Middle Rio Grande Flood Protection
Bernalillo to Belen, New Mexico
Mountain View, Isleta, and Belen Units

Appendix D

Economics

December 2019

US Army Corps
of Engineers
Albuquerque District
South Pacific Division

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D-01 Areas of Consideration:

The study area comprises both banks of a stretch of the Rio Grande extending from southernmost extents of the City of Albuquerque south past the Pueblo de Isleta, the Village of Los Lunas and the Town of Belen, NM, a distance of approximately 20 river miles. The study area is contained within Bernalillo and Valencia Counties, New Mexico. As noted in Para. 2.4 of the main report, the study area includes several small rural communities. Bernalillo County is the largest population center in New Mexico, with a 2008 census estimate of 635,139. Valencia County is largely characterized as bedroom communities to the City of Albuquerque, and had 2000 census population of 66,152. The 2008 County population is estimated to be 72,207, indicating the rapid development of the region. The largest employment sectors in the region are construction and retail trades (2006 County Business Patterns).

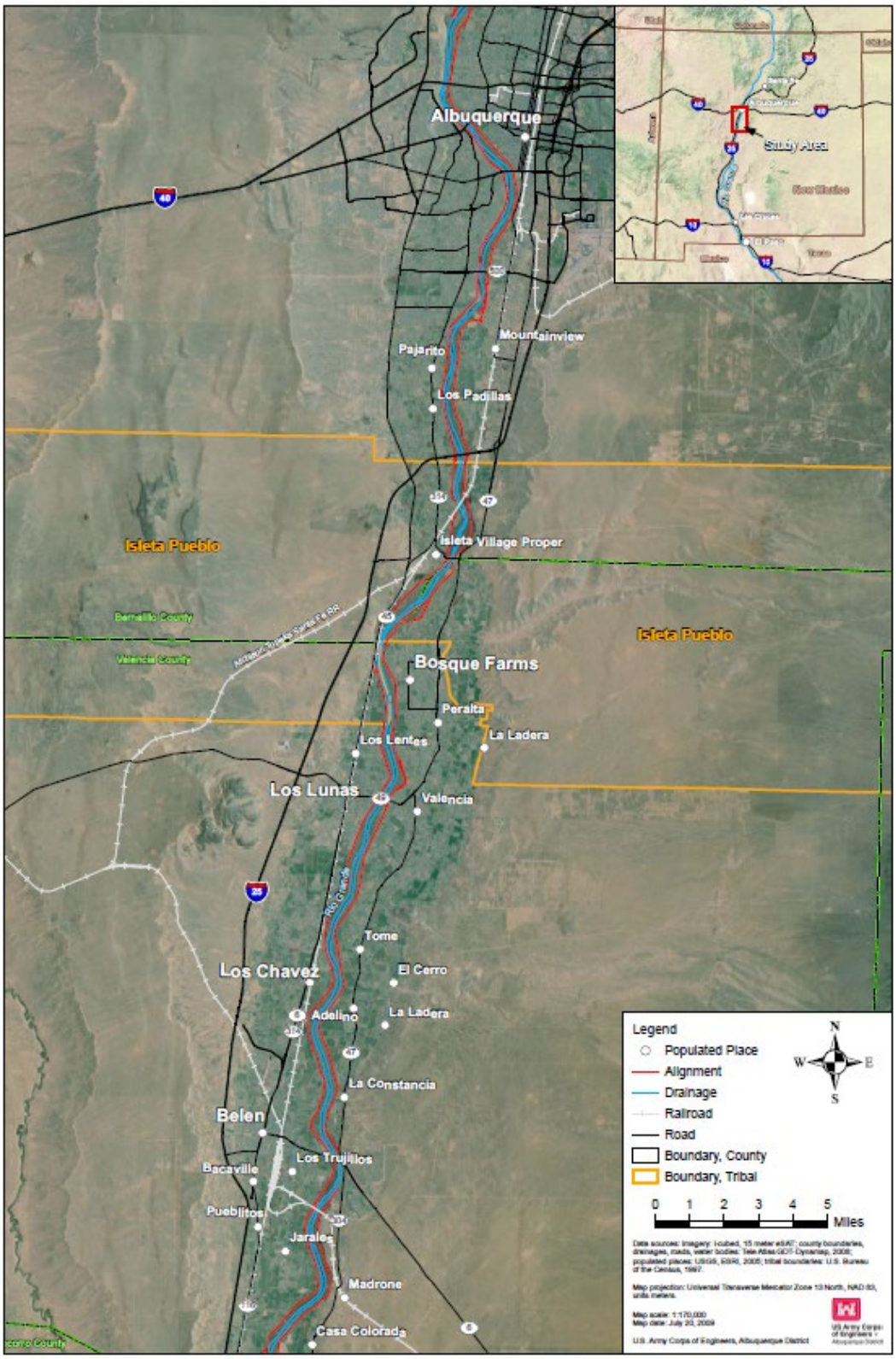


Figure D-1 - Study Area

The study area is comprised of low, flat, and wide floodplains situated along both banks of the Rio Grande, which is perched. A typical perched channel cross section follows:

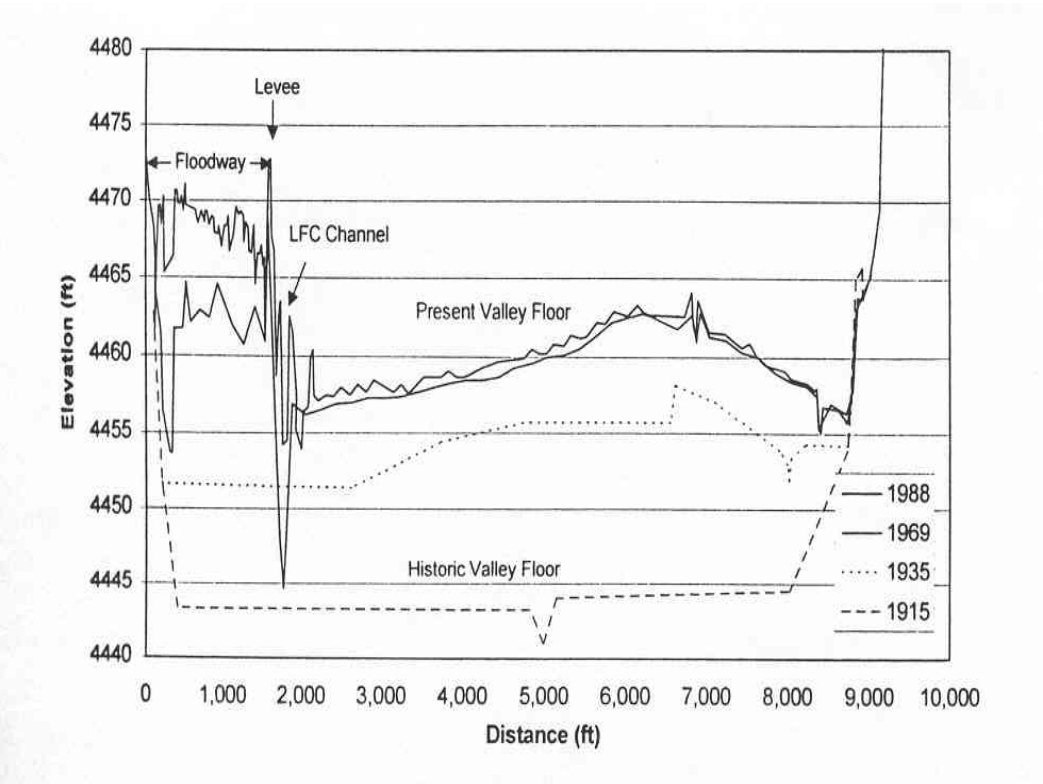


Figure D-2 - Typical perched channel cross-section

This differs from the typical cross-section of an incised river channel and the adjacent lands, diagrammed here:

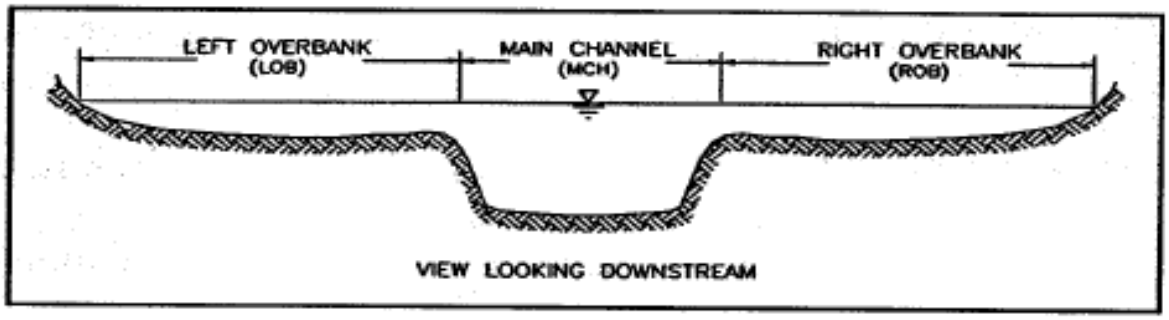


Figure D-3 - Typical incised channel cross-section

The perched channel provided additional modeling challenges to the study team. For one, the rating curves that were developed for the floodway differ from each overbank. Second, where flood waters leave the floodway and enter into the overbank, those waters may continue in the OVERBANK area for miles before reuniting with the floodway. Further discussion of modeling perched channels follows in this appendix.

The study area has an extensive history of flooding, as outlined in Para. 2.1.1 of the

main report. Much of that flood threat has been mitigated with the construction of Cochiti Dam, but a substantial residual risk exists from uncontrolled drainages downstream of the dam, as well as the risk of a substantial spring snowmelt runoff. Over the past 30 years, numerous levee patrols have been conducted to monitor controlled releases from Cochiti Reservoir that threaten the spoil banks.

D-02 General Computational Procedures:

The assumptions and procedures used to analyze and quantify the economic variables are presented in this section. The hydro-economic model used to develop expected annual damages is based on discharge-frequency, stage-frequency, and stage-damage curves used to develop a damage-frequency curve. Stage-percent damage curves express dollar damages resulting from varying depths of water based on a percentage of the value of structure and contents.

Each surveyed property is assigned to a category (e.g., commercial, residential, public, apartment, transportation facilities, utilities, and vehicles) with as many subcategories (e.g., contents) as necessary, and details of ground and first floor elevations are noted. Each category has an associated depth-damage relationship expressed as a cumulative percentage of value for each foot of inundation. The depth-damage relationships were derived from historical data obtained from insurance companies, a recent commercial content survey conducted by the Albuquerque District, the Flood Insurance Administration, and prior Corps of Engineers experience. Note that the 2003 residential curves developed by the Institute of Water Resources (IWR) were used; thus, the residential content damages are a direct relationship to structure value. Table D-1 depicts the depth-damage relationships used in this study. Table D-2 and Table D-3 display the rating curves used in this study. For the without-project and without-project, future conditions, the error bands around the overbank rating curves are up to 0.3'. The main channel rating curves are much greater, at 1-2'.

Table D-1 Depth-Damage Relationships

DEPTH-DAMAGE RELATIONSHIPS

(expressed as proportion of property value)

	Stage (ft.)									
	1	2	3	4	5	6	7	8	9	10
Structures										
1 story no bsmt.	0.23	0.32	0.40	0.47	0.53	0.59	0.63	0.67	0.71	0.73
1 story no bsmt. (comm./public)	0.14	0.21	0.26	0.29	0.30	0.41	0.43	0.44	0.45	0.46
1 story w/ bsmt.	0.32	0.39	0.46	0.52	0.59	0.65	0.70	0.74	0.78	0.80
2 story no bsmt.	0.15	0.21	0.26	0.31	0.36	0.41	0.45	0.49	0.52	0.56
2 story no bsmt. (comm./public)	0.16	0.28	0.37	0.43	0.47	0.49	0.50	0.51	0.55	0.58
2 story w/ bsmt.	0.22	0.27	0.32	0.37	0.42	0.47	0.52	0.56	0.61	0.65
Mobile home	0.44	0.64	0.73	0.78	0.80	0.81	0.82	0.84	0.86	0.88
Metal	0.07	0.10	0.15	0.18	0.20	0.23	0.28	0.33	0.37	0.40
Outbuilding	0.25	0.35	0.41	0.46	0.54	0.65	0.71	0.80	0.85	0.90
Contents										
1 story no bsmt. (Residential)*	0.13	0.18	0.22	0.26	0.29	0.32	0.34	0.36	0.37	0.38
2 story no bsmt. (Residential)*	0.09	0.12	0.16	0.19	0.21	0.24	0.26	0.28	0.30	0.32
1 story w/ bsmt. (Residential)*	0.19	0.22	0.25	0.27	0.30	0.32	0.35	0.36	0.38	0.39
2 story w/ bsmt. (Residential)*	0.14	0.16	0.18	0.20	0.22	0.24	0.27	0.29	0.32	0.34
Mobile home (Residential)**	0.27	0.50	0.64	0.70	0.76	0.78	0.79	0.81	0.83	0.92
Motel, Office, Church (1 story)**	0.35	0.50	0.60	0.68	0.74	0.78	0.81	0.83	0.85	0.87
Motel, Office, Church (2 story)**	0.26	0.39	0.48	0.55	0.61	0.67	0.73	0.78	0.83	0.87
Food Related**	0.55	0.70	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.95
Gas Station, Car Service**	0.22	0.43	0.70	0.92	0.95	0.95	0.95	0.95	0.95	0.95
Retail (1 story)**	0.18	0.30	0.59	0.70	0.90	0.95	0.95	0.95	0.95	0.95
Retail (2 story)**	0.12	0.22	0.34	0.54	0.74	0.83	0.87	0.91	0.93	0.95
Clothing Store**	0.35	0.45	0.67	0.83	0.95	0.95	0.95	0.95	0.95	0.95
Car Dealership**	0.10	0.72	0.80	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Furniture Store**	0.75	0.85	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Outbuilding Contents**	0.30	0.51	0.62	0.67	0.69	0.71	0.80	0.85	0.90	0.95
Aircraft	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Roads	0.11	0.22	0.35	0.50	0.66	0.76	0.76	0.76	0.76	0.76
Unpaved roads	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Utilities	0.06	0.13	0.22	0.32	0.42	0.52	0.63	0.76	0.88	0.92
Railroad	0.03	0.04	0.12	0.15	0.18	0.21	0.31	0.64	0.76	0.82
Vehicles	0.05	0.17	0.20	0.75	0.80	0.85	0.90	0.95	0.95	0.95

* Content stage-damage function expressed as a percentage of structure value.

** Content stage-damage function expressed as a percentage of content value.

Table D-2 Rating Curves by Reach (Present)

RATING CURVES BY REACH
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

LEFT OVERBANK	EVENT							
	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1 - Mountain View	4,923.70	4,924.00	4,924.40	4,924.50	4,925.70	4,925.80	4,926.60	4,927.40
2 - Isleta North	4,901.00	4,901.60	4,902.00	4,902.00	4,902.10	4,902.10	4,903.40	4,904.50
3 - Isleta South	4,886.90	4,887.00	4,887.10	4,887.20	4,887.20	4,887.20	4,887.50	4,888.50
4 - Bosque Farms	4,866.80	4,867.00	4,867.00	4,867.00	4,867.00	4,867.00	4,867.20	4,867.50
5 - Los Lunas	4,849.80	4,850.00	4,850.00	4,850.00	4,850.50	4,850.50	4,850.50	4,851.20
6 - Los Chaves	4,825.00	4,825.50	4,825.50	4,825.50	4,825.50	4,825.50	4,825.70	4,826.60
7 - Belen	4,802.10	4,802.80	4,802.80	4,802.80	4,802.90	4,802.90	4,803.80	4,804.90
8 - Belen RR	4,794.00	4,794.50	4,794.50	4,794.50	4,794.50	4,794.50	4,795.20	4,795.80
RIGHT OVERBANK	EVENT							
	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1 - Mountain View	4,922.70	4,923.40	4,923.40	4,923.40	4,924.90	4,925.10	4,926.30	4,927.70
2 - Isleta North	4,902.00	4,902.90	4,902.90	4,902.90	4,903.10	4,903.10	4,903.80	4,904.30
3 - Isleta South	4,889.00	4,889.30	4,889.40	4,889.40	4,889.40	4,889.40	4,889.80	4,890.50
4 - Bosque Farms	4,867.20	4,867.80	4,867.80	4,867.80	4,867.80	4,867.80	4,868.00	4,868.30
5 - Los Lunas	4,850.80	4,851.30	4,851.30	4,851.30	4,851.30	4,851.30	4,851.70	4,852.00
6 - Los Chaves	4,823.30	4,823.90	4,824.00	4,824.00	4,824.00	4,824.00	4,824.20	4,824.50
7 - Belen	4,802.30	4,802.60	4,802.60	4,802.60	4,802.60	4,802.60	4,803.00	4,803.10
8 - Belen RR	4,793.00	4,793.50	4,793.50	4,793.50	4,793.50	4,793.50	4,793.80	4,794.00

Table D-3 Rating Curves by Reach (Future)

RATING CURVES BY REACH
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

LEFT OVERBANK	EVENT							
	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1 - Mountain View	4,923.70	4,924.00	4,924.40	4,924.50	4,925.70	4,925.80	4,926.60	4,927.40
2 - Isleta North	4,901.00	4,901.60	4,902.00	4,902.00	4,902.10	4,902.10	4,903.40	4,904.50
3 - Isleta South	4,887.10	4,887.30	4,887.30	4,887.30	4,887.30	4,887.30	4,887.60	4,888.60
4 - Bosque Farms	4,867.00	4,867.10	4,867.10	4,867.20	4,867.20	4,867.20	4,867.50	4,867.90
5 - Los Lunas	4,850.10	4,850.40	4,850.40	4,850.40	4,850.40	4,850.40	4,850.70	4,851.10
6 - Los Chaves	4,825.00	4,825.50	4,825.50	4,825.50	4,825.50	4,825.50	4,825.70	4,826.20
7 - Belen	4,802.10	4,802.70	4,802.80	4,802.80	4,802.90	4,802.90	4,803.80	4,804.80
8 - Belen RR	4,794.00	4,794.50	4,794.50	4,794.50	4,794.60	4,794.60	4,795.20	4,795.80
RIGHT OVERBANK	EVENT							
	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
1 - Mountain View	4,922.70	4,923.40	4,923.40	4,923.40	4,924.90	4,925.10	4,926.30	4,927.70
2 - Isleta North	4,902.00	4,902.90	4,902.90	4,902.90	4,903.10	4,903.10	4,903.90	4,904.30
3 - Isleta South	4,889.20	4,889.60	4,889.60	4,889.60	4,889.70	4,889.70	4,890.20	4,890.80
4 - Bosque Farms	4,867.30	4,867.80	4,867.80	4,867.80	4,867.80	4,867.80	4,868.10	4,868.50
5 - Los Lunas	4,851.00	4,851.60	4,851.60	4,851.60	4,851.60	4,851.60	4,852.20	4,852.70
6 - Los Chaves	4,823.50	4,823.90	4,824.00	4,824.00	4,824.00	4,824.00	4,824.20	4,824.40
7 - Belen	4,802.30	4,802.60	4,802.60	4,802.60	4,802.60	4,802.60	4,802.70	4,803.00
8 - Belen RR	4,793.00	4,793.50	4,793.50	4,793.50	4,793.50	4,793.50	4,793.70	4,793.90

The elevation of each property (determined from GIS-based topographic maps and field investigations) is aggregated by location and structure type to compute the vertical distribution of damageable property at that location. Each property category is then tabulated in terms of the number of units, value per unit and aggregate value, within consecutive inundation depth ranges for each location. That inventory is set into The Hydrologic Engineering Center's Flood Damage Analysis (FDA) ver. 1.2.5 to compute expected annual and Equivalent Annual Damages.

This report contains descriptive tables (number of structures subject to flooding by event, value of damageable property by property type and event, and single occurrence damages associated with specific frequency events) that were generated as a reality check of the FDA analysis. The study area's floodplain is fairly wide and flat, such that structure first floor height has a tremendous bearing on start of damages and damages attributable to specific events. To compute the number of structures in a given floodplain, the FDA_StrucDetail.out file was consulted, which computes number of structures, value of damageable property, and single occurrence damages. This computation occurs "without-risk" but serves as a consistency check on EAD and equivalent annual benefit calculations.

Table D-4 and Table D-5 displays the number of damageable property units by floodplain, in the present hydraulic condition. Table D-6 and Table D-1 displays the number of damageable property units by floodplain in the future hydraulic conditions (The future conditions represent the end of the period of analysis.). Table D-8, Table D-9, Table D-10, and Table D-11 presents the depreciated replacement values of those properties, by floodplain, for the present and future hydraulic conditions. As a quality check, these tables also display average value per structure, which is computed by dividing the number of structures in Tables D-4 to D-7 by the corresponding values in Tables D-8 to D-11.

Table D-4 Number of Structures (East Bank, Present)

NUMBER OF STRUCTURES - EAST BANK
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category								
	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	2,292		2,380		2,381		3,033	
Commercial	209		225		225		281	
Public	29		30		30		41	
Apartment	0		0		0		1	
Outbuildings	2,461		2,551		2,552		3,172	
Vehicles	1,725		1,737		1,740		2,118	
TOTAL STR.	**4,991**		**5,186**		**5,188**		**6,528**	

Table D-5 Number of Structures (West Bank, Present)

NUMBER OF STRUCTURES - WEST BANK WITHOUT PROJECT CONDITIONS (PRESENT) MIDDLE RIO GRANDE FLOODPLAIN								
	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	1,422		1,436		1,437		1,638	
Commercial	160		160		160		182	
Public	44		44		44		60	
Apartment	9		9		10		11	
Outbuildings	1,886		1,889		1,890		2,054	
Vehicles	1,190		1,191		1,191		1,368	
Aircraft	10		10		10		11	
TOTAL STR.	**3,521**		**3,538**		**3,541**		**3,945**	

Table D-6 Number of Structures (East Bank, Future)

NUMBER OF STRUCTURES - EAST BANK WITHOUT PROJECT CONDITIONS (FUTURE) MIDDLE RIO GRANDE FLOODPLAIN								
	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	1,954		2,347		2,347		2,794	
Commercial	155		213		213		268	
Public	25		30		30		39	
Apartment	0		0		0		1	
Outbuildings	1,985		2,500		2,500		2,830	
Vehicles	1,382		1,738		1,740		2,105	
TOTAL STR.	**4,119**		**5,090**		**5,090**		**5,932**	

Table D-7 Number of Structures (West Bank, Future)

NUMBER OF STRUCTURES - WEST BANK
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	1,431		1,445		1,446		1,575	
Commercial	160		160		160		180	
Public	44		44		44		47	
Apartment	9		9		10		11	
Outbuildings	1,886		1,889		1,890		1,992	
Vehicles	1,200		1,201		1,201		1,348	
Aircraft	10		10		10		11	
TOTAL STR.	**3,530**		**3,547**		**3,550**		**3,805**	

Table D-8 Value of Damageable Property (East Bank, Present)

VALUE OF DAMAGEABLE PROPERTY - EAST BANK
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN
(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	64		63		63		63	
Residential	146,497		150,354		150,400		190,366	
Res. Content	72,942		74,848		74,871		94,740	
$/str	73		76		76		66	
Commercial	15,273		17,098		17,098		18,500	
Comm. Content	22,965		24,357		24,357		25,697	
$/str	391		400		400		308	
Public	11,331		12,004		12,004		12,618	
Pub. Content	7,196		7,358		7,358		7,793	
$/str	#DIV/0!		#DIV/0!		#DIV/0!		39	
Apartment	0		0		0		39	
Apt. Contents	0		0		0		19	
$/str	4		4		4		5	
Outbuilding	10,828		11,140		11,141		14,361	
Out.. Contents	7,140		7,332		7,332		9,348	
$/veh	15		15		15		15	
Vehicles	25,720		25,899		25,943		31,579	
Total	**319,893**		**330,389**		**330,503**		**405,060**	

Table D-9 Value of Damageable Property (West Bank, Present)

VALUE OF DAMAGEABLE PROPERTY - WEST BANK
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN
(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	48		49		49		49	
Residential	68,920		69,688		69,728		80,308	
Res. Content	33,971		34,355		34,375		39,623	
$/str	249		249		249		230	
Commercial	39,890		39,890		39,890		41,890	
Comm. Content	70,389		70,389		70,389		70,999	
$/str	329		329		329		455	
Public	14,463		14,463		14,463		27,298	
Pub. Content	7,124		7,124		7,124		18,450	
$/str	84		84		76		166	
Apartment	757		757		757		1,821	
Apt. Contents	378		378		378		911	
$/str	5		5		5		5	
Outbuilding	8,902		8,906		8,917		9,550	
Out.. Contents	5,879		5,883		5,889		6,242	
$/veh	15		15		15		15	
Vehicles	17,743		17,758		17,758		20,397	
Aircraft	1,500		1,500		1,500		1,650	
Total	**268,416**		**269,591**		**269,667**		**317,489**	

Table D-10 Value of Damageable Property (East Bank, Future)

VALUE OF DAMAGEABLE PROPERTY - EAST BANK
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	63		63		63		63	
Residential	123,805		148,417		148,417		176,103	
Res. Content	61,700		73,885		73,885		87,710	
$/str	69		74		74		67	
Commercial	10,723		15,741		15,741		17,849	
Comm. Content	12,274		23,559		23,559		25,464	
$/str	452		400		400		309	
Public	11,304		12,004		12,004		12,047	
Pub. Content	7,166		7,358		7,358		7,407	
$/str	#DIV/0!		#DIV/0!		#DIV/0!		39	
Apartment	0		0		0		39	
Apt. Contents	0		0		0		19	
$/str	4		4		4		5	
Outbuilding	8,067		10,927		10,927		12,837	
Out.. Contents	5,310		7,210		7,210		8,411	
$/veh	15		15		15		15	
Vehicles	20,606		25,914		25,943		31,386	
Total	**260,956**		**325,014**		**325,044**		**379,273**	

Table D-11 Value of Damageable Property (West Bank, Future)

VALUE OF DAMAGEABLE PROPERTY - WEST BANK WITHOUT PROJECT CONDITIONS (FUTURE) MIDDLE RIO GRANDE FLOODPLAIN (x $1,000 May, 2016 price level)								
	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	48		49		49		49	
Residential	69,395		70,163		70,203		76,581	
Res. Content	34,196		34,580		34,599		37,763	
$/str	249		249		249		233	
Commercial	39,890		39,890		39,890		41,883	
Comm. Content	70,389		70,389		70,389		70,982	
$/str	329		329		329		316	
Public	14,463		14,463		14,463		14,836	
Pub. Content	7,124		7,124		7,124		7,267	
$/str	84		84		76		166	
Apartment	757		757		757		1,821	
Apt. Contents	378		378		378		911	
$/str	5		5		5		5	
Outbuilding	8,902		8,906		8,917		9,402	
Out.. Contents	5,879		5,883		5,889		6,131	
$/veh	15		15		15		15	
Vehicles	17,892		17,907		17,907		20,099	
Aircraft	1,500		1,500		1,500		1,650	
Total	**269,264**		**270,439**		**270,515**		**287,676**	

The 2010 American Community Survey conducted by the Bureau of the Census indicates the average household size in Valencia County is 2.63 persons. Multiplying this figure by the number residential and apartment structures in the 1% chance and 0.2% chance floodplains suggest that the study area has a Population at Risk (PAR) of 10,068 persons from the 1% chance flood and 12,316 persons from the 0.2% chance flood.

Section 308 of the Water Resources Development Act of 1990 states “The Secretary shall not include in the benefit base for justifying Federal flood damage reduction projects...any new or substantially improved structure...built in the 100-year flood plain with a first floor elevation less than the 100-year flood elevation after July 1,1991.” To comply with that requirement, the latest Flood Insurance Rate Maps (FIRM) of the study area were consulted and compared to identify study floodplains. (http://map1.msc.fema.gov/idms/IntraView.cgi?ROT=0&O_X=7200&O_Y=5173&O_ZM=0.065365&O_SX=941&O_SY=676&O_DPI=400&O_TH=54556965&O_EN=54573584&O_PG=1&O_MP=1&CT=0&DI=0&WD=14400&HT=10346&JX=1259&JY=839&MPT=0&MPS=0&ACT=0&KEY=54556267&ITEM=1&ZX1=335&ZY1=156&ZX2=508&ZY2=491 accessed 4/26/2011)

The latest applicable FIRM mapping in Valencia County, NM has an effective date of

8/19/2010. In terms of the study area, Valencia County FIRM maps cover communities south of the Isleta Pueblo. Bernalillo County has a more extensive flood mapping history, with major FIRM revisions in 1996, 2003 and 2008. The current effective date of the FIRM is August 16, 2012. The study inventory was compared to these maps, paying particular attention to the date of applicable FIRM revisions, to determine whether new construction or substantial improvements (which showed up in field inventory as a structure with a very low effective age). 4377 structures were identified by comparing FIRM coverage with estimates or records of structure age. Of those structures, 4259 were elevated clear of the FIRM-identified 1% AEP water surface elevation, leaving a remainder of 118 structures subject to the Section 308 exclusion. Table D-12 and Table D-13 presents the results of this analysis.

Table D-12 Properties Excluded from Benefit Calculations (East Bank)

PROPERTIES EXCLUDED FROM BENEFIT CALCULATIONS MIDDLE RIO GRANDE FLOODPLAIN (EAST BANK)				
	Identified within FIRM	Elevated clear of 1% chance WSEL	Remainder	Structures excluded from benefit calculations
Number of Structures	2206	2095	111	111

Table D-13 Properties Excluded from Benefit Calculations (West Bank)

PROPERTIES EXCLUDED FROM BENEFIT CALCULATIONS MIDDLE RIO GRANDE FLOODPLAIN (WEST BANK)				
	Identified within FIRM	Elevated clear of 1% chance WSEL	Remainder	Structures excluded from benefit calculations
Number of Structures	2170	2163	7	7

These 118 structures were largely comprised of single-story, detached sheds, stable awnings, garages, and carports of fairly average value. There were a couple dozen residences and mobile homes. A without project, present and future condition FDA simulation was run on those structures alone to determine whether these properties contributed substantially to the description of flood problems in the study area. Those results and sensitivity analyses indicate excluding these properties, consistent with the law, would have no material impact on EAD, project benefits, project sizing to identify the NED plan, or project cost-sharing.

For each category, the aggregate value of property at each flood depth is combined with the depth-damage relationship to compute total, single event damages for each level of flooding. Table D-14, Table D-15, Table D-16, and Table D-17 displays the single occurrence damages by category for the floodplain evaluated. The "FDA_StrucDetail.out" file is consulted to produce these tables describing the impacts of specific frequency events such as number of structures, value of damageable property, and single occurrence damages. Table D-4 to Table D-5 and Table D-8 to Table D-9 shows number of property units and value of damageable property affected by the 10-percent, 2-percent, 1-percent and 0.2 percent chance flood events,

respectively. Table D-6 and Table D-7 as well as Table D-10 and Table D-11 show number of property units and value of damageable property affected by the 10-percent, 4-percent, 2-percent, 1-percent and 0.2 percent chance flood events, respectively, in the future hydraulic condition. These tables were generated for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA.

The value of damageable property in the HEC-FDA model is computed "with risk," and is essentially combined with the discharge-frequencies of the reference floods to produce damage-frequency relationships. Damage-frequency relationships provide probable average annual damages for each category under the conditions of each reference flood, and can then be compared to the hydrologic, hydraulic, and economic data analyzed within HEC-FDA. Table D-18, Table D-19 show the average annual damages computation for the study area, in the present and future hydraulic condition. Table D-20 discounts the future condition damages to present values, to create Equivalent Annual Damages (EAD) which serve as the basis for which residual damages and benefits for any benefit/cost calculations will be made.

Table D-14 Single Occurrence Damages (East Bank, Present)

SINGLE OCCURRENCE DAMAGES (EAST BANK)
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	37,557		40,647		40,772		53,437	
Res. Content	10,778		11,684		11,723		15,429	
Commercial	3,095		3,297		3,318		4,277	
Comm. Content	17,149		17,868		17,903		20,024	
Public	2,680		2,987		2,996		3,327	
Pub. Content	3,992		4,344		4,350		4,855	
Apartment	0		0		0		4	
Apt. Contents	0		0		0		1	
Outbuildings	1,893		2,023		2,032		2,969	
Out. Contents	1,813		1,944		1,953		2,840	
Subtotal - Structures	**45,225**		**48,955**		**49,118**		**64,015**	
Subtotal - Contents	**33,732**		**35,840**		**35,929**		**43,150**	
Subtotal - Structures and	**78,956**		**84,795**		**85,047**		**107,165**	
Streets, roads	94,887		97,175		97,792		152,403	
Utilities	4,978		5,096		5,126		8,019	
Railroad	8		8		8		140	
Vehicles	5,196.00		5,202.00		5,950.00		6,430.00	
Agriculture	73		77		78		103	
Irr. Drains	596		612		617		951	
Aircraft	0		0		0		0	
Clean-Up	17,748.02		19,351.47		19,422.03		25,703.87	
Recreation	0.00		0.00		0.00		0.00	
Emergency Costs	3,036.64		3,184.75		3,210.60		4,513.72	
Total	**205,479**		**215,501**		**217,251**		**305,428**	

Table D-15 Single Occurrence Damages (West Bank, Present)

SINGLE OCCURRENCE DAMAGES (WEST BANK)
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	18,875		18,974		19,021		21,607	
Res. Content	5,710		5,739		5,754		6,534	
Commercial	8,022		8,058		8,076		8,850	
Comm. Content	36,046		36,437		36,632		46,033	
Public	3,699		3,717		3,726		4,089	
Pub. Content	4,267		4,282		4,290		4,638	
Apartment	303		304		304		335	
Apt. Contents	82		83		83		93	
Outbuildings	1,702		1,715		1,720		1,991	
Out. Contents	1,866		1,877		1,883		2,137	
Subtotal - Structures	**32,602**		**32,767**		**32,847**		**36,870**	
Subtotal - Contents	**47,971**		**48,418**		**48,641**		**59,436**	
Subtotal - Structures and	**80,573**		**81,185**		**81,488**		**96,306**	
Streets, roads	75,664		78,075		78,821		137,441	
Utilities	3,986		4,128		4,173		7,288	
Railroad	69		69		69		145	
Vehicles	4,766.00		4,771.00		5,542.00		6,515.00	
Agriculture	52		53		54		79	
Irr. Drains	567		577		581		883	
Aircraft	22,500		22,500		22,500		22,500	
Clean-Up	14,609.97		14,693.98		14,735.99		16,859.16	
Recreation	0.00		0.00		0.00		0.00	
Emergency Costs	3,041.81		3,090.79		3,119.46		4,320.25	
Total	**205,829**		**209,143**		**211,083**		**292,337**	

Table D-16 Single Occurrence Damages (East Bank, Future)

SINGLE OCCURRENCE DAMAGES (EAST BANK)
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	32,057		40,278		40,398		51,163	
Res. Content	9,228		11,577		11,614		14,765	
Commercial	1,988		3,267		3,281		4,123	
Comm. Content	7,594		17,794		17,829		19,625	
Public	2,889		2,916		2,927		3,278	
Pub. Content	4,254		4,293		4,301		4,774	
Apartment	0		0		0		4	
Apt. Contents	0		0		0		1	
Outbuildings	1,425		2,012		2,020		2,808	
Out. Contents	1,294		1,934		1,943		2,687	
Subtotal - Structures	**38,359**		**48,473**		**48,626**		**61,376**	
Subtotal - Contents	**22,371**		**35,599**		**35,687**		**41,851**	
Subtotal - Structures and Contents	**60,729**		**84,072**		**84,313**		**103,227**	
Streets, roads	98,243		100,976		123,161		197,031	
Utilities	5,147		5,280		6,445		10,590	
Railroad	8		8		8		140	
Vehicles	5,365		5,388		5,469		6,524	
Agriculture	76		79		80		127	
Irr. Drains	607		626		737		1,391	
Aircraft	0		0		0		0	
Clean-Up	14,899.44		19,161.86		19,227.64		24,659.90	
Recreation	0		0		0		0	
Emergency Costs	2,776		3,234		3,592		5,155	
Total	**187,851**		**218,824**		**243,032**		**348,846**	

Table D-17 Single Occurrence Damages (West Bank, Future)

SINGLE OCCURRENCE DAMAGES (WEST BANK) WITHOUT PROJECT CONDITIONS (FUTURE) MIDDLE RIO GRANDE FLOODPLAIN								
	(x $1,000 May, 2016 price level)							
	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	18,961		19,083		19,132		21,293	
Res. Content	5,734		5,772		5,786		6,438	
Commercial	8,022		8,058		8,076		8,681	
Comm. Content	36,047		36,437		36,632		44,025	
Public	3,703		3,720		3,729		4,006	
Pub. Content	4,270		4,286		4,293		4,538	
Apartment	303		304		304		327	
Apt. Contents	82		83		83		90	
Outbuildings	1,709		1,724		1,729		1,957	
Out. Contents	1,870		1,882		1,887		2,097	
Subtotal - Structures	**32,698**		**32,889**		**32,969**		**36,264**	
Subtotal - Contents	**48,003**		**48,459**		**48,682**		**57,189**	
Subtotal - Structures and Contents	**80,701**		**81,348**		**81,651**		**93,453**	
Streets, roads	77,224		79,873		97,320		185,274	
Utilities	4,067		4,221		5,163		10,076	
Railroad	69		69		69		142	
Vehicles	4,780		4,782		5,555		6,481	
Agriculture	53		55		55		98	
Irr. Drains	574		587		690		1,211	
Aircraft	22,500		22,500		22,500		22,500	
Clean-Up	14,631		14,724		14,766		16,472	
Recreation	0		0		0		0	
Emergency Costs	3,069		3,122		3,417		5,036	
Total	**207,668**		**211,281**		**231,186**		**340,742**	

Residual, average annual damages for each alternative, including the without project alternative, are obtained through consecutive iterations of the above computations for each alternative. The difference between damages in the without-project alternative and the residual damages for each alternative is the value of the benefits (inundation reduction) for each alternative. The following figure demonstrates the integration of hydrology, hydraulic data, and the economic information developed in this appendix is integrated to generate the Equivalent Annual Damages (EAD) computation:

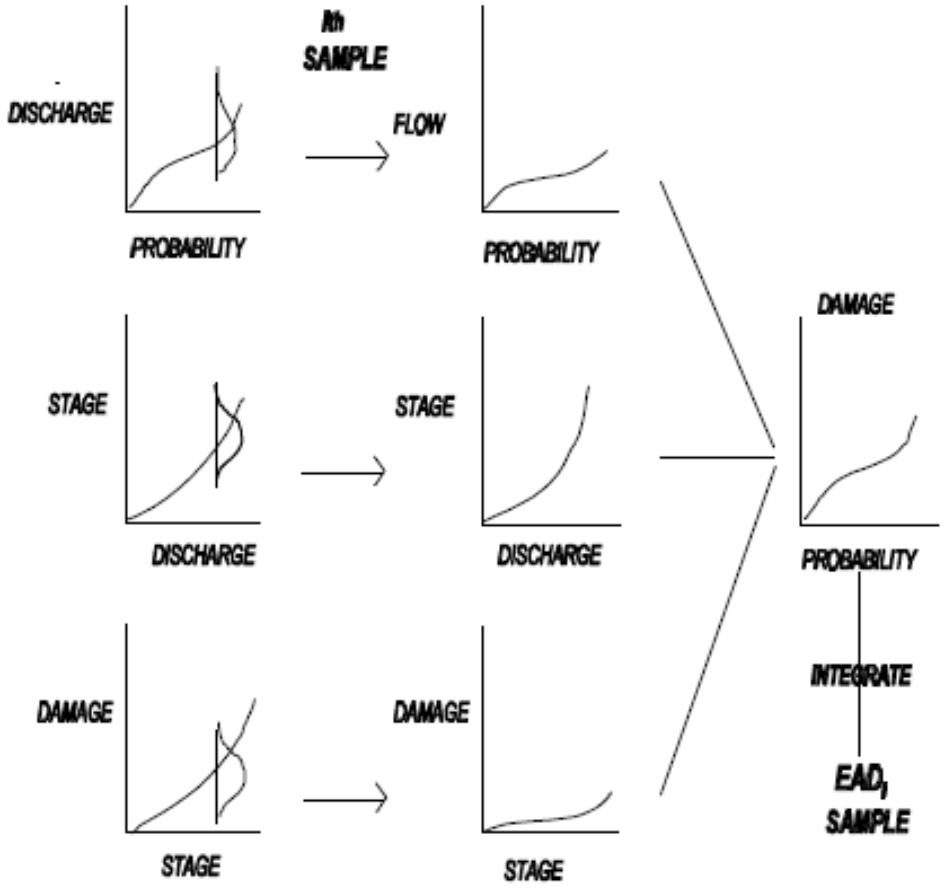


Figure D-4 - EAD Development Methodology

D-03 Value of Property:

A survey of structures within the floodplain was initially conducted in 2008, to evaluate the flood threat to the area. The property examined was categorized into residential, commercial, public, and apartment buildings, as well as, vehicles, streets and utilities, irrigation drainages, and outbuildings (sheds and detached garages). The field survey gathered primary data such as structure description (quality of construction, construction materials, number of floors, and presence of basements), an estimate of effective age for depreciation purposes, occupancy type, elevation above grade, an estimate of structure size in square feet, and the number of nearby structures that share these attributes.

Depreciated, replacement residential structure values were computed using the factors and methods described in the Real Estate Cost Handbook, published by the Marshall

and Swift Company. Corps regulations require cost-benefit evaluations use depreciated replacement costs. Replacement cost is the cost of physically replacing (reconstructing) the structure. Depreciation accounts for deterioration occurring prior to flooding, and variation in remaining useful life of structures. Depreciated replacement cost computations include factors such as construction type (wood, masonry) and quality, effective age (for depreciation purposes), and local market prices that bring the value of the structure to what we'd expect to spend on a "replacement in kind" structure in the study area. That computation was then verified in the field through interviews with local Realtors, and insurance agents to verify structure ages and replacement costs of structures in the floodplain. A windshield survey of all structures was also conducted to establish average first floor elevation above grade of structures in each damage reach. That "elevation above grade" was added to the ground surface elevation DTM data used in the hydraulic model (NAVD 88) to tie the economic inventory to the floodplain model. Commercial, public and apartment structures were inventoried in the field survey using the Marshall and Swift Valuation Service.

Content values were estimated from several sources. Residential and apartment content values were held at 50% of the structure value. Insurers contacted estimated content values are greater than 55% of structure value. (Where the IWR 2001 and 2003 structure and content stage-damage relationships were used, content damages are expressed as a percentage of structure value.) Commercial and public content values were computed using surveys of similar establishments and interviews.

Vehicle value estimates were determined using in-house data and published surveys. Total vehicles in the floodplain depicted are for residential structures and apartments. The typical household in the State of New Mexico has 2.3 vehicles. It is assumed that one of these vehicles is driven out of the floodplain before any flood event. The remaining vehicles were distributed to the residential and apartment structures located within the 0.2 percent annual exceedance probability flood plain. It was assumed that all business-related vehicles were already evacuated from the floodplain. Per a 2008 New York Times article, the average price of a used sedan was $11,500 (http://www.nytimes/com/2008/12/21/automobiles/21USED.html, accessed August 20, 2009). Edmunds indicated used sedan values in excess of $13,900 (http://www.edmunds.com/advice/buying/articles/45310/article.html, accessed August 20, 2009), but the more conservative value was used for this analysis.

Streets and utilities were measured from GIS-based floodplain maps to determine quantities susceptible to flooding for each event. Streets, roads within the floodplain were elevated to a median elevation for each particular flood event for which floodplains were generated, and were "damaged" per elevation-damage relationships produced by the Galveston District. The resulting damages per event were then probability-adjusted per the likelihood of the event, and summed to compute equivalent annual damages. A sample of that calculation follows:

Roads Present

freq	interval	value	single occ	total
0		289,844,361.04		
	0.002		289,844,361.04	579,688.72
0.002		289,844,361.04		
	0.008		233,228,862.60	1,865,830.90
0.005		210,061,328.10		
	0.005		193,337,346.14	966,686.73
0.01		176,613,364.17		
	0.01		175,931,782.02	1,759,317.82
0.02		175,250,199.86		
	0.08		172,901,144.63	13,832,091.57
0.1		170,552,089.40		
	0.01		85,276,044.70	852,760.45
0.11		0.00		
sum				19,856,376.19

Figure D-5 - Sample Event-Damage Calculation

Construction costs for roads were obtained from the City of Alamogordo, NM (http://ci.alamogordo.nm.us/Assets/COA+Document/City+Clerk/Minutes/04-08-2008+Regular+Minutes.pdf, accessed 10/30/2009) and the Arkansas State Highway and Transportation Department (http://www.arkansashighways.com/roadway_design_division/Cost_per_Mile_JULY_2009.pdf, accessed 10/30/2009) Utility construction costs were obtained from the Arizona and Texas Departments of Transportation. Damage estimates were calculated from published data provided by the Galveston District. Emergency costs were derived from locations that have had similar flood characteristics (Carlsbad, NM).

Agricultural acreage was measured using aerial photography of the floodplains used in this study. Agricultural valuation and damage assessment for crops within the study area was calculated using crop budgets from the NMSU Cooperative Extension Service for the study area. Using the hydrologic data, the crop budget was applied to a typical calendar year to calculate sunk costs if the flood event were to occur before the harvest. The long duration events predicted suggest a total loss of that year's crop if the event occurs before the harvest. Flood events occurring after harvest activities were conservatively assumed not to damage the value of the agricultural land, since the crop was already harvested. Officials at the Natural Resources Conservation Service provided estimates of crop composition (alfalfa hay, wheat, green chile, corn) and relative distribution.

Average values for general aviation aircraft were obtained through interviews with local aircraft mechanics and sales people. Stage-damage relationships for general aviation aircraft were created through interviews with local aircraft mechanics. They observed that, even when inundated, a typical single-engine, general aviation aircraft would not receive substantial damages until flood waters reach cockpit instrumentation, which is increasingly electronic, not repairable (must be replaced with other, flight-worthy

components), and comprises the bulk of the aircraft's value.

The assessment methods used to estimate clean-up follow the same ones used in the Sutter Basin Feasibility Study and the American River Common Features General Reevaluation Report (GRR). Both of these studies concluded with a recommended FRM project that was approved by the Secretary of the Army and authorized by Congress.

Flood waters leave debris, sediment, salts and the dangers of diseases throughout flooded structures, making the cleaning of these structures a necessary post-flood activity. Clean-up costs for the extraction of flood waters, dry-out, and decontamination vary significantly based upon various factors, including depth of flooding. Studies conducted by both Sacramento and New Orleans Districts indicate a maximum value of $10/ft² for such clean-up costs. Two firms specializing in disaster recovery and water damage clean up were contacted for this study to get updated costs, to no avail. The maximum value covers costs associated with mold and mildew abatement, which involves the professional application of fans, chemicals, and other techniques to eliminate mold and mildew in the areas that were flooded. The maximum clean-up cost of $10/ft² was used for this assessment and was applied to flood depths equal to and exceeding five feet, with damage percentages scaled down for depths between zero and five feet. Clean-up costs were not claimed for structures where depth of flooding (above the first floor) was below zero. For example, a structure could sustain a half-foot of flooding but also may have a foundation height of one foot. In this case no clean-up costs would be incurred. Another modification to the prior work described here was an assumption that structures that had clean-up costs in excess of replacement value less depreciation would incur zero clean-up costs, as the expected clean-up would exceed the value of the structure. This criteria had the impact of removing smaller outbuildings, such as residential scaled sheds and detached garages, from the inventory of structures subject to clean-up expenses, while keeping larger commercial barns and garages, and even horse stables and various commercial agricultural properties.

Clean-up costs are calculated based on the depth of flooding at the structure, the square footage of a structure, an estimated maximum value ($10/ft²) of clean-up expense, and a depth-percent damage curve. Figure D-6 and Figure D-7 displays the depth-percent damage curve used in the HEC-FDA analysis.

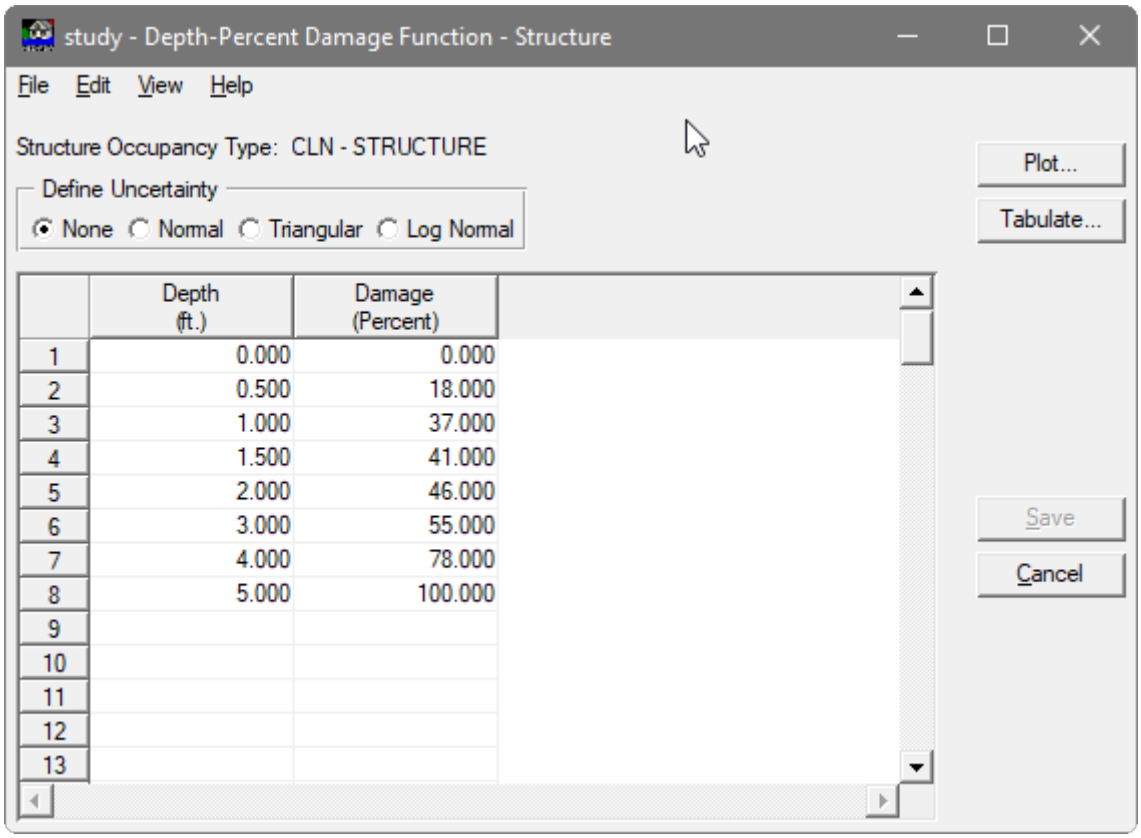


Figure D-6 – Clean-Up Depth-%damage relationship

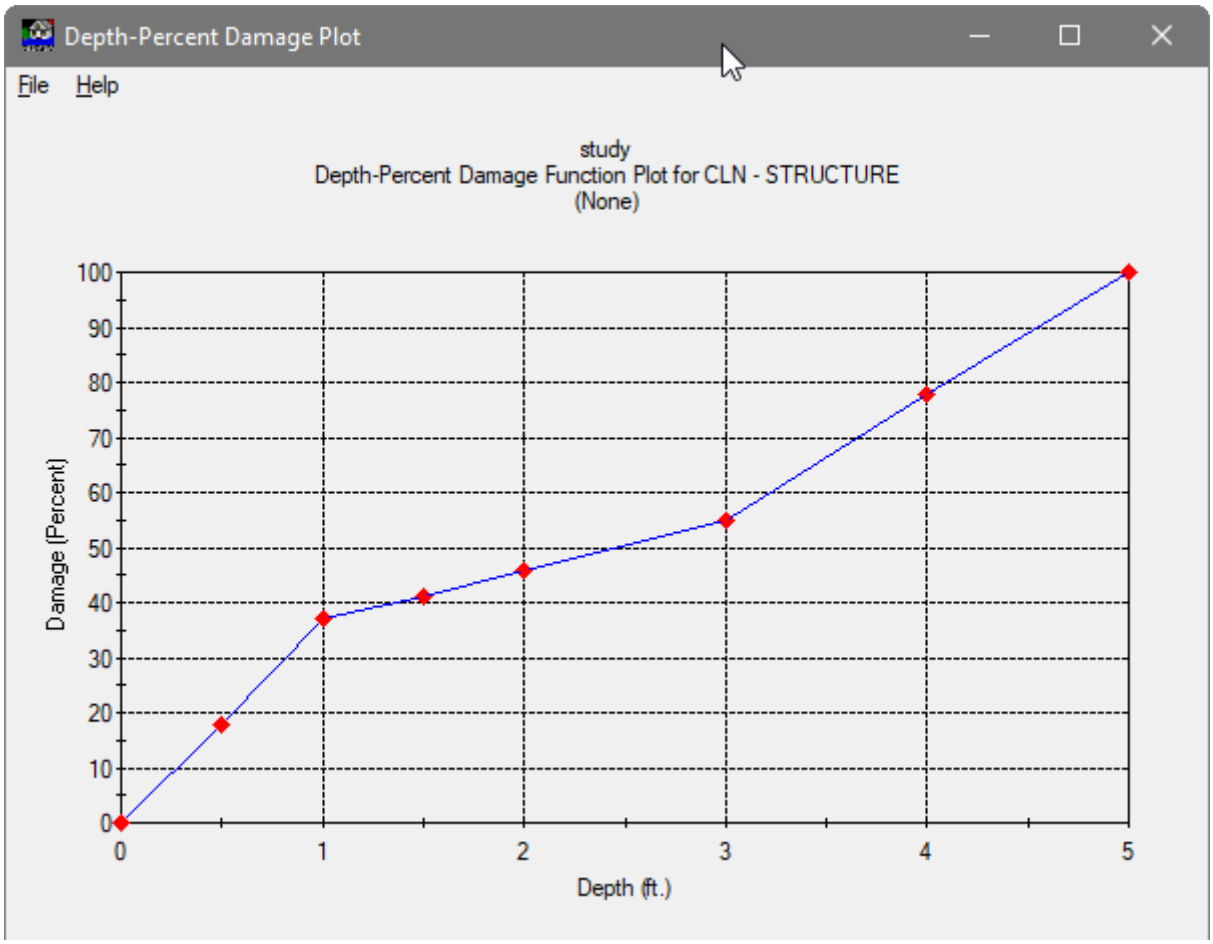


Figure D-7 – Clean-Up Depth-%damage relationship

D-04 Sources of Uncertainty:

The major sources of economic uncertainty include many of the same variables identified above in the damage estimate analysis and others noted as follows:

1. Value of property;
2. Value of property contents;
3. Flood stage at which damage begins;
4. First floor elevations of structures;
5. Responses to flood forecasts and warnings;
6. Flood fighting efforts;
7. Cleanup costs;
8. Business losses;
9. Depth-percent damage curves;
10. Estimate of the stage associated with a given discharge;
11. Estimate of damage for a given flood stage; and
12. Estimate of future land use

Principal sources of error affecting the stage-damage relationship were examined in a risk and uncertainty framework. Those sources of error are 1) errors associated with the damageable property elevation, 2) errors associated with the values of structures in the floodplain inventory, 3) errors associated with values of structure contents in the floodplain inventory, 4) errors associated with the damage functions used against the floodplain inventory.

There are numerous factors which affect the frequency distributions as well as the rating curves for the study area's hydraulic reaches. Those factors are discussed in detail in Appendix E.

Elevation of damageable property:

A standard deviation of 0.4 feet was used to account for the uncertainty associated with the elevation of damageable property. In the study area, the flooding depths are relatively shallow and the flood plains are large and flat; therefore, an elevation difference of one foot could potentially double the damages associated with a given stage. The 0.4 feet standard deviation was used for two reasons. First, since the economic inventory was conducted by a visual windshield inspection, the first floor elevations of structures were estimated rather than measured. Second, the digital terrain model (DTM) used to develop specific frequency event floodplains introduces a source of uncertainty relative to elevation. Sensitivity analyses also indicated that the flat overbank flooding areas was overstating the impact of relatively frequent flooding, so a more conservative start of damages condition was established in HEC-FDA to minimize this impact. Para. D-10 of this appendix discusses how the start of damages condition was modeled in HEC-FDA.

Structure value:

It was assumed that the estimated structure value, which was derived from a field inventory of replacement value estimation using the Marshall Valuation Service, less depreciation, has a standard deviation of 15 percent of the structure value. That 15 percent standard deviation comes from prior Albuquerque District studies, and prior experience of the Ft. Worth District, which developed that estimate from interviews with various County Assessor's offices.

The structure inventory values and associated error distribution were then evaluated to compute floodplain inventory that incorporates errors concerning structure value. It was assumed that the estimated structure value (derived from field inventory and consultations with Realtors, insurance agents) could be off by 15% of the structure value. The floodplain inventory was then assessed using these assumptions, dropping all values more than three standard deviations from the reported (mean) value. The resulting distribution of structure values with error would contain 99% of possible values given the assumptions above.

Content value:

The error distribution associated with content value varied by structure type. In terms of average annual damages for residential contents the damage curves relate to the structure value rather than the content value.

The content value error distribution varied by structure type. Corps guidance stipulates residential content values should be held to no more than 50% of structure values, though local insurers note that contents are valued at 55-60% of structure value, or more. Residential and apartment content value distributions with error were fixed to the error distributions associated with residential and apartment structures. New stage-damage relationships published by IWR in 2001 and 2003 compute content damages as a percentage of structure value. Content valuation in this appendix is for illustrative purposes only, and content damages for residences use the IWR methods. Commercial and public contents used standard deviations that were equal to the content value to develop the content value with error. All content relationships were truncated to eliminate the possibility of negative values.

Depth-percent damage relationship:

Depth-percent damage curves are among the most important and least exact data in benefit estimation. Depth-percent damage curves express dollar damages resulting from varying depths of water based on a percentage of the value of structure and contents. Errors associated with the depth-percent damage functions were applied after the structure and content values were determined. The errors associated with the stage-percent damage relationship were evaluated for structures and contents of all occupancy types. The standard deviations used were those estimated by IWR for residential and apartment structures and contents.

The errors associated with the depth-percent damage relationship were evaluated for structures and contents of commercial and public occupancy types. It was assumed that the damage value used +/- 40% of that value would contain the true damages for a given stage 95% of the time. The 40% standard deviation came from prior Albuquerque District studies, depth-percent damage relationships developed by Galveston and Albuquerque Districts through post-flood surveys of property owners, and interviews with local business owners. Residential and apartment structures and contents use the IWR depth-percent damage relationships, which include errors for each stage presented. Errors associated with the depth-percent damage functions used were applied after the uncertain structure and content values were determined.

D-05 HEC-FDA Use

Consistent with the requirements set forth in EC 1105-2-412, “Planning Models Improvement Program: Model Certification” HEC-FDA version 1.2.5 was used to compute average annual and equivalent annual damages (EAD). Corps guidance

stipulates that the plan which reasonably maximizes net national economic development benefits, consistent with the Federal objective, be identified. Project benefits for flood risk management measures are identified through successive iterations of existing and future without-project scenarios, changing key hydrologic and/or hydraulic variables as the measures warrant. HEC-FDA is the only model certified for formulation and evaluation of flood risk management plans using risk analysis methods, and was used in this study. Damages and benefits for the individual components are computed in May, 2016 price levels using the fiscal year 2019 Federal discount rate of 2.875%. The period of analysis is 50 years.

There were special conditions in the Middle Rio Grande study area that required changes to how HEC-FDA performs its analysis. First, HEC-FDA is set up expecting an incised channel with overbank flooding areas higher than the channel. The Rio Grande River is perched in many portions of the study area, meaning the river sits higher within its banks than many of the lower spots in the overbank areas. A typical effect of perched channels is severe events can have LOWER stages than less severe, more frequent events, as the river breaks through its banks and rushes into the expansive (and lower) overbanks. A second consequence of the perched channel is different banks of the same damage reach can have different water surface elevations for the same event.

The study team developed “virtual” channels to address HEC-FDA’s limitations to handle perched channels. For each damage reach, hydraulic water surface elevations were computed for the main channel, the left (east) overbank and the right (west) overbank locations. The HEC-FDA model contains three streams for purposes of analysis, identified in this appendix as the “Rio Grande”, the “Rio Grande LOB” (left overbank, east of the channel), and the “Rio Grande ROB” (right overbank, west of the channel). Each stream has its own water surface profiles, exceedance-probability functions, and stage-discharge functions. The economic inventory was assigned to either the left or right overbank “stream.”

A second issue created by perched channels is an exaggeration of the damages associated with frequent, though relatively not severe, events. The hydraulics appendix notes that there is considerable concern over the quality of the existing spoil banks, such that upstream dam releases are kept to below 7,000 cfs, which corresponds to somewhere between the 20% and 10%-chance events in this study. The FLO-2D model showed overbank depths with the 50% and 20%-chance events, which didn’t seem reasonable for this evaluation. Therefore, a beginning damage depth was applied in HEC-FDA corresponding to the present condition, 20%-chance water surface elevation. This ensures that events more frequent than the 20%-chance event doesn’t damage the floodplain inventory, as the flows are expected to be contained within the banks of the Rio Grande. Absent the starting damage elevations, average annual damages were more than double what is presented here. Table D-2 and Table D-3 displays the rating curves used in this evaluation.

D-06 Potential Flood Damages:

It is currently estimated that the mean 1-percent annual exceedance probability flood would cause damages of about $427.8 million in the study area. Table D-14, Table D-15, Table D-16 and Table D-17 presents the single occurrence damages associated with the 10%, 2%, 1%, and 0.2% chance flows in the assorted floodplains for each bank of the Rio Grande, for the present and future conditions. These tables were generated using HEC-FDA results for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA. HEC-FDA does not generate point estimates of flows, stages, or damages for a specific event. The software, essentially, performs a statistical analysis of hydrology, hydraulic, and economic information using concepts of risk and uncertainty, meaning that a specific event frequency can have a range of flows, stages, and damages as a result of all the variables entered into the study. HEC-FDA was used to compute average and equivalent annual damages for structures and their contents only. Other damage categories were evaluated by identifying damages associated with the same event frequencies, as described below. This study's hydrology and hydraulic evaluations assume that flood events of a magnitude greater than the 20% chance event damage structures, contents, and vehicles in the flooding areas analyzed. It should be noted that many intangible damages (such as loss of life, disruption to community services, and increased health risks) that could occur because of flooding are not represented in these damage values.

Several damage categories (agriculture, roads, utilities, railroads, irrigation drains) were evaluated outside HEC-FDA using the following method: Within each floodplain, quantities (in acres for agriculture, in lineal feet for other categories) of each property type were measured in GIS. The 10% chance floodplain inventory represents all property falling within the 10% floodplain polygon. The 2% chance floodplain represents the entire inventory in the 10% chance floodplain, plus the measurements in the floodplain polygon between the 10% and 2% chance floodplain boundaries. The 1% floodplain represents the contents in the 10% floodplain, the floodplains between the 10% and 2% chance boundaries, plus the polygon bounded by the 2% and 1% chance floodplain boundaries. Finally, the 0.2% chance floodplain represents the sum of the 10% chance polygon, plus the polygon bounded by the 10% and 2% floodplain boundaries, plus the polygon bounded by the 2% and 1% floodplain boundaries, and finally, the polygon bounded by the 1% and 0.2% chance floodplain boundaries.

Streets, roads, utility lines, railroads, and irrigation drains within each floodplain were elevated to a median elevation for each particular flood for which floodplains were generated. Therefore, for the first floodplain a particular stretch of road is inundated, the first inundation event stage is equal to half the marginal stage between identified floodplain and the prior event or start of damages (for the 10% chance floodplain). Subsequently more severe flood stages have the effect of damaging more property, as the floodplains grow, and providing even more inundation depths for properties located within lesser floodplains.

Agricultural valuation and damage assessment for crops within the study area was

calculated using crop budgets from the NMSU Cooperative Extension Service for the study area. GIS data and the floodplain boundaries were used to determine the acreage subject to flooding by specific events. Using the hydrologic data to determine the likelihood of precipitation in a given month, the crop budget was applied to a typical calendar year to calculate sunk costs if the flood event were to occur before the harvest. The long duration events predicted suggest a total loss of that year's crop if the event occurs before the harvest, therefore crop surface elevations were not necessary. Flood events occurring after harvest activities were conservatively assumed not to damage the value of the agricultural land, since the crop was already harvested. Officials at the Natural Resources Conservation Service provided estimates of crop composition (alfalfa hay, wheat, green chile, corn) and relative distribution.

Construction costs for roads and interstates were obtained from the Arkansas Department of Transportation and the City of Alamogordo, NM. Utility construction costs were obtained from the Arizona and Texas Departments of Transportation. Stage-damage relationships were calculated from published data provided by the Galveston District as well as prior Albuquerque District studies.

Enumerated damages derived for the Pueblo de Isleta's Isleta Lakes represent the value of recreational opportunity lost for one month in the year that the flood event occurs. In addition to calculating values and damages to physical assets contained within the refuge, it was assumed that floods generate adverse changes to the generalized recreation values for the facility. Hydrologic data was provided to estimate when during a typical year a significant flood event would occur, and general recreational values were developed per Economic Guidance Memorandum 14-03. A probability distribution of event occurrence in any given month was developed, and it was assumed that recreation opportunities would not be available for several days or even weeks, according to officials with the Pueblo de Isleta Tribe.

The general recreation values were estimated through interviews with Corps personnel, who looked at the quality of the recreation experience, the availability of the recreation opportunity, the carrying capacity of the facilities, the accessibility of the facilities, and the general aesthetic condition. Each respondent provided a point estimate for the general recreation experience per Economic Guidance Memorandum (EGM) 14-03. An arithmetic mean of the general recreation values was used to compute the value per general recreation day.

To date, the Pueblo de Isleta Tribe has been unwilling to provide estimates of visitation to the Isleta Lakes. Until a reasonable estimate of visitation can be obtained, tables in this appendix do not include damages associated with the loss of the recreation opportunity. The damages attributable to physical property at the Isleta Lakes, such as buildings and their contents, do show up in Public structures and their contents.

Emergency costs include the costs of evacuation, reoccupation, disaster relief, and other similar expenses. The emergency costs incurred are dependent upon factors including number of residences damaged, evacuated, etc. Factors used in this study

are based upon historical flooding in Carlsbad, NM and interviews with American Red Cross personnel.

Future flood damages resulting from basin development or growth in the floodplain have not been included, but are not expected to be significant for several reasons. 1) Local Realtors contacted noted that growth in Belen, Los Lunas, and the surrounding area has been flat and may remain stagnant in the future. 2) Local Realtors have noted that most recent development in the study area has occurred outside the floodplain.

Future flood damages to existing properties are expected to increase in parts of the study area due to sediment aggradation within the Rio Grande downstream of the Isleta Diversion dam. Any project evaluated in this light will have to account for the increased stages caused by sediment deposition in selected areas along the Rio Grande. Several tables in this appendix show existing conditions information, information for conditions 50 years hence. Table D-20 presents Expected Annual Equivalent damages and benefits, discounting future values to present value for purposes of selecting the NED plan.

Table D-18 Average Annual Damages (Present)

AVERAGE ANNUAL DAMAGES (PRESENT)
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Average Annual Damages (x$1,000, May, 2016 price level)		
	East Bank	West Bank	Total
Residential	22,643.97	10,484.54	33,128.51
Commercial	8,372.92	18,831.98	27,204.90
Public	3,616.53	3,581.51	7,198.04
Apartments	0.29	165.93	166.22
Outbuildings	1,687.11	1,519.51	3,206.62
Subtotal - Structures and Contents	36,320.82	34,583.47	70,904.29
Streets, roads	10,961.15	8,895.18	19,856.38
Utilities	575.06	469.83	1,044.89
Railroad	2.07	8.68	10.75
Vehicles	6,912.54	4,185.92	11,098.46
Agriculture	7.68	5.41	13.10
Irr. Drains	68.98	65.14	137.95
Aircraft	0.00	220.02	220.02
Clean-Up	5,462.23	3,763.23	9,225.46
Recreation			
Emergency Costs	821.69	722.23	1,543.92
TOTAL			**114,055.22**

Table D-19 Average Annual Damages (Future)

AVERAGE ANNUAL DAMAGES (FUTURE) BY LAND USE CATEGORY (x$1,000, May, 2016 price level)			
LAND USE CATEGORY	Average Annual Damages (x$1,000, May, 2016 price level)		
	East Bank	West Bank	Total
Residential	25,224.07	9,477.60	34,701.67
Commercial	8,446.06	16,087.26	24,533.32
Public	4,899.84	3,023.10	7,922.94
Apartments	0.07	142.23	142.30
Outbuildings	1,703.33	1,357.62	3,060.95
Subtotal - Structures and Contents	40,273.37	30,087.81	70,361.18
Streets, roads	11,907.81	9,613.27	21,521.13
Utilities	624.96	509.37	1,134.33
Railroad	2.17	8.91	11.08
Vehicles	7,816.27	3,668.47	11,484.74
Agriculture	8.01	5.61	13.62
Irr. Drains	74.45	69.48	148.91
Aircraft	0.00	165.21	165.21
Clean-Up	5,263.75	3,553.54	8,817.29
Recreation			
Emergency Costs	909.49	658.40	1,567.89
TOTAL			**115,225.38**

D-07 Equivalent Annual Damages:

Risk and uncertainty analysis was used to derive average annual damages. Hydrologic and hydraulic uncertainty was combined through Monte Carlo simulations within HEC-FDA. When flooding from all sources is considered, the study area faces the risk of approximately $114.1 million in equivalent annual damages. Sediment deposition over the proposed project's life is expected to slightly increase those damages, which has been discounted to present value, summed, and amortized over the period of analysis. Table D-18 and Table D-19 presents the average annual damages that could occur from flooding in the study area without any flood protection, by land use category and floodplain for the present and future hydraulic conditions. Table D-20 discounts the future damages to present values, and presents the Equivalent Annual Damages

(EAD).

Table D-20 Equivalent Annual Damages

EQUIVALENT ANNUAL DAMAGES BY LAND USE CATEGORY			
(x$1,000, May, 2016 price level)			
LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential	23,533.28	10,137.45	33,670.73
Commercial	8,398.26	17,885.90	26,284.16
Public	4,058.87	3,389.03	7,447.90
Apartments	0.21	157.76	157.97
Outbuildings	1,692.70	1,463.71	3,156.41
Subtotal - Structures and Contents	37,683.32	33,033.85	70,717.17
Streets, roads	11,347.35	9,188.13	20,535.52
Utilities	595.42	485.96	1,081.38
Railroad	2.11	8.77	10.89
Vehicles	7,224.04	4,007.56	11,231.60
Agriculture	7.82	5.49	13.31
Irr. Drains	71.21	66.91	142.42
Aircraft	0.00	201.13	201.13
Clean-Up	5,387.66	3,684.45	9,072.11
Recreation			
Emergency Costs	565.25	495.51	1,060.76
TOTAL	**62,884.17**	**51,177.77**	**114,066.29**

D-08 Analysis of Existing Spoil banks:

A reliability assessment of the existing system of spoil banks was performed to determine applicable Probable Non-Failure and Probable Failure Points (PNP and PFP, respectively). The results of that evaluation are presented in Appendix F of this report. In it, the conditions under which the spoil banks fail are limited to foundation seepage, piping, and, which would occur before flows break out of the river channel.

As a result of the subsurface investigations, the Probable Non-Failure Point (PNP) was determined to be some point within the Rio Grande channel. The Probable Failure Point (PFP) was determined to be the toe of the existing spoil banks just above the point where water first breaks out of the river channel. For purposes of determining damages and benefits for this appendix, the existing spoil banks provides no protection from any of the flood events evaluated.

An application of Policy Guidance Letter Number 26, Benefit Determination Involving Existing Levees, was performed for the existing system of spoil banks. The geo-technical analysis that appears in Appendix F notes that the existing spoil banks are not adequate to withstand water against or near the spoil banks from the Rio Grande. Previous iterations of this report did not consider the protective value of the existing system of spoil banks, and no adjustment of the benefits provided by those spoil banks is necessary.

D-09 Evaluation of Pueblo de Isleta Properties:

Previous evaluations within the study area have indicated there were insufficient benefits within the Isleta East reach to justify extension of the authorized plan through Pueblo lands. Therefore, an objective of this evaluation was to determine the nature of the flood risk to properties within this two reaches specifically. This evaluation represents the only identified separable elements (apart from the east bank and west bank division) of the study area at this time. Table D-21, Table D-22, Table D-23 and Table D-24 displays the number of structures within the floodplains identified, for the present and future, without-project, hydraulic conditions. Table D-25, Table D-26, Table D-27 and Table D-28 identifies the value of damageable property by property type and floodplain for the present and future, without-project conditions. Table D-29, Table D-30, Table D-31 and Table D-32 describes the structure damages attributed to specific flood events.

Table D-21 Number of Structures (Isleta East Bank, Present)

NUMBER OF STRUCTURES - Isleta Pueblo East Bank
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category								
	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	51		62		62		65	
Commercial	13		16		16		18	
Public	13		16		16		18	
Apartment	13		16		16		18	
Outbuildings	63		73		74		75	
Vehicles	52		53		53		59	
TOTAL STR.	**153**		**183**		**184**		**194**	

Table D-22 Number of Structures (Isleta West Bank, Present)

NUMBER OF STRUCTURES - Isleta Pueblo West Bank
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	82		82		82		114	
Commercial	1		1		1		3	
Public	4		4		4		4	
Apartment	0		0		0		0	
Outbuildings	109		109		109		144	
Vehicles	32		32		32		74	
Aircraft	0		0		0		0	
TOTAL STR.	**196**		**196**		**196**		**265**	

Table D-23 Number of Structures (Isleta East Bank, Future)

NUMBER OF STRUCTURES - Isleta Pueblo East Bank
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	54		55		55		68	
Commercial	14		14		14		20	
Public	14		14		14		20	
Apartment	14		14		14		20	
Outbuildings	66		66		66		75	
Vehicles	53		53		53		59	
TOTAL STR.	**162**		**163**		**163**		**203**	

Table D-24 Number of Structures (Isleta West Bank, Future)

NUMBER OF STRUCTURES - Isleta Pueblo West Bank
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	91		91		91		116	
Commercial	1		1		1		3	
Public	4		4		4		4	
Apartment	0		0		0		0	
Outbuildings	109		109		109		149	
Vehicles	42		42		42		76	
Aircraft	0		0		0		0	
TOTAL STR.	**205**		**205**		**205**		**272**	

Table D-25 Value of Damageable Property (Isleta East Bank, Present)

VALUE OF DAMAGEABLE PROPERTY - Isleta Pueblo East Bank
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN
(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10% Mean	10% SD	2% Mean	2% SD	1% Mean	1% SD	0.20% Mean	0.20% SD
$/str	36		35		35		36	
Residential	1,835		2,189		2,189		2,335	
Res. Content	874		1,029		1,029		1,102	
$/str	27		30		30		34	
Commercial	348		476		476		610	
Comm. Content	1,015		1,283		1,283		1,546	
$/str	27		30		30		34	
Public	348		476		476		610	
Pub. Content	1,015		1,283		1,283		1,546	
$/str	27		30		30		34	
Apartment	348		476		476		610	
Apt. Contents	1,015		1,283		1,283		1,546	
$/str	7		7		7		7	
Outbuilding	468		495		495		500	
Out.. Contents	457		473		473		473	
$/veh	15		15		15		15	
Vehicles	775		790		790		880	
Total	**8,499**		**10,253**		**10,254**		**11,759**	

Table D-26 Value of Damageable Property (Isleta West Bank, Present)

VALUE OF DAMAGEABLE PROPERTY - Isleta Pueblo West Bank
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN
(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10% Mean	10% SD	2% Mean	2% SD	1% Mean	1% SD	0.20% Mean	0.20% SD
$/str	48		48		48		48	
Residential	3,969		3,969		3,969		5,513	
Res. Content	1,980		1,980		1,980		2,725	
$/str	5		5		5		3	
Commercial	5		5		5		9	
Comm. Content	6		6		6		19	
$/str	9		9		9		9	
Public	35		35		35		35	
Pub. Content	40		40		40		40	
$/str	#DIV/0!		#DIV/0!		#DIV/0!		#DIV/0!	
Apartment	0		0		0		0	
Apt. Contents	0		0		0		0	
$/str	5		5		5		4	
Outbuilding	517		517		517		615	
Out.. Contents	285		285		285		325	
$/veh	15		15		15		15	
Vehicles	477		477		477		1,103	
Aircraft	0		0		0		0	
Total	**7,314**		**7,314**		**7,314**		**10,383**	

Table D-27 Value of Damageable Property (Isleta East Bank, Future)

VALUE OF DAMAGEABLE PROPERTY - Isleta Pueblo East Bank
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	35		36		36		35	
Residential	1,900		1,966		1,966		2,365	
Res. Content	890		923		923		1,117	
$/str	33		33		33		34	
Commercial	469		469		469		675	
Comm. Content	1,255		1,255		1,255		1,794	
$/str	33		33		33		34	
Public	469		469		469		675	
Pub. Content	1,255		1,255		1,255		1,794	
$/str	33		33		33		34	
Apartment	469		469		469		675	
Apt. Contents	1,255		1,255		1,255		1,794	
$/str	7		7		7		7	
Outbuilding	479		479		479		500	
Out.. Contents	464		464		464		473	
$/veh	15		15		15		15	
Vehicles	790		790		790		880	
Total	**9,694**		**9,793**		**9,793**		**12,740**	

Table D-28 Value of Damageable Property (Isleta West Bank, Future)

VALUE OF DAMAGEABLE PROPERTY - Isleta Pueblo West Bank
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

Land Use Category	EVENT 10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$/str	49		49		49		49	
Residential	4,444		4,444		4,444		5,634	
Res. Content	2,204		2,204		2,204		2,785	
$/str	5		5		5		3	
Commercial	5		5		5		9	
Comm. Content	6		6		6		19	
$/str	9		9		9		9	
Public	35		35		35		35	
Pub. Content	40		40		40		40	
$/str	#DIV/0!		#DIV/0!		#DIV/0!		#DIV/0!	
Apartment	0		0		0		0	
Apt. Contents	0		0		0		0	
$/str	5		5		5		4	
Outbuilding	517		517		517		634	
Out.. Contents	285		285		285		331	
$/veh	15		15		15		15	
Vehicles	626		626		626		1,133	
Aircraft	0		0		0		0	
Total	**8,162**		**8,162**		**8,162**		**10,619**	

Table D-29 Single Occurrence Damages (Isleta East Bank, Present)

SINGLE OCCURRENCE DAMAGES (Isleta Pueblo East Bank)
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	439		523		526		676	
Res. Content	127		158		159		213	
Commercial	29		42		43		61	
Comm. Content	416		650		653		884	
Public	29		42		43		61	
Pub. Content	416		650		653		884	
Apartment	29		42		43		61	
Apt. Contents	416		650		653		884	
Outbuildings	44		56		56		69	
Out. Contents	135		177		178		218	
Subtotal - Structures	**571**		**706**		**710**		**929**	
Subtotal - Contents	**1,509**		**2,284**		**2,295**		**3,083**	
Subtotal - Structures and	**2,080**		**2,990**		**3,005**		**4,012**	
Streets, roads	0		0		0		0	
Utilities	0		0		0		0	
Railroad	0		0		0		0	
Vehicles	0		0		0		0	
Agriculture	0		0		0		0	
Irr. Drains	0		0		0		0	
Recreation	0		0		0		0	
Emergency Costs	31		45		45		60	
Total	**2,111**		**3,035**		**3,050**		**4,072**	

Table D-30 Single Occurrence Damages (Isleta West Bank, Present)

SINGLE OCCURRENCE DAMAGES (Isleta Pueblo West Bank)
WITHOUT PROJECT CONDITIONS (PRESENT)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT							
Land Use Category	10%		2%		1%		0.20%	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Residential	516		522		524		923	
Res. Content	157		159		159		276	
Commercial	0		0		0		1	
Comm. Content	0		0		1		5	
Public	3		3		3		5	
Pub. Content	20		20		20		29	
Apartment	0		0		0		0	
Apt. Contents	0		0		0		0	
Outbuildings	69		70		70		108	
Out. Contents	54		55		55		74	
Subtotal - Structures	**589**		**595**		**598**		**1,036**	
Subtotal - Contents	**231**		**234**		**235**		**385**	
Subtotal - Structures and	**820**		**829**		**833**		**1,421**	
Streets, roads	0		0		0		0	
Utilities	0		0		0		0	
Railroad	0		0		0		0	
Vehicles	0		0		0		0	
Agriculture	0		0		0		0	
Irr. Drains	0		0		0		0	
Aircraft	0		0		0		0	
Recreation	0		0		0		0	
Emergency Costs	12		12		12		21	
Total	**832**		**841**		**845**		**1,442**	

Table D-31 Single Occurrence Damages (Isleta East Bank, Future)

SINGLE OCCURRENCE DAMAGES (Isleta Pueblo East Bank)
WITHOUT PROJECT CONDITIONS (FUTURE)
MIDDLE RIO GRANDE FLOODPLAIN

(x $1,000 May, 2016 price level)

	EVENT			
Land Use Category	10%	2%	1%	0.20%
	Mean	Mean	Mean	Mean
Residential	505	509	511	658
Res. Content	152	153	154	206
Commercial	39	40	40	59
Comm. Content	610	620	624	860
Public	39	40	40	59
Pub. Content	610	620	624	860
Apartment	39	40	40	59
Apt. Contents	610	620	624	860
Outbuildings	53	54	54	67
Out. Contents	172	173	174	212
Subtotal - Structures	**676**	**682**	**686**	**900**
Subtotal - Contents	**2,154**	**2,185**	**2,201**	**2,999**
Subtotal - Structures and Contents	**2,830**	**2,868**	**2,886**	**3,899**
Streets, roads	0	0	0	0
Utilities	0	0	0	0
Railroad	0	0	0	0
Vehicles	0	0	0	0
Agriculture	0	0	0	0
Irr. Drains	0	0	0	0
Recreation	0	0	0	0
Emergency Costs	42	43	43	58
Total	**2,872**	**2,911**	**2,930**	**3,957**

Table D-32 Single Occurrence Damages (Isleta West Bank, Future)

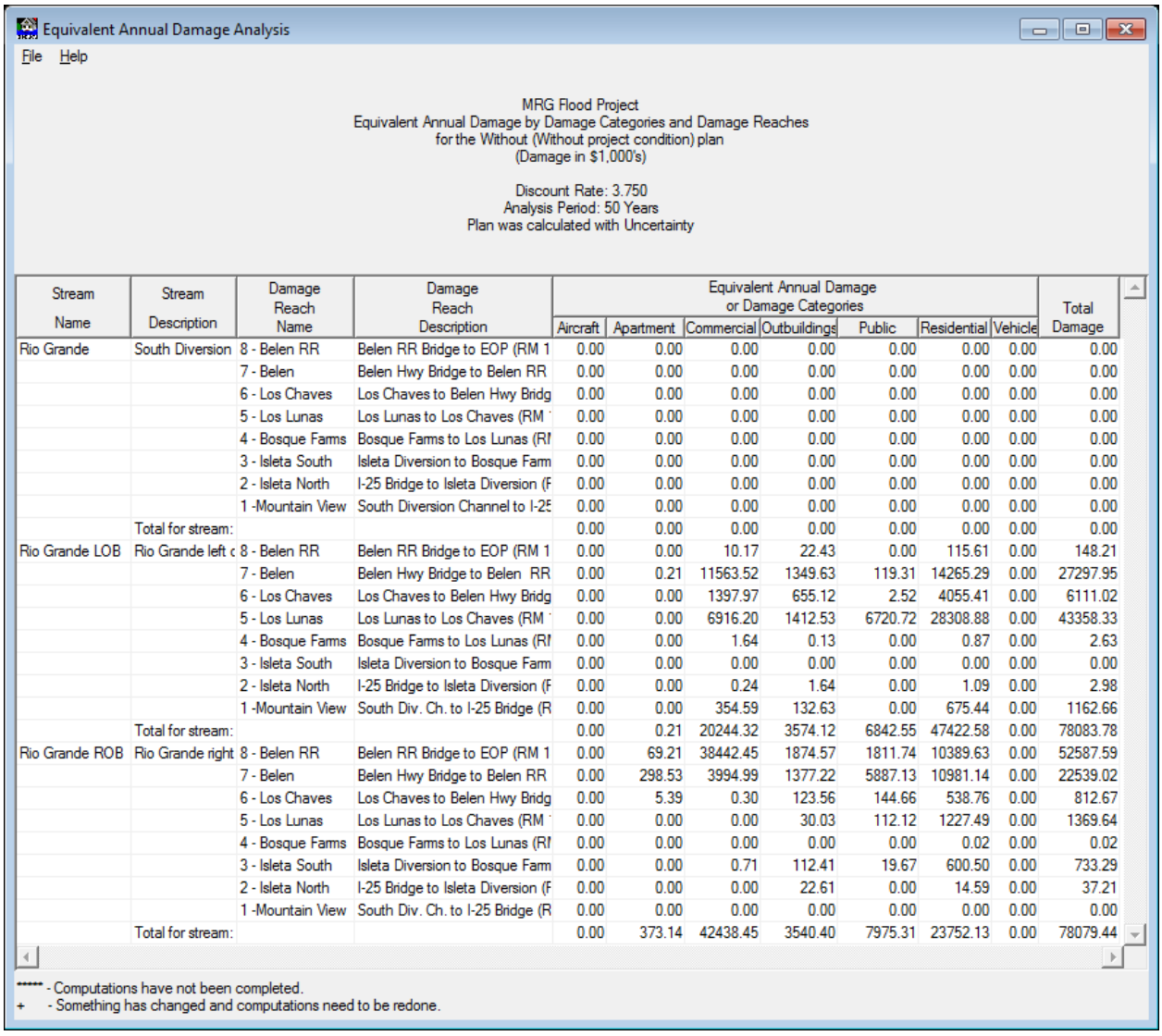
SINGLE OCCURRENCE DAMAGES (Isleta Pueblo West Bank)				
WITHOUT PROJECT CONDITIONS (FUTURE)				
MIDDLE RIO GRANDE FLOODPLAIN				
(x $1,000 May, 2016 price level)				
	EVENT			
Land Use Category	10%	2%	1%	0.20%
	Mean	Mean	Mean	Mean
Residential	579	609	612	1,058
Res. Content	176	185	186	315
Commercial	0	0	0	1
Comm. Content	1	1	1	8
Public	3	4	4	5
Pub. Content	22	23	23	31
Apartment	0	0	0	0
Apt. Contents	0	0	0	0
Outbuildings	75	78	78	121
Out. Contents	58	59	59	80
Subtotal - Structures	**658**	**691**	**694**	**1,186**
Subtotal - Contents	**257**	**268**	**269**	**435**
Subtotal - Structures and Contents	**915**	**959**	**964**	**1,620**
Streets, roads	0	0	0	0
Utilities	0	0	0	0
Railroad	0	0	0	0
Vehicles	0	0	0	0
Agriculture	0	0	0	0
Irr. Drains	0	0	0	0
Aircraft	0	0	0	0
Recreation	0	0	0	0
Emergency Costs	14	14	14	24
Total	**928**	**973**	**978**	**1,645**

The tables identified in the previous paragraph identified residential and commercial values are remarkably lower than the remainder of the floodplain. This was due to a couple reasons: One, a significantly higher number of outbuildings (detached garages, sheds, privately-owned barns and stables) were included with the "Residential" property category. Two, many commercial properties identified within the floodplain were constructed of portable structures and mobile homes.

D-10 Sensitivity Studies of the Without-Project Condition:

The impacts of imperfect information on the existing spoil banks on EAD were evaluated through a series of sensitivity studies, discussed further here:

The first attempt to populate HEC-FDA uses the hydrologic, hydraulic, and economic information developed to get a handle on EAD. The study area is populated with bedroom communities to the Albuquerque metro area and patches of semi-urban and semirural land. The initial economic inventory identified approximately 19,000 structures within the study area. Results of that first analysis follow:



Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircraft	Apartment	Commercial	Outbuildings	Public	Residential	Vehicle	
Rio Grande	South Diversion	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1 -Mountain View	South Diversion Channel to I-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream:			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rio Grande LOB	Rio Grande left c	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	10.17	22.43	0.00	115.61	0.00	148.21
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.21	11563.52	1349.63	119.31	14265.29	0.00	27297.95
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	1397.97	655.12	2.52	4055.41	0.00	6111.02
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	6916.20	1412.53	6720.72	28308.88	0.00	43358.33
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	1.64	0.13	0.00	0.87	0.00	2.63
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.24	1.64	0.00	1.09	0.00	2.98
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	354.59	132.63	0.00	675.44	0.00	1162.66
	Total for stream:			0.00	0.21	20244.32	3574.12	6842.55	47422.58	0.00	78083.78
Rio Grande ROB	Rio Grande right	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	69.21	38442.45	1874.57	1811.74	10389.63	0.00	52587.59
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	298.53	3994.99	1377.22	5887.13	10981.14	0.00	22539.02
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	5.39	0.30	123.56	144.66	538.76	0.00	812.67
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	0.00	30.03	112.12	1227.49	0.00	1369.64
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.71	112.41	19.67	600.50	0.00	733.29
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	22.61	0.00	14.59	0.00	37.21
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream:			0.00	373.14	42438.45	3540.40	7975.31	23752.13	0.00	78079.44

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-8 First pass of model (H&H as written, economic inventory as written)

Observations on the first pass:

For the without-project condition, the relevant damages are pulled from the “Rio Grande LOB” and “Rio Grande ROB” “streams” (LOB = “left overbank” and ROB = “right overbank”). The Rio Grande is perched, relative to the floodplain. Placing the inventory against that perched channel has the effect of increasing damages, which is a clearly inappropriate description of the flooding problem. Each subsequent pass of the HEC-FDA model has the Rio Grande channel modeled, but should not be considered a valid description of the flood damages/damages reduced.

Second pass of the HEC-FDA model

The EAD calculations in HEC-FDA were clearly high, and an adjustment to the economic inventory was made consistent with other studies (such as Middle Rio Grande, San Acacia to Bosque Del Apache) to mitigate the impacts of frequent occurrence events. HEC-FDA provides a "Begin_Dmg_Depth" feature whereby a depth relative to the first floor of a given structure serves as the start of damages condition for that structure. This study uses the mean depth associated with the 20% chance occurrence event, calculated at each structure in the inventory. That depth is computed at each structure, relative to the structure first floor. What follows is two examples of that Begin_Dmg_Depth. The first example demonstrates that computation for a structure with a relatively high first floor elevation, and the second one for a structure with a relatively low first floor elevation.

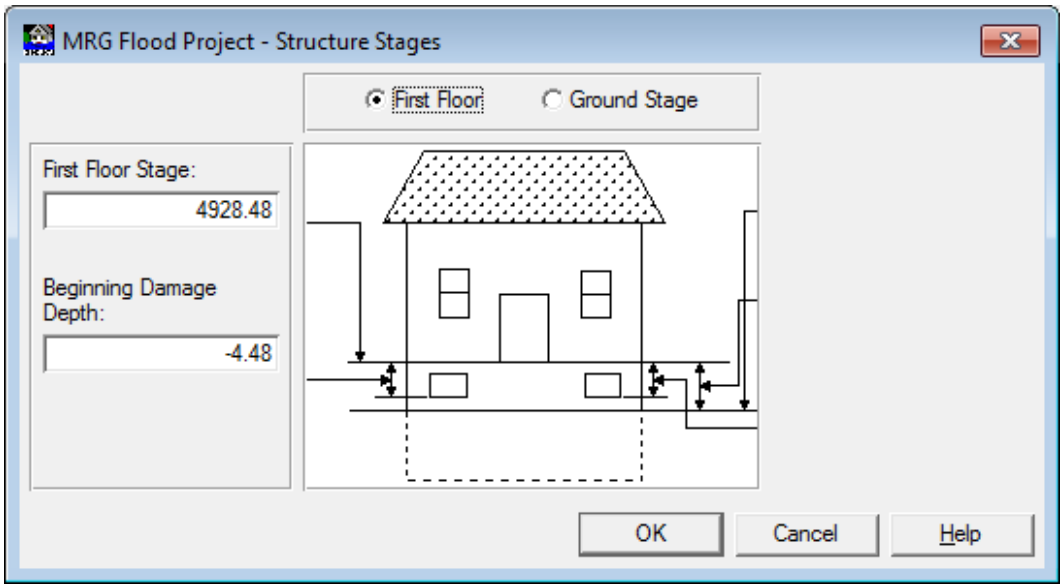


Figure D-9 Sample Begin_Dmg_Depth entry, high first floor elevation

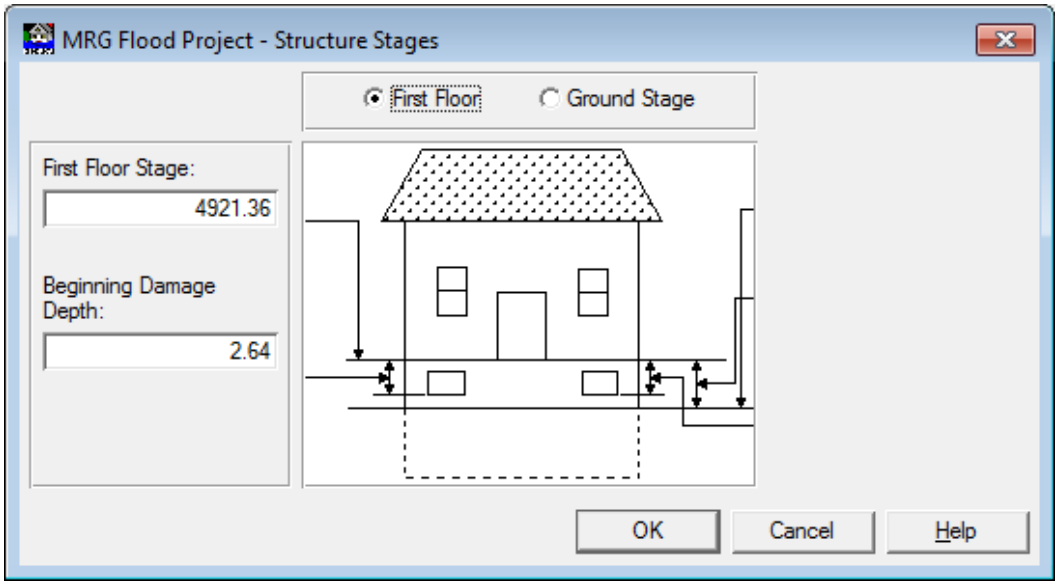
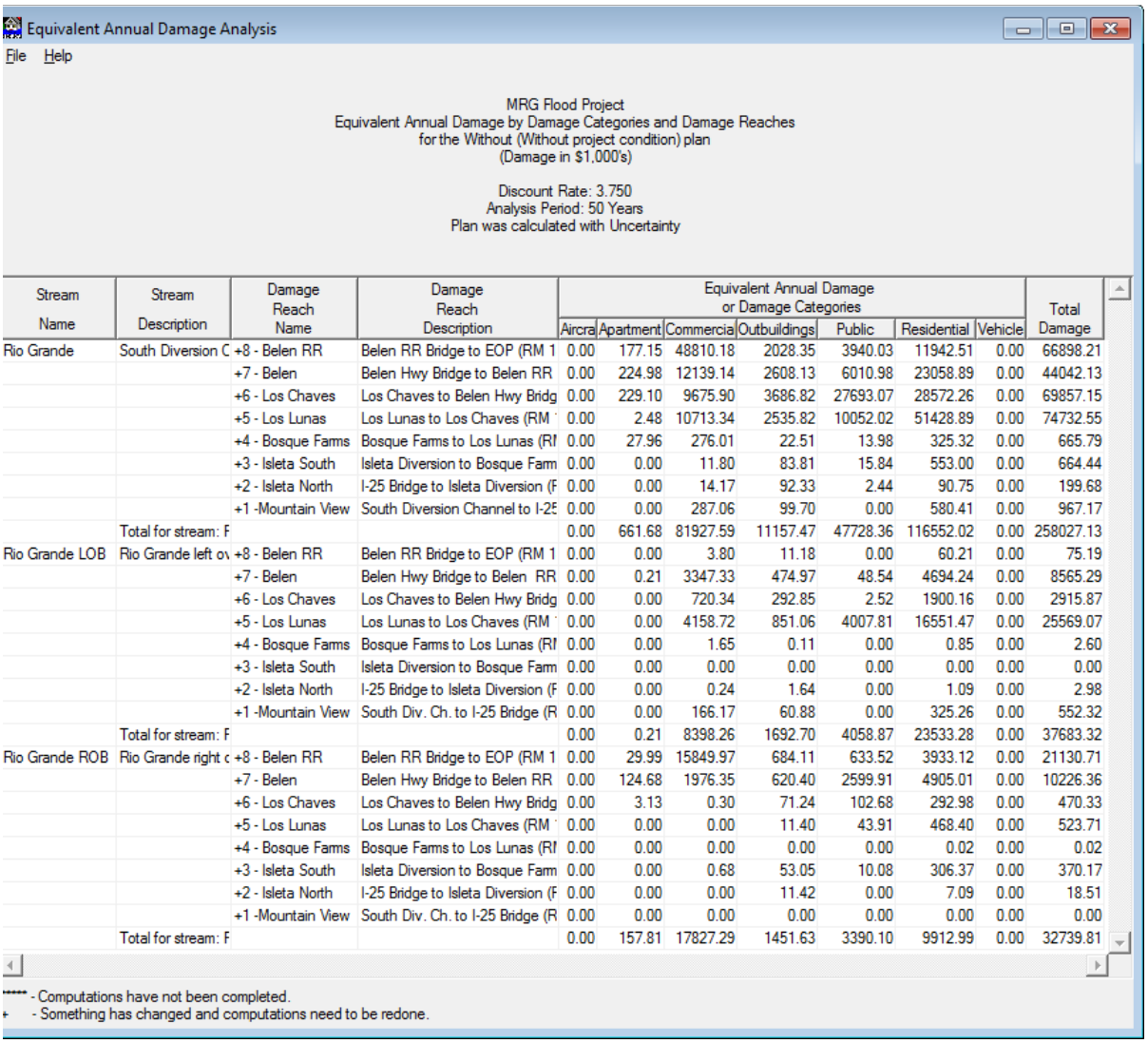


Figure D-10 Sample Begin_Dmg_Depth entry, low first floor elevation

The Begin_Dmg_Depth feature in FDA is significant because the user can force the model to ignore flooding below a certain stage, even if the structure is in low-lying areas within the floodplain.



Equivalent Annual Damage Analysis

File Help

MRG Flood Project
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 3.750
Analysis Period: 50 Years
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircra	Apartment	Commercia	Outbuildings	Public	Residential	Vehicle	
Rio Grande	South Diversion C	+8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	177.15	48810.18	2028.35	3940.03	11942.51	0.00	66898.21
		+7 - Belen	Belen Hwy Bridge to Belen RR	0.00	224.98	12139.14	2608.13	6010.98	23058.89	0.00	44042.13
		+6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	229.10	9675.90	3686.82	27693.07	28572.26	0.00	69857.15
		+5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	2.48	10713.34	2535.82	10052.02	51428.89	0.00	74732.55
		+4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	27.96	276.01	22.51	13.98	325.32	0.00	665.79
		+3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	11.80	83.81	15.84	553.00	0.00	664.44
		+2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	14.17	92.33	2.44	90.75	0.00	199.68
		+1 -Mountain View	South Diversion Channel to I-25	0.00	0.00	287.06	99.70	0.00	580.41	0.00	967.17
	Total for stream: F			0.00	661.68	81927.59	11157.47	47728.36	116552.02	0.00	258027.13
Rio Grande LOB	Rio Grande left ov	+8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	3.80	11.18	0.00	60.21	0.00	75.19
		+7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.21	3347.33	474.97	48.54	4694.24	0.00	8565.29
		+6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	720.34	292.85	2.52	1900.16	0.00	2915.87
		+5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	4158.72	851.06	4007.81	16551.47	0.00	25569.07
		+4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	1.65	0.11	0.00	0.85	0.00	2.60
		+3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		+2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.24	1.64	0.00	1.09	0.00	2.98
		+1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	166.17	60.88	0.00	325.26	0.00	552.32
	Total for stream: F			0.00	0.21	8398.26	1692.70	4058.87	23533.28	0.00	37683.32
Rio Grande ROB	Rio Grande right c	+8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	29.99	15849.97	684.11	633.52	3933.12	0.00	21130.71
		+7 - Belen	Belen Hwy Bridge to Belen RR	0.00	124.68	1976.35	620.40	2599.91	4905.01	0.00	10226.36
		+6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	3.13	0.30	71.24	102.68	292.98	0.00	470.33
		+5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	0.00	11.40	43.91	468.40	0.00	523.71
		+4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
		+3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.68	53.05	10.08	306.37	0.00	370.17
		+2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	11.42	0.00	7.09	0.00	18.51
		+1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream: F			0.00	157.81	17827.29	1451.63	3390.10	9912.99	0.00	32739.81

***** - Computations have not been completed.
+ - Something has changed and computations need to be redone.

Figure D-11 Second pass of model (H&H as written, economic inventory adds Begin_Dmg_Depth corresponding to 5 yr Water Surface Elevation [WSEL] at each structure.)

Observations on the second pass:

This is the model run currently used for reporting damages and benefits in the study area. For this model run, a Begin_Dmg_Depth was created corresponding to the 20% chance WSEL. This does not negate WSEL for events > 20% with high WSEL. Therefore, 50% and other frequent events that generate high WSEL in the model computations will create positive economic damages.

The hydraulic rating curve data is pulled into @RISK to see if there was decent separation between the 50% WSEL and the 20% WSEL, which would show up in @RISK by significantly overlapping histograms. For the left overbank, the 50% and 20% stages show decent separation, except for the Los Lunas damage reach. The right overbank shows more overlap between the 50% and 20% WSEL across several

reaches. A few examples follow:

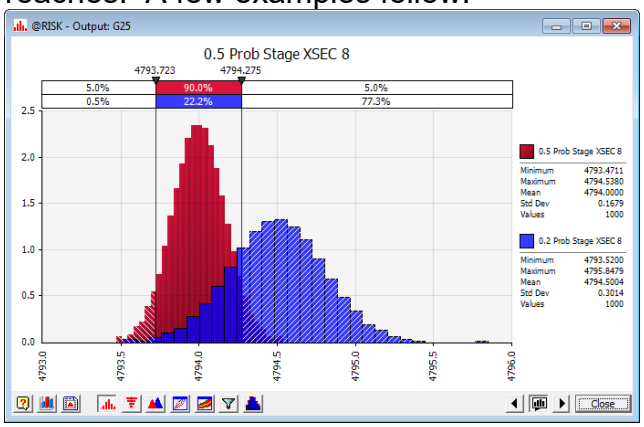


Figure D-12 Typical left bank distribution of 50% and 20% WSEL

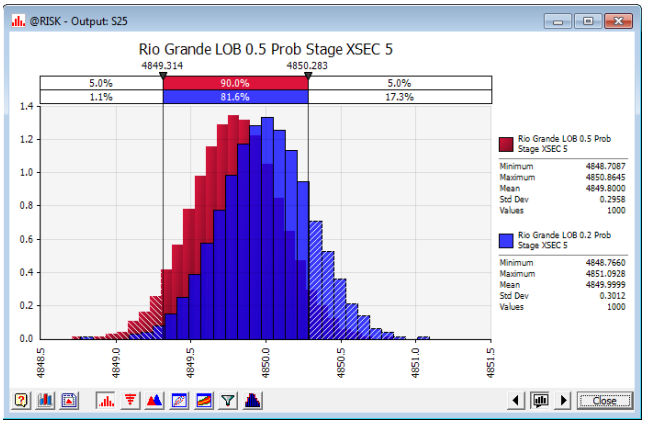


Figure D-13 Distribution of 50% and 20% WSEL in Los Lunas reach, left overbank

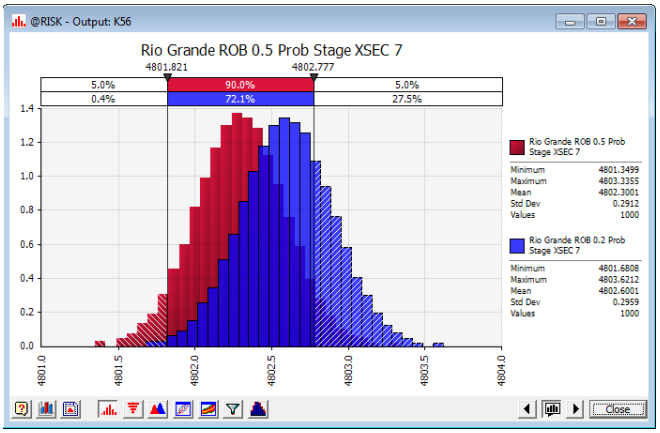


Figure D-14 Distribution of 50% and 20% WSEL in Belen reach, right overbank

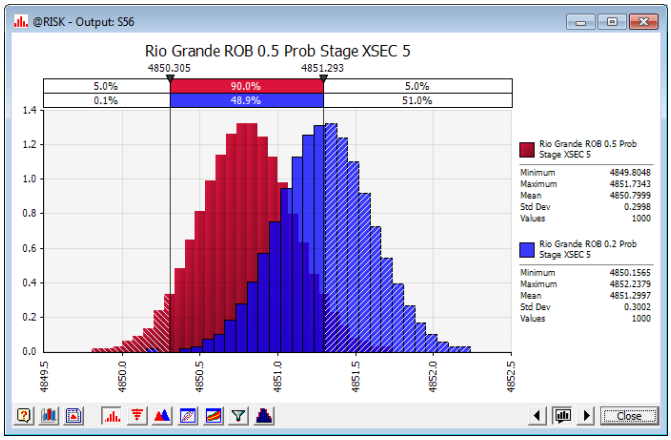


Figure D-15 Distribution of 50% and 20% WSEL in Los Lunas reach, right overbank

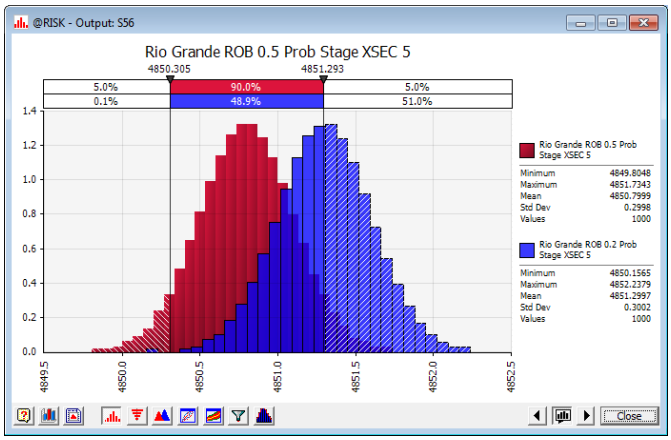


Figure D-16 Distribution of 50% and 20% WSEL in Isleta South reach, right overbank

The rating curves used in this study follow:

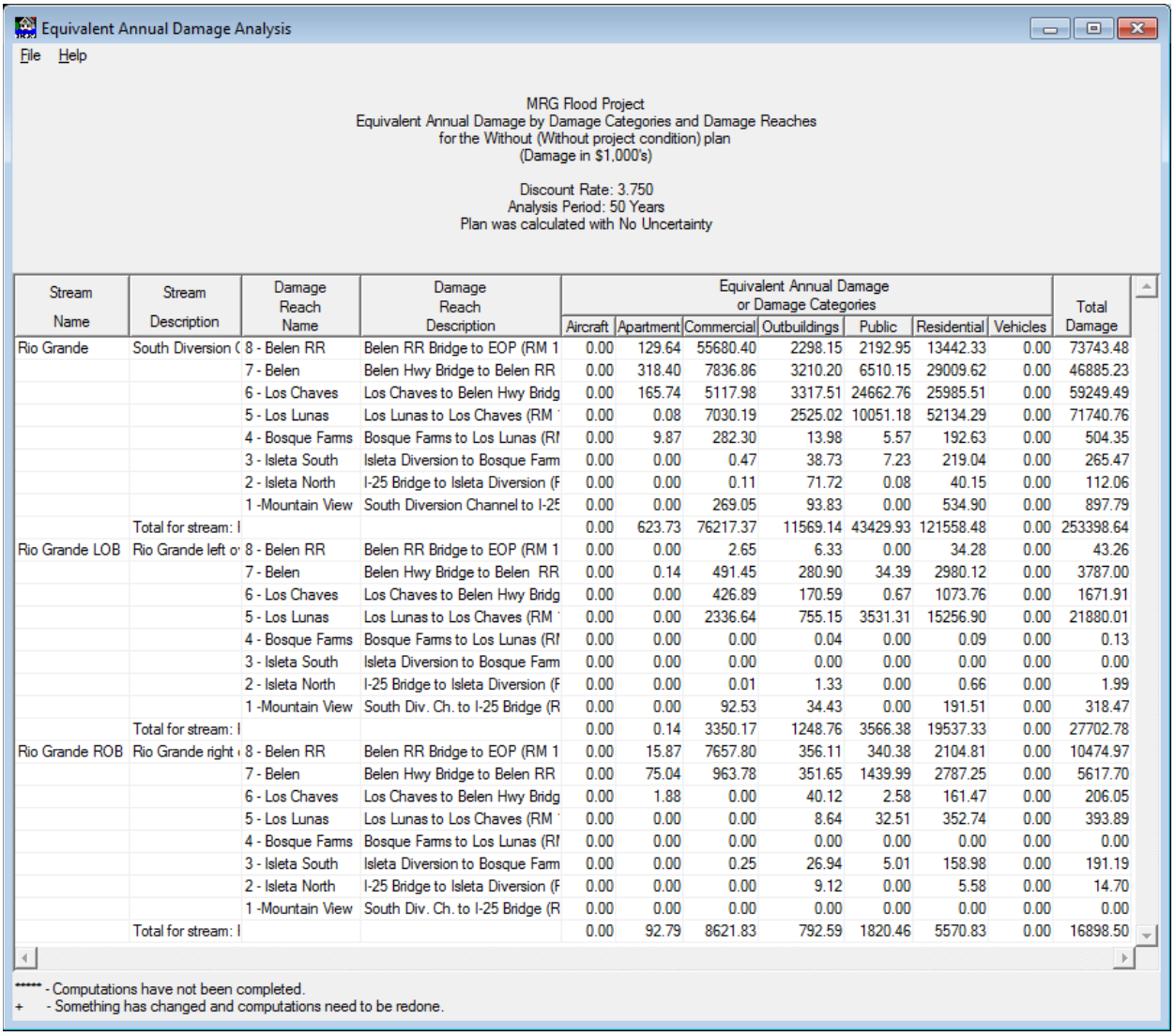
LEFT		8 - Belen RR				7 - Belen				6 - Los Chaves				5 - Los Lunas				4 - Bosque Farms				3 - Isleta South				2 - Isleta North				1 -Mountain View		
OVERBANK																																
	Reach ID	**148.3**			**Reach ID**	**150.34**			**Reach ID**	**155.92**			**Reach ID**	**161.48**			**Reach ID**	**165.26**			**Reach ID**	**169.29**			**Reach ID**	**172.46**			**Reach ID**	**176.9**		
	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK
Event		4793.36		OUTPUT		4783.36		OUTPUT		4818.39		OUTPUT		4837.33		OUTPUT		4866.78		OUTPUT		4886.89		OUTPUT		4896.38		OUTPUT		4923.44		OUTPUT
0.5	5364	4794	0.168	#NAME?	5362	4802.1	0.288	#NAME?	5446	4825	0.279	#NAME?	5514	4849.8	0.295	#NAME?	5516	4866.8	0.027	#NAME?	6032	4886.9	0.009	#NAME?	5569	4901	0.242	#NAME?	5585	4923.7	0.033	#NAME?
0.2	7177	4794.5	0.3	#NAME?	7063	4802.8	0.298	#NAME?	7067	4825.5	0.3	#NAME?	7116	4850	0.3	#NAME?	7636	4867	0.3	#NAME?	7865	4887	0.106	#NAME?	7323	4901.6	0.274	#NAME?	7351	4924	0.071	#NAME?
0.1	7256	4794.51	0.3	#NAME?	7129	4802.81	0.299	#NAME?	7124	4825.51	0.3	#NAME?	7161	4850.01	0.3	#NAME?	7637	4867.01	0.3	#NAME?	7911	4887.1	0.203	#NAME?	7391	4902	0.295	#NAME?	7452	4924.4	0.122	#NAME?
0.05	7285	4794.52	0.3	#NAME?	7139	4802.82	0.299	#NAME?	7125	4825.52	0.3	#NAME?	7197	4850.02	0.3	#NAME?	7638	4867.02	0.3	#NAME?	7999	4887.2	0.3	#NAME?	7490	4902.01	0.295	#NAME?	9710	4924.5	0.135	#NAME?
0.02	7450	4794.53	0.3	#NAME?	7303	4802.9	0.3	#NAME?	7295	4825.53	0.3	#NAME?	7357	4850.5	0.3	#NAME?	7639	4867.03	0.3	#NAME?	8083	4887.21	0.3	#NAME?	7688	4902.1	0.3	#NAME?	15355	4925.7	0.287	#NAME?
0.01	7455	4794.54	0.3	#NAME?	7305	4802.91	0.3	#NAME?	7300	4825.54	0.3	#NAME?	7361	4850.51	0.3	#NAME?	7640	4867.04	0.3	#NAME?	8135	4887.22	0.3	#NAME?	7691	4902.11	0.3	#NAME?	16322	4925.8	0.3	#NAME?
0.005	10086	4795.2	0.3	#NAME?	9933	4803.8	0.3	#NAME?	9938	4825.7	0.3	#NAME?	10059	4850.52	0.3	#NAME?	10106	4867.2	0.3	#NAME?	10961	4887.5	0.3	#NAME?	10574	4903.4	0.3	#NAME?	22962	4926.6	0.3	#NAME?
0.002	14229	4795.8	0.3	#NAME?	14059	4804.9	0.3	#NAME?	14047	4826.6	0.3	#NAME?	14141	4851.2	0.3	#NAME?	14176	4867.5	0.3	#NAME?	15345	4888.5	0.3	#NAME?	14571	4904.5	0.3	#NAME?	31362	4927.4	0.3	#NAME?
RIGHT		8 - Belen RR				7 - Belen				6 - Los Chaves				5 - Los Lunas				4 - Bosque Farms				3 - Isleta South				2 - Isleta North				1 -Mountain View		
OVERBANK																																
	Reach ID	**148.3**			**Reach ID**	**150.34**			**Reach ID**	**155.92**			**Reach ID**	**161.48**			**Reach ID**	**165.26**			**Reach ID**	**169.29**			**Reach ID**	**172.46**			**Reach ID**	**176.9**		
	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK	Flow	WSEL	SD	@RISK
Event		4788.34		OUTPUT		4782.54		OUTPUT		4819.37		OUTPUT		4839.33		OUTPUT		4867.19		OUTPUT		4883.9		OUTPUT		4886.37		OUTPUT		4922.69		OUTPUT
0.5	5364	4793	0.247	4793	5362	4802.3	0.291	4802.3	5446	4823.3	0.23	4823.3	5514	4850.8	0.3	4850.8	5516	4867.2	0.36	4867.2	6032	4889	0.3	4889	5569	4902	0.298	4902	5585	4922.7	0.001	4922.7
0.2	7177	4793.5	0.273	4793.5	7063	4802.6	0.296	4802.6	7067	4823.9	0.265	4823.9	7116	4851.3	0.3	4851.3	7636	4867.8	0.36	4867.8	7865	4889.3	0.3	4889.3	7323	4902.9	0.3	4902.9	7351	4923.4	0.078	4923.4
0.1	7256	4793.51	0.274	4793.51	7129	4802.61	0.296	4802.61	7124	4824	0.271	4824	7161	4851.31	0.3	4851.31	7637	4867.81	0.36	4867.81	7911	4889.4	0.3	4889.4	7391	4902.91	0.3	4902.91	7452	4923.41	0.079	4923.41
0.05	7285	4793.52	0.275	4793.52	7139	4802.62	0.296	4802.62	7125	4824.01	0.272	4824.01	7197	4851.32	0.3	4851.32	7638	4867.82	0.36	4867.82	7999	4889.41	0.3	4889.41	7490	4902.92	0.3	4902.92	9710	4923.42	0.8	4923.42
0.02	7450	4793.53	0.275	4793.53	7303	4802.63	0.296	4802.63	7295	4824.02	0.272	4824.02	7357	4851.33	0.3	4851.33	7639	4867.83	0.36	4867.83	8083	4889.42	0.3	4889.42	7688	4903.1	0.3	4903.1	15355	4924.9	0.242	4924.9
0.01	7455	4793.54	0.276	4793.54	7305	4802.64	0.296	4802.64	7300	4824.03	0.273	4824.03	7361	4851.34	0.3	4851.34	7640	4867.84	0.36	4867.84	8135	4889.43	0.3	4889.43	7691	4903.11	0.3	4903.11	16332	4925.1	0.264	4925.1
0.005	10086	4793.8	0.289	4793.8	9933	4803	0.3	4803	9938	4824.2	0.283	4824.2	10059	4851.7	0.3	4851.7	10106	4868	0.36	4868	10961	4889.8	0.3	4889.8	10574	4903.8	0.3	4903.8	22962	4926.3	0.34	4926.3
0.002	14229	4794	0.3	4794	14059	4803.1	0.3	4803.1	14047	4824.5	0.3	4824.5	14141	4852	0.3	4852	14176	4868.3	0.36	4868.3	15345	4890.5	0.3	4890.5	14571	4904.3	0.3	4904.3	31362	4927.7	0.34	4927.7

Figure D-17 Rating curves used in study

A similar @RISK evaluation of hydrology would show even more overlap than the hydraulic curves, but lacked the time to develop those tests.

Third pass of the HEC-FDA model

This model run removes all the uncertainties surrounding hydraulics, economics, and is essentially a “without-risk” run to see what the impact of uncertain information has on the investment decision. This run does preserve the Begin_Dmg_Depth set to 20% WSEL at each structure.



Equivalent Annual Damage Analysis

File Help

MRG Flood Project
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 3.750
Analysis Period: 50 Years
Plan was calculated with No Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircraft	Apartment	Commercial	Outbuildings	Public	Residential	Vehicles	
Rio Grande	South Diversion (	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	129.64	55680.40	2298.15	2192.95	13442.33	0.00	73743.48
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	318.40	7836.86	3210.20	6510.15	29009.62	0.00	46885.23
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	165.74	5117.98	3317.51	24662.76	25985.51	0.00	59249.49
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.08	7030.19	2525.02	10051.18	52134.29	0.00	71740.76
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	9.87	282.30	13.98	5.57	192.63	0.00	504.35
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.47	38.73	7.23	219.04	0.00	265.47
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.11	71.72	0.08	40.15	0.00	112.06
		1 -Mountain View	South Diversion Channel to I-25	0.00	0.00	269.05	93.83	0.00	534.90	0.00	897.79
	Total for stream: I			0.00	623.73	76217.37	11569.14	43429.93	121558.48	0.00	253398.64
Rio Grande LOB	Rio Grande left o	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	2.65	6.33	0.00	34.28	0.00	43.26
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.14	491.45	280.90	34.39	2980.12	0.00	3787.00
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	426.89	170.59	0.67	1073.76	0.00	1671.91
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	2336.64	755.15	3531.31	15256.90	0.00	21880.01
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.04	0.00	0.09	0.00	0.13
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.01	1.33	0.00	0.66	0.00	1.99
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	92.53	34.43	0.00	191.51	0.00	318.47
	Total for stream: I			0.00	0.14	3350.17	1248.76	3566.38	19537.33	0.00	27702.78
Rio Grande ROB	Rio Grande right	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	15.87	7657.80	356.11	340.38	2104.81	0.00	10474.97
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	75.04	963.78	351.65	1439.99	2787.25	0.00	5617.70
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	1.88	0.00	40.12	2.58	161.47	0.00	206.05
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	0.00	8.64	32.51	352.74	0.00	393.89
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.25	26.94	5.01	158.98	0.00	191.19
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	9.12	0.00	5.58	0.00	14.70
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream: I			0.00	92.79	8621.83	792.59	1820.46	5570.83	0.00	16898.50

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-18 Third pass of model (run with no risk in Hydraulic SD, no risk in depth-% damage relationship, no risk in STR or CON value, or CON/STR ratio)

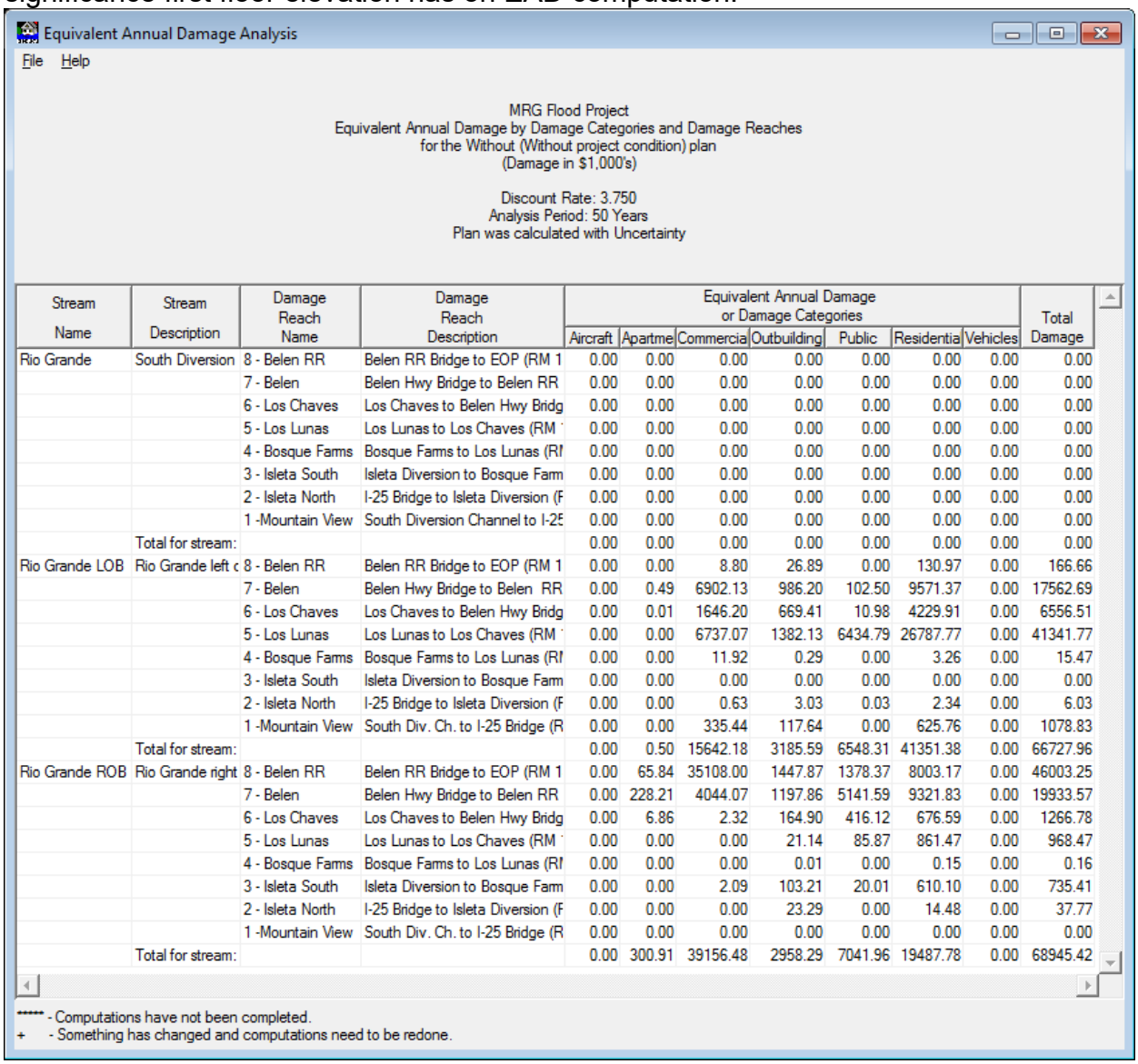
Observations on the third pass:

This is the “without risk” run where hydraulic standard deviations, error bands around the stage-% damage relationships, errors in structure or content value, and errors in the content value/structure value ratio are removed. The HEC-FDA model is also run “without risk” to compute EAD. Begin_Dmg_Depth is set to the 20% WSEL for each structure. This model run can serve as a benchmark for other model runs.

Fourth pass of the HEC-FDA model

This particular model run replicates the assumptions made in the second pass (using H&H as developed, using developed economic inventory, adding Begin_Dmg_Depth set

to 20% WSEL at each structure) with the one distinction being the entire economic inventory was LOWERED 0.5'. The purpose of this model run is to evaluate the significance first floor elevation has on EAD computation.



Equivalent Annual Damage Analysis

File Help

MRG Flood Project
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 3.750
Analysis Period: 50 Years
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircraft	Apartme	Commercia	Outbuilding	Public	Residentia	Vehicles	
Rio Grande	South Diversion	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1 -Mountain View	South Diversion Channel to I-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream:			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rio Grande LOB	Rio Grande left c	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	8.80	26.89	0.00	130.97	0.00	166.66
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.49	6902.13	986.20	102.50	9571.37	0.00	17562.69
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.01	1646.20	669.41	10.98	4229.91	0.00	6556.51
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	6737.07	1382.13	6434.79	26787.77	0.00	41341.77
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	11.92	0.29	0.00	3.26	0.00	15.47
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.63	3.03	0.03	2.34	0.00	6.03
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	335.44	117.64	0.00	625.76	0.00	1078.83
	Total for stream:			0.00	0.50	15642.18	3185.59	6548.31	41351.38	0.00	66727.96
Rio Grande ROB	Rio Grande right	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	65.84	35108.00	1447.87	1378.37	8003.17	0.00	46003.25
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	228.21	4044.07	1197.86	5141.59	9321.83	0.00	19933.57
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	6.86	2.32	164.90	416.12	676.59	0.00	1266.78
		5 - Los Lunas	Los Lunas to Los Chaves (RM	0.00	0.00	0.00	21.14	85.87	861.47	0.00	968.47
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.01	0.00	0.15	0.00	0.16
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	2.09	103.21	20.01	610.10	0.00	735.41
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	23.29	0.00	14.48	0.00	37.77
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream:			0.00	300.91	39156.48	2958.29	7041.96	19487.78	0.00	68945.42

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-19 Fourth pass of model (H&H as written, economic inventory adds Begin_Dmg_Depth corresponding to 20% WSEL at each structure, first floor elevation lowered 0.5')

Observations on the fourth HEC-FDA model run:

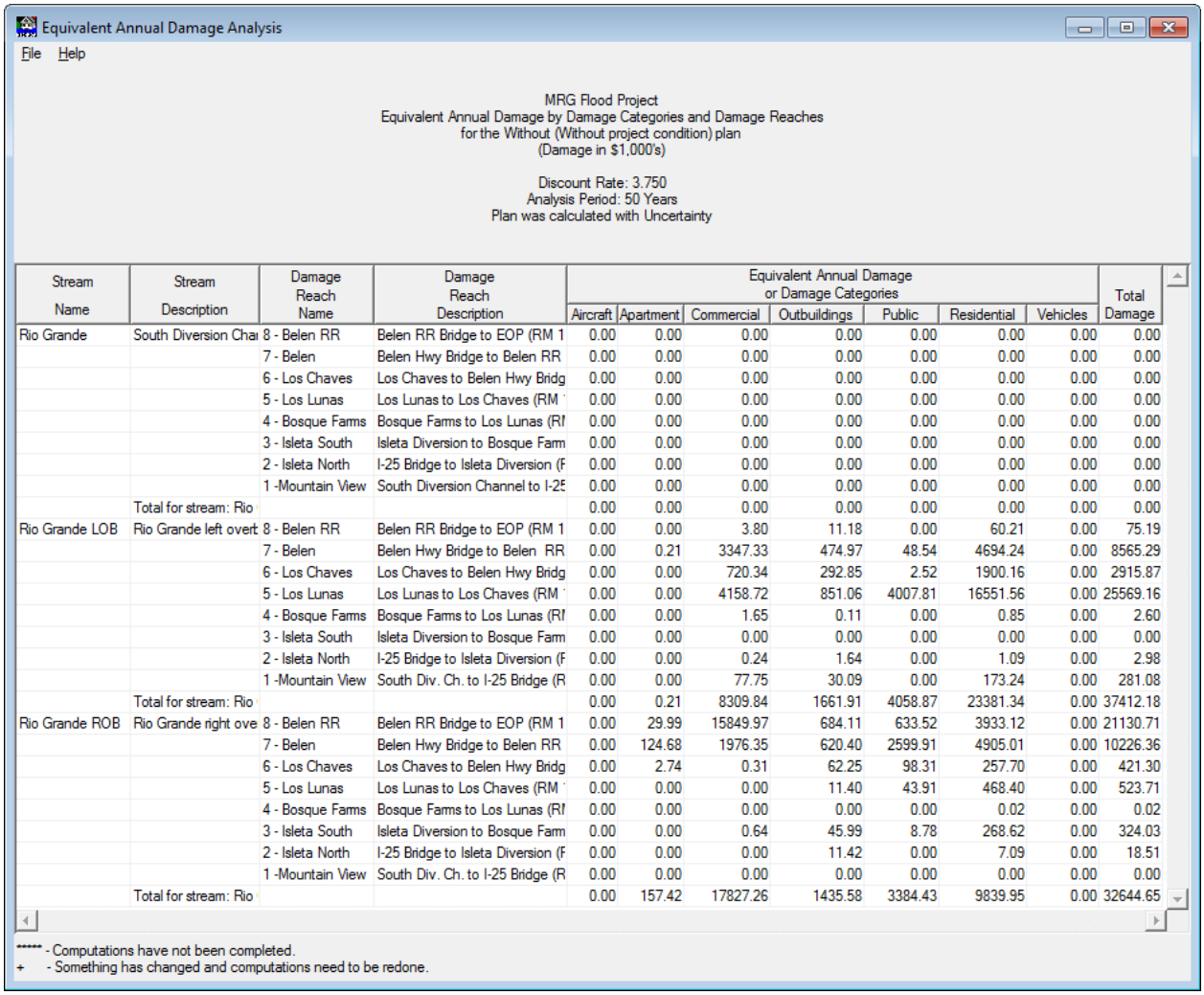
This run is essentially the adopted HEC-FDA model run, with the only change being the economic inventory's first floor elevation is lowered 0.5'. It demonstrates that EAD is highly sensitive to structure first floor elevation.

The economic inventory was conducted with a windshield survey, which gathered primary data such as structure description (quality of construction, construction materials, number of floors, presence of basements), an estimate of effective age for depreciation purposes, occupancy type, elevation above grade, an estimate of structure size in square feet, and the number of nearby structures that share these attributes. Structure elevation at grade was computed in GIS using the same data used to develop

the FLO-2D model.

Fifth pass of the HEC-FDA model

This particular model run replicates the assumptions made in the second pass (currently the adopted model for reporting purposes) with the single alteration being a change to the Begin_Dmg_Depth altered from the 20% chance event to the 10% chance event.



Equivalent Annual Damage Analysis

File Help

MRG Flood Project
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 3.750
Analysis Period: 50 Years
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircraft	Apartment	Commercial	Outbuildings	Public	Residential	Vehicles	
Rio Grande	South Diversion Chai	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1 -Mountain View	South Diversion Channel to I-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream: Rio			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rio Grande LOB	Rio Grande left overt	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	0.00	3.80	11.18	0.00	60.21	0.00	75.19
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	0.21	3347.33	474.97	48.54	4694.24	0.00	8565.29
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	0.00	720.34	292.85	2.52	1900.16	0.00	2915.87
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	4158.72	851.06	4007.81	16551.56	0.00	25569.16
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	1.65	0.11	0.00	0.85	0.00	2.60
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.24	1.64	0.00	1.09	0.00	2.98
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	77.75	30.09	0.00	173.24	0.00	281.08
	Total for stream: Rio			0.00	0.21	8309.84	1661.91	4058.87	23381.34	0.00	37412.18
Rio Grande ROB	Rio Grande right ove	8 - Belen RR	Belen RR Bridge to EOP (RM 1	0.00	29.99	15849.97	684.11	633.52	3933.12	0.00	21130.71
		7 - Belen	Belen Hwy Bridge to Belen RR	0.00	124.68	1976.35	620.40	2599.91	4905.01	0.00	10226.36
		6 - Los Chaves	Los Chaves to Belen Hwy Bridg	0.00	2.74	0.31	62.25	98.31	257.70	0.00	421.30
		5 - Los Lunas	Los Lunas to Los Chaves (RM '	0.00	0.00	0.00	11.40	43.91	468.40	0.00	523.71
		4 - Bosque Farms	Bosque Farms to Los Lunas (RI	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
		3 - Isleta South	Isleta Diversion to Bosque Farm	0.00	0.00	0.64	45.99	8.78	268.62	0.00	324.03
		2 - Isleta North	I-25 Bridge to Isleta Diversion (F	0.00	0.00	0.00	11.42	0.00	7.09	0.00	18.51
		1 -Mountain View	South Div. Ch. to I-25 Bridge (R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream: Rio			0.00	157.42	17827.26	1435.58	3384.43	9839.95	0.00	32644.65

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-20 Fifth pass of model (H&H as written, economic inventory adds Begin_Dmg_Depth corresponding to 10-yr WSEL at each structure)

Observations on the fifth HEC-FDA model pass:

This run is similar to a previously described run, with the sole exception being that Begin_Dmg_Depth is set, for each structure, to the 10% WSEL at each structure. This had VERY little impact on EAD, which was initially a surprise. However, examining the rating curve data above indicates the hydraulic rating curve for many cross sections is essentially flat between the 20% chance event and the 1% chance event. HEC-FDA would crash with a flat rating curve, so incremental 0.01' depths were added to make the model run. There is no reason to believe this incremental depth adjustment is significant.

The floodplain inventory has over 19,000 structures. Altering the Begin_Dmg_Depth

from the 20% chance WSEL to the 10% chance WSEL did not impact over 90% of those structures. Of the remaining 10%, the Begin_Dmg_Depth increased 0.1' for approximately 1500 structures, and the remaining 400 saw a Begin_Dmg_Depth increase 0.4'.

Sixth pass of the HEC-FDA model

This particular model run replicates the assumptions made in the second pass (using H&H as developed, using developed economic inventory, adding Begin_Dmg_Depth set to 20% WSEL at each structure) with the one distinction being the entire economic inventory was RAISED 0.5'. The purpose of this model run is to evaluate the significance first floor elevation has on EAD computation.

Observations on the sixth HEC-FDA model run:

This run is essentially the adopted HEC-FDA model run, with the only change being the economic inventory's first floor elevation is raised 0.5'. It demonstrates that EAD is highly sensitive to structure first floor elevation.

The economic inventory was conducted with a windshield survey, which gathered primary data such as structure description (quality of construction, construction materials, number of floors, presence of basements), an estimate of effective age for depreciation purposes, occupancy type, elevation above grade, an estimate of structure size in square feet, and the number of nearby structures that share these attributes. Structure elevation at grade was computed in GIS using the same data used to develop the FLO-2D model.

Prior modeling runs completed:

Seventh pass - Comparing 15 equivalent years of record to 100 equivalent years of record.

A prior milestone conference suggested the equivalent years of record was introducing uncertainty in the hydrologic frequency distributions, and HEC-FDA was rerun using a longer equivalent years of record. The current evaluation uses a graphical frequency distribution with 15 equivalent years of record. So, a separate HEC-FDA run was set up using 100 equivalent years of record. The net effect of that analysis was to lower EAD for structures and contents 1.5%.

Eighth through eleventh pass - Altering the start of damages condition by extracting the probability-damage relationship and ignoring damages greater than specified frequency.

HEC-FDA creates a probability-damage relationship covering events from the 99% annual exceedance probability down to the 0.1% chance events. The present analysis uses 38 events, which are presented here and recomputed to estimate average annual damages in the present, without-project condition. This sensitivity analysis was done

using the probability-damage relationships generated by HEC-FDA. This was performed on the adopted model, which has a Begin_Dmg_Depth corresponding to the 20% chance WSEL. In effect, this analysis post-processes the EAD computation.

EAD Verifi	From Exceedance Probability - Damage Functions				
				Total	
00			332,071		
		0.002		332070.6	664.1412
500 yr	0.002		332,071		
		0.008		317782.8	2542.262
100 yr	0.01		303,495		
		0.01		290030.3	2900.303
50 yr	0.02		276,566		
		0.08		226974.1	18157.93
10 yr	0.1		177,382		
		0.1		88691.25	8869.125
5 yr	0.2		0		
					33133.76
EAD Verifi	From Exceedance Probability - Damage Functions				
				Total	
00			332,071		
		0.002		332070.6	664.1412
500 yr	0.002		332,071		
		0.003		317782.8	953.3484
200 yr	0.005		321,379		
		0.005		298972.6	1494.863
100 yr	0.01		303,495		
		0.01		290030.3	2900.303
50 yr	0.02		276,566		
		0.03		226974.1	6809.222
20 yr	0.05		223,329		
		0.05		179799.5	8989.976
10 yr	0.1		177,382		
		0.1		156826	15682.6
5 yr	0.2		136,270		
		0.01		68134.77	681.3476
5 yr	0.21		0		
					38175.8
EAD Verifi	From Exceedance Probability - Damage Functions				
				Total	
00			335,838.83		
		0.001		335838.8	335.8388
1000	0.0010		335,838.83		
		0.0010		333954.7	333.9547
500	0.0020		332,070.58		
		0.0020		328643.3	657.2866
250	0.0040		325,216.01		
		0.0010		323297.7	323.2977
200	0.0050		321,379.48		
		0.0010		319572.9	319.5729
166.6667	0.0060		317,766.40		
		0.0010		315973	315.973
142.8571	0.0070		314,179.65		
		0.0010		312393.8	312.3938
125	0.0080		310,607.87		
		0.0010		308827.3	308.8273
111.1111	0.0090		307,046.73		
		0.0010		305270.9	305.2709
100	0.0100		303,495.02		
		0.0050		295491.6	1477.458
66.66667	0.0150		287,488.18		
		0.0050		282026.9	1410.135
50	0.0200		276,565.67		
		0.0050		271489.8	1357.449
40	0.0250		266,413.93		
		0.0150		252823.7	3792.355
25	0.0400		239,233.41		
		0.0100		231281.5	2312.815
20	0.0500		223,329.49		
		0.0250		207290.9	5182.272
13.33333	0.0750		191,252.26		
		0.0250		184317.4	4607.934
10	0.1000		177,382.49		
		0.0250		171362.8	4284.071
8	0.1250		165,343.16		
		0.0250		160124.4	4003.111
6.666667	0.1500		154,905.68		
		0.0250		149149.8	3728.744
5.714286	0.1750		143,393.82		
		0.0250		139831.7	3495.792
5	0.2000		136,269.53		
		0.0250		132102.7	3302.567
4.444444	0.2250		127,935.85		
		0.0250		124165.2	3104.13
4	0.2500		120,394.53		
		0.0250		116920.2	2923.006
3.636364	0.2750		113,445.96		
		0.0250		110227	2755.675
3.333333	0.3000		107,008.02		
		0.0250		104052	2601.3
3.076923	0.3250		101,095.99		
		0.0250		98298.81	2457.47
2.857143	0.3500		95,501.62		
		0.0250		92838.57	2320.964
2.666667	0.3750		90,175.52		
		0.0250		87689.65	2192.241
2.5	0.4000		85,203.78		
		0.0250		82826.3	2070.658
2.352941	0.4250		80,448.82		
		0.0250		78251.38	1956.284
2.222222	0.4500		76,053.93		
		0.0250		73990.66	1849.767
2.105263	0.4750		71,927.39		
		0.0250		69981.76	1749.544
2	0.5000		68,036.12		
		0.1000		60990.87	6099.087
1.666667	0.6000		53,945.61		
		0.1000		51661.92	5166.192
1.428571	0.7000		49,378.22		
		0.1000		49368.44	4936.844
1.25	0.8000		49,358.65		
		0.1000		49358.65	4935.865
1.111111	0.9000		49,358.65		
		0.0500		49358.65	2467.933
1.052632	0.9500		49,358.65		
		0.0400		49358.65	1974.346
1.010101	0.9900		49,358.65		
				Total	93728.42
			5 yr SOD	Total	38864.55

Figure D-21 EAD Verification from Exceedance Probability – Damage Functions

Changing the frequency at which damages occur does have a fairly significant impact on average annual damages, and EAD as a result.

Table D-33 Impact of Altering Start of Damages in EAD Computations

Impact of altering start of damages condition in EAD computations	
Scenario	EAD (x$1,000, August, 2013 prices, 3.75%)
Modeled Avg. Ann. Damages	$93,728.42
20% chance exceedance start of damages	$38,864.55
50% chance exceedance start of damages	$68,148.16
10% chance exceedance start of damages	$23,352.83

This analysis is showing damages occurring at fairly common events, contributing materially to the EAD computation. This is a result of damaging flows (greater than 6000 cfs) occurring on an almost annual basis in HEC-FDA. Current hydraulic modeling shows damaging flows occurring at the 50% chance occurrence, which does correspond with reports that flows greater than 4000 cfs causing damage to existing spoil banks and drainages landward of those spoil banks. The flood modeling of a perched channel indicates that flood waters leaving the Rio Grande main channel traverse a flat, low floodplain until reunited with the Rio Grande somewhere in southern Valencia County, downstream of the study area. Setting a Begin_Dmg_Depth does mitigate the impacts of frequent flows, but the distribution of flow and stage around the established means does mean there is a residual damage being computed at very frequent events. Post-processing the EAD computations induces a compensating downward bias by ignoring model results below a specific recurrence interval, but indicates there is still a substantial flood threat.

Twelfth pass - Selecting different depth-%damage relationships

This study uses residential structure and content curves identified in EGM (Economic Guidance Memorandum) 04-01 “Generic Depth-Damage Relationships for Residential Structures with Basements.” Vehicle depth-%damage relationships come from EGM 09-04 “Generic Depth-Damage Relationships for Vehicles.” Both curves are applicable nationwide, and their use obviates the need for locally developed depth-%damage relationships. To date, no nationally applicable depth-%damage relationships apply for commercial or public structures or contents, and in some studies, that can represent a significant source of damages and benefits. This study uses depth-%damage relationships presented in Table D-1. Those relationships are from prior District experience in other studies, FIA claims data, and a recent post-flood commercial content survey conducted by the District.

To evaluate the impact of curve selection on EAD computation, a selection of other depth-%damage relationships were applied to commercial and public structures and contents. Curves identified and used in Table 5-3 of the Natomas Basin Post Authorization Change Report (October, 2010) were applied for this particular analysis. Those curves correspond to the long duration, fresh water curves identified in the Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Ratios (CSVR) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies (May, 1997). “Long duration” is

identified in both studies as more than 3 days of inundation, which is applicable to this study. Figure D-20 presents the EAD calculations changing the depth-%damage relationships. Table D-34 presents a direct comparison between structure depth-%damage relationships used in this study and those used in the Natomas and Morganza studies. Table D-35 and Table D-36 presents the same comparison for contents. Relative to those expressions of depth-%damage, the curves used in this study are reasonable and conservative.

Table D-34 Comparison of Depth-%Damage Curves

COMPARISON OF DEPTH-%DAMAGE CURVES							
CATEGORY	**DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET**						
	-1.0	**0**	**1**	**3**	**5**	**10**	**15**
1 Story, **MRG**	**0**	**0**	**14**	**26**	**30**	**46**	**48**
1 Story Long Duration, **Natomas**	**0**	**7**	**22**	**31**	**32**	**54**	**86**
2 Story, **MRG**	**0**	**0**	**16**	**37**	**47**	**58**	**69**
2 Story Long Duration, **Natomas**	**0**	**5**	**15**	**22**	**23**	**46**	**80**

Table D-35 Comparison of Depth-%Damage Curves, 1 Story Contents

COMPARISON OF DEPTH-%DAMAGE CURVES, 1 STORY CONTENTS					
CATEGORY	**DEPTH OF FLOODING (in feet)**				
	-1.0	**0**	**1**	**3**	**5**
Food Stores, **Natomas**	**0**	**0**	**78**	**100**	**100**
Food Related contents, **MRG**	**0**	**0**	**55**	**85**	**95**
Furniture-Retail, **Natomas**	**0**	**0**	**98**	**100**	**100**
Furniture Store contents, **MRG**	**0**	**0**	**75**	**95**	**95**
Grocery Store, **Natomas**	**0**	**0**	**87**	**100**	**100**
Food Related contents, **MRG**	**0**	**0**	**55**	**85**	**95**
Hotel-Full Service, **Natomas**	**0**	**0**	**88**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Medical, **Natomas**	**0**	**0**	**75**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Office, **Natomas**	**0**	**0**	**97**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Restaurant, **Natomas**	**0**	**0**	**91**	**100**	**100**
Food Related contents, **MRG**	**0**	**0**	**55**	**85**	**95**
Rest-Fast Food, **Natomas**	**0**	**0**	**88**	**100**	**100**
Food Related contents, **MRG**	**0**	**0**	**55**	**85**	**95**
Retail, **Natomas**	**0**	**0**	**80**	**100**	**100**
Retail contents, **MRG**	**0**	**0**	**22**	**70**	**95**
Service-Auto, **Natomas**	**10**	**10**	**74**	**100**	**100**
Gas Sta. Car care contents, **MRG**	**0**	**0**	**22**	**70**	**95**
Shopping Centers, **Natoma**s	**0**	**0**	**96**	**100**	**100**
Retail contents, **MRG**	**0**	**0**	**22**	**70**	**95**
Churches, **Natomas**	**0**	**0**	**73**	**99**	**99**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Government, **Natomas**	**0**	**0**	**97**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Recreation, **Natomas**	**0**	**0**	**98**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**
Schools, **Natomas**	**0**	**0**	**88**	**100**	**100**
Motel, Office, Church contents, **MRG**	**0**	**0**	**35**	**60**	**74**

Table D-36 Comparison of Depth-%Damage Curves, 2 Story Contents

COMPARISON OF DEPTH-%DAMAGE CURVES, 2 STORY CONTENTS					
CATEGORY	DEPTH OF FLOODING (in feet)				
	-1.0	0	1	3	5
Food Stores, **Natomas**	0	0	38	56	56
Food Related contents, **MRG**	0	0	55	85	95
Furniture-Retail, **Natomas**	0	0	47	56	56
2 story Retail contents**, MRG**	0	0	12	34	74
Grocery Store, **Natomas**	0	0	42	56	56
Food Related contents, **MRG**	0	0	55	85	95
Hotel-Full Service, **Natomas**	0	0	42	56	56
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61
Medical, **Natomas**	0	0	36	56	56
Two story Motel, Office, Church contents,	0	0	26	48	61
Office, **Natomas**	0	0	46	56	56
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61
Restaurant, **Natomas**	0	0	44	56	56
Food Related contents, **MRG**	0	0	55	85	95
Rest-Fast Food, **Natomas**	0	0	42	56	56
Food Related contents, **MRG**	0	0	55	85	95
Retail, **Natomas**	0	0	38	56	56
2 story Retail contents**, MRG**	0	0	12	34	74
Service-Auto, **Natomas**	5	5	35	56	56
Gas Sta. Car care contents, **MRG**	0	0	22	70	95
Shopping Centers, **Natomas**	0	0	46	56	56
2 story Retail contents**, MRG**	0	0	12	34	74
Churches, **Natomas**	0	0	35	55	55
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61
Government, **Natomas**	0	0	45	56	56
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61
Recreation, **Natomas**	0	0	47	56	56
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61
Schools, **Natomas**	0	0	42	56	56
Two story Motel, Office, Church contents, **MRG**	0	0	26	48	61

MRG Flood Project
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 3.750
Analysis Period: 50 Years
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories							Total Damage
				Aircraft	Apartment	Commercial	Outbuildings	Public	Residential	Vehicles	
Rio Grande	South Diversion Channel to Belen RR Bridge	8 - Belen RR	Belen RR Bridge to EOP (RM 148.4 to RM 147.04)	0.00	178.73	68134.09	2046.00	6886.12	12046.93	0.00	89291.87
		7 - Belen	Belen Hwy Bridge to Belen RR Bridge (RM 150.4 to RM 148.5)	0.00	226.02	16300.16	2620.23	9775.66	23166.08	0.00	52088.16
		6 - Los Chaves	Los Chaves to Belen Hwy Bridge (RM 156.02 to RM 150.43)	0.00	230.92	18780.44	3716.03	45538.58	28798.63	0.00	97064.59
		5 - Los Lunas	Los Lunas to Los Chaves (RM 161.54 to RM 156.12)	0.00	2.51	14435.82	2562.45	14634.85	51969.66	0.00	83605.29
		4 - Bosque Farms	Bosque Farms to Los Lunas (RM 165.35 to RM 161.57)	0.00	28.05	300.04	22.58	38.26	326.35	0.00	715.27
		3 - Isleta South	Isleta Diversion to Bosque Farms (RM 169.38 to RM 165.44)	0.00	0.00	14.29	83.91	27.56	554.01	0.00	679.76
		2 - Isleta North	I-25 Bridge to Isleta Diversion (RM 172.53 to RM 169.41)	0.00	0.00	35.16	92.71	12.95	91.44	0.00	232.25
		1 -Mountain View	South Diversion Channel to I-25 Bridge (RM 177.0 to RM 172.56)	0.00	0.00	475.47	99.88	0.00	581.47	0.00	1156.82
	Total for stream: Rio Grande			0.00	666.24	118475.47	11243.79	76913.97	117534.55	0.00	324834.03
Rio Grande LOB	Rio Grande left overbank	8 - Belen RR	Belen RR Bridge to EOP (RM 148.4 to RM 147.04) left overbank	0.00	0.00	8.19	11.35	0.00	61.10	0.00	80.63
		7 - Belen	Belen Hwy Bridge to Belen RR bridge (RM 150.4 to RM 148.5) LOB	0.00	0.21	4550.14	477.30	74.82	4716.85	0.00	9819.32
		6 - Los Chaves	Los Chaves to Belen Hwy Bridge (RM 156.02 to RM 150.43) LOB	0.00	0.00	1612.30	296.69	36.83	1924.33	0.00	3870.14
		5 - Los Lunas	Los Lunas to Los Chaves (RM 161.54 to RM 156.12) LOB	0.00	0.00	6088.99	861.70	7013.07	16760.26	0.00	30724.01
		4 - Bosque Farms	Bosque Farms to Los Lunas (RM 165.35 to RM 161.57) LOB	0.00	0.00	2.99	0.10	0.00	0.83	0.00	3.92
		3 - Isleta South	Isleta Diversion to Bosque Farms (RM 169.38 to RM 165.44) LOB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2 - Isleta North	I-25 Bridge to Isleta Diversion (RM 172.5 to RM 169.41) LOB	0.00	0.00	0.89	1.68	0.31	1.12	0.00	4.00
		1 -Mountain View	South Div. Ch. to I-25 Bridge (RM 177.0 to RM 172.56) LOB	0.00	0.00	299.37	61.96	0.00	331.00	0.00	692.32
	Total for stream: Rio Grande LOB			0.00	0.22	12562.86	1710.77	7125.02	23795.48	0.00	45194.34
Rio Grande ROB	Rio Grande right overbank	8 - Belen RR	Belen RR Bridge to EOP (RM 148.4 to 147.04) ROB	0.00	31.38	28516.66	716.07	1053.81	4116.75	0.00	34434.67
		7 - Belen	Belen Hwy Bridge to Belen RR Bridge (RM 150.4 to 148.5) ROB	0.00	129.28	4191.95	643.05	4889.00	5085.01	0.00	14938.29
		6 - Los Chaves	Los Chaves to Belen Hwy Bridge (RM 156.02 to 150.43) ROB	0.00	3.72	4.73	84.77	1491.86	348.55	0.00	1933.64
		5 - Los Lunas	Los Lunas to Los Chaves (RM 161.54 to 156.12) ROB	0.00	0.00	0.00	11.69	62.84	480.24	0.00	554.77
		4 - Bosque Farms	Bosque Farms to Los Lunas (RM 165.35 to 161.57) ROB	0.00	0.00	0.00	0.00	0.82	0.03	0.00	0.85
		3 - Isleta South	Isleta Diversion to Bosque Farms (RM 169.38 to 165.44) ROB	0.00	0.00	2.20	53.13	21.11	306.83	0.00	383.27
		2 - Isleta North	I-25 Bridge to Isleta Diversion (RM 172.53 to 169.41) ROB	0.00	0.00	0.00	11.42	0.00	7.09	0.00	18.51
		1 -Mountain View	South Div. Ch. to I-25 Bridge (RM 17.0to 172.56) ROB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total for stream: Rio Grande ROB			0.00	164.38	32715.55	1520.14	7519.44	10344.48	0.00	52264.00

Figure D-22 EAD calculation with altered Public and Commercial Depth-%damage relationships

Concluding thoughts – Sensitivity studies on the Without-Project Condition

Table D-37, which follows, displays the various methods described to compute EAD, with a calculation of the change in EAD based upon the assumption change based on the change in assumptions regarding the without-project condition. Questions surrounding the without project condition were initially generated during one of the internal reviews of this study, tasked with ensuring this evaluation follows current guidance. The issue has focused on the magnitude of the damages, which is pretty large. However, absent a context, the EAD figures used in the study are not the entire story for several reasons, which is explored following the table:

Table D-37 EAD Tests

		Left Overbank							Right Overbank							Both Banks	
	Notes	Residential	Commercial	Public	Apartment	Outbuildings	Total	Delta relative to adopted	Residential	Commercial	Public	Apartment	Outbuildings	Total	Delta relative to adopted		Delta relative to adopted
First Pass		47,422.58	20,244.32	6,842.55	0.21	3,574.12	78,083.78	207.21%	23,752.13	42,438.45	7,975.31	373.14	3,540.40	78,079.44	236.36%	156,163.22	220.83%
Second Pass	(add Begin_Dmg_Depth at 20% chance event, adopted)	23,533.28	8,398.26	4,058.87	0.21	1,692.70	37,683.32	100.00%	10,137.45	17,885.90	3,389.03	157.76	1,463.71	33,033.85	100.00%	70,717.17	100.00%
Third Pass	(20% chance Begin_Dmg_Depth, no risk)	19,537.33	3,350.17	3,566.38	0.14	1,248.76	27,702.78	73.51%	5,570.83	8,621.83	1,820.46	92.79	792.59	16,898.50	51.16%	44,601.28	63.07%
Fourth Pass	(lower inventory 0.5')	41,351.38	15,642.18	6,548.31	0.50	3,185.59	66,727.96	177.08%	19,487.78	39,156.48	7,041.96	300.91	2,958.29	68,945.42	208.71%	135,673.38	191.85%
Fifth Pass	(Begin_Dmg_Depth set to 10% chance WSEL)	23,381.34	8,309.84	4,058.87	0.21	1,661.91	37,412.18	99.28%	9,839.95	17,827.26	3,384.43	157.42	1,435.58	32,644.65	98.82%	70,056.83	99.07%
Sixth Pass	(raise inventory 0.5')	9,938.82	3,311.62	1,653.46	0.09	665.86	15,569.84	41.32%	3,247.63	5,172.40	989.26	53.20	452.73	9,915.22	30.02%	25,485.06	36.04%
Seventh Pass	(change hydrologic years of record)	23,247.61	8,268.54	4,027.18	0.20	1,667.82	37,211.35	98.75%	10,031.89	17,705.28	3,356.20	56.22	1,447.80	32,697.37	98.98%	69,908.72	98.86%
Eighth Pass	(Computing EAD from 38 probability-damage points in FDA_StrucDetail.out file)						22,808.51	60.53%						20,957.82	63.44%	43,766.33	61.89%
Ninth Pass	(EAD from FDA_StrucDetail.out. 20% ACE start of damages)						20,056.86	53.22%						18,807.69	56.93%	38,864.55	54.96%
Tenth Pass	(EAD from FDA_StrucDetail.out. 50% ACE start of damages)						22,808.51	60.53%						20,957.82	63.44%	43,766.32	61.89%
Eleventh Pass	(EAD from FDA_StrucDetail.out. 10% ACE start of damages)						11,493.37	30.50%						11,859.47	35.90%	23,352.83	33.02%
Twelfth Pass	(Alternative depth-%damage curves)	23,533.28	12,562.86	7,125.02	0.21	1,692.70	44,914.07	119.19%	10,137.45	32,715.55	7,519.44	157.76	1,463.71	51,993.91	157.40%	96,907.98	137.04%

This is a big study area:

Table D-4 and Table D-5 presents the number of structures on the east and west bank of the Rio Grande, respectively. The 0.2% Annual Exceedance Probability floodplain contains 10,473 structures worth $722.6 million (gleaning the value of damageable property from Table D-8 and Table D-9). Equivalent Annual Damages (EAD) for structures and contents for both banks is $70.7 million, which is less than 10% of the value of damageable property. Damages to properties like streets, roads, agriculture, aircraft, increase EAD to $105.4 million.

The study area is broken down into hydraulically independent units:

Paragraph D-10 below outlines the hydraulic units, the solutions authorized in prior studies, and the present array of structural alternatives considered for each unit. The description of the study area to this point has been as a monolithic entity, but further evaluation of alternatives and their effects breaks the study area into more meaningful units.

The study area (particularly the Belen Units) suffers from long duration flooding:

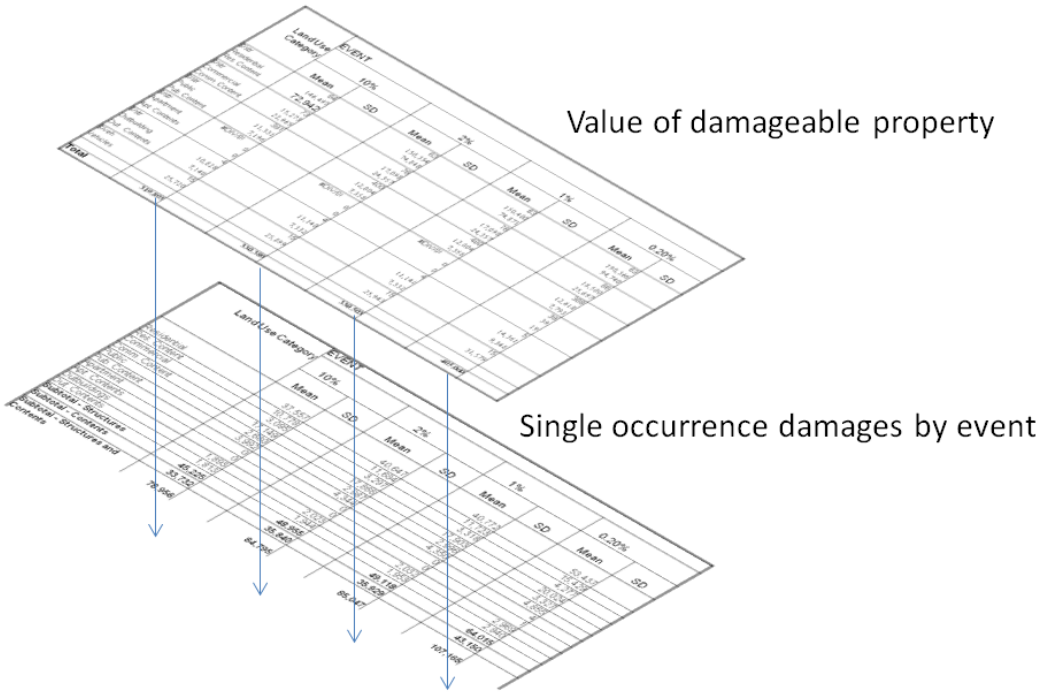
Many of the comments about the hydrology and hydraulics has been skeptical how a fairly low flow (around 7,000 cfs) can produce such catastrophic damage in the study area. The hydraulics appendix asserts this is due to the dominance of long duration snowmelt hydrology being the controlling influence when developing the frequency distribution for the Belen Units. Essentially, running a faucet for a month that spills out of a perched channel (by exceeding channel capacity) into the overbank will produce the stages and flood volumes presented here. The Belen Units' flood problems are not described by a short duration/high peak flow typical of summer monsoon thunderstorms.

On an event-by-event basis, damages received per event are fairly low compared to the value of damageable property:

Comparing the damages received (presented in Table D-14, Table D-15, Table D-16 and Table D-17) to the value of damageable property for the equivalent bank of the Rio Grande and time period (Table D-8, Table D-9, Table D-10 and Table D-11). We see that flooding produces damages on the East Bank in the neighborhood of 26-28% of the structure and content value. Damages on the west bank are a bit higher, around 30% of structure and content value. This tells us a few things about the flooding problem. First, the flooding is shallow. The depth-%damage relationships presented in Table D-1 suggest that those damages kick in around 2-3' of depth. Content damages are much higher at those depths but content values are typically a fraction of structure value. This study makes no attempt to describe the average flooding depth, as that is a function of

water surface elevation (rating curves for this study are presented in Table D-2 and Table D-3) and first floor elevation (in the case of structures and contents). The second lesson of this view of the data is that, as event severity increases, additional damages tend to come from the floodplain's extent growing more so than the depth. As event severity increases, the value of damageable property increases, while the damages associated with that event frequency increases proportionately.

Concerns about the EAD calculation evaluated in these sensitivity studies do not affect overall Federal interest nor the net benefit-maximizing size of the Tentatively Selected Plan. It's clear that EAD is sensitive to structure first floor elevation, but the "without risk" HEC-FDA iteration demonstrates that, while EAD will go down substantially if the error bands surrounding first floor elevation were eliminated, there is still a substantial flood threat (as displayed in the EAD calculation) such that there is a Federal interest in identifying a solution. Issues surrounding the estimation of the start of damages condition only impact the overall BCR of the TSP, but considering the floodplain is the largest improved area in the State of New Mexico second only to the Albuquerque metropolitan area, there is a substantial threat to life and property presented within this study and significant opportunities to identify alternatives which meet the Federal interest.



	Event (Annual Chance Exceedance)			
	10%	2%	1%	0.20%
East Bank, without project, present	26.31%	27.24%	27.53%	28.04%
West Bank, without project, present	40.40%	40.23%	40.62%	39.47%

Damages as a % of value of damageable property

Figure D-23 Damages as % of value of damageable property

What about rebuilding?

A recent line of thinking suggests Corps' modeling efforts induce a bias which may exaggerate damages and benefits as the HEC-FDA model doesn't account for the possibility that the damageable property doesn't rebuild within one year. HEC-FDA's average annual damages computation doesn't have the possibility of a reduced damageable property inventory following a modeled catastrophic event. Those concerns don't apply to this study for a few reasons discussed here.

First, the flood events modeled in this study are a big problem but are not catastrophic in terms of destroying property. As described above, flood events are shallow, damaging 28-30% of a structure's value.

Second, recent flooding in the District, such as Hatch, NM, Alamogordo, NM, and El Paso, TX in August, 2006 suggests that flood victims can recover fairly quickly, such that visitors may not recognize portions of the community that were underwater only a year ago (http://www.populist.com/07.13.paterson.html, Accessed 11/18/2013). Other accounts from more severely damaged properties suggest that the biggest hurdle to recovery was access to funding (http://www.abqjournal.com/138505/biz/money/stimulus-funds-rescued-hatch-

flood-recovery.html, Accessed 11/18/2013). Flood recovery anecdotes vary from recovery from complete destruction within one year (http://www.abqjournal.com/119528/biz/emcore-nearing-flood-recovery.html, accessed 11/18/2013) to inability to recover four years following a destructing event (http://www.lcsun-news.com/las_cruces-news/ci_15801037, accessed 11/18/2013). There is no consistent story on flood recovery that would make for meaningful model development that accounts for factors such as degree of damage to individual structures, availability of construction/cleanup resources to the community, availability of resources dedicated to recovery with or absent a disaster declaration, etc…

Third, there is no guidance or modeling available to account for this perceived bias. The closest approach to accounting for damaged inventory in subsequent years is a tool developed by the Sacramento District in support of a flood risk management study in the Natomas Basin, CA. The N@RM (Natomas @Risk Model) was developed to explicitly account for this bias, attempting to "account for human behavior in the form of a rebuilding period, a rebuilding schedule (percent rebuilt per year during the rebuild period), loss of inventory stock following a flood event, and the number of flood events allowed before floodplain occupants decide to completely abandon the Natomas Basin." That model makes assumptions regarding the amount of property rebuilt, a timeframe of rebuilding, and a limit on the number of rebuilds before the floodplain is abandoned, but makes no effort to validate those assumptions or cite research that would support those assumptions. For example, there's plenty of evidence to support what is known as the "sunk cost fallacy" which would contradict the assumption that people rationally conclude it's time to abandon a particular flood-damaged property instead of rebuild, given the resources.

Finally, inducing a known bias to capture an unknown bias doesn't improve data accuracy. The Natomas Basin study was using the N@RM model to account for high EAD computations. To illustrate, the 50% chance event caused 6.3 BILLION dollars (October, 2010 prices), which was 73% of the value of damageable property in the 0.2% chance floodplain. More severe events created more damages to the same floodplain, as the basin was bounded by geography and engineering features. By comparison, this study's 10% chance event damages are 28-30% of the value of damageable property, and as previously discussed, the damages increase proportionately to the value of damageable property. So, absent some basis to validate assumptions made for a closed basin in California, and plenty of evidence to suggest those assumptions don't work in the study area, this study hesitates to adopt any sort of massaging of the HEC-FDA data.

D-11 Levee Sizes Considered:

Several alternative levee heights, with sizes corresponding to the mean 1% annual chance exceedance event stage to about five feet greater than the mean 1% annual chance exceedance event stage, were evaluated in a framework incorporating elements of risk and uncertainty in hydrology, hydraulics and economics. Any analysis of alternatives must include the no action alternative. If no action is taken, the floodplains defined by the study will continue to suffer damages described in Table D-18, Table

D-19 and Table D-20. Each height uses the same real estate footprint and will substantially replace existing spoilbank.

The table which follows describes how the alternative levee sizes were selected to contain specific flood events. Given the Risk and Uncertainty framework used in plan selection, it is inappropriate to describe an alternative in terms of "level of protection." The terms ("Base levee", "Base + 1 ft. levee", etc...) describe a height that corresponds to a mean event stage. The hydraulics appendix describes how the base levee height was computed, taking into account differing error bands between the without-project and the with-project conditions. Project performance measurements (formerly known as Reliability) are discussed in paragraph D-16.

Table D-38 Alternative Levee Heights Evaluated

ALTERNATIVE LEVEE HEIGHTS EVALUATED	
Alternative	Description
Base Levee	Height with 90% CNP of 1% ACE flood stage, present conditions
Base Levee+ 1 ft	Base levee plus 1.0 foot of levee height
Base Levee+ 2 ft	Base levee plus 2.0 foot of levee height
Base Levee+ 3 ft	Base levee plus 3.0 foot of levee height
Base Levee+ 4 ft	Base levee plus 4.0 foot of levee height
Base Levee+ 5 ft	Base levee plus 5.0 foot of levee height
Base Levee+ 6 ft	Base levee plus 6.0 foot of levee height
Base Levee+ 7 ft	Base levee plus 7.0 foot of levee height
Base Levee+ 8 ft	Base levee plus 8.0 foot of levee height

The exterior-interior relationship defines a relationship between the water surface stage on the river or exterior side of the levee versus the stage in the floodplain or the interior side of the levee. This relationship is necessary if the stage in the interior will not reach the same stage that is overtopping the levee. This may be due to floods that results in stages near the top of the levee overtopping as designed in a safe, controlled manner, or a flood hydrograph volume not sufficient to fill the floodplain to the stage equal to the top of the levee. For this project, there is insufficient volume to fill the floodplain once the flows are contained within the levees. In either case, the relationship must be developed from hydrologic or hydraulic analyses external to the FDA program. If the relationship is not specified, the assumption is that the floodplain fills to the stage in the river (represented by the exterior stage-discharge function for the reach) for all events that result in stages that cause levee failure or are above the top of levee. Because the levee cuts off portions of the floodplain, the remaining water is “stacked” in a smaller cross section and areal extent. The exterior relationships are expected to be somewhat

higher than the corresponding interior rating curve.

To capture the benefits of the proposed levees, the study team evaluated the beneficial effects of flood protection for the virtual “Right Overbank (ROB)” and “Left Overbank (LOB)” channels as interior rating curves in the main channel. In the without-project and without-project, future conditions, the main channel and the overbank “virtual channels” have significantly different hydrology and hydraulic properties. However, the with-project conditions have identical properties for both the main channel (which is perched several feet over the overbank areas) and the overbanks. Several attempts were made to create a proxy for main channel levee height in the overbanks, but were not successful. The economic inventory of the right overbank was relocated to the main channel to most effectively capture the effect of channel aggradation in the main channel, which was not modeled over the period of analysis in the with-project condition. The main channel used the exterior rating curves to model the impact of a levee. The main channel uses the exterior rating curve to measure the project performance and capture data like annual exceedance probability, cumulative risk of failure, and likelihood of capturing key events of specific magnitudes, such as the 1% chance event.

The levee heights analyzed started at the height corresponding to the mean 1% chance stage for each damage reach. Incremental heights of one foot were analyzed, up to the 1% annual exceedance probability (AEP) stage + 8’ design heights. Across all reaches, that final levee height exceeds the mean 0.2% chance event stage, so the team was assured of analyzing alternatives that would include capturing almost all events. New rating curves were developed by Corps hydraulic engineers to define the with-project (exterior) relationships for the main channel and the overbanks, and are presented in Table D-2 and Table D-3. Since the Right Overbank’s damageable property would be afforded flood protection by any proposed levee, the same rating curves developed for the without project condition in the overbanks were placed in HEC-FDA’s levee interior-exterior relationships as the “interior” relationship in the with-project and the with-project, future condition. That relationship was used to evaluate the benefits of the levee alternatives.

A consequence of this approach is that the main channel’s error bands surrounding the rating curve now applies to the overbank flood-prone properties in the with-project condition that didn’t apply in the without-project condition. Put another way, the standard deviation for hydraulic stage was up to 0.3’ in the without-project condition, but goes up to 1-2’ in the with-project condition. Some tables which follow in Para. D-12 indicate small levees have negative benefits, which are a result of these higher standard deviations around hydraulic stage for given events.

D-12 Alternative Levee Alignments Considered:

Mountainview East Levee (and alternative alignments)

The Mountainview reach is east of the Rio Grande from the northern extent of this study area at the South Diversion Channel to just south of the Interstate 25 crossing of the Rio Grande. This reach was authorized in 1979 and subsequently removed from consideration following a 1986 General Design Memorandum (GDM) which concluded the Benefit Cost Ratio (BCR) for the proposed levee was below 1.0. Changes in levee design and growth in the floodplain (screened for compliance with Section 308 of WRDA 1990) has indicated a Federal interest in providing flood mitigation services to the region. For purposes of this analysis, the Mountainview reach is considered a separable element. Figures and tables which follow describe the flooding problems and opportunities within the unit, and benefits of any proposed solutions. Figure D-22 displays the Mountainview Unit. Table D-39 describes the floodplain in terms of number of damageable properties, value of those properties, and damages by event frequency, for key events in the Mountainview Unit. Table D-40 displays Equivalent Annual Damages in the Unit by property type. Table D-41 displays the equivalent annual residual damages and benefits of the various levee heights considered. Table D-42 displays the benefits and costs of the various levee heights considered, identifying the size which maximizes net equivalent annual benefits. The construction period is 12 months, so interest during construction is not computed. Figure D-23 displays the optimization curve for the Mountainview Unit levees.

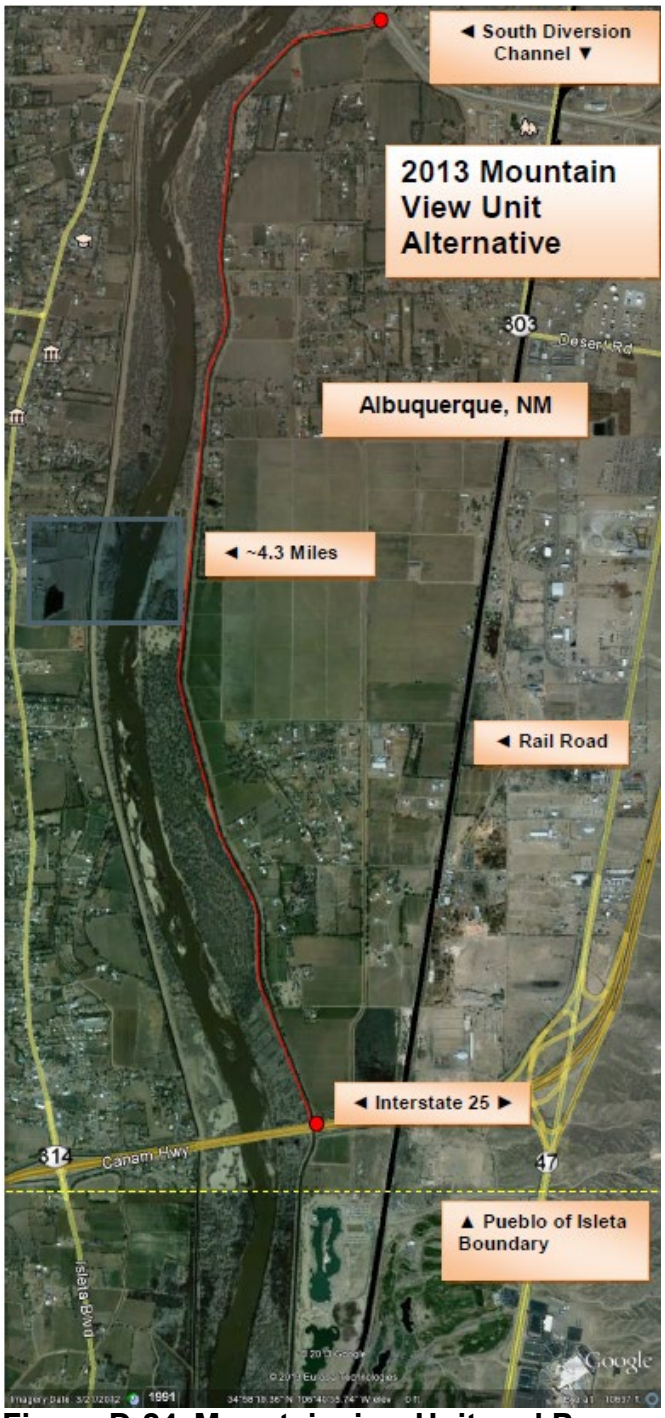


Figure D-24 Mountainview Unit and Proposed Levee Alignment

Table D-39 Floodplain Description, Mountainview Unit

FLOODPLAIN DESCRIPTION MOUNTAINVIEW UNIT												
	EVENT											
Project Area	# STR				VALDAMPROP				SINGOCCDAM			
Land Use Category	10%	2%	1%	0.20%	10%	2%	1%	0.20%	10%	2%	1%	0.20%
Mountainview					($thousands)				($thousands)			
Residential	37	48	48	100	3,506.04	4,974.99	4,974.99	12,860.95	763.66	1,102.53	1,127.70	1,684.08
Commercial	11	13	13	23	693.44	1,377.67	1,377.67	1,956.07	372.18	534.71	547.44	722.82
Public	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apartments	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbuildings	58	78	78	130	596.53	694.02	694.02	1,894.72	142.77	183.81	187.02	315.05
Vehicles	30	35	37	42	447.30	521.85	551.67	626.22	291.28	385.91	392.27	509.35
Total Bldgs.	106	139	139	253	5,243.31	7,568.53	7,598.35	17,337.96	1,569.89	2,206.97	2,254.43	3,231.29
Clean-Up									458.37	684.32	700.62	894.82
Pop. At Risk	97	126	126	262								

Table D-40 Mountainview East Levee, EAD

MOUNTAINVIEW EAST LEVEE EQUIVALENT ANNUAL DAMAGES BY LAND USE CATEGORY (x$1,000, May, 2016 price level)			
LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank		
Residential	326.35		
Commercial	166.40		
Public	0.00		
Apartments	0.00		
Outbuildings	62.53		
Subtotal - Structures and Contents	555.28		
Streets, roads	167.21		
Utilities	8.77		
Railroad	0.03		
Vehicles	108.68		
Agriculture	0.12		
Irr. Drains	1.05		
Aircraft	0.00		
Clean-Up	124.39		
Recreation			
Emergency Costs	8.33		
TOTAL	**973.86**		

Table D-41 Mountainview East Levee, Equivalent Annual Residual Damages and Benefits

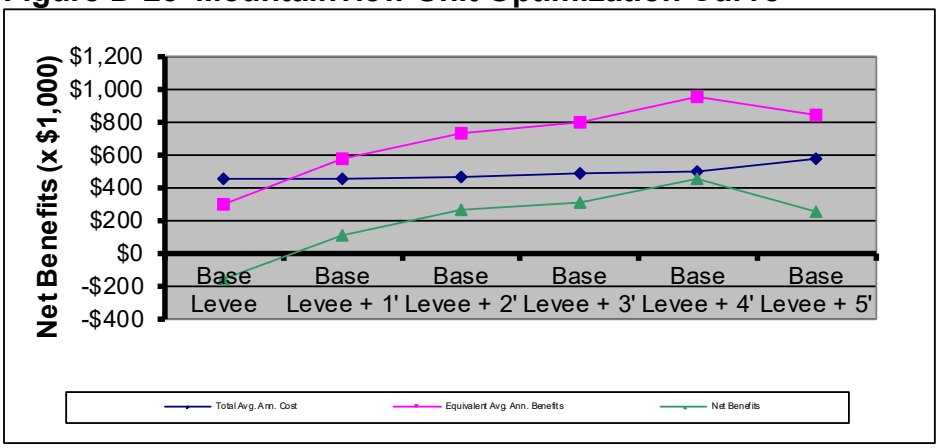
MOUNTAINVIEW EAST LEVEE
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)						Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)					
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'
Residential	326.35	203.66	98.71	40.83	15.38	5.69	2.41	122.69	227.64	285.52	310.97	320.66	323.94
Commercial	166.40	81.23	36.99	14.52	5.46	2.14	1.00	85.17	129.41	151.88	160.94	164.26	165.40
Public	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apartments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbuildings	62.53	89.04	53.22	25.64	9.71	3.03	0.87	-26.51	9.31	36.89	52.82	59.50	61.66
Subtotal - Structures and Contents	**555.28**	**373.93**	**188.92**	**80.99**	**30.55**	**10.86**	**4.28**	**181.35**	**366.36**	**474.29**	**524.73**	**544.42**	**551.00**
Streets, roads	167.21	112.60	56.89	24.39	9.20	3.27	1.29	54.61	110.32	142.82	158.01	163.94	165.92
Utilities	8.77	5.91	2.99	1.28	0.48	0.17	0.07	2.87	5.79	7.49	8.29	8.60	8.71
Railroad	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03
Vehicles	108.68	54.97	26.76	12.24	5.08	1.88	0.75	53.71	81.92	96.44	103.60	106.80	107.93
Agriculture	0.12	0.08	0.04	0.02	0.01	0.00	0.00	0.04	0.08	0.10	0.11	0.11	0.11
Irr. Drains	1.05	0.71	0.36	0.15	0.06	0.02	0.01	0.34	0.69	0.90	0.99	1.03	1.04
Clean-Up	124.39					1.98						122.41	
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	8.33	0.00	0.00	0.00	0.00	0.00	0.00	8.33	8.33	8.33	8.33	8.33	8.33
TOTAL	**973.86**	**548.21**	**275.96**	**119.07**	**45.38**	**18.19**	**6.40**	**301.25**	**573.51**	**730.39**	**804.09**	**955.67**	**843.07**

Table D-42 Mountainview East Levee, Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED MOUNTAINVIEW EAST LEVEE (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Construction Cost	10,220.76	10,316.55	10,606.57	11,153.33	11,396.41	13,672.28
Real Estate	14.21	14.21	14.21	14.21	14.21	14.21
Construction Mgt.	1,317.84	1,317.84	1,317.84	1,317.84	1,317.84	1,317.84
PED	722.48	722.48	722.48	722.48	722.48	722.48
Total First Cost	12,275.30	12,371.08	12,661.11	13,207.87	13,450.95	15,726.82
IDC (12 months construction, 2.75%)*						
Total Investment	12,275.30	12,371.08	12,661.11	13,207.87	13,450.95	15,726.82
Avg. Ann. Cost (2.75%, 50 yr. project life)	454.69	458.24	468.98	489.23	498.24	582.54
OMRR&R						
Total Avg. Ann. Cost	454.69	458.24	468.98	489.23	498.24	582.54
Equivalent Avg. Ann. Benefits	301.25	573.51	730.39	804.09	955.67	843.07
Benefit/Cost Ratio	0.66	1.25	1.56	1.64	1.92	1.45
Net Benefits	-153.43	115.27	261.42	314.86	457.44	260.54

Figure D-25 Mountainview Unit Optimization Curve



Mountainview East Levee (1979 Authorized Version)

The Mountainview East Levee is not in the Authorized Plan as it was not justified at the time of the analysis. Development in the area since then is a major source of benefits in this analysis (consistent with the benefit exclusion requirements of Section 308 of WRDA 1990).

Isleta East Levee (and alternative alignments)

The Isleta East reach complements the Mountainview Reach described above and is east of the Rio Grande from the Interstate 25 crossing of the Rio Grande to a railroad crossing 0.71 miles south. Where damages, costs, and benefits are calculated in this analysis, this reach is inclusive of the previously described Mountainview reach. This reach was not authorized in 1979 or in subsequent investigations as the Benefit Cost Ratio (BCR) for the proposed levee was below 1.0. Subsequent investigations have never identified sufficient benefits warranting including a levee through this unit. Figures and tables which follow describe the flooding problems and opportunities within the unit, and benefits of any proposed solutions. Figure D-24 displays the Isleta East Unit. The damageable property within the unit is limited to structures surrounding the Isleta Lakes fishing area (such as picnic shelters and awnings by the lakes) and the adjacent golf course. To date, the Pueblo de Isleta Tribe has been unwilling to provide estimates of visitation to the Isleta Lakes. Until a reasonable estimate of visitation can be obtained, tables in this appendix do not include damages associated with the loss of the recreation opportunity. The damages attributable to physical property at the Isleta Lakes, such as buildings and their contents, do show up in Commercial structures and their contents. Table D-43 displays Equivalent Annual Damages in the Unit by property type. Table D-43 also repeats the Mountainview Unit's EAD computations to show the damages attributable to the east bank of the Rio Grande downstream of the Interstate 25 crossing. Essentially, the properties inventoried during the windshield survey were elevated clear of the floodplain. Figure D-25 presents some of the levee alignments proposed for the Isleta East Unit. Table D-44 displays the equivalent annual residual damages and benefits of the various levee heights considered. Table D-45 displays the benefits and costs of the various levee heights considered, identifying the size which maximizes net equivalent annual benefits. The construction period is 12 months, so interest during construction is not computed. Only the costs of Alternative A, the lowest cost alternative, is presented. Other Alternatives within this Unit had slightly longer lengths, but only protected small stretches of riverside irrigation drains, and didn't materially contribute to project benefits, and certainly not enough to include the Isleta East Unit relative to the Mountainview Unit alone. Table D-46 presents the costs of various levee alternatives through the Isleta East Unit, at the various levee heights analyzed. Figure D-26 displays the optimization curve for the Isleta East Unit levees. Given that no additional benefits were identified for properties on the east bank south of Interstate 25, there is no benefit to extending any proposed levee south of the

Interstate 25 crossing of the Rio Grande.

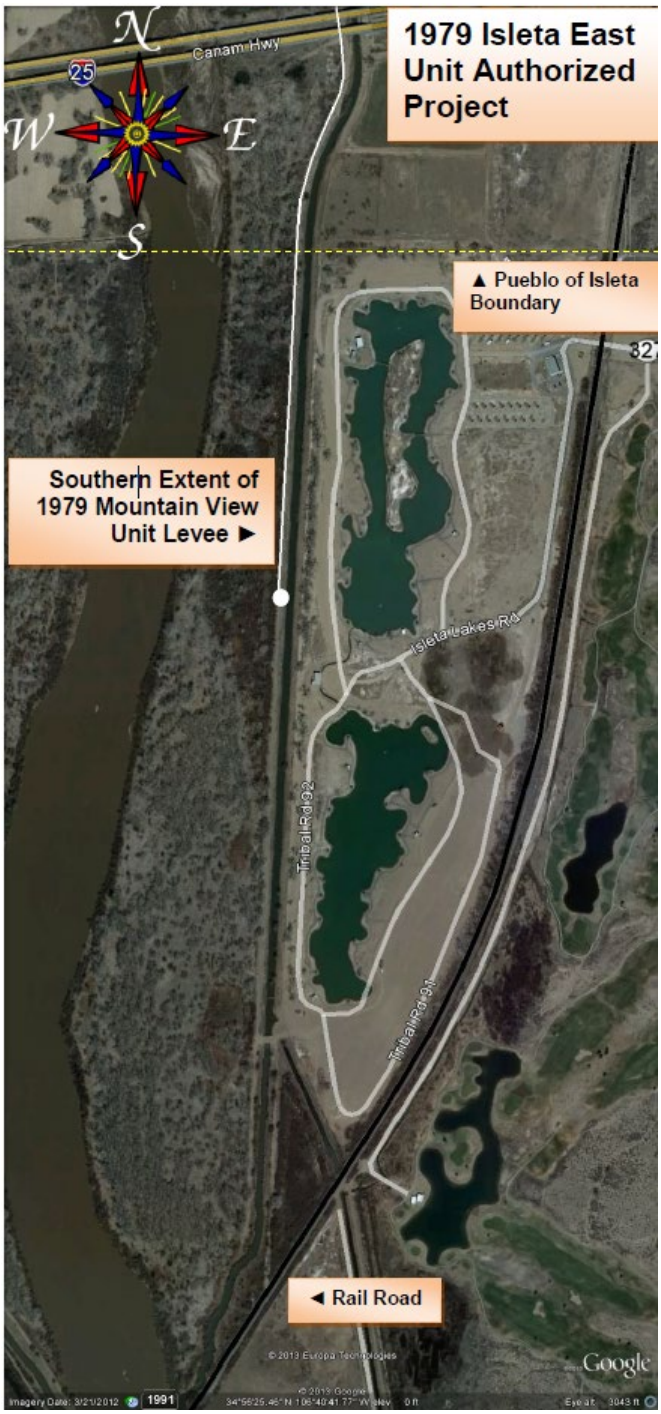


Figure D-26 Isleta East Unit

Table D-43 Isleta East Levee, EAD

ISLETA EAST LEVEE
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	Mountainview East Bank	
Residential	0.00	326.35	
Commercial	0.02	166.40	
Public	0.00	0.00	
Apartments	0.00	0.00	
Outbuildings	0.00	62.53	
Subtotal - Structures and Contents	0.02	555.28	
Streets, roads	0.01	167.21	
Utilities	0.00	8.77	
Railroad	0.00	0.03	
Vehicles	0.00	108.68	
Agriculture	0.00	0.12	
Irr. Drains	0.00	1.05	
Aircraft	0.00	0.00	
Recreation			
Emergency Costs	0.00	8.33	
TOTAL	**0.03**	**973.86**	

Figure D-27 Alternative Isleta East Unit Levee Alignments

Table D-44 Isleta East Levee, Equivalent Annual Residual Damages and Benefits

ISLETA EAST LEVEE
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)						Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)					
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial	0.02	4.47	3.37	1.92	0.84	0.26	0.06	-4.45	-3.35	-1.90	-0.82	-0.24	-0.04
Public	0.00	1.85	1.37	0.77	0.33	0.10	0.02	-1.85	-1.37	-0.77	-0.33	-0.10	-0.02
Apartments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbuildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal - Structures and Contents	**0.02**	**6.32**	**4.74**	**2.69**	**1.17**	**0.36**	**0.08**	**-6.30**	**-4.72**	**-2.67**	**-1.15**	**-0.34**	**-0.06**
Streets, roads	0.01	1.90	1.43	0.81	0.35	0.11	0.02	-1.90	-1.42	-0.80	-0.35	-0.10	-0.02
Utilities	0.00	0.10	0.07	0.04	0.02	0.01	0.00	-0.10	-0.07	-0.04	-0.02	-0.01	0.00
Railroad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irr. Drains	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**0.03**	**8.34**	**6.25**	**3.55**	**1.54**	**0.47**	**0.11**	**-8.31**	**-6.23**	**-3.52**	**-1.52**	**-0.45**	**-0.08**

Table D-45 Isleta East Levee, Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED ISLETA EAST LEVEE (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Construction Cost*	12,468.11	12,599.45	12,963.40	13,675.60	14,000.84	16,492.12
Real Estate	14.21	14.21	14.21	14.21	14.21	14.21
Construction Mgt.	1,466.76	1,466.76	1,466.76	1,466.76	1,466.76	1,466.76
PED	722.48	722.48	722.48	722.48	722.48	722.48
Total First Cost	14,671.56	14,802.90	15,166.86	15,879.06	16,204.30	18,695.58
IDC (12 months construction, 2.75%)*						
Total Investment	14,671.56	14,802.90	15,166.86	15,879.06	16,204.30	18,695.58
Avg. Ann. Cost (2.75%, 50 yr. project life)	543.45	548.31	561.79	588.17	600.22	692.50
OMRR&R						
Total Avg. Ann. Cost	543.45	548.31	561.79	588.17	600.22	692.50
Equivalent Avg. Ann. Benefits	-8.31	-6.23	-3.52	-1.52	-0.45	-0.08
Benefit/Cost Ratio	-0.02	-0.01	-0.01	0.00	0.00	0.00
Net Benefits	-551.76	-554.54	-565.32	-589.69	-600.67	-692.58
*Presented for Alternative A, the lowest cost Alternative in this Unit.						

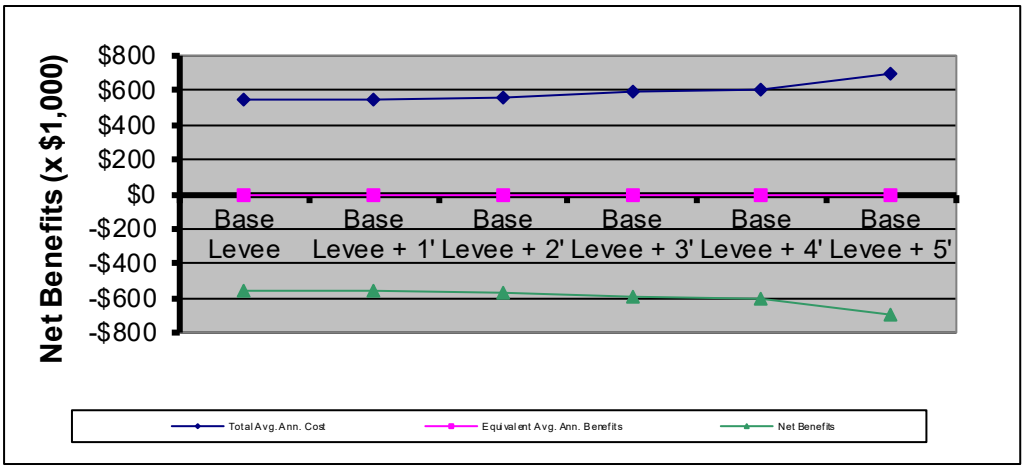


Figure D-28 Isleta East Unit Optimization Curve

Table D-46 Isleta East Levee, Alternative Alignment Construction Costs

ISLETA EAST LEVEE ALTERNATIVE ALIGNMENT CONSTRUCTION COSTS (x$1,000, May, 2016 price level)			
Alignment	Stations		Construction Cost
2013 Isleta East Unit Alternative A	0+00 to 284+83	Base	$14,671.56
		Base + 1'	$14,802.90
		Base + 2'	$15,166.86
		Base + 3'	$15,879.06
		Base + 4'	$16,204.30
		Base + 5'	$18,695.58
2013 Isleta East Unit Alternative B	0+00 to 294+32	Base	$14,805.48
		Base + 1'	$14,936.93
		Base + 2'	$15,301.57
		Base + 3'	$16,014.48
		Base + 4'	$16,281.69
		Base + 5'	$18,791.00
2013 Isleta East Unit Alternative C	0+00 to 294+32	Base	$14,974.76
		Base + 1'	$15,106.21
		Base + 2'	$15,478.02
		Base + 3'	$16,183.76
		Base + 4'	$16,450.97
		Base + 5'	$18,960.28
2013 Isleta East Unit Alternative D	0+00 to 284+83 and	Base	$14,887.90
	10+00 to 23+55	Base + 1'	$15,019.69
		Base + 2'	$15,384.11
		Base + 3'	$15,994.70
		Base + 4'	$16,296.52
		Base + 5'	$18,487.88

Belen East Levee (and alternative alignments)

The Belen East Unit is east of the Rio Grande from the Highway 147 river crossing at the Isleta Pueblo Village proper to the southern limits of this study. This reach was authorized in 1979 and subsequent investigations. Changes in levee design and growth in the floodplain (screened for compliance with Section 308 of WRDA 1990) has indicated a Federal interest in providing flood mitigation services to the region. For purposes of this analysis, the Belen East Unit is considered a separable element. Figures and tables which follow describe the flooding problems and opportunities within the unit, and benefits of any proposed solutions. Figure D-27 displays the Belen East Units northern configuration, which is shared by all the levee alternatives evaluated here. The northern elements of the Belen East Unit start within the Pueblo de Isleta reservation, and extend south. Various lineal extents of proposed levees were developed, and presented in Figure D-28, Figure D-29 and Figure D-30. Table D-47 describes both the Belen East and Belen West units in terms of number of structures inundated by occupancy type and event, value of those properties, and damages by event recurrence interval. Table D-48 displays Equivalent Annual Damages in the Unit by property type and lineal extent. The purpose here is to establish the baseline and determine the length and height of any proposed levee. Table D-48 indicates that extending the length downstream would not likely have any impact on plan selection, as EAD did not increase substantially with the increased length. Therefore, further exploration of benefits in the Belen East Unit will focus on Unit A. Table D-49 displays the equivalent annual residual damages and benefits of the various levee heights considered. Table D-50 displays the benefits and costs of the various levee heights considered, identifying the size which maximizes net equivalent annual benefits. Interest during construction (IDC) was computed with equal, midmonthly payments during a 60 month construction period at the FY 2018 discount rate of 2.75%. Figure D-31 displays the optimization curve for the Belen East Unit levees. Table D-51 displays, for each height and lineal extent, construction costs for the proposed levees. Table D-52 displays the equivalent annual costs and benefits of all the levee alignments and heights.

Figure D-29 Belen East Unit (north)

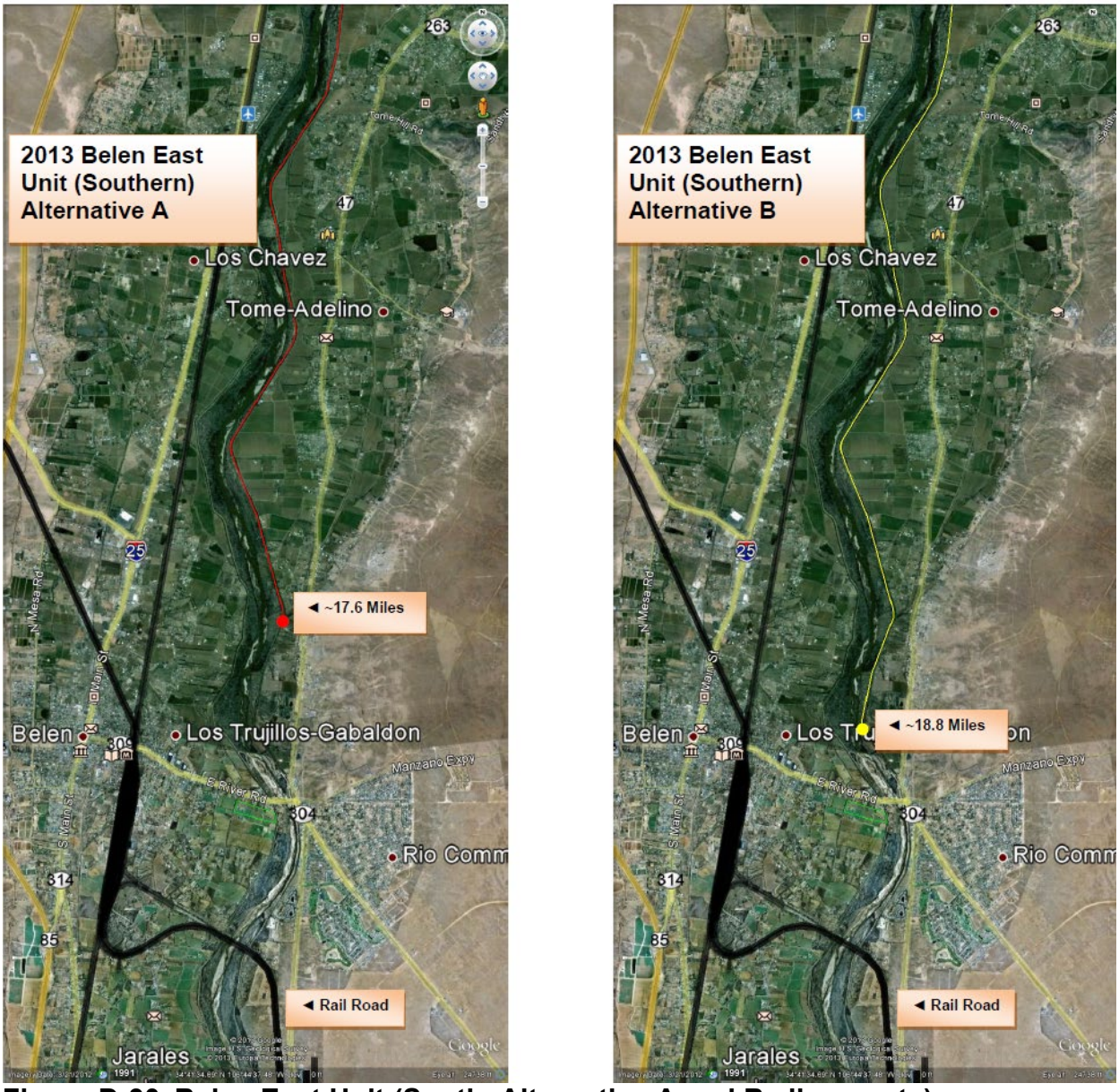


Figure D-30 Belen East Unit (South, Alternative A and B alignments)

Figure D-31 Belen East Unit (South, Alternative C and D alignments)

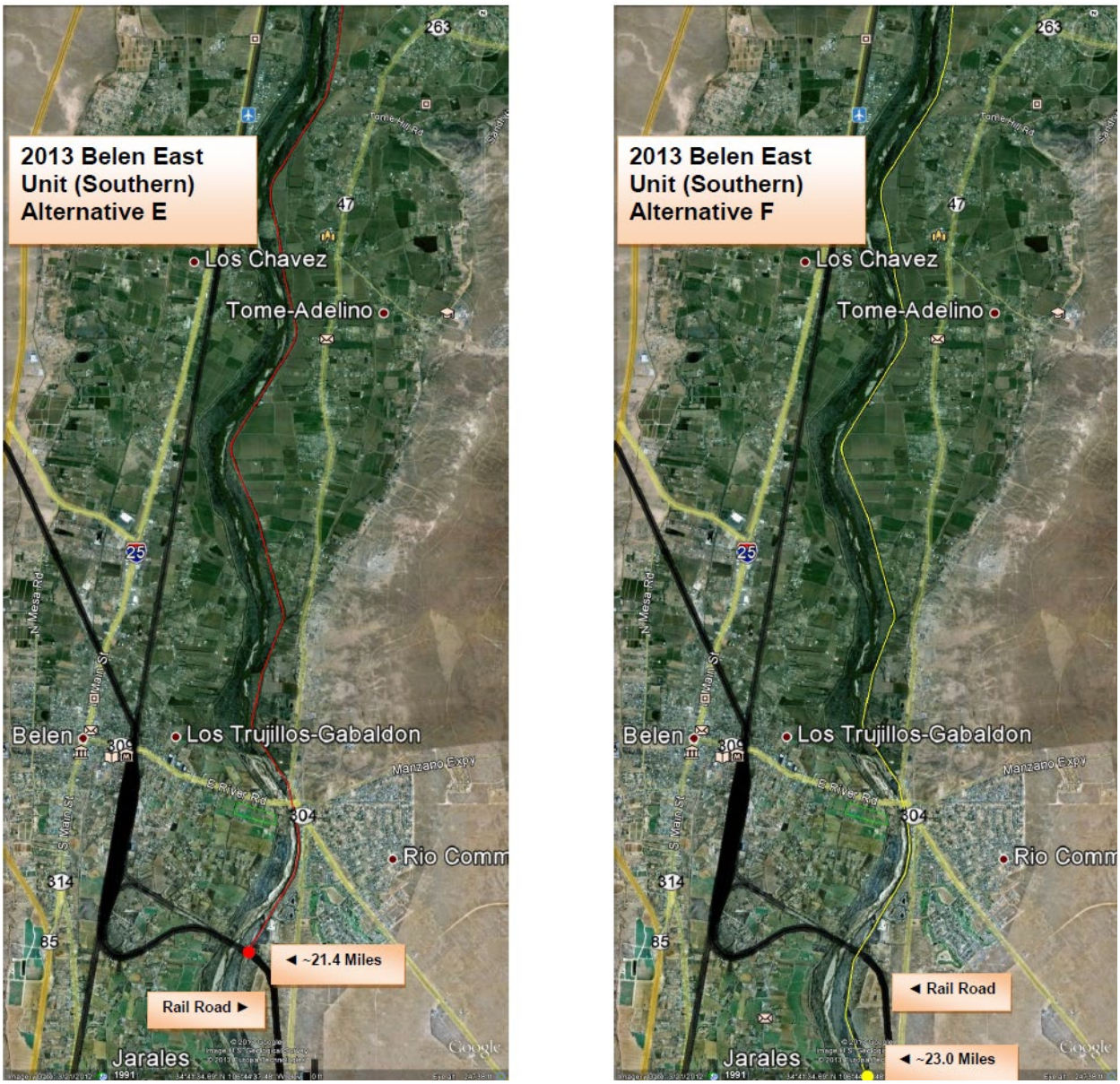


Figure D-32 Belen East Unit (South, Alternative E and F alignments)

Table D-47 Floodplain Description, Belen Units

FLOODPLAIN DESCRIPTION BELEN EAST AND WEST UNITS												
	EVENT											
Project Area	# STR				VALDAMPROP				SINGOCCDAM			
Land Use Category	10%	2%	1%	0.20%	10%	2%	1%	0.20%	10%	2%	1%	0.20%
Belen East					($thousands)				($thousands)			
Residential	2,255	2,332	2,333	2,932	215,932.71	220,227.08	220,295.65	272,171.42	47,571.30	51,228.76	51,367.16	67,179.99
Commercial	198	212	212	257	37,545.30	40,077.07	40,077.07	42,226.66	19,871.17	20,630.26	20,673.38	23,578.45
Public	29	30	30	41	18,527.48	19,361.56	19,361.56	20,410.27	6,671.93	7,330.91	7,346.61	8,181.93
Apartments	0	0	0	1	0.00	0.00	0.00	58.38	0.00	0.00	0.00	5.51
Outbuildings	2,403	2,473	2,474	3,042	17,371.30	17,778.28	17,778.46	21,814.12	3,563.37	3,783.93	3,797.93	5,494.23
Vehicles	1,695	1,702	1,703	2,076	25,272.45	25,376.82	25,391.73	30,953.16	16,119.79	17,078.91	17,109.45	21,829.66
Total Bldgs.	4,885	5047	5,049	6273	314,649.24	322,820.81	322,904.47	387,634.01	93,797.56	100,052.76	100,294.53	126,269.76
Clean-Up									17,289.64	18,667.15	18,721.41	24,808.98
Pop. At Risk	5,908	6,110	6,112	7,684								
Belen West					($thousands)				($thousands)			
Residential	1,335	1,349	1,350	1,519	96,803.08	97,954.86	98,014.75	111,553.30	23,890.29	24,007.81	24,066.56	26,899.79
Commercial	159	159	159	179	110,267.14	110,267.14	110,267.14	112,861.48	44,067.95	44,494.07	44,706.99	54,877.01
Public	40	40	40	56	21,512.25	21,512.25	21,512.25	45,673.18	7,943.44	7,975.75	7,991.98	8,692.85
Apartments	9	9	9	11	1,135.38	1,135.38	1,135.38	2,732.19	384.91	386.14	386.76	427.36
Outbuildings	1,761	1,764	1,765	1,893	13,649.10	13,657.08	13,673.49	14,521.86	3,408.78	3,427.40	3,436.68	3,875.56
Vehicles	1,153	1,154	1,154	1,289	17,191.23	17,206.14	17,206.14	19,218.99	11,216.98	11,274.60	11,303.40	12,612.97
Aircraft	10	10	10	11	1,500.00	1,500.00	1,500.00	1,650.00	14.22	17.70	20.88	713.28
Total Bldgs.	3,304	3321	3,323	3658	262,058.18	263,232.85	263,309.15	308,211.00	90,926.57	91583.47	91,913.26	108,098.84
Clean-Up									14,422.65	14,504.95	14,546.10	16,529.10
Pop. At Risk	3,521	3,558	3,561	4,009								
Total					($thousands)				($thousands)			
Land Use Category	10%	2%	1%	0.20%	10%	2%	1%	0.20%	10%	2%	1%	0.20%
Residential	**3,590**	**3,681**	**3,683**	**4,451**	**312,735.79**	**318,181.94**	**318,310.40**	**383,724.72**	**71,461.60**	**75,236.57**	**75,433.73**	**94,079.77**
Commercial	**357**	**371**	**371**	**436**	**147,812.44**	**150,344.21**	**150,344.21**	**155,088.14**	**63,939.12**	**65,124.33**	**65,380.37**	**78,455.46**
Public	**69**	**70**	**70**	**97**	**40,039.73**	**40,873.81**	**40,873.81**	**66,083.45**	**14,615.37**	**15,306.66**	**15,338.60**	**16,874.78**
Apartments	**9**	**9**	**9**	**12**	**1,135.38**	**1,135.38**	**1,135.38**	**2,790.57**	**384.91**	**386.14**	**386.76**	**432.88**
Outbuildings	**4,164**	**4,237**	**4,239**	**4,935**	**31,020.40**	**31,435.36**	**31,451.95**	**36,335.98**	**6,972.15**	**7,211.33**	**7,234.61**	**9,369.80**
Vehicles	**2,848**	**2,856**	**2,857**	**3,365**	**42,463.68**	**42,582.96**	**42,597.87**	**50,172.15**	**27,336.77**	**28,353.51**	**28,412.85**	**34,442.63**
Aircraft	**10**	**10**	**10**	**11**	**1,500.00**	**1,500.00**	**1,500.00**	**1,650.00**	**14.22**	**17.70**	**20.88**	**713.28**
Pop. At Risk	**9,429**	**9,668**	**9,673**	**11,693**								
Clean-Up									**31,712.30**	**33,172.10**	**33,267.51**	**41,338.08**
TOTALBLDGS.	**8,189**	**8,368**	**8,372**	**9,931**	**576,707.42**	**586,053.66**	**586,213.62**	**695,845.01**	**184,724.13**	**191,636.23**	**192,207.79**	**234,368.60**

Table D-48 Belen East Levee, EAD

BELEN EAST LEVEE UNIT EQUIVALENT ANNUAL DAMAGES BY LAND USE CATEGORY (x$1,000, May, 2016 price level)					
LAND USE CATEGORY	Alt. A EAD	Alt. B EAD	Alt. C EAD	Alt. D EAD	Alt. E EAD
Residential	23,206.62	23,206.62	23,206.73	23,206.73	23,206.73
Commercial	8,231.75	8,231.75	8,231.75	8,231.75	8,231.84
Public	4,058.87	4,058.87	4,058.87	4,058.87	4,058.87
Apartments	0.21	0.21	0.21	0.21	0.21
Outbuildings	1,630.15	1,630.15	1,630.15	1,630.15	1,630.17
Subtotal - Structures and Contents	**37,127.60**	**37,127.60**	**37,127.71**	**37,127.71**	**37,127.82**
Streets, roads	11,180.01	11,180.01	11,180.04	11,180.04	11,180.07
Utilities	586.63	586.63	586.64	586.64	586.64
Railroad	2.08	2.08	2.08	2.08	2.08
Vehicles	7,115.36	7,115.36	7,115.36	7,115.36	7,115.36
Agriculture	7.70	7.70	7.70	7.70	7.70
Irr. Drains	70.16	70.16	70.16	70.16	70.16
Clean-Up	5,263.27				
Recreation	0.00	0.00	0.00	0.00	0.00
Emergency Costs	556.91	556.91	556.92	556.92	556.92
TOTAL	**61,909.73**	**56,646.46**	**56,646.61**	**56,646.61**	**56,646.75**

Table D-49 Belen East Levee, Equivalent Annual Residual Damage and Benefits

BELEN EAST LEVEE ALT. A
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)										Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)								
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'
Residential	23206.62	53,350.00	36112.55	20,783.22	9,830.66	3,749.68	1,219.22	366.89	115.92	43.98	-30,143.38	-12905.93	2,423.40	13,375.96	19,456.94	21,987.40	22,839.73	23,090.70	23,162.64
Commercial	8231.75	17,703.79	12061.99	7,022.08	3,380.66	1,325.03	447.87	141.67	47.92	19.34	-9,472.04	-3830.24	1,209.67	4,851.09	6,906.72	7,783.88	8,090.08	8,183.83	8,212.41
Public	4058.87	5,884.90	3702.35	1,942.41	838.03	294.01	87.99	25.31	7.88	3.00	-1,826.03	356.52	2,116.46	3,220.84	3,764.86	3,970.88	4,033.56	4,050.99	4,055.87
Apartments	0.21	2.58	1.73	1.01	0.51	0.22	0.09	0.03	0.01	0.01	-2.37	-1.52	-0.80	-0.30	-0.01	0.12	0.18	0.20	0.20
Outbuildings	1630.15	5,031.48	3538.36	2,120.72	1,035.48	402.70	132.27	39.35	12.01	4.37	-3,401.33	-1908.21	-490.57	594.67	1,227.45	1,497.88	1,590.80	1,618.14	1,625.78
Subtotal - Structures and	**37,127.60**	**81,972.75**	**55416.98**	**31,869.44**	**15,085.34**	**5,771.64**	**1,887.44**	**573.25**	**183.74**	**70.70**	**-44,845.15**	**-18289.38**	**5,258.16**	**22,042.26**	**31,355.96**	**35,240.16**	**36,554.35**	**36,943.86**	**37,056.90**
Streets, roads	11,180.01	24,683.95	16687.38	9,596.65	4,542.56	1,737.98	568.35	172.62	55.33	21.29	-13,503.95	-5507.37	1,583.36	6,637.45	9,442.03	10,611.65	11,007.39	11,124.68	11,158.72
Utilities	586.63	1,295.21	875.62	503.55	238.36	91.19	29.82	9.06	2.90	1.12	-708.58	-288.98	83.08	348.28	495.44	556.81	577.58	583.73	585.52
Railroad	2.08	4.59	3.10	1.79	0.85	0.32	0.11	0.03	0.01	0.00	-2.51	-1.02	0.29	1.23	1.76	1.97	2.05	2.07	2.08
Vehicles	7,115.36	16,997.93	11254.43	6,238.79	2,862.68	1,079.71	350.83	107.46	35.64	14.27	-9,882.57	-4139.07	876.57	4,252.68	6,035.65	6,764.53	7,007.90	7,079.72	7,101.09
Agriculture	7.70	17.01	11.50	6.61	3.13	1.20	0.39	0.12	0.04	0.01	-9.30	-3.79	1.09	4.57	6.51	7.31	7.58	7.66	7.69
Irr. Drains	70.16	154.91	104.72	60.22	28.51	10.91	3.57	1.08	0.35	0.13	-84.74	-34.56	9.94	41.65	59.25	66.59	69.08	69.81	70.03
Clean-Up	5,263.27						126.35									5,136.92			
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	556.91	1,229.59	831.25	478.04	226.28	86.57	28.31	8.60	2.76	1.06	-672.68	-274.34	78.87	330.63	470.34	528.60	548.32	554.16	555.85
TOTAL	**61,909.73**	**126355.94**	**85,184.98**	**48,755.10**	**22,987.69**	**8,779.53**	**2,995.17**	**872.22**	**280.76**	**108.59**	**-69709.48**	**-28,538.52**	**7,891.36**	**33,658.77**	**47,866.93**	**58,914.56**	**55,774.24**	**56,365.70**	**56,537.87**

Table D-50 Belen East Levee, Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED BELEN EAST LEVEE ALT. A (x$1,000, May, 2016 price level)									
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'	Base Levee + 6'	Base Levee + 7'	Base Levee + 8'
Construction Cost*	67,620.00	73,494.20	77,132.18	78,739.34	85,102.69	95,812.92	109,170.64	119,133.45	134,484.34
Real Estate	710.38	763.65	795.31	806.52	879.41	985.44	1,134.46	1,236.79	1,236.79
Construction Mgt.	4,962.31	4,962.31	4,962.31	4,962.31	4,962.31	4,962.31	4,962.31	4,962.31	4,962.31
PED	839.87	839.87	839.87	839.87	839.87	839.87	839.87	839.87	839.87
Total First Cost	74,132.56	80,060.04	83,729.67	85,348.05	91,784.29	102,600.55	116,107.29	126,172.43	141,523.32
IDC (60 months construction, 2.75%)*	5,510.37	5,950.96	6,223.73	6,344.03	6,822.44	7,626.43	8,630.40	9,378.56	10,519.61
Total Investment	79,642.93	86,011.00	89,953.40	91,692.08	98,606.74	110,226.97	124,737.69	135,550.99	152,042.93
Avg. Ann. Cost (2.75%, 50 yr. project life)	2,950.05	3,185.93	3,331.96	3,396.36	3,652.48	4,082.91	4,620.40	5,020.93	5,631.81
OMRR&R									
Total Avg. Ann. Cost	2,950.05	3,185.93	3,331.96	3,396.36	3,652.48	4,082.91	4,620.40	5,020.93	5,631.81
Equivalent Avg. Ann. Benefits	-69,709.48	-28,538.52	7,891.36	33,658.77	47,866.93	58,914.56	55,774.24	56,365.70	56,537.87
Benefit/Cost Ratio	-23.63	-8.96	2.37	9.91	13.11	14.43	12.07	11.23	10.04
Net Benefits	-72,659.53	-31,724.45	4,559.41	30,262.41	44,214.45	54,831.65	51,153.84	51,344.76	50,906.06

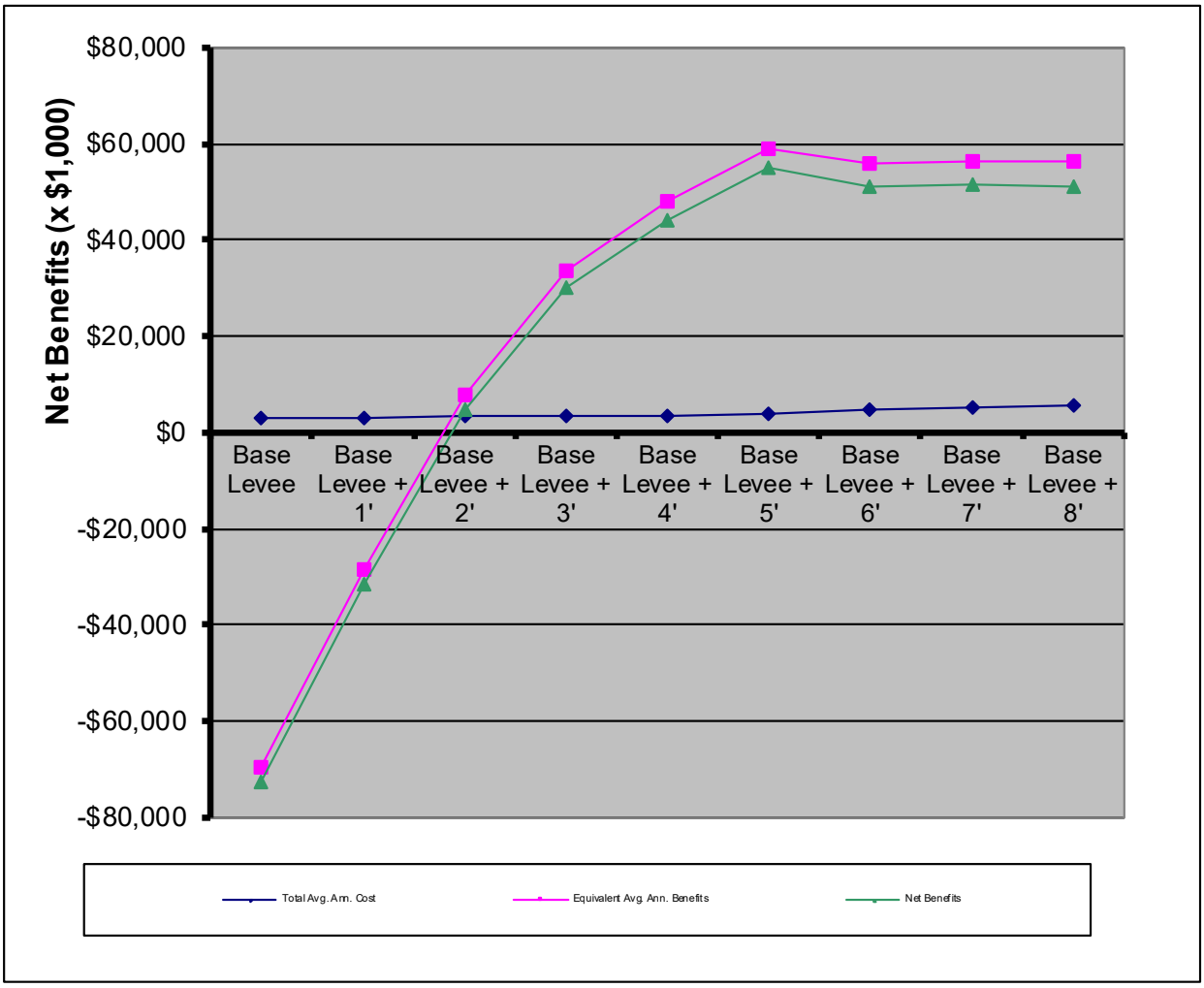


Figure D-33 Belen East Unit Alternative A Optimization Curve

Table D-51 Belen East Levee, Alternative Alignment Construction Costs

BELEN EAST LEVEE ALTERNATIVE ALIGNMENT CONSTRUCTION COSTS (x$1,000, May, 2016 price level)		
Alignment		Construction Cost
2013 Belen East Unit A 0+00 to 934+00	Base	$74,132.56
	Base + 1'	$80,060.04
	Base + 2'	$83,729.67
	Base + 3'	$85,348.05
	Base + 4'	$91,784.29
	Base + 5'	$102,600.55
	Base + 6'	$116,107.29
	Base + 7'	$126,172.43
	Base + 8'	$141,523.32
2013 Belen East Unit B 0+00 to 994+00	Base	$76,553.98
	Base + 1'	$82,506.78
	Base + 2'	$85,381.88
	Base + 3'	$87,857.84
	Base + 4'	$93,709.82
	Base + 5'	$105,066.34
2013 Belen East Unit C 0+00 to 1028+00	Base	$56,527.18
	Base + 1'	$60,902.94
	Base + 2'	$62,935.79
	Base + 3'	$64,758.12
	Base + 4'	$68,982.02
	Base + 5'	$77,168.13
2013 Belen East Unit D 0+00 to 1044+00	Base	$57,250.40
	Base + 1'	$61,889.04
	Base + 2'	$64,115.72
	Base + 3'	$66,018.13
	Base + 4'	$70,418.35
	Base + 5'	$78,755.59
2013 Belen East Unit E 0+00 to 1135+98	Base	$62,199.63
	Base + 1'	$67,257.60
	Base + 2'	$69,676.50
	Base + 3'	$71,755.75
	Base + 4'	$75,083.10
	Base + 5'	$81,513.10
2013 Belen East Unit F 0+00 to 1120+63	Base	$65,836.27
	Base + 1'	$71,263.48
	Base + 2'	$73,847.19
	Base + 3'	$76,063.00
	Base + 4'	$79,619.49
	Base + 5'	$86,514.24

Table D-52 Belen East Levee, Alternative Alignment Equivalent Annual Costs and Benefits

BELEN EAST LEVEE ALTERNATIVE ALIGNMENT EQUIVALENT ANNUAL COSTS AND BENEFITS (x$1,000, May, 2016 price level)				
Alignment		Avg. annual cost	Equivalent Annual Benefits (all)	Net Benefits (all)
2013 Belen East Unit A 0+00 to 934+00	Base	$2,745,938.28	-$69,709,480.35	-$72,455,418.64
	Base + 1'	$2,965,497.43	-$28,538,522.29	-$31,504,019.71
	Base + 2'	$3,101,423.96	$7,891,363.50	$4,789,939.54
	Base + 3'	$3,161,370.29	$33,658,765.45	$30,497,395.16
	Base + 4'	$3,399,774.61	$47,866,934.05	$44,467,159.44
	Base + 5'	$3,800,418.55	$58,914,558.29	$55,114,139.74
	Base + 6'	$4,300,720.62	$55,774,239.74	$51,473,519.12
	Base + 7'	$4,673,542.88	$56,365,696.31	$51,692,153.43
	Base + 8'	$5,242,153.86	$56,537,870.44	$51,295,716.58
2013 Belen East Unit B 0+00 to 994+00	Base	$2,835,629.93	-$69,709,480.35	-$72,545,110.29
	Base + 1'	$3,056,126.85	-$28,538,522.29	-$31,594,649.14
	Base + 2'	$3,162,623.38	$7,891,363.50	$4,728,740.13
	Base + 3'	$3,254,335.20	$33,658,765.45	$30,404,430.26
	Base + 4'	$3,471,097.75	$47,866,934.05	$44,395,836.30
	Base + 5'	$3,891,753.73	$58,914,558.29	$55,022,804.56
2013 Belen East Unit C 0+00 to 1028+00	Base	$2,093,818.83	-$69,709,480.35	-$71,803,299.18
	Base + 1'	$2,255,900.80	-$28,538,522.29	-$30,794,423.08
	Base + 2'	$2,331,199.42	$7,891,363.50	$5,560,164.08
	Base + 3'	$2,398,700.22	$33,658,765.45	$31,260,065.24
	Base + 4'	$2,555,157.49	$47,866,934.05	$45,311,776.56
	Base + 5'	$2,858,378.62	$58,914,558.29	$56,056,179.67
2013 Belen East Unit D 0+00 to 1044+00	Base	$2,120,607.59	-$69,709,480.35	-$71,830,087.95
	Base + 1'	$2,292,426.80	-$28,538,522.29	-$30,830,949.09
	Base + 2'	$2,374,905.40	$7,891,363.50	$5,516,458.11
	Base + 3'	$2,445,372.10	$33,658,765.45	$31,213,393.36
	Base + 4'	$2,608,360.50	$47,866,934.05	$45,258,573.55
	Base + 5'	$2,917,179.35	$58,914,558.29	$55,997,378.94
2013 Belen East Unit E 0+00 to 1135+98	Base	$2,303,931.46	-$69,725,375.16	-$72,029,306.62
	Base + 1'	$2,491,283.30	-$28,550,795.20	-$31,042,078.49
	Base + 2'	$2,580,881.73	$7,886,310.98	$5,305,429.25
	Base + 3'	$2,657,899.00	$33,657,838.35	$30,999,939.35
	Base + 4'	$2,781,147.10	$47,867,020.78	$45,085,873.68
	Base + 5'	$3,019,320.19	$53,777,905.10	$50,758,584.91
2013 Belen East Unit F 0+00 to 1120+63	Base	$2,438,635.90	-$69,725,375.16	-$72,164,011.06
	Base + 1'	$2,639,664.81	-$28,550,795.20	-$31,190,460.00
	Base + 2'	$2,735,367.85	$7,886,310.98	$5,150,943.13
	Base + 3'	$2,817,443.46	$33,657,838.35	$30,840,394.89
	Base + 4'	$2,949,179.26	$47,867,020.78	$44,917,841.51
	Base + 5'	$3,204,566.98	$53,777,905.10	$50,573,338.13

During policy review, the Corps determined the plan which reasonably maximizes net benefits for the Belen East and Belen West Units was at the Base + 5' levee height. The benefits produced by levees at Base + 5' and greater were close enough that selecting an alternative with lesser cost would still reasonably maximize net benefits.

Belen East Levee (1979 Authorized Version)

The 1979 Belen East Levee had a length of 22.1 miles, placing it equivalent to Belen East E and Belen East F in this analysis. As the previous section indicates, extending the Belen East Unit levee south didn't provide much in additional benefits, as the inventory isn't really susceptible to flooding that far south. Figure D-32 demonstrates the northern extent of the authorized levee, which closely parallels the northern extent of the levees analyzed here. Figure D-33 displays the southern extent of the authorized levee.

Figure D-34 Belen East Unit Authorized Plan (Northern Alignment)

Figure D-35 East Unit Authorized Plan (Southern Alignment)

Isleta West Levee (and alternative alignments)

The Isleta West Unit is west of the Rio Grande from south of the Interstate 25 crossing over the Rio Grande to the Isleta Village Proper and the Highway 147 river crossing at the southern limits of this study. This reach was authorized in 1979 and subsequent investigations. Changes in levee design and growth in the floodplain (screened for compliance with Section 308 of WRDA 1990) has indicated a Federal interest in providing flood mitigation services to the region (an explanation of the Federal interest is described in the conclusion to this section). For purposes of this analysis, the Isleta West Unit is considered a separable element. Figures and tables which follow describe the flooding problems and opportunities within the unit, and benefits of any proposed solutions. Figures D-36 to D-40 display the Isleta West Units A through Unit D, which extend from one embankment of the Interstate 25 crossing of the Rio Grande south to a railroad crossing roughly 1.5 to 1.8 miles to the south. Alternatives differ in various setback features and crossing some local drainages, but in terms of managing the flood risk, essentially perform the same. Figure D-40 presents one additional levee length that extend past the railroad crossing down to the Isleta Village proper.

Table D-60 describes the floodplain in terms of number of property units inundated by type and event severity, as well as their values and the damages associated with the events modeled. Table D-61 displays Equivalent Annual Damages in the Unit by property type and lineal extent for the stretch of floodplain extending from the Interstate 25 river crossing to the railroad river crossing. Table D-62 displays Equivalent Annual Damages in the Unit by property type and lineal extent for the stretch of floodplain extending from the Interstate 25 river crossing to just past the Isleta Pueblo village proper. The purpose here is to establish the baseline and determine the length and height of any proposed levee. Tables D-61 and D-62 indicate that extending the length downstream of the railroad crossing generates substantial additional benefits meriting extension of the levee. Table D-63 displays the equivalent annual residual damages and benefits of the various levee heights considered for properties north of the railroad crossing, and Table D-64 extends that analysis to all properties in the Isleta West reach from Interstate 25 past the Isleta Pueblo village proper. Table D-65 displays the benefits and costs of the various levee heights considered for Alternative A. Table D-66 displays the benefits and costs of the various levee heights considered for Alternative E, which was the length of levee through this reach with greatest net benefits. The construction period is 12 months for the Isleta West levee alternatives, so interest during construction is not computed. Figure D-42 displays the optimization curve for the Isleta West Unit Alternative E levees. Table D-67 displays, for each height and lineal extent, construction costs for the proposed levees. Generally, longer levees for a given height cost more due to the material and labor requirements. Table D-68 displays the equivalent annual costs and benefits of all the levee alignments and heights.

Table D-68 indicates that benefits significantly increase in the Isleta West Reach once properties south of the railroad crossing are considered. This study has evaluated the hydraulic separability of proposed structures north and south of the railroad crossing and concluded there is no feasible way of tying levee alignment E into the railroad embankment, ignoring the reach protected by Alignments A-D.

Rail Transportation Impacts

The Isleta Pueblo contains segments of railroad track that are vulnerable to flooding, and would benefit from the proposed levees. Amtrak and the BNSF railway operate segments that extend north of the Isleta Pueblo Village along the Rio Grande. Both services also use a junction just west of the Isleta Pueblo Village to connect to major interstate routes that extend west into Arizona and North into Colorado. This segment of railway has been designated by the NM State Department of Transportation (NMDOT) as a "Priority Freight Corridor." Further, the New Mexico Rail Runner, a commuter train serving Rio Grande communities from Belen to Santa Fe, NM and points between makes several trips north and south through the threatened floodplain daily. Any flooding in the Isleta Pueblo would sever these lines, forcing traffic reroutes. Other segments of the railroad that would be threatened by flooding on the Rio Grande will be protected by proposed levees in the Belen Units. The railroad goes to high ground once it crosses the Rio Grande from west to east on a bridge north of the Isleta Pueblo. This analysis will focus on the impact to passenger and freight travel through the threatened segment in the event of a disruption of service.

Freight service impacts

About 6.5 miles west of Los Lunas, a railroad junction exists that can take inbound traffic from the west and route it north through the Isleta Pueblo, and the threatened railroad segment, or to the south, and through the Belen Railyards. There route to the north follows roughly the same path as Interstate 25 and serves freight and passenger travel needs to Albuquerque, Santa Fe, Las Vegas, and smaller communities along the way to the town of Trinidad, Colorado. In the event this north-south route were cut, the nearest reroute goes through Belen, and points east through the Texas panhandle, turning north and back to the west to Trinidad, Colorado. Figure D-34 presents the threatened route (in white, 300 miles) and the closest reroute (in red, 480 miles).

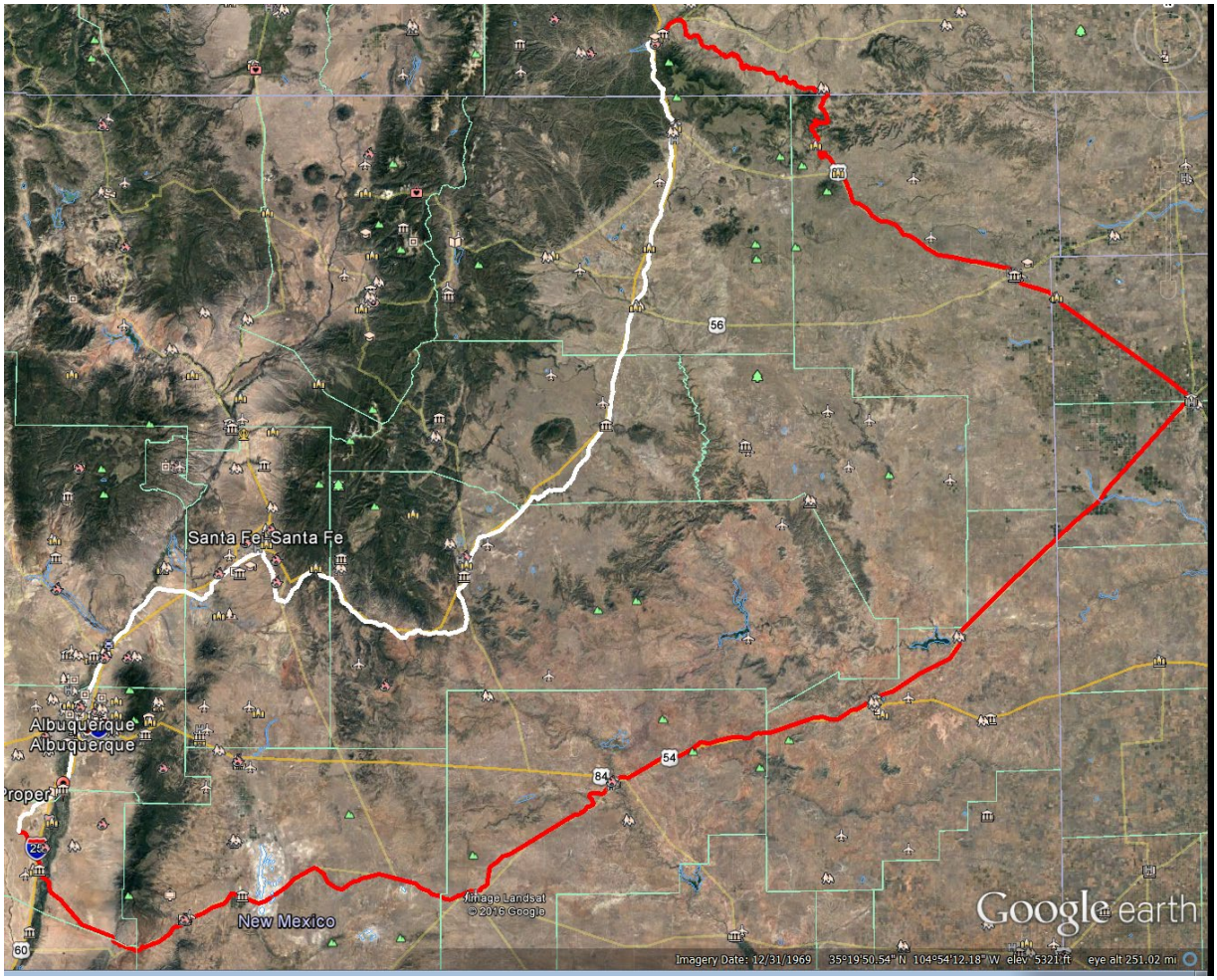
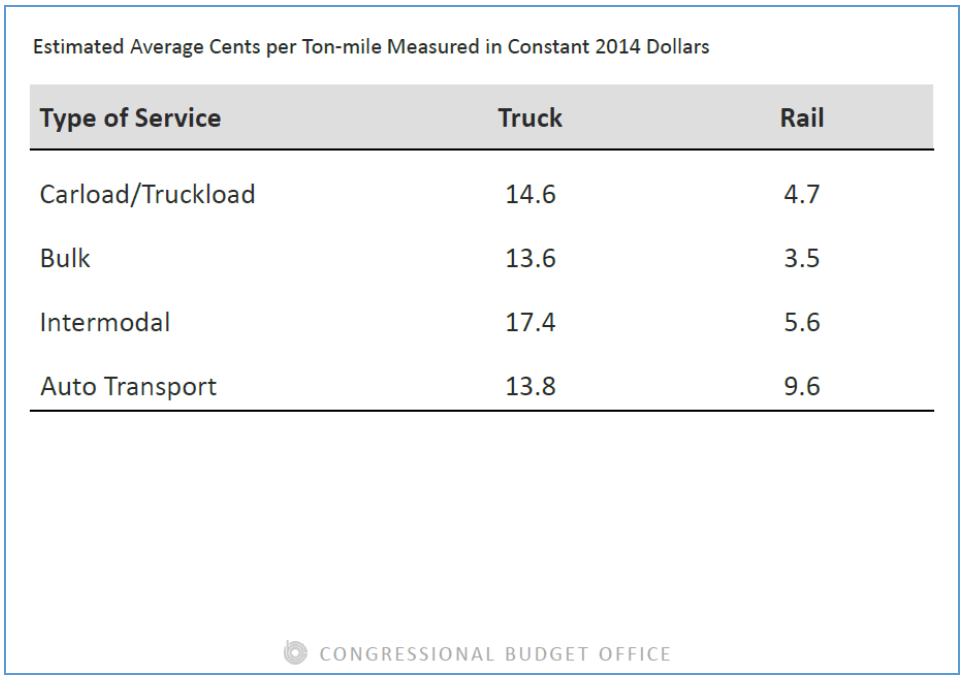


Figure D-36 Map of the threatened route plus nearest railroad detour

The NMDOT indicates that 2011 freight traffic on the affected segment between the Isleta Pueblo and Trinidad, Colorado varies between 5 and 10 million tons/year. (2014 New Mexico State Rail Plan, page 4-29, Figure 4.15). Any service interruption would force a reroute of at least 180 miles for the duration of the interruption. Per the H&H appendix, snowmelt floods in the study area would likely last 90-100 days, while thunderstorm events would have a 3-4 day duration. The closest rail reroute adds a minimum of 180 miles to freight trips.

Acknowledging that train freight can be offloaded to trucks is a viable option to offset the distance, it is then necessary to identify the difference in shipping costs between rail and truck. The Bureau of Transportation Statistics indicates in 2007 (latest year available from the 2016 National Transportation Statistics report), Class 1 rail receives 2.99 cents per ton-mile while truck firms receive 16.54 cents per ton-mile. Revenue is not a good indicator of cost, but it does suggest that trucking is an expensive alternative to shipping by rail, even with lower barriers to entry. The Congressional Budget Office

estimates 2007 trucking costs vary between 13.6 and 17.4 cents per ton-mile (2014 prices) and railroad costs vary between 3.5 and 9.6 cents per ton-mile. Using that metric, truck freight can cost an extra 4.2 and 11.8 cents per ton-mile over the rail shipping costs. Changing modes to save 180 miles in freight distance is not a cost-effective means to avoid an interruption in rail service. At a rail cost of 4.7 cents per ton-mile, truck freight would have to cost less than 7.2 cents per ton-mile to be cost-effective. At the upper end of 9.6 cents per rail ton-mile, trucking would have to cost less than 15.36 cents per ton-mile. Neither scenario was feasible, per the CBO report. These estimates also ignore time and cost to change shipping modes from rail to truck. Further, the 2014 New Mexico State Rail Plan indicates that 88% of rail traffic by weight is through traffic, and not local (<1%), inbound (2%) or outbound (10%) (NM State Rail Plan 2014, Table 4.5).



Estimated Average Cents per Ton-mile Measured in Constant 2014 Dollars

Type of Service	Truck	Rail
Carload/Truckload	14.6	4.7
Bulk	13.6	3.5
Intermodal	17.4	5.6
Auto Transport	13.8	9.6

CONGRESSIONAL BUDGET OFFICE

Figure D-37 ***https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/presentation/50738-presentation.pdf***

Eliminating alternative modes of travel and assuming a 3 day storm forces a reroute of 13,700 tons (assuming 5 million tons shipped per year, the low end of the estimated range of values) of rail freight around the flooded reach incurs an average annual loss of $31,000. This is conservative, as the railroad would clearly need time to evaluate the flooded rail tracks and conduct any necessary repairs following any flood event. A longer duration flood, more extensive damage due to extra length or depth of track inundation or more daily traffic through the affected area would all raise this estimate. Table D-53 shows the calculation to support the annual estimate of freight shipment damages.

Table D-53 Computation of average annual freight losses due to service interruption

ISLETA WEST, 6.3 cents per ton-mile, 3 day detour, 10% ACE start of damages						
Frequency	Interval	Value	Damages	Total		
0		$258,904.11				
	0.002		$258,904.11	$517.81		
0.002		$258,904.11				
	0.008		$258,904.11	$2,071.23		
0.005		$258,904.11				
	0.015		$258,904.11	$3,883.56		
0.01		$258,904.11				
	0.01		$258,904.11	$2,589.04		
0.02		$258,904.11				
	0.08		$258,904.11	$20,712.33		
0.1		$258,904.11				
	0.01		$129,452.05	$1,294.52		
0.11		$0.00				
sum				$31,068.49		

Passenger service impacts

In addition to daily freight travel, the threatened rail line serves as a passenger conveyance. AMTRAK's Southwest Chief runs once daily through the Isleta West reach. The train is a major interstate route that originates in Los Angeles, California and terminates in Chicago, Illinois. The following table indicates the annual passenger figures for that service. Roughly 1/3 of the Southwest Chief's passengers start or finish their travel in New Mexico, and 31 percent along the "white" route that would require either a delay in travel, a reroute to Interstate 25, or a reroute along the longer "red" route.

In the event of a service interruption, passengers traveling through the route would be detoured 180 miles to continue their trip, incurring time losses and extra mileage due to the reroute. Passengers who end or begin a trip along the affected route would have to change to a bus or shuttle to complete the travel. Passengers who are passing through the affected area would be merely rerouted and incur the extra time and distance necessary to complete the detour. Most tracks in New Mexico have a 79 mile per hour speed limit, which means, apart from time losses due to track changes, fuel and supply stops, and switching, it would take roughly 2.3 hours to cover the additional 180 miles. Interstate 25 between Belen, New Mexico and Trinidad, Colorado has a 75 mph speed limit, except for construction zones and a 65 mph speed limit throughout Albuquerque, New Mexico. For simplicity's sake, we will assume a constant 75 mph speed limit, which means a 300 mile surface trip would take 4 hours. To simplify the assumptions even further, we will assume that shuttle or bus travel will not take more than 2.25 hours (at which point it's faster to take the train route) to cover the distance between the

nearest train station at Trinidad, Colorado or Belen, New Mexico and their origin/destination point along the white route. Local shuttle service between Albuquerque and Santa Fe runs $30 per passenger, while bus service between Albuquerque and Raton, NM costs $45 and up. This analysis will use the cheaper shuttle rate on a per passenger basis.

Table D-54 Computation of passenger travel losses by event

	Start/Finish NM		Through NM	
Average Daily Passengers	354.25753		619.21096	NM State Rail Plan 2014
Median household size	2.66		2.54	Bureau of the Census, 2014
Time to detour (hours)	2.25		2.25	
Median household income	$44,968		$51,939	Bureau of the Census, 2014
Hourly wage	21.36		23.23	Bureau of Labor Statistics
High time savings (% hourly wage)	60%		60%	(Social/Recreation trips, Table D-4, ER 1105-2-100)
Time losses/3 day detour	$11,521.09		$22,935.55	
Mileage losses/person (shuttle fee)	30			https://www.sandiashuttle.com/
			0.63	1/10 cost/ton-mile of freight per 180 mile trip.
Mileage losses/3 day detour	$31,883.18		$1,170.31	
Total losses/3 day event	$43,404.27		$24,105.86	
GRAND TOTAL		$67,510.13		

Table D-55 Computation of average annual passenger travel losses by service interruption

Isleta West, 3 day detour, 10% ACE start of damages						
Frequency	Interval	Value	Damages	Total		
0		$67,510.13				
	0.002		$67,510.13	$135.02		
0.002		$67,510.13				
	0.008		$67,510.13	$540.08		
0.005		$67,510.13				
	0.015		$67,510.13	$1,012.65		
0.01		$67,510.13				
	0.01		$67,510.13	$675.10		
0.02		$67,510.13				
	0.08		$67,510.13	$5,400.81		
0.1		$67,510.13				
	0.01		$33,755.07	$337.55		
0.11		$0.00				
sum				$8,101.22		

Commuter rail service impacts

The New Mexico Rail Runner Express (NMRX) is a commuter rail service linking the

cities of Belen, Albuquerque, and Santa Fe along a 97 mile rail corridor. There are 13 stops along this corridor, and 22 trains run each weekday, with 11 more Saturdays and 7 more Sundays. The commuter service has had an annual ridership over 1 million each year since 2009, with average weekday ridership at 3,647 in 2013. Approximately 60 percent of weekday and 85 percent of weekend trips have one end in Santa Fe and the other in Valencia, Bernalillo, or Sandoval Counties (New Mexico State Rail Plan 2014). That suggests the most common use of the train is to commute between the Albuquerque metropolitan area (Albuquerque and surrounding communities) and Santa Fe.

In the event of a service interruption, commuters at the Isleta Pueblo and points south would most likely resort to personal vehicle use (at a marginal operating cost of 14.54 cents per mile for a small sedan, per AAA Driving Costs 2015). The distance between Albuquerque and Santa Fe is 64.6 miles (ignoring local travel and origination points north and south of the Albuquerque metro area). Assuming the daily weekday ridership is comprised of commuters, who would be forced to personal vehicle use for the duration of the service interruption, each 3 day interruption in service would cost about $17,200 as computed in Table D-56.

Table D-56 Computation of commuter travel losses by event

Average weekday ridership 2012		610	
marginal operating costs (small sedan)		$0.1454	dollars
I-25 mileage, ABQ to Santa Fe		64.6	miles
	TOTAL mileage losses	$17,188.90	per event

Table D-57 Computation of average annual commuter travel losses by service interruption

Isleta West, 3 day detour, 10% ACE start of damages				
Frequency	Interval	Value	Damages	Total
0		$17,188.90		
	0.002		$17,188.90	$34.38
0.002		$17,188.90		
	0.008		$17,188.90	$137.51
0.005		$17,188.90		
	0.015		$17,188.90	$257.83
0.01		$17,188.90		
	0.01		$17,188.90	$171.89
0.02		$17,188.90		
	0.08		$17,188.90	$1,375.11
0.1		$17,188.90		
	0.01		$8,594.45	$85.94
0.11		$0.00		
sum				$2,062.67

This estimate is a reasonable upper bound of commuter impacts. During previous

service interruptions, the NMRX has elected to bus rail commuters around the interruption to the next rail stop. Bus travel would have a lower per mile per passenger cost on mileage, but not on time. The disincentives of personal auto use versus a combination of rail and bus to perform a daily commute would suggest that a significant riders would elect to personal auto use during any service interruption.

Impacts of rail service interruption loss and sensitivity impacts

Table D-58 provides total impacts as a sum of the previous impacts decribed to provide a grand total. The value of the railroad itself has already been computed elsewhere in the economics appendix.

Table D-58 Computation of total annual losses by rail service interruption

FREIGHT losses		$31,068.49
PASSENGER losses		$8,101.22
COMMUTER losses		$2,062.67
GRAND TOTAL		$41,232.38

The most significant impact to this estimate of benefits would be a change to the first event in which damages occur. This analysis ignores any damages from events greater than 10% AEP, which is slightly more conservative than the start of damages condition adopted in the economics appendix (20% AEP). Moving the start of damages condition to 4% AEP would lower average annual damages by 37% to $25,942.04. Conversely, moving the start of damages condition to 20% AEP would roughly triple EAD to $137,441.25. However, the assumptions presented in this analysis are considered VERY conservative, and are only expected to go up from the value presented here. For one, flood durations given in the assumptions here give no time for the railroad to perform needed post-event inspections, testing and repairs prior to resuming service. The freight quantities presented here assume an annual freight haul of 5 million tons per year, but there are some segments on the affected route that indicate 10 million tons per year, per the 2014 New Mexico State Rail Plan. Finally, time loss computation was merely computed at the time required to complete a distance at a given speed, ignoring such factors such as stops to embark/disembark people or goods, time needed to change tracks or navigate switchyards, time needed to navigate local surface roads or arrange alternative transportation. All these factors are expected to be additive of the value of time calculations presented here.

Benefits of proposed levees

The proposed levees would eliminate or mitigate the frequency at which these losses occur. Assuming that the service interruption impacts only occur at events more severe than the 0.5% AEP event, Table D-59 presents a new total residual damages from a proposed levee.

Table D-59 Residual service impacts to freight, passenger and commuter travel with damages > 0.5% AEP ignored.

Frequency	Interval	Value	Damages	Total
0		$343,603.14		
	0.002		$343,603.14	$687.21
0.002		$343,603.14		
	0.0031		$171,801.57	$532.58
0.005		$343,603.14		
	0.006		$171,801.57	$1,030.81
0.0051		$0.00		
	0.0059		$0.00	$0.00
0.011		$0.00		
	0.089		$0.00	$0.00
0.1		$0.00		
	0.01		$0.00	$0.00
0.11		$0.00		
sum				$2,250.60

That represents a 95% reduction in transportation impacts and means roughly $39,000 in benefits, assuming the without-project conditions start at 10% AEP. Each of the proposed levee heights have a different Annual Exceedance Probability, as calculated in HEC-FDA, which serves as the point that transportation impacts occur. Those values were pulled into a calculation table much like Figure D-5 to compute residual risk. As the proposed project is at a height corresponding to the 1% AEP water surface elevation plus 4 feet, it's likely that the residual risk impacts start at events < 0.5% AEP. In fact, project performance metrics indicate the levee height has a median annual exceedance probability of 0.17% which is substantially less frequent than what is modeled here.

Sensitivity Analysis

A sensitivity analyses demonstrates where the damages and benefits calculations go when key assumptions are changed. The most critical assumption identified in this analysis varies the hydraulics assumption that a thunderstorm based flood event is 3-4 days. This analysis uses the conservative 3 day duration, which doesn't give the railroads time to even check the track conditions following inundation to see whether repairs are necessary, or allocate time for those repairs. Adding one day to the event duration increases damages to $54,300 and benefits to $51,300, other factors held constant (i.e. *ceteris paribus*). Each day of rail service interruption adds $13,056.57 to average annual damages and $12,343.89 to the benefits of the proposed levee. Three recent storm events that touched the rail line that is used by the Rail Runner (August 2012, 2014, and 2015) all had one day of additional service interruption to conduct repairs following track inundation.

The current levee in the Isleta West Unit which maximizes net benefits, before applying

railroad transit impacts discussed here is Alignment E, at a height corresponding to the 1% AEP event, present condition, termed the “Base” in the following table, plus 4’. Other alignments (A, B, D) start in the same upstream location, but terminate at the upstream embankment of the railroad as it crosses the river. Those alignments would not protect the railroad from service impacts described here. Alignment E extends further south, tying into high ground near the oldest inhabited portion of the Isleta Pueblo, roughly 1.2 miles longer than Alignments A, B, and D, and would provide the transportation benefits described here. Table D-66 outlines the costs and benefits of the Isleta West levee alignments and their various heights, at the price level of the most recent cost estimate (May, 2016)

As the table indicates, Isleta West Unit E, at the Base elevation + 4’ is the alternative where net benefits are at a positive value. A higher structure provides even more net benefits.

Corps of Engineers guidance prescribes SMART planning principles, to make risk-informed decisions given incomplete information. The purpose of this analysis is to present transportation service impacts of a rail service interruption in the Isleta West reach. The NED plan for the Isleta West Unit Alignment E, at a height corresponding to the Base water surface elevation plus 4 feet, has a benefit/cost ratio (BCR) of .99 and was roughly $156 short in net equivalent annual benefits to get to a BCR of 1.0 (May, 2016 price levels, 2.75% discount rate). By any reasoning, the benefits and costs are identical. Any transportation benefits would bring that BCR up over 1.0 and would indicate a Federal interest in the proposed levee. This analysis indicates there are benefits sufficient to cover the equivalent annual benefits shortfall computed for the Isleta West Levee. Adding “rail transportation impacts” to the benefits computed for the Isleta West levee (Alignment E) would easily bring the BCR for this unit above 1.0 and indicate that it’s in the Federal interest to build a structure in the Isleta West Unit. There are plenty of conditions that would add to the damage and benefit figures (more frequent start of damages condition, longer flood duration, time added for inspection and repair of rail tracks, additional freight hauling). However, it must be acknowledged that as time goes on, costs of a project go up faster than benefits, so the compensating risk is that this justified Unit’s Benefit/Cost Ratio can once again fall below unity.

Going to the “Base + 5’” levee height is not justified, largely on the basis of stakeholder acceptability and uncaptured costs. For one, the Isleta Tribe has indicated general dissatisfaction with levees as they encroach upon scarce bosque habitat, and higher structures obscure views of the river and its surrounds. Next, there are a slew of uncaptured costs that accompany higher structures (extra real estate, extra mitigation) that make higher structures marginally less attractive than a smaller structure. The proposed levee at “Base + 4’” height has an Annual Exceedance Probability (AEP) of 0.17%. The “Base + 5’” levee has an AEP of 0.09%. The proposed levees already capture 99% of EAD at the “Base + 4’” elevation, and going higher only captures an additional $20k on an equivalent annual basis, which is a poor justification for the

marginal $1.3 million in project costs (not knowing the marginal costs for extra real estate and mitigation).

Table D-60 Floodplain Description, Isleta West Unit

FLOODPLAIN DESCRIPTION ISLETA WEST UNIT												
	EVENT											
Project Area	# STR				VALDAMPROP				SINGOCCDAM			
Land Use Category	10%	2%	1%	0.20%	10%	2%	1%	0.20%	10%	2%	1%	0.20%
Isleta West					($thousands)				($thousands)			
Residential	87	87	87	119	6,088.25	6,088.25	6,088.25	8,377.69	694.67	705.20	709.02	1,241.18
Commercial	1	1	1	3	11.33	11.33	11.33	27.96	0.60	0.63	0.65	5.68
Public	4	4	4	4	74.46	74.46	74.46	74.46	23.09	23.33	23.46	34.09
Apartments	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbuildings	125	125	125	161	1,132.33	1,132.33	1,132.33	1,270.37	159.71	165.09	165.82	252.68
Vehicles	37	37	37	79	551.67	551.67	551.67	1,177.89	232.75	245.68	246.75	422.42
Total Bldgs.	217	217	217	287	7,858.04	7,858.04	7,858.04	10,928.37	1,110.81	1,139.94	1,145.70	1,956.05
Clean-Up									181.23	182.91	183.75	323.18
Pop. At Risk	228	228	228	312								

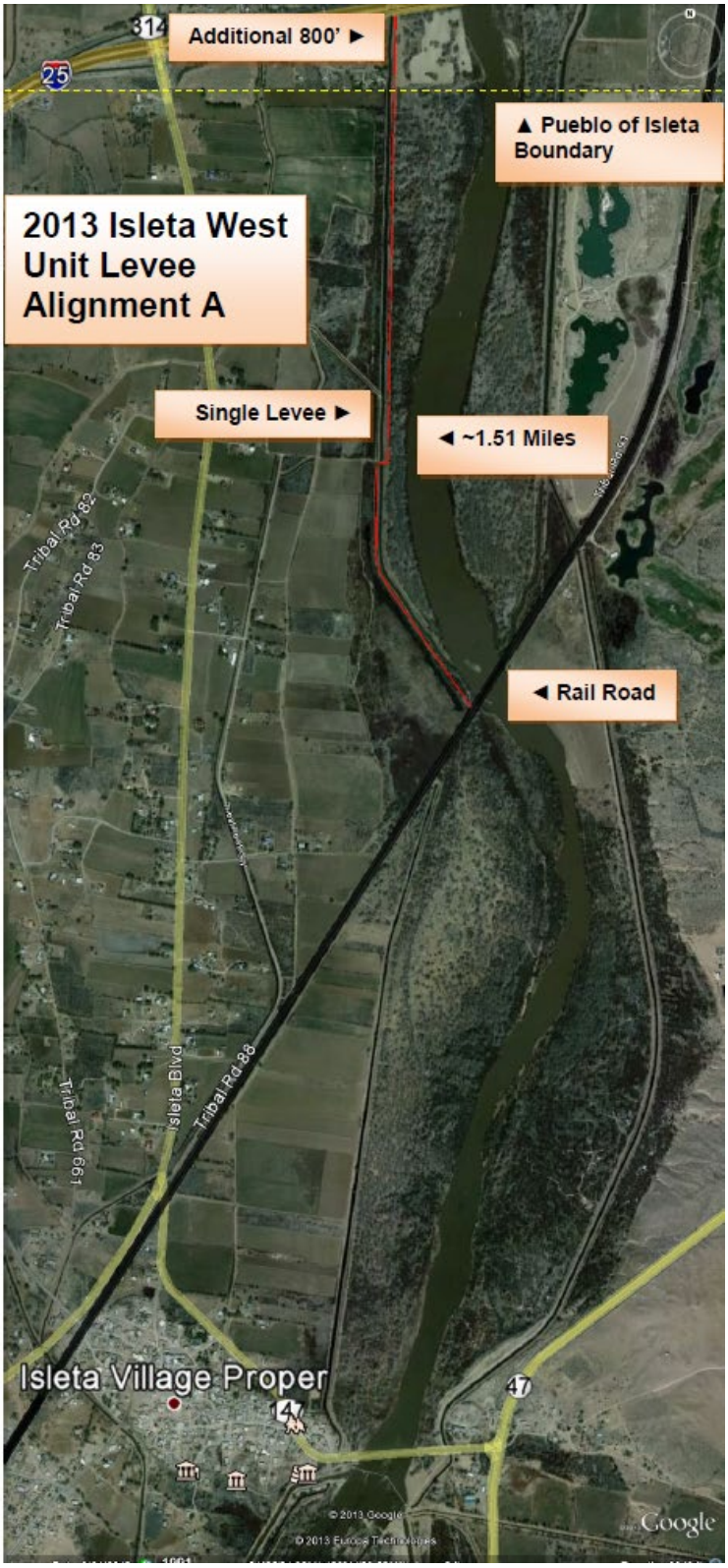


Figure D-38 Isleta West Unit Alignment A

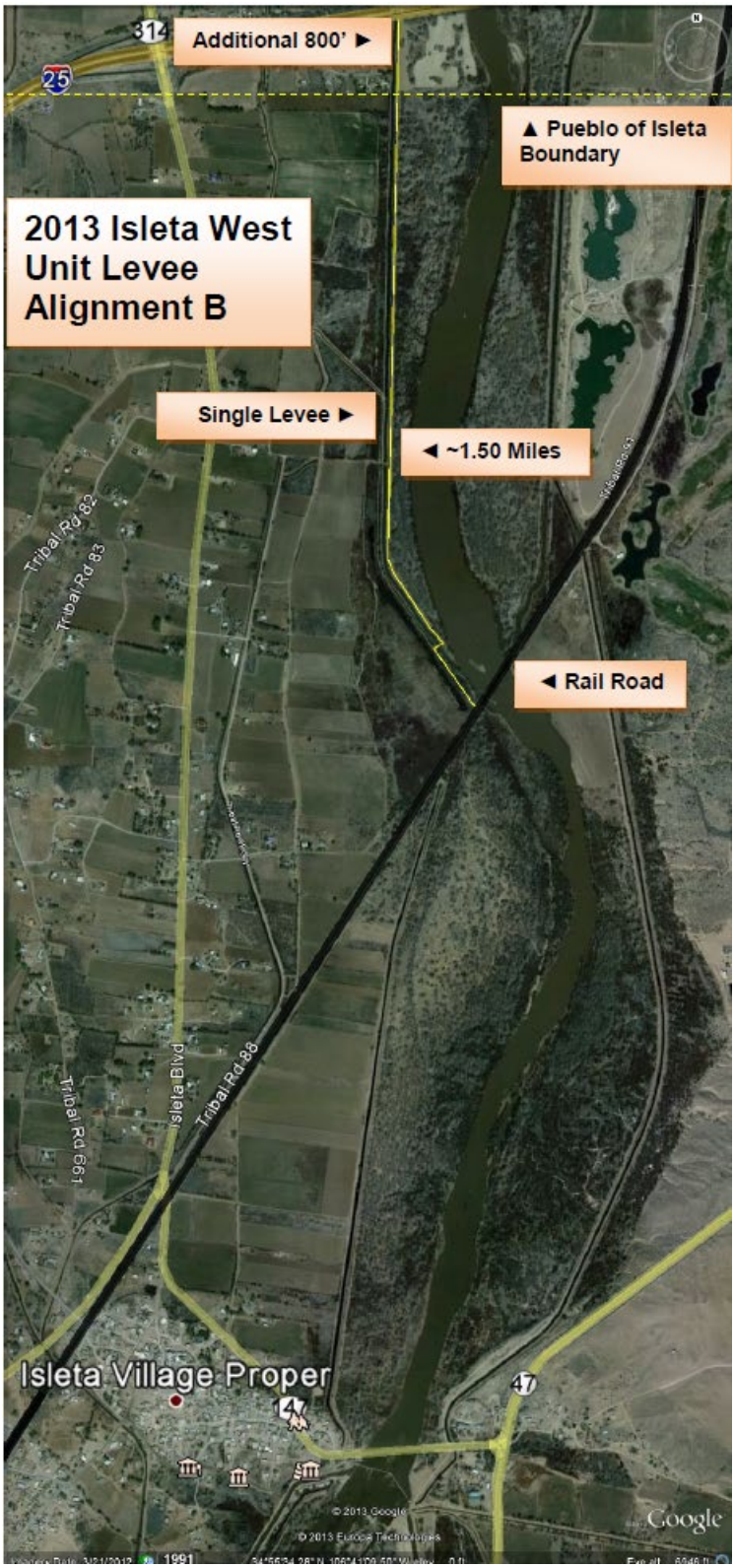


Figure D-39 Isleta West Unit Alignment B

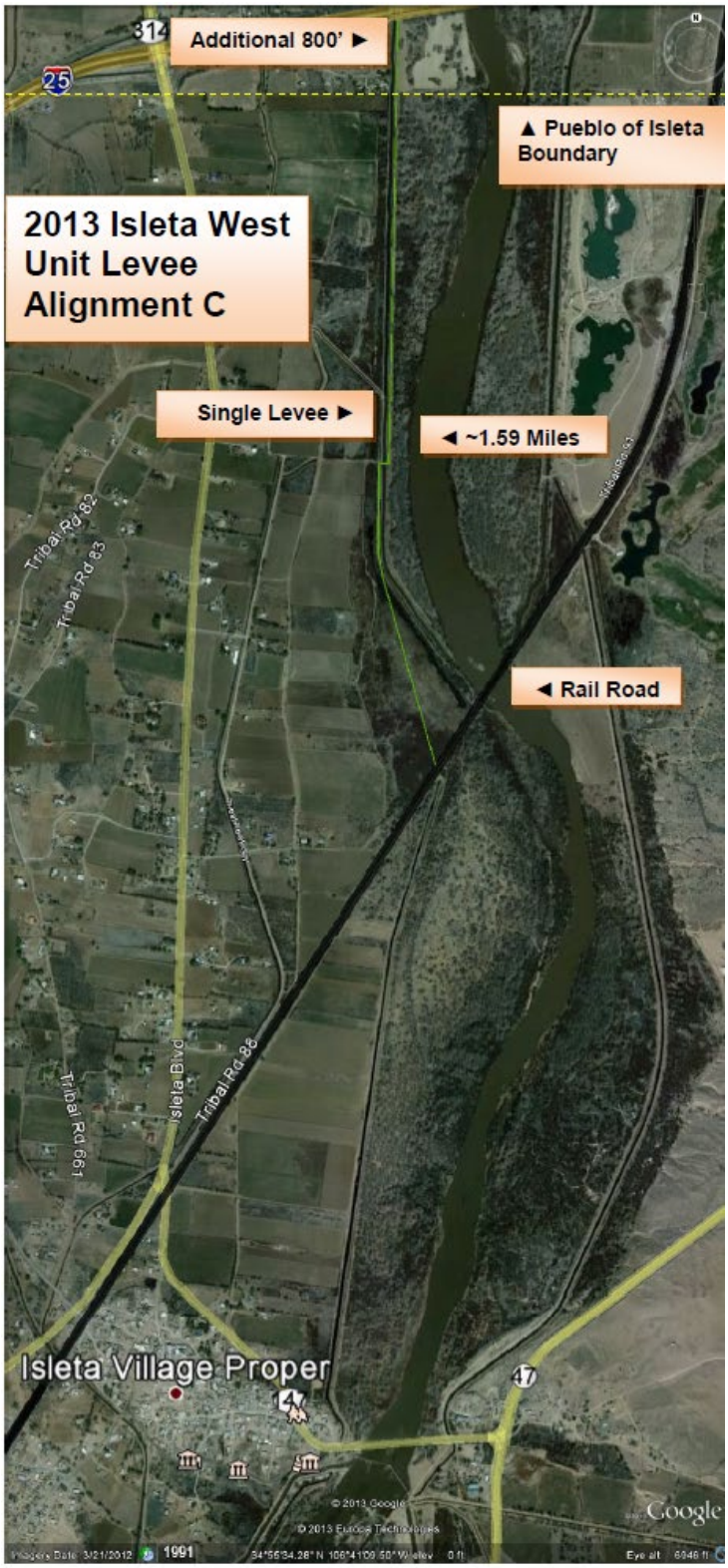


Figure D-40 Isleta West Unit Alignment C

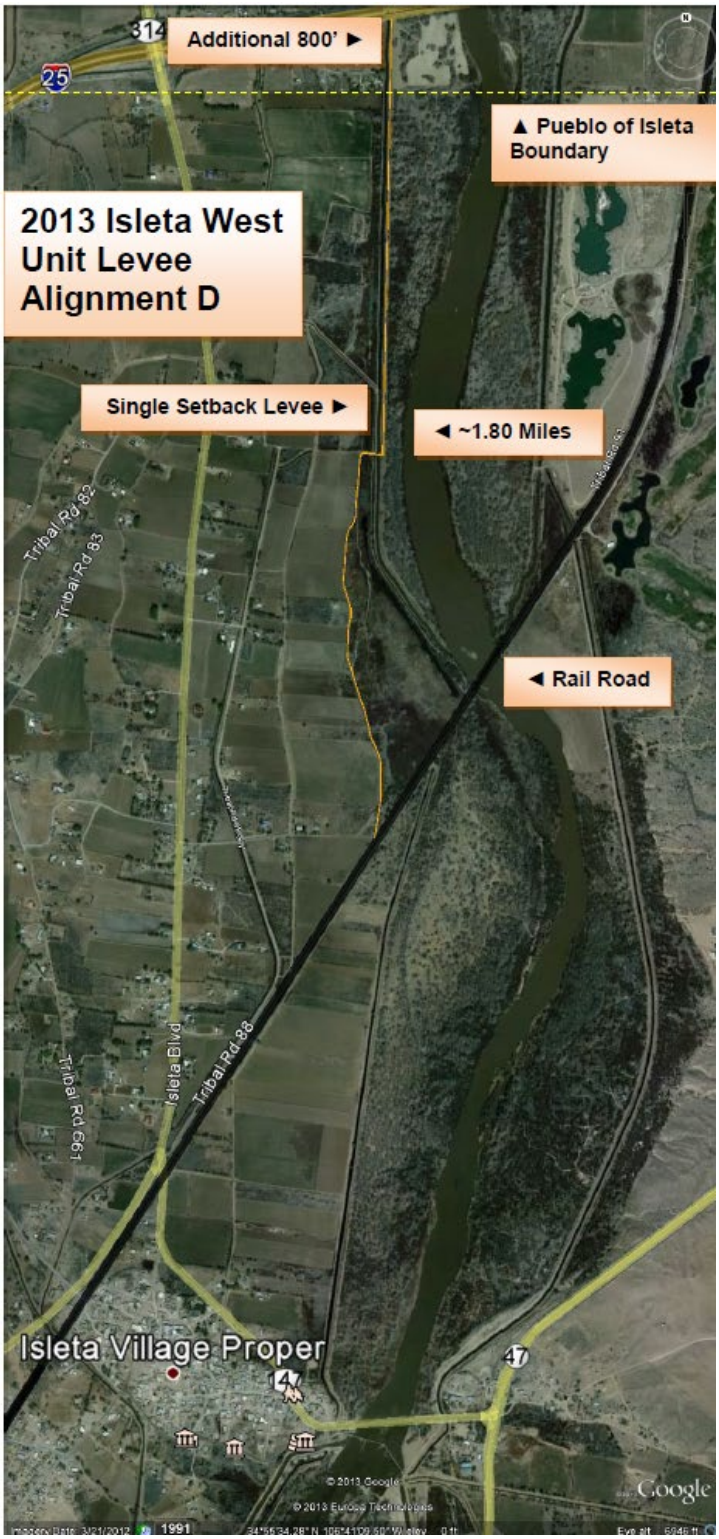


Figure D-41 Isleta West Unit Alignment D

Table D-61 Isleta West Levee (Alignments A-D), EAD

ISLETA WEST LEVEE (Alignments A-D)
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential		106.54	
Commercial		0.47	
Public		0.00	
Apartments		0.00	
Outbuildings		22.03	
Subtotal - Structures and Contents		129.04	
Streets, roads		35.89	
Utilities		1.90	
Railroad		0.03	
Vehicles		25.88	
Agriculture		0.02	
Irr. Drains		0.26	
Aircraft			
Recreation			
Emergency Costs		1.94	
TOTAL		**194.96**	

Table D-62 Isleta West Levee (Alignment E), EAD

ISLETA WEST LEVEE (Alignment E)
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential		313.47	
Commercial		0.68	
Public		10.08	
Apartments		0.00	
Outbuildings		64.47	
Subtotal - Structures and Contents		388.70	
Streets, roads		108.11	
Utilities		5.72	
Railroad		0.10	
Vehicles		99.07	
Agriculture		0.06	
Irr. Drains		0.79	
Aircraft			
Transportation (Railroad)		41.23	
Recreation			
Clean-Up		73.71	
Emergency Costs		5.83	
TOTAL		**723.33**	

Table D-63 Isleta West Levee (Alignments A-D), Equivalent Annual Residual Damages and Benefits

ISLETA WEST LEVEE (Alignments A-D)

EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS

BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)						Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)					
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'
Residential	106.54	187.48	135.45	79.89	39.08	15.80	5.45	-80.94	-28.91	26.65	67.46	90.74	101.09
Commercial	0.47	1.67	1.39	0.84	0.42	0.17	0.06	-1.20	-0.92	-0.37	0.05	0.30	0.41
Public	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apartments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbuildings	22.03	49.15	29.95	15.06	6.31	2.28	0.76	-27.12	-7.92	6.97	15.72	19.75	21.27
Subtotal - Structures and Contents	**129.04**	**238.30**	**166.79**	**95.79**	**45.81**	**18.25**	**6.27**	**-109.26**	**-37.75**	**33.25**	**83.23**	**110.79**	**122.77**
Streets, roads	33.19	61.29	42.90	24.64	11.78	4.69	1.61	-28.10	-9.71	8.55	21.41	28.50	31.58
Utilities	1.75	3.24	2.27	1.30	0.62	0.25	0.09	-1.48	-0.51	0.45	1.13	1.51	1.67
Railroad	0.03	0.06	0.04	0.02	0.01	0.00	0.00	-0.03	-0.01	0.01	0.02	0.03	0.03
Vehicles	25.88	69.54	51.03	30.65	15.37	6.32	2.15	-43.66	-25.15	-4.77	10.51	19.56	23.73
Agriculture	0.02	0.04	0.03	0.01	0.01	0.00	0.00	-0.02	-0.01	0.01	0.01	0.02	0.02
Irr. Drains	0.24	0.45	0.31	0.18	0.09	0.03	0.01	-0.21	-0.07	0.06	0.16	0.21	0.23
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	1.94	3.57	2.50	1.44	0.69	0.27	0.09	-1.64	-0.57	0.50	1.25	1.66	1.84
TOTAL	**192.09**	**376.49**	**265.87**	**154.04**	**74.38**	**29.83**	**10.23**	**-184.40**	**-73.78**	**38.06**	**117.72**	**162.27**	**181.87**

Table D-64 Isleta West Levee (Alignment E), Equivalent Annual Residual Damages and Benefits

ISLETA WEST LEVEE (Alignment E)
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)						Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)					
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'
Residential	313.47	770.64	579.31	344.53	160.82	60.09	19.09	-457.17	-265.84	-31.06	152.65	253.38	294.38
Commercial	0.68	3.82	3.30	1.98	0.97	0.40	0.14	-3.14	-2.62	-1.30	-0.29	0.28	0.54
Public	10.08	15.06	10.88	6.52	3.21	1.30	0.45	-4.98	-0.80	3.56	6.87	8.78	9.63
Apartments	0.00	0.43	0.33	0.20	0.08	0.03	0.01	-0.43	-0.33	-0.20	-0.08	-0.03	-0.01
Outbuildings	64.47	123.53	84.82	47.85	22.07	8.46	2.82	-59.06	-20.35	16.62	42.40	56.01	61.65
Subtotal - Structures and Contents	**388.70**	**913.48**	**678.64**	**401.08**	**187.15**	**70.28**	**22.51**	**-524.78**	**-289.94**	**-12.38**	**201.55**	**318.42**	**366.19**
Streets, roads	108.11	254.08	188.76	111.56	52.05	19.55	6.26	-145.96	-80.64	-3.44	56.06	88.57	101.85
Utilities	5.72	13.44	9.98	5.90	2.75	1.03	0.33	-7.72	-4.27	-0.18	2.97	4.68	5.39
Railroad	0.10	0.24	0.18	0.11	0.05	0.02	0.01	-0.14	-0.08	0.00	0.05	0.08	0.10
Vehicles	99.07	221.49	168.75	105.18	52.97	21.46	7.23	-122.42	-69.68	-6.11	46.10	77.61	91.84
Agriculture	0.06	0.15	0.11	0.07	0.03	0.01	0.00	-0.09	-0.05	0.00	0.03	0.05	0.06
Irr. Drains	0.79	1.85	1.37	0.81	0.38	0.14	0.05	-1.06	-0.59	-0.03	0.41	0.64	0.74
Transportation	41.23	4.98	4.98	4.98	4.98	2.06	2.06	36.25	36.25	36.25	36.25	39.17	39.17
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clean-Up	73.71					4.81						68.9	
Emergency Costs	5.83	13.70	10.18	6.02	2.81	1.05	0.34	-7.87	-4.35	-0.19	3.02	4.78	5.49
TOTAL	**723.33**	**1423.42**	**1,062.96**	**635.70**	**303.18**	**120.42**	**38.79**	**-773.80**	**-413.34**	**13.92**	**346.44**	**602.91**	**610.83**

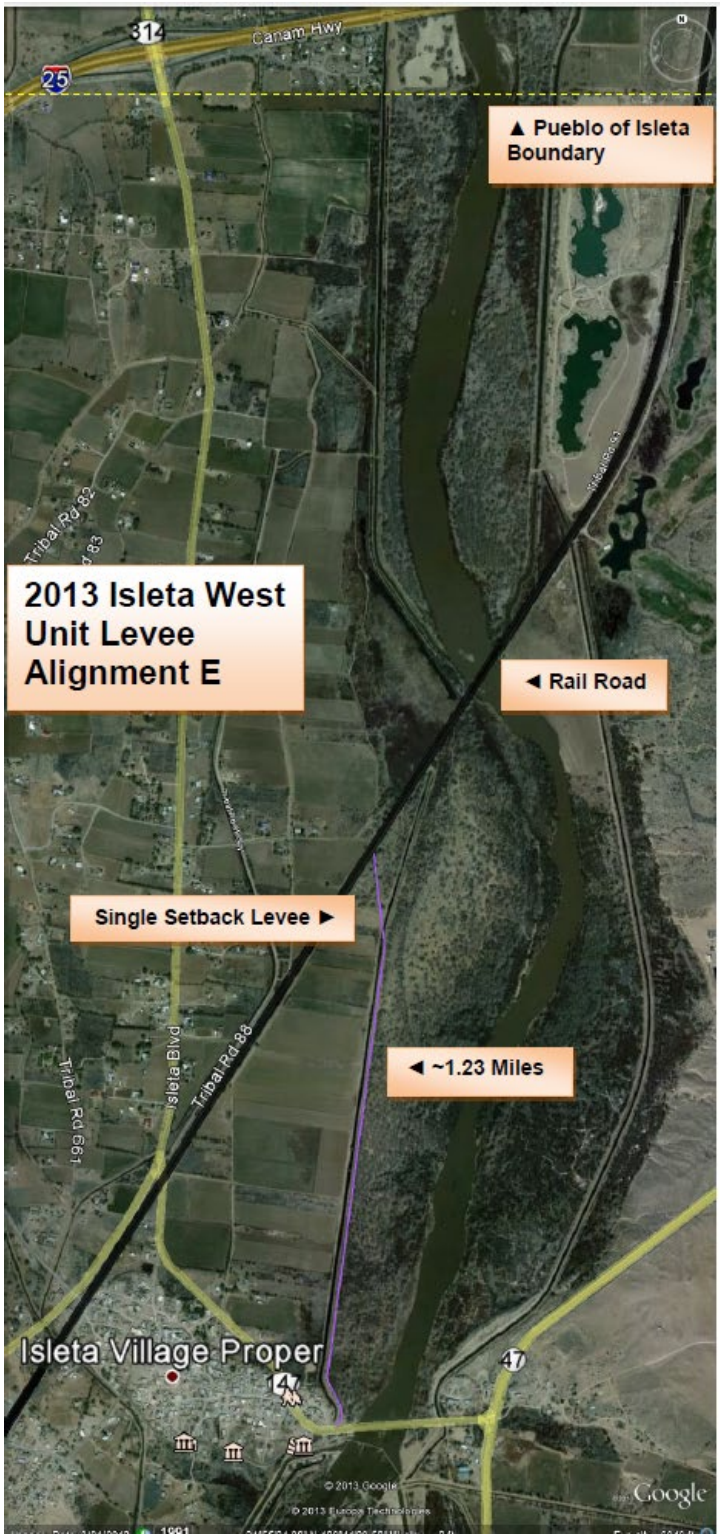


Figure D-42 Isleta West Unit Alignment E

Table D-65 Isleta West Levee (Alignment A), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED ISLETA WEST LEVEE (Alignments A-D) (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Construction Cost*	4,288.76	4,313.60	4,338.81	4,666.06	5,191.17	5,761.24
Real Estate						
PED (9%)						
Total First Cost	4,288.76	4,313.60	4,338.81	4,666.06	5,191.17	5,761.24
IDC (12 months construction, 2.75%)*						
Total Investment	4,288.76	4,313.60	4,338.81	4,666.06	5,191.17	5,761.24
Avg. Ann. Cost (2.75%, 50 yr. project life)	158.86	159.78	160.71	172.84	192.29	213.40
OMRR&R						
Total Avg. Ann. Cost	158.86	159.78	160.71	172.84	192.29	213.40
Equivalent Avg. Ann. Benefits	-186.82	-74.61	38.80	119.57	164.73	184.60
Benefit/Cost Ratio	-1.18	-0.47	0.24	0.69	0.86	0.87
Net Benefits	-345.68	-234.39	-121.92	-53.27	-27.56	-28.80
*Presented for Alternative A, the alternative which maximizes net NED benefits.						

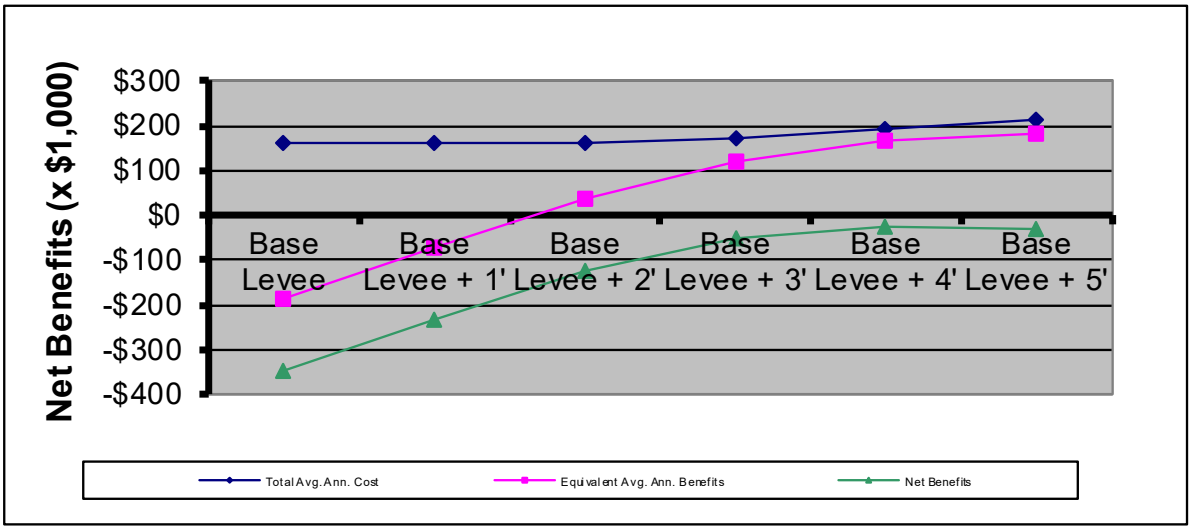


Figure D-43 Isleta West Unit Alternative A Optimization Curve

Table D-66 Isleta West Levee (Alignment E), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED ISLETA WEST LEVEE (Alignment E) (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Construction Cost*	7,166.55	7,754.44	8,360.10	9,791.30	10,757.55	12,086.28
Real Estate	14.57	14.57	14.57	14.57	14.57	14.57
Construction Mgt.	730.05	730.05	730.05	730.05	730.05	730.05
PED	759.26	759.26	759.26	759.26	759.26	759.26
Total First Cost	8,670.43	9,258.32	9,863.99	11,295.18	12,261.43	13,590.17
IDC (12 months construction, 2.75%)*						
Total, Interest During Construction						
Total Investment	8,670.43	9,258.32	9,863.99	11,295.18	12,261.43	13,590.17
Avg. Ann. Cost (2.75%, 50 yr. project life)	321.16	342.94	365.37	418.38	454.17	503.39
OMRR&R						
Total Avg. Ann. Cost	321.16	342.94	365.37	418.38	454.17	503.39
Equivalent Avg. Ann. Benefits	-773.80	-413.34	13.92	346.44	602.91	610.83
Benefit/Cost Ratio	-2.41	-1.21	0.04	0.83	1.33	1.21
Net Benefits	-1,094.96	-756.28	-351.45	-71.94	148.73	107.44

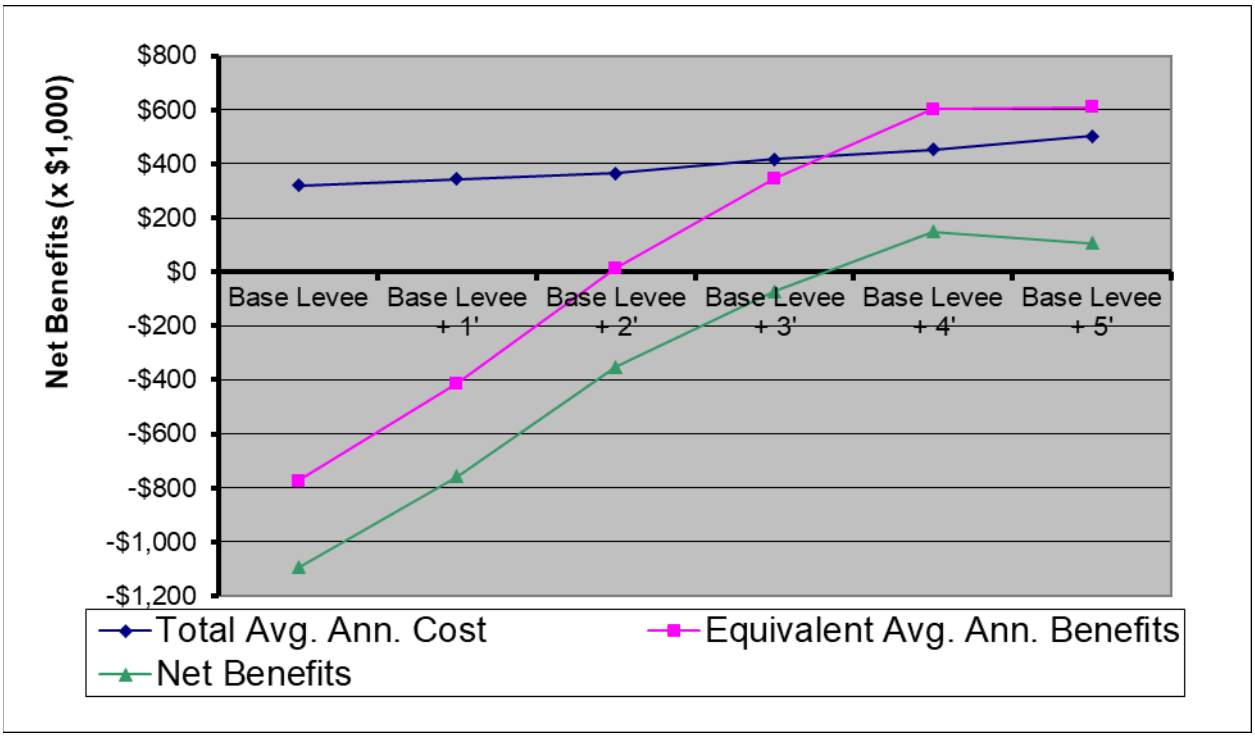


Figure D-44 Isleta West Unit Alternative E Optimization Curve

Table D-67 Isleta West Levee, Alternative Alignment Construction Costs

ISLETA WEST LEVEE ALTERNATIVE ALIGNMENT CONSTRUCTION COSTS (x$1,000, May, 2016 price level)			
Alignment			Construction Cost
2013 Isleta West Unit A 0+00 to 80.52		Base	$4,288.76
		Base + 1'	$4,313.60
		Base + 2'	$4,338.81
		Base + 3'	$4,666.06
		Base + 4'	$5,191.17
		Base + 5'	$5,761.24
2013 Isleta West Unit B 0+00 to 80.52		Base	$4,288.76
		Base + 1'	$4,313.60
		Base + 2'	$4,338.81
		Base + 3'	$4,664.80
		Base + 4'	$5,191.17
		Base + 5'	$5,761.24
2013 Isleta West Unit D 0+00 to 93+26		Base	$4,706.05
		Base + 1'	$5,184.98
		Base + 2'	$5,527.47
		Base + 3'	$6,970.26
		Base + 4'	$7,385.17
		Base + 5'	$8,110.07
2013 Isleta West Unit E 0+00 to 93+26 & 10+00 to 77+18		Base	$8,670.43
		Base + 1'	$9,258.32
		Base + 2'	$9,863.99
		Base + 3'	$11,295.18
		Base + 4'	$12,261.43
		Base + 5'	$13,590.17

Table D-68 Isleta West Levee, Alternative Alignment Equivalent Annual Costs and Benefits

ISLETA WEST LEVEE ALTERNATIVE ALIGNMENT EQUIVALENT ANNUAL COSTS AND BENEFITS (x$1,000, May, 2016 price level)				
Alignment		Avg. annual cost	Equivalent Annual Benefits (all)	Net Benefits (all)
2013 Isleta West Unit A 0+00 to 80.52	Base	$158,859.68	-$186,824.62	-$345,684.30
	Base + 1'	$159,779.70	-$74,614.26	-$234,393.95
	Base + 2'	$160,713.63	$38,797.85	-$121,915.78
	Base + 3'	$172,835.33	$119,567.22	-$53,268.11
	Base + 4'	$192,285.55	$164,729.40	-$27,556.15
	Base + 5'	$213,401.79	$184,596.93	-$28,804.86
2013 Isleta West Unit B 0+00 to 80.52	Base	$158,859.68	-$186,824.62	-$345,684.30
	Base + 1'	$159,779.70	-$74,614.26	-$234,393.95
	Base + 2'	$160,713.63	$38,797.85	-$121,915.78
	Base + 3'	$172,788.47	$119,567.22	-$53,221.25
	Base + 4'	$192,285.55	$164,729.40	-$27,556.15
	Base + 5'	$213,401.79	$184,596.93	-$28,804.86
2013 Isleta West Unit D 0+00 to 93+26	Base	$174,316.55	-$186,824.62	-$361,141.17
	Base + 1'	$192,056.34	-$74,614.26	-$266,670.60
	Base + 2'	$204,742.71	$38,797.85	-$165,944.86
	Base + 3'	$258,184.99	$119,567.22	-$138,617.78
	Base + 4'	$273,553.44	$164,729.40	-$108,824.03
	Base + 5'	$300,404.60	$184,596.93	-$115,807.67
2013 Isleta West Unit E 0+00 to 93+26 & 1(	Base	$321,160.72	-$773,795.09	-$1,094,955.81
	Base + 1'	$342,936.60	-$413,341.56	-$756,278.15
	Base + 2'	$365,371.17	$13,918.48	-$351,452.69
	Base + 3'	$418,383.81	$346,443.39	-$71,940.42
	Base + 4'	$454,174.68	$602,909.07	$148,734.39
	Base + 5'	$503,392.24	$610,832.64	$107,440.40

Isleta West Levee (1979 Authorized Version)

The 1979 Isleta West Levee had a length of 2.9 miles, placing it equivalent to Isleta West Alternative E in this analysis with the exception of an 800’ stretch covering properties outside of the Isleta Pueblo boundary and south of the I-25 crossing over the Rio Grande. Figure D-43 presents the alignment, highlighting the small gap south of Interstate 25 and portions of a double levee.

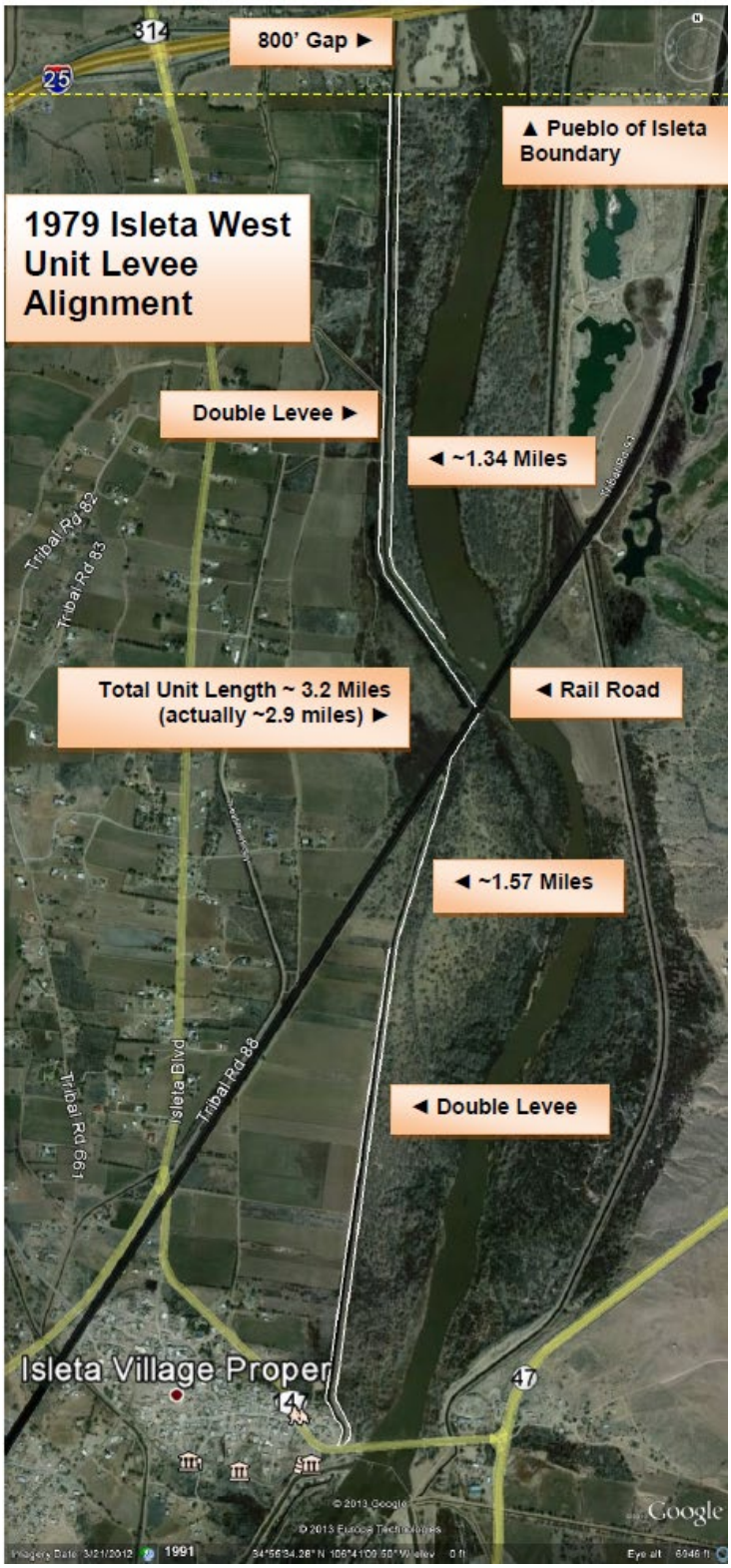


Figure D-45 Isleta West Unit Authorized Alignment

Table D-69 Isleta West Levee (Authorized Version), EAD

ISLETA WEST LEVEE (1979 AUTHORIZED)
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential		306.49	
Commercial		0.68	
Public		10.08	
Apartments		0.00	
Outbuildings		53.06	
Subtotal - Structures and Contents		370.31	
Streets, roads		103.00	
Utilities		5.45	
Railroad		0.10	
Vehicles		95.48	
Agriculture		0.06	
Irr. Drains		0.75	
Aircraft		0.00	
Recreation			
Emergency Costs		5.55	
TOTAL		**580.70**	

Table D-70 Isleta West Levee (Authorized Version), Equivalent Annual Residual Damages and Benefits

ISLETA WEST LEVEE (1979 AUTHORIZED)
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)						Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)					
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'
Residential	306.49	758.39	574.27	343.19	160.59	60.04	19.05	-451.90	-267.78	-36.70	145.90	246.45	287.44
Commercial	0.68	3.82	3.30	1.98	0.97	0.40	0.14	-3.14	-2.62	-1.30	-0.29	0.28	0.54
Public	10.08	15.06	10.88	6.52	3.21	1.30	0.45	-4.98	-0.80	3.56	6.87	8.78	9.63
Apartments	0.00	0.43	0.33	0.20	0.08	0.03	0.01	-0.43	-0.33	-0.20	-0.08	-0.03	-0.01
Outbuildings	53.06	91.65	67.62	40.48	19.57	7.72	2.60	-38.59	-14.56	12.58	33.49	45.34	50.46
Subtotal - Structures and Contents	**370.31**	**869.35**	**656.40**	**392.37**	**184.42**	**69.49**	**22.25**	**-499.04**	**-286.09**	**-22.06**	**185.89**	**300.82**	**348.06**
Streets, roads	95.25	223.60	168.83	100.92	47.43	17.87	5.72	-128.36	-73.58	-5.67	47.81	77.37	89.52
Utilities	5.03	11.81	8.92	5.33	2.51	0.94	0.30	-6.78	-3.89	-0.30	2.53	4.09	4.73
Railroad	0.09	0.22	0.16	0.10	0.05	0.02	0.01	-0.13	-0.07	-0.01	0.05	0.08	0.09
Vehicles	95.48	207.14	161.14	102.05	51.95	21.05	7.11	-111.66	-65.66	-6.57	43.53	74.43	88.37
Agriculture	0.06	0.14	0.10	0.06	0.03	0.01	0.00	-0.08	-0.04	0.00	0.03	0.05	0.05
Irr. Drains	0.70	1.64	1.24	0.74	0.35	0.13	0.04	-0.94	-0.54	-0.04	0.35	0.57	0.66
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	5.55	13.04	9.85	5.89	2.77	1.04	0.33	-7.49	-4.29	-0.33	2.79	4.51	5.22
TOTAL	**572.47**	**1326.94**	**1,006.64**	**607.46**	**289.50**	**110.56**	**35.77**	**-754.47**	**-434.17**	**-34.99**	**282.97**	**461.91**	**536.70**

Table D-70 is best compared to Table D-66, which presents the benefits presented by Alternative E. The small dip in benefits for a given height represents the damageable properties located in the small stretch of the Rio Grande floodplain between the Interstate 25 crossing and the Isleta Pueblo boundary.

Isleta West Levee (Concluding Thoughts)

Following the evaluations of Alternatives A-E, above, additional formulation alternatives were considered to further refine the NED plan for this reach. First, the tables above indicate that the benefits of the Isleta West levee don't really kick in until the levee extends south of the railroad crossing. Can a levee be constructed using the railroad crossing as the northern tieback? Hydraulic analysis indicates no, as existing embankments to the raised railroad are not capable of withstanding long duration flooding (the snowmelt floods modeled for this study have durations of 90-100 days). Extending the levee northward to the Interstate 25 crossing is necessary to ensure the Isleta West Unit functions, and would be much cheaper than reinforcing the railroad embankment.

Another small alternative analysis was conducted to evaluate the need to extend the levee past the Isleta Village proper. The Tribe has indicated a wastewater treatment plant exists to the south that could represent a significant damage center. Current mapping of the plant's stilling ponds indicate there might be a flood threat in the most extreme events. Other properties south of the Highway 147 crossing are also unprotected by any proposed levee. A separate HEC-FDA run was created to determine the nature of damages and benefits to properties unprotected by the proposed levees. 160 structures were identified, of which over 100 were unaffected by any of the flood events modeled. Equivalent annual damages for the unprotected portions of the Isleta West Unit were roughly $24,000 which would not justify extending the proposed levee south of the Highway 147 crossing.

Generally, no alternative alignment or height could meet the minimum benefit-cost ratio requirements. No alternative could be developed with a BCR of at least 1.0. This information was presented to the Isleta Pueblo, who indicated that if no flood protection was afforded to tribal lands, then tribal lands would be unavailable in the separable, downstream Belen East and Belen West levee alternatives. The study team has indicated that tying the upstream tiebacks on Pueblo lands would be a cost-effective means of providing effective tiebacks to the Belen levees. Obeying the Pueblo boundary means turning the upstream tieback at the border, crossing 1.5 – 2 miles of privately held land, taking a couple hundred privately held parcels and demolishing existing structures on all of them, to establish the tiebacks necessary to keep the Rio

Grande from flanking the levees at the northernmost end. With those assumptions in mind, a separate cost analysis was developed for the Belen East and Belen West reaches (Alternative X) to determine the marginal cost of obeying the Pueblo boundaries while providing flood protection to the Belen reaches as described below. Other factors held constant, obeying the Pueblo borders would add $142.9 million to the Belen east reach and $98.8 million to the Belen West reach. While the added cost would not jeopardize the benefit-cost ratio or alter plan selection (levee height and length), it makes more sense to spend $5.7 million to provide flood protection to the Pueblo to avoid a significant hit to the net benefits due to dramatically increased construction costs for the Belen East and Belen West levees. Further, the Belen Units protect over 9,100 structures worth $640 million and 10,800 lives. Therefore, the Isleta West levee, Alignment A, at the Base levee + 4' alternative, which maximizes net benefits, is recommended for this reach.

Belen West Levee (and alternative alignments)

The Belen West Unit is west of the Rio Grande, directly across from the village of Bosque Farms, at the southern portion of the Isleta Pueblo. It extends from there to the southern limits of the study. This unit has yet to be authorized, although there is significant damageable property that could be afforded protection. Growth in the floodplain (screened for compliance with Section 308 of WRDA 1990) has indicated a Federal interest in providing flood mitigation services to the region. For purposes of this analysis, the Belen West Unit is considered a separable element. Figures and tables which follow describe the flooding problems and opportunities within the unit, and benefits of any proposed solutions. Figure D-44 displays the Belen West Unit's northern configuration, which is shared by all the levee alternatives evaluated here. Two lineal extents of proposed levees were developed, and presented in Figure D-45. Table D-47, above, describes the Belen West floodplain, in terms of properties inundated by type and event severity, their values, and damages associated with specified frequency events. Table D-71 and Table D-72 displays Equivalent Annual Damages in the Unit by property type and lineal extent. The purpose here is to establish the baseline and determine the length and height of any proposed levee. Table D-73 and Table D-74 displays the equivalent annual residual damages and benefits of the various levee heights and lengths considered. Table D-75 displays the benefits and costs of the various levee heights considered, identifying the size which maximizes net equivalent annual benefits. Interest during construction (IDC) was computed with equal, midmonthly payments during a 60 month construction period at the FY 2018 discount rate of 2.75%. Figure D-46 displays the optimization curve for the Belen West Unit levees. Table D-76 displays, for each height and lineal extent, construction costs for the proposed levees. Table D-77 displays the equivalent annual costs and benefits of all the levee alignments and heights.

Figure D-46 Belen West Unit (North)

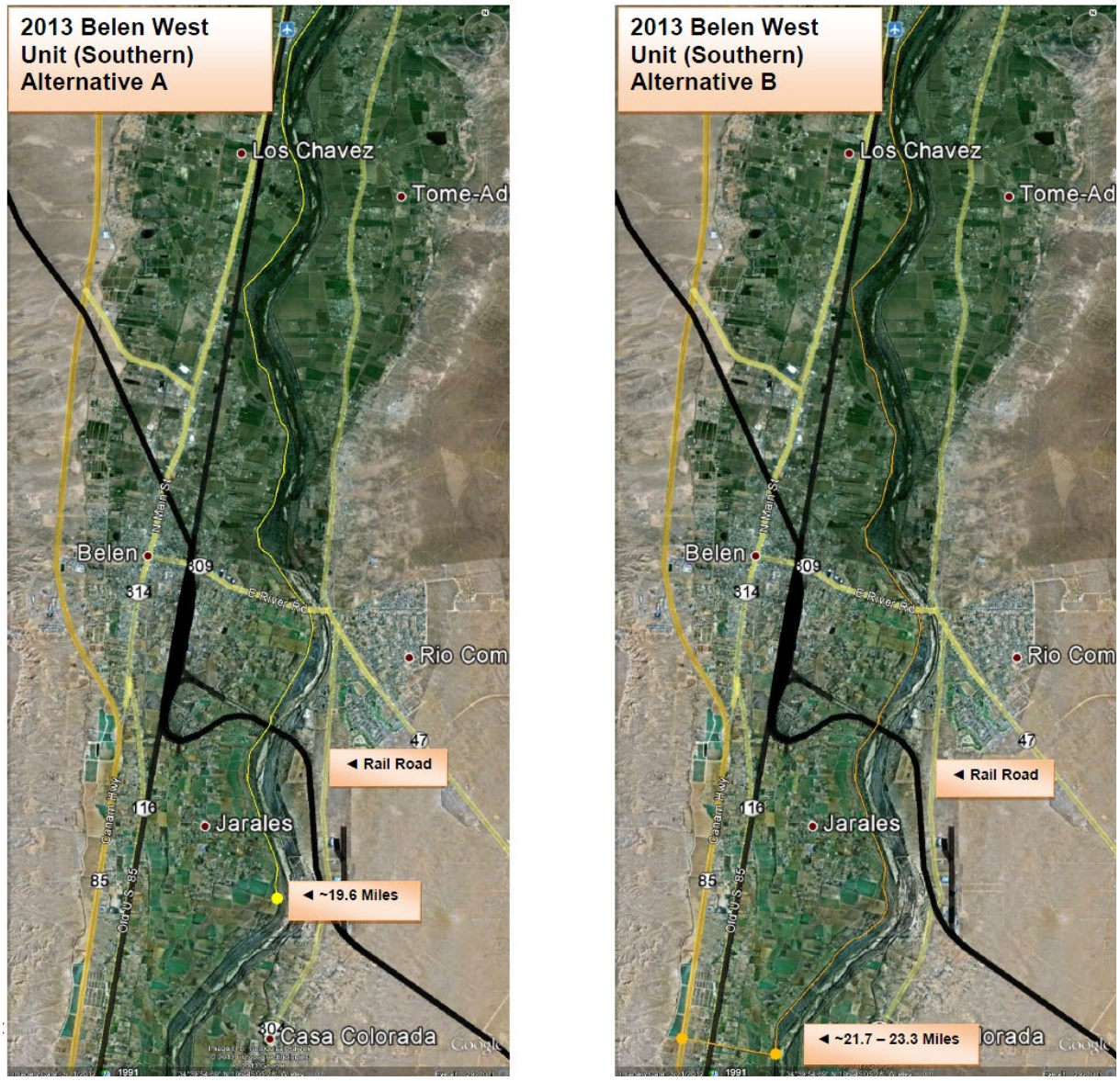


Figure D-47 Belen West Unit (South, Alternative A and B Alignments)

Table D-71 Belen West Levee (Alignment A), EAD

BELEN WEST LEVEE (Alignment A)
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential		8,731.97	
Commercial		17,709.50	
Public		3,377.43	
Apartments		158.00	
Outbuildings		1,253.90	
Subtotal - Structures and Contents		31,230.80	
Streets, roads		8,686.63	
Utilities		459.44	
Railroad		8.30	
Vehicles		3,390.14	
Agriculture		5.19	
Irr. Drains		63.26	
Aircraft		201.13	
Recreation			
Emergency Costs		468.46	
TOTAL		**44,513.34**	

Table D-72 Belen West Levee (Alignment B), EAD

BELEN WEST LEVEE (Alignment B)
EQUIVALENT ANNUAL DAMAGES
BY LAND USE CATEGORY

(x$1,000, May, 2016 price level)

LAND USE CATEGORY	Equivalent Annual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)		
	East Bank	West Bank	Total
Residential		9,607.94	
Commercial		17,826.12	
Public		3,380.00	
Apartments		157.81	
Outbuildings		1,387.33	
Subtotal - Structures and Contents		32,359.20	
Streets, roads		9,000.48	
Utilities		476.04	
Railroad		8.60	
Vehicles		3,783.61	
Agriculture		5.38	
Irr. Drains		65.55	
Aircraft		201.13	
Clean-Up		3,609.40	
Recreation			
Emergency Costs		485.39	
TOTAL		**49,994.77**	

Table D-73 Belen West Levee (Alignment A), Equivalent Annual Residual Damages and Benefits

BELEN WEST LEVEE (Alignment A)
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)									Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)								
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'
Residential	8731.97	22,785.34	14123.45	7,429.05	3,409.70	1,350.88	463.16	145.61	48.61	18.94	-14,053.37	-5391.48	1,302.92	5,322.27	7,381.09	8,268.81	8,586.36	8,683.36	8,713.03
Commercial	17709.50	32,945.41	15755.65	5,434.44	1,612.99	527.90	197.96	86.28	44.22	25.05	-15,235.91	1953.85	12,275.06	16,096.51	17,181.60	17,511.54	17,623.22	17,665.28	17,684.45
Public	3377.43	18,046.58	11881.58	6,644.69	3,161.31	1,253.71	414.90	119.83	34.39	11.19	-14,669.15	-8504.15	-3,267.26	216.12	2,123.72	2,962.53	3,257.60	3,343.04	3,366.24
Apartments	158.00	327.75	207.55	112.35	52.92	21.50	7.66	2.54	0.91	0.37	-169.75	-49.55	45.65	105.08	136.50	150.34	155.46	157.09	157.63
Outbuildings	1253.90	3,989.89	2467.81	1,291.56	589.69	231.78	78.02	23.70	7.53	2.81	-2,735.99	-1213.91	-37.66	664.21	1,022.12	1,175.88	1,230.20	1,246.37	1,251.09
Subtotal - Structures and	**31,230.80**	**78,094.97**	**44436.04**	**20,912.09**	**8,826.61**	**3,385.77**	**1,161.70**	**377.96**	**135.66**	**58.36**	**-46,864.17**	**-13205.24**	**10,318.71**	**22,404.19**	**27,845.03**	**30,069.10**	**30,852.84**	**31,095.14**	**31,172.44**
Streets, roads	8,686.63	21,721.56	12359.57	5,816.55	2,455.06	941.73	323.12	105.13	37.73	16.23	-13,034.94	-3672.94	2,870.08	6,231.57	7,744.90	8,363.51	8,581.50	8,648.89	8,670.39
Utilities	459.44	1,148.86	653.70	307.64	129.85	49.81	17.09	5.56	2.00	0.86	-689.42	-194.26	151.80	329.59	409.63	442.35	453.88	457.44	458.58
Railroad	8.30	20.74	11.80	5.55	2.34	0.90	0.31	0.10	0.04	0.02	-12.45	-3.51	2.74	5.95	7.40	7.99	8.20	8.26	8.28
Vehicles	3,390.14	11,228.91	7273.32	3,847.99	1,713.99	652.68	219.25	68.94	23.29	8.95	-7,838.77	-3883.18	-457.85	1,676.15	2,737.46	3,170.89	3,321.20	3,366.85	3,381.19
Agriculture	5.19	12.98	7.39	3.48	1.47	0.56	0.19	0.06	0.02	0.01	-7.79	-2.20	1.72	3.72	4.63	5.00	5.13	5.17	5.18
Irr. Drains	63.26	158.19	90.01	42.36	17.88	6.86	2.35	0.77	0.27	0.12	-94.93	-26.75	20.90	45.38	56.40	60.91	62.49	62.99	63.14
Aircraft	201.13	847.05	600.82	342.42	161.35	64.44	22.66	7.39	2.57	0.96	-645.92	-399.69	-141.29	39.78	136.69	178.47	193.74	198.56	200.17
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	468.46	1,171.42	666.54	313.68	132.40	50.79	17.43	5.67	2.03	0.88	-702.96	-198.08	154.78	336.06	417.68	451.04	462.79	466.43	467.59
TOTAL	**44,513.34**	**114404.69**	**66,099.19**	**31,591.76**	**13,440.95**	**5,153.53**	**1,764.10**	**571.58**	**203.62**	**86.38**	**-69891.35**	**-21,585.85**	**12,921.58**	**31,072.40**	**39,359.81**	**42,749.24**	**43,941.77**	**44,309.73**	**44,426.96**

Table D-74 Belen West Levee (Alignment B), Equivalent Annual Residual Damages and Benefits

BELEN WEST LEVEE (Alignment B)
EQUIVALENT ANNUAL RESIDUAL DAMAGES AND BENEFITS
BY LAND USE CATEGORY

LAND USE CATEGORY		Residual Damages (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)									Benefits (x$1,000, May, 2016 price level) (2.75% discount rate, 50 year period of analysis)								
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'	Base + 5'	Base + 6'	Base + 7'	Base + 8'
Residential	9607.94	24,213.93	14766.60	7,623.34	3,454.79	1,362.85	467.80	148.11	50.15	19.92	-14,605.99	-5158.66	1,984.60	6,153.15	8,245.09	9,140.14	9,459.83	9,557.79	9,588.02
Commercial	17826.12	33,019.71	15767.63	5,434.92	1,615.27	529.76	199.07	86.90	44.60	25.30	-15,193.59	2058.49	12,391.20	16,210.85	17,296.36	17,627.05	17,739.22	17,781.52	17,800.82
Public	3380.00	18,046.45	11880.68	6,644.29	3,161.31	1,253.75	414.94	119.85	34.40	11.20	-14,666.45	-8500.68	-3,264.29	218.69	2,126.25	2,965.06	3,260.15	3,345.60	3,368.80
Apartments	157.81	327.19	207.25	112.25	52.90	21.50	7.66	2.54	0.91	0.37	-169.38	-49.44	45.56	104.91	136.31	150.15	155.27	156.90	157.44
Outbuildings	1387.33	4,213.49	2568.35	1,321.91	596.74	233.66	78.75	24.10	7.77	2.97	-2,826.16	-1181.02	65.42	790.59	1,153.67	1,308.58	1,363.23	1,379.56	1,384.36
Subtotal - Structures and	**32,359.20**	**79,820.77**	**45190.51**	**21,136.71**	**8,881.01**	**3,401.52**	**1,168.22**	**381.50**	**137.83**	**59.76**	**-47,461.57**	**-12831.31**	**11,222.49**	**23,478.19**	**28,957.68**	**31,190.98**	**31,977.70**	**32,221.37**	**32,299.44**
Streets, roads	9,000.48	22,201.58	12569.42	5,879.03	2,470.19	946.11	324.93	106.11	38.34	16.62	-13,201.10	-3568.94	3,121.46	6,530.29	8,054.37	8,675.55	8,894.37	8,962.15	8,983.86
Utilities	476.04	1,174.25	664.80	310.94	130.65	50.04	17.19	5.61	2.03	0.88	-698.21	-188.76	165.09	345.39	426.00	458.85	470.43	474.01	475.16
Railroad	8.60	21.20	12.00	5.61	2.36	0.90	0.31	0.10	0.04	0.02	-12.61	-3.41	2.98	6.24	7.69	8.28	8.49	8.56	8.58
Vehicles	3,783.61	11,852.57	7543.98	3,930.06	1,734.35	658.65	221.71	70.27	24.11	9.48	-8,068.96	-3760.37	-146.45	2,049.26	3,124.96	3,561.90	3,713.34	3,759.50	3,774.13
Agriculture	5.38	13.27	7.51	3.51	1.48	0.57	0.19	0.06	0.02	0.01	-7.89	-2.13	1.87	3.90	4.81	5.19	5.32	5.36	5.37
Irr. Drains	65.55	161.68	91.54	42.81	17.99	6.89	2.37	0.77	0.28	0.12	-96.14	-25.99	22.73	47.56	58.66	63.18	64.77	65.27	65.42
Aircraft	201.13	847.05	600.82	342.42	161.35	64.44	22.66	7.39	2.57	0.96	-645.92	-399.69	-141.29	39.78	136.69	178.47	193.74	198.56	200.17
Clean-Up	3,609.40						52.49									3,556.91			
Recreation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Costs	485.39	1,197.31	677.86	317.05	133.22	51.02	17.52	5.72	2.07	0.90	-711.92	-192.47	168.34	352.17	434.37	467.86	479.67	483.32	484.49
TOTAL	**49,994.77**	**117289.69**	**67,358.44**	**31,968.15**	**13,532.59**	**5,180.14**	**1,827.59**	**577.54**	**207.28**	**88.74**	**-70904.32**	**-20,973.07**	**14,417.22**	**32,852.78**	**41,205.23**	**48,167.18**	**45,807.82**	**46,178.09**	**46,296.62**

Table D-75 Belen West Levee (Alignment B), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED BELEN WEST LEVEE (Alignment B) (x$1,000, May, 2016 price level)									
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'	Base Levee + 6'	Base Levee + 7'	Base Levee + 8
Construction Cost	39,756.84	40,969.77	47,091.20	52,919.62	56,844.53	68,882.53	77,824.61	88,194.74	100,423.01
Real Estate	556.11	569.01	624.96	676.61	681.34	669.83	791.57	892.14	892.14
Construction Mgt.	6,122.71	6,122.71	6,122.71	6,122.71	6,122.71	6,122.71	5,987.92	5,987.92	5,987.92
PED (9%)	1,018.50	1,018.50	1,018.50	1,018.50	1,018.50	1,018.50	996.08	996.08	996.08
Total First Cost	47,454.16	48,679.99	54,857.37	60,737.45	64,667.08	76,693.58	85,600.19	96,070.89	108,299.15
IDC (60 months construction, 2.75%)*	3,527.33	3,618.45	4,077.62	4,514.69	4,806.79	5,700.73	6,362.77	7,141.07	8,050.01
Total Investment	50,981.49	52,298.44	58,934.99	65,252.14	69,473.87	82,394.31	91,962.96	103,211.96	116,349.17
Avg. Ann. Cost (2.75%, 50 yr. project life)	1,888.40	1,937.18	2,183.01	2,417.00	2,573.38	3,051.96	3,406.39	3,823.07	4,309.68
OMRR&R									
Total Avg. Ann. Cost	1,888.40	1,937.18	2,183.01	2,417.00	2,573.38	3,051.96	3,406.39	3,823.07	4,309.68
Equivalent Avg. Ann. Benefits	-70,904.32	-20,973.07	14,417.22	32,852.78	41,205.23	48,167.18	45,807.82	46,178.09	46,296.62
Benefit/Cost Ratio	-37.55	-10.83	6.60	13.59	16.01	15.78	13.45	12.08	10.74
Net Benefits	-72,792.72	-22,910.25	12,234.21	30,435.78	38,631.85	45,115.22	42,401.43	42,355.02	41,986.94

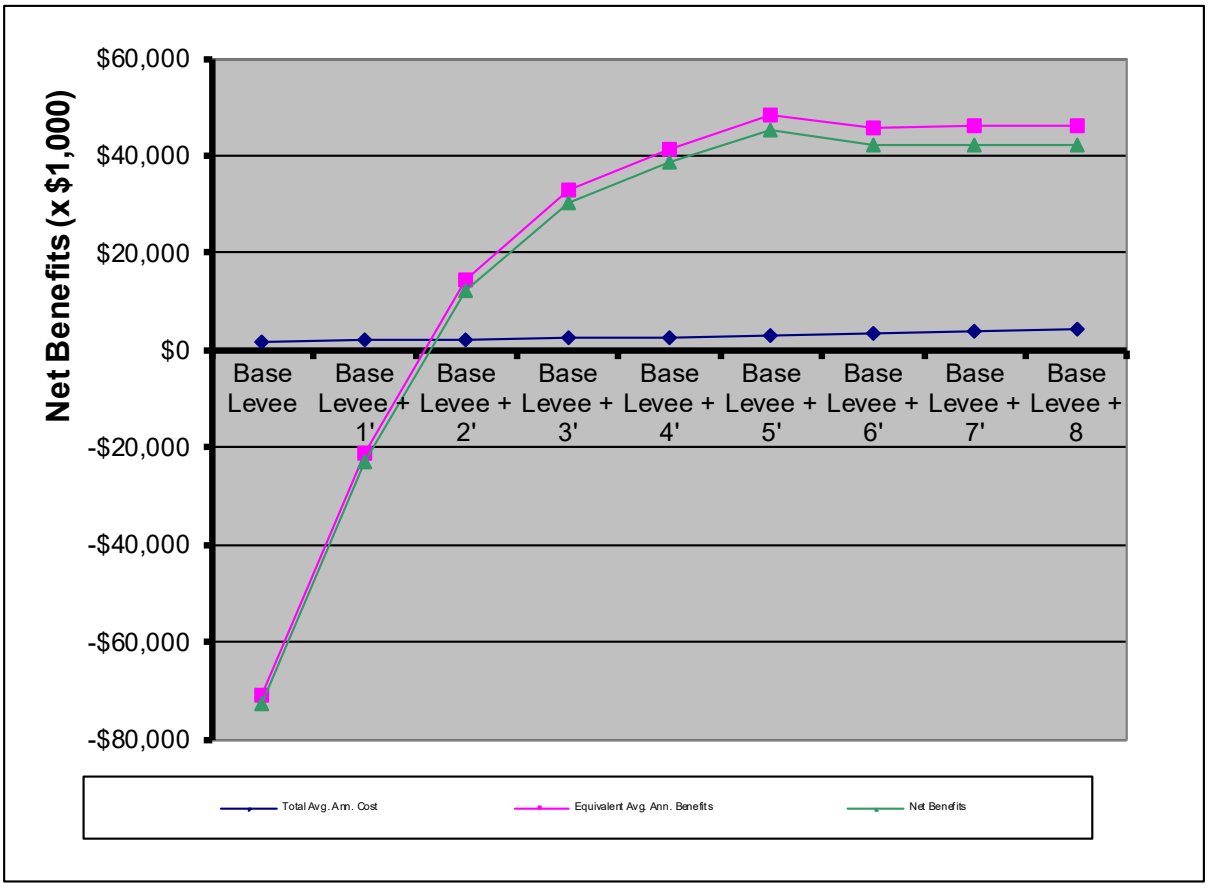


Figure D-48 Belen West Unit Alternative B Optimization Curve

Table D-76 Belen West Levee, Alternative Alignment Construction Costs

BELEN WEST LEVEE ALTERNATIVE ALIGNMENT CONSTRUCTION COSTS (x$1,000, May, 2016 price level)		
Alignment		Construction Cost
2013 Belen West Unit A 0+00 to 1041+51	Base	$40,929.41
	Base + 1'	$42,167.62
	Base + 2'	$47,206.74
	Base + 3'	$52,345.05
	Base + 4'	$55,703.19
	Base + 5'	$67,148.29
2013 Belen West Unit B 0+00 to 1235+80	Base	$47,454.16
	Base + 1'	$48,679.99
	Base + 2'	$54,857.37
	Base + 3'	$60,737.45
	Base + 4'	$64,667.08
	Base + 5'	$76,693.58
	Base + 6'	$85,600.19
	Base + 7'	$96,070.89
	Base + 8'	$108,299.15

Table D-77 Belen West Levee, Alternative Alignment Equivalent Annual Costs and Benefits

BELEN WEST LEVEE ALTERNATIVE ALIGNMENT EQUIVALENT ANNUAL COSTS AND BENEFITS (x$1,000, May, 2016 price level)				
Alignment		Avg. annual cost	Equivalent Annual Benefits (all)	Net Benefits (all)
2013 Belen West Unit A 0+00 to 1041+51	Base	$1,516,062.88	-$69,891,346.39	-$71,407,409.27
	Base + 1'	$1,561,927.35	-$21,585,846.57	-$23,147,773.91
	Base + 2'	$1,748,581.14	$12,921,583.39	$11,173,002.25
	Base + 3'	$1,938,908.71	$31,072,395.66	$29,133,486.94
	Base + 4'	$2,063,297.39	$39,359,810.36	$37,296,512.97
	Base + 5'	$2,487,234.28	$42,749,244.64	$40,262,010.36
2013 Belen West Unit B 0+00 to 1235+80	Base	$1,757,745.65	-$70,904,316.43	-$72,662,062.07
	Base + 1'	$1,803,151.77	-$20,973,071.82	-$22,776,223.59
	Base + 2'	$2,031,967.44	$14,417,216.63	$12,385,249.19
	Base + 3'	$2,249,770.82	$32,852,780.10	$30,603,009.28
	Base + 4'	$2,395,328.15	$41,205,228.34	$38,809,900.19
	Base + 5'	$2,840,800.63	$48,167,176.80	$45,326,376.16
	Base + 6'	$3,170,709.61	$45,807,824.99	$42,637,115.37
	Base + 7'	$3,558,554.10	$46,178,088.57	$42,619,534.46
	Base + 8'	$4,011,500.22	$46,296,624.58	$42,285,124.36

The Belen West Levee sits across the Rio Grande from the proposed Belen East Levee, so a quick check of the net NED benefits was necessary to see whether the net benefit maximizing levee height was different on each bank. The West Levee's net benefits maximize at Base + 6', which is slightly lower than the East Levee's optimum height of Base + 7'. This is unacceptable, as a higher levee on the bank would transfer additional residual risk to the west bank of the Rio Grande. Therefore, looking at the East and West Units as a combined project, the height which corresponds to maximum net benefits is the Base + 7' levee, and is the height recommended in this report.

During policy review, the Corps determined the plan which reasonably maximizes net benefits for the Belen East and Belen West Units was at the Base + 5' levee height. The benefits produced by levees at Base + 5' and greater were close enough that selecting an alternative with lesser cost would still reasonably maximize net benefits.

Belen West Levee (1979 Authorized Version)

The 1979 Belen West Levee had a length of 18.6 miles, placing it equivalent to Belen West Alternative A in this analysis. Figures D-44 and D-45 presents the alignment. Table D-71 (above) describes the floodplain's EAD for Alternative A, which shares the same lineal extent as the authorized project. Table D-73 presents residual damages and equivalent annual benefits.

Figure D-49 Belen West Unit Authorized Plan (Northern Alignment)

Figure D-50 Belen West Unit Authorized Plan (Southern Alignment)

Evaluation of Alternative Alignments, Conclusions

This evaluation of levees essentially serves as five independent evaluations of structural solutions to five flood problems in five hydraulically independent Units within the study area. The units are far enough apart geographically such that upstream solutions do not alter the flood regime downstream. Further, levees proposed on one bank of the Rio Grande do not alter flood risks on the opposite bank.

During policy review, the Corps determined the plan which reasonably maximizes net benefits for the Belen East and Belen West Units was at the Base + 5' levee height. The benefits produced by levees at Base + 5' and greater were close enough that selecting an alternative with lesser cost would still reasonably maximize net benefits.

D-13 Average Annual Cost:

Table D-45, Table D-50, Table D-66, and Table D-75 shows, for each alternative considered within each unit, construction cost, interest during construction, total investment cost, interest and amortization costs, and total average annual costs. The period of construction varies by analysis unit and is notated on the tables, with equal mid-monthly payments and no project benefits until the project phase is complete. The 2020 Federal interest rate of 2.75% was used in the calculations to identify the tentatively selected plan.

Mitigation plan

The recommended plan includes required mitigation features. The following analysis evaluates the mitigation plan for efficiency and effectiveness per guidance and the certified CE/ICA analysis software (IWR Planning Suite).

Table D-78 Mitigation Measures

CEICA codes	Habitat management action	1979 mitigation	Required mitigation Biological Opinion	acres	Cost		
A	Lower terrace to groundwater	Wetland Creation		75	$ 21,810,700		Mitigation for 1979 levee
B	Purchase alfalfa fields at value ($60,000)	Acquire woodland for riparian		200	$ 12,000,000		
B	Plant native riparian trees	Acquire woodland for riparian		200	$ 974,317.66		
C	Remove exotic vegetation		replace riparian habitat	235.8	$ 824,874		Mitigation for
C	Plant native riparian trees		replace riparian habitat	235.8	$ 1,148,721		Recommended Plan (E)
D	Terrace lowering w/ planting		replace flycatcher critical habitat	45	$ 6,014,108		Bernalillo to Belen Levee 2018
E	Remove exotic vegetation			197.4			Sandia to Isleta Ecosystem
E	Plant native riparian trees			197.4			Restoration
E	Terrace lowering w/ planting			49.0			
E	Lower terrace to groundwater			4.1	$ 23,797,136		

Table D-78 presents the initial array of mitigation alternatives presented, their outputs and costs.

Measures A and B were initially presented as mitigation for the 1979 levee (the authorized plan). Measure B has purchase and plant activities within them and are considered inseparable in this analysis. There is no reasonable way to resequence the activities within Measure B (such as plant prior to purchasing land) and therefore the activities within Measure B are considered one and only one measure, with no means of further subdividing the effort. Activities comprising Measure C are also in the “plant” and “purchase” variety and are evaluated in cost effectiveness analysis the same as Measure B.

Measures A and D are similar “terrace lowering” activities that add acreage to their complementary “remove exotics/plant natives” activities, but have been modeled as separable in this analysis. Thus it is possible to get purchase and planting measures (B and C) combined with either A or D. This analysis also presents the opportunity for alternatives that include Measures A and/or D without other measures.

Activities in Measure E are lumped together by direction of the PDT biologist. Removing exotic vegetation is a necessary precursor step to planting native vegetation in the same land. The terrace lowering and “lowering w/ planting” appear to be additive tasks to the larger exotic planting removal followed by native planting.

The assumptions in Table D-78 are modeled in the IWR Planning Suite as follows:

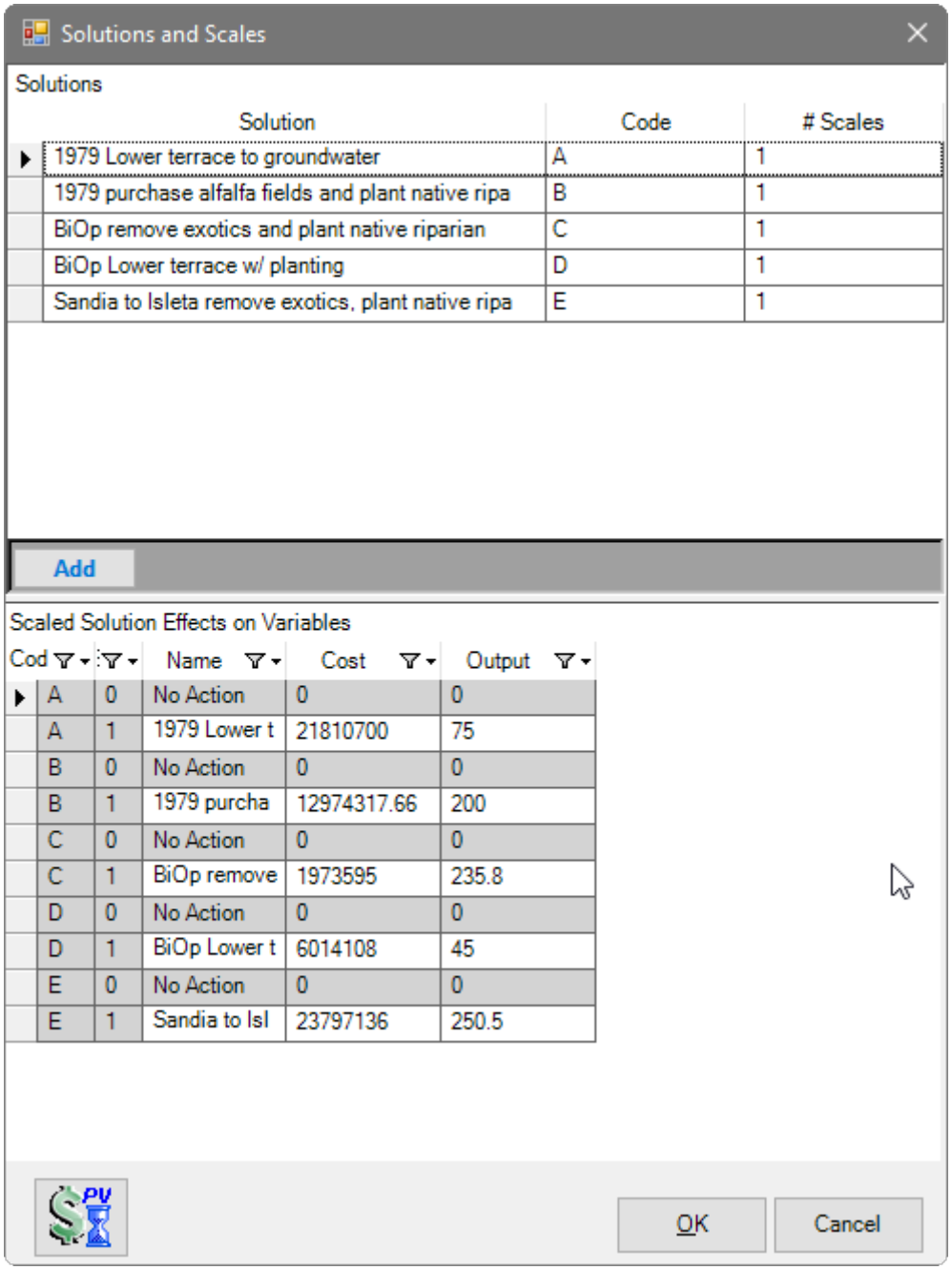
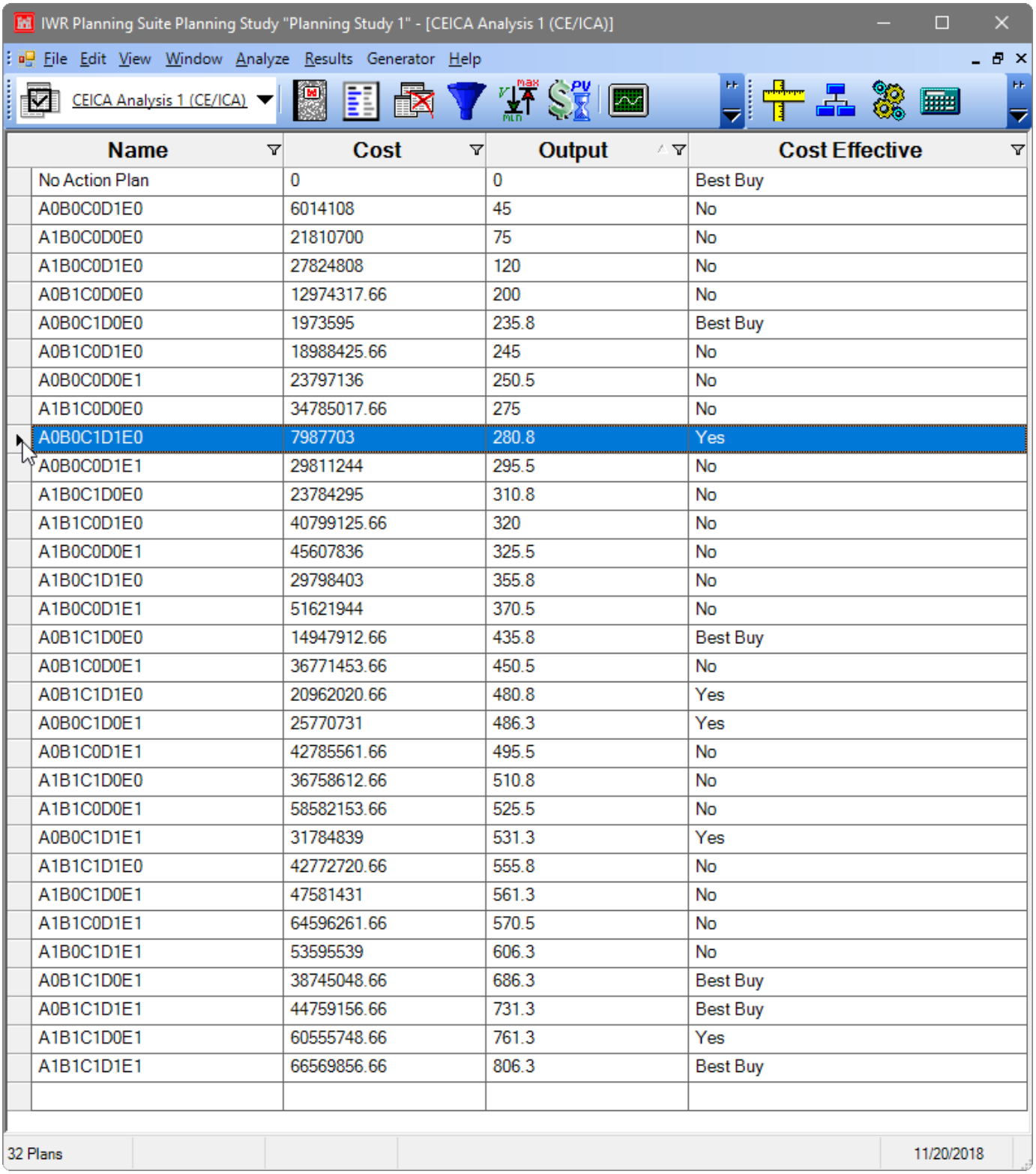


Figure D-51 Mitigation measures in IWR Planning Suite

With no additional dependencies created, this array of measures generated 32 plans within IWR Planning Suite. Ranking by output, the cost effectiveness follows:



Name	Cost	Output	Cost Effective
No Action Plan	0	0	Best Buy
A0B0C0D1E0	6014108	45	No
A1B0C0D0E0	21810700	75	No
A1B0C0D1E0	27824808	120	No
A0B1C0D0E0	12974317.66	200	No
A0B0C1D0E0	1973595	235.8	Best Buy
A0B1C0D1E0	18988425.66	245	No
A0B0C0D0E1	23797136	250.5	No
A1B1C0D0E0	34785017.66	275	No
A0B0C1D1E0	7987703	280.8	Yes
A0B0C0D1E1	29811244	295.5	No
A1B0C1D0E0	23784295	310.8	No
A1B1C0D1E0	40799125.66	320	No
A1B0C0D0E1	45607836	325.5	No
A1B0C1D1E0	29798403	355.8	No
A1B0C0D1E1	51621944	370.5	No
A0B1C1D0E0	14947912.66	435.8	Best Buy
A0B1C0D0E1	36771453.66	450.5	No
A0B1C1D1E0	20962020.66	480.8	Yes
A0B0C1D0E1	25770731	486.3	Yes
A0B1C0D1E1	42785561.66	495.5	No
A1B1C1D0E0	36758612.66	510.8	No
A1B1C0D0E1	58582153.66	525.5	No
A0B0C1D1E1	31784839	531.3	Yes
A1B1C1D1E0	42772720.66	555.8	No
A1B0C1D0E1	47581431	561.3	No
A1B1C0D1E1	64596261.66	570.5	No
A1B0C1D1E1	53595539	606.3	No
A0B1C1D0E1	38745048.66	686.3	Best Buy
A0B1C1D1E1	44759156.66	731.3	Best Buy
A1B1C1D0E1	60555748.66	761.3	Yes
A1B1C1D1E1	66569856.66	806.3	Best Buy

Figure D-52 Alternative plans in IWR Planning Suite

Figure D-50 has identified the cost effective and Best Buy plans among all plans considered. The first Best Buy plan is Measure C, which affects 235.8 acres. Measure C is the “remove exotic/plant native vegetation” activity. The next Best Buy plan is Measure B plus Measure C, which recommends an additional “acquire land/plant native vegetation” activity, much like Measure C.

The combination of Measures C and D were identified as mitigation required for this study this year, and is deemed cost effective when implemented in isolation. This combination has been highlighted in the figure. Implementing measures B and C do fall within the two first Best Buys as a cost effective means to incrementally add output to the first Best Buy (Measure C). Alternatives don’t cost effectively contain this measure until the alternative containing B, C and D. Alternatives which contain C and D as a Best Buy start with the alternative containing B, C, D, and E, which puts it close do “Do Everything.”

The mitigation presented here is for the Recommended Plan and is not for the component units, as those were not alternatives provided to the Fish and Wildlife Service during consultation, which happened after the plan identification process identified in Para. D-12, above. It is inappropriate to disaggregate the mitigation plan to the component units, as the consultation process was not Unit specific. The PDT biologist further indicated that the mitigation strategy has a vegetation components, which might follow some arithmetic formula that could be distributed among the units, but there is a willow flycatcher component, which would not follow the formula. The willow flycatcher habitat is not present in all units, and has some rather expensive mitigation components (terrace lowering/swales) specifically designed for this species’ benefit.

D-14 Average Annual Benefits:

Table D-41, Table D-44, Table D-49, Table D-64 and shows equivalent annual residual damages and benefits for the analyzed levee heights for each of the units. These tables discount the benefit stream of future damages and benefits to present value to present an Equivalent Annual Damage figure to serve as the basis of project benefits. Benefit determination for the post project condition was computed by changing the proposed levee height to remove damageable property from lesser magnitude events.

D-15 Benefit-Cost Comparisons and Plan Selection:

Table D-42, Table D-50, Table D-66, and Table D-75 shows the expected B/C ratio and net benefits for the damageable property on an equivalent annual basis. It was not possible to show the distribution of residual damages, net benefits, or the benefit/cost ratio.

Paragraph D-10, above, describes 12 different sensitivity studies that were conducted to evaluate the impact of changed assumptions on EAD for the without-project conditions. Rather than run 12 different models of the with-project condition, the one scenario with the largest adverse impact to EAD was selected and run against the varied with-project alternative levee alignments and heights for all the identified reaches in the study area. That scenario describes raising structures and their contents 0.5’. Table D-79, Table D-80, Table D-81, and Table D-82 displays the alignments

and heights for the recommended plan, their costs and benefits, as well as the costs and benefits based on the changed assumption in the scenario.

Table D-79 Mountainview East Levee (Sensitivity Run), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED MOUNTAINVIEW EAST LEVEE (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Total Avg. Ann. Cost	454.69	458.24	468.98	489.23	498.24	582.54
Data from Table D-41						
EAD 973.86						
Equivalent Avg. Ann. Benefits	301.25	573.51	730.39	804.09	955.67	843.07
Benefit/Cost Ratio	0.66	1.25	1.56	1.64	1.92	1.45
Net Benefits	-153.43	115.27	261.42	314.86	457.44	260.54
Data from sensitivity run (Sixth pass, raise inventory 0.5')						
EAD 205.82						
Equivalent Avg. Ann. Benefits	148.10	340.03	414.85	462.32	603.92	489.17
Benefit/Cost Ratio	0.33	0.74	0.88	0.94	1.21	0.84
Net Benefits	-306.58	-118.21	-54.12	-26.91	105.69	-93.36

Table D-80 Belen East Levee (Sensitivity Run), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED BELEN EAST LEVEE ALT. A (x$1,000, May, 2016 price level)									
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'	Base Levee + 6'	Base Levee + 7'	Base Levee + 8'
Total Avg. Ann. Cost	2,950.05	3,185.93	3,331.96	3,396.36	3,652.48	4,082.91	4,620.40	5,020.93	5,631.81
Data from Table D-49									
EAD 61909.73									
Equivalent Avg. Ann. Benefits	-69,709.48	-28,538.52	7,891.36	33,658.77	47,866.93	58,914.56	55,774.24	56,365.70	56,537.87
Benefit/Cost Ratio	-23.63	-8.96	2.37	9.91	13.11	14.43	12.07	11.23	10.04
Net Benefits	-72,659.53	-31,724.45	4,559.41	30,262.41	44,214.45	54,831.65	51,153.84	51,344.76	50,906.06
Data from sensitivity run (Sixth pass, raise inventory 0.5')									
Equivalent Avg. Ann. Benefits	-46,714.00	-19,994.97	-2,029.73	9,121.51	13,638.95	14,931.03	15,234.21	15,306.36	15,328.39
Benefit/Cost Ratio	-15.84	-6.28	-0.61	2.69	3.73	3.66	3.30	3.05	2.72
Net Benefits	-49,664.05	-23,180.90	-5,361.69	5,725.15	9,986.47	10,848.12	10,613.81	10,285.43	9,696.58

Table D-81 Isleta West Levee (Sensitivity Run), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED ISLETA WEST LEVEE (Alignment E) (x$1,000, May, 2016 price level)						
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'
Total Avg. Ann. Cost	321.16	342.94	365.37	418.38	454.17	503.39
Data from Table Table D-64						
EAD 723.33						
Equivalent Avg. Ann. Benefits	-773.80	-413.34	13.92	346.44	602.91	610.83
Benefit/Cost Ratio	-2.41	-1.21	0.04	0.83	1.33	1.21
Net Benefits	-1,094.96	-756.28	-351.45	-71.94	148.73	107.44
Data from sensitivity run (Sixth pass, raise inventory 0.5')						
Equivalent Avg. Ann. Benefits	-65.12	-3.94	5.50	64.66	94.66	106.57
Benefit/Cost Ratio	-0.20	-0.01	0.02	0.15	0.21	0.21
Net Benefits	-386.29	-346.88	-359.87	-353.73	-359.52	-396.83

Table D-82 Belen West Levee (Sensitivity Run), Comparison of Equivalent Annual Costs and Benefits

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED BELEN WEST LEVEE (Alignment B) (x$1,000, May, 2016 price level)									
	Base Levee	Base Levee + 1'	Base Levee + 2'	Base Levee + 3'	Base Levee + 4'	Base Levee + 5'	Base Levee + 6'	Base Levee + 7'	Base Levee + 8'
Total Avg. Ann. Cost	1,888.40	1,937.18	2,183.01	2,417.00	2,573.38	3,051.96	3,406.39	3,823.07	4,309.68
Data from Table Table D-74									
EAD 49994.77									
Equivalent Avg. Ann. Benefits	-70,904.32	-20,973.07	14,417.22	32,852.78	41,205.23	48,167.18	45,807.82	46,178.09	46,296.62
Benefit/Cost Ratio	-37.55	-10.83	6.60	13.59	16.01	15.78	13.45	12.08	10.74
Net Benefits	-72,792.72	-22,910.25	12,234.21	30,435.78	38,631.85	45,115.22	42,401.43	42,355.02	41,986.94
Data from sensitivity run (Sixth pass, raise inventory 0.5')									
Equivalent Avg. Ann. Benefits	-50,572.24	-18,358.72	-1,685.22	6,003.94	8,630.47	9,419.49	9,634.70	9,699.21	9,725.27
Benefit/Cost Ratio	-26.78	-9.48	-0.77	2.48	3.35	3.09	2.83	2.54	2.26
Net Benefits	-52,460.64	-20,295.90	-3,868.23	3,586.94	6,057.09	6,367.53	6,228.31	5,876.14	5,415.59

This sensitivity study of the recommended plan demonstrates that raising the structural inventory 0.5' has some impact on the overall identification of the Federal interest. Most units that have levee systems would still have justifiable levee systems. In some reaches (Belen West, Belen East, Mountainview East), the inventory's higher vertical elevation reduced project benefits in such a way that a slightly smaller levee would maximize net benefits. In the case of the Isleta West reach, raising the inventory did not have an effect on optimizing levee height, but the overall benefit/cost ratio fell as expected. The Mountainview East Unit did have a benefit/cost ratio problem, as the BCR fell below 1.0.

D-16 Benefits and Costs of the Proposed Project Prior to the Base Year:

Paragraphs D-13 to D-15 of this appendix describe the process by which individual units were analyzed, any justified project identified and optimized for lineal extent and height. That process was conducted using May, 2016 prices and applicable discount rates and updated since then to identify the recommended plan. The most recent update used the FY 2018 discount rate of 2.75% to identify

the recommended plan at the Agency Decision Milestone. Post-milestone, the cost of the recommended plan was updated again to October 2020 prices, and the applicable 2.75% discount rate. The unit analysis presented up to here has done its job of identifying the recommended plan, and will remain presented here at 2016 prices and 2.75% discount rate, and is not germane to the discussion which follows, dealing with the recommended plan as one large project with a 16-year construction period.

Generally, benefits are only anticipated after plan implementation, but for some projects, benefits can occur during the construction period. The problem is to convert the varying benefit and cost streams to the equivalent and comparable average annual measures over a common time period that is the period of analysis. The present value, in terms of the base year, is determined for benefits derived prior to the base year.

Benefits accruing prior to the base year should be documented and included in the benefit evaluation. These benefits should be brought forward from the time the benefits begin to the beginning of the period of analysis, using the project interest rate. All benefits and costs are stated in present worth terms as of the period of analysis.

Due to the time length required for construction of all alternatives for the study, benefits that accrue prior to the base year are substantial. Several elements of each project start to provide some limited flood control benefit prior to the 2036 base year. The following will estimate the benefits during construction for the alternatives being considered.

Some elements of the proposed project will be completed and provide some protection prior to the 2036 base year. The current construction schedule calls for completion of the Mountainview and Isleta West Units first, followed by construction of the Belen Units, upstream to downstream. The Mountainview and Isleta West Units of the proposed project tie into geographic features, such that benefits accrue when the phase is completed. For the rest of the study area, the threat of backwater flows downstream of the protected reaches delay project benefits until the subsequent phase is completed. Backwater flows are a significant threat to the study area, especially considering the perched nature of the Rio Grande. Each project phase is one year in duration and approximately 1.5-3 river miles in length.

During policy review, the Corps determined the plan which reasonably maximizes net benefits for the Belen East and Belen West Units was at the Base + 5’ levee height. The benefits produced by levees at Base + 5’ and greater were close enough that selecting an alternative with lesser cost would still reasonably maximize net benefits. The plan which is to be constructed consists of the Mountainview Unit, at the Base+4’ height, the Isleta West Unit, Alignment E at the Base+4’ levee height, the Belen East Unit, Alignment A, at the Base+5’ levee height, and the Belen West Unit, Alignment B, at the Base+5’ levee height.

All benefits that accrue prior to the base year of 2036 must be brought forward in the same manner as all costs prior to the base year. Those benefits are then amortized over the period of analysis. The following tables display this process.

Table D-83 Incremental Benefits Prior to Base Year

INCREMENTAL BENEFITS PRIOR TO BASE YEAR
(x $1,000, October, 2019 Prices)

period in years =	50
interest rate =	0.0275
capital recovery factor	0.0370409

		Benefits prior to 2036					Benefits brought foward to Base Year			
Phase	Year	West Bank (marginal)	West Bank (cumulative)	East Bank (marginal)	East Bank (cumulative	Total Benefits TB=	Interest Rate Factor 1+r=	Period to 2036 n=	Factor 1+r^n	Benefit in 2036 value TB*r^n
1	2020	0.00	0.00	965.80	965.80	965.80	1.0275	17.5	1.607615	1,552.63
2	2021	599.94	599.94	0.00	965.80	1,565.73	1.0275	16.5	1.564589	2,449.73
3	2022	0.00	599.94	0.00	965.80	1,565.73	1.0275	15.5	1.522714	2,384.17
4	2023	-20.32	579.62	0.00	965.80	1,545.42	1.0275	14.5	1.48196	2,290.25
5	2024	0.00	579.62	1.17	966.96	1,546.58	1.0275	13.5	1.442297	2,230.63
6	2025	882.27	1,461.89	0.00	966.96	2,428.85	1.0275	12.5	1.403695	3,409.36
7	2026	0.00	1,461.89	0.00	966.96	2,428.85	1.0275	11.5	1.366127	3,318.12
8	2027	0.00	1,461.89	0.00	966.96	2,428.85	1.0275	10.5	1.329564	3,229.31
9	2028	0.00	1,461.89	42,776.74	43,743.71	45,205.59	1.0275	9.5	1.293979	58,495.11
10	2029	298.33	1,760.21	0.00	43,743.71	45,503.92	1.0275	8.5	1.259347	57,305.24
11	2030	0.00	1,760.21	0.00	43,743.71	45,503.92	1.0275	7.5	1.225642	55,771.52
12	2031	0.00	1,760.21	0.00	43,743.71	45,503.92	1.0275	6.5	1.192839	54,278.85
13	2032	0.00	1,760.21	0.00	43,743.71	45,503.92	1.0275	5.5	1.160914	52,826.14
14	2033	16,380.49	18,140.70	0.00	43,743.71	61,884.41	1.0275	4.5	1.129843	69,919.69
15	2034	0.00	18,140.70	16,941.57	60,685.28	78,825.98	1.0275	3.5	1.099604	86,677.38
16	2035	31,296.03	49,436.73	0.00	60,685.28	110,122.01	1.0275	2.5	1.070174	117,849.76
17	2036	0.00	49,436.73	0.00	60,685.28	110,122.01	1.0275	1.5	1.041532	114,695.63
18	2037	0.00	49,436.73	0.00	60,685.28	110,122.01	1.0275	0.5	1.013657	111,625.92
	2036 TO 2086	49,436.73		60,685.28		110,122.01				
	Total									**800,309.43**

The value of all benefits prior to the base year are equal to $800.4 million when brought forward to the year 2036. When these benefits are amortized over the 50 year period of analysis, they provide an additional $29.6 million in average annual benefits.

The proposed levees will be constructed in 16, 1-year phases. The Total Project Cost Summary (TPCS), certified 30 October 2019, is used as the basis of developing the cost of constructing the recommended plan, comprised of four individual units, which are Mountainview at Base + 4', Isleta West at Base + 4', and Belen East and West at Base + 5'. Prior tables in this estimate are based upon prior cost estimates, indicated by the price level of those analyses. This October 2019 TPCS does not revisit those evaluations. The October 2019 project cost estimate was used to develop costs for each of the phases of construction. Interest during construction was computed for each phase using equal, mid-monthly payments at the FY 2020 interest rate (2.75%) for that phase. Table D-85 summarizes the IDC calculations into yearly totals.

Table D-84 Construction Costs

CONSTRUCTION COSTS (PROGRAM YEAR FY 2020)																		
1 Oct 2019 Price Level																		
Levees	Mountainview	Isleta West	Belen Eas	Belen Wes	Belen Eas	Belen Wes	Belen Eas	Belen Wes	Belen Eas	Belen West	Belen Eas	Belen Wes	Belen Eas	Belen West	Belen Wes	Belen Wes	Belen Wes	Belen Wes
	10/1/2020	10/1/2021	10/1/2022	10/2/2023	10/1/2024	10/1/2025	10/1/2026	10/2/2027	10/1/2028	10/1/2029	10/1/2030	10/2/2031	10/1/2032	10/1/2033	10/1/2034	10/2/2035	10/1/2036	10/1/2037
Project Cost	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8	Phase 9	Phase 10	Phase 11	Phase 12	Phase 13	Phase 14	Phase 15	Phase 16	Phase 17	Phase 18
Levee	21,099.00	12,284.00	16,193.00	14,808.00	15,161.00	15,000.00	14,252.00	14,150.00	13,924.00	13,501.00	14,088.00	13,101.00	14,807.00	12,829.00	12,855.00	13,189.00	0.00	0.00
Relocations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	412.00	0.00	0.00
Lands and Damages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	395.00	0.00	0.00
PED	2,522.00	1,540.00	2,078.00	1,957.00	1,979.00	1,945.00	1,856.00	1,835.00	1,820.00	1,764.00	1,842.00	1,731.00	1,906.00	1,689.00	1,695.00	1,842.00	0.00	0.00
Construction Management	1,812.00	1,013.00	1,398.00	1,279.00	1,313.00	1,295.00	1,238.00	1,223.00	1,211.00	1,170.00	1,227.00	1,137.00	1,284.00	1,115.00	1,122.00	1,179.00	0.00	0.00
Fish & Wildlife Facilities	867.00	0.00	758.00	692.00	758.00	692.00	758.00	692.00	758.00	692.00	802.00	692.00	758.00	692.00	758.00	692.00		
Total First Cost	26,300.00	14,837.00	20,427.00	18,736.00	19,211.00	18,932.00	18,104.00	17,900.00	17,713.00	17,127.00	17,959.00	16,661.00	18,755.00	16,325.00	16,430.00	17,709.00	0.00	0.00
IDC, Construction (192 months, 2.75%)*	13,748.63	7,151.53	9,035.72	7,564.46	7,034.48	6,240.09	5,322.93	4,643.02	3,997.48	3,303.39	2,890.50	2,163.91	1,868.72	1,146.14	682.91	242.41	0.00	0.00
Total, Interest During Construction	13,748.63	7,151.53	9,035.72	7,564.46	7,034.48	6,240.09	5,322.93	4,643.02	3,997.48	3,303.39	2,890.50	2,163.91	1,868.72	1,146.14	682.91	242.41	0.00	0.00
Study Sunk Costs																		
Total Investment	40,048.63	21,988.53	29,462.72	26,300.46	26,245.48	25,172.09	23,426.93	22,543.02	21,710.48	20,430.39	20,849.50	18,824.91	20,623.72	17,471.14	17,112.91	17,951.41	0.00	0.00

Table D-85 Interest During Construction Calculation

INCREMENTAL COSTS PRIOR TO BASE YEAR
(x $1,000, October, 2019 Prices)

period in years =	50
interest rate =	0.0275
capital recovery factor =	0.0370409

		Costs prior to 2036	Interest During Construction		
Phase	Year	Total Costs TC=	Interest Rate Factor 1+r=		
1	2020	26,300.00	1.0275		13,748.63
2	2021	14,837.00	1.0275		7,151.53
3	2022	20,427.00	1.0275		9,035.72
4	2023	18,736.00	1.0275		7,564.46
5	2024	19,211.00	1.0275		7,034.48
6	2025	18,932.00	1.0275		6,240.09
7	2026	18,104.00	1.0275		5,322.93
8	2027	17,900.00	1.0275		4,643.02
9	2028	17,713.00	1.0275		3,997.48
10	2029	17,127.00	1.0275		3,303.39
11	2030	17,959.00	1.0275		2,890.50
12	2031	16,661.00	1.0275		2,163.91
13	2032	18,755.00	1.0275		1,868.72
14	2033	16,325.00	1.0275		1,146.14
15	2034	16,430.00	1.0275		682.91
16	2035	17,709.00	1.0275		242.41
	2036 TO 2086	0.00			
	Total	**293,126.00**			**77,036.30**

The value of these interest during construction costs are equal to $77.0 million. When these costs are amortized over the 50 year period of analysis, they provide an additional $2.9 million in average annual costs.

The following table presents project costs (to include costs prior to base year computed in Table D-85) and benefits (to include benefits accrued prior to base year computed in Table D-83) and during the period of analysis.

The mitigation plan for the Recommended Plan assumes equal, mid-monthly payments over the course of 16 years of construction at the FY 2020 interest rate of 2.75%. As those assumptions differ from the construction payments schedule, the Interest During Construction costs are presented in Table D-86 as a separate line item.

Table D-86 Comparison of Costs and Equivalent Annual Benefits of Recommended Plan

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE RECOMMENDED LEVEE (INCLUDING BENEFITS PRIOR TO BASE YEAR) (x $1,000, October, 2019 prices, 2.75%)							
Phase		1		2	3, 5, 7, 9, 11, 13	4, 6, 8, 10, 12, 14-	6RECOMMENDED
	CORRALES	MOUNTAINVIEW	ISLETA	ISLETA WEST	BELEN EAST	BELEN WEST	PLAN
Construction Cost*		21,098.57		12,283.61	88,425.10	109,433.29	231,240.58
Real Estate		0.00		0.00	0.00	411.85	411.85
PED (9%)	CONSTRUCTED	2,524.71	NOT JUSTIFIED	1,540.92	11,486.12	14,459.39	30,011.15
Construction Management		1,811.52		1,013.02	7,671.06	9,520.70	20,016.29
Lands and Damages		0.00		0.00	0.00	395.38	395.38
Fish & Wildlife Facilities		867.49		0.00	4,592.55	5,600.80	11,060.85
Total First Cost		26,302.30		14,837.54	112,174.84	139,821.41	293,136.09
Interest During Construction		13,749.83		7,151.79	30,151.26	25,985.97	77,038.85
Total Investment Costs		40,052.12		21,989.33	142,326.10	165,807.38	370,174.94
Avg. Ann. Cost (2.75%, 50 yr. project life)		1,483.57		814.51	5,271.89	6,141.66	13,711.62
OMRR&R							380.00
Total Avg. Ann. Cost		1,483.57		814.51	5,271.89	6,141.66	14,091.62
Equivalent Avg. Ann. Benefits		955.67		602.91	56,365.70	48,167.18	106,091.45
Equiv. Avg. Ann. Benefits (prior to Base year)		830.18		479.97	20,853.92	7,480.14	29,644.20
Total benefits		1,785.85		1,082.87	77,219.61	55,647.32	135,735.65
Benefit/Cost Ratio		1.20		1.33	14.65	9.06	9.63
Net Benefits		302.28		268.37	71,947.72	49,505.66	121,644.03

The Recommended Plan comprises four individual Units. The Mountainview Unit is constructed first, within 12 months, and in Table D-85, is held “on the books” and accrues benefits (and costs per Interest During Construction, which front-loaded the interest on the first payments in the 16 year payment stream) until the Base Year. The Isleta Unit is constructed in the next year, within 12 months, and accrues benefits and costs until the Base Year. Construction continues for the remainder of the 16 year construction period with the Belen East and Belen West Units, with payments and benefits accruing per descriptions in Table D-84, Table D-85 and Table D-86.

A description of the economic performance of the Units' performance in isolation is enclosed within the following table:

Table D-87 - Comparison of Costs and Equivalent Annual Benefits of Recommended Plan (and component units)

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE RECOMMENDED LEVEE (INDIVIDUAL COMPONENTS) (x $1,000, October, 2019 prices, 2.75%)							
Phase							RECOMMENDED
	CORRALES	MOUNTAINVIEW	ISLETA	ISLETA WEST	BELEN EAST	BELEN WEST	PLAN
Construction Cost*		21,098.57		12,283.61	88,425.10	109,433.29	231,240.58
Real Estate		0.00		0.00	0.00	411.85	411.85
PED (9%)	CONSTRUCTED	2,524.71	NOT JUSTIFIED	1,540.92	11,486.12	14,459.39	30,011.15
Construction Management		1,811.52		1,013.02	7,671.06	9,520.70	20,016.29
Fish and Wildlife Facilities							11,060.85
Total First Cost		25,434.80		14,837.54	107,582.29	133,825.23	292,740.71
Construction period (months)		12		12	60	60	192
IDC (xx months, 2.75%)*		0.00		0.00	7,996.73	9,947.40	77,038.85
Investment Costs		25,434.80		14,837.54	115,579.02	143,772.62	369,779.55
Avg. Ann. Cost (2.75%, 50 yr. project life)		942.13		549.60	4,281.15	5,325.47	13,711.62
OMRR&R							380.00
Total Avg. Ann. Cost		942.13		549.60	4,281.15	5,325.47	14,091.62
Equivalent Avg. Ann. Benefits		955.67		602.91	56,365.70	48,167.18	106,091.45
Equiv. Avg. Ann. Benefits (prior to Base year)							29,644.20
Total benefits		955.67		602.91	56,365.70	48,167.18	135,735.65
Benefit/Cost Ratio		1.01		1.10	13.17	9.04	9.63
Net Benefits		13.54		53.31	52,084.54	42,841.71	121,644.03

Here, each component unit is presented with new costs, but the assumptions from individual unit analysis presented earlier in this appendix. This table represents more current costs than equivalent information in Table D-42, Table D-50, Table D-66, and Table D-75.

D-17 Impact of Addressing Flood Risk in Four Accounts (NED, NER, OSE, RED):

The Principles and Guidelines establish four accounts to facilitate the evaluation and display of effects of alternative plans. They are described in ER 1105-2-100, para. 2-3. The evaluation of the tentatively selected plan against those accounts follows:

- The National Economic Development (NED) Account displays changes in the economic value of the national output of goods and services. The damages and benefits described in this appendix describe NED impacts of flooding in the study area and the effects of alternatives designed to address the flood threat.
- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The array of plans described in this

appendix have flood risk management as their stated goals. EQ benefits or impacts are identified within the Environmental appendix to this report. Implementing the recommendations for the various units in this evaluation involves repurposing lands already owned by the Bureau of Reclamation and the Isleta Pueblo, and does not require additional land acquisition. No additional acreages were identified as needed to ensure project success. Some disturbances during levee construction were identified, and appropriate mitigations are in place. A completed project is desirable by the biological and ecological community as an increased channel capacity permits increased releases from Cochiti Dam upstream that benefit the endangered Rio Grande silvery minnow and other species using the riparian corridor. Increased flows along the Rio Grande also promote increased overbank flows in the critical bosque habitat and other riparian zones along the Rio Grande.

- The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account is typically used to capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. A recent study for the Nuclear Watch of New Mexico suggests that public sector multipliers tend to be below 1.5, while the Department of Energy claimed multipliers of 2.4 to 3.5 in fiscal year 1998. (Dumas, L.J., Economic Multipliers and the Economic Impact of DOE Spending in New Mexico, March 2003) The important point to be made here is that a large infrastructure project in the Middle Rio Grande Valley will have a positive impact on local income and employment.
- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. In most cases, impacts of proposed projects not covered in other accounts are described and evaluated here. Generally, the plans described here meet USACE criteria for project adequacy (completeness, effectiveness, efficiency, and acceptability). Residual risk of implementing levees of various heights is described in Para. D-16 of this appendix. In the unfortunate circumstance that the proposed levees were exceeded, the resultant flood magnitude, timing, and duration is not expected to become even more severe than the without-project and without-project, future condition.

  The Isleta Lakes represent a significant recreation opportunity in the study area that is important to both the region. Providing flood protection to the facilities (in the form of levees) preserves this recreation opportunity for continued enjoyment by visitors. Alternatives that excluded the levees provided no means to preserve this recreation opportunity.

  The floodplain is roughly 1.5 to 2 miles wide, and sits below the perched Rio Grande. In the event of a flood, warning times may prevent evacuation, but flood velocities are not expected to be sufficient to dislodge vehicles using local roads,

however, the field inventory did not identify any high water marks as the floodplain is generally flat, and does not include low water crossings, although there may be unexpected areas with more flood depth due to local topography. Most projected flood fatalities occur in vehicles moving through the floodplain (http://www.nws.noaa.gov/oh/hic/flood_stats/recent_individual_deaths.shtml, accessed 12/03/2013).

The flood hydrograph described in the H&H appendix outlines two flood scenarios. Floods generated by local thunderstorms have short warning, rapid onset, and relatively short duration (3-4 days) with the flood peak passing within hours. Floods generated by snowmelt in uncontrolled drainages downstream of Cochiti dam have considerably more warning time, but the volume and duration suggests 90-100 days inundation duration. Public services are not expected to be disrupted outside of the floodplain. The flood impacts will fall mostly upon the rural areas outside of the Town. Evacuations will be necessary, and reoccupation and cleanup time and costs from New Orleans and Mississippi River floods (longer duration, though much deeper than projected for this study) suggest that the emergency costs used in this report (from Carlsbad, NM) are fairly conservative.

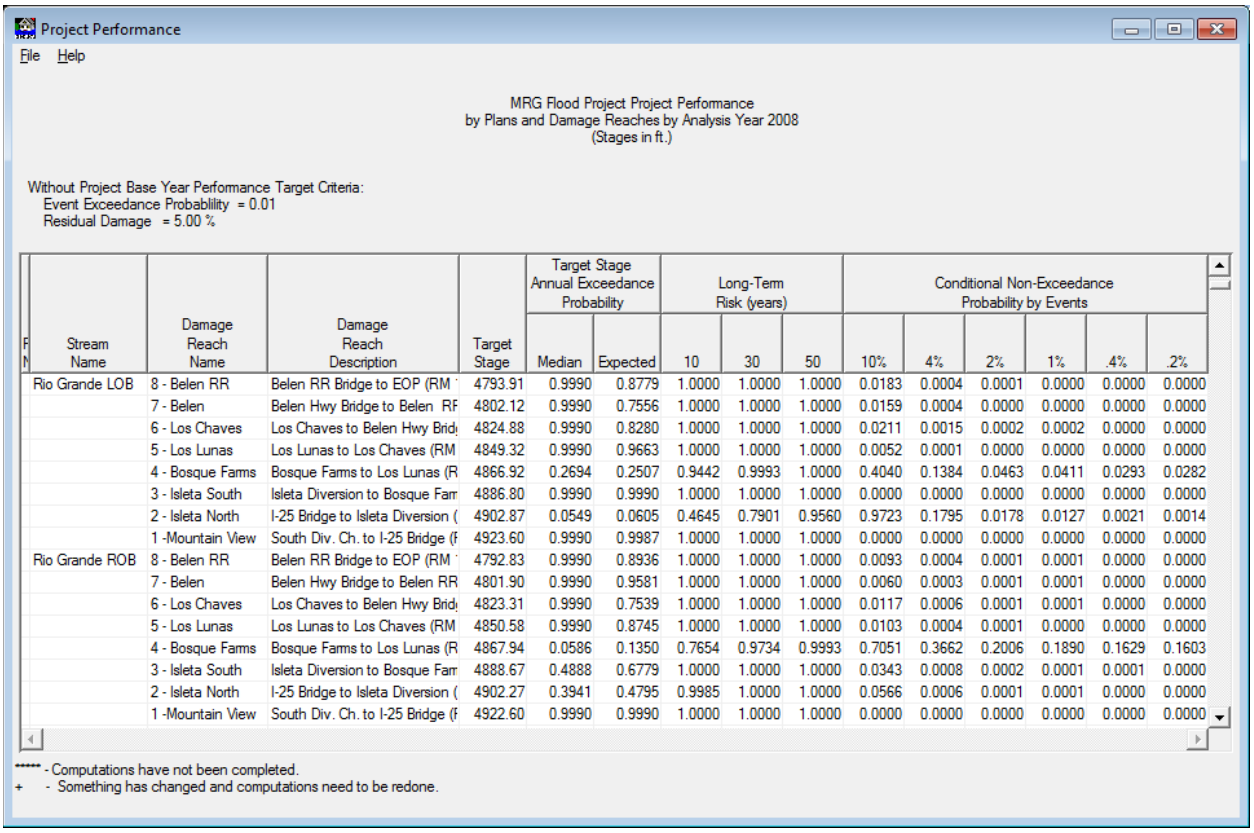
A completed project which increases Rio Grande channel capacity improves a constraint on Cochiti Dam to not release flows that induce damages downstream. Dam operators indicate that Cochiti Dam releases are less than authorized values due to downstream capacity constraints such as unprotected structures proximate to the channel, or existing spoil banks that are damaged annually by unregulated summer monsoon flows.

Increased flow capacity (a side effect of implementing the proposed project) downstream of Cochiti Dam benefits the region in two ways: First, dam operators can increase releases in anticipation of big inflows to Cochiti reservoir that would potentially threaten dam structural integrity or capacity. Second, improved channel capacity makes it easier to release water for delivery obligations outlined in the Rio Grande Compact and other treaties with Texas and Mexico.

D-18 Project Performance:

Besides a strict benefit/cost comparison, another measure of the effectiveness of flood protection is its ability to contain damaging floods where there was limited protection before. Limitations of the analysis package preclude a rigorous analysis of project performance, but inspection of the available data could provide decision makers a glimpse of the nature of the flood problem and how the project will act to contain it. Tables D-78 to D-81 present the likelihood of flood stages being exceeded by specific

flood events at each cross section used within the study in the without and with-project, future conditions. Figure D-51 presents project performance characteristics of the study area in the present, without-project condition. Figure D-52 displays the same data for the future, without-project condition. One scenario was developed to describe the effectiveness of the various alternatives considered.



Project Performance

File Help

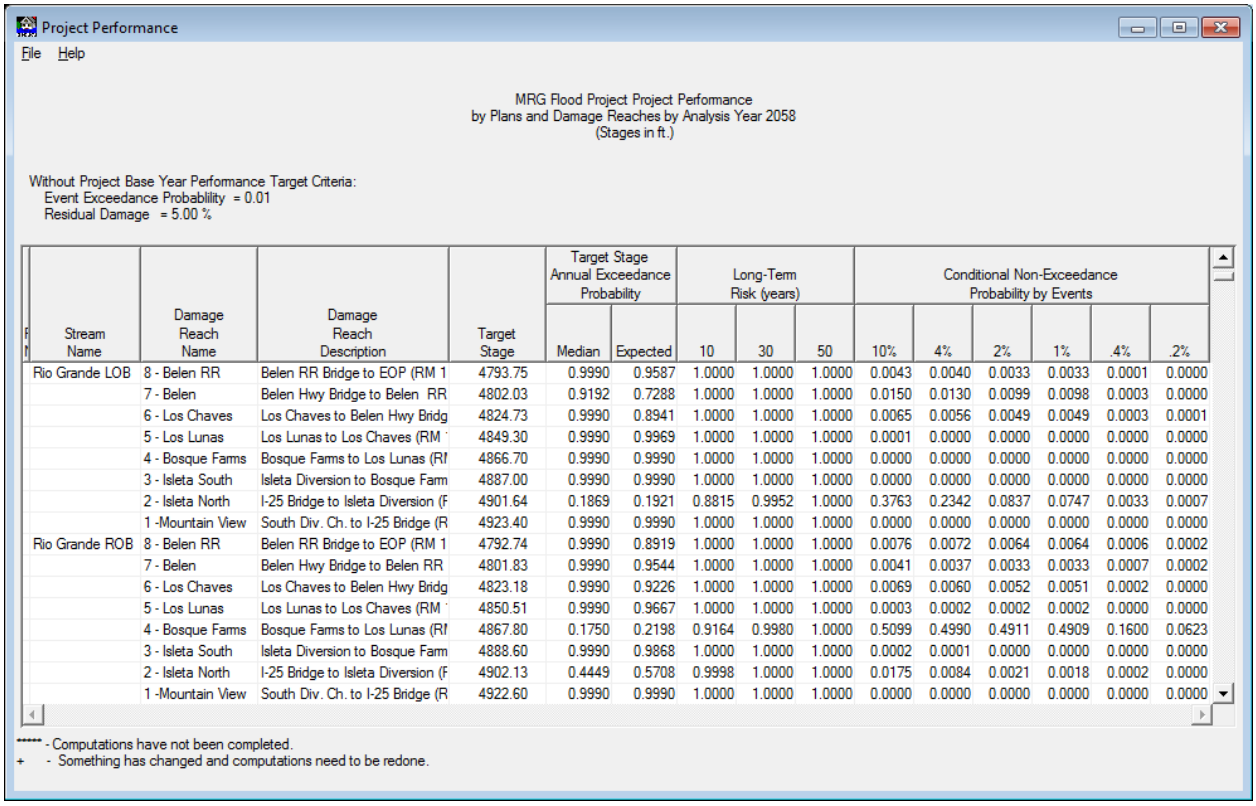
MRG Flood Project Project Performance
by Plans and Damage Reaches by Analysis Year 2008
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
				Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Rio Grande LOB	8 - Belen RR	Belen RR Bridge to EOP (RM	4793.91	0.9990	0.8779	1.0000	1.0000	1.0000	0.0183	0.0004	0.0001	0.0000	0.0000	0.0000
	7 - Belen	Belen Hwy Bridge to Belen RF	4802.12	0.9990	0.7556	1.0000	1.0000	1.0000	0.0159	0.0004	0.0000	0.0000	0.0000	0.0000
	6 - Los Chaves	Los Chaves to Belen Hwy Brid	4824.88	0.9990	0.8280	1.0000	1.0000	1.0000	0.0211	0.0015	0.0002	0.0002	0.0000	0.0000
	5 - Los Lunas	Los Lunas to Los Chaves (RM	4849.32	0.9990	0.9663	1.0000	1.0000	1.0000	0.0052	0.0001	0.0000	0.0000	0.0000	0.0000
	4 - Bosque Farms	Bosque Farms to Los Lunas (R	4866.92	0.2694	0.2507	0.9442	0.9993	1.0000	0.4040	0.1384	0.0463	0.0411	0.0293	0.0282
	3 - Isleta South	Isleta Diversion to Bosque Farr	4886.80	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2 - Isleta North	I-25 Bridge to Isleta Diversion (	4902.87	0.0549	0.0605	0.4645	0.7901	0.9560	0.9723	0.1795	0.0178	0.0127	0.0021	0.0014
	1 -Mountain View	South Div. Ch. to I-25 Bridge (F	4923.60	0.9990	0.9987	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Rio Grande ROB	8 - Belen RR	Belen RR Bridge to EOP (RM	4792.83	0.9990	0.8936	1.0000	1.0000	1.0000	0.0093	0.0004	0.0001	0.0001	0.0000	0.0000
	7 - Belen	Belen Hwy Bridge to Belen RR	4801.90	0.9990	0.9581	1.0000	1.0000	1.0000	0.0060	0.0003	0.0001	0.0001	0.0000	0.0000
	6 - Los Chaves	Los Chaves to Belen Hwy Brid	4823.31	0.9990	0.7539	1.0000	1.0000	1.0000	0.0117	0.0006	0.0001	0.0001	0.0000	0.0000
	5 - Los Lunas	Los Lunas to Los Chaves (RM	4850.58	0.9990	0.8745	1.0000	1.0000	1.0000	0.0103	0.0004	0.0001	0.0000	0.0000	0.0000
	4 - Bosque Farms	Bosque Farms to Los Lunas (R	4867.94	0.0586	0.1350	0.7654	0.9734	0.9993	0.7051	0.3662	0.2006	0.1890	0.1629	0.1603
	3 - Isleta South	Isleta Diversion to Bosque Farr	4888.67	0.4888	0.6779	1.0000	1.0000	1.0000	0.0343	0.0008	0.0002	0.0001	0.0001	0.0000
	2 - Isleta North	I-25 Bridge to Isleta Diversion (	4902.27	0.3941	0.4795	0.9985	1.0000	1.0000	0.0566	0.0006	0.0001	0.0001	0.0000	0.0000
	1 -Mountain View	South Div. Ch. to I-25 Bridge (F	4922.60	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-53 Study Area Performance Characteristics (Present, Without-Project Condition)



Project Performance

File Help

MRG Flood Project Project Performance
by Plans and Damage Reaches by Analysis Year 2058
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
				Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Rio Grande LOB	8 - Belen RR	Belen RR Bridge to EOP (RM 1	4793.75	0.9990	0.9587	1.0000	1.0000	1.0000	0.0043	0.0040	0.0033	0.0033	0.0001	0.0000
	7 - Belen	Belen Hwy Bridge to Belen RR	4802.03	0.9192	0.7288	1.0000	1.0000	1.0000	0.0150	0.0130	0.0099	0.0098	0.0003	0.0000
	6 - Los Chaves	Los Chaves to Belen Hwy Bridg	4824.73	0.9990	0.8941	1.0000	1.0000	1.0000	0.0065	0.0056	0.0049	0.0049	0.0003	0.0001
	5 - Los Lunas	Los Lunas to Los Chaves (RM	4849.30	0.9990	0.9969	1.0000	1.0000	1.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	4 - Bosque Farms	Bosque Farms to Los Lunas (RI	4866.70	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	3 - Isleta South	Isleta Diversion to Bosque Farm	4887.00	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2 - Isleta North	I-25 Bridge to Isleta Diversion (F	4901.64	0.1869	0.1921	0.8815	0.9952	1.0000	0.3763	0.2342	0.0837	0.0747	0.0033	0.0007
	1 -Mountain View	South Div. Ch. to I-25 Bridge (R	4923.40	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Rio Grande ROB	8 - Belen RR	Belen RR Bridge to EOP (RM 1	4792.74	0.9990	0.8919	1.0000	1.0000	1.0000	0.0076	0.0072	0.0064	0.0064	0.0006	0.0002
	7 - Belen	Belen Hwy Bridge to Belen RR	4801.83	0.9990	0.9544	1.0000	1.0000	1.0000	0.0041	0.0037	0.0033	0.0033	0.0007	0.0002
	6 - Los Chaves	Los Chaves to Belen Hwy Bridg	4823.18	0.9990	0.9226	1.0000	1.0000	1.0000	0.0069	0.0060	0.0052	0.0051	0.0002	0.0000
	5 - Los Lunas	Los Lunas to Los Chaves (RM	4850.51	0.9990	0.9667	1.0000	1.0000	1.0000	0.0003	0.0002	0.0002	0.0002	0.0000	0.0000
	4 - Bosque Farms	Bosque Farms to Los Lunas (RI	4867.80	0.1750	0.2198	0.9164	0.9980	1.0000	0.5099	0.4990	0.4911	0.4909	0.1600	0.0623
	3 - Isleta South	Isleta Diversion to Bosque Farm	4888.60	0.9990	0.9868	1.0000	1.0000	1.0000	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
	2 - Isleta North	I-25 Bridge to Isleta Diversion (F	4902.13	0.4449	0.5708	0.9998	1.0000	1.0000	0.0175	0.0084	0.0021	0.0018	0.0002	0.0000
	1 -Mountain View	South Div. Ch. to I-25 Bridge (R	4922.60	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure D-54 Study Area Performance Characteristics (Future, Without-Project Condition)

Vulnerable location identified –

A reference point was selected in the without project scenario where the flood flow would exceed the start of damages first, or most often. Project performance was evaluated at that reference point for all project sizes that effect that location. For each alternative and project size, that reference point was selected in the protected area where residual flows for the events analyzed would exceed the start of damages most often, wherever that reference point may be. For purposes of this analysis, this reference point is important in that start of damages flows occur most frequently, thus the term "vulnerable location" is applied. The vulnerable location does not move to other reference points as various project sizes are applied to the floodplain. With that in mind, project performance tables indicate only where the preproject condition is worst, as there are several other reference points where levee protection is much improved. Table D-88, Table D-89, Table D-90 and Table D-91 describes project performance within the most vulnerable location within the study area as a set of probabilities of structural alternatives containing various damaging flood events.

Worst case scenario –

Given that each flood protection project could affect several of the reference points that collectively describe the flooding problem, a single reference point was selected where

the flood flow would exceed the start of damages first, or most often. For each alternative and project size, a new reference point was selected in the protected area where residual flows for the events analyzed would exceed the start of damages most often, wherever that reference point might be. This scenario tends to discount expected performance of structural alternatives more than the vulnerable location scenario.

Table D-88, Table D-89, Table D-90, and Table D-91 presents the probability that, within each separable element the recommended height, and various sizes of that alternative, that the structure would contain the array of events on an annual basis and for specified time periods (10, 30, or 50 years). The tables also present the conditional non-exceedance probability (CNP), for specific recurrence interval events in both the present and future hydraulic conditions.

Table D-88 Project Performance, Mountainview

Middle Rio Grande, Bernalillo to Belen

Project Performance by Unit

Mountainview Unit

"Worst case" = highest expected AEP.

2008

			Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Model state	Damage reach	Scenario	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	1	Vulnerable	4866.92	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	1	Vulnerable		0.0105	0.0506	0.4052	0.7271	0.9255	0.9321	0.7943	0.5273	0.4921	0.1977	0.1155	
	4	Worst Case		0.1121	0.4175	0.9955	1.0000	1.0000	0.4984	0.3667	0.2299	0.2156	0.0975	0.0594	
Base levee + 1'	1	Vulnerable		0.0058	0.0150	0.1407	0.3156	0.5316	0.9869	0.9385	0.7633	0.7328	0.3775	0.2331	
	4	Worst Case		0.0255	0.1931	0.8830	0.9953	1.0000	0.7473	0.6137	0.4357	0.4141	0.2148	0.1396	
Base levee + 2'	1	Vulnerable		0.0029	0.0049	0.0477	0.1150	0.2168	0.9984	0.9879	0.9126	0.8944	0.5801	0.3911	
	4	Worst Case		0.0064	0.0664	0.4972	0.8207	0.9679	0.9087	0.8178	0.6570	0.6346	0.3825	0.2654	
Base levee + 3'	1	Vulnerable		0.0015	0.0022	0.0222	0.0545	0.1060	0.9999	0.9984	0.9760	0.9689	0.7520	0.5559	
	3	Worst Case		0.0030	0.0208	0.1899	0.4093	0.6510	0.9736	0.9307	0.8230	0.8046	0.5468	0.3931	
Base levee + 4'	1	Vulnerable		0.0009	0.0013	0.0129	0.0319	0.0627	0.9999	0.9999	0.9954	0.9932	0.8680	0.6990	NED
	3	Worst Case		0.0015	0.0065	0.0632	0.1506	0.2786	0.9934	0.9777	0.9219	0.9105	0.7029	0.5404	
Base levee + 5'	1	Vulnerable		0.0005	0.0008	0.0079	0.0196	0.0387	0.9999	1.0000	0.9993	0.9988	0.9361	0.8079	
	3	Worst Case		0.0008	0.0020	0.0200	0.0493	0.0961	0.9987	0.9944	0.9713	0.9658	0.8247	0.6769	
Base levee + 6'	1	Vulnerable		0.0003	0.0003	0.0028	0.0070	0.0139	1.0000	1.0000	0.9999	0.9998	0.9712	0.8843	
	2	Worst Case		0.0007	0.0011	0.0111	0.0274	0.0541	0.9999	0.9999	0.9975	0.9962	0.9048	0.7619	
Base levee + 7'	1	Vulnerable		0.0002	0.0001	0.0009	0.0023	0.0046	1.0000	1.0000	1.0000	1.0000	0.9880	0.9342	
	2	Worst Case		0.0004	0.0005	0.0049	0.0121	0.0241	0.9999	1.0000	0.9996	0.9992	0.9522	0.8459	

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		Damage	Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Scenario		Reach	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	1	Vulnerable		0.9990	0.7495	1.0000	1.0000	1.0000	0.1242	0.0333	0.0083	0.0071	0.0013	0.0007	
Base levee	1	Vulnerable		0.0105	0.0506	0.4052	0.7271	0.9255	0.9321	0.7943	0.5273	0.4921	0.1977	0.1120	
	4	Worst Case		0.1121	0.4175	0.9955	1.0000	1.0000	0.4984	0.3667	0.2299	0.2156	0.0975	0.0594	
Base levee + 1'	1	Vulnerable		0.0058	0.0150	0.1407	0.3156	0.5316	0.9869	0.9385	0.7633	0.7328	0.3775	0.2331	
	4	Worst Case		0.0255	0.1931	0.8830	0.9953	1.0000	0.7473	0.6137	0.4357	0.4141	0.2148	0.1396	
Base levee + 2'	1	Vulnerable		0.0029	0.0049	0.0477	0.1150	0.2168	0.9984	0.9879	0.9126	0.8944	0.5801	0.3911	
	4	Worst Case		0.0064	0.0664	0.4972	0.8207	0.9679	0.9087	0.8178	0.6570	0.6346	0.3825	0.2654	
Base levee + 3'	1	Vulnerable		0.0015	0.0022	0.0222	0.0545	0.1060	0.9999	0.9984	0.9760	0.9689	0.7520	0.5559	
	3	Worst Case		0.0030	0.0208	0.1899	0.4093	0.6510	0.9736	0.9307	0.8230	0.8046	0.5468	0.3931	
Base levee + 4'	1	Vulnerable		0.0009	0.0013	0.0129	0.0319	0.0627	0.9999	0.9999	0.9954	0.9932	0.8680	0.6990	NED
	3	Worst Case		0.0015	0.0065	0.0632	0.1506	0.2786	0.9934	0.9777	0.9219	0.9105	0.7029	0.5404	
Base levee + 5'	1	Vulnerable		0.0005	0.0008	0.0079	0.0196	0.0387	0.9999	1.0000	0.9993	0.9988	0.9361	0.8079	
	3	Worst Case		0.0008	0.0020	0.0200	0.0493	0.0961	0.9987	0.9944	0.9713	0.9658	0.8247	0.6769	
Base levee + 6'	1	Vulnerable		0.0003	0.0003	0.0028	0.0070	0.0139	1.0000	1.0000	0.9999	0.9998	0.9712	0.8843	
	2	Worst Case		0.0007	0.0011	0.0111	0.0274	0.0541	0.9999	0.9999	0.9975	0.9962	0.9048	0.7619	
Base levee + 7'	1	Vulnerable		0.0002	0.0001	0.0009	0.0023	0.0046	1.0000	1.0000	1.0000	1.0000	0.9880	0.9342	
	2	Worst Case		0.0004	0.0005	0.0049	0.0121	0.0241	0.9999	1.0000	0.9996	0.9992	0.9522	0.8459	

Table D-89 Project Performance, Isleta West

Middle Rio Grande, Bernalillo to Belen

Project Performance by Unit

Isleta West Unit

"Worst case" = highest expected AEP.

2008

			Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Model state	Damage reach	Scenario	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	4	Vulnerable	4823.31	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	4	Vulnerable		0.1121	0.4175	0.9955	1.0000	1.0000	0.4984	0.3667	0.2299	0.2156	0.0975	0.0594	
	5	Worst Case		0.1511	0.4382	0.9969	1.0000	1.0000	0.4830	0.3471	0.2205	0.2074	0.0981	0.0629	
Base levee + 1'	4	Vulnerable		0.0255	0.1931	0.8830	0.9953	1.0000	0.7473	0.6137	0.4357	0.4141	0.2148	0.1396	
	5	Worst Case		0.0282	0.2297	0.9264	0.9985	1.0000	0.7127	0.5769	0.4139	0.3946	0.2162	0.1456	
Base levee + 2'	4	Vulnerable		0.0064	0.0664	0.4972	0.8207	0.9679	0.9087	0.8178	0.6570	0.6346	0.3825	0.2654	
	6	Worst Case		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
Base levee + 3'	4	Vulnerable		0.0027	0.0179	0.1655	0.3638	0.5953	0.9772	0.9359	0.8312	0.8138	0.5685	0.4209	
	6	Worst Case		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
Base levee + 4'	4	Vulnerable		0.0013	0.0045	0.0445	0.1075	0.2035	0.9961	0.9834	0.9341	0.9238	0.7332	0.5812	NED
	6	Worst Case		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
Base levee + 5'	4	Vulnerable		0.0007	0.0013	0.0127	0.0313	0.0617	0.9995	0.9968	0.9794	0.9749	0.8536	0.7204	
	6	Worst Case		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	

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		Damage	Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Scenario		Reach	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	4	Vulnerable		0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	4	Vulnerable		0.1121	0.4175	0.9955	1.0000	1.0000	0.4984	0.3667	0.2299	0.2156	0.0975	0.0594	
	5	Worst Case		0.1511	0.4382	0.9969	1.0000	1.0000	0.4830	0.3471	0.2205	0.2074	0.0981	0.0629	
Base levee + 1'	4	Vulnerable		0.0255	0.1931	0.8830	0.9953	1.0000	0.7473	0.6137	0.4357	0.4141	0.2148	0.1396	
	5	Worst Case		0.0282	0.2297	0.9264	0.9985	1.0000	0.7127	0.5769	0.4139	0.3946	0.2162	0.1456	
Base levee + 2'	4	Vulnerable		0.0064	0.0664	0.4972	0.8207	0.9679	0.9087	0.8178	0.6570	0.6346	0.3825	0.2654	
	6	Worst Case		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
Base levee + 3'	4	Vulnerable		0.0027	0.0179	0.1655	0.3638	0.5953	0.9772	0.9359	0.8312	0.8138	0.5685	0.4209	
	6	Worst Case		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
Base levee + 4'	4	Vulnerable		0.0013	0.0045	0.0445	0.1075	0.2035	0.9961	0.9834	0.9341	0.9238	0.7332	0.5812	NED
	6	Worst Case		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
Base levee + 5'	4	Vulnerable		0.0007	0.0013	0.0127	0.0313	0.0617	0.9995	0.9968	0.9794	0.9749	0.8536	0.7204	
	6	Worst Case		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	

Table D-90 Project Performance, Belen East

Middle Rio Grande, Bernalillo to Belen

Project Performance by Unit

Belen East Unit

"Worst case" = highest expected AEP.

2008

			Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Model state	Damage reach	Scenario	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	6	Vulnerable	4824.88	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	6	Vulnerable		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
	6	Worst Case		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
Base levee + 1'	6	Vulnerable		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
	6	Worst Case		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
Base levee + 2'	6	Vulnerable		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
	7	Worst Case		0.0227	0.1074	0.6790	0.9416	0.9966	0.8481	0.6860	0.4556	0.4276	0.1871	0.1098	
Base levee + 3'	6	Vulnerable		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
	7	Worst Case		0.0072	0.0434	0.3583	0.6701	0.8912	0.9416	0.8464	0.6514	0.6230	0.3219	0.2019	
Base levee + 4'	6	Vulnerable		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
	7	Worst Case		0.0041	0.0157	0.1463	0.3267	0.5467	0.9829	0.9406	0.8112	0.7883	0.4806	0.3223	
Base levee + 5'	6	Vulnerable		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	NED
	7	Worst Case		0.0022	0.0055	0.0534	0.1282	0.2399	0.9961	0.9819	0.9149	0.9004	0.6359	0.4571	
Base levee + 6'	6	Vulnerable		0.0005	0.0008	0.0077	0.0192	0.0380	0.9997	0.9984	0.9893	0.9867	0.8988	0.7805	
	7	Worst Case		0.0013	0.0020	0.0196	0.0482	0.0942	0.9993	0.9958	0.9683	0.9609	0.7661	0.5894	
Base levee + 7'	6	Vulnerable		0.0003	0.0003	0.0026	0.0064	0.0128	1.0000	0.9997	0.9973	0.9965	0.9513	0.8663	
	7	Worst Case		0.0008	0.0009	0.0087	0.0216	0.0426	0.9999	0.9992	0.9901	0.9870	0.8609	0.7059	
Base levee + 8'	6	Vulnerable		0.0002	0.0001	0.0012	0.0030	0.0059	1.0000	1.0000	0.9994	0.9992	0.9783	0.9230	
	7	Worst Case		0.0005	0.0006	0.0057	0.0143	0.0284	1.0000	0.9999	0.9973	0.9963	0.9231	0.8006	

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		Damage	Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Scenario		Reach	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	6	Vulnerable		0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	6	Vulnerable		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
	6	Worst Case		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
Base levee + 1'	6	Vulnerable		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
	6	Worst Case		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
Base levee + 2'	6	Vulnerable		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
	7	Worst Case		0.0227	0.1074	0.6790	0.9416	0.9966	0.8481	0.6860	0.4556	0.4276	0.1871	0.1098	
Base levee + 3'	6	Vulnerable		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
	7	Worst Case		0.0072	0.0434	0.3583	0.6701	0.8912	0.9416	0.8464	0.6514	0.6230	0.3219	0.2019	
Base levee + 4'	6	Vulnerable		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
	7	Worst Case		0.0041	0.0157	0.1463	0.3267	0.5467	0.9829	0.9406	0.8112	0.7883	0.4806	0.3223	
Base levee + 5'	6	Vulnerable		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	NED
	7	Worst Case		0.0022	0.0055	0.0534	0.1282	0.2399	0.9961	0.9819	0.9149	0.9004	0.6359	0.4571	
Base levee + 6'	6	Vulnerable		0.0005	0.0008	0.0077	0.0192	0.0380	0.9997	0.9984	0.9893	0.9867	0.8988	0.7805	
	7	Worst Case		0.0013	0.0020	0.0196	0.0482	0.0942	0.9993	0.9958	0.9683	0.9609	0.7661	0.5894	
Base levee + 7'	6	Vulnerable		0.0003	0.0003	0.0026	0.0064	0.0128	1.0000	0.9997	0.9973	0.9965	0.9513	0.8663	
	7	Worst Case		0.0008	0.0009	0.0087	0.0216	0.0426	0.9999	0.9992	0.9901	0.9870	0.8609	0.7059	
Base levee + 8'	6	Vulnerable		#N/A	0.0001	0.0012	0.0030	0.0059	1.0000	1.0000	0.9994	0.9992	0.9783	0.9230	
	7	Worst Case		0.0005	0.0006	0.0057	0.0143	0.0284	1.0000	0.9999	0.9973	0.9963	0.9231	0.8006	

Table D-91 Project Performance, Belen West

Middle Rio Grande, Bernalillo to Belen

Project Performance by Unit

Belen West Unit

"Worst case" = highest expected AEP.

2008

			Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Model state	Damage reach	Scenario	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	8	Vulnerable	4792.83	0.9990	0.9181	1.0000	1.0000	1.0000	0.0275	0.0060	0.0013	0.0012	0.0003	0.0003	
Base levee	8	Vulnerable		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
	6	Worst Case		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
Base levee + 1'	8	Vulnerable		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
	6	Worst Case		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
Base levee + 2'	8	Vulnerable		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
	7	Worst Case		0.0227	0.1074	0.6790	0.9416	0.9966	0.8481	0.6860	0.4556	0.4276	0.1871	0.1098	
Base levee + 3'	8	Vulnerable		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
	7	Worst Case		0.0072	0.0434	0.3583	0.6701	0.8912	0.9416	0.8464	0.6514	0.6230	0.3219	0.2019	
Base levee + 4'	8	Vulnerable		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
	7	Worst Case		0.0041	0.0157	0.1463	0.3267	0.5467	0.9829	0.9406	0.8112	0.7883	0.4806	0.3223	
Base levee + 5'	8	Vulnerable		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	NED
	7	Worst Case		0.0022	0.0055	0.0534	0.1282	0.2399	0.9961	0.9819	0.9149	0.9004	0.6359	0.4571	
Base levee + 6'	8	Vulnerable		0.0005	0.0008	0.0077	0.0192	0.0380	0.9997	0.9984	0.9893	0.9867	0.8988	0.7805	
	7	Worst Case		0.0013	0.0020	0.0196	0.0482	0.0942	0.9993	0.9958	0.9683	0.9609	0.7661	0.5894	
Base levee + 7'	8	Vulnerable		0.0003	0.0003	0.0026	0.0064	0.0128	1.0000	0.9997	0.9973	0.9965	0.9513	0.8663	
	7	Worst Case		0.0008	0.0009	0.0087	0.0216	0.0426	0.9999	0.9992	0.9901	0.9870	0.8609	0.7059	
Base levee + 8'	8	Vulnerable		0.0002	0.0001	0.0012	0.0030	0.0059	1.0000	1.0000	0.9994	0.9992	0.9783	0.9230	
	7	Worst Case		0.0005	0.0006	0.0057	0.0143	0.0284	1.0000	0.9999	0.9973	0.9963	0.9231	0.8006	

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		Damage	Target	Target Stage AEP		Long Term Risk (years)			Conditional Non-Exceedance Probability						
Scenario		Reach	Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%	
Without Project	8	Vulnerable		0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Base levee	8	Vulnerable		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
	6	Worst Case		0.1234	0.4277	0.9962	1.0000	1.0000	0.4914	0.3552	0.2184	0.2039	0.0871	0.0519	
Base levee + 1'	8	Vulnerable		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
	6	Worst Case		0.0290	0.2266	0.9234	0.9984	1.0000	0.7154	0.5777	0.4005	0.3797	0.1892	0.1200	
Base levee + 2'	8	Vulnerable		0.0076	0.0958	0.6347	0.9194	0.9935	0.8760	0.7744	0.6068	0.5841	0.3363	0.2264	
	7	Worst Case		0.0227	0.1074	0.6790	0.9416	0.9966	0.8481	0.6860	0.4556	0.4276	0.1871	0.1098	
Base levee + 3'	8	Vulnerable		0.0036	0.0321	0.2786	0.5581	0.8047	0.9593	0.9051	0.7839	0.7644	0.5095	0.3665	
	7	Worst Case		0.0072	0.0434	0.3583	0.6701	0.8912	0.9416	0.8464	0.6514	0.6230	0.3219	0.2019	
Base levee + 4'	8	Vulnerable		0.0017	0.0093	0.0895	0.2089	0.3741	0.9901	0.9688	0.9026	0.8900	0.6766	0.5198	
	7	Worst Case		0.0041	0.0157	0.1463	0.3267	0.5467	0.9829	0.9406	0.8112	0.7883	0.4806	0.3223	
Base levee + 5'	8	Vulnerable		0.0009	0.0026	0.0257	0.0629	0.1219	0.9982	0.9921	0.9641	0.9578	0.8092	0.6631	NED
	7	Worst Case		0.0022	0.0055	0.0534	0.1282	0.2399	0.9961	0.9819	0.9149	0.9004	0.6359	0.4571	
Base levee + 6'	8	Vulnerable		0.0005	0.0008	0.0077	0.0192	0.0380	0.9997	0.9984	0.9893	0.9867	0.8988	0.7805	
	7	Worst Case		0.0013	0.0020	0.0196	0.0482	0.0942	0.9993	0.9958	0.9683	0.9609	0.7661	0.5894	
Base levee + 7'	8	Vulnerable		0.0003	0.0003	0.0026	0.0064	0.0128	1.0000	0.9997	0.9973	0.9965	0.9513	0.8663	
	7	Worst Case		0.0008	0.0009	0.0087	0.0216	0.0426	0.9999	0.9992	0.9901	0.9870	0.8609	0.7059	
Base levee + 8'	8	Vulnerable		0.0002	0.0001	0.0012	0.0030	0.0059	1.0000	1.0000	0.9994	0.9992	0.9783	0.9230	
	7	Worst Case		0.0005	0.0006	0.0057	0.0143	0.0284	1.0000	0.9999	0.9973	0.9963	0.9231	0.8006	

D-19 Evaluation of Non-Structural Alternatives:

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Floodplain Management Regulations

Bernalillo and Valencia Counties participate in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for the Rio Grande River and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced. Floodplain management regulations and enforcement would have the effect of mitigating flood damages in the future due to new development, but does nothing for the exiting flood problem, nor the future flooding condition. Floodplain management is considered a reasonable and prudent measure with or without a constructed flood risk management feature, but this measure was not carried forward for alternative evaluation in this appendix. The future conditions in this economic evaluation does not include any future development in the floodplain for reasons described in Para. D-06.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts given early warning); the primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

The evaluation presented in the Economics Appendix assumes that 1.0 of the 2.3 vehicles per capita in New Mexico residences have been evacuated, and that all operable commercial and public vehicles have already been evacuated prior to any flooding. A flood warning system would present benefits by reducing the amount of residential contents subject to flooding. Assuming that residential contents were half the Residential EAD presented in Table D-20, that would indicate an effective and understood flood warning system would decrease EAD by at most 10.6%. The high residual damages, and the flood threat to other infrastructure (roads, agriculture, utilities, public and commercial properties) suggests that a flood warning system is ineffective and incomplete on its own. Further, relative to the structural alternatives presented, it's impossible for a flood warning system to provide greater net benefits.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the

structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

   Corps experience has indicated that relocations and buyouts only work when the land left behind is repurposed to some other public good, such as a public park or reuniting the acquired land with the floodway. The Federal Emergency Management Agency estimates relocation costs at between $99 and $116 per square foot (1999 dollars), which exceeds the depreciated replacement costs of just about every structure in the floodplain. (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-28, Table 3-9).The study area floodplain extends for over 43 river miles, and represents a wide and flat area next to the perched Rio Grande main channel. Reuniting the overbank with the channel, which sits higher than the overbank, exacerbates the flooding problem, and this measure is considered impractical. Relocations also do nothing for the flood risk to public properties (e.g. public infrastructure such as roads and utilities), and is therefore an incomplete solution to the flood problem.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-federal sponsor.

   As stated previously with relocations, acquiring properties in a floodplain next to a perched channel has limited utility. The acquired land cannot be returned to the floodway without exacerbating the flood problem. Further, the study area's floodplains extend over 43 river miles, and is over 1 mile wide in parts. Repurposing land for a public good like a park is also infeasible, as it would represent an incomplete solution to the flood problem.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are

greater than three (3) feet per second. It would also not be applicable to mobile homes, due to the type of construction and typical lack of anchoring to a foundation.

Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Table D-2 and Table D-3 in the economics appendix displays the water surface elevations associated with various events. In many locations, flood stages are expected to exceed 3', rendering the flood proofing measures ineffective. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator. Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space. Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

   FEMA has estimated that elevation in place for slab-on-grade homes (the most common foundation type in the study area) can cost $80-88 per square foot (2009 dollars) for a frame home, and $88-96 per square foot for a masonry home (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-20, Table 3-3). That value exceeds the per square foot depreciated replacement cost of most of the improvements in the floodplain, which makes this alternative infeasible.

D-20 Comparison of the Tentatively Selected Plan to the Authorized Plan:

The authorized plan was last presented in a 1986 General Design Memorandum, which describes a system of levees extending through various reaches throughout the study area, as described above. Table D-92 compares the benefits and costs of the tentatively selected plan to the Authorized Project. Table D-93 identifies the changes in cost apportionment between the authorized project and this

tentatively selected plan.

There have been several changes in the damages and benefit computations between the Authorized Plan (1979) and the tentatively selected plan (2013). Table D-94 outlines, by damage category, the equivalent annual damages by property type for both the 1979 and the present analysis. Table D-95 describes the benefits attributable to the authorized plan (1979) and the tentatively selected plan (2016).

1979

The economic analysis performed for the 1979 Appendix to Update Project Decision Document was done in a non-risk and uncertainty based model called LA Damages, which was consistent with guidance at the time, but is no longer used by the Army Corps of Engineers. The 1979 analysis used floodplain data from 4 events (10%, 2%, 1%, and 0.5% chance exceedance) to compute equivalent annual damages.

2017

As described in this economics appendix, the 2017 economic analysis was performed using the Corps' certified risk and uncertainty tool, HEC-FDA version 1.2.5. The 2014 analysis uses 8 events for the without-project condition, and 5 events for the with-project condition. Several other factors in this present evaluation differ from the evaluation supporting the Authorized Plan, which are highlighted below:

New hydraulics and hydrology – The 2017 analysis includes factors that weren't evaluated in 1979, such as the perched channel, and significant sediment accumulations over the study time period, which substantially alters the future without- and future with-project conditions. Sediment accumulations have the effect of increasing future damages for a given flow, and attenuating any project's performance in the future, with-project condition.

New economic evaluation guidance – The Corps' shift from a deterministic, point-estimate of damages and benefits attributable to specific-frequency events to an evaluation incorporating concepts of risk and uncertainty has had the impact of increasing damages and benefits attributable to projects. Experience with prior Albuquerque District studies in the mid-1990s suggested that merely shifting from a deterministic model to a risk and uncertainty-based model increased EAD and benefits by 25%. The biggest boost to EAD came from the variability surrounding the probability economic damages began (the "start of damages" condition).

Another factor serving to increase EAD and claimable benefits came from Economic Guidance Memorandum (EGM) 04-01, which provided generic depth-damage relationships for residential structures and contents. Studies conducted prior to the memo used FIA claims data to populate depth-damage relationships, where the newer curves used research conducted by the Corps' Institute for Water Resources (IWR) evaluation of factors such as warning time, inundation duration, etc... The curves were developed for nation-wide applicability, and per the EGM, site-specific depth-damage relationships, content valuations, and content-to-structure ratios are not required to be developed when using these newer curves. This saves study dollars. The newer curves also differ from prior studies in that non-zero damages start at -2' for a one-story, no basement structure, which

is the predominant residential structure type in the study area. A direct comparison of the IWR curves, which contain a mean and standard deviation of damages for each inundation depth, to the curves used in the 1979 analysis demonstrated slightly higher damages for each inundation depth. Curve selection served to increase EAD about 60% for residential structures and contents, holding other factors constant.

New floodplain inventory of damageable properties and NED benefits – Since the 1979 evaluation, several changes to the nature of the economic evaluation took place. The 1979 evaluation contains property types (Equipment, Sediment and Business Losses) that weren't directly correlated to the present evaluation. In the 2017 evaluation, significant lengths of railroad track were in the study area floodplain, which doesn't seem to be the case with the 1979 analysis. Several structures (97) were hay storage shelters, and were coded as "Commercial." Those structures had content values up to 10 times structure value, and were located close to the river. Further, those contents (bales of hay) use depth-% damage curves that show 85% damage with three feet of inundation. In the present evaluation, outbuildings referred to material storage sheds, shelters for vehicles or covered storage, like hay storage buildings. In some cases, a storage shed on a residential property would merely be coded "Residential" during the field inventory. The outbuildings category served as a catch-all to identify structures and contents, where ownership and use (public or commercial) was not easily identifiable.

The agricultural damages and benefits changed slightly from 1979 to 2017, which is largely attributable to new crop budget data showing increased input costs, and relatively flat revenues per acre relative to 33 years ago. Subsequently, there appears to be less acreage in production.

One factor that's indeterminable in the comparison between the 1979 analysis and this document is the change in damages attributable to specific frequency events. The reported damages by event in 1979 were limited to the 1% AEP and less frequent. This analysis sees significant damages at the 10% AEP event, because the floodplain is flat and extensively inundated by then. Frequent events are a significant contributor to AED because of the high structure count in the 10% AEP floodplain. Table D-4 and Table D-5 demonstrate that the structure count for the 10% AEP floodplain is 76% of the 1% AEP floodplain in the east bank and about 89% for the west bank.

Finally, the 1979 evaluation does a fairly decent breakdown of the source of damages by property type, but doesn't do a similar breakdown of project *benefits.* Therefore, many fields in Table D-95 remain unfilled.

Table D-92 Comparison of Recommended Plan to Authorized Plan – Benefits and Costs

Category	Authorized Project			LRR/SEIS (May 2016)
	1979 Decision Document		**Values in Current Prices[3]**	**Preliminary Preferred Plan**
Structures or Parcels in 0.4% probability floodplain	9783		9783	10,473
Structures or Parcels in 1% probability floodplain	7540		7540	8,729
Total Value of Damageable Property (x$1,000,000)	359.3		1311.45	722.55
Damages 1% Probability Event (x$1,000,000)	87.9		320.84	428
Damage 0.4% Probability Event (x$1,000,000)	117.9		430.335	598
Price Level	Jan-77		Jul-14	May-16
Interest Rate	6-3/8%		3-1/2%	2.75%
Period of Analysis	100 years		50 years	50 years
Risk-Based	No		No	Yes
EAD – Without-Project (existing, x $1,000,000)	3.9		14.235	113.6 million4
EAD – With-Project (x $1,000,000)	0.6		2.19	5 million4
Benefits (x $1,000,000)	3.3 [1]		12.05	135.7 million4
Annual Costs (x $1,000,000)	2.2 [1]		8.03	14.1 million4
Net Benefits (x $1,000,000)	1.1 [1]		4.02	122 million4
B/C Ratio	1.5		1.5	9.63

[1] October 1978 Price Level, 6 7/8%

[2] October 1993 Price Level, 8 1/4%

[3] Will incorporate information in subsequent submittals.

[4] Based on the NED Levee Plan – Height varies by unit

[5] Includes IDC and benefits during construction

Table D-93 Comparison of Recommended Plan to Authorized Plan – Cost Apportionment

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - COST APPORTIONMENT						
Item	Authorized Project (October 1978 Prices)		Authorized Project (May 2016 Prices)		Preliminary Preferred Plan (Program Year, 1 Oct 2016 Prices)	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
Construction[a] (Flood Risk Management)	$22,418,000	$3,290,000	$77,984,523		240,885.44	
LERRDs		0		0	-c	0.00
Total First Cost (Flood Risk Management)	**$22,418,000**	**$3,290,000**	**$77,984,523**		**$240,885**	**$0**
Mandatory 5% Cash		$4,184,000	($3,899,200)	$3,899,200	($12,000)	$12,000
Subtotals	$22,418,000	$7,474,000	$74,085,323	$3,899,200	$228,885	$12,000
Percentage of Total Cost-Shared Amount	*95%*	*5%*	*95%*	*5%*	*95%*	*5%*
Additional Cash to Provide Minimum Non-Federal Share of Total Project Costs	($1,420,500)	$1,420,500	($15,596,900)	$15,596,900	($72,300)	$72,300
Subtotals	$20,997,500	$8,894,500	$58,488,423	$19,496,100	$156,585	$84,300
Percentage of Total Cost-Shared Amount	*75%*	*25%*	*75%*	*25%*	*65%*	*35%*
TOTALS	**$20,997,500**	**$8,894,500**	**$58,488,423**	**$19,496,100**	**$156,585**	**$84,300**
Percentage of Total Cost-Shared Amount	*90%*	*10%*	*75%*	*25%*	*65.00%*	*35.00%*

Table D-94 Comparison of Recommended Plan to Authorized Plan - EAD

COMPARISON OF RECOMMENDED PLAN TO AUTHORIZED PLAN - EAD							
	Authorized Project (x$1,000)				LRR/SEIS (May 2016)		
Category	**1979 Decision Document**	**Price Level Update Factor**	**Values in Current Prices3**	**Basis of Price Level update**	**Preliminary Preferred Plan**	**Difference**	**Basis of Difference**
Residential	2118.1	3.65	7731.065	CPI-U (annual average)	33,671	25,939.67	Additional structures evaluated, perched channel evaluation, new structure and content curves, risk based analysis, new H&H data, price level update of structures, content damages a function of structure value
Commercial	758.2	3.65	2767.43	CPI-U (annual average)	26,284.16	23,516.73	Additional structures evaluated, perched channel evaluation, new structure, risk based analysis, new H&H data, price level update of structures and contents
Public	841.8	3.65	3072.57	CPI-U (annual average)	7,447.90	4,375.33	Additional structures evaluated, perched channel evaluation, new structure, risk based analysis, new H&H data, price level update of structures and contents
Apartments	Not available				157.97	157.97	
Outbuildings	Not available				3,156.41	3,156.41	
						0.00	
Vehicles	Not available				11,231.60	11,231.60	Price level update of vehicles, risk based analysis, vehicles a function of additional structures in floodplain, perched channel evaluation
Streets, Roads	Not available				20,535.52	20,535.52	Railroad track length included in floodplain
Utilities	Not available				1,081.38	1,081.38	
Crops	13.6	2.62	35.68721805	PPI (Farm Products, US Average, Not seasonally adjusted)	13.31	-22.38	Updated crop budgets yield lower revenues on per acre basis. Less acreage in production as a result.
Irrigation Facilities	31	3.94	122.2427947	ENR Construction Cost Index	142.42	20.18	
Equipment	56.7					0.00	Reclassified into other damage categories in current evaluation.
Business Losses	108	3.65	394.2	CPI-U (annual average)		-394.20	Value of water in Middle Rio Grande basin increased, new volume of water saved.
Aircraft	Not available				201.13	201.13	Aircraft damages are included in current evaluation.
Railroad	Not available				10.89	10.89	Railroad track length included in floodplain
Sediment	16.2	3.94	63.88171852	ENR Construction Cost Index		-63.88	Current recommended plan does not include sediment management features.
Emergency Costs	Not available				1,060.76	1,060.76	
TOTAL	3943.6		14187.07673		104,994.18	90,807.10	

Table D-95 Comparison of Recommended Plan to Authorized Plan – Average Annual Benefits

	Authorized Project (x$1,000)					LRR/SEIS (May 2016)		
Category	1979 Decision Document	Price Level Update Factor	Values in Current Prices3	Basis of Price Level update	Authorized Plan (May 2016 prices)	Preliminary Preferred Plan	Difference (1979 Authorized to 2013 Authorized)	Difference (2016 Authorized to 2016 Recommended)
Residential					30,502.76	31,701.58		1,198.82
Commercial					25,295.78	25,575.47		279.69
Public					6,942.19	6,944.72		2.53
Apartments					150.43	150.24		-0.19
Outbuildings					2,719.12	2,921.97		202.85
								0.00
Vehicles					10,009.85	10,510.84		500.99
Streets, Roads					19,058.89	19,539.71		480.82
Utilities					1,003.59	1,028.95		25.36
Crops					12.36	12.66		0.30
Irrigation Facilities					128.11	131.45		3.34
Equipment								0.00
Business Losses								0.00
Aircraft					178.47	178.47		0.00
Railroad					10.04	10.37		0.33
								0.00
Emergency Costs					984.15	1,009.57		25.42
								0.00
TOTAL	3,372.80	3.65	12,310.72	CPI-U (annual average)	96,995.75	108,640.32	84,685.03	11,644.57

D-21 Plan for Updating Project Benefits in the Future:

At the time that a project update is required, the significant assumptions regarding hydrology and hydraulics will be reviewed. All pertinent economic assumptions shall be reviewed. After determining whether there have been changes in the basic assumptions, the following shall be analyzed:

Residential neighborhoods shall be sampled to determine current values. Real estate agents, appraisers and the Marshall and Swift Valuation Service will be used in updating residential values.

Discussions with local realtors and businessmen combined with field sampling will be made to determine if major changes have occurred to businesses existing at the time of the initial inventory. Important changes affecting structure or content values will be included in the update. As is the case of residential values, the Marshall and Swift Valuation Service and local appraisers and realtors will be contacted regarding commercial values.

After consultation with city planners and examining city building permits; residential, public and commercial growth since the inventory was taken shall be sampled as needed within the flood plain. The growth shall be included, as appropriate, in the updated benefit computations.

The results of the reanalysis shall be documented in a "Special Evaluation Report" (SER).