Appendix C

Economic Damage Analysis

Economic Benefit/Cost Modeling Analysis

Estimation of Flood Damages

This chapter describes the data, methodology, and results of the August 2004 Property Appraisal and HEC-FDA flood damage analysis. The HEC-FDA model (Hydrologic Engineering Center – Flood Damage Analysis) is a model built and supported by the U.S. Army Corps of Engineers to perform Monte-Carlo simulation-based estimation of flood damages using estimated flood levels, flooded structure and content values, and specified depth-damage functions that attribute percentage damages to certain depths of structure and content flooding. The NRCS 2002 flood damage analysis of Rockhouse Creek used the URB1 model and a May 2001 property appraisal. In each subsection of this chapter the corresponding 2002 analysis information is provided, for purposes of comparison and documentation.

Property Valuation

2004 Mass Valuation Property Appraisal

The HEC-FDA flood damage estimates were based on the market value and estimated content value of the homes and businesses along Rockhouse Creek. Structure market values were based on a mass valuation appraisal of the properties located within the 500-year floodplain of Rockhouse Creek, which was conducted in August 2004 by the Kentucky Field Service Realty, Inc. Table 1 lists the total estimated market value of the residential and commercial structures and lands in the Rockhouse Creek floodplain as of August 23, 2004. The content values of selected commercial and special purpose structures and a general estimate of the content values of the remaining commercial and residential structures and bridges as estimated in the August 2004 appraisal are provided in Table 2. The total estimated value of property and contents, as appraised in 2004, is **$26,241,100.**

Table 1. Rockhouse Creek Structure and Land Values, 2004

Property Category	Structures	Land	Total
Estimated Value of Improved Residential Properties	$8,500,800	$2,994,900	$11,495,700
Estimated Value of Vacant Residential Land	---	$538,000	$538,000
Estimated Value of Improved Commercial and Special Purpose Properties	$5,556,680	$1,675,720	$7,232,400
Estimate of Value of Vacant Commercial Land	---	$410,000	$410,000
Total Estimated Value of All Properties	$14,057,480	$5,618,620	**$19,676,100**

Table 2. Rockhouse Creek Commercial and Residential Content Values and Bridge Values, 2004	
Property Category	**Contents**
Begley Lumber Company – Lumber and Logs (1,400,000 bd.ft)	$600,000
Leslie Lumber and Supply	$500,000
Kemper Furniture	$500,000
Special Purpose properties (churches)	$100,000
Estimated Value of Content for remaining commercial properties	$915,000
Estimated Content Value Residential (234 residence properties in the Rockhouse Creek watershed, average content = $15,000 each)	$3,510,000
22 Bridges (KFSR estimated average value of $20,000@)	$440,000
Total Estimated Value of Contents of all structures	**$6,565,000**

2001 Mass Valuation Property Appraisal

An appraisal of the properties located within the floodplain of Rockhouse Creek was previously conducted in 2001 by the Kentucky Field Service Realty, Inc. This appraisal estimated only the value of the structures on properties and did not estimate the value of the land. The appraisal was conducted to exclude the value of the land because the non-structural alternative of a buy-out was not considered in the 2002 NRCS Watershed Flood Protection Analysis of the Rockhouse Creek Watershed, whereas such alternative will be considered in the 2004 NRCS Flood Protection Analysis. Table 3 lists the estimated market values of the Rockhouse properties in 2001. The content values of selected commercial and special purpose structures and a general estimate of the content values of the remaining residential structures and bridges as estimated in the May 2001 appraisal are provided in Table 4. The total estimated value of property and contents, as appraised in 2001, was **$17,180,283.**

Table 3. Rockhouse Creek Property Values, 2001	
Estimated Value of Residential and Commercial properties	$11,820,243
Value of Bridges	$440,000
Estimated Value of special purpose properties	$920,040
Total Estimated Value of All Properties	**$13,180,283**

Table 4. Rockhouse Creek Content Values, 2001	
Property Category	**Contents**
Begley Lumber Company – Lumber and Logs (1,400,000 bd.ft)	$500,000
Leslie Lumber and Supply	$350,000
Kemper Furniture	$200,000
Special Purpose properties	$100,000
Estimated Contents of the 241 residence properties in the Rockhouse Creek watershed, average content at $10,000 each.	$2,410,000
22 Bridges (KFSR assumed average value of $20,000@)	$440,000
Total Estimated Value of Contents for all properties	**$4,000,000**

Note: Several structures that were reported in the 2002 survey of the community could not be identified during the resurvey conducted in 2004. In addition, several new structures were present in the 2004 survey that did not appear in the 2002 survey.

Adjustment of Content Values

Content values for properties located in the floodplain of the Rockhouse Creek were estimated by KFSR in 2001 and 2004, as part of their mass appraisal reports. However, the flood damage economic models allow the user either to input the appraisal estimates or use content- to-structure value ratios (CSVR) to estimate content values.

The content values for the majority of the Rockhouse properties evaluated in the 2002 and 2005 flood damage analyses were based on CSVR's in the URB1 model in the 2002 NRCS analysis and in the HEC-FDA model in the 2005 NRCS Analysis. The estimated content values from the two KFSR appraisals, the URB1 model and the HEC-FDA model are listed in Table 5.

Table 5. Summary of Rockhouse Creek Content Values				
Source	Residential	Commercial	Special Purpose	Total Value
2001 KFSR appraisal	$2,410,000	$1,050,000	100,000	$3,560,000
2002 URB1 model	$3,564,800	$1,735,000	-	$5,299,800
2004 KFSR appraisal	$3,510,000	$2,955,000	$100,000	$6,565,000
2005 HEC-FDA model	$4,020,800	$3,753,500	$353,400	$8,127,700

In the 2002 analysis using the URB1 model, the content value was estimated as 40 percent of the structure value for structures other than those, such as Begley Lumber, with specific appraisal estimates of content value.

The CSVR's for residential structures (except for mobile homes) used in the HEC-FDA model are the weighted averages of all the non-mobile home types found in the US Army Corp of Engineers Risk-Based Analysis for Flood Damage Reduction Studies (EM 1110-2-1619). The higher mobile-home-specific value from that study was used as the CSVR for HEC-FDA

analysis of mobile homes. Table 6 list the CSVR for residential structures used in the HEC-FDA analysis.

For commercial structures evaluation in HEC-FDA, the CSVR used varied according to the type of structure and its use. The CSVR for commercial structures are listed in Table 7.

Table 6. Content-to-Structure Value Ratios for Residential Structures Used in the HEC-FDA flood damage analysis.

Structure Type	Description	CSVR
SFNB	Single-family, no basement	0.43
SFWB	Single-family, with basement	0.43
APT	Apartment	0.43
MH	Mobile Home	0.64

Source: US Army Corp of Engineers Risk-Based Analysis for Flood Damage Reduction Studies (EM 1110-2-1619).

Table 7. Content-to-Structure Value Ratios for Non-residential Structures Used in the HEC-FDA flood damage analysis.

Structure Type	Structure Description	CSVR
MaER	Masonry bearing eating and recreation	0.40
MaGG	Masonry bearing groceries/gas stations	1.42
MaPB	Masonry bearing professional business	0.91
MaRH	Masonry bearing repairs/home use	0.62
MaRP	Masonry bearing retail/personal services	1.71
MaWC	Masonry bearing warehouse/contractor service	0.68
NR-MH	Non-residential mobile home	0.64
WSGG	Wood or steel frame groceries/gas stations	1.42
WSPB	Wood or steel frame professional business	0.91
WSRP	Wood or steel frame retail/personal services	1.71
WSRH	Wood or steel frame repairs and home use	0.62
WSWC	Wood or steel frame warehouse/contractor service	0.68
MaPS	Masonry bearing public and semi-public	0.37

Source: USACE Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya Re-evaluation and Morganza to the Gulf, Louisiana Feasibility Studies.

Bridges

In the 2002 NRCS Rockhouse Creek Analysis, 22 bridges were included in the URB1 model, compared to 24 bridges included in the 2005 analysis using the HEC-FDA model. The two bridges omitted from the 2002 study were the Kate Ireland Bridge, located in Hyden City, and the Laurel Bridge, located on Laurel Fork. The values of the bridges used in the HEC-FDA model were taken from the 2002 NRCS analysis, with the exception of the Kate Ireland and Laurel Bridge. The bridge values were based on the square footage multiplied by $55.00 per square-foot (cost provided to Bill Waits by the KY State Hwy Dept). The value of the 2 bridges not included in the 2002 analysis is estimated at $20,000 according to the 2004 appraisal

conducted by Vance Mosley of Kentucky Field Service Realty, Inc. A detailed list of bridges, and their values, as included in the HEC-FDA model is provided in Table 8.

Table 8. Value of Bridges on Rockhouse Creek

Name	Location (Stream Station)	Value
Kate Ireland Bridge	11400	$20,000
Appalachia Motel Bridge	14270	$28,875
HWY 421 Bridge	15410	$90,090
Lily Drive	17618	$23,100
All Steel (Flatland Place)	19275	$23,100
Private 3	19470	$13,860
Saw Dust Road	22544	$35,640
Brookside Lane	23785	$25,410
Private 4	24035	$26,400
Private 5	25115	$16,500
Private 6	25327	$15,180
Rolling Rock Lane	25770	$18,480
Perch Dr	26130	$26,400
Baywood Lane	27045	$15,180
Jerry Lane	27852	$28,380
Napier Farm Lane	29825	$17,820
Private 7	33435	$18,480
Private 8	34980	$18,480
Private 9	38267	$17,160
Paradise Lane	38655	$13,200
Private 10	40020	$24,420
L.Laurel Fork	40507	$18,480
Winding Way	42280	$12,540
Laurel Bridge	60535	$20,000

HEC-FDA Modeling

The HEC-FDA model is a computer simulation model that requires inputs on potentially flooded structures, depth-damage functions, and storm-event based flooding and the uncertainties associated with those variables and that provides output on average annual damages to affected structures.

Property Information

Structure inventory data was needed for the HEC-FDA model, which included structure attributes such as the name for the structure, structure value, and content value or CSVR. Additional property information needed included structure stages associated with the ground or first floor, stream station, stream, and bank designation.

Damage Categories and Structure Occupancy Codes

The property information was used to compute an aggregate stage-damage function by damage category at the damage reach index location. The damage categories are comprised of structures with similar attributes. In this analysis, three major categories were created – Residential, Non-residential, and Bridges. Each damage category was further broken down into structure occupancy types, i.e. single-family, 1-story buildings with basements, mobile homes, and wood or steel-framed professional business structures.

Depth-Damage Functions

Depth-damage functions are curvilinear relationships that express the relationship between flooding depths and amount of damage for specific structure types.

<u>Residential properties without basements</u>

URB1 depth-damage functions for residential properties without basements (Table 9) included the following categories:

H1N – 1-story wood, rock or brick, mostly on slab foundation, no basement.
H2N – 2-story wood, rock or brick, with crawl space, no basement.
H3N – Split-level brick or wood, with lower level actually the basement
T – trailer home

HEC-FDA depth-damage functions for residential properties without basements (Table 10) included the following categories:

SFNB – single-family, one-story, without basement
APT – two or more stories, without basement
MH – mobile home

The depth-damage relationships for residential structures without basement that was used in the URB1 model estimate structure damage at a lower level and content damage at a higher level than the relationships used in the HEC-FDA model. The URB1 depth-damage relationship

estimates damages from 4 feet below to 6 feet above the first floor elevation, whereas the HEC-FDA relationship ranges from 2 feet below to 16 feet above the first floor elevation.

Table 9. URB1 Depth Damage Function for Rockhouse Creek Residential Properties without Basements

Depth	H1N		H2N		H3N		T	
(ft.)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)
-4	0	0	0	0	0	0	0	0
-3	.1	0	.1	0	.1	0	.1	0
-2	.3	0	.3	0	.3	0	2	0
-1	.5	0	.5	0	.5	0	4	0
0	6	4	5	4	4	2	8	0
1	17	28	10	12	12	15	50	25
2	25	40	15	22	18	25	70	60
3	30	50	18	30	23	35	80	70
4	35	55	20	35	25	40	90	80
5	37	60	25	40	28	42	95	90
6	40	65	30	45	30	45	-	-

Sources: Damage curves based upon similar flood protection studies used by original project economist and Federal Insurance Administration average values.

Table 10. HEC-FDA Depth Damage Function for Rockhouse Creek Residential Properties without Basements						
Depth	**SFNB**		**APT**		**MH**	
(ft.)	**Struct. (%)**	**Cont. (%)**	**Struct. (%)**	**Cont. (%)**	**Struct. (%)**	**Cont. (%)**
-2	0	0	0	0	0	0
-1	2.5	2.4	3.0	1.0	0	0
0	13.4	8.1	9.3	5.0	8	12
1	23.3	13.3	15.2	8.7	44	66
2	32.1	17.9	20.9	12.2	63	90
3	40.1	22.0	26.3	15.5	73	90
4	47.1	25.7	31.4	18.5	78	90
5	53.2	28.8	36.2	21.3	80	90
6	58.6	31.5	40.7	23.9	81	90
7	63.2	33.8	44.9	26.3	82	90
8	67.2	35.7	48.8	28.4	82	90
9	70.5	37.2	52.4	30.3	82	90
10	73.2	38.4	55.7	32.0	82	90
11	75.4	39.2	58.7	33.4	82	90
12	77.2	39.7	61.4	34.7	82	90
13	78.5	40.0	63.8	35.6	82	90
14	79.5	40.0	65.9	36.4	82	90
15	80.2	40.0	67.7	36.9	82	90
16	80.7	40.0	69.2	37.2	82	90

Sources: USACE Economic Guidance Memorandum (EGM) 04-01 and FIA Depth-Damage data.

Residential properties with basements

URB1 depth-damage functions for residential properties with basements (Table 11) included the following categories:

H1B – 1-story wood, rock or brick, mostly on slab foundation, with basement.
H2B – 2-story wood, rock or brick, with crawl space, with basement.
H3B – Split-level brick or wood, with basement

HEC-FDA depth-damage functions for residential properties with basements (Table 12) included the single category SFWB – single family, one-story with basement

The depth-damage relationships for residential structures with basement that was used in the URB1 model estimate structure damage at a lower level and content damage at a higher level than the relationships used in the HEC-FDA model. The URB1 depth-damage relationship estimates damages from 6 feet below to 5 feet above the first floor elevation, whereas the HEC-FDA relationship ranges from 8 feet below to 16 feet above the first floor elevation.

Table 11. URB1 Depth Damage Function for Rockhouse Creek Residential Properties with Basements						
Depth	**H1B**		**H2B**		**H3B**	
(ft.)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)
-6	0	0	0	0	0	0
-5	2	0	1	0	1	0
-4	3	0	2	0	2	0
-3	4	2	3	1	3	2
-2	5	5	4	3	4	5
-1	6	10	5	6	5	10
0	8	17	6	8	6	15
1	20	30	10	20	12	25
2	25	45	15	25	18	35
3	30	55	20	35	20	40
4	35	60	25	40	25	45
5	40	65	30	45	30	55

Sources: Damage curves based upon similar flood protection studies used by original project economist and Federal Insurance Administration average values.

Table 12. HEC-FDA Depth Damage Function for Rockhouse Creek Residential Properties with Basements					
Depth (ft.)	SFWB		Depth (ft.)	SFWB	
	Struct. (%)	Cont. (%)		Struct. (%)	Cont. (%)
-8	0	0.0	5	58.6	30.0
-7	0.7	0.8	6	64.5	32.4
-6	0.8	2.1	7	69.8	34.5
-5	2.4	3.7	8	74.2	36.3
-4	5.2	5.7	9	77.7	37.7
-3	9.0	8.0	10	80.1	38.6
-2	13.8	10.5	11	81.1	39.1
-1	19.4	13.2	12	81.1	39.1
0	25.5	16.0	13	81.1	39.1
1	32.0	18.9	14	81.1	39.1
2	38.7	21.8	15	81.1	39.1
3	45.5	24.7	16	81.1	39.1
4	52.2	27.4			

Source: USACE Economic Guidance Memorandum (EGM) 04-01.

Commercial properties

URB1 depth-damage functions for commercial properties (Table 13) included the following categories:

RB1 – retail
SB1 – service
MB1 – manufacturing

HEC-FDA depth-damage functions for commercial properties (Table 14) included the following categories:

WSRP – wood or steel frame, retail and personal services
WSPB – wood or steel frame, professional business
WSWC – wood or steel frame, warehouse and contractor services
MaSP – masonry bearing, public and semi-public, special purpose

Note: the types of commercial structures in Table 2-6 represent just a few of the commercial structures included in the HEC-FDA analysis. The three structure types highlighted are closely comparable to the structure types used in the URB1 analysis.

The depth-damage relationships for commercial structures used in the URB1 model estimated structure damage at a lower level and content damage at a higher level than the relationships used in the HEC-FDA model. The URB1 depth-damage relationship estimates damages from 4 feet below to 4 feet above the first floor elevation, whereas the HEC-FDA relationship ranges from 1 foot below to 15 feet above the first floor elevation.

Table 13. URB1 Depth Damage function for Rockhouse Creek Commercial Properties

Depth (ft.)	RB1		SB1		MB1	
	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)
-4	0	0	0	0	0	0
-3	1	0	1	0	1	0
-2	2	0	2	0	2	0
-1	3	0	3	0	3	0
0	6	5	6	5	6	5
1	18	20	18	17	18	22
2	25	50	25	40	25	45
3	30	85	30	70	30	90
4	40	99	40	95	40	99

Sources: Damage curves based upon similar flood protection studies used by original project economist and Federal Insurance Administration average values.

Table 14. HEC-FDA[1] Depth Damage Function for Rockhouse Creek Commercial Properties								
Depth (ft.)	**WSRP**		**WSPB**		**WSWC**		**MaSP**	
	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)	Struct. (%)	Cont. (%)
-1	0	0	0	0	0	0	0	0
-0.5	0	0	0	0	0	0	0	0
0	1.1	0	1.1	0	1.1	0	1.6	0
0.5	18.3	10.9	18.3	12.8	18.3	8.1	12.0	36.1
1	18.3	23.0	18.3	16.2	18.3	12.0	12.0	65.0
1.5	24.4	33.3	24.4	28.9	24.4	16.0	17.2	65.0
2	27.2	55.0	27.2	34.0	27.2	20.1	17.4	65.0
3	30.9	68.5	30.9	64.8	30.9	26.6	22.4	90.0
4	37.0	77.4	37.0	80.2	37.0	30.9	26.3	100.0
5	44.5	85.9	44.5	81.9	44.5	39.0	29.5	100.0
6	44.5	94.4	44.5	89.5	44.5	46.2	29.5	100.0
7	46.2	94.4	46.2	91.8	46.2	53.4	29.5	100.0
8	47.6	94.4	47.6	91.8	47.6	60.6	31.9	100.0
9	52.1	94.4	52.1	91.8	52.1	67.9	42.3	100.0
10	52.1	97.0	52.1	91.8	52.1	72.5	48.4	100.0
11	52.1	97.0	52.1	91.8	52.1	72.5	48.4	100.0
12	54.9	97.0	54.9	91.8	54.9	72.5	52.4	100.0
13	54.9	97.0	54.9	91.8	54.9	72.5	52.4	100.0
14	54.9	97.0	54.9	91.8	54.9	72.5	52.4	100.0
15	54.9	97.0	54.9	91.8	54.9	72.5	52.4	100.0

(1) Figures based on short duration flooding (one day or less)

Source: USACE Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya Re-evaluation and Morganza to the Gulf, Louisiana Feasibility Studies.

Bridges

The depth-damage relationship used for bridges (Table 15 below) in the HEC-FDA analysis is the same relationship that was used in the 2002 NRCS URB1 analysis.

Table 15. Bridge Depth-Damage Function	
Depth	**BR**
(ft.)	**(%) Structure Damage**
-6	0
-5	0.5
-4	1
-3	2
-2	3
-1	4
0	6
1	11
2	15
3	18
4	20
6	25

Source: NRCS 2002 Watershed Flood Protection Analysis, Economic Evaluation, and Resource Assessment, Rockhouse Creek, Leslie County, Kentucky URB1 input. Damage curves based upon similar projects and information from the Kentucky State Highway Department.

Comparison of Elevation of Zero Damage (first floor where flooding occurs)

In the 2002 URB1 analysis, the NRCS economist assumed that some amount of damage would occur at 4 feet below the first floor elevation for structures without basements, and 6 feet below the first floor elevation for structures with basements (or bottom of deck for bridges). These assumptions were made using empirical data gathered at the time.

In the 2005 HEC-FDA analysis, the elevation of zero damage was based on the depth-damage relationships for each structure type. This elevation is at a depth below the 1st floor elevation. The depth at which damage first occurs is listed in Table 16.

Table 16. Depth Where Damage Begins

Structure type	Elevation of zero damage (from 1st floor elevation, ft.)	Source
APT	-2.0	USACE, EGM 04-01
MH (incl. commercial use)	-1.0	FIA Depth-Damage data
SFNB	-2.0	USACE, EGM 04-01
SFWB	-8.0	USACE, EGM 04-01
Commercial structures, incl. special purpose	-0.5	USACE, Louisiana Feasibility Study
BR	-6.0	NRCS, 2002 Rockhouse Creek Watershed Flood Protection Study

Additional Damages Valuation for Flood Damage Analysis

For the flood damage analysis, additional categories of damage were also incorporated into the analysis, separate from the HEC-FDA modeling that only analyzed damages to structure and content of residential, non-residential structure and bridges. The additional damages are listed in Table 17.

Table 17. Average Annual Costs Associated with Additional Damage Categories for Future without Project

Category	Average Annual Costs
Lost wages from people employed in the Rockhouse Creek Community	$6,364
Lost revenue by Begley Lumber	$16,776
Lost revenue by businesses (other than Begley Lumber) in the Rockhouse Creek Community	$20,451
Roads	
Highway 421	$11,686
County Roads	$8,880
Utilities (KY Power and TDS Telecom)	$3,030
Total Additional Flood-Related Damages	**$67,187**

To calculate average annual costs, an estimated damage cost was first associated with a flood event (see Table 18 below). To calculate average annual damage, damage attributed to each storm event (1 to 500 year) were calculated using either the percentage of road points flooded, bridges flooded, or non-residential structures flooded during each storm event. This method was used to calculate the cost of the additional damages for each of the alternative. Tables 19, 20, and

21 shows the percent of roads, bridges, and non-residential structures flooded with each storm event during the conditions associated with each alternative.

Table 18. Damage attributed to a Specific Storm Event for Additional Cost Categories

Category	Damage	Attributed Storm Event	Additional Information	Source(s)
Lost wages from people employed in the Rockhouse Creek Community	$37,933.44	25-year	Loss from 3 days of downtime; used percent of non-residential structures flooded to calculate damages associated with storm events	Economic Census 1997 – NAICS Basis; Bureau of Labor Statistics 2001 – Manufacturing hours and earnings for KY; Personal communication with Vance Mosley (Kentucky Field Services Realty, Inc.)
Lost revenue by Begley Lumber	$100,000	25-year	Loss from 5 days of downtime; used percent of non-residential structures flooded to calculate damages associated with storm events	Personal communication with Tate Begley -Begley Lumber; HEC-FDA analysis.
Lost revenue by businesses (other than Begley Lumber) in the Rockhouse Creek Community	$121,910	25-year	Loss from 5 days of downtime; used percent of non-residential structures flooded to calculate damages associated with storm events	Economic Census 1997 – NAICS Basis; Bureau of Labor Statistics 2001 – Manufacturing hours and earnings for KY; Personal communication with Vance Mosley (Kentucky Field Services Realty, Inc.); HEC-FDA analysis.
Roads				
US Highway 421	$52,500	25-year	Damage to portions of US Hwy 421 located within the Rockhouse Creek Community; used percent of	Gary Mitchell - KY Highway Department

			road points flooded to calculate damages associated with storm events	
County Roads	$40,000	10-year	Used percent of bridges flooded to calculate damages associated with storm events	Charles Pence - Coordinator, Leslie County Emergency Management and Angela Muncy - Hyden City Clerk
Utilities (electric and telephone)	$10,000 each	10-year for electric and 25-year for telephone	Used percent of road points and bridges flooded to calculate damages associated with storm events (averaged)	Personal communication with James Whitaker -TDS Telecom; Everett Phillips – Kentucky Power Company

Table 19. Percent of Road Points Flooded

STORM	FWOP	FRS123	FRS23	FRS2	FRS3	Bridge & Channel Improvements
500-year	68.2%	36.4%	47.0%	62.1%	57.6%	68.2%
100-year	53.0%	22.7%	25.8%	37.9%	39.4%	53.0%
50-year	40.9%	19.7%	22.7%	28.8%	28.8%	39.4%
25-year	28.8%	10.6%	15.2%	22.7%	22.7%	24.2%
10-year	18.2%	6.1%	7.6%	6.1%	10.6%	13.6%
5-year	4.5%	3.0%	4.5%	4.5%	4.5%	4.5%
2-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 20. Percent of Bridges Flooded

STORM	FWOP	FRS123	FRS23	FRS2	FRS3	Bridge & Channel Improvements
500-year	95.8%	87.5%	95.8%	95.8%	95.8%	95.8%
100-year	95.8%	79.2%	79.2%	95.8%	95.8%	95.8%
50-year	95.8%	75.0%	79.2%	83.3%	83.3%	91.7%
25-year	83.3%	62.5%	70.8%	79.2%	79.2%	83.3%
10-year	83.3%	50.0%	58.3%	66.7%	75.0%	75.0%

5-year	58.3%	20.8%	25.0%	37.5%	45.8%	54.2%
2-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 21. Percent of Non-residential Structures Flooded						
STORM	**FWOP**	**FRS123**	**FRS23**	**FRS2**	**FRS3**	**Bridge & Channel Improvements**
500-year	37.5%	23.1%	26.1%	30.6%	30.4%	36.8%
100-year	28.3%	7.7%	11.6%	21.9%	22.1%	28.6%
50-year	23.0%	3.4%	5.2%	12.7%	12.5%	23.5%
25-year	8.4%	1.0%	1.0%	3.4%	3.5%	8.8%
10-year	1.9%	0.6%	0.7%	1.3%	1.2%	1.6%
5-year	0.9%	0.4%	0.5%	0.6%	0.6%	0.9%
2-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1-year	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Detailed calculations for average annual damages for each category of additional damage are provided in the tables 22- 74.

Lost Wages from Employees Employed in the Rockhouse Creek Community

Table 22. Future without Project (FWOP)					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$168,222.89			
			0.008	$147,739.93	$1,181.92
100	0.01	$127,256.96			
			0.01	$115,174.29	$1,151.74
50	0.02	$103,091.62			
			0.02	$70,510.22	$1,410.20
25	0.04	$37,928.82			
			0.06	$23,163.34	$1,389.80
10	0.1	$8,397.85			
			0.1	$6,192.21	$619.22
5	0.2	$3,986.58			
			0.3	$2,009.14	$ 602.74
2	0.5	$31.70			
			0.5	$15.85	$7.92
1	1	$ -			
				Total	**$6,363.55**

Table 23. With FRS 1,2 and 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$103,912.18			
			0.008	$69,227.77	$ 553.82
100	0.01	$34,543.36			
			0.01	$24,973.62	$249.74
50	0.02	$15,403.87			
			0.02	$9,931.16	$ 198.62
25	0.04	$4,458.44			
			0.06	$3,464.46	$ 207.87
10	0.1	$2,470.49			
			0.1	$2,228.68	$ 222.87
5	0.2	$1,986.88			
			0.3	$993.44	$298.03
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$1,730.95**

Table 24. With FRS 2 and 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$117,364.05			
			0.008	$84,752.25	$ 678.02
100	0.01	$52,140.45			
			0.01	$37,761.40	$ 377.61
50	0.02	$23,382.36			
			0.02	$13,968.10	$ 279.36
25	0.04	$4,553.83			
			0.06	$3,795.53	$ 227.73
10	0.1	$3,037.22			
			0.1	$2,645.81	$ 264.58
5	0.2	$2,254.40			
			0.3	$1,127.20	$338.16
2	0.5	$-			
			0.5	$ -	$-
1	1	$-			
				Total	**$2,165.47**

Table 25. With FRS 2					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$137,511.31			
			0.008	$117,965.27	$943.72
100	0.01	$ 98,419.23			
			0.01	$77,742.10	$777.42
50	0.02	$57,064.97			
			0.02	$36,263.35	$ 725.27
25	0.04	$15,461.72			
			0.06	$10,561.09	$633.67
10	0.1	$5,660.46			
			0.1	$ 4,068.05	$406.80
5	0.2	$2,475.64			
			0.3	$1,237.82	$371.35
2	0.5	$-			
			0.5	$ -	$-
1	1	$-			
				Total	**$3,858.23**

Table 26. With FRS 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$136,471.56			
			0.008	$117,812.12	$942.50
100	0.01	$99,152.67			
			0.01	$77,733.65	$777.34
50	0.02	$56,314.64			
			0.02	$36,011.62	$720.23
25	0.04	$15,708.60			
			0.06	$10,606.79	$636.41
10	0.1	$5,504.99			
			0.1	$3,999.07	$399.91
5	0.2	$2,493.15			
			0.3	$1,246.58	$373.97
2	0.5	$-			
			0.5	$-	$-
1	1	$-			

				Total	**$3,850.35**

Table 27. Bridge & Channel Improvement					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$165,330.70			
			0.008	$146,866.43	$1,174.93
100	0.01	$128,402.17			
			0.01	$116,928.14	$1,169.28
50	0.02	$105,454.12			
			0.02	$72,422.07	$1,448.44
25	0.04	$39,390.03			
			0.06	$23,366.28	$1,401.98
10	0.1	$7,342.54			
			0.1	$5,664.56	$ 566.46
5	0.2	$3,986.58			
			0.3	$2,009.14	$602.74
2	0.5	$31.70			
			0.5	$ 15.85	$7.92
1	1	$-			
				Total	**$6,371.75**

Lost Revenue – Begley Lumber Company

Table 28. Future without Project (FWOP)					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$443,468.61			
			0.008	$389,471.50	$3,115.77
100	0.01	$335,474.38			
			0.01	$303,622.08	$3,036.22
50	0.02	$271,769.78			
			0.02	$185,878.80	$3,717.58
25 [(1)]	0.04	$99,987.83			
			0.06	$61,063.11	$3,663.79

10	0.1	$22,138.39			
			0.1	$16,323.89	$1,632.39
5	0.2	$10,509.40			
			0.3	$5,296.48	$1,588.94
2	0.5	$83.56			
			0.5	$41.78	$ 20.89
1	1	$-			
				Total	**16,775.58**

(1) Income loss during a 25-year storm is from 3 weeks of down time.

Table 29. With FRS 1,2, and 3 only

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$273,932.94			
			0.008	$182,498.02	$1,459.98
100	0.01	$91,063.10			
			0.01	$65,835.37	$658.35
50	0.02	$40,607.63			
			0.02	$26,180.48	$523.61
25 (1)	0.04	$11,753.32			
			0.06	$9,133.01	$547.98
10	0.1	$6,512.69			
			0.1	$5,875.24	$587.52
5	0.2	$5,237.80			
			0.3	$2,618.90	$785.67
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$4,563.12**

Table 30. With FRS 2, and 3 only

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$309,394.72			
			0.008	$223,423.60	$1,787.39
100	0.01	$137,452.47			
			0.01	$99,546.49	$995.46
50	0.02	$61,640.50			
			0.02	$36,822.65	$736.45
25 (1)	0.04	$12,004.79			
			0.06	$10,005.75	$600.35

10	0.1	$8,006.71			
			0.1	$6,974.87	$697.49
5	0.2	$5,943.04			
			0.3	$2,971.52	$891.46
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$5,708.59**

Table 31. With FRS 2 only

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$362,506.87			
			0.008	$310,979.66	$2,487.84
100	0.01	$259,452.44			
			0.01	$204,943.47	$2,049.43
50	0.02	$150,434.49			
			0.02	$95,597.31	$1,911.95
25 (1)	0.04	$40,760.14			
			0.06	$27,841.11	$1,670.47
10	0.1	$14,922.08			
			0.1	$10,724.17	$1,072.42
5	0.2	$6,526.27			
			0.3	$3,263.14	$978.94
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$10,171.04**

Table 32. With FRS 3 only

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$359,765.88			
			0.008	$310,575.91	$2,484.61
100	0.01	$261,385.93			
			0.01	$204,921.00	$2,049.21
50	0.02	$148,456.46			
			0.02	$94,933.71	$1,898.67
25 (1)	0.04	$41,410.95			
			0.06	$27,961.59	$1,677.70
10	0.1	$14,512.23			

			0.1	$10,542.34	$1,054.23
5	0.2	$6,572.44			
			0.3	$3,286.22	$985.87
2	0.5	$-			
			0.5	$-	$ -
1	1	$-			
				Total	**$10,150.29**

Table 33. With Bridge and Channel Improvements					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$435,844.24			
			0.008	$387,168.80	$3,097.35
100	0.01	$338,493.36			
			0.01	$308,245.58	$3,082.46
50	0.02	$277,997.80			
			0.02	$190,918.83	$3,818.38
25 (1)	0.04	$103,839.86			
			0.06	$61,598.12	$3,695.89
10	0.1	$19,356.38			
			0.1	$14,932.89	$1,493.29
5	0.2	$10,509.40			
			0.3	$5,296.48	$1,588.94
2	0.5	$83.56			
			0.5	$41.78	$20.89
1	1	$-			
				Total	**$16,797.19**

Lost Revenue – All Businesses Located in the Rockhouse Creek Community (except Begley Lumber Company)

Table 34. Future without Project (FWOP)					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$540,635.49			
			0.008	$474,807.26	$3,798.46
100	0.01	$408,979.02			
			0.01	$370,147.67	$3,701.48
50	0.02	$331,316.31			
			0.02	$226,606.07	$4,532.12
25	0.04	$121,895.82			

			0.06	$74,442.44	$4,466.55
10	0.1	$26,989.05			
			0.1	$19,900.57	$1,990.06
5	0.2	$12,812.08			
			0.3	$6,456.98	$1,937.09
2	0.5	$101.87			
			0.5	$50.93	$25.47
1	1	$-			
				Total	**$20,451.22**

Table 35. With FRS 1,2, and 3

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$333,953.45			
			0.008	$224,484.53	$1,779.88
100	0.01	$111,015.62			
			0.01	$80,260.33	$802.60
50	0.02	$49,505.03			
			0.02	$31,916.79	$638.34
25	0.04	$14,328.55			
			0.06	$11,134.11	$668.05
10	0.1	$7,939.66			
			0.1	$7,162.55	$716.25
5	0.2	$6,385.44			
			0.3	$3,192.72	$957.82
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$5,562.93**

Table 36. With FRS 2 and 3

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$377,185.14			
			0.008	$272,377.17	$2,179.02
100	0.01	$167,569.21			
			0.01	$121,357.77	$1,213.58
50	0.02	$75,146.34			
			0.02	$44,890.73	$897.81
25	0.04	$14,635.12			

			0.06	$12,198.08	$731.88
10	0.1	$9,761.04			
			0.1	$8,503.12	$850.31
5	0.2	$7,245.19			
			0.3	$3,622.60	$1,086.78
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$6,959.39**

Table 37. With FRS 2

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$441,934.50			
			0.008	$379,117.34	$3,032.94
100	0.01	$316,300.18			
			0.01	$249,847.92	$2,498.48
50	0.02	$183,395.67			
			0.02	$116,543.31	$2,330.87
25	0.04	$ 49,690.95			
			0.06	$33,941.28	$2,036.48
10	0.1	$18,191.60			
			0.1	$13,073.91	$1,307.39
5	0.2	$7,956.22			
			0.3	$3,978.11	$1,193.43
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$12,399.58**

Table 38. With FRS 3

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$438,592.94			
			0.008	$378,625.12	$3,029.00
100	0.01	$318,657.30			
			0.01	$249,820.77	$2,498.21
50	0.02	$180,984.24			
			0.02	$115,734.30	$2,314.69
25	0.04	$50,484.37			

			0.06	$34,088.16	$2,045.29
10	0.1	$17,691.96			
			0.1	$12,852.24	$1,285.22
5	0.2	$8,012.51			
			0.3	$4,006.26	$1,201.88
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$12,374.28**

Table 39. With Bridge and Channel Improvements

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$531,340.57			
			0.008	$472,000.02	$3,776.00
100	0.01	$412,659.48			
			0.01	$375,784.21	$3,757.84
50	0.02	$338,908.95			
			0.02	$232,750.40	$4,655.01
25	0.04	$126,591.85			
			0.06	$75,094.67	$4,505.68
10	0.1	$23,597.49			
			0.1	$18,204.78	$1,820.48
5	0.2	$12,812.08			
			0.3	$6,456.98	$1,937.09
2	0.5	$101.87			
			0.5	$50.93	$25.47
1	1	$-			
				Total	**$20,477.57**

Damages to Highway 421

Table 40. Future without Project (FWOP)

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$124,322.92			
			0.008	$110,468.75	$ 883.75
100	0.01	$96,614.58			
			0.01	$85,585.94	$855.86
50	0.02	$74,557.29			

			0.02	$63,528.65	$1,270.57
25	0.04	$52,500.00			
			0.06	$42,838.54	$2,570.31
10	0.1	$33,177.08			
			0.1	$20,690.10	$2,069.01
5	0.2	$8,203.13			
			0.3	$4,101.56	$1,230.47
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$8,879.97**

Table 41. With FRS 1,2, and 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$66,354.17			
			0.008	$53,867.19	$430.94
100	0.01	$41,380.21			
			0.01	$38,645.83	$386.46
50	0.02	$35,911.46			
			0.02	$27,617.19	$ 552.34
25	0.04	$19,322.92			
			0.06	$15,221.35	$913.28
10	0.1	$11,119.79			
			0.1	$8,294.27	$829.43
5	0.2	$5,468.75			
			0.3	$2,734.38	$820.31
2	0.5	$-			
			0.5	$-	$ -
1	1	$-			
				Total	**$3,932.76**

Table 42. FRS 2,3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$85,677.08			
			0.008	$66,354.17	$530.83
100	0.01	$47,031.25			
			0.01	$44,205.73	$442.06
50	0.02	$41,380.21			

			0.02	$34,544.27	$690.89
25	0.04	$27,708.33			
			0.06	$20,781.25	$1,246.88
10	0.1	$13,854.17			
			0.1	$11,028.65	$1,102.86
5	0.2	$8,203.13			
			0.3	$4,101.56	$1,230.47
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$5,243.98**

Table 43. With FRS 2

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$113,203.13			
			0.008	$91,145.83	$729.17
100	0.01	$69,088.54			
			0.01	$60,794.27	$607.94
50	0.02	$52,500.00			
			0.02	$46,940.10	$938.80
25	0.04	$ 41,380.21			
			0.06	$26,250.00	$1,575.00
10	0.1	$11,119.79			
			0.1	$9,661.46	$966.15
5	0.2	$8,203.13			
			0.3	$4,101.56	$1,230.47
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$6,047.53**

Table 44. With FRS 3

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$105,000.00			
			0.008	$88,411.46	$707.29
100	0.01	$71,822.92			
			0.01	$62,161.46	$621.61
50	0.02	$52,500.00			
			0.02	$46,940.10	$938.80

25	0.04	$41,380.21			
			0.06	$30,351.56	$1,821.09
10	0.1	$19,322.92			
			0.1	$13,763.02	$1,376.30
5	0.2	$8,203.13			
			0.3	$4,101.56	$1,230.47
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$6,695.57**

Damages to County Roads

Table 45. Future without Project (FWOP)					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$46,265.06			
			0.008	$46,265.06	$370.12
100	0.01	$46,265.06			
			0.01	$46,265.06	$462.65
50	0.02	$46,265.06			
			0.02	$43,132.53	$ 862.65
25	0.04	$40,000.00			
			0.06	$40,000.00	$2,400.00
10	0.1	$40,000.00			
			0.1	$33,975.90	$3,397.59
5	0.2	$27,951.81			
			0.3	$13,975.90	$4,192.77
2	0.5	$ -			
			0.5	$ -	$-
1	1	$-			
				Total	**$11,685.78**

Table 46. With FRS 1,2, and 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$42,409.64			
			0.008	$40,240.96	$321.93
100	0.01	$38,072.29			
			0.01	$37,108.43	$371.08
50	0.02	$36,144.58			

			0.02	$33,253.01	$665.06
25	0.04	$30,361.45			
			0.06	$27,228.92	$1,633.73
10	0.1	$24,096.39			
			0.1	$17,108.43	$1,710.84
5	0.2	$10,120.48			
			0.3	$5,060.24	$1,518.07
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$6,220.72**

Table 47. With FRS 2 and 3

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$46,265.06			
			0.008	$42,168.67	$337.35
100	0.01	$38,072.29			
			0.01	$38,072.29	$380.72
50	0.02	$38,072.29			
			0.02	$36,144.58	$722.89
25	0.04	$34,216.87			
			0.06	$ 31,084.34	$1,865.06
10	0.1	$27,951.81			
			0.1	$20,000.00	$2,000.00
5	0.2	$12,048.19			
			0.3	$6,024.10	$1,807.23
2	0.5	$ -			
			0.5	$-	$ -
1	1	-			
				Total	**$7,113.25**

Table 48. With FRS 2

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$46,265.06			
			0.008	$46,265.06	$370.12
100	0.01	$46,265.06			
			0.01	$43,132.53	$431.33
50	0.02	$40,000.00			
			0.02	$39,036.14	$780.72

25	0.04	$38,072.29			
			0.06	$35,180.72	$2,110.84
10	0.1	$32,289.16			
			0.1	$25,301.20	$2,530.12
5	0.2	$18,313.25			
			0.3	$9,156.63	$2,746.99
2	0.5	$-			
			0.5	$ -	$-
1	1	$ -			
				Total	**$8,970.12**

Table 49. With FRS 3					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$46,265.06			
			0.008	$46,265.06	$370.12
100	0.01	$46,265.06			
			0.01	$43,132.53	$431.33
50	0.02	$40,000.00			
			0.02	$39,036.14	$780.72
25	0.04	$38,072.29			
			0.06	$37,108.43	$2,226.51
10	0.1	$36,144.58			
			0.1	$29,156.63	$2,915.66
5	0.2	$22,168.67			
			0.3	$11,084.34	$3,325.30
2	0.5	$-			
			0.5	-	$ -
1	1	$ -			
				Total	**10,049.64**

Table 50. Bridge & Channel Improvement					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$46,265.06			
			0.008	$46,265.06	$370.12
100	0.01	$46,265.06			
			0.01	$45,301.20	$453.01
50	0.02	$44,337.35			
			0.02	$42,168.67	$843.37
25	0.04	$40,000.00			

			0.06	$38,072.29	$2,284.34
10	0.1	$36,144.58			
			0.1	$31,084.34	$3,108.43
5	0.2	$26,024.10			
			0.3	$13,012.05	$3,903.61
2	0.5	$ -			
			0.5	$ -	$-
1	1	$-			
				Total	**$10,962.89**

Damage to Utilities

Table 51. Future without Project (FWOP) - KY Power					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$37,472.53			
			0.008	$33,296.70	$266.37
100	0.01	$29,120.88			
			0.01	$25,796.70	$257.97
50	0.02	$22,472.53			
			0.02	$19,148.35	$382.97
25	0.04	$15,824.18			
			0.06	$12,912.09	$774.73
10	0.1	$10,000.00			
			0.1	$6,236.26	$623.63
5	0.2	$2,472.53			
			0.3	$1,236.26	$370.88
2	0.5	$ -			
			0.5	-	$-
1	1	$-			
				Total	**$2,676.54**

*Damages calculated using percent of road points flooded.

Table 52. Future without Project - TDS Telecom					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$2,368.06			
			0.008	$2,104.17	$16.83
100	0.01	$1,840.28			
			0.01	$1,630.21	$ 16.30

50	0.02	$1,420.14			
			0.02	$1,210.07	$24.20
25	0.04	$1,000.00			
			0.06	$815.97	$ 48.96
10	0.1	$631.94			
			0.1	$394.10	$ 39.41
5	0.2	$156.25			
			0.3	$ 78.13	$ 23.44
2	0.5	$ -			
			0.5	$-	$ -
1	1	$-			
				Total	**$169.14**

*Damages calculated using percent of road points flooded.

Table 53. Future without Project (FWOP) - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$11,566.27			
			0.008	$11,566.27	$92.53
100	0.01	$11,566.27			
			0.01	$11,566.27	$115.66
50	0.02	$ 11,566.27			
			0.02	$10,783.13	$215.66
25	0.04	$10,000.00			
			0.06	$10,000.00	$ 600.00
10	0.1	$10,000.00			
			0.1	$8,493.98	$849.40
5	0.2	$6,987.95			
			0.3	$3,493.98	$1,048.19
2	0.5	$ -			
			0.5	$ -	$-
1	1	$-			
				Total	**$2,921.45**

*Damages calculated using percent of bridges flooded.

Table 54. Future without Project - TDS Telecom)

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$1,156.63			
			0.008	$ 1,156.63	$ 9.25

100	0.01	$1,156.63			
			0.01	$1,156.63	$11.57
50	0.02	$1,156.63			
			0.02	$1,078.31	$21.57
25	0.04	$1,000.00			
			0.06	$ 1,000.00	$60.00
10	0.1	$1,000.00			
			0.1	$849.40	$84.94
5	0.2	$698.80			
			0.3	$349.40	$104.82
2	0.5	$-			
			0.5	$-	$ -
1	1	$ -			
				Total	**$ 292.14**

*Damages calculated using percent of bridges flooded.

Table 55. With FRS 1,2, and 3 - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$20,000.00			
			0.008	$16,236.26	$129.89
100	0.01	$12,472.53			
			0.01	$11,648.35	$116.48
50	0.02	$10,824.18			
			0.02	$8,324.18	$166.48
25	0.04	$5,824.18			
			0.06	$4,587.91	$275.27
10	0.1	$3,351.65			
			0.1	$2,500.00	$250.00
5	0.2	$1,648.35			
			0.3	$824.18	$ 247.25
2	0.5	$-			
			0.5	$ -	$ -
1	1	$ -			
				Total	**$1,185.38**

*Damages calculated using percent of road points flooded.

Table 56. With FRS 1,2, and 3 – TDS Telecom

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage

500	0.002	$1,263.89			
			0.008	$1,026.04	$8.21
100	0.01	$788.19			
			0.01	$ 736.11	$ 7.36
50	0.02	$684.03			
			0.02	$ 526.04	$10.52
25	0.04	$368.06			
			0.06	$ 289.93	$17.40
10	0.1	$211.81			
			0.1	$157.99	$15.80
5	0.2	$104.17			
			0.3	$ 52.08	$ 15.63
2	0.5	$ -			
			0.5	$-	$-
1	1	$ -			
				Total	**$ 74.91**

*Damages calculated using percent of road points flooded.

Table 57. With FRS 1,2, and 3 - KY Power					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$10,602.41			
			0.008	$10,060.24	$80.48
100	0.01	$9,518.07			
			0.01	$ 9,277.11	$92.77
50	0.02	$9,036.14			
			0.02	$8,313.25	$166.27
25	0.04	$7,590.36			
			0.06	$6,807.23	$408.43
10	0.1	$6,024.10			
			0.1	$4,277.11	$427.71
5	0.2	$2,530.12			
			0.3	$1,265.06	$379.52
2	0.5	$-			
			0.5	$ -	$ -
1	1	$ -			
				Total	**$1,555.18**

*Damages calculated using percent of bridges flooded.

Table 58. With FRS 1,2, and 3 – TDS Telecom)					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage

500	0.002	$1,060.24			
			0.008	$1,006.02	$8.05
100	0.01	$951.81			
			0.01	$927.71	$9.28
50	0.02	$ 903.61			
			0.02	$831.33	$16.63
25	0.04	$759.04			
			0.06	$680.72	$40.84
10	0.1	$ 602.41			
			0.1	$427.71	$42.77
5	0.2	$253.01			
			0.3	$126.51	$37.95
2	0.5	$ -			
			0.5	$ -	$-
1	1	$-			
				Total	**$155.52**

*Damages calculated using percent of bridges flooded.

Table 59. With FRS 2 and 3 - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$25,824.18			
			0.008	$20,000.00	$ 160.00
100	0.01	$14,175.82			
			0.01	$13,324.18	$ 133.24
50	0.02	$12,472.53			
			0.02	$10,412.09	$208.24
25	0.04	$8,351.65			
			0.06	$6,263.74	$375.82
10	0.1	$4,175.82			
			0.1	$3,324.18	$332.42
5	0.2	$2,472.53			
			0.3	$1,236.26	$ 370.88
2	0.5	$-			
			0.5	$ -	$ -
1	1	$ -			
				Total	**$1,580.60**

*Damages calculated using percent of road points flooded.

Table 60. With FRS 2 and 3 - TDS Telecom

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual

					damage
500	0.002	$1,631.94			
			0.008	$1,263.89	$10.11
100	0.01	$895.83			
			0.01	$ 842.01	$ 8.42
50	0.02	$788.19			
			0.02	$ 657.99	$ 13.16
25	0.04	$527.78			
			0.06	$ 395.83	$ 23.75
10	0.1	$263.89			
			0.1	$ 210.07	$ 21.01
5	0.2	$156.25			
			0.3	$ 78.13	$ 23.44
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$ 99.89**

*Damages calculated using percent of road points flooded.

Table 61. With FRS 2 and 3 - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$ 11,566.27			
			0.008	$10,542.17	$84.34
100	0.01	$9,518.07			
			0.01	$9,518.07	$95.18
50	0.02	$9,518.07			
			0.02	$9,036.14	$180.72
25	0.04	$8,554.22			
			0.06	$ 7,771.08	$466.27
10	0.1	$6,987.95			
			0.1	$5,000.00	$500.00
5	0.2	$3,012.05			
			0.3	$ 1,506.02	$451.81
2	0.5	$ -			
			0.5	$ -	$ -
1	1	$-			
				Total	**$1,778.31**

*Damages calculated using percent of bridges flooded.

Table 62. With FRS 2 and 3 - TDS Telecom)

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$1,156.63			
			0.008	$1,054.22	$8.43
100	0.01	$951.81			
			0.01	$951.81	$ 9.52
50	0.02	$ 951.81			
			0.02	$903.61	$18.07
25	0.04	$855.42			
			0.06	$777.11	$46.63
10	0.1	$698.80			
			0.1	$500.00	$50.00
5	0.2	$301.20			
			0.3	$150.60	$45.18
2	0.5	$ -			
			0.5	$ -	$-
1	1	$-			
				Total	**177.83**

*Damages calculated using percent of bridges flooded.

Table 63. With FRS 2 - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$34,120.88			
			0.008	$27,472.53	$219.78
100	0.01	$20,824.18			
			0.01	$18,324.18	$183.24
50	0.02	$15,824.18			
			0.02	$14,148.35	$282.97
25	0.04	$12,472.53			
			0.06	$7,912.09	$474.73
10	0.1	$3,351.65			
			0.1	$2,912.09	$291.21
5	0.2	$2,472.53			
			0.3	$1,236.26	$370.88
2	0.5	$-			
			0.5	$-	$ -
1	1	$ -			
				Total	**$1,822.80**

*Damages calculated using percent of road points flooded.

Table 64. With FRS 2 - TDS Telecom					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$2,156.25			
			0.008	$1,736.11	$13.89
100	0.01	$1,315.97			
			0.01	$1,157.99	$11.58
50	0.02	$1,000.00			
			0.02	$ 894.10	$ 17.88
25	0.04	$788.19			
			0.06	$500.00	$ 30.00
10	0.1	$211.81			
			0.1	$184.03	$18.40
5	0.2	$156.25			
			0.3	$ 78.13	$23.44
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$115.19**

*Damages calculated using percent of road points flooded.

Table 65. With FRS 2 - KY Power					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$11,566.27			
			0.008	$11,566.27	$92.53
100	0.01	$11,566.27			
			0.01	$10,783.13	$107.83
50	0.02	$10,000.00			
			0.02	$9,759.04	$195.18
25	0.04	$9,518.07			
			0.06	$8,795.18	$527.71
10	0.1	$8,072.29			
			0.1	$6,325.30	$632.53
5	0.2	$4,578.31			
			0.3	$2,289.16	$686.75
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$2,242.53**

*Damages calculated using percent of bridges flooded.

Table 66. With FRS 2 - TDS Telecom					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$1,156.63			
			0.008	$1,156.63	$9.25
100	0.01	$1,156.63			
			0.01	$1,078.31	$10.78
50	0.02	$1,000.00			
			0.02	$975.90	$19.52
25	0.04	$ 951.81			
			0.06	$879.52	$52.77
10	0.1	$807.23			
			0.1	$632.53	$ 63.25
5	0.2	$457.83			
			0.3	$ 228.92	$68.67
2	0.5	$-			
			0.5	$ -	$-
1	1	$-			
				Total	**$224.25**

*Damages calculated using percent of bridges flooded.

Table 67. With FRS 3 - KY Power					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$31,648.35			
			0.008	$26,648.35	$213.19
100	0.01	$21,648.35			
			0.01	$18,736.26	$187.36
50	0.02	$15,824.18			
			0.02	$14,148.35	$282.97
25	0.04	$12,472.53			
			0.06	$9,148.35	$ 548.90
10	0.1	$5,824.18			
			0.1	$4,148.35	$414.84
5	0.2	$2,472.53			
			0.3	$1,236.26	$370.88
2	0.5	$-			
			0.5	$ -	$ -
1	1	$ -			
				Total	**$2,018.13**

*Damages calculated using percent of road points flooded.

Table 68. With FRS 3 - TDS Telecom					
Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$2,000.00			
			0.008	$1,684.03	$13.47
100	0.01	$1,368.06			
			0.01	$1,184.03	$ 11.84
50	0.02	$1,000.00			
			0.02	$ 894.10	$ 17.88
25	0.04	$788.19			
			0.06	$578.13	$ 34.69
10	0.1	$368.06			
			0.1	$262.15	$ 26.22
5	0.2	$156.25			
			0.3	$ 78.13	$23.44
2	0.5	$ -			
			0.5	$-	$-
1	1	$ -			
				Total	**$127.53**

*Damages calculated using percent of road points flooded.

Table 69. With FRS 3 - KY Power					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$11,566.27			
			0.008	$11,566.27	$92.53
100	0.01	$11,566.27			
			0.01	$10,783.13	$107.83
50	0.02	$10,000.00			
			0.02	$9,759.04	$195.18
25	0.04	$9,518.07			
			0.06	$9,277.11	$556.63
10	0.1	$9,036.14			
			0.1	$7,289.16	$728.92
5	0.2	$5,542.17			
			0.3	$2,771.08	$831.33
2	0.5	$-			
			0.5	$ -	$ -
1	1	$ -			

				Total	**$2,512.41**

*Damages calculated using percent of bridges flooded.

Table 70. With FRS 3 - TDS Telecom

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$1,156.63			
			0.008	$ 1,156.63	$ 9.25
100	0.01	$1,156.63			
			0.01	$1,078.31	$10.78
50	0.02	$1,000.00			
			0.02	$975.90	$19.52
25	0.04	$951.81			
			0.06	$927.71	$55.66
10	0.1	$903.61			
			0.1	$728.92	$72.89
5	0.2	$554.22			
			0.3	$277.11	$83.13
2	0.5	$-			
			0.5	$-	$-
1	1	$-			
				Total	**$251.24**

*Damages calculated using percent bridges flooded.

Table 71. With Bridge and Channel Improvements - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$37,462.54			
			0.008	$33,300.03	$266.40
100	0.01	$29,137.53			
			0.01	$25,391.28	$253.91
50	0.02	$21,645.02			
			0.02	$17,482.52	$349.65
25	0.04	$13,320.01			
			0.06	$10,406.26	$624.38
10	0.1	$7,492.51			
			0.1	$4,995.00	$ 499.50
5	0.2	$2,497.50			
			0.3	$1,248.75	$374.63
2	0.5	$-			
			0.5	$-	$-

1	1	$-			
				Total	**$2,368.46**

*Damages calculated using percent of road points flooded.

Table 72. With Bridge and Channel Improvements - TDS Telecom

Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$2,367.42			
			0.008	$2,104.38	$16.84
100	0.01	$1,841.33			
			0.01	$1,604.59	$ 16.05
50	0.02	$1,367.85			
			0.02	$1,104.80	$22.10
25	0.04	$841.75			
			0.06	$657.62	$ 39.46
10	0.1	$473.48			
			0.1	$ 315.66	$ 31.57
5	0.2	$157.83			
			0.3	$ 78.91	$ 23.67
2	0.5	$ -			
			0.5	$ -	$ -
1	1	$-			
				Total	**$149.67**

*Damages calculated using percent of road points flooded.

Table 73. With Bridge and Channel Improvements - KY Power

Year Occurrence	Frequency	Damage*	Change in Frequency	Average damage	Average Annual damage
500	0.002	$11,566.27			
			0.008	$11,566.27	$92.53
100	0.01	$11,566.27			
			0.01	$11,325.30	$113.25
50	0.02	$11,084.34			
			0.02	$10,542.17	$210.84
25	0.04	$10,000.00			
			0.06	$9,518.07	$571.08
10	0.1	$9,036.14			
			0.1	$7,771.08	$777.11
5	0.2	$6,506.02			
			0.3	$3,253.01	$975.90
2	0.5	$-			

			0.5	$-	$-
1	1	$ -			
				Total	**$2,740.72**

*Damages calculated using percent bridges flooded.

Table 74. With Bridge and Channel Improvements - TDS Telecom					
Year Occurrence	Frequency	Damage	Change in Frequency	Average damage	Average Annual damage
500	0.002	$1,156.63			
			0.008	$1,156.63	$9.25
100	0.01	$1,156.63			
			0.01	$ 1,132.53	$11.33
50	0.02	$1,108.43			
			0.02	$1,054.22	$21.08
25	0.04	$1,000.00			
			0.06	$951.81	$57.11
10	0.1	$903.61			
			0.1	$777.11	$77.71
5	0.2	$650.60			
			0.3	$325.30	$97.59
2	0.5	$-			
			0.5	$-	$-
1	1	$ -			
				Total	**$274.07**

*Damages calculated using percent bridges flooded.

Modeling Uncertainty

The URB1 model does not take into account the uncertainty of the modeled parameters in its flood damage analysis.

HEC –FDA does incorporate risk and uncertainty in its estimate of flood damages. Risk involves exposure to a chance of loss. The fact that risk inherently involves chance leads directly to a need to describe and to deal with uncertainty.

In planning, decisions are made with information that is uncertain. In flood-damage-reduction planning, uncertainty is associated with:

- future hydrologic events, including future streamflow and rainfall. In discharge probability analysis, this includes uncertainty regarding the choice of a statistical distribution and uncertainty regarding values of parameters of the distribution.
- use of simplified models to describe complex hydraulic phenomena, from the lack of detailed geometric data, from material variability, and from errors in estimating slope and roughness factor.

- lack of information regarding economics and social conditions, about the relationship between depth and inundation damage and lack of accuracy in estimating structure values and locations.

As mentioned above, uncertainty takes into account the error that could be introduced when calculating stage-discharge and stage-damage. A statistical distribution is used to describe the error.

Uncertainty in Stage-discharge

Data for Rockhouse Creek came from modeling and not gauged data. Therefore, Summit Engineering estimated the stage uncertainty by estimating the upper and lower bounds on stage for a given discharge. Then we took that data and converted the stage range to the needed uncertainty statistics.

Uncertainty in Stage-damage

The depth-damage functions used for residential structures (SFNB, SFWB and APT), from EGM 04-01, addresses uncertainty, by providing the standard deviation of damage attributed with structure and content. Standard deviation for residential structures without basements range from 1.6 to 5.0, for structures with basement, the range is 0.83 to 2.88. Standard deviation for content in residential structures without basement range from 1.2 to 4.2, for content in structures with basement, the range is 0.72 to 2.45.

The depth-damage functions used for mobile homes and commercial structures do not address uncertainty, and therefore do not provide standard deviation of damage attributed with structure and content. In these cases, an average standard deviation, based on EGM 04-01, was used. For mobile homes (MH), an average standard deviation of 3 percent for structure and 4 percent for content was used. For commercial and special purpose structures, an average standard deviation of 4 percent for both structure and content was used.

Specification of the first floor elevation is needed to estimate flood damage using the depth-damage relationships. Errors are associated with establishing this elevation, whether the data was gathered using field or aerial surveys. In this case, the first floor elevation was obtained by conducting field surveys using an automatic level. The error associated with this method of elevation estimation is +- 0.03 feet @ 800 ft. The standard deviation used is 0.02 feet. The standard deviation for field survey assumes a 99-percent confidence interval and normal distribution. However, for structures 9100, 9102, 9103, 9104, and 9105, the first floor elevation was estimated using a topographic map. The error associated with this method is +- 5.88 feet and the standard deviation is 3.00 feet. Errors for topographic maps are calculated at the 99-percent confidence level, and assume the deviations from the true elevation are normally distributed with zero mean and indicated standard deviations.

Monte Carlo Simulation

Monte Carlo simulation is used in HEC-FDA to derive the expected annual damage corresponding to a particular analysis year. The expected annual damage is the mean damage obtained by integrating the damage exceedance probability curve for the damage reach. The damage-exceedance probability function is obtained from the discharge-exceedance probability, stage-discharge, and damage-stage relationships. The inclusion of uncertainty for these variables requires a numerical integration approach be applied. If uncertainty is not considered, the damage-exceedance probability curve can be calculated directly without using numerical simulation approaches, in this case, Monte Carlo simulation. This simulation relies on an exceedance probability analysis of samples of the contributing random variable obtained from the generation of random numbers.

The inclusion of uncertainty in estimates of the variable contributing to damage makes it possible to obtain both a best estimate of expected annual damage and a distribution of possible values about the best estimate.

HEC-FDA Modeling Results

Total Damage and Remaining Damage Estimates

Future without Project (FWOP)

Using HEC-RAS to model the floodplain and HEC-FDA to determine flood damages (to basement, foundation, and /or first floor), it is estimated that with current conditions a 100-year storm event floodwaters would affect 128 residences, 19 businesses and public buildings, and 24 bridges. Of those structures affected, 87 residences and 13 businesses would receive first floor flood damages. The table below presents information on the total damages from flooding by storm frequency, as calculated by HEC-FDA.

Table 75. HEC-FDA Estimated Total Property and Content Damage by Frequency, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	23	5	19	$25,400	$17,000	$8,400
2	28	8	20	$43,000	$28,200	$14,800
5	53	30	23	$253,600	$165,400	$88,200
10	90	67	23	$743,400	$500,400	$243,000
25	122	98	24	$1,402,000	$754,900	$647,100
50	148	124	24	$2,769,600	$1,262,900	$1,506,700
100	171	147	24	$3,633,800	$1,729,400	$1,904,400
500	184	160	24	$5,029,800	$2,563,500	$2,466,300

The HEC-FDA analysis resulted in an average annual flood damage to structures and contents, including all storm events, in the Rockhouse Creek floodplain at $339,000 (bridges – $24,300.00, non-residential - $88,700.00, residential - $226,300.00). An additional $67,200 of average annual flood damage is expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total average annual flood damage in the Rockhouse Creek floodplains is estimated to be **$406,500.**

With FRS 1,2, and 3

With the installation of FRSs 1, 2, and 3, annual damages will be reduced 63 percent by $257,300. A total of 52 residential structures and 11 non-residential structures will be completely or significantly protected from 100-year flood damages. All 24 bridges will continue to be flooded; however, damages would be reduced by 41 percent. Flood damages would decrease 51 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 73 percent.

Remaining flood damages can be attributed to structures that will not protected by the three Flood Retarding Structures. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 76. HEC-FDA Estimated Total Property and Content Damage by Frequency, with Installation of FRSs 1,2 and 3, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	19	4	15	$20,700	$13,600	$7,100
2	27	7	20	$29,800	$19,900	$9,900
5	33	12	21	$114,600	$74,800	$39,800
10	41	18	23	$215,200	$144,300	$70,900
25	70	47	23	$383,600	$263,100	$120,500
50	93	69	24	$691,500	$429,000	$262,500
100	108	84	24	$1,056,500	$567,700	$488,800
500	143	119	24	$2,426,400	$1,042,000	$1,384,400

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the implementation of FRSs 1,2, and 3 are estimated at $125,700 (bridges – $14,200.00, non-residential - $21,500.00, residential - $90,000.00). An additional $23,500 of annual flood damage would still be expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated to be **$149,200.**

With FRS 2 and 3

With the installation of FRS 2 and FRS 3, annual damages will be reduced 55 percent by $224,400. A total of 37 residential structures and 10 non-residential structures will be completely or significantly protected from 100-year flood damages. All 24 bridges will continue to be flooded; however, damages would be reduced by 33 percent. Flood damages would decrease 40 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 66 percent.

Remaining flood damages can be attributed to structures that will not protected by FRS 2 and FRS 3. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 77. HEC-FDA Estimated Total Property and Content Damage by Frequency, with Installation of FRSs 2 and 3, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	20	4	16	$21,300	$14,000	$7,300
2	27	7	20	$31,600	$21,000	$10,600
5	37	14	23	$139,600	$92,100	$47,500
10	53	30	23	$275,000	$188,200	$86,800
25	77	54	23	$451,900	$314,400	$137,500
50	98	74	24	$855,600	$479,200	$376,400
100	124	100	24	$1,465,300	$709,800	$755,500
500	154	130	24	$2,996,000	$1,337,500	$1,658,500

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the implementation of FRS 2 and FRS 3 are estimated at $153,200 (bridges – $16,200.00, non-residential - $29,200.00, residential - $107,800.00). An additional $29,000 of annual flood damage would still be expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated at **$182,200.**

With FRS 2

With the installation of FRS 2, annual damages will be reduced 33 percent by $135,800. A total of 15 residential structures and 7 non-residential structures will be completely or significantly protected from 100-year flood damages. All 24 bridges will continue to be flooded; however, damages would be reduced by 19 percent. Flood damages would decrease 27 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 39 percent.

Remaining flood damages can be attributed to structures that will not protected by FRS 2. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 78. HEC-FDA Estimated Total Property and Content Damage by Frequency, with Installation of FRS 2, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	22	4	18	$22,800	$15,000	$7,800
2	28	8	20	$36,600	$24,200	$12,400
5	44	21	23	$172,800	$115,300	$57,500
10	69	46	23	$392,400	$261,200	$131,200
25	99	76	23	$828,200	$513,800	$314,400
50	123	99	24	$1,632,800	$792,700	$840,100
100	149	125	24	$2,544,400	$1,122,400	$1,422,000
500	176	152	24	$3,974,500	$1,947,400	$2,027,100

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the installation of FRS 2 are estimated at $227,100 (bridges – $19,700.00, non-residential - $54,100.00, residential - $153,300.00). An additional $43,600 of annual flood damage would still be expected for roads, utilities, lost of income earned and lost revenue to businesses. The total expected average annual flood damage in the Rockhouse Creek floodplains is estimated to be **$270,700.**

With FRS 3

With the installation of FRS 3, annual damages will be reduced 24 percent by $98,700. A total of 15 residential structures and 6 non-residential structures will be completely or significantly protected from 100-year flood damages. All 24 bridges will continue to be flooded; however, damages would be reduced by 13 percent. Flood damages would decrease 19 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 39 percent.

Remaining flood damages can be attributed to structures that will not protected by FRS 3. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 79. HEC-FDA Estimated Total Property and Content Damage by Frequency, with Installation of FRS 3, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	23	4	19	$23,400	$15,500	$7,900
2	28	8	20	$38,200	$25,200	$13,000
5	47	24	23	$184,000	$123,500	$60,500
10	76	53	23	$407,800	$266,800	$141,000
25	105	82	23	$874,300	$533,800	$340,500
50	126	102	24	$1,706,900	$839,800	$867,100
100	150	126	24	$2,622,900	$1,186,000	$1,436,900
500	175	151	24	$3,957,100	$1,936,600	$2,020,500

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the implementation of FRS 3 are estimated at $237,200 (bridges – $21,100.00, non-residential - $54,900.00, residential - $161,200.00). An additional $45,600 of annual flood damage would still be expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated to be **$282,700.**

With Non-structural Measures

Non-structural measures would reduce annual damages 79 percent by $320,500. A total of 94 residential structures and 12 non-residential structures will be completely or significantly protected from 100-year flood damages. All 24 bridges, portions of Highway 421 and county roads will continue to be flooded with no appreciable reduction in flood damages. Disruptions to utilities and businesses would be similar to the existing conditions.

Flood damages that remain after the implementation of the non-structural measures can be attributed to damage from the 500-year flood event (in the case of 94 residential and 12 non-residential structures floodproofed up to the 100-year flood level) and from structures that did not receive any non-structural floodproofing measures because the 100-year flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 80. Estimated Residual Damage by Frequency, with Installation of Non-structural Measures, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	20	0	20	$5,200	$5,200	$-
2	20	0	20	$10,300	$10,300	$-
5	24	1	23	$40,700	$40,700	$-
10	24	1	23	$97,800	$97,800	$-
25	31	7	24	$114,700	$113,900	$800
50	45	21	24	$173,200	$160,800	$12,400
100	71	47	24	$254,700	$219,000	$35,000
500	85	61	24	$1,002,100	$596,000	$406,100

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the implementation of non-structural measures are estimated at $40,600 (bridges – $24,300, non-residential - $9,200, residential - $7,100). An additional $45,400 of annual flood damage would still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total remaining annual flood damage in the Rockhouse Creek floodplains is estimated to be **$86,000.**

When voluntary participation rates are applied to non-structural measures, annual damages would be reduced 62 percent by $254,900. A total of 74 residential structures and 10 non-residential structures will be completely or significantly protected from 100-year flood damages. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by the participation rates applied.

With Non-structural and Other structural Measures

Employing a combination of non-structural measures, bridge improvements, and channel modifications would reduce annual damages 80 percent by $327,200. A total of 94 residential structures and 12 non-residential structures would be completely or significantly protected from 100-year flood damages. All remaining 22 bridges would continue to be flooded. Flood damages would decrease 9 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 50 percent.

Flood damages that remain after the implementation of the non-structural measures, bridge improvements, and channel modifications can be attributed to damage of flood proofed structures from the 500-year flood event and from structures that did not receive any non-

structural floodproofing measures because the 100-year flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 81. Estimated Residual Damage by Frequency, with Installation of Bridge and Channel Modifications and Non-structural Measures, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	16	0	16	$4,500	$4,500	$-
2	18	0	18	$8,800	$8,800	$-
5	22	1	21	$37,000	$37,000	$-
10	22	1	21	$86,100	$86,100	$-
25	27	6	21	$106,000	$105,600	$400
50	43	21	22	$140,500	$136,300	$4,200
100	65	43	22	$198,000	$179,800	$18,200
500	84	62	22	$907,200	$536,100	$371,100

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the implementation of bridge and channel modifications and non-structural measures are estimated at $35,900 (bridges – $21,600, non-residential - $9,000, residential - $5,300). An additional $43,400 of annual flood damage is still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total remaining annual flood damage in the Rockhouse Creek floodplains is estimated at **$79,300.**

When voluntary participation rates are applied to the non-structural measures, annual damages would be reduced 64 percent by $260,600. A total of 69 residential structures and 9 non-residential structures will be completely or significantly protected from 100-year flood damages. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by participation rates applied to non-structural measures.

With Non-structural Measures and Combination of Flood Retarding Structures

FRS 2, 3, and 1 + non-structural measures

Installing three Flood Retarding Structures and non-structural measures would reduce annual damages 87 percent by $355,300. FRSs 1, 2, and 3 would protect 59 residences and 7 businesses, while non-structural measures would protect 28 residences and 5 businesses from first floor damage in the100-year flood. All 24 bridges will continue to be flooded; however, damages would be reduced by 41 percent. Flood damages would decrease 51 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 73 percent.

Flood damages that remain after the construction of FRSs 1, 2, and 3 and non-structural measures can be attributed to damage of flood proofed structures from the 500-year flood event

and from structures that did not receive any non-structural floodproofing measures because the 100-year flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 82. HEC-FDA Estimated Average Annual Residual Damage by Frequency, with Installation of FRSs 2 and 3 and Non-structural Measures, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	15	0	15	$3,100	$3,100	$-
2	20	0	20	$6,100	$6,100	$-
5	22	0	22	$19,400	$19,400	$-
10	24	1	23	$37,400	$37,400	$-
25	33	10	23	$56,900	$56,100	$800
50	61	37	24	$125,500	$112,400	$13,100
100	65	41	24	$183,600	$153,000	$30,600
500	101	77	24	$561,300	$404,100	$157,200

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the construction of FRSs 1, 2, and 3 and non-structural measures are estimated at $27,700 (bridges – $14,500, non-residential - $1,900, residential - $11,300). An additional $23,500 of annual flood damage is still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated at **$51,200.**

When voluntary participation rates are applied the non-structural measures, in combination with FRSs 1, 2, and 3, annual damages would be reduced 71 percent by $287,800. A total of 22 residential structures and 4 non-residential structures will be completely or significantly protected from 100-year flood damages by non-structural measures; FRSs 1, 2, and 3 would protect 28 residences and 5 businesses. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by participation rates applied to non-structural measures.

FRS 2 and 3 + non-structural measures

Installing FRS2, FRS 3, and non-structural measures would reduce annual damages 84 percent by $342,200. The two Flood Retarding Structures would protect 51 residences and 7 businesses, while non-structural measures would protect 36 residences and 5 businesses from first floor damage in the100-year flood. All 24 bridges will continue to be flooded; however, damages would be reduced by 33 percent. Flood damages would decrease 40 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 66 percent.

Flood damages that remain after the installation of FRS 2, FRS 3, and non-structural measures can be attributed to damage of flood proofed structures from the 500-year flood event and from structures that did not receive any non-structural floodproofing measures because the 100-year

flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 83. HEC-FDA Estimated Average Annual Residual Damage by Frequency, with Installation of FRSs 2 and 3 and Non-structural Measures, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	16	0	16	$3,400	$3,400	$-
2	20	0	20	$6,700	$6,700	$-
5	22	0	22	$23,700	$23,700	$-
10	24	1	23	$54,100	$54,100	$-
25	33	10	23	$91,800	$89,500	$2,300
50	47	23	24	$138,000	$122,300	$15,700
100	74	50	24	$208,600	$172,100	$36,500
500	104	80	24	$929,600	$556,500	$373,100

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the construction of FRSs 2 and 3 and non-structural measures are estimated at $35,300 (bridges – $16,500, non-residential - $5,100, residential - $13,700). An additional $29,000 of annual flood damage is still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated at **$64,300.**

When voluntary participation rates are applied the non-structural measures, in combination with FRSs 2 and 3, annual damages would be reduced 68 percent by $276,000. A total of 28 residential structures and 4 non-residential structures will be completely or significantly protected from 100-year flood damages by non-structural measures; FRSs 2 and 3 would protect 51 residences and 7 businesses. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by participation rates applied to non-structural measures.

FRS 2 + non-structural measures

Installing FRS 2 and non-structural measures would reduce annual damages 80 percent by $325,800. FRS 2 would protect 31 residences and 5 businesses, while non-structural measures would protect 56 residences and 7 businesses from first floor damage in the 100-year flood. . All 24 bridges will continue to be flooded; however, damages would be reduced by 19 percent. Flood damages would decrease 27 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 39 percent.

Flood damages that remain after the installation of FRS 2 and non-structural measures can be attributed to damage of flood proofed structures from the 500-year flood event and from structures that did not receive any non-structural floodproofing measures because the 100-year flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 84. HEC-FDA Estimated Average Annual Residual Damage by Frequency, with Installation of FRS 2 and Non-structural Measures, Rockhouse Creek Watershed, Kentucky.

Storm Frequency (Years)	Structures Affected by Floodwaters (Number)			Damages ($)		
	Total	Buildings	Bridges	Total	Structure	Content
1	18	0	18	$4,100	$4,100	$-
2	20	0	20	$8,200	$8,200	$-
5	24	1	23	$30,200	$30,200	$-
10	25	2	23	$55,400	$55,200	$200
25	34	11	23	$114,700	$109,700	$5,000
50	49	25	24	$156,100	$139,100	$17,000
100	79	55	24	$267,300	$219,000	$48,300
500	107	83	24	$1,135,600	$666,000	$469,600

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the construction of FRS 2 and non-structural measures are estimated at $37,100 (bridges – $19,700, non-residential - $7,000, residential - $10,400). An additional $43,600 of annual flood damage is still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total remaining annual flood damage in the Rockhouse Creek floodplains is estimated at **80,700.**

When voluntary participation rates are applied the non-structural measures, in combination with FRS 2, annual damages would be reduced 64 percent by $259,400. A total of 44 residential structures and 5 non-residential structures will be completely or significantly protected from 100-year flood damages by non-structural measures; FRS 2 would protect 31 residences and 5 businesses. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by participation rates applied to non-structural measures.

FRS 3 + non-structural measures

Installing FRS 3 and non-structural measures would reduce annual damages 74 percent by $299,500. FRS 3 would protect 29 residences and 2 businesses, while non-structural measures would protect 58 residences and 10 businesses from first floor damage in the100-year flood. All 24 bridges will continue to be flooded; however, damages would be reduced by 13 percent. Flood damages would decrease 19 percent for Highway 421, county roads, and utilities. Lost of income and lost of revenue from businesses would decrease by 39 percent.

Flood damages that remain after the installation of FRS 3 and non-structural measures can be attributed to damage of flood proofed structures from the 500-year flood event and from structures that did not receive any non-structural floodproofing measures because the 100-year flood level was not at or above the first floor. The table below presents information on the total remaining damages from flooding by storm frequency.

Table 85. HEC-FDA Estimated Average Annual Residual Damage by Frequency, with Installation of FRS 3 and Non-structural Measures, Rockhouse Creek Watershed, Kentucky.						
Storm Frequency (Years)	**Structures Affected by Floodwaters (Number)**			**Damages ($)**		
	Total	Buildings	Bridges	Total	Structure	Content
1	19	0	19	$4,400	$4,400	$-
2	20	0	20	$8,800	$8,800	$-
5	24	1	23	$33,400	$33,400	$-
10	26	3	23	$62,900	$62,600	$300
25	36	13	23	$115,200	$110,600	$4,600
50	54	30	24	$164,000	$145,700	$18,300
100	77	53	24	$274,400	$225,300	$49,100
500	101	77	24	$930,400	$571,300	$359,100

Remaining annual damages to structures and contents in the Rockhouse Creek floodplain with the construction of FRS 3 and non-structural measures are estimated at $36,400 (bridges – $21,200, non-residential - $5,100, residential - $10,100). An additional $70,700 of annual flood damage is still expected for streets, roads, utilities, lost of income earned and lost revenue to businesses. The total expected annual flood damage in the Rockhouse Creek floodplains is estimated at **$107,100.**

When voluntary participation rates are applied the non-structural measures, in combination with FRS 3, annual damages would be reduced 57 percent by $232,500. A total of 45 residential structures and 8 non-residential structures will be completely or significantly protected from 100-year flood damages by non-structural measures; FRS 3 would protect 29 residences and 2 businesses. Annual damages to bridge, roads, disruptions to utilities, and businesses would not be affected by participation rates applied to non-structural measures.

Average Annual Damages

FWOP; FRS 1,2, and 3; FRS 2 and 3; FRS 2; FRS3

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	24.30	88.72	226.32	339.34
Plan 1	FRS 1,2,3	14.26	21.50	89.95	125.71
Plan 2	FRS 2,3	16.19	29.18	107.80	153.17
Plan 3	FRS 2	19.70	54.11	153.28	227.09
Plan 4	FRS 3	21.11	54.89	161.17	237.17

Non-structural Measures only

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	24.30	9.18	7.16	40.65

Non-structural and Other structural Measures

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	21.66	9.00	5.29	35.96

Non-structural and Combination of Flood Retarding Structures

FRS 2, 3, and 1 + non-structural measures

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	*****	*****	*****	*****
Plan 1	FRS 1,2,3	14.48	1.93	11.33	27.74

FRSs 2 and 3+ non-structural measures

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	*****	*****	*****	*****
Plan 2	FRS 2,3	16.53	5.10	13.71	35.34

FRS 2 + non-structural measures

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	*****	*****	*****	*****
Plan 3	FRS 2	19.72	6.93	10.43	37.07

FRS 3 + non-structural measures

Rockhouse Creek
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2005
(Damage in $1,000's)

Plan Name	Plan Description	Damage Categories			Total Damage
		BRIDGE	NON-RESIDENTIAL	RESIDENTIAL	
Without	Without project condition	*****	*****	*****	*****
Plan 4	FRS 3	21.16	5.09	10.13	36.37

Benefits Calculations

Benefits for each Alternative were calculated using the Future without Project (FWOP) Average Annual Damages as base. HEC-FDA was used to calculate residual damages once measures (structural, non-structural, other structural) were implemented. The difference between the FWOP and the residual damages for each alternative was considered benefits received. All benefits and costs used in the economic analysis were derived using a 5-1/8% discount rate for water resource project submissions during FY 2006.

For non-structural measures, residential structures were grouped into categories – high risk, low risk, dry floodproofing, and add-room; non-residential structures were considered as one group.

- The highest risk group consists of structures with predicted flooding in the 10 and 25-year floods and flood level in the 100-year flood greater than or equal to 4 feet above the first floor.
- The low risk group consists of structures with predicted flooding in the 50 and 100-year floods and flood level in the 100-year flood less than 4 feet above the first floor.
- The dry floodproofing group consists of residential structures eligible for dry floodproofing measures.
- The add-room group consists of residential structures eligible for construction of an addition room only

Estimated participations rates (shown below) were applied to calculate the cost to implement non-structural measures for each of the residential and non-residential groups; therefore, the same rates were applied to benefits received in alternatives that included non-structural measures.

Table 86. Estimated Participation Rate

Category	Estimated Participation Rate (%)
Residential	
High Risk Structures	85
Low Risk Structures	78
Dry floodproof	67
Add-room	83
Non-residential	75

Cost Calculations

Future without Project

No costs would be incurred under this Alternative.

Flood Retarding Structures

Costs for construction of the Flood Retarding Structures were based on preliminary design estimates developed by Fuller, Mossbarger, Scott, and May (FMSM). Estimated construction cost for FRS 2 includes the most expensive access routes considered – the Laurel Creek route.

Table 87. Preliminary Cost for Access Routes to FRS 1 and 2

	Laurel Creek	Rockhouse Creek	Stinnett Road	Muncy Creek Road
FRS 1	-	-	-	$955,000*
FRS 2	$1,020,000	$777,700	$955,000	

* Estimated cost for Muncy Creek Road is similar to estimated cost for Stinnett Road.

(FMSM, 2004b; FMSM, 2005a)

Average annual cost includes $2000 for operation and maintenance. Operation and maintenance costs include labor and equipment necessary to mow the embankments and remove woody debris from the face of the dam. Mitigation costs were calculated using the In-Lieu Fee Compensatory Mitigation Calculator (Version 2002.8) for perennial streams for the USACE Louisville District. Engineering and project administration costs were a percentage of net construction cost and varied depending on the individual flood retarding structure. Average annual costs were derived using a 5-1/8% discount rate for water resource project submissions during FY 2006. Estimated installation cost and average annual cost for each FRS is shown in **Table 88 and 89.**

Table 88. Engineering and Project Administration (Percentage of Net Construction Cost)

Flood Retarding Structure	Engineering (%)	Project Administration (%)
FRS 1	6.75	3.5
FRS 2	6.55	3.2
FRS 3	6.90	3.7

Source: USDA, 2005

Table 89. Dam Costs					
Flood Retarding Structure	**Construction**	**Mitigation**	**Land Rights**	**Engineering**	**Administration**
FRS 1	$5,545,000*	$376,200	$1,900,000	$366,267	$ 189,237
FRS 2	$7,089,000**	$1,121,890	-	$464,329	$226,848
FRS 3	$4,001,000	$826,848	-	$276,690	$148,370

Flood Retarding Structure	**Total Installation Cost**	**Average Annual Cost**
FRS 1	$8,381,204	$368,747
FRS 2	$8,902,067	$461,332
FRS 3	$5,261,908	$273,505
*Construction cost was calculated by using an average of FRS 2 and 3 construction costs. ** Includes cost for Laurel Creek access route.		

(FMSM, 2005a; FMSM, 2005b; USDA, 2005)

Non-Structural Measures

Elevation Cost Factors

Costs estimates for elevation were based on average costs of house elevations in the Harlan County project. The costs for elevating different types of residential structures are shown in **Table 90**.

Table 90. Elevation Costs by Structure Type					
Structure Type	**Construction Cost (1)**	**Administrative & Engineering Cost**	**Construction of addroom**	**Living Expense**	**Total Cost**
Mobile home	$20,000	$5,000	-	$685	$25,685
Double-wide	$30,000	$7,000	-	$685	$37,685
Single-family w/o basement	$37,500	$7,000	-	$685	$43,185
Single-family w/ basement and first floor flooding	$40,000	$7,000	$20,000	$685	$67,685

(1) Construction costs obtained from Danny B. Ferrell, US Army Corp of Engineers, Harlan, Kentucky

EWR Cost Factors

EWR cost estimates were based on the cost of an elevation plus the reconstruction work. Reconstruction work was estimated at $6.45/ square foot.

Add-room Cost Factors

Add-room cost estimates were based on the cost to construct additional living space, upgrading foundation with a wet floodproof foundation, and administrative and engineering costs.

D&R Cost Factors

Costs for demolition & replacement depend on the square footage of the original home to be replaced with a new modular home, set-up, elevation cost, demolition cost, administrative and engineering, and living expense.

Voluntary Acquisition (Buyout) Cost Factors

Costs for buyouts include the fair market value of the home, demolition, and a purchase supplement of up to $22,500.

Structure-Specific Floodwalls

The estimated cost for the two structure-specific floodwalls proposed is $232,000. Costs include construction ($222,000), engineering ($6,000) and project administration ($4,000). With 75% participation rate applied, the estimated cost is $174,000.

Wet Floodproofing

The estimated cost to implement wet floodproofing measures is $50,000, which includes construction, engineering, and project administration. With 75$ participation rate applied, the estimated cost is $37,500.

Table 91 shows the itemized costs for each non-structural measure.

Table 91. ITEMIZED COSTS FOR NON-STRUCTURAL MEASURES		
Rockhouse Creek Watershed, Kentucky		
(Dollars [1])		
MEASURE	**ESTIMATED COST**	**UNIT**
Elevation		
Construction [2]		
Mobile homes	$20,000.00	LS
Double-wides	$30,000.00	LS
Single-family with basements	$37,500.00	LS
Single-family without basements	$40,000.00	LS
Administrative and engineering		
Mobile homes	$5,000.00	LS
Double-wides, Single-family with and without basements	$7,000.00	LS
Construction for addroom (for basement homes only) [3]	$20,000.00	LS
Living Expense [4]	$ 685.00	LS
Structure Restoration [5]	$6.45	ft^2
Addroom and Wet Floodproof		
Construction for addroom	$ 20,000.00	LS
Wet floodproofing [6]	$10.00	ft^2
Administrative and engineering	$5,000.00	LS
Buyout		
Appraised Market Value of property and structure [7]	variable	LS
Purchase Supplement	$ 22,500	LS
Demolition [8]	$3,125.00	LS
Real estate administration	$5,000.00	LS
Demolish & Replace		
Demolition	$ 3,125.00	LS

Cost of replacement manufactured home [9]	$ 30.00	ft^2
Set up	$3,500.00	LS
Elevating home		
Mobile homes	$20,000.00	LS
Double-wides	$30,000.00	LS
Single-family with basements	$37,500.00	LS
Single-family without basements	40,000.00	LS
Administrative and engineering		
Mobile homes	$7,000.00	LS
Double-wides, Single-family with and without basements	$ 9,000.00	LS
Living Expense [4]	$ 1,170.00	LS
Dry Floodproofing		
Dry floodproofing [6]	$33.75	ft^2
Administrative and engineering	$2,000.00	LS

LS - lump sum
ft2 - square foot

1/ Price Base 2005.
2/ Average elevation construction costs taken from Clover Fork Project, Harlan County, KY
3/ cost to construct add-room is approximately 1/3 cost of total cost to elevate single-family home with basement
4/ living expense are based on 8/23/05 CONUS rate for lodging ($60/day) and M&IE ($31 x avg. persons/household of 1.21 - 7 days ($685) for elevations and 12 days ($1170) for D&R. Source for avg. # per household based on Census 2000 data.
5/ structure restoration cost taken from Clover Fork Project, Harlan County, KY
6/ Source: FEMA, 6/1998 - Homeowner's Guide to Retrofitting, Six Ways to Protect Your House from Flooding
7/ 2004 NRCS Rockhouse Creek Watershed Property Appraisal
8/ demolition cost taken from Clover Fork Project, Harlan County, KU
9/ Sources: average cost per Danny Ferrell, USACE, KY and George Humfleet Homes, LLC, London, KY

Table 92. Cost per structure to implement each non-structural measure.

Structure Name	Reach	Stream Name	TYPE	Market Value	First Floor Elevation	Depth at 10-year	Depth at 25-year	Depth at 100year	Elevation Cost	Elevation with Restoration	"add-room" for Structures with basements	Dry Flood Proof	Buyout Cost	D&R Cost	Land Value
5003	RH5	Rockhouse Creek	MH	$ 10,000.00	899.58		0.04452	1.106024	$ 25,685.00	$ 35,050.40			$ 40,625.00	$ 78,355.00	-
5004	RH5	Rockhouse Creek	MH	$ 10,000.00	899.25		0.253916	1.2364792	$ 25,685.00	$ 30,200.00			$ 40,625.00	$ 55,795.00	-
1823	RH5	Rockhouse Creek	MH	$ 60,000.00	897.7		0.201885	1.4218848	$ 25,685.00	$ 33,115.40			$ 90,625.00	$ 69,355.00	43,800.00
1826	RH5	Rockhouse Creek	MH	$ 20,000.00	899.4		0.280859	1.5791817	$ 25,685.00	$ 32,909.00			$ 50,625.00	$ 68,395.00	-
1911	RH2	Rockhouse Creek	SFNB	$ 100,000.00	981.29		0.128646	1.593268	$ 45,185.00	$ 56,021.00			$ 130,625.00	$ 104,695.00	11,100.00
616	RH6	Rockhouse Creek	SFNB	$ 40,000.00	866.39		0.224215	1.710805	$ 45,185.00	$ 49,829.00			$ 70,625.00	$ 75,895.00	34,800.00
1824	RH5	Rockhouse Creek	MH	$ 20,000.00	898.5		0.610704	1.8701309	$ 25,685.00	$ 31,257.80			$ 50,625.00	$ 60,715.00	-
1833	RH5	Rockhouse Creek	SFNB	$ 110,000.00	900.24		0.308206	1.9482058	$ 45,185.00	$ 51,377.00			$ 140,625.00	$ 83,095.00	30,000.00
1843	RH5	Rockhouse Creek	SFNB	$ 50,000.00	905.28	0.259983		2.0443741	$ 45,185.00	$ 51,377.00			$ 80,625.00	$ 83,095.00	45,000.00
1946	RH2	Rockhouse Creek	SFNB	$ 75,000.00	994.34		0.788136	2.1194367	$ 45,185.00	$ 51,686.60			$ 105,625.00	$ 84,535.00	5,700.00
1839	RH5	Rockhouse Creek	SFNB	$ 20,000.00	902.49		0.437438	2.2353013	$ 45,185.00	$ 49,145.30			$ 50,625.00	$ 72,715.00	7,500.00
4007	RH2	Rockhouse Creek	SFNB	$ 75,000.00	980.81		0.718082	2.2743258	$ 45,185.00	$ 52,615.40			$ 105,625.00	$ 88,855.00	25,200.00
746	RH6	Rockhouse Creek	SFNB	$ 40,000.00	881.19		0.203228	2.323495	$ 45,185.00	$ 56,072.60			$ 70,625.00	$ 88,855.00	-
1943	RH2	Rockhouse Creek	MH	$ 20,000.00	994.72		0.779824	2.4477636	$ 25,685.00	$ 31,103.00			$ 50,625.00	$ 59,995.00	-
1837	RH5	Rockhouse Creek	SFNB	$ 30,000.00	899.82		0.705881	2.4605833	$ 37,685.00	$ 45,115.40			$ 60,625.00	$ 81,355.00	16,800.00
1944	RH2	Rockhouse Creek	SFNB	$ 55,000.00	993.14		1.053105	2.5881479	$ 45,185.00	$ 53,234.60			$ 85,625.00	$ 91,735.00	30,000.00
1909	RH2	Rockhouse Creek	MH	$ 30,200.00	979.97		1.263495	2.7366582	$ 25,685.00	$ 30,329.00			$ 60,825.00	$ 56,395.00	10,200.00
1821	RH5	Rockhouse Creek	SFWB	$ 100,000.00	891.31	0.280303		2.9121369	$ 67,685.00	$ 75,560.45			$ 130,625.00	$ 93,425.00	37,800.00
5121	LF1	Laurel Fork	MH	$ 45,000.00	996.1		0.963681	2.9201541	$ 25,685.00	$ 35,076.20			$ 75,625.00	$ 78,475.00	30,000.00
1813	RH5	Rockhouse Creek	SFNB	$ 20,000.00	890.49		0.456531	3.03796	$ 45,185.00	$ 48,797.00			$ 50,625.00	$ 71,095.00	-
1810	RH5	Rockhouse Creek	SFNB	$ 60,000.00	890.51	0.659146		3.2691456	$ 45,185.00	$ 51,377.00			$ 90,625.00	$ 83,095.00	45,000.00
1910	RH2	Rockhouse Creek	MH	$ 70,000.00	979.51		1.880215	3.2844227	$ 25,685.00	$ 33,941.00			$ 100,625.00	$ 73,195.00	9,900.00
5113	RH4	Rockhouse Creek	MH	$ 10,000.00	912.23		0.196458	3.3487917	$ 25,685.00	$ 30,329.00			$ 40,625.00	$ 56,395.00	-
1931	RH2	Rockhouse Creek	SFNB	$ 60,000.00	990.61		1.39169	3.56458	$ 45,185.00	$ 51,841.40			$ 90,625.00	$ 85,255.00	22,500.00

557	RH6	Rockhouse Creek	SFNB	$ 10,000.00	861.9	0.607684		3.5869368	$ 45,185.00	$ 60,923.00			$ 130,625.00	$ 127,495.00	9,900.00
1815	RH5	Rockhouse Creek	SFNB	$ 60,000.00	890.17	1.168689		3.7786888	$ 45,185.00	$ 51,564.05			$ 79,375.00	$ 83,965.00	7,800.00
1868	RH4	Rockhouse Creek	SFNB	$ 30,000.00	923.29		0.967079	3.8582584	$ 45,185.00	$ 50,861.00			$ 60,625.00	$ 80,695.00	15,000.00
9102	RH2	Rockhouse Creek	SFNB	$ 60,000.00	991.31		2.538554	4.1486747	$ 45,185.00	$ 53,750.60			$ 90,625.00	$ 94,135.00	7,200.00
1947	RH2	Rockhouse Creek	SFNB	$ 60,000.00	993.59		2.184147	4.1505273	$ 45,185.00	$ 53,570.00			$ 90,625.00	$ 93,295.00	15,000.00
510	RH6	Rockhouse Creek	SFNB	$ 70,000.00	859.22		0.606647	4.1988792	$ 37,685.00	$ 47,901.80			$ 100,625.00	$ 94,315.00	45,000.00
1862	RH4	Rockhouse Creek	SFNB	$ 70,000.00	922.78		1.478292	4.31992	$ 45,185.00	$ 51,106.10			$ 100,625.00	$ 81,835.00	30,000.00
328	RH7	Rockhouse Creek	MH	$ 20,000.00	853.9	-5.559259	-2.9524	4.3631418	$ 25,685.00	$ 30,329.00			$ 50,625.00	$ 56,395.00	3,900.00
511	RH6	Rockhouse Creek	SFWB	$ 50,000.00	858.33	1.934809		5.1317498	$ 67,685.00	$ 73,412.60			$ 80,625.00	$ 83,435.00	37,200.00
864	RH5	Rockhouse Creek	SFNB	$ 100,000.00	890.9	2.025854		5.2924857	$ 45,185.00	$ 55,221.20			$ 130,625.00	$ 100,975.00	71,400.00
4001	RH7	Rockhouse Creek	SFNB	$ 40,000.00	853.04	-4.222563	-1.72919	5.37375	$ 45,185.00	$ 59,117.00			$ 70,625.00	$ 119,095.00	4,200.00
299	RH7	Rockhouse Creek	SFNB	$ 75,000.00	853.38	-2.713423	-0.86301	5.5352051	$ 45,185.00	$ 53,079.80			$ 105,625.00	$ 91,015.00	15,000.00
1929	RH2	Rockhouse Creek	MH	$ 20,000.00	989.32	0.737139		5.8356006	$ 25,685.00	$ 35,592.20			$ 50,625.00	$ 80,875.00	-
1938	RH1	Rockhouse Creek	SFWB	$ 25,000.00	998.9	4.040329		6.4750219	$ 67,685.00	$ 73,103.00			$ 55,625.00	$ 81,995.00	3,000.00
1822	RH5	Rockhouse Creek	SFNB	$ 135,000.00	892.55	5.285437		6.5563099	$ 45,185.00	$ 59,213.75			$ 165,625.00	$ 119,545.00	21,900.00
1812	RH5	Rockhouse Creek	SFWB	$ 50,000.00	884.16	5.382373		9.2734195	$ 67,685.00	$ 73,077.20			$ 80,625.00	$ 81,875.00	37,800.00
							Total		$1,580,715.00	$1,876,105.65			$ 3,228,325.00	$3,233,835.00	
							Average		$ 40,531.15	$ 48,105.27			$ 82,777.56	$ 82,918.85	18,240.00
															109,440.00
Add-room homes															
Structure Name		**Stream Name**	**TYPE**	**Market Value**	**First Floor Elevation**	**Depth at 50-year**	**Depth at 100year**		**Elevation Cost**		**"add-room" for Structures with basements**	**Dry Flood Proof**	**Buyout Cost**	**D&R Cost**	
432	RH7	Rockhouse Creek	SFWB	$ 50,000.00	866.64		-3.46978				$ 36,520.00				
1838	RH5	Rockhouse Creek	SFWB	$ 60,000.00	903.2		-0.12642				$ 39,300.00				
1880	RH4	Rockhouse Creek	SFWB	$ 60,000.00	931.73		-4.19529				$ 36,440.00				
1886	RH3	Rockhouse Creek	SFWB	$ 50,000.00	942.11		-3.71812				$ 42,880.00				
1889	RH3	Rockhouse Creek	SFWB	$ 60,000.00	945.56		-1.87389				$ 44,760.00				
1893	RH2	Rockhouse Creek	SFWB	$ 100,000.00	967.47		-4.98168				$ 42,600.00				

1921	RH2	Rockhouse Creek	SFWB	$ 120,000.00	985.73		-2.15526				$ 35,720.00				
											$ 278,220.00				
Structures flooded in 50 and 100-Year Flood															
Structure Name		**Stream Name**	**TYPE**	**Market Value**	**First Floor Elevation**	**Depth at 50-year**	**Depth at 100year**		**Elevation Cost**	**Elevation with Restoration**	**"add-room" for Structures with basements**	**Dry Flood Proof**	**Buyout Cost**	**D&R Cost**	
1927	RH2	Rockhouse Creek	SFNB	$ 60,000.00	996.32	-0.495614	0.012722		$ 45,185.00	$ 55,711.40		$ 12,935.00	$ 90,625.00	$ 103,255.00	
1885	RH3	Rockhouse Creek	SFNB	$ 100,000.00	938.58	-0.719122	0.04619		$ 45,185.00	$ 59,504.00		$ 14,690.00	$ 130,625.00	$ 120,895.00	
460	RH7	Rockhouse Creek	SFWB	$ 30,000.00	863.18	-1.610222	0.061772		$ 67,685.00	$ 72,329.00			$ 60,625.00	$ 78,395.00	
5007	RH5	Rockhouse Creek	MH	$ 10,000.00	901.01	-0.441498	0.164342		$ 25,685.00	$ 30,716.00			$ 40,625.00	$ 58,195.00	
9105	RH4	Rockhouse Creek	SFNB	$ 60,000.00	913.81	-0.761036	0.207186		$ 45,185.00	$ 53,686.10		$ 11,855.00	$ 130,625.00	$ 96,335.00	
1900	RH2	Rockhouse Creek	SFNB	$ 45,000.00	959.33	-0.42754	0.25164		$ 45,185.00	$ 54,266.60		$ 12,125.00	$ 75,625.00	$ 96,535.00	
611	RH6	Rockhouse Creek	SFNB	$ 30,000.00	866.43	-0.489254	0.282973		$ 45,185.00	$ 49,829.00		$ 9,560.00	$ 60,625.00	$ 75,895.00	
4003	RH6	Rockhouse Creek	SFWB	$ 30,000.00	866.21	-0.47821	0.30778		$ 67,685.00	$ 73,335.20			$ 60,625.00	$ 83,075.00	
169	RH8	Rockhouse Creek	SFNB	$ 35,000.00	850.49	-1.958577	0.319385		$ 45,185.00	$ 55,950.00		$ 13,070.00	$ 65,625.00	$ 104,365.00	
1848	RH4	Rockhouse Creek	SFNB	$ 40,000.00	915.21	-0.878422	0.368157		$ 45,185.00	$ 51,918.80		$ 15,770.00	$ 70,625.00	$ 85,615.00	
8025	RH4	Rockhouse Creek	MH	$ 10,000.00	916.47	-0.55828	0.382166		$ 25,685.00	$ 30,019.40			$ 40,625.00	$ 54,955.00	
560	RH6	Rockhouse Creek	SFNB	$ 50,000.00	865.63	-0.438577	0.383006		$ 45,185.00	$ 54,240.80		$ 12,125.00	$ 80,625.00	$ 96,415.00	
1898	RH2	Rockhouse Creek	SFNB	$ 60,000.00	959.16	-0.224671	0.443553		$ 45,185.00	$ 52,151.00		$ 11,045.00	$ 90,625.00	$ 86,695.00	
1858	RH4	Rockhouse Creek	MH	$ 25,000.00	916.82	-0.318459	0.481384		$ 25,685.00	$ 30,716.00			$ 55,625.00	$ 58,195.00	
1920	RH2	Rockhouse Creek	SFNB	$ 60,000.00	983.74	-0.260925	0.496016		$ 45,185.00	$ 52,228.40		$ 14,960.00	$ 90,625.00	$ 87,055.00	
9103	RH5	Rockhouse Creek	SFWB	$ 100,000.00	900.21	0.03808	0.51804		$ 67,685.00	$ 83,410.10			$ 130,625.00	$ 129,935.00	
5006	RH5	Rockhouse Creek	MH	$ 30,000.00	900.41	-0.005018	0.536582		$ 25,685.00	$ 32,909.00			$ 60,625.00	$ 68,395.00	
1919	RH2	Rockhouse Creek	SFNB	$ 60,000.00	984.02	-0.13201	0.557404		$ 45,185.00	$ 52,151.00		$ 14,960.00	$ 90,625.00	$ 86,695.00	
5005	RH5	Rockhouse Creek	MH	$ 10,000.00	900.18	0.089462	0.577822		$ 25,685.00	$ 30,329.00			$ 40,625.00	$ 56,395.00	
1840	RH5	Rockhouse Creek	MH	$ 20,000.00	905.63	-0.026036	0.585389		$ 25,685.00	$ 30,200.00			$ 50,625.00	$ 55,795.00	
1841	RH5	Rockhouse Creek	SFNB	$ 20,000.00	905.24	-0.055436	0.593269		$ 45,185.00	$ 51,241.55		$ 10,235.00	$ 50,625.00	$ 82,465.00	
1942	RH1	Rockhouse Creek	SFNB	$ 175,000.00	1000.14	0.167625	0.605761		$ 45,185.00	$ 64,070.60		$ 24,072.00	$ 205,625.00	$ 142,135.00	

1847	RH4	Rockhouse Creek	SFNB	$ 50,000.00	914.92	-0.608263	0.639418		$ 45,185.00	$ 50,396.60		$ 14,150.00	$ 80,625.00	$ 78,535.00	
1945	RH2	Rockhouse Creek	MH	$ 45,000.00	995.75	0.15081	0.659913		$ 25,685.00	$ 33,528.20			$ 75,625.00	$ 71,275.00	
1948	LF1	Laurel Fork	SFNB	$ 150,000.00	997.98	0.114	0.761368		$ 45,185.00	$ 67,837.40		$ 26,300.00	$ 180,625.00	$ 159,655.00	
5114	RH4	Rockhouse Creek	MH	$ 10,000.00	914.8	-0.43714	0.807701		$ 25,685.00	$ 29,555.00			$ 40,625.00	$ 52,795.00	
1827	RH5	Rockhouse Creek	SFWB	$ 60,000.00	900.11	0.553928	1.114323		$ 67,685.00	$ 76,431.20			$ 90,625.00	$ 97,475.00	
1855	RH4	Rockhouse Creek	SFNB	$ 50,000.00	914.92	0.027634	1.170059		$ 45,185.00	$ 55,788.80		$ 18,605.00	$ 80,625.00	$ 103,615.00	
1949	LF1	Laurel Fork	MH	$ 45,000.00	1002.32	0.849652	1.257925		$ 25,685.00	$ 30,329.00			$ 75,625.00	$ 56,395.00	
1819	RH5	Rockhouse Creek	SFNB	$ 70,000.00	893.29	0.23437	1.281795		$ 37,685.00	$ 47,076.00		$ 17,390.00	$ 100,625.00	$ 90,475.00	
1814	RH5	Rockhouse Creek	SFNB	$ 35,000.00	892.32	0.009378	1.319746		$ 45,185.00	$ 53,570.00		$ 16,782.00	$ 65,625.00	$ 93,295.00	
5112	RH4	Rockhouse Creek	MH	$ 40,000.00	914.2	0.121106	1.368267		$ 25,685.00	$ 33,941.00			$ 70,625.00	$ 73,195.00	
539	RH6	Rockhouse Creek	MH	$ 10,000.00	863.5	0.451225	1.441881		$ 25,685.00	$ 33,941.00			$ 40,625.00	$ 73,195.00	
688	RH6	Rockhouse Creek	SFNB	$ 50,000.00	875.04	0.349758	1.441978		$ 45,185.00	$ 50,990.00		$ 14,150.00	$ 80,625.00	$ 81,295.00	
1897	RH2	Rockhouse Creek	SFNB	$ 45,000.00	958.14	0.855127	1.503418		$ 45,185.00	$ 53,131.40		$ 16,377.00	$ 75,625.00	$ 91,255.00	
1849	RH4	Rockhouse Creek	SFNB	$ 20,000.00	913.98	0.298961	1.548463		$ 45,185.00	$ 52,615.40			$ 50,625.00	$ 88,855.00	
778	RH5	Rockhouse Creek	MH	$ 10,000.00	891.96	0.260244	1.56252		$ 25,685.00	$ 31,619.00			$ 40,625.00	$ 62,395.00	
401	RH7	Rockhouse Creek	SFNB	$ 10,000.00	859.22	-0.037821	1.863747		$ 45,185.00	$ 56,021.00			$ 40,625.00	$ 104,695.00	
1846	RH4	Rockhouse Creek	SFNB	$ 50,000.00	913.14	0.926951	2.130093		$ 45,185.00	$ 51,164.15			$ 80,625.00	$ 82,105.00	
776	RH5	Rockhouse Creek	SFNB	$ 100,000.00	890.22	1.385926	2.323915		$ 45,185.00	$ 56,072.60			$ 130,625.00	$ 104,935.00	
777	RH5	Rockhouse Creek	SFNB	$ 40,000.00	890.36	1.293446	2.806792		$ 45,185.00	$ 51,067.40			$ 70,625.00	$ 81,655.00	
329	RH7	Rockhouse Creek	SFNB	$ 60,000.00	854.82	-0.513935	3.491215		$ 37,685.00	$ 46,973.00			$ 90,625.00	$ 89,995.00	
							Total		$1,738,770.00	$2,082,961.10		$ 301,156.00	$ 3,336,250.00	$3,644,780.00	
							Average		$ 41,399.29	$ 49,594.31		$ 15,057.80	$ 79,434.52	$ 86,780.48	
Dry floodproof															
586	RH6	Rockhouse Creek	SFWB	$ 30,000.00	873.76		-7.27906					$ 10,370.00			
												$ 311,526.00			

Other Structural Measures

Estimates for Bridge and Channel Work

Rolling Rock Section

Rolling Rock Bridge
- Cost to Demolish Bridge $6,000
- Cost to Construct Bridge $65,000
- Cost to Renovate Stream Section $43,200

Perch Drive Bridge
- Cost to Demolish Bridge $6,000

Estimated cost for bridge and channel work in the Rolling Rock section is $120,200.

Napier Lane Section

Napier Lane Bridge
- Cost to Demolish Bridge $6,000
- Cost to Construct Bridge $86,000
- Cost to Renovate Stream Section $52,000

Estimated cost for bridge and channel work in the Napier Lane section is $144,000.

Paradise Lane Section

Paradise Lane Bridge
- Cost to Demolish Bridge $6,000
- Cost to Construct Bridge $69,000
- Cost to Construct New Access/Driveway $10,000
- Cost to Renovate Stream Section $32,300

Private 9 Bridge
- Cost to Demolish Bridge $6,000
- Cost to Renovate Stream Section $7,300

Estimated cost for bridge and channel work in the Paradise Lane section is $130,600.

Table 93. Summary and Comparison of Alternatives

	FWOP	Structural Measures (Flood Retarding Structures)				Non-structural & Structural Measures								Non-structural Only	Non-structural and Other Structural (Bridge & Channel) Measures
Measures	Future without project scenario	Construct three flood retarding structure, FRS#1, # 2 and #3.	Construct two flood retarding structures (FRS #2, and #3).	Construct one flood retarding structure (FRS #2)	Construct one flood retarding structure (FRS #3)	Construct three flood retarding structure, FRS#1, # 2 and #3.	FRS 1, 2, and 3 Combo with Participation rate	Construct two flood retarding structures (FRS #2, and #3).	FRS 2 and 3 Combo with Participation rate	Construct one flood retarding structure (FRS #2)	FRS 2 Combo with Participation rate	Construct one flood retarding structure (FRS #3)	FRS 3 Combo with Participation rate	No dams scenario (Residential elevation, dry floodproof, D&R, addroom, Bos & Non-residential floodwalls, WFPs, Bos & bank stabilization & floodplain restoration)	Bridge & Channel Improvements + Residential and Non-residential NS measures
Total Cost	0	$21,271,701.00	$14,163,976.00	$8,902,068.00	$5,261,908.00	$23,677,346.00		$17,052,947.00		$12,897,781.00		$9,389,855.00		$4,591,552.00	$4,690,136.00
PL 83-566 Share	0														
Average Annual Benefits	0	$257,321.00	$224,349.00	$135,788.00	$123,782.00	$355,291.00	$287,800.63	$342,179.00	$275,988.07	$325,798.00	$259,365.93	$324,572.00	$ 257,616.03	$ 253,930.51	$260,648.26
% Damage Reduction	0%	63%	55%	33%	30%	87%	71%	84%	68%	80%	64%	80%	63%	62%	64%
At 5.375% Discount Rate:															
Avg. Annual Cost	$ -	$1,099,585.00	$734,838.00	$461,332.00	$273,506.00	$1,221,712.00	$34,473.00	$879,904.00	$14,278.00	$665,504.00	$17,303.00	$484,501.00	$14,278.00	$242,097.58	$245,691
Net Economic Benefits	$ -	$ (842,264.00)	$(510,489.00)	$(325,544.00)	$(149,724.00)	$(866,421.00)	$253,327.63	$(537,725.00)	$261,710.07	$(339,706.00)	$242,062.93	$(159,929.00)	$243,338.03	$17,013.93	$18,644.93
B:C Ratio	**0.00**	**0.23**	**0.31**	**0.29**	**0.45**	**0.29**		**0.39**		**0.49**		**0.67**		**1.05**	**1.05**
Floodwater Damages															
													(Average Annual Remaining Damages)		
Residential															
Structure and Content	$226,320.00	$89,950.00	$107,800.00	$153,280.00	$161,170.00	$11,330.00	$57,122.87	$13,710.00	$58,995.93	$10,430.00	$56,414.57	$10,130.00	$56,178.47	$ 53.841.08	$51,927.33
Non-residential															
Structure and Content	$ 88,720.00	$21,500.00	$29,180.00	$54,110.00	$54,890.00	$1,930.00	$23,627.50	$5,100.00	$26,005.00	$6,930.00	$27,377.50	$5,090.00	$25,997.50	$29,065.00	$28,930.00
Bridges	$24,300.00	$14,260.00	$16,190.00	$19,700.00	$21,110.00	$14,480.00	$14,480.00	$16,530.00	$16,530.00	$19,720.00	$19,720.00	$21,160.00	$21,160.00	$ 24,300.00	$21,660.00
Total	**$339,340.00**	**$125,710.00**	**$153,170.00**	**$227,090.00**	**$237,170.00**	**$27,740.00**	**$95,230.37**	**$35,340.00**	**$101,530.93**	**$37,080.00**	**$103,512.07**	**$36,380.00**	**$103,335.97**	**$107,206.08**	**$102,517.33**
													Ancillary Costs/Damages		
Lost wages	$6,364.00	$1,731.00	$2,165.00	$3,858.00	$3,850.00	$1,731.00	$1,731.00	$2,165.00	$2,165.00	$3,858.00	$3,858.00	$3,850.00	$3,850.00	$3,181.84	$3,181.84

Lost Income from Begley	$16,776.00	$4,563.00	$5,709.00	$ 10,171.00	$10,150.00	$4,563.00	$4,563.00	$5,709.00	$5,709.00	$10,171.00	$10,171.00	$10,150.00	$10,150.00	$8,387.58	$8,387.58
Lost income from ALL other businesses in RH	$20,451.00	$5,563.00	$6,959.00	$12,400.00	$12,374.00	$5,563.00	$5,563.00	$ 6,959.00	$6,959.00	$12,400.00	$12,400.00	$12,374.00	$12,374.00	$ 10,224.99	$10,224.99
Roads									$-						
County	$11,686.00	$6,221.00	$7,113.00	$ 8,970.00	$10,050.00	$6,221.00	$6,221.00	$7,113.00	$7,113.00	$8,970.00	$8,970.00	$10,050.00	$10,050.00	$11,686.00	$10,963.00
Highway 421	$8,880.00	$3,933.00	$5,244.00	$6,048.00	$6,696.00	$3,933.00	$3,933.00	$5,244.00	$5,244.00	$6,048.00	$6,048.00	$6,696.00	$6,696.00	$8,880.00	$7,858.00
Utilities (powerlines, poles, etc.)	$3,030.00	$1,485.00	$1,818.00	$ 2,202.00	$2,455.00	$1,485.00	$1,485.00	$1,818.00	$1,818.00	$2,202.00	$2,202.00	$2,455.00	$2,455.00	$3,030.00	$2,766.00
Total Ancillary Damages/Costs	**$67,187.00**	**$23,496.00**	**$29,008.00**	**$43,649.00**	**$45,575.00**	**$23,496.00**	**$23,496.00**	**$29,008.00**	**$29,008.00**	**$43,649.00**	**$43,649.00**	**$45,575.00**	**$45,575.00**	**$45,390.41**	**$43,381.41**
Total Average Annual Remaining Damages	**$406,527.00**	**$149,206.00**	**$182,178.00**	**$270,739.00**	**$282,745.00**	**$51,236.00**	**$118,726.37**	**$64,348.00**	**$130,538.93**	**$80,729.00**	**$147,161.07**	**$81,955.00**	**$148,910.97**	**$152,596.49**	**$145,878.74**
% Remaining Damages	**100%**	**37%**	**45%**	**67%**	**70%**	**13%**	**29%**	**16%**	**32%**	**20%**	**36%**	**20%**	**37%**	**38%**	**36%**