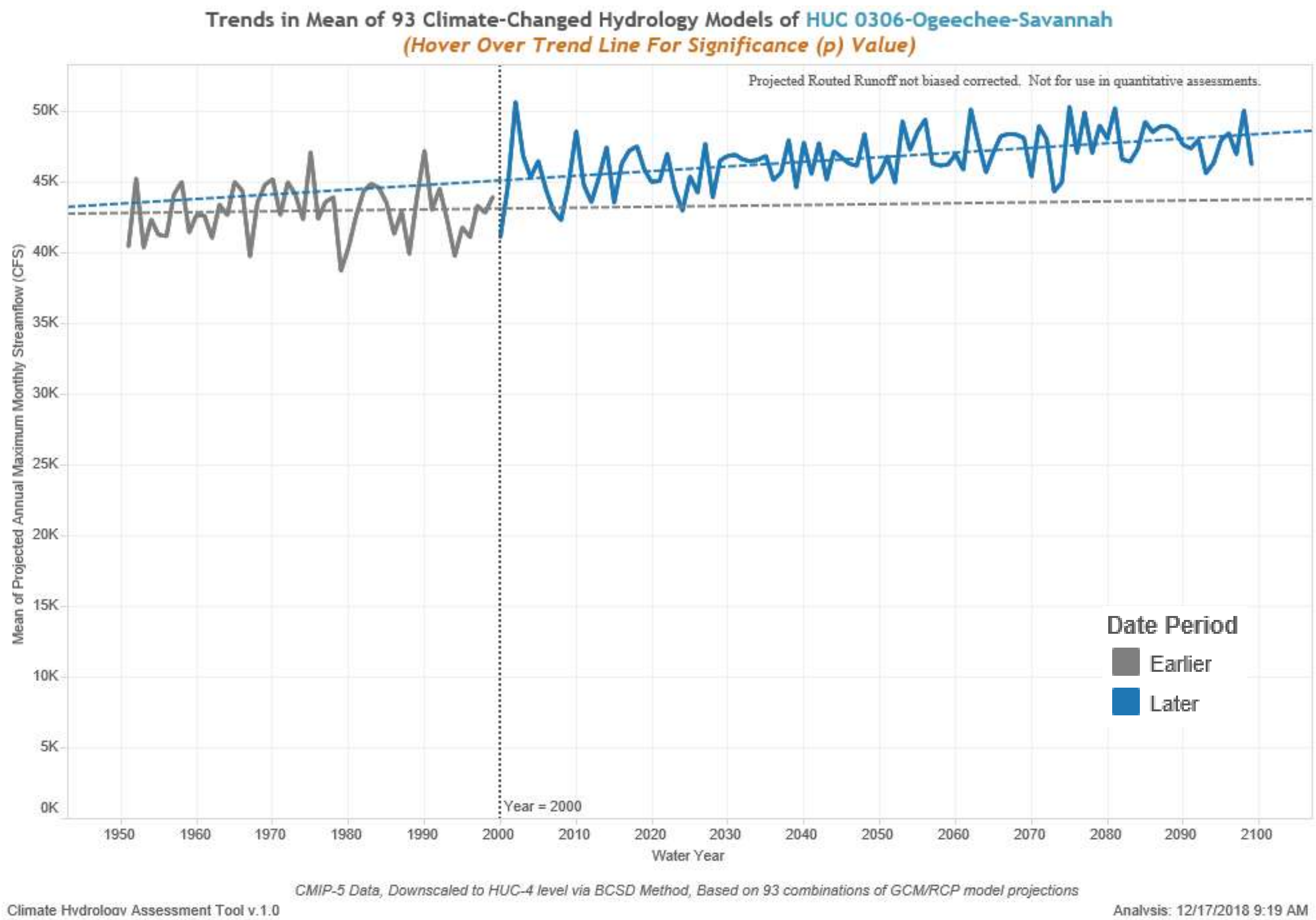


Figure 7: Mean Projected Annual Maximum Monthly Streamflow, HUC 306 Ogeechee-Savannah.

1.3 Screening Level Vulnerability Assessment to Climate Change Impacts

The USACE Watershed Climate Vulnerability Assessment Tool (VA Tool) was used to compare the relative vulnerability to climate change of the HUC 0306, Ogeechee-Savannah watershed, to all HUC 04 watersheds across the continental United States (CONUS). The tool facilitates a screening level, comparative assessment of how vulnerable a given HUC 04 watershed is to the impacts of climate change. The tool can be used to assess the vulnerability of a specific USACE business line such as "Ecosystem Restoration" to projected climate change impacts. Assessments using this tool help to identify and characterize specific climate threats and particular sensitivities or vulnerabilities, at least in a relative sense, across regions and business lines. The four (4) USACE business lines relevant to the Fish Passage project include; Ecosystem Restoration (Mitigation), Recreation, Water Supply, and Flood Risk Reduction. The tool uses the Weighted Order Weighted Average (WOWA) method to represent a composite index of how vulnerable a given HUC 04 watershed (Vulnerability Score) is to climate change specific to a given business line.

WOWA stands for "Weighted Ordered Weighted Average," which reflects the aggregation approach used to get the final score for each HUC. After normalization and standardization of indicator data, the data are weighted with "importance weights" determined by the Corps (the first "W"). Then, for each HUC-epoch-scenario, all indicators in a business line are ranked according to their weighted score, and a second set of weights (which are the OWA weights," are applied, based on the specified ORness level. This yields a single aggregate score for each HUC-epoch-scenario called the WOWA score. WOWA contributions/indicator contributions are calculated after the aggregation to give a sense of which indicators dominate the WOWA score at each HUC. Further information regarding indicators can be found in Table 1.

Indicators considered within the WOWA score for Ecosystem Restoration (Mitigation; Table 3) include: macroinvertebrate index (sum score of six metrics indicating biotic condition), percent of at risk freshwater plant communities, runoff elasticity (ratio of streamflow runoff to precipitation), short-term variability in hydrology, change in sediment load, mean annual runoff, two indicators of flood magnification (indicator of how much high flows are projected to change overtime), and change in low runoff.

Indicators considered within the WOWA score for Recreation (Table 4) include: two indicators of flood flow, runoff elasticity (ratio of streamflow runoff to precipitation), short-term variability in hydrology, change in sediment load, drought severity, two indicators of flood magnification (indicator of how much high flows are projected to change overtime), and change in low runoff.

Indicators considered within the WOWA score for Water Supply (Table 5) include: change in sediment load, long-term variability in hydrology, short-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), and drought severity.

Indicators considered within the WOWA score for Flood Risk Reduction (Table 6) include: long-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), two indicators of flood magnification (indicator of how much high flows are projected to change overtime), and the acres of urban area within the 500-year floodplain.

When assessing future risk projected by climate change, the USACE VA Tool makes an assessment for two 30-year epochs of analysis centered at 2050 and 2085. These two periods were selected to be consistent with many of the other national and international analyses. The tool assesses how vulnerable a given HUC 04 watershed is to the impacts of climate change for a given business line using climate hydrology based on a combination of projected climate outputs from the general climate models (GCMs) and representative concentration pathway (RCPs) resulting in 100 traces per watershed per time period. The top 50% of the traces by flow magnitude is called “wet” and the bottom 50% of the traces is called “dry.” Meteorological data projected by the GCMs is translated into runoff using the VIC macroscale hydrologic model. Many of the indicators included in the VA Tool rely on an ensemble of GCMs to capture the uncertainty inherent in climate projections.

In the context of the VA Tool, there is uncertainty in all of the inputs to the vulnerability assessments. Some of this uncertainty is already accounted for in that the tool presents separate results for each of the scenario-epoch combinations rather than presenting a single aggregate result. Despite that, analyses may include significant uncertainty.

For this assessment the default, National Standards Settings are used to carry out the vulnerability assessment.

Table 1: Descriptions for indicators used in the Fish Passage Vulnerability Tool analysis.

Indicator Short Name	Indicator Name	Large Values = High Vulnerability	Indicator Description	Data Sources	Last Updated
8 AT RISK FRESHWATER PLANT	% of freshwater plant communities at risk	Yes	% of wetlands & riparian plant communities that are at risk of extinction, based on remaining number & condition, remaining acreage, threat severity, etc.	NatureServe - Explorer (customized dataset). Data were obtained from Jason McNees at NatureServe, 1101 Wilson Blvd., 15th Floor Arlington, VA 22201 via email on July 31, 2009	Feb-2016
65L MEAN ANNUAL RUNOFF	Mean annual runoff (local)	No	Mean runoff: average annual runoff, excluding upstream freshwater inputs (local).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
95 DROUGHT SEVERITY	Drought Severity Index	Yes	Greatest precipitation deficit: The most negative value calculated by subtracting potential evapotranspiration from precipitation over any 1-, 3-, 6-, or 12-month period.	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Jul-2015
156 SEDIMENT	Change in sediment load due to change in future precipitation	Yes	The ratio of the change in the sediment load in the future to the present load.	CDM	Feb-2016
175L ANNUAL COV	Annual CV of unregulated runoff (local)	Yes	Long-term variability in hydrology: ratio of the SD of annual runoff to the annual runoff mean. Excludes upstream freshwater inputs (local).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
221C MONTHLY COV	Monthly CV of runoff (cumulative)	Yes	Measure of short-term variability in the region's hydrology: 75th percentile of annual ratios of the SD of monthly runoff to the mean of monthly runoff. Includes upstream freshwater inputs (cumulative).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
277 RUNOFF PRECIP	% change in runoff divided by % change in precipitation	Yes	Median of: deviation of runoff from monthly mean times average monthly runoff divided by deviation of precipitation from monthly mean times average monthly precipitation.	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014) using method of Sankarasubramanian & Vogel 2001 WRR 37(6)1771-1781	Feb-2015
297 MACROINVERTEBRATE	Macroinvertebrate index of biotic condition	No	The sum (ranging from 0-100) of scores for six metrics that characterize macroinvertebrate assemblages: taxonomic richness, taxonomic composition, taxonomic diversity, feeding groups, habits, pollution tolerance.	USEPA - Wadeable Streams Assesment (WSA) (Stream Water Benthic Macroinvertebrate Metrics)	Feb-2016
568C FLOOD MAGNIFICATION	Flood magnification factor (cumulative)	Yes	Change in flood runoff: ratio of indicator 571C (monthly runoff exceeded 10% of the time, including upstream freshwater inputs) to 571C in	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
568L FLOOD MAGNIFICATION	Flood magnification factor (local)	Yes	Change in flood runoff: Ratio of indicator 571L (monthly runoff exceeded 10% of the time, excluding upstream freshwater inputs) to 571L in base period.	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
570L 90PERC EXCEEDANCE	Low flow (monthly flow exceeded 90% of time; local)	No	Low runoff: monthly runoff that is exceeded 90% of the time, excluding upstream freshwater inputs (local).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
571C 10PERC EXCEEDANCE	Flood flow (monthly flow exceeded 10% of time; cumulative)	Yes	Flood runoff: monthly runoff that is exceeded 10% of the time, including upstream freshwater inputs (cumulative).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
571L 10PERC EXCEEDANCE	Flood flow (monthly flow exceeded 10% of time; local)	Yes	Flood runoff: monthly runoff that is exceeded 10% of the time, excluding upstream freshwater inputs (local).	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014
590 URBAN 500YRFLOODPLAIN AREA	Acres of urban area within 500-year floodplain	Yes	Acres of urban area within the 500-year floodplain.	(1) FEMA - 500 year Flood Zones (2) EPA - Integrated Climate & L& Use Scenarios (ICLUS)	Jan-2011
700C LOW FLOW REDUCTION	Low flow reduction factor (cumulative)	No	Change in low runoff: ratio of indicator 570C (monthly runoff exceeded 90% of the time, including upstream freshwater inputs) to 570C in base period.	Data calculated from interagency CMIP5 GCM - BCSD - VIC dataset (2014)	Sep-2014

The results of the USACE VA Tool analysis of the 4 business lines in the HUC 306 Ogeechee-Savannah watershed are found in Table 2. Within Table 2, a comparison can be made between the Ogeechee-Savannah watershed's WOWA scores, the CONUS Range of WOWA scores, the SAD range of WOWA scores, and the Savannah District range of WOWA scores. Note: The Savannah District only has two HUC 04 watersheds. The Ogeechee-Savannah watershed has zero business lines considered vulnerable (falls within the top 20% of vulnerability scores) relative to the other 201 HUC 04 watersheds in the CONUS.

Table 2: Projected Vulnerability (WOWA Score) comparison chart.

Summary of Vulnerability					
Business Line	**Scenario - Epoch**	**WOWA Score**	**Range Nationally**	**Range SAD**	**Range in District**
Ecosystem Restoration (Mitigation)	Dry 2050	70.93	55.95 - 81.73	64.82 -73.30	69.15 - 70.93
	Dry 2085	71.31	55.84 - 81.85	65.21 - 73.76	69.14 - 71.31
	Wet 2050	70.25	55.64 - 89.84	64.20 -73.16	68.31 - 70.25
	Wet 2085	70.83	54.69 - 89.43	64.65 - 73.36	68.46 - 70.83
Recreation	Dry 2050	59.17	57.05 - 74.39	58.65 - 61.20	59.17
	Dry 2085	68.19	57.42 - 82.23	62.53 - 76.96	68.19
	Wet 2050	57.67	57.67 - 85.65	57.67 - 60.40	57.67
	Wet 2085	57.23	56.67 - 83.62	56.67 - 66.63	57.23
Water Supply	Dry 2050	46.57	43.70 - 73.54	43.70 - 46.57	46.57
	Dry 2085	60.70	46.91 - 79.27	50.13 - 60.70	60.70
	Wet 2050	55.98	49.86 - 80.34	53.78 - 56.03	55.98
	Wet 2085	58.03	49.42 - 81.82	56.56 - 60.68	58.03
Flood Risk Reduction	Dry 2050	43.81	35.15 - 70.08	41.53 - 67.07	43.81 - 49.79
	Dry 2085	44.20	35.66 - 69.10	41.93 - 68.18	44.20 - 51.20
	Wet 2050	47.73	39.80 - 92.85	46.76 - 70.46	47.73 - 52.04
	Wet 2085	48.65	40.86 - 86.71	47.65 - 71.78	48.65 - 54.09

When analyzing the business line Ecosystem Restoration, compared to the national range and the SAD range, the Ogeechee-Savannah watershed has higher WOWA scores (Table 2). Relative to the other HUC 04 watersheds in SAD, the Ogeechee-Savannah watershed is relatively more vulnerable to the impacts of climate change on ecosystem restoration (mitigation) in both the wet and dry scenarios (Figure 8). For the Ogeechee-Savannah watershed, the major drivers of the computed ecosystem restoration vulnerability score are, "At Risk Freshwater Plants", the "Macroinvertebrate Index", and "Runoff Elasticity" (Table 3).

Table 3: Indicators associated with Ecosystem Restoration (Mitigation) and their contribution to the WOWA scores.

Ecosystem Restoration (Mitigation)					
Dry Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
297 MACROINVERTEBRATE	16.55	23.34	16.55	23.21	0.00
8 AT RISK FRESHWATER PLANT	28.50	40.19	28.50	39.97	0.00
277 RUNOFF PRECIP	9.23	13.01	9.47	13.28	2.61
221C MONTHLY COV	5.51	7.77	5.63	7.89	2.10
156 SEDIMENT	1.34	1.89	1.23	1.72	-8.41
65L MEAN ANNUAL RUNOFF	3.01	4.25	3.01	4.23	0.07
568C FLOOD MAGNIFICATION	2.02	2.84	2.04	2.86	1.17
568L FLOOD MAGNIFICATION	0.80	1.12	0.81	1.13	1.17
700C LOW FLOW REDUCTION	3.97	5.59	4.07	5.71	2.59
Wet Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
297 MACROINVERTEBRATE	16.29	23.19	16.40	23.16	0.68
8 AT RISK FRESHWATER PLANT	28.06	39.94	28.25	39.88	0.68
277 RUNOFF PRECIP	9.32	13.27	9.14	12.90	-2.00
221C MONTHLY COV	5.17	7.36	3.06	4.31	-40.95
156 SEDIMENT	2.95	4.20	5.40	7.62	83.05
65L MEAN ANNUAL RUNOFF	2.24	3.18	2.24	3.16	0.16
568C FLOOD MAGNIFICATION	3.86	5.49	4.01	5.66	3.97
568L FLOOD MAGNIFICATION	0.90	1.29	0.94	1.33	3.97
700C LOW FLOW REDUCTION	1.46	2.08	1.40	1.98	-3.87

Ecosystem Restoration (Mitigation)

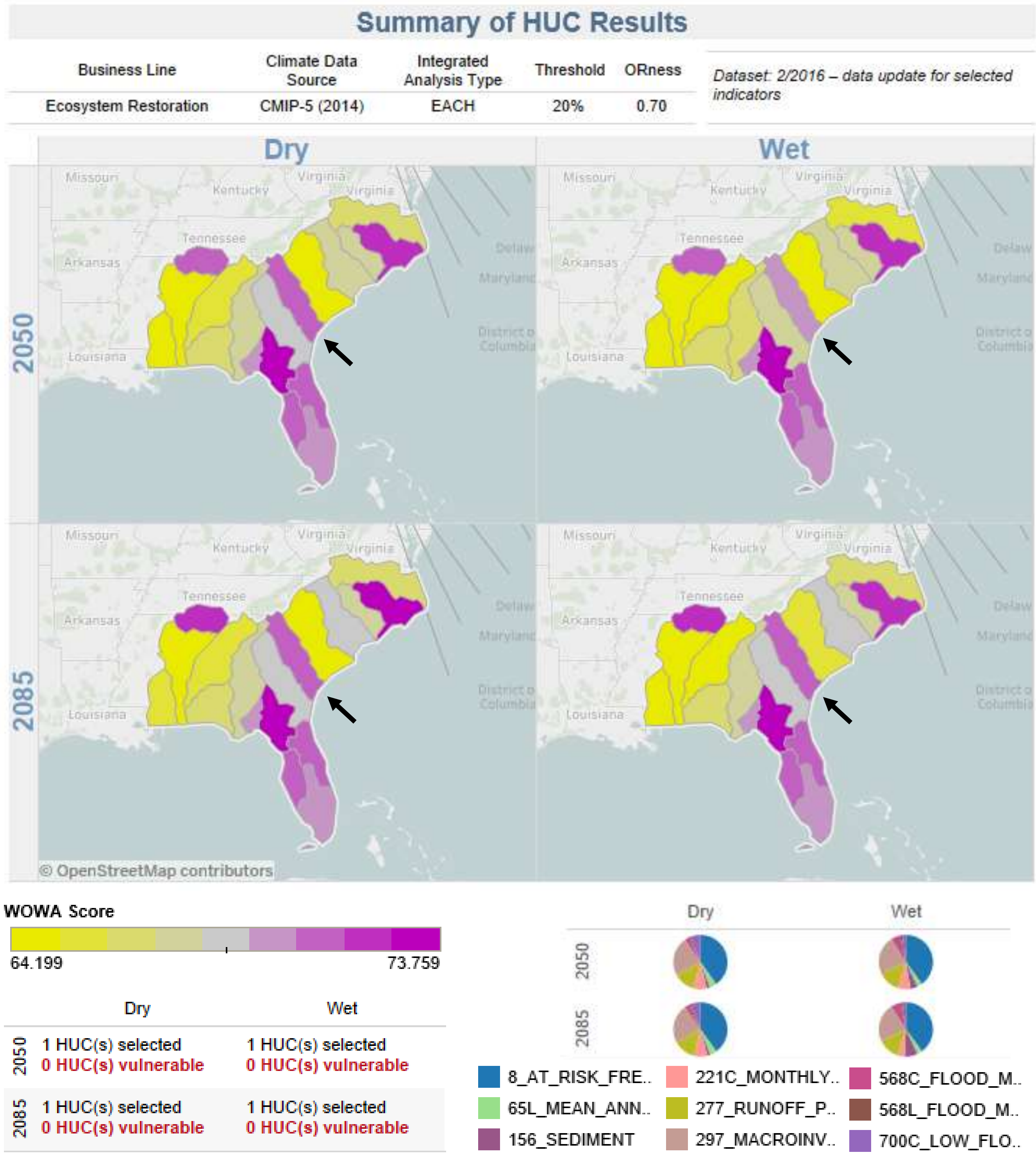


Figure 8: Results of the USACE climate vulnerability analysis for the Ecosystem Restoration WOWA score of the Ogeechee-Savannah watershed (highlighted by the black arrow) compared to SAD.

When analyzing the business line Recreation, compared to the national range and the SAD range, the Ogeechee-Savannah watershed has lower WOWA scores (Table 2). Relative to the other HUC 04 watersheds in SAD, the Ogeechee-Savannah watershed is relatively less vulnerable to the impacts of climate change on recreation in both the wet and dry scenarios (Figure 9). For the Ogeechee-Savannah watershed, the major drivers of the computed recreation vulnerability score are, “Low Flow Reduction”, the Local and cumulative “90% Exceedance”, and in wet scenarios, cumulative “Flood Magnification” (Table 4). “Drought Severity” is a major driver of the computed recreation vulnerability score in the 2085 dry scenario.

Table 4: Indicators associated with Recreation and their contribution to the WOWA scores.

Recreation					
Dry Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
571C 90PERC EXCEEDANCE	8.47	14.31	6.01	8.81	-29.07
570L 90PERC EXCEEDANCE	12.25	20.70	8.75	12.83	-28.56
277 RUNOFF PRECIP	3.13	5.29	2.96	4.33	-5.56
221C MONTHLY COV	2.25	3.81	2.12	3.11	-6.03
156 SEDIMENT	0.89	1.51	0.75	1.11	-15.70
95 DROUGHT SEVERITY	4.07	6.88	27.00	39.59	563.25
568C FLOOD MAGNIFICATION	5.37	9.07	3.85	5.64	-28.32
568L FLOOD MAGNIFICATION	1.35	2.28	1.25	1.84	-6.89
700C LOW FLOW REDUCTION	21.39	36.15	15.51	22.74	-27.52
Wet Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
571C 90PERC EXCEEDANCE	8.95	15.53	8.87	15.50	-0.95
570L 90PERC EXCEEDANCE	12.09	20.97	11.81	20.64	-2.29
277 RUNOFF PRECIP	4.35	7.55	4.18	7.31	-3.88
221C MONTHLY COV	2.91	5.05	1.69	2.95	-42.08
156 SEDIMENT	1.61	2.79	2.88	5.04	79.54
95 DROUGHT SEVERITY	0.49	0.85	2.20	3.84	349.86
568C FLOOD MAGNIFICATION	6.45	11.18	6.58	11.49	1.98
568L FLOOD MAGNIFICATION	2.10	3.64	1.27	2.22	-39.57
700C LOW FLOW REDUCTION	18.71	32.44	17.75	31.01	-5.14

Recreation

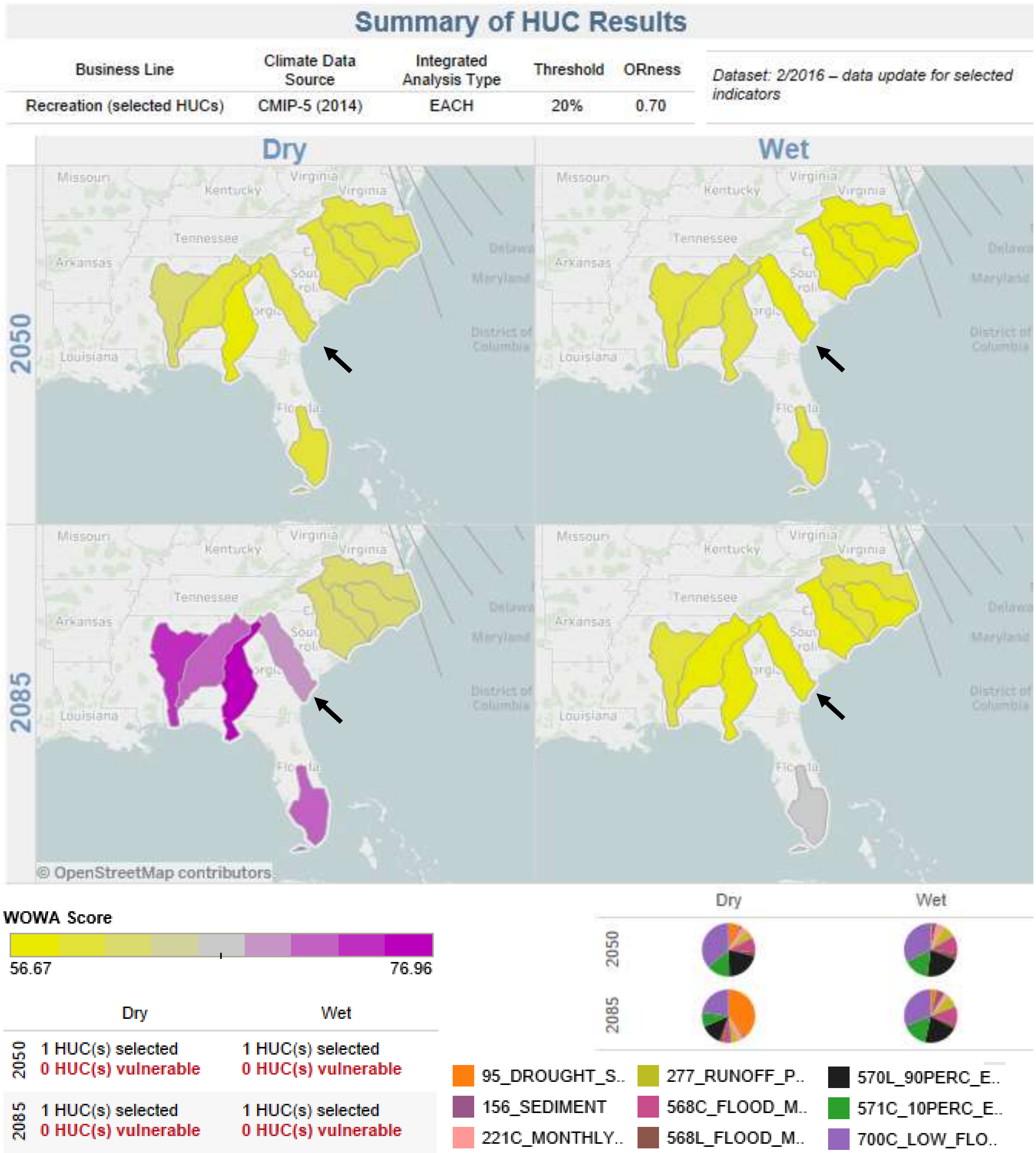


Figure 9: Results of the USACE climate vulnerability analysis for the Recreation WOWA score of the Ogeechee-Savannah watershed (highlighted by the black arrow) compared to SAD.

When analyzing the business line Water Supply, compared to the national range, the Ogeechee-Savannah watershed has lower WOWA scores (Table 2). Relative to the other HUC 04 watersheds in SAD, the Ogeechee-Savannah watershed is relatively more vulnerable to the impacts of climate change on water supply in both the wet and dry scenarios (Figure 10). For the Ogeechee-Savannah watershed, the major drivers of the computed water supply vulnerability score are, “Sediment”, the “Runoff Elasticity”, and during all scenarios except for the 2050 wet scenario, “Drought Severity” (Table 5).

Table 5: Indicators associated with Water Supply and their contribution to the WOWA scores.

Water Supply					
Dry Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
156 SEDIMENT	23.55	50.57	13.21	21.76	-43.91
175C ANNUAL COV	1.89	4.07	1.78	2.93	-6.01
221C MONTHLY COV	3.07	6.60	3.02	4.98	-1.61
277 RUNOFF PRECIP	12.00	25.77	7.71	12.70	-35.76
95 DROUGHT SEVERITY	6.05	13.00	34.97	57.62	477.80
Wet Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
156 SEDIMENT	34.62	61.84	36.00	62.03	3.99
175C ANNUAL COV	2.84	5.08	1.79	3.09	-36.83
221C MONTHLY COV	4.73	8.45	2.90	5.00	-38.68
277 RUNOFF PRECIP	12.91	23.07	11.99	20.66	-7.17
95 DROUGHT SEVERITY	0.88	1.57	5.35	9.22	509.96

Water Supply

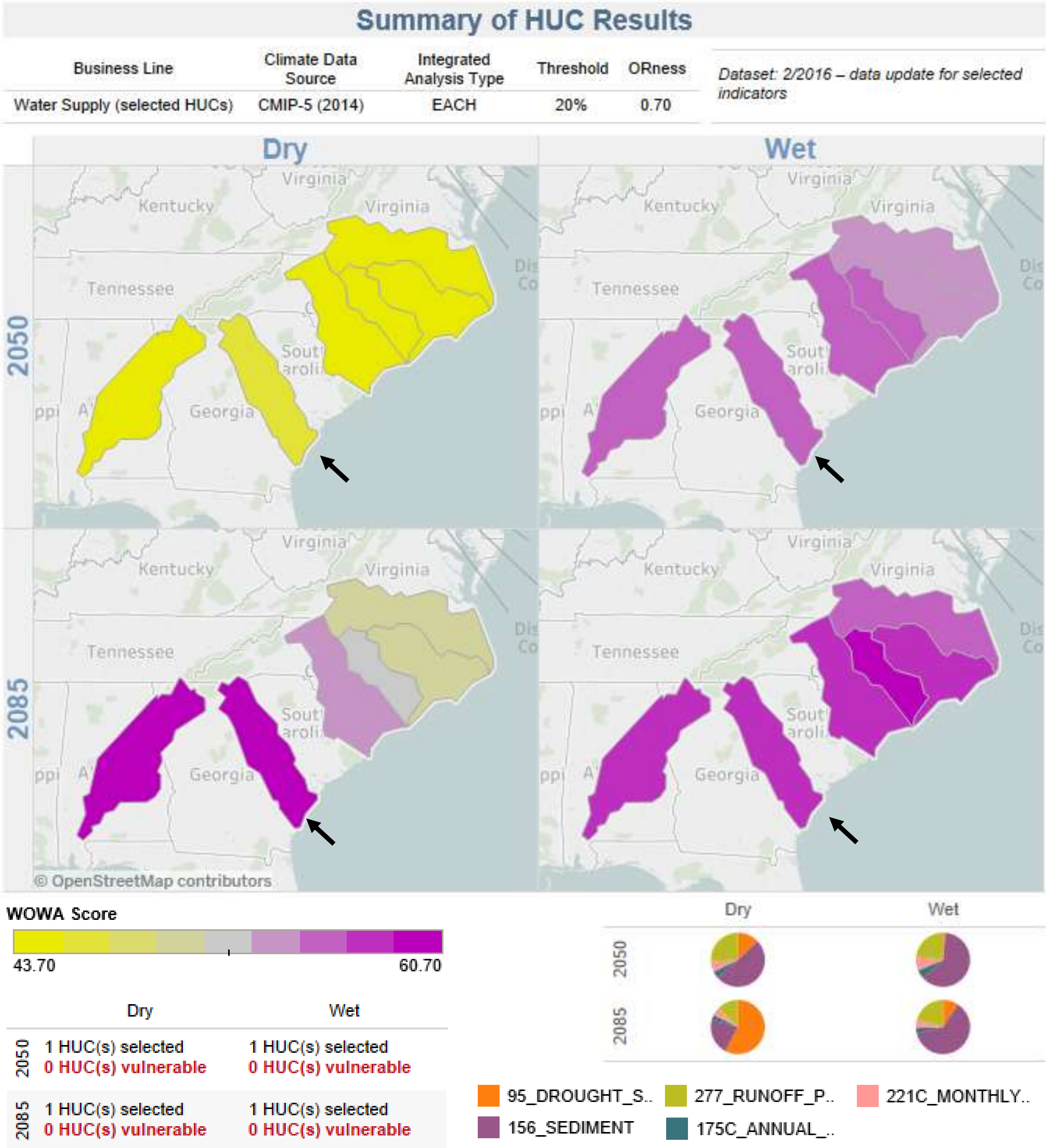


Figure 10: Results of the USACE climate vulnerability analysis for the Water Supply WOWA score of the Ogeechee-Savannah watershed (highlighted by the black arrow) compared to SAD.

When analyzing the business line Flood Risk Reduction, compared to the national range, the Ogeechee-Savannah watershed has lower WOWA scores (Table 2). Relative to the other HUC 04 watersheds in SAD, the Ogeechee-Savannah watershed is relatively less vulnerable to the impacts of climate change on Flood Reduction in both the wet and dry scenarios (Figure 11). For the Ogeechee-Savannah watershed, the major drivers of the computed water supply vulnerability score are, local and cumulative “Flood Magnification”, and the “Urban 500YR Floodplain Area” (Table 6).

Table 6: Indicators associated with Flood Risk Reduction and their contribution to the WOWA scores.

Flood Risk Reduction					
Dry Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
175C ANNUAL COV	1.66	3.79	1.62	3.66	-2.47
277 RUNOFF PRECIP	4.10	9.35	4.20	9.51	2.61
568C FLOOD MAGNIFICATION	19.51	44.55	19.74	44.66	1.17
568L FLOOD MAGNIFICATION	6.41	14.62	6.48	14.66	1.17
590 URBAN 500YR FLOODPLAIN AREA	12.13	27.69	12.16	27.51	0.23
Wet Scenario					
Indicator #	**2050 Value**	**2050 % Score**	**2085 Value**	**2085 % Score**	**% Change**
175C ANNUAL COV	1.54	3.23	1.57	3.23	1.96
277 RUNOFF PRECIP	4.20	8.80	4.09	8.41	-2.67
568C FLOOD MAGNIFICATION	22.48	47.09	23.21	47.71	3.26
568L FLOOD MAGNIFICATION	7.38	15.46	7.62	15.66	3.26
590 URBAN 500YR FLOODPLAIN AREA	12.13	25.42	12.16	24.99	0.23

Flood Risk Reduction

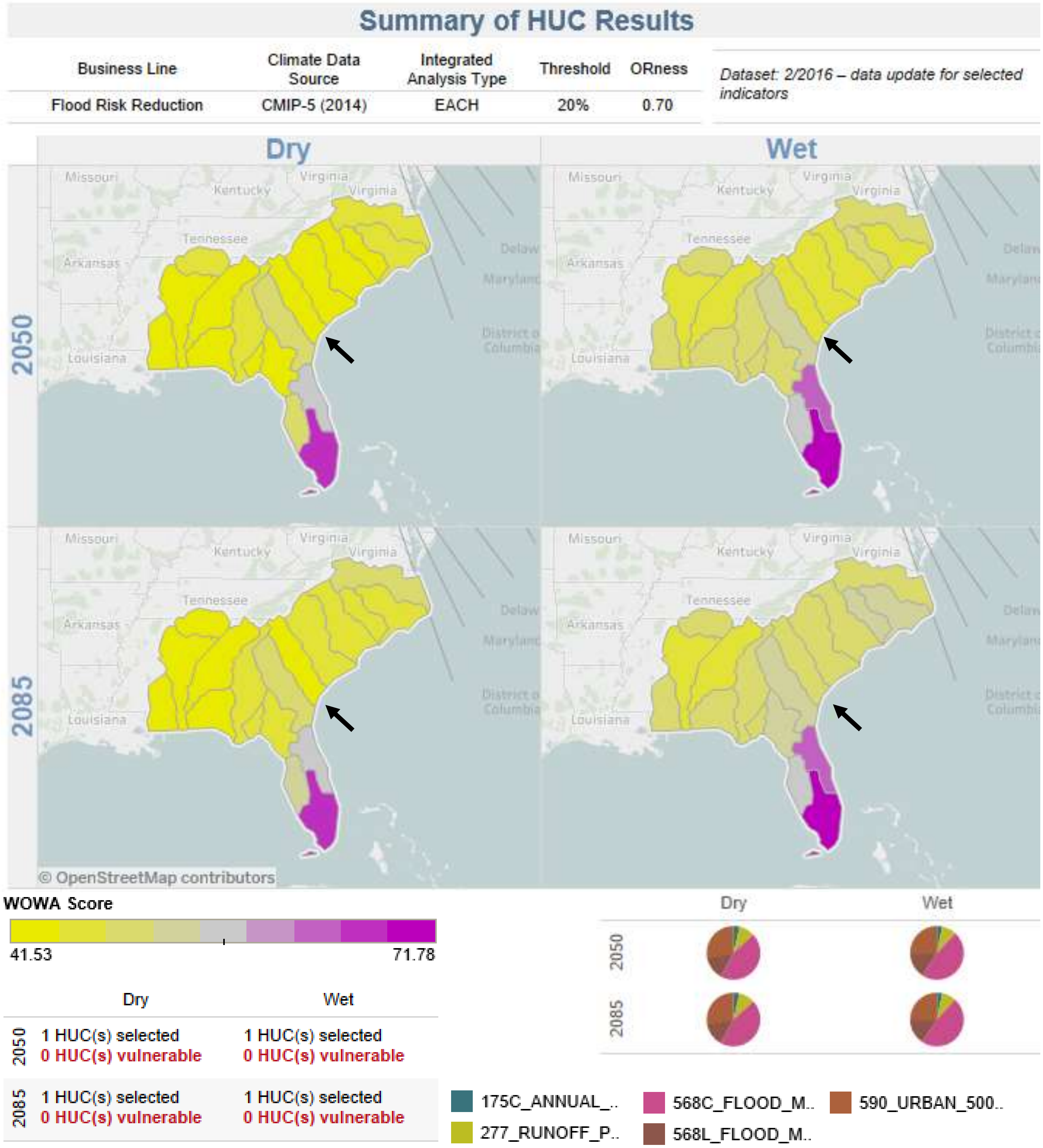


Figure 11: Results of the USACE climate vulnerability analysis for the Flood Risk Reduction WOWA score of the Ogeechee-Savannah watershed (highlighted by the black arrow) compared to SAD

1.4 First Order Statistical Analysis: Site Specific Trends and Nonstationarity Assessment

A series of twelve different nonstationarity detection tests were carried out on the peak annual discharge record collected at USGS gage 02197000 Savannah River at Augusta, GA using the USACE Nonstationarity Detection Tool. Maximum annual flow was chosen for this analysis due to the nature of the project. NSBLD Fish Passage is a mitigation project focused on creating a passageway for the Atlantic sturgeon to reach spawning grounds. Flow down river is a strong signal for the fish to find their way upriver to the spawning grounds.

A "strong" nonstationarity is one for which there is a consensus among multiple nonstationarity detection methods, robustness in detection of changes in statistical properties, and relatively large change in the magnitude of a dataset's statistical properties. Output from the Nonstationarity Detection Tool offers insight into the following three key criteria related to each identified nonstationarity, which can be used to help the user select a homogenous dataset that can be further used for hydrologic analysis (Friedman et al 2018) .

> i. A nonstationarity that is detected can be considered strong if it is detected by two or more detection methods of the same type (e.g. mean or variance/standard deviation or distribution). This represents consensus that a statistically significant nonstationarity occurs at a given point in a flow record. If consensus cannot be found for a given year or short period of time, then it is reasonable to discount it.
>
> ii. A statistically significant nonstationarity can be considered robust when tests targeting changes in two or more different statistical properties (mean, variance/standard deviation and/or overall distribution) are indicating a statistically significant nonstationarity. While a robust nonstationarity is not necessarily stronger, it represents a multifaceted change in the record. This can be taken into consideration when deciding which portion of the period of record to use in order to perform hydrological analysis.
>
> iii. An identified nonstationarity is also associated with a given magnitude of change in the mean or standard deviation/variance in the annual instantaneous peak streamflow datasets prior to and after the identified nonstationarity. Nonstationarities that are produced by greater changes in the statistical properties of the datasets before and after the identified nonstationarities may be important to take into consideration when performing subsequent hydrological analysis.

Annual peak discharge data information for the Savannah River at Augusta, GA (USGS gage 02197000), which includes an annual record of daily river flows from 1876 to 2014, were analyzed. While there are several gages near the project location, this gage was chosen because it is located at the New Savannah Bluff Lock and Dam which is 0.2 miles upstream from Butler Creek, 12 miles downstream from the city of Augusta, GA. The Savannah River at Augusta, GA gage is impacted by regulation.

The upper natural river system above the Savanah gage has been fragmented by a series of reservoirs, including three large federal reservoirs (Hartwell Lake, Richard B. Russell Lake, and J. Strom Thurmond Lake). These reservoirs provide hydropower, water supply, recreational facilities, and a limited degree of flood control. River flows at Augusta and New Savannah Bluff Lock and Dam are regulated by J.

Strom Thurmond Dam and to lesser extent by Stevens Creek Dam. During normal operating conditions flows range from 3,600 cfs to around 8,000 cfs, though there is daily and even hourly variability in flow due in large part to hydropower generation at Thurmond. Stevens Creek Dam, built in 1916 and located between Thurmond Dam and Augusta, impounds a minor run-of-the-river reservoir compared to the three major reservoirs. Stevens Creek dam and other dams upstream of Hartwell Lake have little impact on flood discharges at Augusta. The Savannah River at Augusta, GA gage has a total upstream drainage area of 7,510 square miles and a local drainage area of 1,329 square miles between the NSBLD and J. Strom Thurmond Dam approximately 25 miles upstream The NSBLD is a run-of-river project and does not regulate for flood control. The NSBLD was constructed in 1937 for the purpose of navigation. This project purpose has since been de-authorized.

Figure 12 shows the annual instantaneous peak streamflow time series obtained from the USGS website. A visual examination of this time series suggests that there have been changes in the annual instantaneous peak streamflow record over the past 150 years. In particular, the values prior to the 1950s are on average higher than later years. Examination of the metadata associated with this record indicates that the construction of the J. Strom Thurmond Dam was completed around 1954. Based on this information, a priori knowledge exists that an abrupt change occurred in the early nineteen fifties due to construction of the J. Strom Thurmond Dam, which impounds J. Strom Thurmond Lake. Therefore, the next step in the analysis is to formally test whether a nonstationarity exists in the annual instantaneous peak streamflow record observed at Savannah River at Augusta, GA in the early fifities.

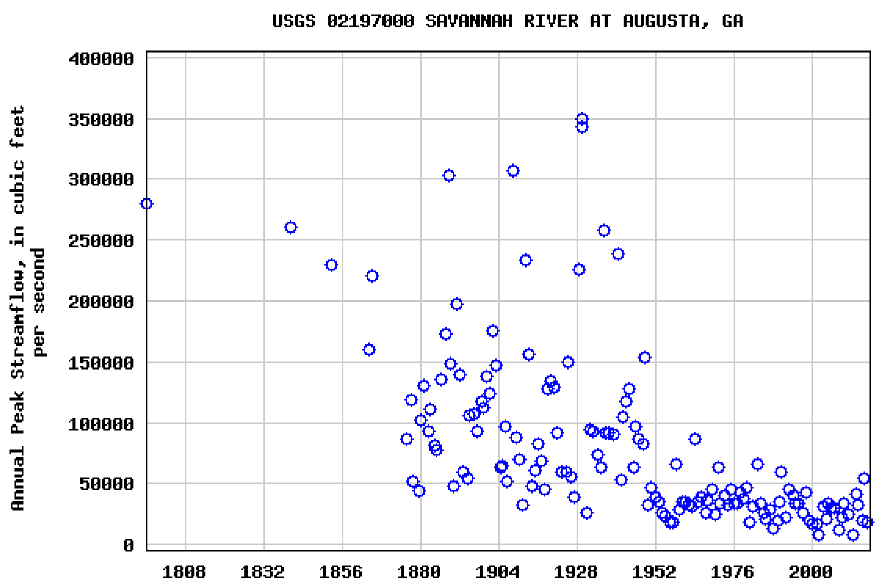


Figure 12: Annual peak streamflow time series for the Savannah River at Augusta, GA (USGS ID 02197000)

Figure 13 shows the results of the nonstationarity analysis. Statistically significant nonstationarities are shown as black lines in the top graph. The heatmap (middle graph) indicates which nonstationarity detection test identified a statistically significant nonstationarity. As shown in Figure 13 below, although a statistically significant, nonstationarity was detected by the Mood (CPM) test in 1926 and 1931 and by the Energy Divisive Method in 1985, there is no consensus between the statistical tests so it can be concluded that there are no operationally significant nonstationarities in the flow record at those times (Friedman, et al. 2018). However, eight of the twelve statistical tests show statistically significant nonstationarities between 1948 and 1950 and three of the twelve statistical tests indicate a statistically significant nonstationarity in 1998 (Figure 13). There is a significant decrease in the segment mean in the pre and post 1948-1950 nonstationarity detection. Between 1948 and 1950, the mean annual instantaneous peak streamflow decreases from approximately 100,000 cfs to approximately 25,000 cfs.

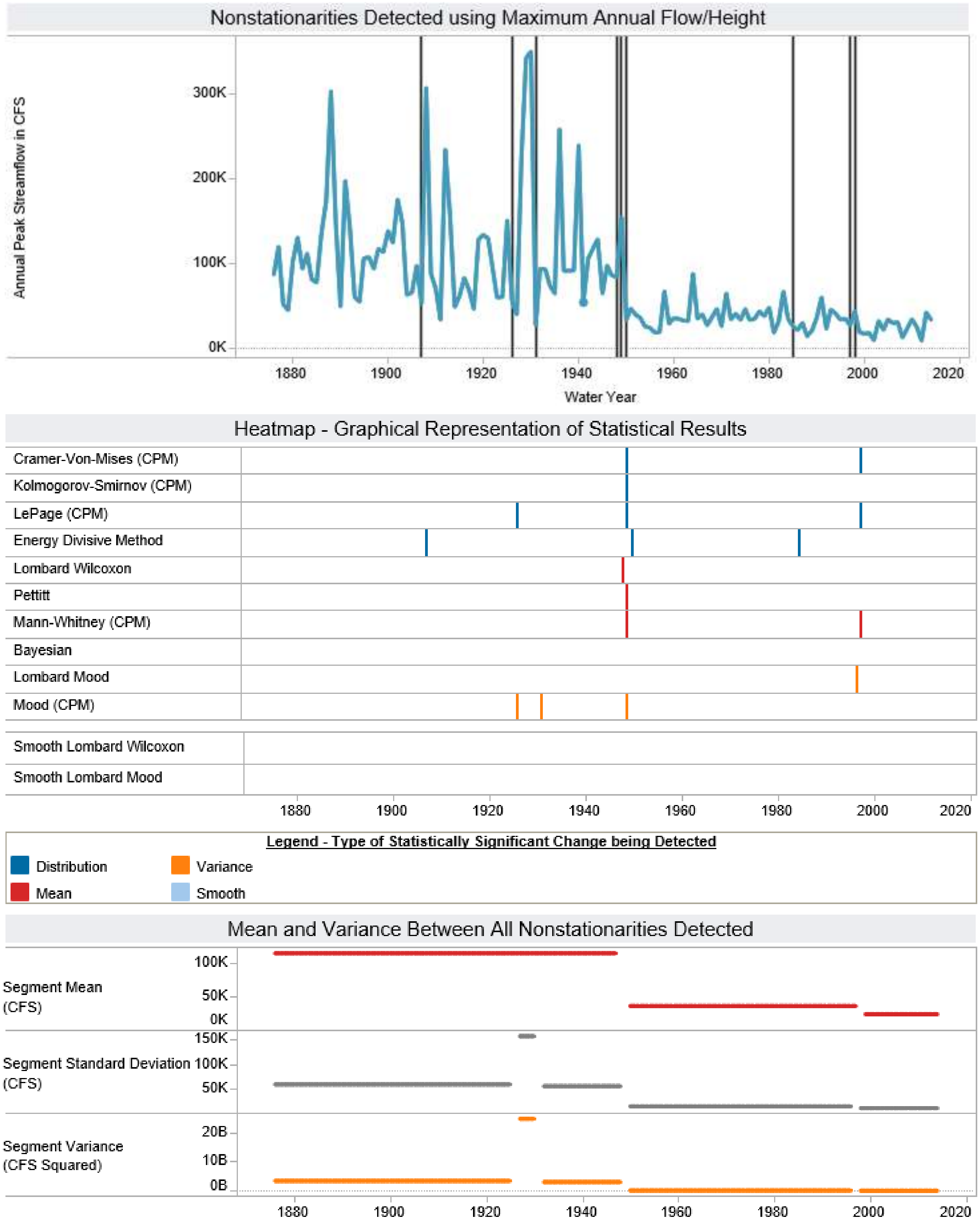


Figure 13: Nonstationary Analysis of Peak Annual Discharge for the Savannah River at the Augusta, GA USGS gage (Gage Number 02197000) from 1876 to 2014.

The next portion of the analysis consists of assessing the subsets of homogenous data for monotonic trends. Because two strong statistically significant nonstationarity was detected between 1948 and

1950, and 1998 the data was divided into three statistically stationary (homogenous) segments or periods of record based on the two nonstationarity periods identified:

- 1876-1949 (Before J. Strom Thurmond Dam)
- 1950-1997 (After J. Strom Thurmond Dam pre – 1998 nonstationarity detection)
- 1998-2014 (After J. Strom Thurmond Dam post – 1998 nonstationarity detection)

To assess monotonic trends within these subsets of the flow record, the trend analysis tab within the USACE Nonstationarity Detection Tool was used. This tool performs multiple statistical tests to detect the presences of monotonic trends in the annual instantiations peak streamflow record. The results indicate that, if the dataset is separated into statistically homogenous subsets of flow data prior to and after the construction of the J. Strom Thurmond Dam, and post 1998 nonstationarity detection, there is not an overall, statistically significant, monotonic trend in the annual instantaneous peak streamflow record for the Savannah River at Augusta (Figures 14-16).

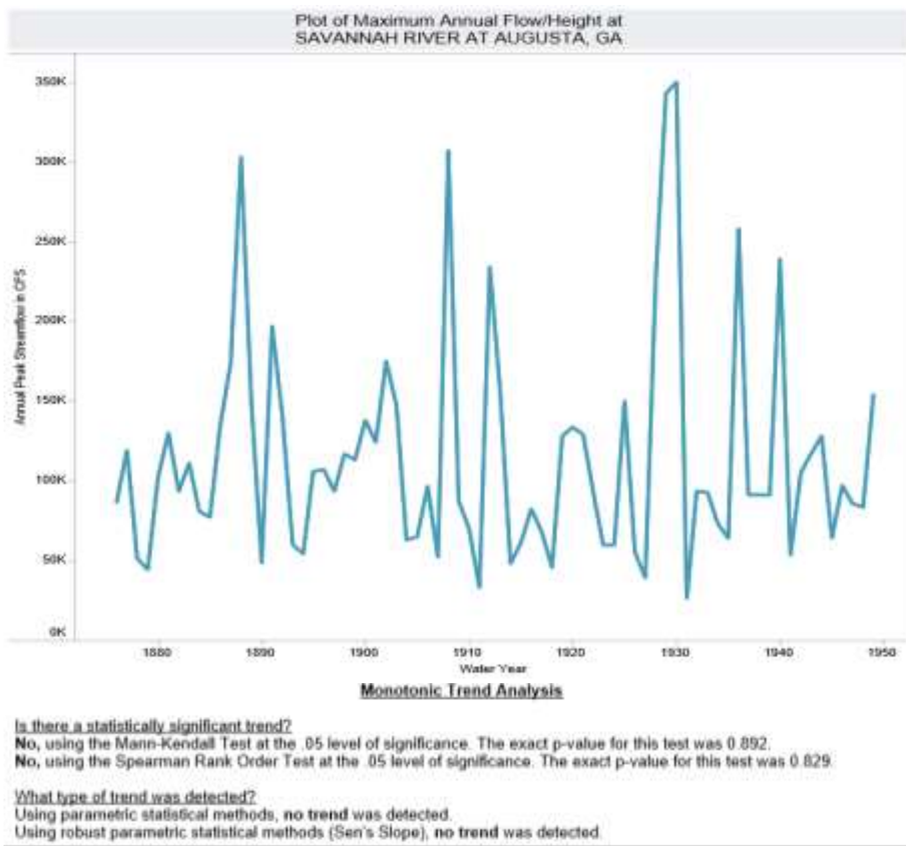


Figure 14: Trend Analysis for the Savannah River at Augusta gage before the J Strom Thurmond Dam was constructed (1876-1949; P-value > 0.05).

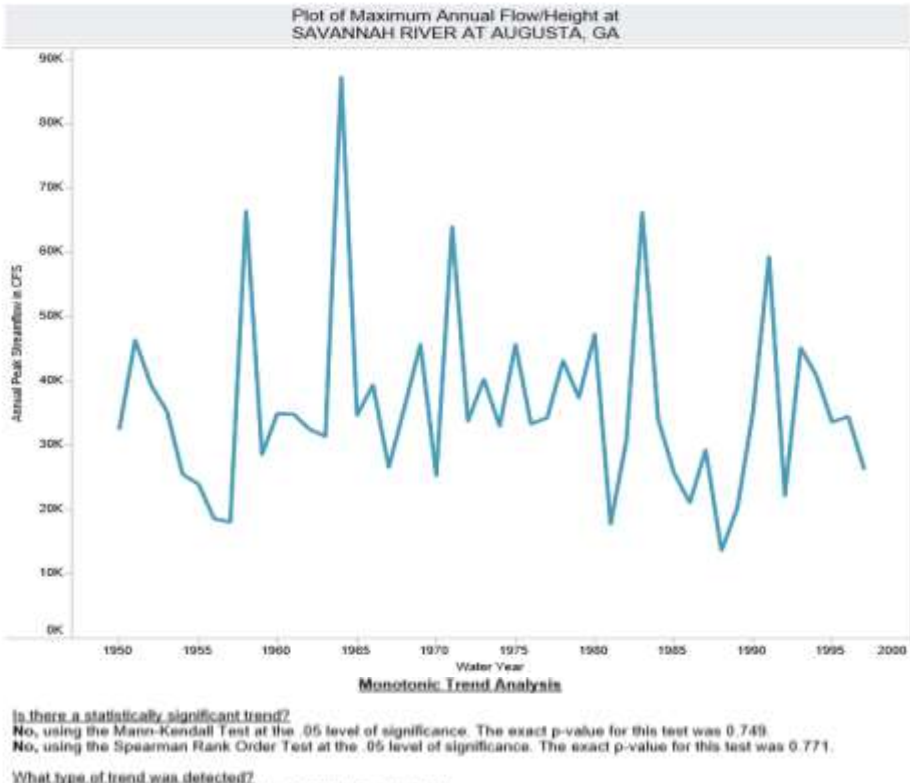


Figure 15: Trend Analysis for the Savannah River at Augusta gage after the J Strom Thurmond Dam was constructed but before the significant drought of record in 1998 (1950-1997; P-value > 0.05).

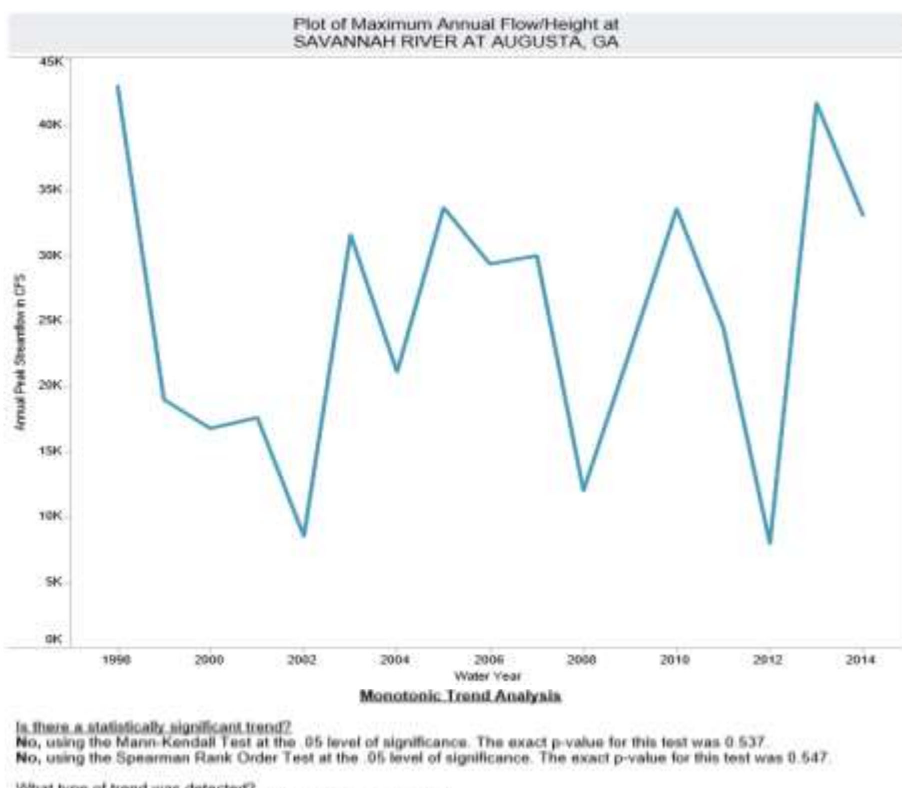


Figure 16: Trend Analysis for the Savannah River at Augusta gage after the significant drought of record in 1998 (1998-2014; P-value > 0.05).

The significant nonstationarity detected between 1948 and 1950 can be attributed to the construction of the J. Strom Thurmond Dam located 34 miles north of Augusta, GA. The dam was constructed between 1946 and 1954 and was officially completed July 1954. Post dam construction, the range in maximum annual flow height is greatly reduced as shown in Figure 13. It is also clear by the large change in the segment mean pre and post dam construction that the J Strom Thurmond Dam construction is the greatest driver discharge/streamflow/nonstationarity at the Augusta, GA gauge (02197000).

The significant nonstationarity detected in 1998 can be attributed to the notable Drought of Record that started in 1998. This drought led to the USACE updating the Drought Plan for the J Strom Thurmond Dam and Lake Project in 2006.

Due to the Savannah River at Augusta, GA gage being impacted by regulation, a second set of analyses were completed on the Broad River near Bell, GA (USGS gage 02192000), an unregulated stream within the Ogeechee-Savannah Watershed (Figure 17). This gage was chosen because it is one of the few gages within the Ogeechee-Savannah Watershed on an unregulated stream with a long record of data collection. By completing this second analysis on an unregulated stream, better consensus can be given to climate impacts within the project area taking the J. Strom Thurmond Dam out of the picture. The Broad River near Bell, GA gage is located 12 miles southeast of Elberton, GA and has a drainage of 1,420 square miles. The dates analyzed were from 1938 to 2014.

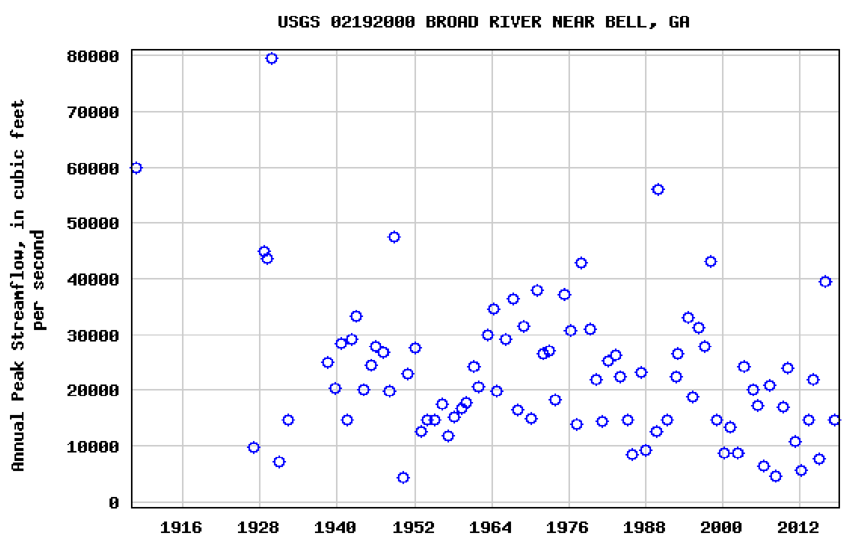
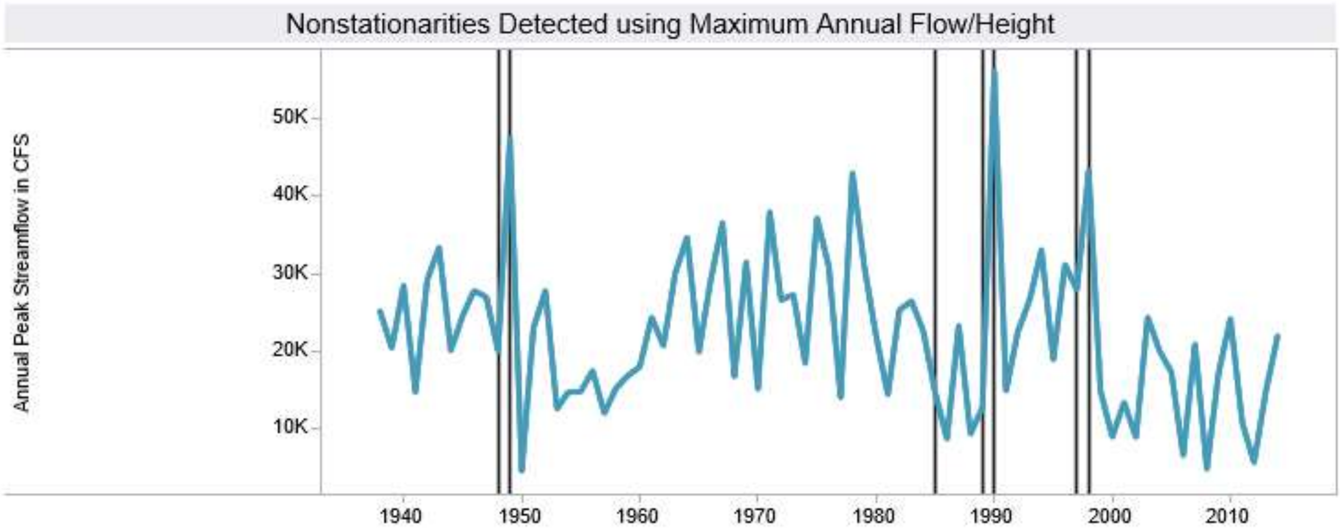


Figure 17: Annual peak streamflow time series for the Broad River near Bell, GA (USGS ID 02192000)

Figure 18 shows the results of the nonstationarity analysis for the Broad River near Bell, GA. Statistically significant nonstationarities are shown as black lines in the top graph. The heatmap (middle graph) indicates which nonstationarity detection test identified a statistically significant nonstationarity. As shown in Figure 18 below, although a statistically significant, nonstationarity was detected by the Bayesian test in 1948, 1949, 1989 and 1990 and by the Lombard Wilcoxon in 1985, there is no consensus between the statistical tests so it can be concluded that there are no operationally significant nonstationarities in the flow record at those times (Friedman, et al. 2018). However, five of the twelve statistical tests show statistically significant nonstationarities between around 1998. There is a significant decrease in the segment mean in the pre and post 1998 nonstationarity detection. Around 1998, the mean annual instantaneous peak streamflow decreases from approximately 25,000 cfs to approximately 14,500 cfs.



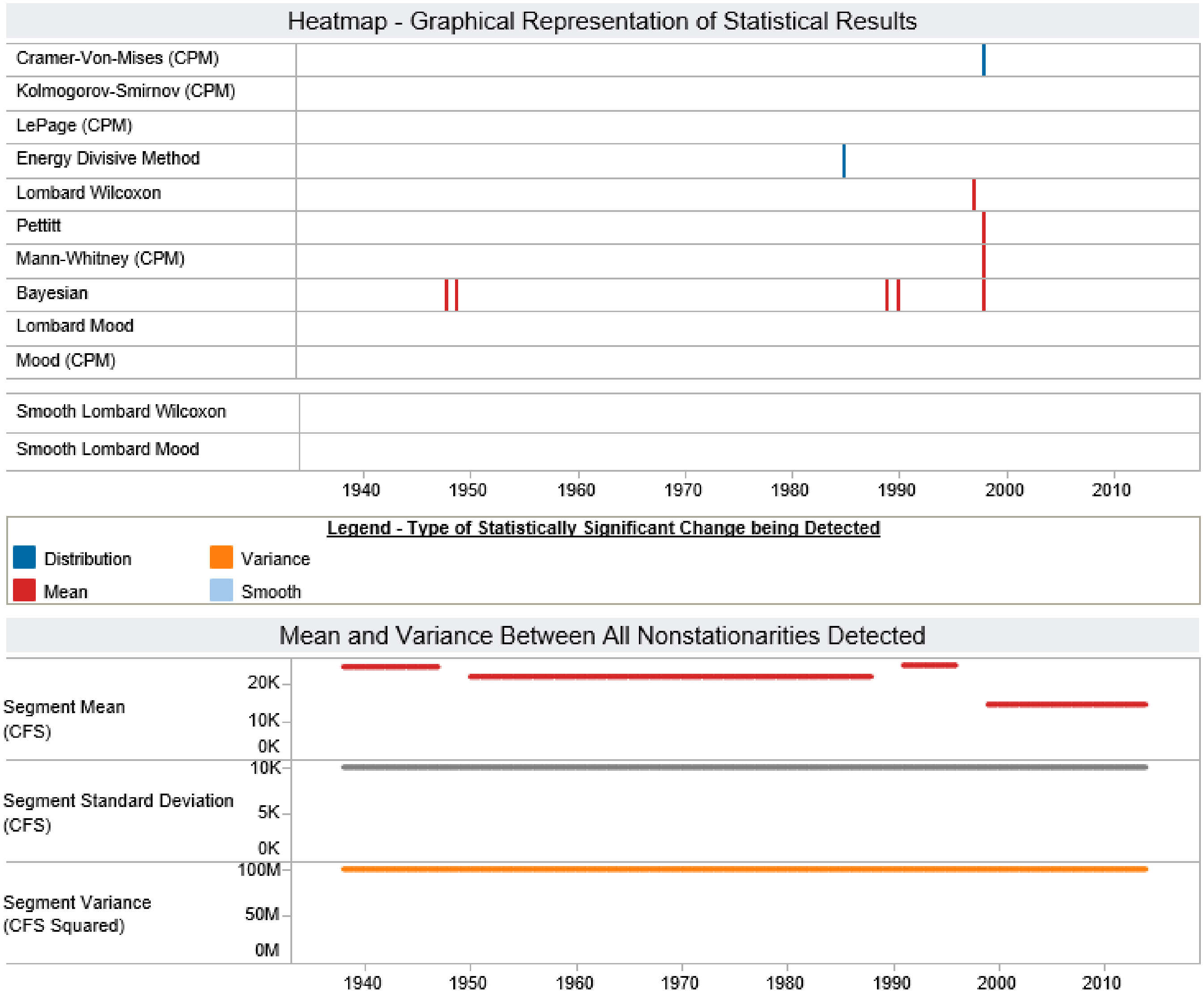


Figure 18: Nonstationary Analysis of Peak Annual Discharge for the Broad River near Bell, GA USGS gage (Gage Number 02192000) from 1938 to 2014.

The next portion of the analysis consists of assessing the subsets of homogenous data for monotonic trends. Because a strong statistically significant nonstationarity was detected around 1998, the data were divided into two statistically stationary (homogenous) segments or periods of record based on the nonstationarity period identified:

- 1938-1997 (Pre start of drought in 1998)
- 1998-2014 (Post start of drought in 1998)

As completed with the Savannah River at Augusta, GA gage, to assess monotonic trends within these subsets of the flow record, the trend analysis tab within the USACE Nonstationarity Detection Tool was used. The results indicate that, if the dataset is separated into statistically homogenous subsets of flow data pre and post the 1998 nonstationarity detection, there is not an overall, statistically significant, monotonic trend in the annual instantaneous peak streamflow record for the Broad River near Bell, GA (Figures 19 and 20).

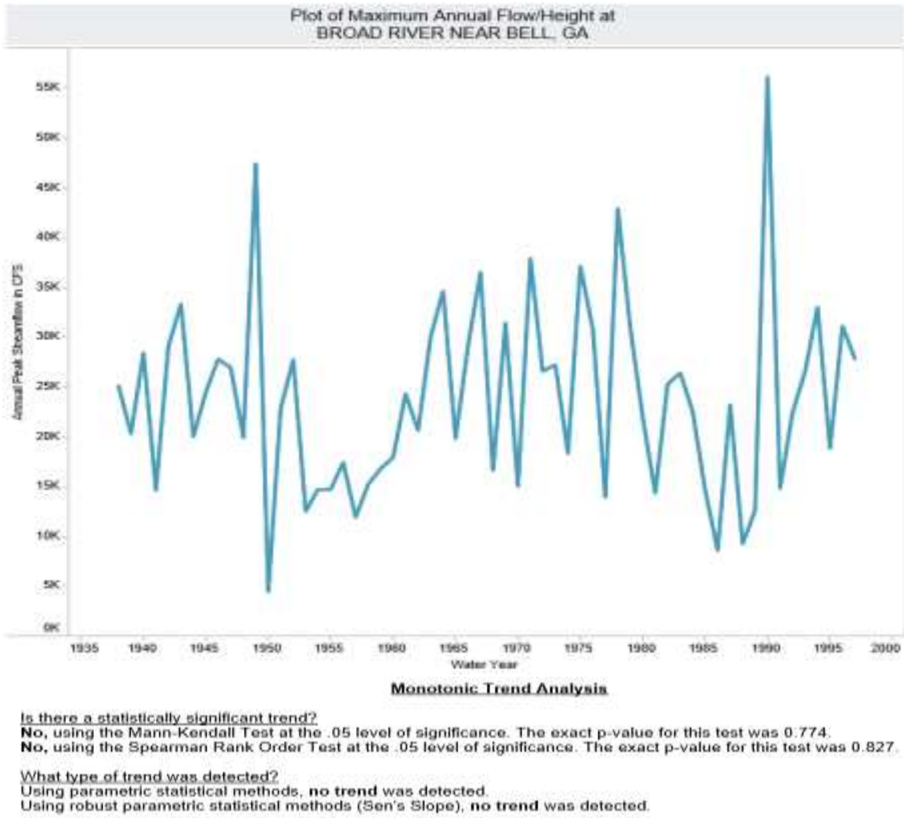


Figure 19: Trend Analysis for the Broad River near Bell gage before the significant drought of record in 1998 (1938-1997; P-value > 0.05).

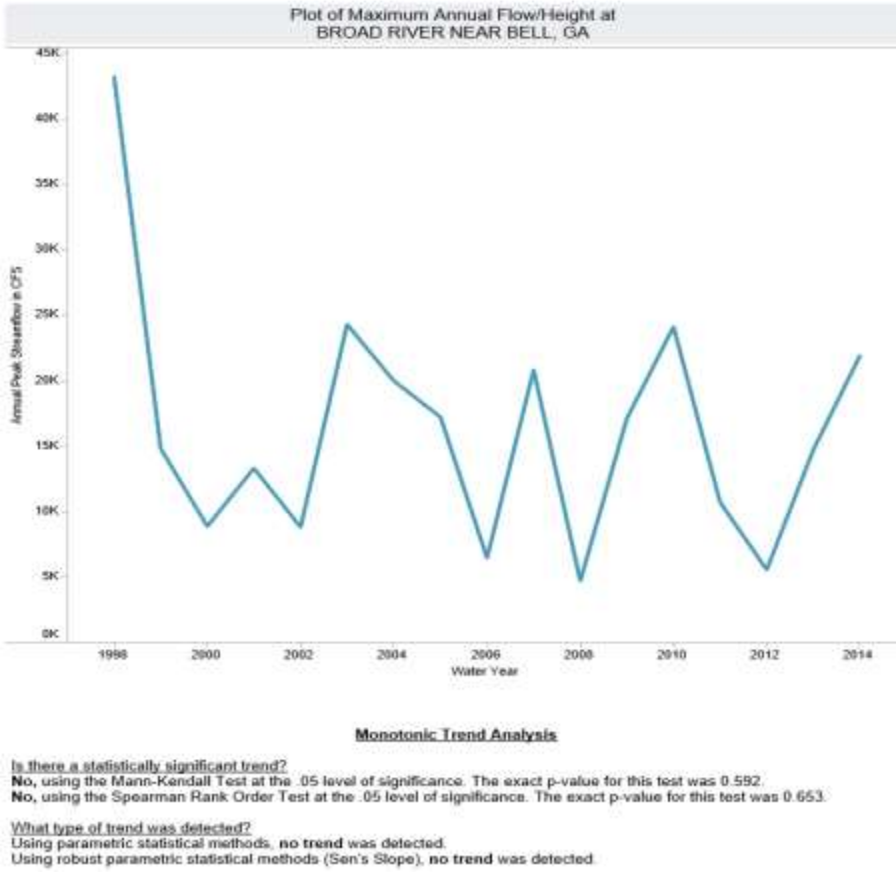


Figure 20: Trend Analysis for the Broad River near Bell, GA gage after the significant drought of record in 1998 (1998-2014; P-value > 0.05).

Upon completion of the second nonstationarity detection on an unregulated river, at the NSBLD project site, the J Strom Thurmond Dam's construction is the main driver of flow. This can be seen by the abrupt change in flow post dam construction. Around the same time period, there was no consensus of detection of nonstationarity at the Broad River near Bell, GA gage. Although the dam caused a detection of nonstationarity, the monotonic trend analysis showed no significant trends pre and post construction. The second nonstationarity detected was the 1998 drought. The drought's impact was basin wide as shown in the Broad River analysis but monotonic trends have remained insignificant showing no increase or decrease in flow at either of the tested locations beyond the nonstationarity detections. This was a significant drought of record. As noted before, this drought led to the USACE updating the Drought Plan for the J Strom Thurmond Dam and Lake Project. At the NSBLD, post the 1998 drought, there were no significant monotonic trends detected.

Besides flow, another important trigger for migration of Atlantic sturgeon upriver is water temperature. Atlantic sturgeon are triggered to spawn during the fall when water temperatures fall below 25˚C (Ingram and Peterson, 2016). Fall was considered the months of September through December for this analysis. To analyze if there are any trends in fall water temperature at the project site, annual fall water temperature data was gathered from the Savannah River at Augusta, GA gage. The gage's temperature data ranges from 1973-1992 (missing 4 years). A Mann-Kendall test was performed using the Kendall Package in R to look for significant trends in the data (McLeod 2011; R

Core Team 2018). Since the 1970's there are no significant trends being detected for fall water temperature in the project area (Figure 21, P-value > 0.05).

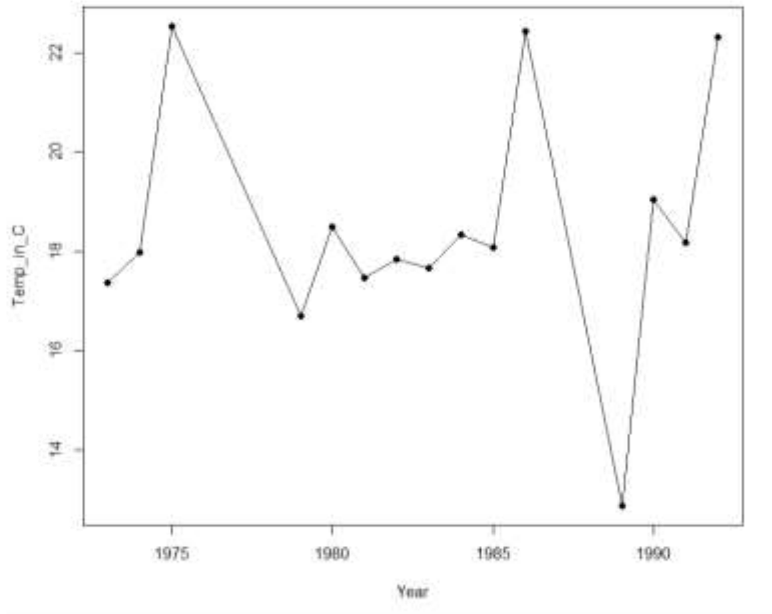


Figure 21: Average Fall temperatures for the Savannah River at Augusta, GA gage (1973-1992).

1.4 Summary and Conclusions

Relative to the other 201 HUC04 watersheds in the continental United States, the Savannah watershed isn't highly vulnerable (top 20% of CONUS watersheds) to the impacts of climate change on any of the four business lines evaluated (Ecosystem Restoration, Recreation, Water Supply, or Flood Risk Reduction). The results of the vulnerability assessment do not conclude that the Savannah watershed will not be impacted by climate change, it just implies that climate change will comparatively have less of an impact in the Savannah watershed relative to its impact on other HUC04 watersheds in the U.S. Climate change could affect the operating objectives of the recommended alternative both negatively and positively. While occasional flooding can be beneficial to the ecosystem and floodplain, it could also negatively affect fish migration due to large flows in the river. Conversely, significant droughts in the basin could also negatively affect fish migration due to insufficient streamflow for adequate spawning pool depths in the breeding grounds known as Augusta Shoals. None of the evaluated project alternatives would be impacted positively or negatively more so than another by climate change effects.

A review of climate change literature specific to the region suggests a strong trend towards warmer climate and a small trend towards more extreme precipitation in the future. Several gages, both regulated and unregulated, were evaluated for site specific trends and nonstationarity detection. The regulated gage showed two instances of nonstationarity, one in 1950 and one in 1998. The 1950 occurrence is attributed to the construction of J. Strom Thurmond Dam in 1954. The 1998 occurrence is attributed to a severe, prolonged drought in the Savannah River Basin in which the mean annual instantaneous peak streamflow decreased from approximately 25,000 cfs to approximately 14,500 cfs. If the dataset is separated into statistically homogenous subsets of flow data prior to and after the construction of the J. Strom Thurmond Dam, and post 1998 nonstationarity detection, there is not an overall, statistically significant, monotonic trend in the annual instantaneous peak streamflow record for the Savannah River at Augusta.

Increased flow rates over time will not be operationally significant due to the large impact the J. Strom Thurmond Dam has on flow rates in the project area (Figure 8). Since the construction of the J Strom Thurmond Dam, flow rates through the project area have not gone above 100,000 cfs, an amount that was topped over 15 times from 1900 – 1948. Both the current NSBLD and the recommended fish passage alternative provide essentially no storage and therefore are run-of-river projects. The three large multi-purpose dams upstream (Hartwell, Richard B. Russell, and J. Strom Thurmond Dams) each have significant storage, including flood control storage. There is not a significant amount of drainage area between J. Strom Thurmond and the NSBLD, and therefore very little additional inflow will be contributed between Thurmond Dam and NSBLD. During droughts, Thurmond Dam operates according to an approved Drought Management Plan (DMP) which provides adequate in-stream flow for fish and wildlife and has been approved by all appropriate state and federal agencies for such.

Table 7 identifies potential hazards that could be caused due to climate change effects, the harms associated with those effects, and the qualitative likelihood of this harm to be realized.

Table 7: Identified climate risks for recommend alternative, 2-6d

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Alternative 2-6d: Fixed crest weir with a flood plain bench	Increased precipitation from larger, slower-moving storms	Some hazard exists with greater than 30,000 cfs flows as to whether the weir may need repair following the event	If the weir is damaged to the point that the water elevation is reduced, municipal and industrial water supply intakes may be impacted	Not likely
Alternative 2-6d: Fixed crest weir with a flood plain bench	Decreased precipitation or increased severity of drought	Because the water releases are controlled from the upstream reservoir based on the Drought Management Plan, flows below 3600 cfs are not likely	Water supply intakes are not impacted at 3600 cfs flows, however they would be impacted with in-stream flows less than 3,600 cfs	Not likely

The New Savannah Bluff Lock and Dam Fish Passage project is a mitigation project and thus falls mostly under the Corps' Ecosystem Restoration business line. By choosing to remove the Lock and Dam structure, the USACE is attempting to improve ecological conditions, thus counter acting any potential negative impacts the Savannah watershed might experience in the face of a changing climate. Further, impacts associated with climate change are not going to severely impact the objective of the project, which is to allow fish to access their native breeding grounds.

1.5 Citations

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