Contents

INTRODUCTION

This economic appendix documents the analysis of flood damage reduction, and regional economic development (RED) undertaken for this study. Section I documents the flood damage reduction analysis and section II documents the evaluation of RED.

SECTION I: FLOOD DAMAGE REDUCTION

PURPOSE

The study area encompassing Sweetwater Creek and its tributaries have experienced multiple large flooding events within the past decade prompting Cobb County, Georgia and the U.S. Army Corps of Engineers to enter into a Feasibility Cost Sharing Agreement. The agreement calls for Cobb County and the USACE to perform the analyses necessary to determine whether a Federal interest exists in measures to reduce the risk of flooding. This document explains what is known about the study area, the floodplain characteristics, existing condition flood damages and expected future condition flood damages in the absence of flood damage reduction measures. Within this report is the documentation of the procedures used to analyze various measures designed to reduce the risk of flood damages, and recommends a plan alternative regarding National Economic Development (NED).

STUDY AREA

The Sweetwater Creek study area is located in Georgia approximately 15 miles west of the city of Atlanta and is within Cobb, Douglas and Paulding Counties. The main urban areas which are affected by flooding are Austell, and Powder Springs in Cobb County. The urban areas mostly affected by flooding are Austell and Lithia springs which both closely boarder the Cobb-Douglas County line with Austell to the north in Cobb County and Lithia Springs directly south in Douglass County.

Cobb, Douglas and Paulding counties have experienced a period of steady growth for the past 40 years as they are in close proximity to the city of Atlanta. The growth of Atlanta has led to growth within the surrounding cities as has been seen with many other large cities across the nation. Since much of the development has occurred after the institution of the National Flood Insurance Program (NFIP), the development has largely occurred with flooding in mind and above the 100-year floodplain. Most of the small number of structures that are within the 100-year floodplain are located within the unincorporated, rural county areas and were built before the NFIP was created in 1968. This results in a scenario where the structures which account for the majority of economic damages to be few and far-between and with lower market prices and depreciated replacement costs than the newer housing developments which were built above the 100-year floodplain. The Sweetwater Creek study area floodplain has been managed wisely and this can be seen in the relatively low economic damages when compared to other areas that experience flooding.

The Federal Government has an interest in reducing economic damages caused by flooding, as doing so not only contributes to NED benefits, but may also improve the living conditions of some minority and low-income groups, may provide opportunities to enhance the environment and may reduce the costs of administering the Federal Flood Insurance program. The cities within the study area also have a valid interest in reducing those losses, as improved economic conditions benefit the area's economy while allowing the city to save on emergency, repair, maintenance and clean-up costs.

For the purposes of the economic and socioeconomic portions of this Report, the 'Study Area' is defined as the 500-year floodplain of Sweetwater Creek and its tributaries. The 'Floodplain' is defined as the area drained by Sweetwater Creek and its tributaries, extending to the boundaries of the 0.02% Annual Chance Exceedance (ACE) flood event. That floodplain will also include areas encompassing the 100-year event and other more frequent flood boundaries. Unless otherwise designated by its recurrence chance, the floodplain discussed in this report is the 500-year floodplain.

SOCIOECONOMIC

Over the last 100 years, Cobb, Douglas and Paulding counties have experienced 2 main periods of growth closely linked to the growth of Atlanta, the state's economic center. The first was in the 1960s and 1970s and the second during the 1990s and 2000s continuing to the current period as the city of Atlanta continues to grow.

Georgia Population and Demographics: The 2016 Census estimates Georgia with a total population of 10,310,371, with 51.3% identifying as female and 48.7% identifying as male. A strong majority of Georgians (97.5%) identify as one race alone, with 58.7% being White, 31.6% being Black or African American, 9.3% being Hispanic or Latino (of any race), 3.9% being Asian, and 0.4% being American Indian and Alaska Native. Within Georgia there are 3,686,135 households and an average household size of 2.73.

Cobb County Population and Demographics:

2016 Census data estimates the population of Cobb County to be 748,150.The population within the county is 51.7% female, 48.3% male and a median age of 36.5 years old. The population identifies as 58.7% being White, 27.0% being Black or African American, 12.9% being Hispanic or Latino (of any race), 5.3% being Asian and 4.9%

being some other race. Within Cobb County there are 297,399 housing units, 277,949 households, and an average household size of 2.66.

Cobb County Industry: The U.S. Census Bureau's American Community Survey 2016 estimates report Cobb County's largest industry as "Educational services and health care and social assistance" followed by "Professional, scientific, and management, and administrative and waste management" and "Retail trade".

Cobb County Employment and Occupations: In 2016 Cobb County's unemployment rate was 4.5%, 1.3% lower than the unemployment rate for Georgia as a whole. The most common occupations are "Management, business, science, and arts occupations" (45.0%), "Sales and office occupations" (23.9%), "Service occupations" (15.9%), "Production, transportation, and material moving occupations" (8.2%), and "Natural resources, construction, and maintenance occupations" (7.10%).

Cobb County Income and Poverty Status: Median household income in Cobb County is $70,947 with 9.6% of all people earning an income below the poverty level compared to the Georgia state median income of $53,559 and poverty rate of 14.0%.

Douglas County Population and Demographics:

2016 Census data estimates the population of Douglas County to be 142,224. The population within the county is 51.6% female, 48.4% male and a median age of 36 years old. The data reports 47.3% of the population as being White, 47.4% being Black or African American, 9.4% being Hispanic or Latino (of any race), 1.6% being Asian and 1.7% being two or more races. Within Douglas County there are 52,194 housing units, 48,901 households, and an average household size of 2.88.

Douglas Industry: The U.S. Census Bureau's American Community Survey 2016 estimates report Douglas County's largest industry as "Educational services and health care and social assistance" followed by "Retail trade" and "Transportation and warehousing, and utilities.

Douglas County Employment and Occupations: In 2016 Douglas County's unemployment rate was 7.5%, 1.7% higher than the unemployment rate for Georgia as a whole. The most common occupations are "Management, business, science, and arts occupations" (35.4%), "Sales and office occupations" (24.4%), "Service occupations" (16.1%), "Production, transportation, and material moving occupations" (14.8%), and "Natural resources, construction, and maintenance occupations" (9.3%).

Douglas County Income and Poverty Status: Median household income in Douglas County is $62,445 with 12.5% of all people earning an income below the poverty level compared to the Georgia state median income of $53,559 and poverty rate of 14.0%.

Paulding County Population and Demographics:

2016 Census data estimates the population of Paulding County to be 155,825. The population within the county is 51.4% female, 48.6% male and a median age of 36.4 years old. Within the county, race is divided to 74.3% of the population as being White, 22.1% being Black or African American, and 6.1% being Hispanic or Latino (of any race). Within Paulding County there are 54,840 housing units, 53,249 households, and an average household size of 2.91.

Paulding County Industry: The U.S. Census Bureau's American Community Survey 2016 estimates report Paulding County's largest industry as "Educational services and health care and social assistance" followed by "Retail trade", "Construction" and "Professional, scientific, and management, and administrative and waste management".

Paulding County Employment and Occupations: In 2016 Paulding County's unemployment rate was 3.0%, 2.8% lower than the unemployment rate for Georgia as a whole. The most common occupations are "Management, business, science, and arts occupations" (33.1%), "Sales and office occupations" (26.7%), "Service occupations" (18.2%), "Production, transportation, and material moving occupations" (11.3%), and "Natural resources, construction, and maintenance occupations" (9.4%).

Paulding County Income and Poverty Status: Median household income in Paulding County is $60,856 with 8.7% of all people earning an income below the poverty level compared to the Georgia state median income of $53,559 and poverty rate of 14.0%.

FLOODPLAIN CHARACTERISTICS

The floodplain primarily consists of single family housing developments built at elevations above the 100-year floodplain. The majority of structures built below the 100-year floodplain are single family houses built between the 1960s and 1980s. Nonresidential structures within the 100-year floodplain are warehouses and service stations built in the same time period. The residential development is typical of periods of fast growth, having structures built on slab and crawlspace foundations. A majority of the rural residential structures are ranch style homes built on slab or crawlspace foundations.

Most of the commercial structures are slab-on-grade pre-fabricated construction with first floor elevations of two feet or less above ground. Many of the residential structures are wood or brick construction with the first floor elevated one to two feet above ground.

No major agricultural production is known to occur within the study area floodplain, with the exception of sever rural ranch properties. Development in the floodplain also includes the transportation, communication and utility infrastructure needed to serve the residents and businesses located in the area. This includes roads, bridges, storm water collection and drainage structures, telephone networks and systems for water distribution, wastewater collection and electricity.

METHODOLOGY

In order to develop plans to address water resource problems within a study area, three conditions must be fully analyzed: the “existing,” the future “without” project and “with” project conditions. In this analysis, the existing condition represents current floodplain conditions, which are the 2017 development and price levels.

The future without project condition (FWOP) is the condition which would likely exist in the future without the implementation of a Federal project. This condition is evaluated for a 50-year period for urban flood control projects, and the results are expressed in terms of mean expected annual damages. For this study, the without project condition project life is for the years 2020-2070. This same 50-year period is then analyzed with a project in place. The difference in expected annual flood damages to the floodplain properties between the future “without” and “with” project conditions represents the flood damage reduction benefits to the project. Other economic and other significant outputs may accrue to the project as well, including recreation benefits, ecosystem restoration benefits, regional economic benefits, and other social effects. Other social effects, which often escape quantification in monetary terms, range from improvement in the quality of life within the study area to community impacts. This report attempts to recognize and, where possible, quantify all of the outputs of a Federal project in the study area.

This section of the analysis presents the assumptions and methods used in computing average annual equivalent flood damages for the study area. The methods employed in computing the outputs of other features are documented in separate sections within the economic appendix.

ASSUMPTIONS

- Floodplain residents will react to a floodplain management plan in a rational manner.
- Real property will continue to be repaired to pre-flood conditions subsequent to each flood event.
- The residential depth-percent damage relationships for structure and content contained in Economic Guidance Memorandum 01-03 (2000) and 04-01 (2003) are assumed to be representative of residential structures in the floodplain.
- The residential depth-percent damage relationships for vehicles contained in Economic Guidance Memorandum 09-04 are assumed to be representative of vehicles in the floodplain.

- Non-residential depth-percent damage relationships for structure and content are from expert elicitation found in the revised 2013 manual by the Institute of Water Resources, USACE, Draft Report, Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation are assumed to be representative of non-residential structures in the floodplain.
- The project's first costs and benefits will be annualized using the FY 2018 Federal discount rate of 2 ¾% assuming a period of analysis of 50 years.
- All values are equivalent to 2017 dollars.
- All project alternatives are evaluated for a 50-year period of analysis.
- The project construction is scheduled to begin in 2020.
- Any new property development will occur above the 100-year floodplain elevation

RISK AND UNCERTAINTY FACTORS

Risk and uncertainty are inherent in water resources planning and design. These factors arise due to errors in measurement and from the innate variability of complex physical, social, and economic situations. The measured or estimated values of key planning and design variables are rarely known with certainty and can take on a range of possible values.

Methodology Description - Risk analysis in flood damage reduction projects is a technical task of balancing risk of design exceedance with flood damage prevented; trading off uncertainty of flood levels with design accommodations; and providing for safe, reasonably predictable project performance. Risk-based analysis is therefore a methodology that enables issues of risk and uncertainty to be included in project formulation. A computerized risk based model, Hydrologic Engineering Center-Flood Damage Reduction Analysis (HEC-FDA); version 1.4.2 (July 2017) was used in this analysis. This model is a product of USACE and was created by the Corps' Hydrologic Engineering Center in Davis, California. HEC-FDA is a certified model used for flood damage analysis. It is a frequency-based model, relating expected flood damages to flood frequency and incorporating a multitude of variables.

Input Variables - Uncertainty was quantified for errors in the underlying components of the stage-damage relationship functions, structure values for all residential, nonresidential and vehicles. Depth-percent damage relationship uncertainty was quantified for both residential and nonresidential structures as well as content to structure value ratios for residential and nonresidential, and first elevations for all structures.

Residential Structural Values - Structure values are crucial sources of uncertainty in the stage-damage relationship. Structure values play an important role in determining the dollar value of damage caused by a given depth of flooding to both to the structure itself and the contents of the structure. In this analysis, the “existing” condition structure values were obtained from County Tax Assessor's Offices. Based on information provided by the tax assessors, the assessed value included a depreciated replacement value for the residential structures. This value was exclusive of market and land values and meant to reflect an estimated replacement value estimate less depreciation for the residential structures. Furthermore, using the Marshall & Swift Residential Estimator Software Program, these values were compared to similar structures derived by the program with similar results. Therefore, the residential structural values obtained from the tax assessor were verified as being reasonable estimates of replacement cost less depreciation. HEC-FDA uses standard deviation as a percentage of value in order to quantify the uncertainty surrounding structure values. The residential structure inventory standard deviation applied to the entire population of residential structures was 21%, based on market value estimates for the same structure from 3 separate real estate database companies. From these separate estimates, the mean value was approximately $159,023.22 in FY2017 dollars. Average standard deviations were shown to be approximately 33,193.17 or 21% of average estimated values. For residential structures which tax assessor data was not available, average value was used based on structure type within the study area.

Vehicle Inventory - Based on 2010-2014 American Community Survey 5-year estimates for the study area, it was determined that the average household had 2 vehicles available. *Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles (2009)* states that the average number of people who do not move vehicles to higher ground during flooding events is 26.93. That is to say, 26.93 percent of vehicles remain in the area of flooding and are susceptible to flood damages. According to the *Edmunds 2016 Used Vehicle Market Report*, the average price of a used vehicle was $19,189 at an average age of 4.5 years. Since only 26.93% of vehicles remain susceptible to damage during a flood event, a value of $10,335 (2*$19,189*0.2693) was assigned to each residential structure. If a structure was composed of multiple units, $10,335 was divided by the number of units. For example vehicle value for a 2 unit property would be recorded as $5,167. This is due to FDA calculating damages twice, or as many times as is input under the number of units ("number of structures") category. Vehicle damages were only calculated for residential properties, and not applied to nonresidential properties such as warehouses or offices. The Edmund's vehicle value adjusted for number of vehicles per household and for the evacuation of vehicles prior to the storm event was used as the most likely value. Moreover, the uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function with a maximum of 268% and a minimum of 21%, the mean value in the triangular distribution is the value of the vehicle within the structure inventory. The average value of a new vehicle before taxes, license, and shipping charges ($27,738) was used as the maximum value which is approximately 268% of $10,335. The average 10-year depreciation value of a used vehicle ($2,215) was used as the minimum value which is approximately 21% of $10,335. These maximum and minimum percent values were entered in as the maximum and minimum values of the triangular distribution.

Nonresidential- Nonresidential structure values were derived using Marshall & Swift Commercial Estimator Software Program and for structures within the tax assessor data which appeared to be outliers. In order to quantify uncertainty, 21% was used as the standard deviation for these structures as was applied to residential structures.

Residential Depth-Damage Curves - The structure and content depth damage functions relate flood damage as a percent of the value of the structure or contents at various depths of flooding above the first floor elevation. These functions are contained in EGM-01-03 (2000) and 04-01 (2003), and are based on surveys administered through the Corps of Engineers Institute for Water Resources. The functions show strong correlations between depth of flooding and percent of value in structure damage. The residential structures in the study area floodplain are represented by these curves. Moreover, both EGMs contained a normal distribution function with an associated standard deviation of damage to account for uncertainty surrounding the damage percentage associated with each depth of flooding.

Nonresidential Depth-Damage curves - The structure and content depth-damage functions relate flood damage as a percent of the value of the structure or contents at various depths of flooding above the first floor elevation. These functions are contained in the Draft Report, Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation. These values can be found in Appendix D, Tables D-22 through D-42 for structures and Tables D-42 through D-63 for content, of the report. In 2008, the Federal Emergency Management Agency (FEMA) contracted to have an expert elicitation panel derive nonresidential content-to-structure value ratios and flood depth-damage functions for 21 of the most commonly affected categories of nonresidential properties. USACE Institute for Water Resources (IWR) fully participated in the planning, process, implementation, and analysis of the results. The functions show strong correlations between depth of flooding and percent of value in structure damage. The vast majority of the nonresidential structures in the Village Creek floodplain are represented by these curves. Moreover, these functions contained a triangular distribution (i.e. minimum, maximum, most likely) to account for the uncertainty surrounding the damage percentage associated with each depth of flooding.

Residential Content to Structure Value Ratio - The content to structure value ratios included in this report are the content depth- damage curves contained in the aforementioned Economic Guidance Memorandum 01-03 and 04-01 . Moreover, both EGMs contained guidance to account for uncertainty associated with content/structure value ratio which implies that the uncertainty in the content-to-structure value ratio should be inherent in the content depth-damage relationship as contained in both respective EGMs.

Nonresidential Content to Structure Value Ratio - The content to structure value ratios included in this report are contained in the aforementioned draft report, Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation, specifically Appendix E, Table E-1. Moreover, these functions contained a triangular distribution (i.e. minimum, maximum, most likely) to account for the uncertainty surrounding the ratio for each nonresidential occupancy type.

First Floor Elevations – Topographical data obtained from Light Detection and Ranging (LIDAR) for the study area were used to determine ground elevations at the structure location of each parcel due to the non-uniform shape and elevation of parcels within the study area. The heights above ground were estimated from a Google earth™ street view survey of the structures in the study area which was conducted in 2017 using imagery from 2017. The sum of the ground elevation plus the finished floor height above ground elevation is the first floor elevation. Vehicles were assigned to the ground elevation of the adjacent residential structures. A first floor standard deviation of 0.6 feet assuming normal distribution was used to quantify uncertainty based on guidance found in Engineering Manual (EM) 1110-2-1619, Table 6-5, aerial survey, 2-ft contour interval.

EXISTING CONDITIONS

In June, 2017, parcels within the 500-year floodplain for Sweetwater Creek and its tributaries within Cobb, Douglas and Paulding Counties were surveyed for use in a FRM study. For the Sweetwater Creek study area parcel data was obtained by each county's tax assessor's office and used to build a GIS database for identifying which parcels were located within the FEMA 500-year floodplain. The structure inventory survey identified 2,230 structures within 1,902 parcels not including vacant lots.

Structure inventory depreciated replacement values for Cobb County were gathered from the Cobb County Tax Assessor's Office. For values not included in the tax assessor data, average values were used based off of structure type. More unique structures, such as apartment complexes, warehouses, shops and schools not included in the tax assessor data were appraised using Marshall and Swift Residential and Commercial estimates based off of structure age, square footage and construction type. In cases where square footage was not available from county data the Square footage was calculated by digitally drawing a polygon over the building and measuring the area of the polygon footprint in GIS software and multiplied by the number of stories.

Base elevations of structures were determined from structure location within each parcel instead each parcel's center. This is due to structure locations often being at one end of a parcel instead of at the parcel's center as is common in more urban settings. Because of the irregular parcel shapes within the floodplain many parcels are located within the 500-year floodplain but the structures themselves are often located outside of all analyzed events as seen in figure 1 below.

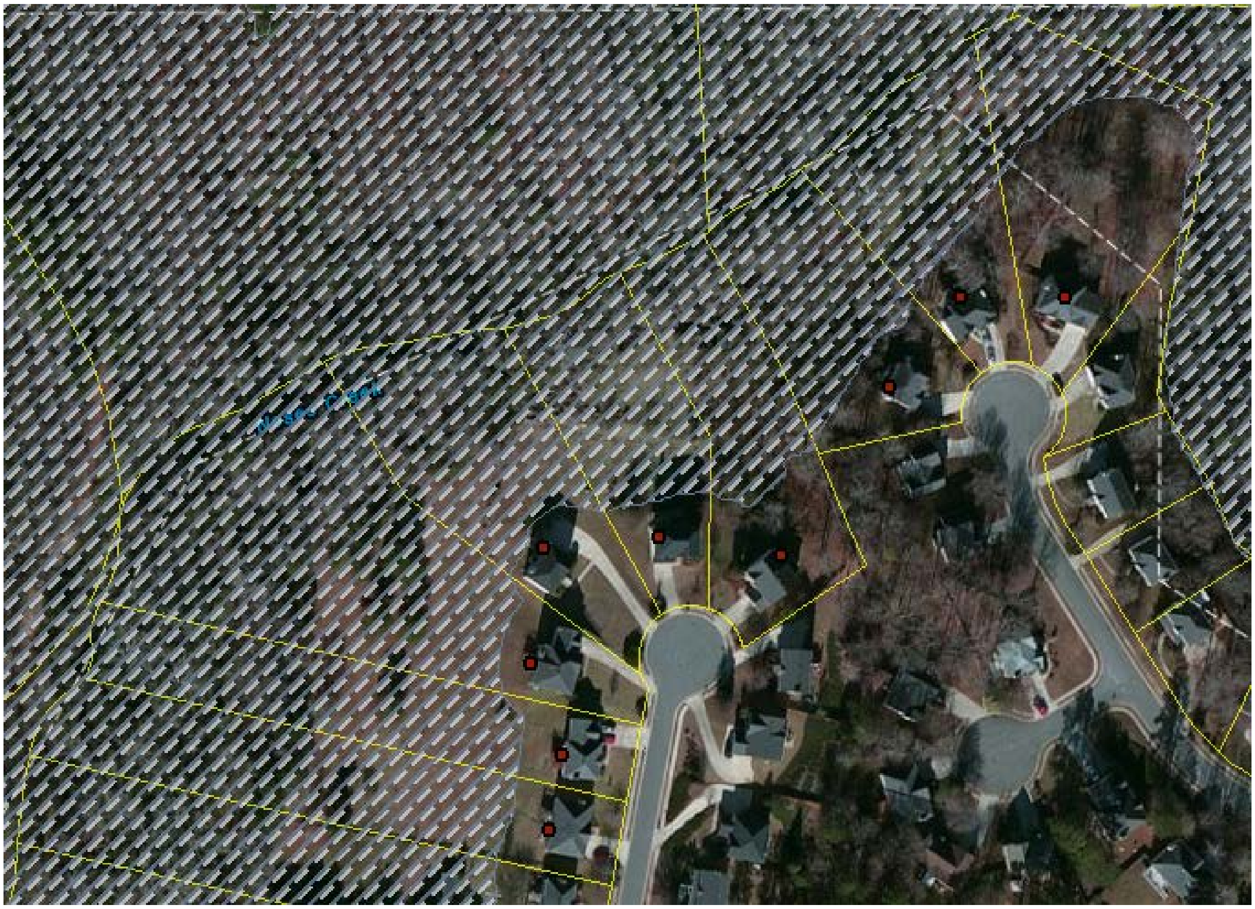

Figure 1: Example of study area floodplain. Hashed grey area represents extent of 500-year floodplain. Red dots represent the point at which ground elevation was measured.

Content values and depth damage relationships were used from EGM 04-01, EGM 01-03 and the Revised 2013 Draft Report: Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation.

STREAMS AND REACH DELINEATION

Within the study area are seven individual streams; Buttermilk Creek, Mill Creek, Mud Creek, Noses Creek, Olley Creek, Powder Springs Creek, and Sweetwater Creek. Each creek is divided into at least one reach, with Noses Creek containing 2 reaches and Sweetwater Creek containing 6 reaches.

The term “reach” describes a section of a stream having similar hydraulic, hydrologic, political, geographic or economic characteristics. Dividing the floodplain into reaches facilitates evaluation of flood damages by breaking the floodplain down into several areas having some common features, and analyzing them separately.

River Stations are sections of an individual reach which represent the water surface elevations during flood events. Hydraulic and hydrologic engineers assign river stations to streams to represent the floodplain as accurate as possible. Structures are assigned river stations to represent water surface elevations based on their proximity to the nearest river station.

Buttermilk Creek begins (downstream) at river station 617.0778 and ends (upstream) at 10413.3600; Mill Creek begins at river station 184.7000 and ends at 14860.0600; Mud Creek begins at 707.0146 and ends at 6502.4520; Noses Creek begins at 30927.4300 and ends at 30292.5300; Olley Creek begins at 778.4826 and ends at 14552.7100; Powder Springs begins at 79.1615 and ends at 34618.2400; and Sweetwater Creek begins at 130930.8000 and ends at 143265.0000.

Table A-1 1: Stream Reach Description and Location

Stream Name	Reach Name	Reach Description	Beginning Station	Ending Station	Index Station
Buttermilk Creek	BMC1	Buttermilk Creek Reach 1	617.0778	10413.36	5929.044
Mud Creek	MDC1	Mud Creek Reach 1	707.0146	6502.452	3090.924
Mill Creek	MIC1	Mill Creek Reach 1	184.7	14860.06	5880.904
Noses Creek 1	NCC1	Noses Creek Reach 1	30927.43	33120.14	31603.33
Noses Creek 2	NCC2	Noses Creek Reach 1	2193.528	30292.53	16578
Olley Creek	OLC1	Olley Creek Reach 1	778.4826	14552.71	7795.065
Powder Springs Creek	PSC1	Powder Springs Creek Reach 1	79.1615	34618.24	19295.86
Sweetwater Creek 1	SWC1	Sweetwater Creek Reach 1	130930.8	143265	137153.1
Sweetwater Creek 2	SWC2	Sweetwater Creek Reach 2	93306.57	130164.6	111349.5
Sweetwater Creek 3	SWC3	Sweetwater Creek Reach 3	75678.23	92326.93	84556.76
Sweetwater Creek 4	SWC4	Sweetwater Creek Reach 4	74534.92	75124.97	75124.97
Sweetwater Creek 5	SWC5	Sweetwater Creek Reach 5	63836.73	73747.23	70253.64
Sweetwater Creek 6	SWC6	Sweetwater Creek Reach 6	43.7165	63230.32	20022.9

Structure Inventory

The setting of the Sweetwater Creek study area is mostly rural and suburban with small cities such as Austell and Powder Springs which have developed near the floodplains of Sweetwater Creek and Powder Springs Creek respectively.

The existing structure inventory within the floodplain contains 2,230 structures on 1902 parcels. Residential structures account for 1,959 of structures, with the remaining 271 being nonresidential. There are 62 structures located within the Buttermilk reach; 69 structures within the Mill Creek reach; 43 structures within the Mud Creek reach; 589 structures within the Noses Creek reaches; 133 structures within the Olley Creek reach; 220 structures within the Powder Springs Creek reach; and 1,114 structures within the Sweetwater Creek reaches.

Table A-1 2 and Table A-1 5 summarize the number of structures in each reach along with their depreciated replacement cost and vehicle depreciated replacement cost in FY 2017 dollars.

All 2,230 structures were entered into the HEC-FDA model. Stage/damage was calculated for each structure, using risk parameters described in the assumptions. Stage/damage simulations were made on the variables described in the assumptions and risk analysis overview. The existing aggregated mean stage/damage of each reach is shown below in Table A-1 3. The error curve limits (standard deviations) for the reaches are not shown in this report but are documented in the study data.

Stage/damage was integrated with stage/frequency in the HEC-FDA model. The result of the integration is damage/frequency. These are the expected annual damages, which reflect both the damage expected from a given event weighted by the incremental probability of that event's occurrence. The Sweetwater Creek Watershed expected annual damages calculation is performed within HEC-FDA using the Annual Chance Exceedance (ACE) events. HEC-FDA performs this calculation using a Monte-Carlo simulation. The simulation samples from the various distributions of each random variable and runs until the expected annual damages in the last iteration falls within 1% of the one before it.

Table A-1 2: Total Depreciated Replacement Value (x 1,000, 2017 prices) of Study Area

Reach	Structures			Total Structure Value	Total Content Value	Total Vehicle Value	Total Value
	Residential	Non-Residential	Total				
Buttermilk Creek	46	16	62	$9,010	$5,588	$475	$15,073
Mill Creek	62	7	69	$6,242	$6,030	$641	$12,913
Mud Creek	38	5	43	$5,827	$5,601	$393	$11,821
Noses Creek 1	36	0	36	$11,917	$11,917	$372	$24,206
Noses Creek 2	515	38	553	$49,427	$46,575	$5,312	$101,314
Olley Creek	116	17	133	$35,570	$15,798	$1,199	$52,567

Powder Springs Creek	189	31	220	$50,829	$32,430	$1,912	$85,171
Sweetwater Creek 1	63	2	65	$6,493	$6,439	$651	$13,583
Sweetwater Creek 2	274	26	300	$30,331	$29,247	$2,822	$62,400
Sweetwater Creek 3	64	21	85	$27,441	$12,179	$661	$40,281
Sweetwater Creek 4	13	0	13	$1,342	$1,342	$134	$2,818
Sweetwater Creek 5	374	39	413	$19,989	$16,079	$1,437	$37,505
Sweetwater Creek 6	169	69	238	$181,229	$79,509	$1,220	$261,958
Total	**1,959**	**271**	**2,230**	**$435,647**	**$268,734**	**$17,229**	**$721,610**

The structure inventory was modeled in HEC-FDA using stage-damage relationship with uncertainty along with stage-probability relationship with uncertainty. The HEC-FDA model used the economic and engineering inputs to generate a stage-damage relationship for each structure category in each study reach in the existing and future conditions. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation and were executed by the model for the Sweetwater Creek study. The sum of all sampled values was divided by the number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage. The HEC-FDA model used an equivalent record length (50 years) for each study area reach to generate a stage-probability relationship with uncertainty for the existing and FWOP through the use of graphical analysis. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided. The eight ACE events that water surface profiles were provided for use in the damage calculations are as followed: 50%(2-year), 20%(5-year), 10%(10-year), 4%(25-year), 2%(50-year), 1%(100-year), 0.4%(250-year), and 0.2%(500-year). Damages were reported at the index location for each study area reach. Following the conclusion of the Monte Carlo simulation, a mean is calculated from the observed expected annual damage calculation. Table A-1 3 displays the existing condition mean expected annual damages according to reach and damage category.

Under the FWOP condition which represents annual damages in the absence of a flood damage reduction project, damages are expected to increase in the future. Changing hydrology as development within the drainage area increases contribute to increased runoff rates. These factors result in higher stages in the future, and correspondingly higher flood levels for any given event. A comparison of damages for the existing and FWOP conditions can be seen in Table A-1 6.

Table A-1 3: Existing Condition Mean Expected Annual Damages (x 1,000, 2017 Prices)

Reach	Category	Existing Condition Damages
Buttermilk Creek	Residential	$5
	Nonresidential	$1
	Total	$6
Mill Creek	Residential	$69
	Nonresidential	$0
	Total	$69
Mud Creek	Residential	$0
	Nonresidential	$0
	Total	$0
Noses Creek 1	Residential	$19
	Nonresidential	$0
	Total	$19
Noses Creek 2	Residential	$466
	Nonresidential	$0
	Total	$466
Olley Creek	Residential	$37
	Nonresidential	$11
	Total	$48
Powder Springs Creek	Residential	$13
	Nonresidential	$1
	Total	$15
Sweetwater Creek 1	Residential	$23
	Nonresidential	$6
	Total	$29
Sweetwater Creek 2	Residential	$296
	Nonresidential	$25
	Total	$321
Sweetwater Creek 3	Residential	$7
	Nonresidential	$53
	Total	$60
Sweetwater Creek 4	Residential	$3
	Nonresidential	$0
	Total	$3
Sweetwater Creek 5	Residential	$21
	Nonresidential	$18
	Total	$39
Sweetwater Creek 6	Residential	$141
	Nonresidential	$96
	Total	$237

Total	**Residential**	**$1,100**
	Nonresidential	**$212**
	Total	**$1,312**

According to Table A-1 3, there are about $1.3 million in expected annual flood damages under existing condition. The existing flood damages are the potential average annual dollar damages to structures, contents, and vehicles affected by flooding at the time of the study. No projection is involved, and the existing conditions encompasses relevant factors that best characterize the planning perceptions of the affected area in the situation without a plan. This existing condition will provide the data from which to evaluate the condition that would likely exist in the future without the implementation of a Federal project. Under the without project condition, damages are expected to increase as development within the drainage area increases and contributes to higher runoff rates. Those higher runoff rates translate into higher stages in the future and correspondingly higher water surface profiles for any given flood event.

FUTURE WITHOUT PROJECT CONDITION

According to Georgia residential population projections, the population of the counties within the study area (Cobb, Douglass and Paulding) are expected to increase by approximately 34.89% by the year 2050. The average household size in the state of Georgia is 2.73 persons. Dividing the percent increase by 2.73 households estimates the expected increase in households in the year 2050 is 12.78%. This is represented by the addition of 213 residential structures in the 2070 analysis year. These structures were added to the year 2050 structure inventory in proportion to the number of structures within each reach. The number of structures for Table A-1 4: Future Structure Counts differs from overall structure count due to counting multi-structure parcels as one, resulting in a difference of 286. These structures were entered into the structure inventory at the year 2050 to assure damage calculation in the 2070 analysis year, but not at the base year 2020. It is assumed that by the year 2050 the floodplain will be fully developed and no future development will occur.

The future residential structures were projected with a first floor elevation equal to the stage elevation of a 1% ACE flood event due to the assumption that floodplain management will restrict development within the 1% ACE floodplain area. Structures were added in proportion to the number of structures within each stream at the index location (point at which damages are aggregated) for the stream. The most common type residential structure built since the year 2000 has been 2 Story single family home with slab foundation and was used to represent future structures with a depreciated replacement cost set to the average value of this structure type. Vehicles were added to the analysis year 2050 as well and in accordance with the vehicle methodology.

Table A-1 4: Future Structure Counts

Reach	Analysis Year 2020 Number of Structures	Percent of Residential Structures	Future Structures Added	Analysis Year 2070 number of structures
Buttermilk	46	2.75%	6	52
Mill	62	3.71%	8	70
Mud	38	2.27%	5	43
Noses	551	32.93%	70	621
Olley	116	6.93%	15	131
Powder Springs	189	11.30%	24	213
Sweetwater	671	40.11%	85	756
Total:	**1,673**	**100%**	**213**	**1,886**

Table A-1 5: Total Depreciated Replacement Value of Future Development

Reach	Structures		Total Future Development Structure Value (x$1,000)	Total Future Development Content Value (x$1,000)	Total Future Development Vehicle Value (x$1,000)	Total Future Development Construction Value (x$1,000)
	Residential	Total				
Buttermilk Creek	6	6	695	$695	$62	$1,452
Mill Creek	8	8	927	$927	$83	$1,936
Mud Creek	5	5	579	$579	$52	$1,210
Noses Creek 1	70	70	8109	$8,109	$723	$16,942
Noses Creek 2	0	0	0	$0	$0	$0
Olley Creek	15	15	1738	$1,738	$155	$3,630
Powder Springs Creek	24	24	2780	$2,780	$248	$5,809
Sweetwater Creek 1	0	0	0	$0	$0	$0
Sweetwater Creek 2	0	0	0	$0	$0	$0
Sweetwater Creek 3	0	0	0	$0	$0	$0
Sweetwater Creek 4	0	0	0	$0	$0	$0
Sweetwater Creek 5	0	0	0	$0	$0	$0
Sweetwater Creek 6	85	85	9847	$9,847	$878	$20,573
Total	**213**	**213**	**$24,676**	**$24,676**	**$2,201**	**$51,553**

The year 2070 was selected to represent the FWOP condition. No additional development within the 100-year floodplain of the study area is anticipated due to the conditions of the Federal Flood Insurance Program. However, a combination of both wealth and complementary effects are likely to contribute to growth in the value of the assets at risk in the floodplain. The same 2,230 structures plus the additional future development of 213 structures lying in the 100-year floodplain will continue to be affected by the risk of flooding and suffer increasing losses each year.

Additional development within the drainage basin, but at elevations beyond the 1% ACE, is likely. The development, consisting of a variety of commercial, industrial and residential construction, will contribute to an increase in the land area impervious to stormwater runoff. This in turn will lead to slightly higher stream inflows at any given event and accordingly, somewhat higher stages at the various flood frequencies. The end result is an increase in the expected annual damages for the future, meaning that the losses suffered by the affected structures will increase between 2020 and 2070.

Like that of the existing condition, the HEC-FDA used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without project alternative, the EAD were totaled for each study area reach to obtain the total without project EAD under future conditions as shown in Table A-1 6.

Table A-1 6: Base Year vs. Future Without Project Mean Expected Annual Damages (x 1,000, 2017 Prices)

Reach	Residential	Nonresidential	Total
Base Year 2020			
Buttermilk Creek	$5	$1	$6
Mill Creek	$69	$0	$69
Mud Creek	$0	$0	$0
Noses Creek 1	$19	$0	$19
Noses Creek 2	$466	$0	$466
Olley Creek	$37	$11	$48
Powder Springs Creek	$13	$1	$15
Sweetwater Creek 1	$23	$6	$29
Sweetwater Creek 2	$296	$25	$321
Sweetwater Creek 3	$7	$53	$60
Sweetwater Creek 4	$3	$0	$3
Sweetwater Creek 5	$21	$18	$39
Sweetwater Creek 6	$141	$96	$237
Total	**$1,100**	**$212**	**$1,312**
Future Year 2070			
Buttermilk Creek	$9	$1	$10

Mill Creek	$94	$0	$94
Mud Creek	$4	$0	$4
Noses Creek 1	$75	$0	$75
Noses Creek 2	$502	$0	$502
Olley Creek	$50	$12	$61
Powder Springs Creek	$38	$2	$40
Sweetwater Creek 1	$29	$8	$37
Sweetwater Creek 2	$330	$29	$359
Sweetwater Creek 3	$8	$58	$65
Sweetwater Creek 4	$3	$0	$3
Sweetwater Creek 5	$22	$20	$42
Sweetwater Creek 6	$220	$105	$325
Total	**$1,385**	**$233**	**$1,618**

Moreover, damages for each of the years during the period of analysis were computed by linear interpolation between 2020 and 2070. The FY 2018 Federal discount rate of 2.75 percent was used to compound the stream of expected annual damages and benefits before the project base year and to discount the stream of expected annual damages and benefits occurring after the base year to calculate the total present value of the damages over the period of analysis. The present value of the expected annual damages was then amortized over the 50 year period of analysis using the Federal discount rate to calculate the equivalent annual damages. The results are shown in Table A-1 7.

Table A-1 7: Future Year 2070 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	FWOP Damages
Buttermilk Creek	Residential	$6
	Nonresidential	$1
	Total	$7
Mill Creek	Residential	$79
	Nonresidential	$0
	Total	$79
Mud Creek	Residential	$2
	Nonresidential	$0
	Total	$2
Noses Creek 1	Residential	$40
	Nonresidential	$0
	Total	$40
Noses Creek 2	Residential	$480
	Nonresidential	$0
	Total	$480

Olley Creek	Residential	$42
	Nonresidential	$11
	Total	$53
Powder Springs Creek	Residential	$23
	Nonresidential	$1
	Total	$24
Sweetwater Creek 1	Residential	$25
	Nonresidential	$7
	Total	$32
Sweetwater Creek 2	Residential	$309
	Nonresidential	$26
	Total	$336
Sweetwater Creek 3	Residential	$7
	Nonresidential	$55
	Total	$62
Sweetwater Creek 4	Residential	$3
	Nonresidential	$0
	Total	$3
Sweetwater Creek 5	Residential	$21
	Nonresidential	$19
	Total	$40
Sweetwater Creek 6	Residential	$171
	Nonresidential	$99
	Total	$270
Total for Stream	**Residential**	**$1,208**
	Nonresidential	**$220**
	Total	**$1,428**

Table A-1 8: Existing Condition Chance Exceedance Water Surface Elevations at Reach Index Locations

Existing Condition									
		Index location Stage in Feet at Chance Exceedance							
Reach Name	Stream Name	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002
BMC1	Buttermilk	887.34	888.24	888.75	889.33	889.88	891.3	892.52	894.21
MDC1	Mud Creek	905.45	907.09	907.85	908.78	909.6	910.04	910.26	910.9
MIC1	Mill Creek	907.51	908.96	910.23	911.17	912.09	913.09	914	915.03
NCC1	Noses Creek	905.06	907.18	908.12	909.08	910.13	910.99	911.75	912.58
NCC2	Noses Creek	893.3	895.27	895.86	897.1	898.24	899.33	899.95	900.52
OLC1	Olley Creek	890.12	891.32	893.61	897.47	901.6	903.67	905.53	907.74

PSC1	Powder Springs	902.65	904.46	905.72	907	908.13	909.12	911.17	913.79
SWC1	Sweetwater	908.02	909.67	910.28	911.35	912.75	913.8	914.84	916.17
SWC2	Sweetwater	894.47	897.8	899.85	902.25	903.88	906.32	907.8	910.4
SWC3	Sweetwater	886.22	889.48	891.25	893.72	894.98	896.47	897.71	899.13
SWC4	Sweetwater	883.04	885.98	887.84	890.49	892.89	894.46	895.76	897.41
SWC5	Sweetwater	880.92	884.17	886.01	888.53	890.93	892.48	893.63	895.18
SWC6	Sweetwater	836.88	837.81	838.28	838.93	839.56	840.53	841.11	841.82

Table A-1 9: Future Without Project Condition Chance Exceedance Water Surface Elevations at Reach Index Locations

Future Without Project Condition									
		Index location Stage in Feet at Chance Exceedance							
Reach Name	Stream Name	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002
BMC1	Buttermilk	887.47	888.33	888.82	889.37	889.9	891.42	892.62	894.33
MDC1	Mud Creek	905.69	907.22	907.95	908.84	909.63	910.05	910.27	910.92
MIC1	Mill Creek	907.94	909.42	910.48	911.33	912.22	913.21	914.1	915.11
NCC1	Noses Creek	905.66	907.47	908.3	909.2	910.2	911.05	911.79	912.62
NCC2	Noses Creek	893.79	895.28	896.04	897.23	898.3	899.38	899.98	900.54
OLC1	Olley Creek	890.2	891.43	893.77	897.71	901.67	903.72	905.57	907.76
PSC1	Powder Springs	903.13	904.73	905.93	907.12	908.19	909.17	911.31	913.88
SWC1	Sweetwater	908.56	909.85	910.51	911.57	912.89	913.91	914.95	916.31
SWC2	Sweetwater	895.3	898.26	900.39	902.46	904.33	906.51	908.01	910.55
SWC3	Sweetwater	887.13	889.92	891.75	893.83	895.15	896.63	897.8	899.26
SWC4	Sweetwater	883.63	886.43	888.29	890.84	893.06	894.61	895.88	897.52
SWC5	Sweetwater	881.59	884.59	886.46	888.88	891.1	892.61	893.74	895.29
SWC6	Sweetwater	837.05	837.91	838.38	839.01	839.65	840.58	841.15	841.87

The forecasted higher stages in the FWOP condition shown in Table A-1 9: Future Without Project Condition Chance Exceedance Water Surface Elevations at Reach Index Locationsabove, resulted in a higher level of FWOP condition damages. According to Table A-1 7, the total FWOP equivalent annual damages are approximately $1.6 million, an increase of approximately $0.3 million from the existing condition equivalent annual damages. This $1.6 million represents the maximum possible annual benefits accruable to a flood damage reduction project at Sweetwater Creek (i.e. with project condition). The forecast of the FWOP condition reflects the conditions expected during the period of analysis and provides the basis from which alternative plans are evaluated, compared, and selected. Because with a Federal project in place, a portion of the flood damages that would occur in the without project condition would be prevented (i.e. flood damages reduced).

FUTURE WITH-PROJECT CONDITION

The with-project condition is the most likely condition expected to exist in the future if a specific project is undertaken. There are as many with project condition as there are project alternatives. A total of 9 alternatives were considered for the Sweetwater Creek Flood Risk Management Study. Of these, 5 were structural and 4 were nonstructural. A discussion of residual flood damages and flood damage reduction for each alternative are as followed:

EVALUATION OF ALTERNATIVE PLANS

Relevant data for each of the alternatives described below were entered into the HEC-FDA and potential for flood damages reduced were calculated. The modeling results for each alternative are summarized as followed:

Alternative 1: Relocation/Evacuation of Structures (Buy Outs)

This alternative would be to purchase structures within first floor elevations at or below the FWOP condition water surface elevations of the 10, 4, 2, or 1 percent chance of exceedance storms. Table A-1 10 shows the number of structures that would be purchased as part of each level of buyout.

Table A-1 10: Structures for Purchase by Return Event

Alternative	Percent Chance of Exceedance	Number of Structures
1	10	20
1.1	4	26
1.2	2	66
1.3	1	117

Alternative 2: Brown Road Detention Alternative

The alternative consists of an inline dry detention facility on Sweetwater Creek located just upstream of Brown Road in Cobb County, creating up to 9,000 acre-feet of flood storage. The objective of the alternative is to temporarily detain floodwaters from the approximately 100 square miles that drain to the facility location. By temporarily detaining floodwaters, the facility will reduce the peak downstream discharges. This alternative would reduce flood risk along a section of Sweetwater Creek and along the tributaries of Mill Creek, Power Springs Creek, Noses Creek, Olley Creek and other small tributaries which experience backwater flooding from Sweetwater Creek. The facility would consist of a 1,400 feet long, 33 feet high structure built approximately perpendicular to Sweetwater Creek and its adjoining floodplain. The outlet works of the structure would consist of a multi-stage concrete slot with vertical side walls discharging into a stilling basin downstream of the structure.

Alternative 4: Austell Channel Modification
This alternative consists of a channel modification from near the CH James Parkway to the rapids in Sweetwater Creek State Park near the historic mill site (14.2 miles). The channel would be widened to 80 feet and would have 2V:1H side slopes. The length of the channel modification is approximately 74,000 linear feet and would remove approximately 3 Million cubic yards of material from the channel. The objective of the alternative is to increase channel conveyance through the creation of a more optimal channel design that will reduce flood elevations and concurrently provide a more stable channel.

Alternative 5H: Multiple Detention Structures on Sweetwater Creek
This alternative consists of two inline dry detention structures on Sweetwater Creek. All the detention sites would be dry within 24 after an event. The first is a 10 feet high structure upstream of Bakers Bridge Road in Paulding County near the Douglas and Paulding County line. This approximately 400 acre detention site would hold water in both Paulding and Douglas Counties. The second is a 33 feet high structure upstream of Brown Road in Cobb County near the Paulding County line. This approximately 900 acre detention site would hold water in both Paulding and Douglas Counties. These structures would provide a combined 18,900 acre-feet of flood storage in the basin. The objective of the alternative is to temporarily detain floodwaters along Sweetwater Creek. By temporarily detaining floodwaters, the facility will reduce the peak downstream discharges. The outlet works on each structure would consist of a multi-stage concrete slot with vertical side walls discharging into a stilling basin downstream of the structure.

Alternative 5D: Multi-subbasin Detention
This alternative consists multiple inline dry detention structures with three on Sweetwater Creek, one on Powder Springs Creek, one on Ollie Creek, and one on Mill Creek. All the detention sites would be dry within 24 hours after an event. The first on Sweetwater Creek is a 24 feet high structure upstream of Bakers Bridge Road in Paulding County near the Douglas and Paulding County line. This approximately 400 acre detention site would hold water in both Paulding and Douglas Counties. The second on Sweetwater Creek is a 15 feet high structure upstream of Highway 92 in Paulding County. This approximately 250 acre detention site would hold water in

Paulding and Douglas Counties. The third on Sweetwater Creek is a 33 feet high structure upstream of Brown Road in Cobb County near the Paulding County line. This approximately 900 acre detention site would hold water in both Paulding and Douglas Counties. The one on Powder Springs Creek is a 25 feet high structure upstream of C.H. James Parkway in Cobb County near the Cobb and Paulding County Line. This approximately 400 acre detention site would hold water in Cobb County. The structure on Ollie Springs Creek is a 29 feet high structure upstream of Flint Hill Rd Southwest in Cobb County. This approximately 250 acre detention site would hold water in Cobb County. The structure on Mill Creek is a 20 feet high structure upstream of Morningside Drive in Paulding County. This approximately 300 acre detention site would hold water in Paulding County. These structures would provide a combined 25,040 acre-feet of flood storage. The objective of the alternative is to temporarily detain floodwaters along Sweetwater Creek. By temporarily detaining floodwaters, the facility will reduce the peak downstream discharges. The outlet works on each structure would consist of a multi-stage concrete slot with vertical side walls discharging into a stilling basin downstream of the structure.

Alternative 5J: South Paulding High Detention Short

This alternative is an inline dry detention facility on Sweetwater Creek, located approximately 1 mile upstream of Bakers Bridge Road in Paulding County, creating up to 7,660 acre-feet of flood storage. The objective of the alternative is to temporarily detain floodwaters from the approximately 42 square miles that drain to the facility location. By temporarily detaining floodwaters, the facility will reduce the peak downstream discharges in addition to delaying the timing of the hydrograph peak. The delaying of the hydrograph at the site will have the additional benefit of allowing Mill Creek, which confluences with Sweetwater Creek approximately 7.5 miles downstream of the site, to drain longer before the peak discharge of Sweetwater Creek reaches the confluence, resulting in less coincidental peaks and reducing the combined peak downstream of the confluence for most flood events. This alternative would reduce flood risk along a section of Sweetwater Creek and along the tributaries of Mill Creek, Powder Springs Creek, Noses Creek, Olley Creek and other small tributaries which experience backwater flooding as a result of Sweetwater Creek. The structure would consist of a 1,500 feet long, 19 feet high structure built approximately perpendicular to Sweetwater Creek and its adjoining floodplain. The outlet works of the structure would consist of a multi-stage concrete slot with vertical side walls discharging into a stilling basin downstream of the structure.

Alternatives Analysis:

Alternative 1 consisted of 4 versions of buyout levels. Each version included both residential and nonresidential structures with first floor elevations at or below a certain FWOP condition flood event.

The first version of Alternative 1 (1.0) was to purchase all 20 structures with a first floor elevation equal to or lesser than the water surface elevation of a 10% ACE flood event. Version 1.0 consisted of 20 structures, both residential and nonresidential. Version 1.1 considered purchasing 6 additional structures at the 4% ACE flood event to total 26. Version 1.2 considered purchasing an additional 40 structures at the 2% ACE flood event for a total of 66. Finally version 1.3 considered purchasing an additional 51 structures at the 1% ACE flood event totaling 117. The number of benefits increased with each larger buyout, however it was not a directly proportional increase due to the larger buyouts purchasing additional structures in the floodplains of less frequent events. This analysis revealed that the damages occurring in the designed flood events are weighted towards the more frequent events, even though there are less structures in the floodplains of the more frequent events.

Table A-1 11: Alternative 1.0 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$6	$0
	Nonresidential	$1	$0
	Total	$7	$0
Mill Creek	Residential	$79	$0
	Nonresidential	$0	$0
	Total	$79	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$31	$9
	Nonresidential	$0	$0
	Total	$31	$9
Noses Creek 2	Residential	$291	$190
	Nonresidential	$0	$0
	Total	$291	$190
Olley Creek	Residential	$34	$7
	Nonresidential	$7	$4
	Total	$42	$12
Powder Springs Creek	Residential	$23	$0
	Nonresidential	$1	$0
	Total	$24	$0
Sweetwater Creek 1	Residential	$25	$0
	Nonresidential	$7	$0

	Total	$32	$0
Sweetwater Creek 2	Residential	$45	$264
	Nonresidential	$26	$0
	Total	$71	$264
Sweetwater Creek 3	Residential	$7	$0
	Nonresidential	$9	$46
	Total	$16	$46
Sweetwater Creek 4	Residential	$3	$0
	Nonresidential	$0	$0
	Total	$3	$0
Sweetwater Creek 5	Residential	$19	$3
	Nonresidential	$11	$8
	Total	$29	$11
Sweetwater Creek 6	Residential	$171	$0
	Nonresidential	$99	$0
	Total	$270	$0
Total for Stream	**Residential**	**$735**	**$473**
	Nonresidential	**$162**	**$58**
	Total	**$897**	**$531**

Table A-1 12: Alternative 1.1 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$4	$3
	Nonresidential	$1	$0
	Total	$5	$3
Mill Creek	Residential	$79	$0
	Nonresidential	$0	$0
	Total	$79	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$31	$9
	Nonresidential	$0	$0
	Total	$31	$9
Noses Creek 2	Residential	$286	$194
	Nonresidential	$0	$0
	Total	$286	$194
Olley Creek	Residential	$31	$11
	Nonresidential	$7	$4
	Total	$38	$15
Powder Springs Creek	Residential	$23	$0
	Nonresidential	$1	$0
	Total	$24	$0

Sweetwater Creek 1	Residential	$25	$0
	Nonresidential	$7	$0
	Total	$32	$0
Sweetwater Creek 2	Residential	$40	$269
	Nonresidential	$15	$11
	Total	$55	$280
Sweetwater Creek 3	Residential	$7	$0
	Nonresidential	$9	$46
	Total	$16	$46
Sweetwater Creek 4	Residential	$3	$0
	Nonresidential	$0	$0
	Total	$3	$0
Sweetwater Creek 5	Residential	$19	$3
	Nonresidential	$11	$8
	Total	$29	$11
Sweetwater Creek 6	Residential	$171	$0
	Nonresidential	$99	$0
	Total	$270	$0
Total for Stream	**Residential**	**$719**	**$489**
	Nonresidential	**$151**	**$69**
	Total	**$870**	**$558**

Table A-1 13: Alternative 1.2 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$4	$3
	Nonresidential	$1	$0
	Total	$5	$3
Mill Creek	Residential	$79	$0
	Nonresidential	$0	$0
	Total	$79	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$28	$13
	Nonresidential	$0	$0
	Total	$28	$13
Noses Creek 2	Residential	$267	$213
	Nonresidential	$0	$0
	Total	$267	$213
Olley Creek	Residential	$19	$23
	Nonresidential	$7	$4
	Total	$26	$28
Powder Springs Creek	Residential	$21	$2

	Nonresidential	$1	$0
	Total	$22	$2
Sweetwater Creek 1	Residential	$25	$0
	Nonresidential	$7	$0
	Total	$32	$0
Sweetwater Creek 2	Residential	$38	$271
	Nonresidential	$15	$11
	Total	$53	$282
Sweetwater Creek 3	Residential	$6	$2
	Nonresidential	$2	$52
	Total	$8	$54
Sweetwater Creek 4	Residential	$3	$0
	Nonresidential	$0	$0
	Total	$3	$0
Sweetwater Creek 5	Residential	$16	$5
	Nonresidential	$8	$11
	Total	$24	$16
Sweetwater Creek 6	Residential	$169	$2
	Nonresidential	$96	$3
	Total	$265	$5
Total for Stream	**Residential**	**$676**	**$532**
	Nonresidential	**$138**	**$82**
	Total	**$814**	**$615**

Table A-1 14: Alternative 1.3 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$3	$3
	Nonresidential	$1	$0
	Total	$4	$3
Mill Creek	Residential	$79	$0
	Nonresidential	$0	$0
	Total	$79	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$26	$14
	Nonresidential	$0	$0
	Total	$26	$14
Noses Creek 2	Residential	$251	$229
	Nonresidential	$0	$0
	Total	$251	$229
Olley Creek	Residential	$13	$29
	Nonresidential	$7	$4

	Total	$20	$33
Powder Springs Creek	Residential	$15	$7
	Nonresidential	$1	$0
	Total	$17	$7
Sweetwater Creek 1	Residential	$25	$0
	Nonresidential	$7	$0
	Total	$32	$0
Sweetwater Creek 2	Residential	$36	$273
	Nonresidential	$15	$11
	Total	$51	$284
Sweetwater Creek 3	Residential	$4	$3
	Nonresidential	$2	$53
	Total	$6	$56
Sweetwater Creek 4	Residential	$3	$0
	Nonresidential	$0	$0
	Total	$3	$0
Sweetwater Creek 5	Residential	$14	$7
	Nonresidential	$5	$14
	Total	$19	$21
Sweetwater Creek 6	Residential	$169	$2
	Nonresidential	$94	$6
	Total	$263	$7
Total for Stream	**Residential**	**$642**	**$567**
	Nonresidential	**$132**	**$88**
	Total	**$774**	**$655**

Alternative 2 produced some flood damage reductions across most reaches. However, in Mill Creek, Sweetwater Creek reach 1 and Sweetwater Creek reach 2 there were small increases in water surface elevations and damages compared to the FWOP condition.

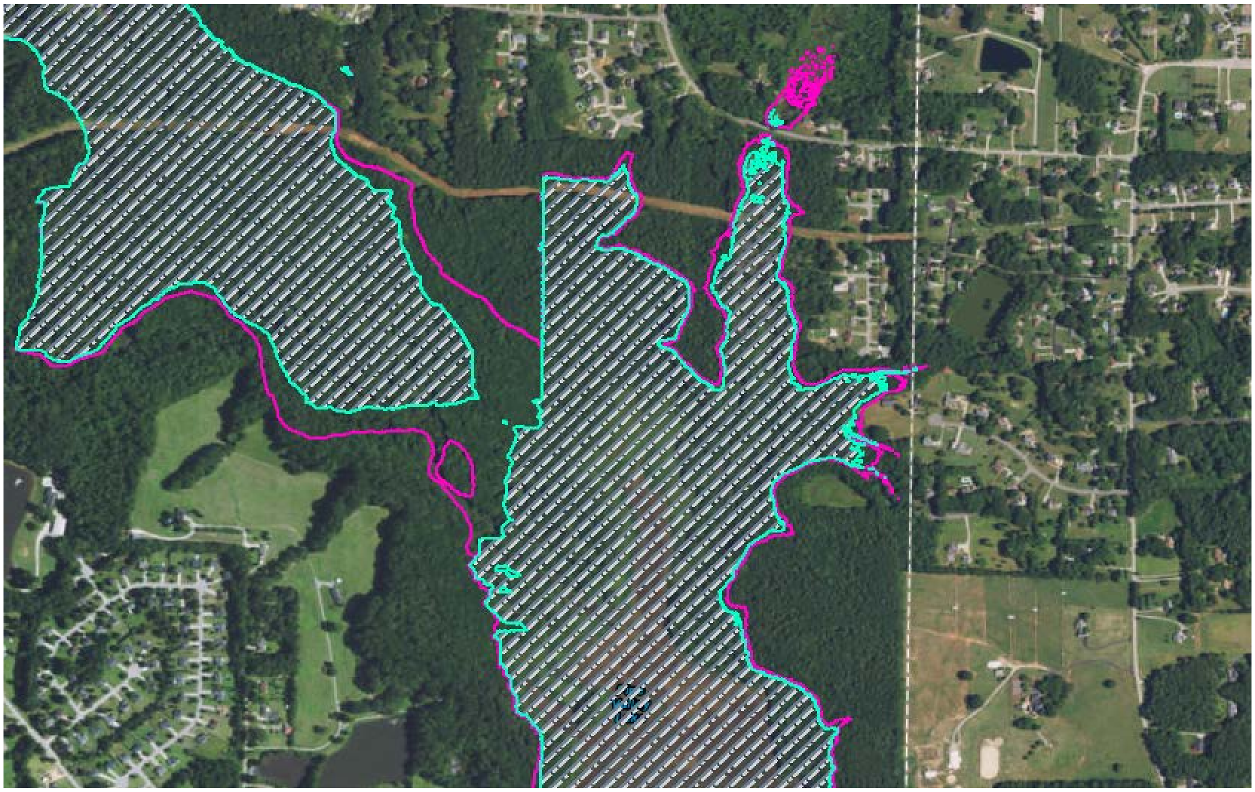

Figure 1: Increased water surface elevations at Mill Creek in Alternative 2 at the 1% chance exceedance. FWOP 1% chance exceedance floodplain is represented by hashed grey and green. Alternative 2 1% chance exceedance floodplain extent represented by pink outline.

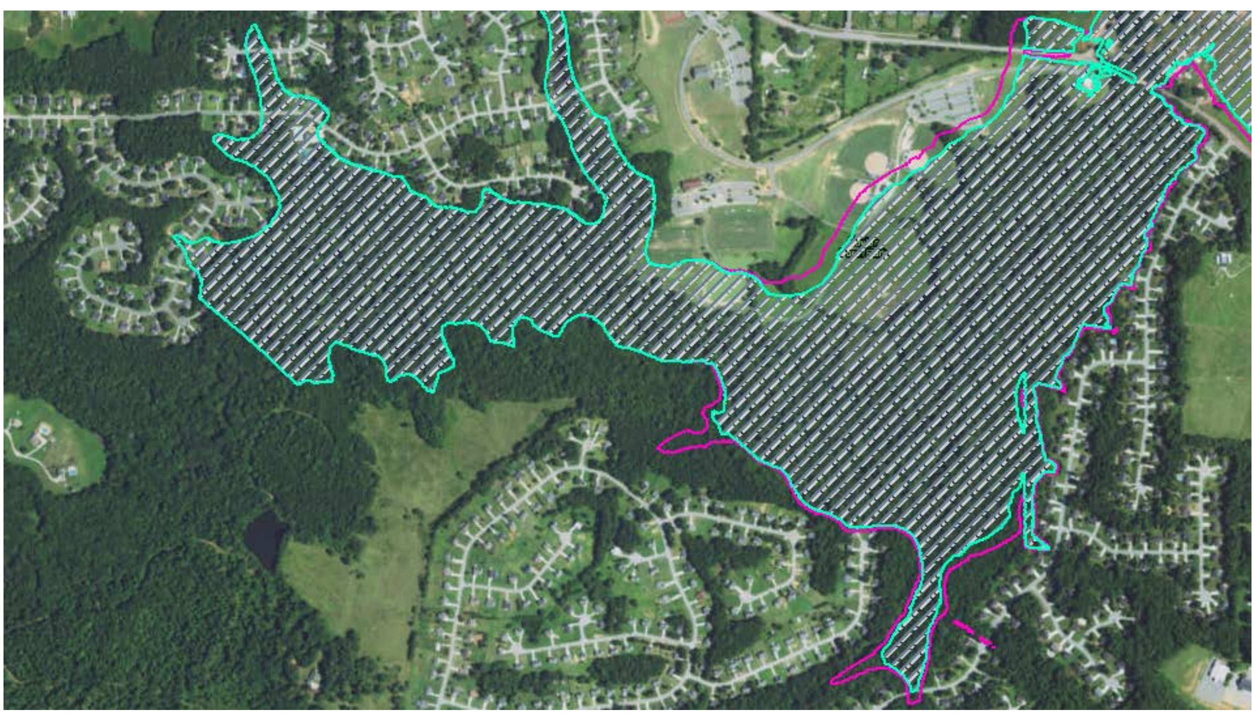

Figure 2: Increased water surface elevations at Sweetwater Creek Reach 1 in Alternative 2 at the 1% chance exceedance. FWOP 1% chance exceedance floodplain is represented by hashed grey and green. Alternative 2 1% chance exceedance floodplain extent represented by pink outline.

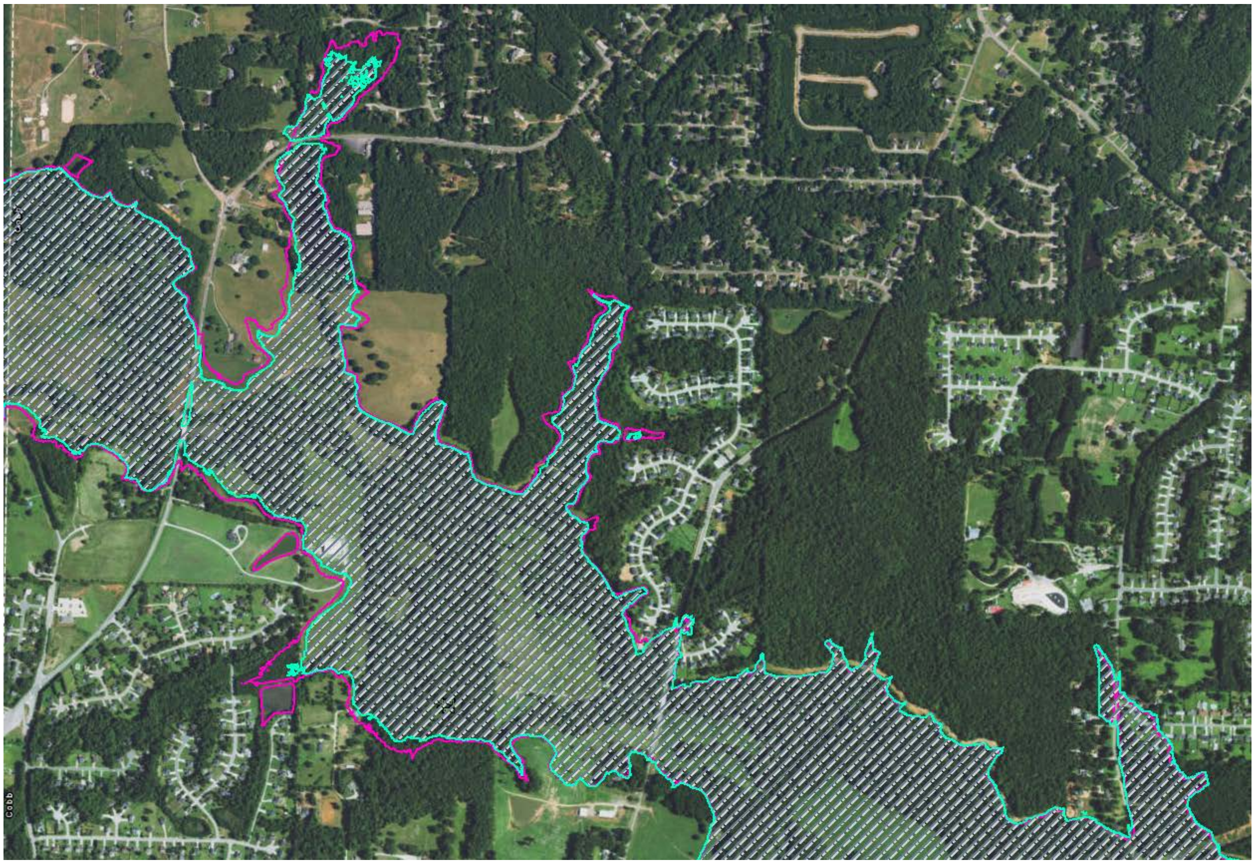

Figure 3: Increased water surface elevations at Sweetwater Creek Reach 2 in Alternative 2 at the 1% chance exceedance. FWOP 1% chance exceedance floodplain is represented by hashed grey and green. Alternative 2 1% chance exceedance floodplain extent represented by pink outline.

Table A-1 15: Alternative 2 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$6	$1
	Nonresidential	$1	$0
	Total	$7	$1
Mill Creek	Residential	$82	-$3
	Nonresidential	$0	$0
	Total	$82	-$3
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$40	$0
	Nonresidential	$0	$0
	Total	$40	$0
Noses Creek 2	Residential	$476	$4
	Nonresidential	$0	$0
	Total	$476	$4

Olley Creek	Residential	$41	$1
	Nonresidential	$11	$0
	Total	$53	$1
Powder Springs Creek	Residential	$22	$1
	Nonresidential	$1	$0
	Total	$23	$1
Sweetwater Creek 1	Residential	$27	-$2
	Nonresidential	$7	$0
	Total	$34	-$2
Sweetwater Creek 2	Residential	$306	$3
	Nonresidential	$27	-$1
	Total	$333	$3
Sweetwater Creek 3	Residential	$7	$1
	Nonresidential	$54	$1
	Total	$60	$2
Sweetwater Creek 4	Residential	$3	$0
	Nonresidential	$0	$0
	Total	$3	$0
Sweetwater Creek 5	Residential	$19	$2
	Nonresidential	$18	$1
	Total	$37	$3
Sweetwater Creek 6	Residential	$164	$7
	Nonresidential	$93	$7
	Total	$256	$14
Total for Stream	**Residential**	**$1,194**	**$15**
	Nonresidential	**$212**	**$8**
	Total	**$1,406**	**$23**

Alternative 4 reduced flood damages in all reaches except for Olley Creek. The slight increases in Olley Creek as well as small damages reduced across the study area caused the alternative produced a low overall level of benefits to the entire study area.

Table A-1 16: Alternative 4 Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$4	$3
	Nonresidential	$1	$0
	Total	$5	$3
Mill Creek	Residential	$78	$0
	Nonresidential	$0	$0
	Total	$78	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0

	Total	$2	$0
Noses Creek 1	Residential	$40	$0
	Nonresidential	$0	$0
	Total	$40	$0
Noses Creek 2	Residential	$446	$34
	Nonresidential	$0	$0
	Total	$446	$34
Olley Creek	Residential	$41	$1
	Nonresidential	$13	-$2
	Total	$54	-$1
Powder Springs Creek	Residential	$21	$2
	Nonresidential	$1	$0
	Total	$22	$2
Sweetwater Creek 1	Residential	$25	$0
	Nonresidential	$7	$0
	Total	$32	$0
Sweetwater Creek 2	Residential	$290	$19
	Nonresidential	$25	$1
	Total	$315	$20
Sweetwater Creek 3	Residential	$5	$2
	Nonresidential	$45	$10
	Total	$50	$12
Sweetwater Creek 4	Residential	$2	$1
	Nonresidential	$0	$0
	Total	$2	$1
Sweetwater Creek 5	Residential	$14	$7
	Nonresidential	$14	$5
	Total	$28	$12
Sweetwater Creek 6	Residential	$137	$34
	Nonresidential	$75	$25
	Total	$212	$59
Total for Stream	**Residential**	**$1,105**	**$103**
	Nonresidential	**$181**	**$39**
	Total	**$1,286**	**$142**

Alternative 5H reduced damages across all reaches except for in Olley Creek. However, ultimately the damages reduced were not great enough to produce a large number of flood damage reduction benefits in the overall study area

Table A-1 17: Alternative 5H Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$4	$2

	Nonresidential	$1	$0
	Total	$5	$2
Mill Creek	Residential	$79	$0
	Nonresidential	$0	$0
	Total	$79	$0
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$40	$0
	Nonresidential	$0	$0
	Total	$40	$0
Noses Creek 2	Residential	$468	$12
	Nonresidential	$0	$0
	Total	$468	$12
Olley Creek	Residential	$40	$2
	Nonresidential	$11	$0
	Total	$52	$2
Powder Springs Creek	Residential	$20	$3
	Nonresidential	$1	$0
	Total	$21	$3
Sweetwater Creek 1	Residential	$17	$8
	Nonresidential	$4	$3
	Total	$21	$11
Sweetwater Creek 2	Residential	$275	$34
	Nonresidential	$22	$4
	Total	$297	$38
Sweetwater Creek 3	Residential	$6	$2
	Nonresidential	$50	$5
	Total	$56	$7
Sweetwater Creek 4	Residential	$2	$1
	Nonresidential	$0	$0
	Total	$2	$1
Sweetwater Creek 5	Residential	$16	$5
	Nonresidential	$15	$4
	Total	$31	$9
Sweetwater Creek 6	Residential	$142	$29
	Nonresidential	$76	$23
	Total	$219	$52
Total for Stream	**Residential**	**$1,111**	**$97**
	Nonresidential	**$181**	**$39**
	Total	**$1,292**	**$136**

Alternative 5D reduced damages across all reaches Except for Mill Creek. Additionally, there were slight increases in water surface elevations in Mill Creek and ultimately the alternative produced a low amount of flood damage reduction benefits.

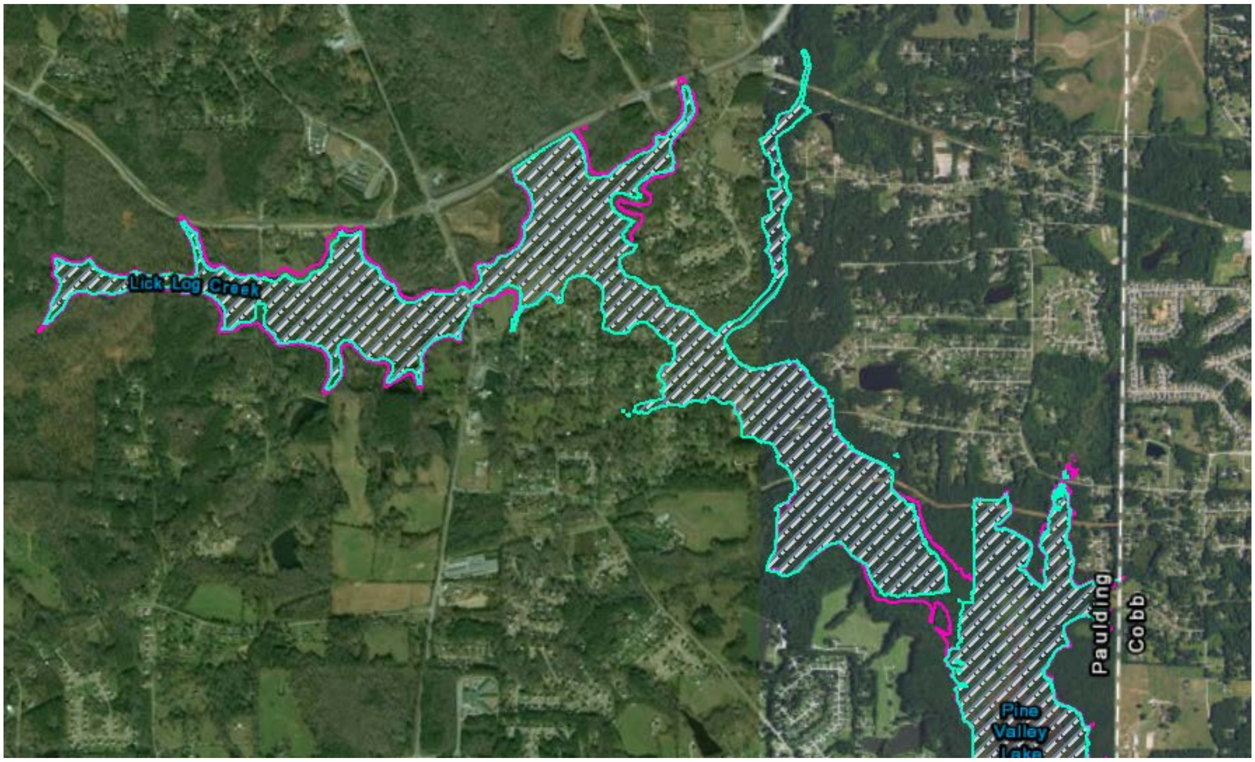

Figure 4: Increased water surface elevations at Mill Creek in Alternative 5D at the 1% chance exceedance. FWOP 1% chance exceedance floodplain is represented by hashed grey and green. Alternative 5D 1% chance exceedance floodplain extent represented by pink outline.

Table A-1 18: Alternative 5D Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$5	$1
	Nonresidential	$1	$0
	Total	$6	$1
Mill Creek	Residential	$83	-$4
	Nonresidential	$0	$0
	Total	$83	-$4
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0
	Total	$2	$0
Noses Creek 1	Residential	$40	$0
	Nonresidential	$0	$0
	Total	$40	$0
Noses Creek 2	Residential	$465	$15
	Nonresidential	$0	$0

	Total	$465	$15
Olley Creek	Residential	$41	$1
	Nonresidential	$11	$0
	Total	$52	$1
Powder Springs Creek	Residential	$20	$3
	Nonresidential	$1	$0
	Total	$21	$3
Sweetwater Creek 1	Residential	$17	$8
	Nonresidential	$4	$3
	Total	$21	$11
Sweetwater Creek 2	Residential	$265	$44
	Nonresidential	$20	$6
	Total	$286	$50
Sweetwater Creek 3	Residential	$5	$2
	Nonresidential	$49	$6
	Total	$54	$8
Sweetwater Creek 4	Residential	$2	$1
	Nonresidential	$0	$0
	Total	$2	$1
Sweetwater Creek 5	Residential	$15	$6
	Nonresidential	$14	$5
	Total	$30	$11
Sweetwater Creek 6	Residential	$135	$36
	Nonresidential	$72	$27
	Total	$207	$63
Total for Stream	**Residential**	**$1,094**	**$114**
	Nonresidential	**$174**	**$46**
	Total	**$1,268**	**$161**

Alternative 5J reduced flood damages across all reaches except for Mill Creek. However, ultimately the alternative produced a low amount of flood damage reduction benefits.

Table A-1 19: Alternative 5J Equivalent Annual Damages (x1000, 2017 Prices)

Reach	Damage Category	Residual Damages	Damages Reduced
Buttermilk Creek	Residential	$5	$1
	Nonresidential	$1	$0
	Total	$6	$1
Mill Creek	Residential	$83	-$4
	Nonresidential	$0	$0
	Total	$83	-$4
Mud Creek	Residential	$2	$0
	Nonresidential	$0	$0

	Total	$2	$0
Noses Creek 1	Residential	$40	$0
	Nonresidential	$0	$0
	Total	$40	$0
Noses Creek 2	Residential	$472	$8
	Nonresidential	$0	$0
	Total	$472	$8
Olley Creek	Residential	$41	$1
	Nonresidential	$11	$0
	Total	$53	$1
Powder Springs Creek	Residential	$21	$2
	Nonresidential	$1	$0
	Total	$22	$2
Sweetwater Creek 1	Residential	$22	$3
	Nonresidential	$5	$2
	Total	$27	$5
Sweetwater Creek 2	Residential	$292	$18
	Nonresidential	$24	$2
	Total	$316	$20
Sweetwater Creek 3	Residential	$6	$1
	Nonresidential	$52	$3
	Total	$58	$4
Sweetwater Creek 4	Residential	$2	$1
	Nonresidential	$0	$0
	Total	$2	$1
Sweetwater Creek 5	Residential	$18	$3
	Nonresidential	$16	$3
	Total	$34	$6
Sweetwater Creek 6	Residential	$142	$29
	Nonresidential	$77	$22
	Total	$219	$51
Total for Stream	**Residential**	**$1,145**	**$63**
	Nonresidential	**$189**	**$31**
	Total	**$1,334**	**$95**

ROUGH ORDER MAGNITUDE (ROM) COSTS

Continuing the evaluation process, ROM first cost estimates were developed for each of the alternatives that were evaluated as described above. The ROM costs were provided by Mobile District’s Cost Engineering Section in January 2018 price levels. For comparison to the benefits, which are average annual flood damages reduced, the ROM first costs were stated in average annual terms using the current Federal discount rate of 2.75% and a 50-year period of analysis. Interest during construction was added to the ROM first costs assuming 36 months for alternative 1, 48 months for alternative 1.1, 60 months for alternative 1.2, 72 months for alternative 1.2, 12 months for alternative 2, 30 months for alternative 4, 17 months for alternative 5h, 29 months for alternative 5d, and 9 months for alternative 5j. In addition, annual operation and maintenance (O&M) costs were added to the alternatives. Table A-1 20 displays the results of the costs calculation.

Table A-1 20: Project Costs

Alternative	Project First Cost	Const. Period (Months)	Interest During Const.	Total Cost	Average Annual Cost	Annual O&M Cost	Total Average Annual Cost
1	$4,669,100	36	$189,764	$4,858,864	$179,978	$0	$179,978
1.1	$5,674,100	48	$312,534	$5,986,634	$221,751	$0	$221,751
1.2	$15,708,300	60	$1,096,202	$16,804,502	$622,455	$0	$622,455
1.3	$23,028,400	72	$1,951,896	$24,980,296	$925,294	$0	$925,294
2	$22,653,000	12	$284,124	$22,937,124	$849,612	$20,000	$869,612
4	$134,178,600	30	$4,497,869	$138,676,469	$5,136,705	$0	$5,136,705
5h	$33,141,000	17	$606,903	$33,747,903	$1,241,053	$26,000	$1,267,053
5d	$152,267,600	29	$4,924,478	$157,192,078	$5,822,539	$36,000	$5,858,539
5j	$8,631,000	9	$78,552	$8,709,552	$322,610	$18,000	$340,610

RESULTS

The equivalent annual benefits were then compared to the average annual cost to develop net benefits and a benefit-to-cost ratio (BCR) for each alternative. The net benefits for each alternative were calculated by subtracting the average annual costs form the equivalent average annual benefits and a benefit-to-cost ratio was derived by dividing average benefits by average annual costs. Net benefits were used for identification of the NED plan in accordance with the Federal objective. For comparison purposes, Table A-1 21 summarizes the equivalent annual damages reduced (benefits), average annual costs, total first cost, net benefits, and benefit-to-cost ratio for each alternative.

Table A-1 21: Benefit-Cost Analysis

Alternative	Description	Average Annualized Benefits	Average Annualized Costs	First Cost	Net Benefits	Benefit Cost Ratio
1	10 Year Buyouts (20 Structures)	$531,210	$179,978	$4,669,100	$351,232	3.0

1.1	25 Year Buyouts (26 Structures)	$558,210	$221,751	$5,674,100	$336,459	2.5
1.2	50 Year Buyouts (66 Structures)	$614,680	$622,455	$15,708,300	-$7,775	0.99
1.3	100 Year Buyouts (117 Structures)	$654,780	$925,294	$23,028,400	-$270,514	0.7
2	SC6	$22,640	$869,612	$22,653,000	-$846,972	0.0
4	Channelization	$142,100	$5,136,705	$134,178,600	-$4,994,605	0.0
5h	SC1, SC6	$135,770	$1,267,053	$33,141,000	-$1,131,283	0.1
5d	All Detention	$160,540	$5,858,539	$152,267,600	-$5,697,999	0.0
5j	SC1 (small)	$98,450	$340,610	$8,631,000	-$242,160	0.3

Since Alternatives 1.0, 1.1, 1.2, and 1.3 are nonstructural plans, there is a potential for benefits to be evaluated using an alternative land use approach. When the candidate (for relocation) structures are removed, the land can no longer be used for urban development, and an alternative land use can be implemented. For Alternatives 1.0, 1.1, 1.2, these alternative land uses were not determined in this study.

As a result of the comparison of the alternatives, Alternative 1.0 is identified as the NED plan yielding the highest net benefits and BCR.

SECTION II: REGIONAL ECONOMIC DEVELOPMENT IMPACTS

BACKGROUND

The Sweetwater Creek flood risk management project alternatives consist of dry detention structures, evacuating structures, and constructing dry detention areas. For this analysis, the regional economic development (RED) effects of implementing each project alternative. The RECONS impact area Apalachicola, Chattahoochee, and Flint Rivers, which included the Atlanta, GA Metropolitan Statistical Areas was selected based on the labor market, commuter-shed, and population centers serving the project area. According to RECONS' 2014 data, the population of the study area is 5,543,990. The number of households is 2,012,567.

METHODOLOGY

This Regional Economic Development (RED) analysis employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect of changes in one industry on others. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending drive the input-output model to project new levels of sales (output), value added (GRP), employment, and income for each industry.

The specific input-output model used in this analysis is RECONS (Regional Economic System). This model was developed by the Institute for Water Resources (IWR), Michigan State University, and the Louis Berger Group. RECONS uses industry multipliers derived from the commercial input-output model IMPLAN to estimate the effects that spending on USACE projects has on a regional economy. The model is linear and static, showing relationships and impacts at a certain fixed point in time. Spending impacts are composed of three different effects: direct, indirect, and induced.

Direct effects represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components to the project. Indirect effects represent changes to secondary industries that support the direct industries. Induced effects are changes in consumer spending patterns caused by the change in employment and income within the industries affected by the direct and induced effects. The additional income workers receive via a project may be spent on clothing, groceries, dining out, and other items in the regional area.

The inputs for the RECONS model are expenditures that are entered by work activity or industry sector, each with its own unique production function. For the relocation alternative 1.0, the production function “FRM Construction” was selected to gauge the impacts of the removal of structures and clearing of the parcel. The baseline data used by RECONS to represent the regional economy of Alabama are annual averages from the Bureau of the Census, the Bureau of Labor Statistics, and the Bureau of Economic Analysis for the year 2009. The model results are expressed in 2014 dollars.

ASSUMPTIONS

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if output is to increase, inputs will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it is assumed that industries use the same technology to produce all of its commodities. Finally, since the model is static, it is assumed that the economic conditions of 2009, the year of the socio-economic data in the RECONS model database, will prevail during the years of the construction process.

DESCRIPTION OF METRICS

“Output” is the sum total of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. “Labor Income” includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. “Gross Regional Product (GRP)” is the value-added output of the study regions. This metric captures all final goods and services produced in the study areas because of the project’s existence. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. “Jobs” is the estimated worker-years of labor required to build the project.

RESULTS

For the region encompassing alternative 1.0, USACE is planning on expending $4,669,100 on the project. Of this total project expenditure $4,101,700 will be captured within the regional impact area. The rest will be leaked out to the state or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity in that can be measured in jobs, income, sales and gross regional product as summarized in the following table and includes impacts to the region, the State impact area, and the Nation. Table A-2 1 is the overall economic impacts for the State and Nation for this analysis.

Table A-2 1: Overall Summary Economic Impacts for Alternative 1.0

Impacts (Impact Areas)		Regional	State	National
Total Spending		$4,669,100	$4,669,100	$4,669,100
Direct Impact				
	Output	$4,101,700	$4,402,353	$4,657,616
	Jobs	44.94	47.29	48.39
	Labor Income	$2,579,389	$2,820,892	$2,905,916
	GRP	$2,883,290	$3,154,812	$3,290,058
Total Impact				
	Output	$8,251,357	$8,948,577	$12,667,531
	Jobs	78.39	84.46	103.5
	Labor Income	$4,145,732	$4,508,277	$5,550,660
	GRP	$5,539,748	$6,029,838	$7,856,420