Dallas Floodway, Dallas, Texas
Draft Feasibility Report

US Army Corps of Engineers

MAIN REPORT

April 2014

City of Dallas

Acronyms and Abbreviations

%	percent
AEP	Annual Exceedance Probability
ALARP	As Low As Reasonably Practicable
ASA(CW)	Assistant Secretary of the Army for Civil Works
AT&SF	Atchison, Topeka and Santa Fe
BVP	Balanced Vision Plan
BCRA	Base Condition Risk Assessment
CDC	Corridor Development Certificate
CEQ	Council of Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
CWWTP	Central Wastewater Treatment Plant
DCFCD	Dallas County Flood Control District
DCLID	Dallas County Levee Improvement District
DDR	Design Documentation Report
DFE	Dallas Floodway Extension
EAD	Equivalent Annual Damages
EAP	Emergency Action Plan
EIS	Environmental Impact Statement
EO	Executive Order
ER	Engineering Regulation
EWLIDS	East and West Levee Interior Drainage Systems
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
FRM-TSP	Flood Risk Management Tentatively Selected Plan
FHWA	Federal Highway Administration
gpm	gallons per minute
H&H	Hydrology and Hydraulics
HEC	Hydrologic Engineering Center
HEC-FDA	Hydrologic Engineering Center – Flood Damage Reduction Analysis
HEC-FIA	Hydrologic Engineering Center – Flood Impact Analysis
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HTRW	Hazardous, Toxic, and Radioactive Waste
HQUSACE	Headquarter U.S. Army Corps of Engineers
HU	habitat unit
IDP	Interior Drainage Plan
IDS	Interior Drainage System
IH	Interstate Highway
K	thousand
LRP	Levee Remediation Plan
MDCP	Maintenance Deficiency Correction Period
NCTCOG	North Central Texas Council of Governments
NED	National Economic Development
NEPA	National Environmental Policy Act
NPV	Net Present Value
NTTA	North Texas Tollway Authority
O&M	Operations and Maintenance
OMRR&R	Operations, Maintenance, Repair, Replacement, and Rehabilitation
P&S	plans and specifications
PAR	Population at Risk
PED	Pre-construction, Engineering and Design
PEIS	Programmatic EIS
PFM	Potential Failure Mode
PI	Periodic Inspection
PMP	Project Management Plan
POV	personal occupancy vehicle
PPA	Project Partnership Agreement
RMC	Risk Management Center
ROD	Record of Decision
SH	State Highway
SPF	Standard Project Flood
TPWD	Texas Parks and Wildlife Department
TRC	Trinity River Corridor
TRCP	Trinity River Corridor Project
TREIS	Trinity River Environmental Impact Statement
TRCCLUP	Trinity River Corridor Comprehensive Land Use Plan
TSP	Tentatively Selected Plan
TxDOT	Texas Department of Transportation
U.S.	United States
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UTRFS	Upper Trinity River Feasibility Study
UTRB PEIS	Upper Trinity River Basin Programmatic EIS
WRDA	Water Resources Development Act

DALLAS FLOODWAY, DALLAS, TEXAS

DRAFT FEASIBILITY REPORT

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EXECUTIVE SUMMARY

STUDY INFORMATION

This report documents the results of a feasibility study initiated in response to Section 5141 of the Water Resources Development Act (WRDA) of 2007 (Public Law 110-114). This report has been developed as a cooperative effort by the United States Army Corps of Engineers (Corps) Fort Worth District and the City of Dallas, Texas (non-Federal sponsor). Further, since implementation of any plan under Section 5141 of WRDA 2007 represents a significant Federal action, an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, is required and will be prepared and provided under separate cover. The EIS development is in progress.

The purpose of the report is to determine the technical and environmental acceptability of the City of Dallas' Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) in accordance with the authorization of Section 5141 of WRDA 2007. It also identifies which features of the BVP and IDP Projects are appropriate for recommendation under Section 5141 of WRDA 2007. Should this feasibility report be approved by the Corps, Director of Civil Works, and a Record of Decision (ROD) be signed by the Assistant Secretary of the Army for Civil Works (ASA [CW]), the project would not require additional authorization for construction (provided it falls within the parameters of the authorization of Section 5141 of WRDA 2007).

The City of Dallas' BVP and IDP are projects that address flood risk, environmental restoration and management, parks and recreation that are part of a long-range vision for the entire Trinity River Corridor (TRC), commonly referred to as the Trinity River Corridor Project (TRCP). Other TRCP proposals include transportation, community and economic development projects. These local features are projects which will not be a part of a Recommended Plan, but their implementation does represent a modification to an existing Federal project, the Dallas Floodway Project. The local features are required to undergo a Section 408 review by the Corps. The local features are evaluated as a part of the "Comprehensive Analysis" along with the BVP and IDP Projects. The local features included in the Comprehensive Analysis are the Trinity Parkway, Trinity River Standing Wave, the Santa Fe Trestle Trail, the Pavaho Wetlands, the Dallas Horseshoe Project, the Sylvan Avenue Bridge, Jefferson Memorial Bridge, Dallas Water Utilities Waterlines, Continental Bridge, and the East Bank/West Bank Interceptor Line.

PROBLEMS AND OPPORTUNITIES

The population of the Dallas-Fort Worth Metroplex has mushroomed to 6.5 million people, making it one of the 10 largest in the United States. The touchstone 1908 Dallas flood, which killed five people and left 4,000 homeless, set in motion what has become a series of major water projects to respond to this dynamic growth environment. Among the major actions taken in response were a major Trinity River relocation and levee construction program in the 1920s, a Federal levee system constructed in the 1950s and construction of a series of upstream flood-control reservoirs (1952-1987).

Following Trinity River flooding in 1989 and 1990, the City of Dallas (in conjunction with regional stakeholders) began looking at ways to outline a long-range vision for the entire TRC. The vision aimed to reclaim the Trinity River as a great natural resource in order to create a unique public domain and achieve a model of environmental stewardship. In 1998, Dallas voters authorized the largest bond package in city history – $246 million – to fund flood control, recreation and transportation projects in the

TRC. In the subsequent years of planning and community input, the City of Dallas and stakeholders developed concepts for addressing five key issues:

- Flood Risk Management;
- Environmental Restoration and Management;
- Parks and Recreation;
- Transportation; and
- Community and Economic Development (City of Dallas 2003).

The outcome of this effort culminated in "The Balanced Vision Plan" for the TRC (December 2003, amended March 2004). The BVP aims to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the Dallas Floodway Project.

The same levees that provide flood damage benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. The City of Dallas' reports entitled, "The Interior Levee Drainage Study, East Levee – Phase I, Dallas, Texas," dated September 2006, and "The Interior Levee Drainage Study, West Levee - Phase II, Dallas, Texas," dated February 2009 (City of Dallas 2006, 2009) identify means to reduce the stormwater flood risk for structures located within the predicted flood area for the 100-year, 24-hour storm event. Collectively, these reports are referred to as the City of Dallas' Interior Drainage Plan (IDP).

The BVP and IDP Projects were developed by the City of Dallas to address problems and opportunities that are above those normally considered by the Corps. Transportation, community and economic development projects do not align with the traditional Corps missions and are generally the responsibility of locals and other Federal agencies. However, the Corps does have an interest in flood risk management (FRM) and ecosystem restoration and an ancillary interest in providing recreation development. Problems and opportunities were identified, and goals and objectives were developed that align with the three identified Corps mission areas of FRM, ecosystem restoration, and recreation. These objectives were used to measure the success of individual measures, as well as determine which parts of the BVP and IDP Projects are appropriate for recommendation under Section 5141 of WRDA 2007.

Flood Risk Management

Levee structural integrity issues were identified with the Periodic Inspection Report Number 9 (PI Report No. 9) for the Dallas Floodway Project, when the system received an overall "unacceptable" rating. The Corps's Institute for Water Resources, Risk Management Center (RMC) developed a Base Condition Risk Assessment (BCRA) for the Dallas Floodway Project. The purpose of the BCRA was to quantify and evaluate risks posed by the East and West Levees associated with Trinity River flooding. The findings in the BCRA were instrumental in determining Dallas Floodway Project risks and solutions and risk informed decision on the path forward. Using the BCRA to define the baseline risks with the Dallas Floodway Project and the knowledge of the conditions of the existing Interior Drainage System (IDS), problem and opportunity statements were developed as shown in Table ES-1.

In addition to the risks associated with the levees themselves, the city is also experiencing frequent inundation due to interior drainage on the protected side of the levees. While interior drainage is normally a local responsibility, the current authorization allows for Corps participation in this problem. The Federal Emergency Management Agency (FEMA) is proposing to remap the floodplain behind the levees not only due to the levee issues identified in PI Report No. 9, but also because the current condition of the Interior Drainage System (IDS) doesn't contain the 100-year flood event.

Table ES-1. Flood Risk Management Problems and Opportunities

Problem 1	*Opportunity 1*
There is approximately $12 billion (in structure and content value) in floodplain investment behind the Dallas Floodway Project that is at risk from a failure of the levee system. There is approximately $5 million in remaining equivalent annual damages with the Dallas Floodway Project in place.	Reduce the equivalent annual damages behind the levees.
Problem 2	*Opportunity 2a*
The levee system could overtop, overtop and breach, or breach prior to overtopping and could result in flood damages and loss-of-life.	Prevent the levees from overtopping, overtopping and breaching, and/or breaching prior to overtopping.
	Opportunity 2b
	Improve the City of Dallas' Emergency Action Plan (EAP).
Problem 3	*Opportunity 3*
Desiccation cracking on the levees has led to slope failures in the past and will continue to contribute to slope failures in the future. Desiccation cracking has been determined to be low risk; however, they do lead to increased operations and maintenance (O&M) cost.	Reduce O&M costs due to desiccation cracking.
Problem 4	*Opportunity 4*
Undersized pumps and sumps result in flood damages and general flooding on the protected side of the levees.	Increase pump and sump capacity to handle the 100-year event.
Problem 5	*Opportunity 5*
Pending FEMA rule, updates may result in remapping of 100-year flood zones behind levee systems that are not protected by 100-year interior drainage projects.	Increase pump and sump capacity to handle the 100-year event.
Problem 6	*Opportunity 6*
Several proposals to modify the Dallas Floodway Project have the potential to impact the functioning of the Dallas Floodway Project.	The Corps could take a bigger role in project design and implementation to ensure major project features do not impact the authorized functioning of the Dallas Floodway Project.

Aquatic Ecosystem Restoration

The major Trinity River relocation and levee construction program in the 1920s channelized the Trinity River and led to a number of ecological consequences for the aquatic ecosystem. Historically, the Trinity River contained natural channel forming processes that supported the function, structure, and diversity of riparian and aquatic components of the riverine ecosystem. The losses to structure and function of the riverine system resulting from channelization and maintenance include:

- Lack of diverse in-channel habitat complexity due to the current structure of the Trinity River channel;
- Steep, uniform channel bank slopes;
- Riparian vegetation along the existing channel is relatively limited in extent, density, and diversity; and
- Transition from in-channel to floodplain habitat is abrupt and limits habitat quality.

The degradations listed above provide an image of the structurally and functionally homogenous and restrained riverine system which characterizes the existing and future condition of the Trinity River. The

result is degraded riverine habitat which no longer supports the historic level of organism diversity at any trophic level. The restoration of some of the historic structure, function and dynamic nature of the Trinity River such as those listed above, will capitalize on the opportunity to provide benefits to fish and wildlife in the Dallas Metroplex. Table ES-2 summarizes the aquatic ecosystem restoration problems and opportunities.

Table ES-2. Aquatic Ecosystem Problems and Opportunities

Problem 7	*Opportunity 7*
River function and habitat has been degraded over time due to relocation of the river channel within the Dallas Floodway.	Restore a more naturally functioning river within the Dallas Floodway to benefit fish and wildlife.

Water Related Problems and Opportunities

There are limited recreational opportunities available in the Dallas Floodway, and most people do not perceive the Dallas Floodway as a desirable destination for active recreation, festivities, or nature observation. There is also inadequate access to the Dallas Floodway, which hampers the public's ability to enjoy the limited existing recreational opportunities. There is a latent recreation demand for open space and water related recreation in the downtown area. While this is not a primary mission area for the Corps, there is an opportunity to modify the Floodway to increase recreational opportunity along the vast areas of the Dallas Floodway Project.

Table ES-3. Water Related Problems and Opportunities

Problem 8	*Opportunity 8*
There is latent recreation demand for open space and water related recreation in the downtown Dallas.	Modify the Floodway to increase recreational opportunity along the vast areas of the Dallas Floodway Project.

PLANS CONSIDERED

While the City of Dallas had broad goals for the entire TRC, the Corps is somewhat limited to determining what combination of the BVP and IDP Projects best align with Corps missions and objectives for recommending a plan to implement under Section 5141 of WRDA 2007. The following are objectives for plans to be implemented under Section 5141 of WRDA 2007:

- Protect the flood risk reduction function of the Dallas Floodway Project over the life of the project;
- Reduce residual flood risk to property and promote life safety over a 50-year period of analysis;
- Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis; and
- Provide water-related recreational opportunities within the boundaries of the Dallas Floodway Project.

Flood Risk Management

A variety of structural and nonstructural plans were developed that address the flood risk due to Trinity River flooding. Plan formulation focuses on identifying a plan that maximizes National Economic Development (NED) in combination with a plan that reduces life-safety risk and maintains or improves levee resiliency. Plans that do not meet these criteria were eliminated from further consideration. The formulation process assumed the Dallas Floodway Extension Project, as authorized, is fully constructed.

Sixteen structural and nonstructural plans were initially considered and screened. Nine structural and nonstructural plans were carried forward for detailed evaluation due their ability to contribute to the objectives of the FRM component of the BVP including:

- Atchison, Topeka and Santa Fe Bridge (AT&SF) Modification;
- Levee Height Modification (Levee Raises);
- Levee Armoring;
- Levee Controlled Overtopping;
- Seepage Cut-Off Walls;
- Levee Side Slope Flattening;
- Improved Emergency Action Planning;
- Localized Buyouts; and
- Instrumentation.

A plan to maximize NED and reduce life-safety risks was identified. The plan (NED Plan) includes raising levee low spots in select locations to pass a 277,000 cubic feet per second (cfs) flow combined with the AT&SF Railroad Bridge modification because it is the plan with the most economic benefits as a stand-alone alternative. Two additional plans were analyzed in a final array of alternatives for their ability to complement the NED Plan and further reduce life-safety risk. The additional plans included in the final array are:

- The 277,000 cfs Levee Raise and AT&SF Railroad Bridge Modification with Controlled Overtopping; and
- The 277,000 cfs Levee Raise with AT&SF Railroad Bridge Modification with Cut-Off Walls.

One of the City of Dallas' goals was to address flood risk management issues, so their BVP included raising the levees up to 2 feet above the Standard Project Flood (SPF) water surface profile combined with riverside side slope flattening to a 4-to-1, width-to-height ratio (4H:1V). The FRM component of the BVP was formulated per Corps NED guidance. It was determined through the formulation process (using NED analysis and loss-of-life estimates) that the 4H:1V side slopes or the system-wide 2-foot levee raise were not required to provide increased levels of risk reduction. The formulation process identified that raising levee low spots to pass the 277,000 cfs flow with 3H:1V side slopes and the AT&SF Railroad Bridge modification was the NED Plan. Table ES-4 presents the economic summary of the NED Plan at the current interest rate and OMB interest rate. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the non-Federal sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, where the existing slopes are steeper than 4H:1V at 100% non-Federal cost.

Table ES-4. Economic Summary of the NED Plan (October 2013 Price Level)

	3.5 Percent	***7 Percent***
INVESTMENT		
Construction	$8,366,000	$8,366,000
PED	$944,000	$944,000
Construction Management	$837,000	$837,000
Estimated First Cost	$10,146,000	$10,146,000
Annual Interest Rate	3.5%	7.0%
Project Life (years)	50	50
Construction Period (months)	22	22

	3.5 Percent	*7 Percent*
Interest During Construction	$328,000	$659,000
Investment Cost	$10,474,000	$10,805,000
Interest	$367,000	$756,000
Amortization	$80,000	$27,000
OMRR&R ($/year)	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$477,000**	**$813,000**
Without Project EAD	$5,511,000	$5,456,000
Residual EAD	$3,817,000	$3,775,000
Flood Reduction Benefits	$1,695,000	$1,681,000
TOTAL BENEFITS	**$1,695,000**	**$1,681,000**
NET BENEFITS	**$1,218,000**	**$868,000**
BENEFIT-COST RATIO	**3.6**	**2.1**

Additional localized nonstructural plans were evaluated to see whether remaining residual risk not captured by more comprehensive alternatives could contribute to the life-safety objective. The City of Dallas has an existing in-depth Emergency Action Plan (EAP) that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. Floodplain inundation maps will be provided to the City of Dallas so emergency action personnel target these areas first. Localized buyouts were considered but not economically viable and not included in the NED Plan.

A risk assessment was performed by the Risk Management Center to measure the changes in life-safety risk that occur for the plans considered. The 277,000 cfs levee raise (including the modification to the AT&SF Railroad Bridge) on the East and West Levee reduces risk of overtopping with a subsequent breach but not below the recommended tolerable risk guideline. Levee armoring, controlled overtopping techniques and seepage cut-off walls were evaluated to see if a breach could be prevented before or following an overtopping thereby reducing life-safety risk. The analysis concluded the alternatives were not cost effective and did little to reduce the total estimated risk. Total estimated risk is dominated by the overtopping and subsequent breach failure mode for the East and West Levee.

Balanced Vision Plan and Interior Drainage Plan

Following identification of the NED Plan, the Corps performed the Comprehensive Analysis to ensure that all of the proposed features of the BVP and IDP Projects are technically sound and environmentally acceptable. In addition, all local features were analyzed to ensure that they meet Section 408 criteria and function in combination with the BVP and IDP Projects from a system-wide approach. The technical soundness and environmental acceptability for the BVP and IDP Projects highly depends on considerations for the proposed Trinity Parkway alternatives. Therefore, the BVP and IDP alternatives were developed for both the Trinity Parkway combined with the BVP and IDP and one without. The following alternatives were considered for the technically sound and environmentally acceptable determinations.

- No-Action Alternative;
- Alternative 2: Proposed Action with the Trinity Parkway; and
- Alternative 3: Proposed Action without the Trinity Parkway.

TECHNICALLY SOUND AND ENVIRONMENTALLY ACCEPTABLE

The The BVP and IDP Projects were evaluated to determine whether the features met the technically sound and environmentally acceptable criteria established for the review. The design completed for the BVP and IDP Projects during this phase is technically sound for the current stage of the projects and will provide a sound basis for future development of engineering products. Making feasibility-level technically sound determinations of multiple projects in various stages of design and construction carries with it some level of risk. Major features of the BVP and IDP Projects are listed in Table ES-5. The key risks identified in the Comprehensive Analysis are related to designs provided for the River Relocation, the BVP Lakes, BVP grading plans, bridge pier modifications, earthen berms separating the River Relocation and the BVP Lakes, the clay liner and lake drainage system associated with the BVP Lakes, River Relocation erosion control, and the Trinity Parkway Geotechnical Report. The risks are related to ensuring levee system integrity, level of design detail and integration of multiple projects across the Floodway. Risks have been determined manageable at this stage given continued coordination and integration of design throughout the remaining design phases as recommended in this report.

The results of the Comprehensive Analysis showed that the overall BVP and IDP Projects did not meet the Trinity River Regional EIS Record of Decision (ROD) criteria in terms of valley storage and water surface rise. Potential negative impacts related to deviations from the ROD criteria are estimated to be insignificant and a variance to the ROD would be recommended.

If an action is "environmentally acceptable," it means the action has been determined to be acceptable through the application of the NEPA process, is acceptable to the public as well as other State and Federal agencies, minimizes the extent of environmental mitigation requirements, and meets other environmental laws and regulations. The BVP was developed after 20 years of coordination with the public, especially the low-income, minority dominated residential neighborhoods within and adjacent to the BVP and IDP Projects. These neighborhoods will receive the greatest benefit from the recreational amenities proposed, as they have been historically under-served. The designs were modified and refined to meet local demand. Based on the extensive communication with the affected residential communities, the recreational amenities proposed directly reflect the requests of the communities. The Corps has similarly lead public outreach efforts to target these residential communities since the NEPA process and feasibility study were initiated, and continues to receive positive feedback thus far. The Corps will continue to coordinate with the public, Federal, State and other agencies. Both alternatives considered in the Comprehensive Analysis along with other cumulative projects, as applicable, have similar impacts to habitat types in terms of habitat acreage and quality throughout the 50-year period of analysis. Results suggest that under both Alternative 2 and Alternative 3, habitat quality would increase over time as compared to the "No Action" alternative or future without-project condition.

Subject to completion of the NEPA process, issuance of Section 401 water quality certification, the BVP and IDP Projects are environmentally acceptable for the purpose of complying with Section 5141 of WRDA 2007. This determination applies to Alternative 2 and Alternative 3 evaluated in the Comprehensive Analysis.

RECOMMENDED PLAN

The BVP and IDP Projects have been determined to be technically sound and environmentally acceptable, but this does not mean that the Corps recommends them for implementation under Section 5141 of WRDA 2007. The Corps determined which features of the BVP and IDP Projects should be

recommended and implemented to align with Corps mission areas and contributed to the objectives developed for the study.

Table ES-5 presents the features of the City of Dallas' BVP and IDP Projects and the Recommend Plan for implementation under Section 5141 of WRDA 2007. The Recommended Plan for Section 5141 of WRDA 2007 is a subset of the overall BVP and IDP Projects because the Corps could not recommend all features due to cost limitations. The Corps recommended the project features that the Corps traditionally participates in, contributed the most to the objectives of the study and had the greatest potential to affect life-safety risk. The Recommended Plan includes the NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements), levee side slope flattening, the IDP Phase I (Able, Hampton, and Baker pump stations, and the Nobles Branch sump improvements), the proposed River Relocation, and the Corinth Wetlands. Currently, the Recommended Plan assumes the Trinity Parkway is built in the Floodway.

Table ES-5. BVP and IDP Projects and the Recommended Plan for Section 5141 of WRDA 2007

Category	*Description*	*Proposed BVP and IDP*	*WRDA Features*
BVP Flood Risk Management			
Levees	Raise to 277,000 cfs Flood Height	✓	✓
AT&SF	Removal of Wood Bridge Segment	✓	✓
	Removal of Concrete Bridge Segment	✓	✓
	Removal of Embankment Segments	✓	✓
Levee Flattening	Flattening the Riverside Levee Side Slopes to 4H:1V	✓	✓
Nonstructural	Emergency Action Plan Improvements	✓	✓
BVP Ecosystem and Recreation			
Lakes	West Dallas Lake	✓	
	Urban Lake	✓	
	Natural Lake	✓	
River	Realignment and Modification	✓	✓
Wetlands	Marshlands	✓	
	Hampton and Biofiltration Wetlands	✓	
	Cypress Ponds	✓	
	Corinth Wetlands	✓	✓
Athletic Facilities	Potential Flex Fields	✓	
	Playgrounds	✓	
	River Access Points	✓	
General Features	Parking and Public Roads	✓	
	Lighting	✓	
	Vehicular Access	✓	
	Pedestrian Amenities	✓	
	Restrooms	✓	
Interior Drainage Outfall Extensions	Extend Pump Station Outfalls	✓	✓
	Extend Pressure Sewer Outfalls	✓	✓
Able Sump Ponds	Recreation and Ecosystem Enhancements	✓	

Category	*Description*	*Proposed BVP and IDP*	*WRDA Features*
IDP Flood Risk Management			
East Levee	Construct Hampton 3 Pump Station, rehabilitate New Hampton and demolish Old Hampton Pump Stations	✓	✓
	Nobles Branch Sump Improvements	✓	✓
	Able Pump Station and Sump Improvement	✓	✓
	Baker Pump Station and Sump Improvement	✓	✓
West Levee	Demolish Charlie Pump Station	✓	
	Construct New Charlie Pumping Station	✓	
	Rehabilitate Existing Delta Pump Station	✓	
	Construct New Delta Pumping Station	✓	
	Eagle Ford and Trinity-Portland Sump Improvements	✓	
	Construct New Trinity-Portland Pumping Plant	✓	

The NED Plan (277,000 cfs levee raise and AT&SF Railroad Bridge modification) was formulated to meet Corps policy and is included in the Recommended Plan. Based on safety hazard of mowing steep side slopes, and because it is part of the BVP, the City of Dallas wishes to pursue construction of the 4H:1V side slopes. This feature will be pursued at 100% non-Federal cost. Floodplain inundation maps are available to the City of Dallas so emergency action personnel target high risk areas first.

The River Relocation would restore the sinuosity to the Trinity River and allow the river to naturally form aquatic habitats such as pools, sandbars (riffles), and more diverse variety of instream structures. When combined with the Corinth Wetlands, and other wetland projects, the channel realignment design will significantly improve floodplain habitat and connectivity. The River Relocation also presents the greatest risk to the functioning of the levee system due to the potential to increase seepage under the levees, which could result in levee failure. This risk is mitigated with the installation of seepage cut-off walls, but it still presents engineering challenges. Because the River Relocation feature is required to implement other BVP features, is an engineering challenge, and poses potential risk to the levee system, is located within the Dallas Floodway Project footprint, and it supports all of the objectives, this feature is recommended for implementation under Section 5141 of WRDA 2007.

The City of Dallas' Interior Drainage Plan (IDP) would reduce predicted 100-year, 24-hour storm event flooding levels, resulting in a significant reduction in the number of structures and people potentially affected by flooding in the City of Dallas. The IDP includes constructing new pump stations and improving some of the existing sumps for interior drainage behind the East and West Levees. These project features all contribute to the two most important objectives by maintaining the functioning of the Floodway through improving interior drainage and further reducing flood damages through increasing risk reduction behind the levee system. The City of Dallas' Interior Drainage Plan is recommended for implementation under Section 5141 of WRDA 2007. The West Levee IDP is part of the City of Dallas' IDP, but because the IDP Phase II report was not specifically named in Section 5141 of WRDA 2007, it cannot be included in the Recommended Plan. These features include Charlie Pump Station, Delta Pump Station, Pavaho Pump Station, and the new Trinity Portland Pump Station. These facilities will be constructed by the City of Dallas as Section 408 projects.

The Urban, Natural and West Dallas Lakes, and other ecosystem restoration projects in the BVP are not recommended to be part of the plan for implementation under Section 5141 of WRDA 2007. While the

Corps could recommend additional BVP features as recreation opportunities or ecosystem restoration, they would increase the project cost above the authorized project cost limit.

The Recommended Plan for implementation under Section 5141 of WRDA 2007 includes:

- NED Plan (277,000 Levee Raise with AT&SF Railroad Bridge Modification and EAP Improvements);
- Levee Side Slope Flattening at 100% non-Federal cost;
- IDP Phase I (Able, Hampton, and Baker Pump Stations, and the Nobles Branch Sump Improvements) on the East Levee;
- River Relocation; and
- Corinth Wetlands.

The Recommended Plan assumes the Trinity Parkway is built in the Floodway.

REMAINING SECTION 408 ACTIVITIES

In the Comprehensive Analysis, the Corps reviewed the City of Dallas' BVP and IDP Projects and found them to be technically sound and environmentally acceptable. The BVP and IDP Projects have several features that are not part of the Recommended Plan for implementation under Section 5141 of WRDA 2007, but can be constructed through the Section 408 permit process under the River and Harbors Act of 1899. The non-Federal sponsor will be responsible for the construction of remaining features of the BVP and IDP Projects and their associated cost. The City of Dallas and the proponents of the Trinity Parkway will provide separate Section 408 permit submittals for Corps approval that can reference the technical and environmental evaluation presented in this feasibility report as appropriate. These 408 packages will be submitted concurrent to the approval of this feasibility report. National Environmental Policy Act (NEPA) compliance and Section 404 for the entire BVP and IDP Projects are provided in the Environmental Impact Statement (EIS) accompanying this report and will be used as supporting documentation for the Section 408 submittal.

RECOMMENDED PLAN HABITAT IMPACTS

While the project moves into the design and implementation phase, the Corps recommends no net loss of bottomland hardwoods and emergent wetlands as construction occurs. Unavoidable impacts during construction would be offset through implementation of the Corinth Wetlands and River Relocation with the addition of emergent wetlands and riparian/bottomland hardwood plantings with the River Relocation in the Recommended Plan. Changes in habitat acres and habitat units over a 50-year period of analysis indicate there would be a net loss in acres for emergent wetlands, a slight increase in bottomland hardwoods, and a relatively large gain in acres of aquatic riverine. The greatest reduction of habitat value is to grassland habitat. This is not because the habitat value is degrading, but because grassland would be converted to other habitat types upon implementing the Recommended Plan. Overall, the environmental features in the Recommended Plan provide better functions and values (considering changes in grassland habitat as a tradeoff for more desirable habitat types) than the future without-project condition. In terms of Habitat Units (HU), the Recommended Plan increases habitat quality by 235 HUs in the project area for the desired habitat types over the 50-year period of analysis.

COSTS

The costs associated with the final Recommended Plan are presented in Table ES-6. The Recommended Plan is estimated to cost approximately $579,077,000 at October 2013 price levels. The project authorization allows the City of Dallas to receive credit for implementing project features in advance of signing a Project Partnership Agreement. Considering credit, the total project cost was adjusted to $529,123,000, to be cost shared at $343,930,000 Federal and $185,193,000 non-Federal.

Table ES-6. Cost Estimate Summary for the Recommended Plan

Total First Cost Oct 2013 Price Level	
Flood Risk Management	
01 Lands and Damages	$16,672,000
06 Fish and Wildlife	$48,000
08 Roads, Railroads, and Bridges	$1,551,000
11 Levees and Floodwalls	$6,767,000
13 Pumping Plant	$196,675,000
30 Planning, Engineering and Design	$18,800,000
31 Construction Management	$16,717,000
FRM Total	**$257,229,000**
Ecosystem Restoration (ER)	
02 Relocations	$42,706,000
06 Fish and Wildlife	$5,679,000
08 Roads, Railroads and Bridges	$38,982,000
09 Channels	$179,838,000
30 Planning, Engineering and Design	$28,924,000
31 Construction Management	$25,720,000
ER Total	**$321,849,000**
Total	**$579,077,000**

TIMELINE

Public Review of the Draft Dallas Floodway Feasibility Report and Environmental Impact Statement will begin April 18, 2014 and a Public Hearing is scheduled for May 8, 2014. A Civil Works Review Board is not required; however, a Senior Leadership Meeting at the Corps Headquarters will take place in August 2014. A Director's Report is anticipated in November 2014. The Record of Decision (ROD) is scheduled to be signed in December 2014.

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CHAPTER 1
STUDY INFORMATION

1.1 OVERVIEW

This report documents the results of a feasibility study initiated in response to Section 5141 of the Water Resources Development Act (WRDA) of 2007 (Public Law 110-114). This report has been developed as a cooperative effort by the United States Army Corps of Engineers (Corps) Fort Worth District and the City of Dallas, Texas (non-Federal sponsor). Further, since implementation of any plan under Section 5141 of WRDA 2007 represents a significant Federal action, an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, is required and will be prepared and provided under separate cover. The EIS development is in progress.

1.2 STUDY AUTHORITY

The study was authorized by Section 5141 of WRDA 2007, which reads as follows:

> *(a) IN GENERAL.— The project for flood control, Trinity River and tributaries, Texas, authorized by Section 2 of the Act entitled, ''An Act authorizing the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes'', approved March 2, 1945 (59 Stat. 18), is modified to—*
>
> *(1) direct the Secretary to review the Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas, dated December 2003 and amended in March 2004, prepared by the non-Federal interest for the project;*
>
> *(2) direct the Secretary to review the Interior Levee Drainage Study Phase-I report, Dallas, Texas, dated September 2006, prepared by the non-Federal interest; and*
>
> *(3) if the Secretary determines that the project is technically sound and environmentally acceptable, authorize the Secretary to construct the project at a total cost of $459,000,000, with an estimated Federal cost of $298,000,000 and an estimated non-Federal cost of $161,000,000.*
>
> *(b) CREDIT.—*
>
> *(1) IN-KIND CONTRIBUTIONS.—The Secretary shall credit, in accordance with section 221 of the Flood Control Act of 1970 (42 U.S. Code [U.S.C.] 1962d–5b), toward the non-Federal share of the cost of the project the cost of planning, design, and construction work carried out by the non-Federal interest for the project before the date of the partnership agreement for the project.*
>
> *(2) CASH CONTRIBUTIONS.—The Secretary shall accept funds provided by the non-Federal interest for use in carrying out planning, engineering, and design for the project. The Federal share of such planning, engineering, and design carried out with non-Federal contributions shall be credited against the non-Federal share of the cost of the project."*

Should this feasibility report be approved by the Corps, Director of Civil Works, and a Record of Decision (ROD) be signed by the Assistant Secretary of the Army for Civil Works (ASA [CW]), the project would not require additional authorization for construction (provided it falls within the parameters of the authorization of Section 5141 of WRDA 2007). The feasibility report will be a full response to Section 5141 of WRDA 2007.

1.3 STUDY PURPOSE AND SCOPE

The primary purpose of this study is to determine the technical and environmental acceptability of the City of Dallas' Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) and which features of the BVP and IDP Projects are appropriate for recommendation under Section 5141 of WRDA 2007. The BVP and IDP Projects address flood risk, environmental restoration and management, parks and recreation that are part of a long-range vision for the entire Trinity River Corridor (TRC), commonly referred to as the Trinity River Corridor Project (TRCP). Other TRCP proposals include transportation, community and economic development projects. These other proposals are evaluated by the Corps in a comprehensive, system-wide assessment of the overall plan for implementing elements of the TRCP, to ensure the integrity of the Dallas Floodway Project. Collectively, these actions result in the development of a "Comprehensive Analysis" as defined in the Implementation Guidance for Section 5141 of WRDA 2007 and described in greater detail in Section 1.7.

1.4 STUDY AREA

1.4.1 Upper Trinity River Watershed

The study area is situated within the Upper Trinity River Watershed (Figure 1-1, box inset), along the Trinity River near Dallas, Texas. The Upper Trinity River watershed is defined as the area from its headwaters to approximately Interstate Highway (IH) 20 Bridge (near Five Mile Creek) in south Dallas and covers about 6,275 square miles. It includes the majority of the Dallas-Fort Worth Metroplex. The headwaters of the three branches included in the Upper Trinity River Watershed (West, Elm, and Clear Forks) are generally north of the Dallas-Fort Worth Metroplex. Terrain in the Upper Trinity River watershed varies in elevation from about 1,200 feet National Geodetic Vertical Datum (NGVD) at the headwaters of the West Fork of the Trinity River just northeast of Olney, Texas, to about 380 feet National Geodetic Vertical Datum at the confluence with Five Mile Creek. Five Corps flood control reservoirs exist in the Upper Trinity watershed including: Lakes Benbrook, Lewisville, Grapevine, Joe Pool and Ray Roberts. Additional major Corps flood control projects in the Upper Trinity watershed include the Fort Worth Floodway, the existing Dallas Floodway Project, and the Dallas Floodway Extension (DFE) Project.

The study area presented in Figure 1-1 was developed during the study process and corresponds to the resources analyzed in the accompanying National Environmental Policy Act (NEPA) document. The study area displayed here covers 48,263 acres, or approximately 19% of the land area of the City of Dallas.

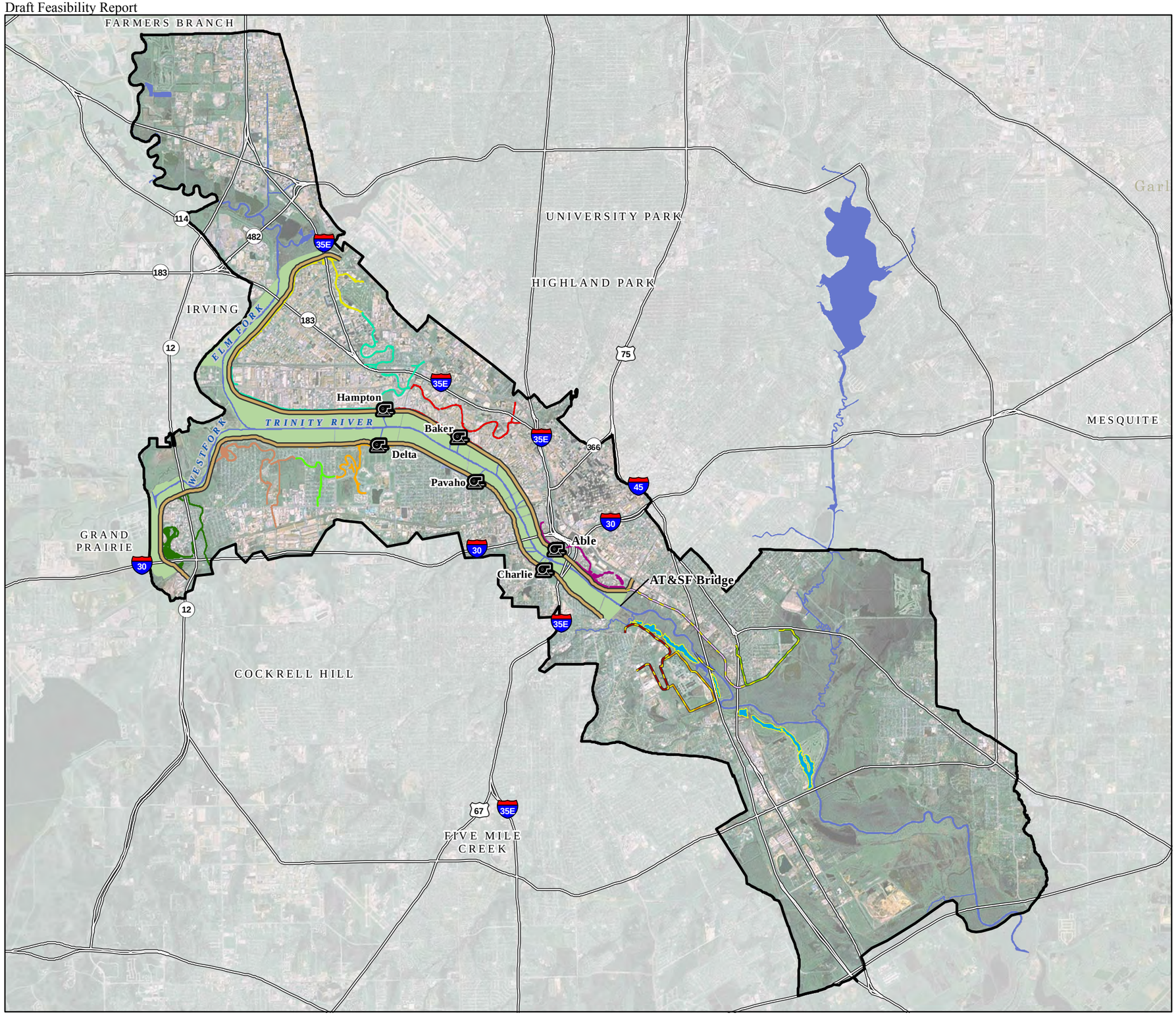


Figure 1-1
Dallas Floodway Study Area

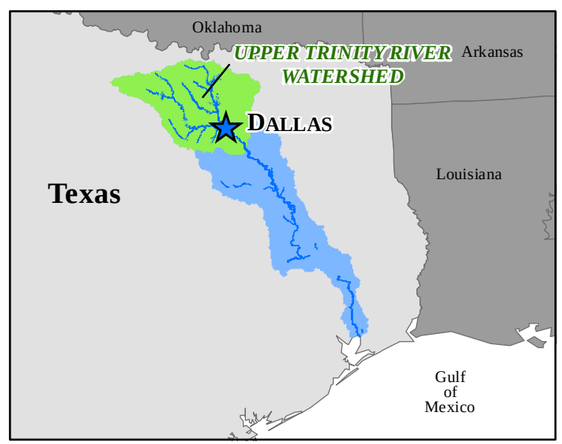
LEGEND

Study Area Features
- Pumping Plant
- Dallas Floodway Levee System Levee
- Freeway
- Study Area
- Dallas Floodway
- Surface Water

DFE Features
- Lamar Street Levee
- Cadillac Heights Levee
- Rochester Park Levee
- Central Wastewater Treatment Plant Levee Upgrade
- Trinity River Realignment

East Levee Sumps
- Able
- Hampton - Oak Lawn
- Nobles Branch
- Record Crossing

West Levee Sumps
- Charlie
- Eagle Ford
- Frances Street
- Pavaho
- Trinity - Portland
- Westmoreland - Hampton



0 0.5 1 2 Kilometers
0 0.5 1 2 Miles

Sources: City of Dallas 2008a, NCTCOG 2008

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1.4.2 Project Area

The focal point in the study area (project area) is the existing Dallas Floodway Project, comprised of the East and West Levees and the area between the levees commonly referred to as the "Floodway." The Dallas Floodway Project encompasses the East and West Levees, Floodway, and interior drainage system features including drainage structures, pressure sewers, pump stations and sump areas. The East and West Levees extends along the Trinity River upstream from approximately the Atchison, Topeka and Santa Fe (AT&SF) Railroad Bridge at Trinity River Mile 497.37, to the confluence of the West and Elm Forks at River Mile 505.50, thence upstream along the West Fork for approximately 2.2 miles and upstream along the Elm Fork approximately 4 miles. Of the 22.6 miles of levees within this reach, the East Levee is 11.7 miles in length and the West Levee is 10.9 miles in length, which includes a 1.5-mile segment along Mountain Creek. The authorized DFE Project area is directly downstream of the East and West Levee (approximately downstream of the AT&SF Railroad Bridge). The distance between the levees vary between approximately 2,500 feet to 3,000 feet and extends for nearly eight river miles on the main stem of the Trinity River. The levees are approximately 30 feet high with slopes that vary. Through the Floodway, the existing river channel is approximately 30 feet deep and 200 to 250 feet wide at its banks. The existing Dallas Floodway Project features are displayed in Figure 1-1.

The same levees that provide flood damage reduction benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. A system of sump areas, pressure sewers and pump stations has been constructed to accommodate the interior drainage. The stormwater runoff collects in low-lying areas on the land side of the levees (typically a remnant of the historic river channel) until it can be pumped into the river, drain through pressure sewers, or drain through gravity sluices. There are six pumping plants and sumps, seven pressure sewers and gravity sluices associated with the Interior Drainage System (IDS). The location of the pump stations and sumps are shown in Figure 1-1.

1.5 STUDY PARTICIPANTS

The Fort Worth District and the City of Dallas are preparing this feasibility report and an Environmental Impact Statement (EIS) in accordance with the study purpose. The Federal Highway Administration (FHWA) is a cooperating agency for the EIS. The study area lies within the jurisdiction of the 30th, 32nd, and 33rd Congressional Districts of Texas, and the representatives are Eddie Bernice Johnson, Pete Sessions, and Marc Veasey, respectively. Current U.S. Senators from Texas are John Cornyn and Ted Cruz. The TRCP organization is an entity within the City of Dallas whose mission is to facilitate the implementation (with regional stakeholders) of the BVP and the Trinity River Corridor Comprehensive Land Use Plan (TRCCLUP) (City of Dallas 2005). The TRCP has several on-going studies/projects, including the DFE Project, Trinity Corridor Transportation Improvements (e.g., the proposed Trinity Parkway), the Trinity Bridges, the Trinity Trails, and the Great Trinity Forest. The on-going studies related to the TRCP involve coordination with multiple Federal (e.g., Corps, FHWA, and the Federal Emergency Management Agency), State (e.g., the Texas Department of Transportation, Texas Historical Commission) and local agencies.

1.6 PRIOR STUDIES, REPORTS AND EXISTING WATER PROJECTS

The water resource studies, reports and water projects (generally presented in chronological order) related to the Dallas Floodway Project prepared by the Corps and non-Federal entities including the City of Dallas are described below.

1.6.1 Historic Dallas Floodway Development

A catastrophic flood in 1908 led the City of Dallas to seek protection from Trinity River flooding. Between 1928 and 1932, the Dallas County Levee Improvement District (DCLID) constructed earthen levees to provide flood risk benefits the City of Dallas from riverine flooding. The DCLID relocated the confluence of the West and Elm Forks, rerouted the Trinity River by constructing a channel within the leveed Floodway, and filled or set aside the original channel for sump storage. These original levees had a total length of 22.6 miles, an average crest width of 6 feet, an average height of 26 feet, and a maximum height of 37 feet (USACE 1955).

1.6.2 U. S. Army Corps of Engineers

Trinity River and Tributaries, Texas; House Document Numbered 403, 77th Congress (USACE 1941) and the Rivers and Harbors Act of 1945; and Trinity River at Dallas and Fort Worth, Texas; House Document Numbered 242, 81st Congress (USACE 1949) and the Rivers and Harbors Act of 1950.

To reduce the riverine flood risk within the City of Dallas, Congress authorized the flood control project (commonly referred to as the Dallas Floodway, Dallas, Texas project, or the Dallas Floodway Project) in 1945, and again in 1950. From August 1952 to June 1955, the Corps produced six reports for design of the Dallas Floodway improvements to the original DCLID levees and interior drainage facilities.

U.S. Army Engineer District, Fort Worth, Corps of Engineers, Operation and Maintenance Manual, Dallas Floodway, West Fork, Elm Fork, Trinity River, Texas (USACE 1960).

In May 1960, the non-Federal sponsor for the Dallas Floodway Project, the Dallas County Flood Control District (DCFCD) formally accepted the Corps Operation and Maintenance (O&M) Manual for the Dallas Floodway Project (USACE 1960). The purpose of the O&M Manual was to furnish detailed information regarding the Dallas Floodway Project and its essential features, and to aid local interests in carrying out their obligation under the regulations governing acceptance of a completed project constructed by the Corps. The DCFCD formally transferred O&M responsibilities to the City of Dallas in 1968.

Trinity River and Tributaries Regional Environmental Impact Statement and Record of Decision.

The Trinity River and Tributaries Regional Environmental Impact Statement (TREIS) was prepared by the Fort Worth District to address the proposed increases in floodplain development occurring in the Upper Trinity River Basin during the Dallas-Fort Worth Metroplex development boom in the mid-1980s (USACE 1988a). Individually or cumulatively, future projects are expected to have the potential to increase the flood risk to development already in the floodplain.

The ROD prepared for the TREIS specified criteria that the Corps would use to evaluate future Section 404 permit applications in the Trinity River basin; specifically, projects located within the Standard Project Flood (SPF) floodplain of the Elm Fork Trinity River, the West Fork Trinity River and the main stem of the Trinity River. The TREIS ROD established criteria for actions that require a Corps permit to address hydrologic and hydraulic impacts and mitigation of habitat losses (USACE 1988a). The findings in the TREIS provided the impetus for follow-on studies under the 1988 Upper Trinity River Study Authority (USACE 1988b).

Regional Trinity River Corridor Development Certificate Process.

In response to the TREIS and ROD, cities and counties in the Trinity River watershed formed the Trinity River Steering Committee (Steering Committee), facilitated by the North Central Texas Council of Governments (NCTCOG). The Steering Committee adopted a Draft Statement of Principles for Common Permit Criteria (in February 1988), a Resolution for a Joint Trinity River Corridor Development Certificate (CDC) Process (in December 1988), and a Regional Policy Position on the TRC (in February 1989).

The CDC and the 1988 ROD hydrologic and hydraulic criteria are used to ensure that projects are designed in such a way that there are no flood rises in the water surface profile and that there are no valley storage losses for the 100-year (or 1% Annual Exceedance Probability) flood and less than 5% valley storage loss for the SPF event. The process requires that a permit applicant prepare a Hydrologic Engineering Center – River Analysis System (HEC-RAS) model for the proposed project using the current CDC HEC-RAS model as a base condition. The CDC HEC-RAS model is maintained and usually distributed by the Corps to be used for evaluation of any and all projects that require a Section 404 Permit or a CDC Permit.

Upper Trinity River Feasibility Study Activities (1990 - 2007).

The Corps initiated the Upper Trinity River Feasibility Study (UTRFS) in response to the authority contained in the U.S. Committee on Environment and Public Works Resolution dated April 22, 1988 and the findings of the 1990 Upper Trinity River Basin Reconnaissance Report. The UTRFS identified approximately 90 potential projects addressing flood risk management (FRM), ecosystem restoration and recreation within the Upper Trinity River Basin (USACE 1988b). Of these 90 projects, three Corps projects were identified that had local sponsorship and were viewed as reasonably foreseeable, including modifications to the Dallas Floodway Project.

Upper Trinity River Basin Programmatic Environmental Impact Statement (USACE 2000).

Initiated in 1996, the Upper Trinity River Basin Programmatic EIS (UTRB PEIS) focused on various potential Corps projects that were identified and investigated as part of the UTRFS. The Corps initiated the study under the 1988 authority. Potential Corps projects that were addressed in the UTRB PEIS included the DFE Project, Johnson Creek Project, Stemmons North Industrial Project, Dallas Floodway Project, and the West Fork-Clear Fork Project. Potential projects by other entities that were also addressed in the PEIS include the Trinity Parkway.

General Reevaluation Report and Integrated EIS for the Dallas Floodway Extension, Trinity River Basin, Texas (USACE 1999, 2003).

The DFE Project, authorized by the Flood Control Act of 1965, was initiated in December 2001 to construct the Chain of Wetlands, the Cadillac Heights Levee and Lamar Levee, and recreation features immediately downstream of the existing Dallas Floodway Project (USACE 2003). Construction of this project is on-going.

Periodic Inspection, Dallas Floodway Project, Trinity River, Dallas, Dallas County, Texas, Report No. 9 (USACE 2009).

The Corps performed Period Inspection Report Number 9 (PI Report No. 9) using a new inspection template on December 3-5, 2007 (USACE 2009). This inspection was the 9th PI for the East Levee and West Levee, and the first PI for both the Rochester Park Levee and the Central Wastewater Treatment Plant (CWWTP) Levee systems which are components of the DFE Project. All eight prior PIs resulted in

an acceptable rating for the Dallas Floodway Project. Very specific language and rating criteria described in the new inspection template resulted in an "unacceptable rating" for the Dallas Floodway Project in the 9th Periodic Inspection.

1.6.3 City of Dallas

Rochester Park and Central Wastewater Treatment Plant Levees.

The approximate 2.8-mile Rochester Park Levee was constructed by the City of Dallas in 1991. The City of Dallas has since maintained the levee as part of its overall project operation and maintenance program. The Rochester Levee protects residential and commercial interests in East Dallas. The approximate 2.6-mile CWWTP Levee was constructed by the City of Dallas in the 1940s and the levee was raised and improved by the City of Dallas in 1994. The CWWTP Levee protects critical utility infrastructure in South Dallas. At the direction of Congress, these two levee systems were added to the DFE Project in 1996.

Dallas Floodway Phase I Construction.

Beginning in the late 1990s and continuing through 2000, the City of Dallas has made improvements to the Trinity River channel, levees and IDS. These improvements included widening portions of the existing river channel and increasing the height of some portions of the levees to two feet above the 1950s design elevation.

Balanced Vision Plan (City of Dallas 2003, 2004).

The BVP contains the flood risk management, environmental restoration and recreation features defined in the report prepared by the City of Dallas entitled, "The Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas," dated December 2003, and amended in March 2004.

Trinity River Corridor Comprehensive Land Use Plan (City of Dallas 2005).

The City of Dallas uses the TRCCLUP as a tool for guiding development and investment decisions in the TRC. In this way, the TRCCLUP guides zoning decisions relating to potential future private development towards land uses that complement identified public BVP elements.

Levee Interior Drainage Study – East Levee Phase I Report, Dallas, Texas; and West Levee Phase II Report (City of Dallas 2006 and 2009a).

Recent stormwater flood events have demonstrated that improvements are needed to the East and West Levee Interior Drainage Systems (ELIDES) to reduce the risk of interior flooding. In March 2006, the need for improving the EWLIDS was demonstrated when a significant local storm caused widespread stormwater flooding in the City of Dallas, resulting in one fatality and significant property damage. These reports outline the City of Dallas plans for improving the EWLIDS, commonly referred to as the Interior Drainage Plan (IDP), IDP Phase I on the East Levee and IDP Phase II for the West Levee.

Draft Problem Identification Report (City of Dallas 2009c) and Draft Levee Remediation Plan.

As a follow-up to PI Report No. 9, the City of Dallas conducted a preliminary analysis and design check of the Dallas Floodway Project for the 100-year riverine flood event and the current SPF event. The report, *Preliminary Analysis and Design Check of the Levee Systems for the 100-Year Flood Event and Current Standard Project Flood Level*, is commonly referred to as the Problem Identification Report (City of Dallas 2009a).

Maintenance Deficiency Correction Period Plan.

The Maintenance Deficiency Correction Period (MDCP) Plan was prepared in response to PI Report No. 9 (USACE 2009) in accordance with Corps policy guidance. As of February 2012, the City of Dallas has completed all of the 198 deficiency maintenance O&M items identified in the MDCP Plan.

Federal Emergency Management Agency (FEMA)/Flood Insurance Rate Maps (on-going).

The Dallas Floodway Project was examined by the Corps in the PI Report No. 9. Based on this review, the Corps withdrew its letter of support for certification provided to FEMA. Because the levee owner has not provided appropriate documentation to support certifying the levee, FEMA, as directed by 44 Code of Federal Regulations (CFR) 65.10, has stated that the Dallas Floodway Project will be de-accredited. FEMA has announced a nationwide revision in their policy of considering no flood protection for de-accredited levees. FEMA has placed mapping for certification purposes on hold until the new mapping process has been fully vetted with the public and other agencies. The City of Dallas plans to have improvements that would restore/provide sump capacity to provide flood risk reduction up to the 100-year event for interior drainage and well as improvements to the levee system for the 100-year (1% AEP) in place before the re-mapping of the Dallas Floodway Project occurs.

Interim 100-year Levee Improvements Section 408 Package.

The City of Dallas is pursuing necessary corrective measures and documentation required by FEMA for certification of the Dallas Floodway Project for the 1% AEP flood event on the Trinity River. The City of Dallas prepared a Section 408 package analyzing the potential impacts from implementing the interim levee improvements to the Dallas Floodway Project (City of Dallas 2012). The Corps approved the Section 408 package and a Finding of No Significant Impact was signed in February 2012.

1.7 STUDY OVERVIEW

Subsequent to the enactment of Section 5141 of WRDA 2007, the Fort Worth District issued the PI Report No. 9, dated March of 2009, which documented significant deficiencies with the existing structural integrity of the Dallas Floodway Project. It became readily apparent that this study was extremely complex with various actions requiring evaluation by the Corps including the deficiencies identified in the PI Report No. 9, multiple local projects requiring Section 408 approval (including the Trinity Parkway), and the authority to review the BVP and IDP Projects. Therefore, as part of the Implementation Guidance prepared for Section 5141 of WRDA 2007 issued December of 2009, a plan was developed to lay out a framework to evaluate all components proposed for implementation within the study area. This plan is referred to as the "Comprehensive Analysis".

In order to perform the Comprehensive Analysis, the study had to be conducted in phases. To comply with the Implementation Guidance, the first phase had to address deficiencies with the levee system and formulate the FRM feature of the BVP utilizing National Economic Development (NED) criteria. The FRM feature would become a component of the BVP. Then all proposed projects and features currently being planned within the Dallas Floodway Project (BVP, IDP, local features, and the Trinity Parkway) were evaluated during the Comprehensive Analysis. This analysis ensures the proposed local features meet Corps engineering and safety standards, are compatible with the proposed BVP and IDP Project features, and would not have significant adverse effects on the functioning of the existing Dallas Floodway Project. It also determines that components of the BVP and IDP Projects are technically sound and environmentally acceptable. Finally, features to be implemented as the Modified Dallas Floodway Project under Section 5141 of WRDA 2007 are presented as a Recommended Plan. Specific evaluation

criteria for each component of the study follow. Appendix K contains figures of the general features of the BVP and IDP Projects (Figures K-1 through K-4).

1.7.1 Levee Structural Integrity

A Levee Remediation Plan (LRP) was developed to address the levee structural integrity concerns and Operation and Maintenance (O&M) deficiencies (which are the responsibility of the City of Dallas) documented in PI Report No. 9. The LRP was also intended to address potential design and construction deficiencies for the existing Dallas Floodway Project as defined in the original 1945 project authorization. The City of Dallas submitted a MDCP Plan and has corrected 198 listed items. The Corps determined there were no design and construction deficiencies with the original project. The 21 items from the PI Report No. 9 were deferred to the feasibility study since they could be considered beyond routine maintenance and repair. The path forward of the 21 remaining items is discussed in Chapter 3. The LRP is the base condition for formulation of the National Economic Development (NED) analysis for the Flood Risk Management component of the Balanced Vision Plan (BVP).

1.7.2 Balanced Vision Plan

The City of Dallas' report, "The Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas" (December 2003, amended March 2004), identifies the plan to implement flood risk management, environmental restoration, and recreation features within the Dallas Floodway project area. Section 5141 of WRDA 2007 directs the ASA(CW) to construct if the BVP is "technically sound" and "environmentally acceptable." As per the Implementation Guidance, the Corps will perform the analysis and make a recommendation with its findings to ASA(CW). The BVP includes language for increasing the height of the existing levees by as much as two feet above the SPF flood event water surface profile and flatten the riverside slope of the levee to reduce the likelihood of slope failures. Further discussion of the SPF is provided in the next Chapter, Section 2.1.2. Current Implementation Guidance requires the FRM component (see Section 1.7.2.1) of the BVP to be evaluated for economic justification. The guidance also states the BVP recreation and environmental features do not require formulation utilizing NED/National Ecosystem Restoration (NER) criteria but will be formulated using sound judgment, prudent analytical approaches and Corps engineering standards. The Fort Worth District recommends designing and implementing the highest risk features to the existing levee system and features that fall within business lines that the Corps normally participates in. They are also evaluated for their ability to contribute to the goals and objectives of this study.

1.7.2.1 National Economic Development (NED) Analysis on the FRM Component of BVP

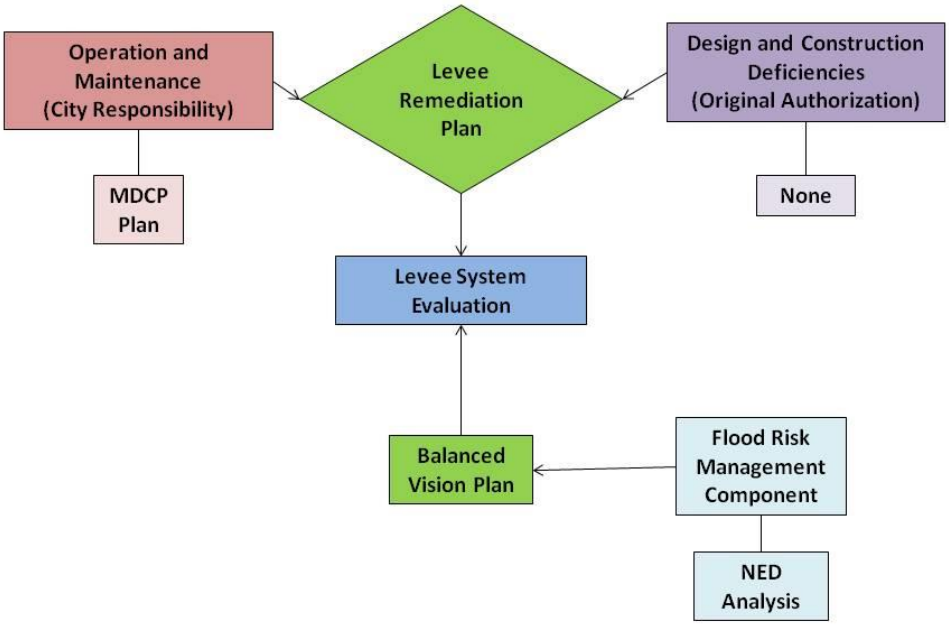
The levee system was evaluated to determine whether additional measures could be implemented to address flood risk, not addressed by routine O&M, and whether reconstruction of the Dallas Floodway Project is warranted. The analysis followed the "Principals and Guidelines for Water and Related Land Resources," dated March 1983, including evaluation of contributions to NED and reducing potential life-safety risk. The NED analysis will only be performed on the levee system, not as a multipurpose project, as stated above. Figure 1-2 presents the Levee System Evaluation Framework to show the relationship between the LRP and the FRM component of the BVP. Reconstruction addresses major performance issues with an existing project beyond normal O&M (City of Dallas responsibility) or a deficiency with the original project design and construction (addressed under the original authorization).

1.7.3 Interior Drainage Plan

Section 5141 of WRDA 2007 authorizes the Corps to review and evaluate the Interior Levee Drainage Study Phase I report (September 2006) and make a recommendation to ASA(CW) to make a

determination on whether the plan is "technically sound" and "environmentally acceptable." The IDP Phase I report proposes improvements to existing and construction of new pumping stations and their associated gravity and pressure storm sewers (including the Able, Baker and Hampton pump stations). These improvements would restore/provide sump capacity to provide flood risk reduction up to the 100-year flood event for interior drainage. The 100-year event is also referred to as the 1% Annual Exceedance Probability (AEP). For IDP discussion, the 100-year terminology is used. Similar to the environmental and recreation BVP features, the IDP does not have to be formulated utilizing NED criteria. They will be formulated solely on their ability to contribute to the goals and objectives of this study. The City of Dallas' IDP Phase II report (February 2009) covers the sumps on the West Levee. The IDP Phase II features are not currently included within Section 5141 authorization and will not be included as part of the Recommended Plan, but will be considered during the Comprehensive Analysis to be implemented by the City of Dallas as a Section 408.

Figure 1-2. Levee System Evaluation Framework



1.7.4 Local Features

Local features are projects which will not be a part of the Recommended Plan, but their implementation does represent a modification to an existing Federal project. These features either have or are required to undergo a Section 408 review by the Corps. The local features are evaluated as a part of the Comprehensive Analysis along with the BVP and IDP Projects. The local features in the Comprehensive Analysis include the Trinity Parkway, Trinity River Standing Wave, the Santa Fe Trestle Trail, the Pavaho Wetlands, the Dallas Horseshoe Project, the Sylvan Avenue Bridge, Jefferson Memorial Bridge, Dallas Water Utilities Waterlines, Continental Bridge, the East Bank/West Bank Interceptor Line, and IDP Phase II features including Charlie, Delta, Pavaho, and Trinity/Portland pump stations. These projects (excluding the Trinity Parkway, and all IDP Phase II features) have received initial "approval"

under Section 408 and are in various stages of design and construction. They are also considered existing or future without-project conditions in accordance with the stage of project design or construction. The City of Dallas has expressed a desire to construct any BVP and IDP Project feature not included in the Recommended Plan as a Section 408 project at 100% local cost.

1.7.5 Planning Considerations

The study was prepared in accordance with the applicable Engineering Regulations (ER) including but not limited to:

- USACE ER 1105-2-100, *USACE Planning Guidance Notebook;*
- USACE ER 1110-2-1150, *Engineering and Design for Civil Works Projects;*
- USACE ER 405-1-12, *Real Estate Handbook, Chapter 12*;
- USACE ER 1110-2-1302, *Civil Works Cost Engineering;*
- 33 CFR Section 230, Procedures for Implementing NEPA (ER 200-2-2). This regulation establishes USACE procedures for implementing NEPA and the Council on Environmental Quality (CEQ) regulations;
- Other pertinent regulations including Executive Order (EO) 11988, *Floodplain Management* (1977). USACE ER 1165-2-26 contains Corps's policy and guidance for implementing EO 11988; and
- A Base Condition Risk Assessment (BCRA) was conducted by the Risk Management Center (RMC) on the Dallas Floodway Project to evaluate levee risks. The BCRA was part of a beta test of a proposed procedure for the Levee Safety Portfolio Risk Management Process. The BCRA was requested by the Corps Headquarters and the Southwestern Division. The purpose of the BCRA was to quantify and evaluate risks posed by the East and West Levees associated with Trinity River flooding. While there are no Corps engineering regulations developed for levee risk assessments, ER 1110-2-1156, Safety of Dams - Policy and Procedures was used as a guideline to develop the BCRA for the Dallas Floodway Project. New policy is under development for levees similar to ER 1110-2-1156. The findings in the BCRA were instrumental in determining Dallas Floodway Project risks and solutions and risk informed decision on the path forward.

1.8 REPORT OUTLINE

Chapter 1 provides general study information, and the remaining chapters provide the results of the Corps evaluation of the BVP and IDP Projects developed by the City of Dallas and the Comprehensive Analysis. Chapter 2 presents the existing and future without-project condition for key resources that drive the NED analysis performed on the FRM component of the BVP. It also focuses on key areas that support the inclusion of BVP and IDP Project features in the Recommended Plan to be implemented under Section 5141 of WRDA 2007. After the existing and future without-project conditions are defined, Chapter 3 defines the problems, opportunities, goals and objectives derived from the BVP and IDP Projects developed by the City of Dallas, and evaluation of the existing and future without-project condition. Chapter 3 continues with the plan formulation, evaluation and selection results of an NED Plan for the FRM component of the BVP. This section of Chapter 3 is followed by the Comprehensive Analysis and determinations of technical soundness and environmental acceptability of the BVP and IDP Projects. The last section of Chapter 3 describes the selection process for the BVP and IDP Projects for implemented under Section 5141 of WRDA 2007. Chapter 4 contains a detailed description of the Recommended Plan. Lastly, Chapter 5 provides implementation requirements for the Recommended Plan.

CHAPTER 2
EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

Chapter 2 provides a description of the existing and future without-project condition for the study area. Additional detailed descriptions of the resources in the project area are provided in the EIS and the technical appendices of this report. Conditions described here focus on summarizing technical evaluations of those resources that drive the NED analysis on the FRM component of the BVP. It also covers technical and environmental acceptability for all the BVP and IDP Projects, and support for BVP and IDP Projects to be included in the Recommended Plan for Section 5141 of WRDA 2007.

2.1 FLOOD RISK

The RMC developed a Base Condition Risk Assessment (BCRA) for the Dallas Floodway Project which details perceived vulnerabilities of the Dallas Floodway Project and its components. The BCRA (included as Appendix C of this report) is part of a beta test of a proposed procedure for the Levee Safety Portfolio Risk Management Process. The purpose of the BCRA was to quantify and evaluate flood risks posed by the East and West Levees associated with Trinity River flooding. While there are no Corps ERs developed for levee risk assessments, ER 1110-2-1156, Safety of Dams – Policy and Procedures was used as a guideline to develop the BCRA for the Dallas Floodway Project. New policy is under development for levees similar to ER 1110-2-1156. Flood risk due to interior drainage is not addressed in the BCRA.

In an initial screening process, the BCRA identified a number of Potential Failure Modes (PFM) with the Dallas Floodway Project. The 14 PFMs are fully described in Appendix C, and are listed as follows:

- PFM #1 – Scour around a bridge pier leading to slope instability;
- PFM #2 – Overtopping and breach of a levee;
- PFM #3 – Failure of a floodwall;
- PFM #4 – Failure of the closure structures;
- PFM #5 – Scour through desiccation cracking in the crest;
- PFM #6 – Internal erosion through the levee;
- PFM #7 – Internal erosion through the foundation;
- PFM #8 – Heave leading to internal erosion through the foundation;
- PFM #9 – Internal erosion following rupture of a pressurized conduit;
- PFM #10 – Internal erosion along a penetration through the embankment or foundation;
- PFM #11 – Global instability following leaks from a pressurized conduit;
- PFM #12 – Instability at the interface between 1930s and 1950s levees;
- PFM #13 – Global slope stability; and
- PFM #14 – Failure Modes Not Developed.

As a result of an initial screening process, PFM #2 levee overtopping, PFM #3 Floodwall Failure, PFM #8 Foundation Heave, and PFM #7 Foundation Sand Piping, and PFM #13 Global Instability, were chosen to carry forward to perform the detailed risk evaluation. The BCRA showed that the "best estimates" for risk identified two PFMs that exceed the recommended tolerable risk guideline established for dams. They are overtopping with breach of the East and West Levees, and overtopping of the floodwall on the East Levee.

Two other PFMs do not exceed the recommended tolerable limits but have estimated risks to life safety associated that plot close to the limit of tolerability and are therefore considered problems to investigate further. The best estimates identified these as internal erosion through the foundation for the East and West Levee and potential heave of the East Levee. More discussion on life-safety tolerable risk limits is provided in Appendix C, and Section 2.1.4 below.

This study uses traditional flood risk analysis for Corps feasibility studies as well as the BCRA flood risk analysis. The Hydrologic Engineering Center – Flood Damage Reduction Analysis (HEC-FDA) and Hydrologic Engineering Center – Flood Impact Analysis (HEC-FIA) models were used to define baseline conditions for flood risk. The HEC-FDA model is used for estimating economic damages, and the HEC-FIA model is used for estimating life-safety risk.

2.1.1 Geotechnical

The geotechnical conditions of the existing levee system (e.g., desiccation cracking, seepage through the foundation of the levee system) have been a concern in this study. Dallas County is situated on the Black Prairie Belt, on the Eagle Ford, Austin and Taylor Formations, which are three broad bands of Cretaceous rocks that are exposed on the surface within the county. The levee system originally built by the DCLID and strengthened by Corps in the late 1950s is comprised of highly plastic clays derived from the Eagle Ford, Austin and Taylor Formations. Highly plastic clays are problematic soils because they expand and contract with the application of moisture. This physical characteristic is known to induce slides on the levees. The occurrence of "shallow slides" in the Dallas Floodway Levee System profile has been reported. Records maintained by the City of Dallas show that landslides on the levee system occur all year long but primarily during the winter months and on the riverward side of the levee. The semi-arid, windy environment found in North Central Texas area renders the highly plastic clays that comprise the levees prone to desiccation cracks, which causes shallow slides. More than 300 shallow slides have been recorded since the Corps completed construction in the late 1950s. Although they are referred to as shallow, the slides are generally deeper than what is considered "normal" for shallow slides, with some slides as deep as 15 feet (USACE 2009). The City of Dallas currently fixes the slides as they fail to maintain the performance of the levee system.

Analysis of boring data shows significant quantities of sand within the subsurface of the project area including under the levee footprint. The locations of shallow sand in the project area represent areas of possible concern regarding levee performance. The near-surface sand deposits in contact with river water can quickly become saturated and serve as seepage pathways. This is of particular concern where a shallow sand lens laterally transects a levee, creating a seepage pathway from an area exposed to river water to the near surface substrate on the protected side of the levee (e.g. exposed on the landward side in the sump areas).

Feasibility level seepage and stability analyses were performed for the existing levee system. These analyses are described in greater detail in Appendix B (Geotechnical Appendix) and Appendix C (Risk Assessments). The geotechnical analyses for existing conditions of the levee system were adopted from the BCRA (Appendix A of the BCRA). Transient seepage analysis was used in the seepage and stability analysis performed. Routine Corps practice in the past has been to use steady state seepage analysis. The main difference between transient and steady is the duration of flood loading. Transient analysis is appropriate for the Dallas Floodway Project because of the relatively short periods of time for the river flood stages.

Analyses were conducted in accordance with Corps policy, as well as policy under development (analyses presented in the BCRA and subsequent risk assessments performed). With the adoption of the criteria developed by the BCRA, the use of unsteady (transient) flow in both seepage and stability analyses resulted, in most cases, in an increase in safety factors which met or exceeded Corps requirements for the critical cross-sections analyzed. Safety factors are based on deterministic criteria defined in Corps Engineer Regulations. Meeting deterministic criteria is a requirement for Corps design. The detailed risk evaluation in the BCRA concluded the probabilities of failure due to internal erosion or heave were low. Although the failure mode probabilities were low, they were considered problems to investigate further in the flood risk analysis.

The City of Dallas is located in an area of historically low seismic activity and there are no known active faults. Moreover, the U.S. Geological Survey Quaternary Fault and Fold Database indicate that there are no known active faults within 60 miles of the Floodway (Dallas Geological Society 1965).

Current geotechnical conditions within the study area would generally remain the same for the future without-project condition. Desiccation cracking will continue to result in slides and continue to be an operation and maintenance cost for the City of Dallas. Desiccation cracking has been determined to be low risk in the BCRA. The risk described in the BCRA and here is based on the fact that the City of Dallas fixes slides (a result of desiccation) as they occur to maintain the integrity of the levee system.

2.1.2 Hydrology and Hydraulics

The Upper Trinity River watershed contributes to the hydrology of the project area. Through the Dallas Floodway Project, the existing channel of the Trinity River is approximately 30 feet deep and 200 to 250 feet wide at its banks. The Floodway itself generally ranges from 2,500 to 3,000 feet wide, levee to levee, and extends for nearly eight river miles on the main stem of the Trinity River. The Trinity River main channel in the study area provides a maximum channel capacity of 13,000 cubic feet per second (cfs). When the volume of water exceeds the maximum capacity of the channel, water flows into the floodplain. Flows measured in the Trinity River range from a base flow of about 500 cfs to a record high flow of 184,000 cfs (1908). The May 1990 flood at 82,300 cfs (approximately a 40-year flood event) was the largest flood since 1908 and the largest flood since the original levee system was constructed.

Hydraulic analyses were performed on the Trinity River main stem, the Elm Fork, and the West Fork of the Trinity River. Water surface profiles were computed for a wide range of flood events including the SPF and flood events greater in magnitude than the SPF. The SPF is defined as the flood that would be expected from the most severe combination of meteorological and hydrologic conditions that are considered to be reasonably characteristic of the geographical region involved, excluding extremely rare combinations. A detailed description of the hydrology and hydraulic models used for this study is contained in Appendix A (Hydrology and Hydraulics Appendix).

A HEC-RAS steady flow was primarily used for computing water surface profiles for flow contained within the Floodway. However, during the BCRA, it was recommended that HEC-RAS with unsteady flow be used to better account for the effects of timing and flood volume during a levee overtopping and breach. Therefore, an unsteady HEC-RAS analysis was performed for baseline and future without-project conditions to measure the performance of the existing Dallas Floodway Levee System against a range of flood events and to evaluate the economic consequences of the failure modes of concern.

Assumptions that are made regarding the potential failure of the levees have a significant effect on interior flooding depths, as well as the resulting estimates of economic damage and loss-of-life. However, there is very little existing guidance for levee breach analysis. Very few studies or research efforts in this

area have been completed, and published breach regression equations, such as the ones used by the Modeling, Mapping and Consequence Center during the BCRA, were developed primarily for application to dam breach analysis. It is commonly accepted that there is a high degree of uncertainty with using the regression equations for dam breach analysis (Wahl 2004), and thus their application to levee breach would be questionable as well. The Corps is still in the process of formulating its guidance on how to model levee failures and estimate levee breach sizes. In light of the lack of guidance, the unsteady flow model was developed with close coordination between team members from the Fort Worth District, the Corps Hydrologic Engineering Center (HEC), the RMC, and the Modeling, Mapping and Consequence Center production center. The team members reviewed the levee failure methodologies and assumptions as they were being modeled and made recommendations on improvements.

Two potential failure modes for the levee system were considered: internal erosion (piping) failures and levee overtopping resulting in a breach. Internal erosion involves a process whereby seepage of floodwater during a flood event is assumed to flow through the foundation of the levee template where porous strata exists and eventually flows through to the protected side of the levee. If this seepage occurs for a long enough period of time, it is assumed to erode the levee internally and potentially result in a levee breach. Initially the focus of the study was only on the overtopping with breach failure mode. However, the internal erosion failure mode was added to the economic analysis following the determination that the life-safety risk could potentially be reduced by measures to address internal erosion.

The breach progressions for these two failure modes are entirely different and independent from one another. Therefore, the evaluation of these two failure modes required two different analyses for baseline conditions. Appendix A, Section 4, describes the assumptions and analysis for baseline conditions for the overtopping failure mode. The internal erosion failure mode was later analyzed as a separate baseline condition, and its analysis is discussed in Section 5.6 of Appendix A.

For purposes of evaluating flood risk, the area of concern is bounded outward from the East and West Levees, to the approximate limits of the SPF. The SPF flood event under existing conditions has a return interval of 2,500-year, or 0.04% Annual Exceedance Probability (AEP), assuming future flows of 277,000 cfs. Floodplain inundation maps were created by intersecting the water surface elevations computed in the analysis with the land surface for the SPF flood event. The map shows the areas behind the Dallas Floodway East and West Levees that are within the area estimated to be flooded by a levee breach due to overtopping under future without-project conditions (277,000 cfs). The assumed breach location for the East Levee was at river station 134952 (near the Hampton Road Bridge), which would have an incipient overtopping AEP of 0.066% (or a return interval of 1,500 years) under future without-project conditions. The assumed overtopping and breach location for the West Levee was at river station 139920 (near the Westmoreland Road Bridge), which has an incipient overtopping AEP of 0.055 % (or a return interval of 1,800 years) under future without-project. The flooding depths for the internal erosion failure mode would be similar to what is shown for overtopping with breach assuming the same flood event, according to the hydraulic analysis. The estimated flooding depths for the SPF for both failure modes are shown in Figure 2-1.

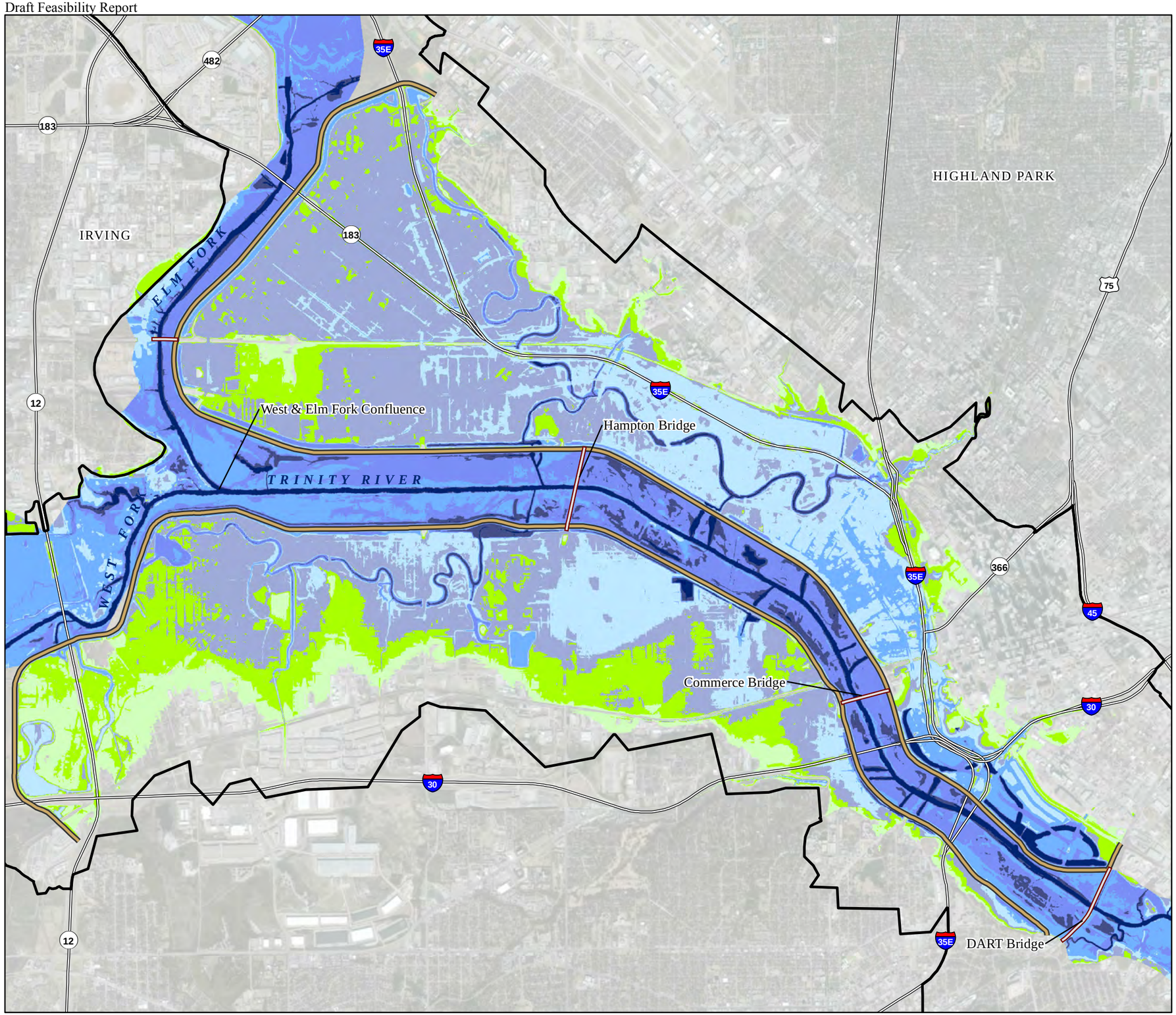
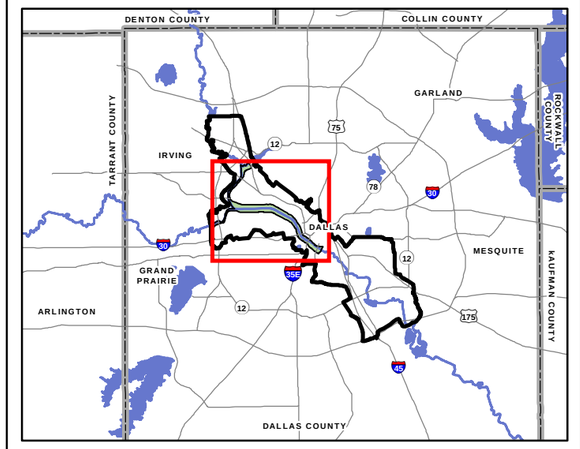


Figure 2-1
Flood Extents for the Future Without Project SPF Event

LEGEND

Estimated SPF Flood Depth
- 0 - 5 Feet
- 5.1 - 10 Feet
- 10.1 - 15 Feet
- 15.1 - 20 Feet
- 20.1 - 25 Feet
- 25.1 - 30 Feet
- 30.1 - 35 Feet
- 35.1+ Feet

Study Area Features
- Dallas Floodway Levee System Levee
- Freeway
- Bridge
- Study Area



0 0.5 1 Kilometers
0 0.5 1 Miles

N
S

Sources: City of Dallas 2008a, NCTCOG 2008, USACE 2012

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2.1.3 Economic Analysis

A structure file of the floodplain inundation area was developed to determine the potential flood damages for properties behind the East and West Levees if a failure were to occur. Tables displaying structure and content values by reach, type and major damage category at October 2013 price levels are presented in Appendix E (Economic Appendix). A total of 9,057 structures are estimated within the SPF floodplain limits. These structures have a total estimated investment value of approximately $7.4 billion in structures at a 2010 level of development and $4.8 billion in contents. If the levees are breached during a major flood event, floodwaters could potentially inundate developed areas of the City of Dallas and result in damages to structures behind the East and West Levees. Estimates of Equivalent Annual Damages (EAD) under the future without-project condition were calculated. Damages are estimated using the risk and uncertainty within HEC-FDA version 1.2.5, through integration of frequency-damage data. Estimates of EADs are the summation of the base year expected annual damages, in this case 2015, plus the discounted value of the most likely future year expected annual damages, for this analysis, 2025. The future expected annual damages shown here are discounted over the period of analysis of 50 years at the fiscal year 2014 Federal discount rate of 3.5%. Table 2-1 shows a breakdown of where these damages are predicted to occur behind the East and West Levee under an overtopping and breach failure estimate. Damage categories are defined as the following; *Comm*. (commercial), Ind. (industrial), *MFR* (multi-family residential), *Mobil* (mobile residences), *Public* (public), *POV* (personal occupancy vehicles), *SFR* (single-family residential), and *Tunnels* (businesses operating in the tunnel system under the Central Business District).

Table 2-1. Overtopping Equivalent Annual Damages Without-Project Condition (October 2013 Price Level; $000)

	Comm.	*Ind.*	*MFR*	*Mobil*	*Public*	*POV*	*SFR*	*Tunnels*	*Totals*
East	$3,131	$101	$99	$0	$1,427	$26	$30	$3	$4,815
West	$141	$23	$58	$0	$104	$72	$299	$0	$696
Total	**$3,271**	**$124**	**$156**	**$0**	**$1,531**	**$98**	**$328**	**$3**	**$5,511**

Internal erosion required a different future without-project condition with different inflow events and breach settings for EAD. Baseline EAD for internal erosion is discussed in greater detail in Section 3.4.5.2 of Chapter 3.

In the future without-project condition, the economic damages in the study area would remain unchanged, and the City of Dallas would accept the $5,511,000 estimate of equivalent annual damages. The economic risk of overtopping and breach, or a breach prior to overtopping would remain in the future without-project condition.

2.1.4 Life-Safety Analysis

The population at risk (PAR) to flooding was identified to estimate life-safety risk for the study area if a breach of the levee system were to occur. Behind the East Levee, the PAR is primarily a commercial zone, filled with warehouses, offices, and retail buildings. Likewise, the population behind the East Levee consists largely, but not entirely, of commercial workers who work within the hazard zone mainly during business hours but reside elsewhere. Because of the migration of workers in and out of the floodplain, there is a significant difference between the PAR behind the East Levee during the day and the PAR at night (potentially 91,400 Day PAR and 35,500 Night PAR). Much of the night PAR are visitors staying in hotels in the downtown area or institutionalized populations. It is important to note that such PAR are

generally in hi-rises. Because this PAR is able to "vertically evacuate," they are less directly threatened by floodwaters.

Though smaller in number (19,600 Day PAR and 23,500 Night PAR), the PAR behind the West Levee is largely, but not entirely, made up of residential occupants. Most of the PAR lives in one-story single-family structures, with a smaller percentage living in multi-family units. According to 2000 Census data used in this analysis, households behind the West Levee are often low-income, without a fluent English speaker, and may not have access to a vehicle. Such demographic factors reduce the likelihood that the PAR will perceive the flood risk warnings, perceive significant risk differently and may not have the resources available to successfully evacuate.

The BCRA conducted detailed evaluation on probabilities and consequences to characterize the life-safety risk of each Potential Failure Mode (PFM). The Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) model was used to estimate the potential loss-of-life based on the load ranges for each PFM. Methodology in HEC-FIA is based on the LifeSim methodology developed by Utah State University's Institute for Dam Safety Risk Management. The process of computing potential loss-of-life within HEC-FIA includes evaluation of several factors like, structure type, number of stories, the PAR from a given event, warning time, mobilization rates and flooding arrival time.

The annualized likelihood (probability) and consequences (loss-of-life) are determined for each PFM using the @Risk program. An f-N Chart plots the estimated annualized probability of failure and the estimated consequences (loss-of-life) to describe the risk. Figures 2-2 and 2-3 are the f-N Charts for the East and West Levee. Each PFM has a designated point (referred to as the best estimate) on the chart with a box that represents the Monte Carlo simulation uncertainty "clouds." A Tolerable Risk Guideline for Dams as detailed in ER 1110-2-1156 is plotted on the f-N Chart, and is used as a guide to establish whether a PFM has tolerable risk or does not fall within a tolerable level of risk in terms of life safety. If the PFM falls above or near the recommended tolerable risk guideline it is recommended that further evaluation and potential action be pursued. As stated previously, PFM #2 Levee Overtopping, PFM #3 Floodwall Failure, PFM #8 Foundation Heave, and PFM #7 Foundation Sand Piping, and PFM #13 Global Instability, were chosen for detailed risk evaluation in the BCRA and are shown on the following f-N Charts. Those that plot above or approach the recommended tolerable risk guideline including PFM #2, PFM #7 and PFM #8 are analyzed further for risk reduction in this study. Floodwall Failure (PFM #3) was not evaluated because the DFE Project is assumed to be fully constructed and addresses this PFM in the future without-project condition.

The concept of "As-Low-As-Reasonably-Practicable" is that risks lower than the tolerable risk limit are tolerable only if further risk reduction is impracticable or if the cost is grossly disproportional to the risk reduction. In making a judgment whether risks are ALARP, the Corps takes the following into account: level of risk in relation to the tolerable risk limit; the cost–effectiveness of the risk reduction measures; disproportion between the sacrifice and risk reduction achieved; compliance with Corps guidelines; and social concerns as revealed by consultation with the community and other stakeholders. There are no Corps ERs developed for levee risk assessments; however, additional information on this topic can be found in ER 1110-2-1156, Safety of Dams – Policy and Procedures. New policy is under development for levees similar to ER 1110-2-1156.

Figure 2-2. Base Condition Risk Assessment f-N Chart for the East Levee

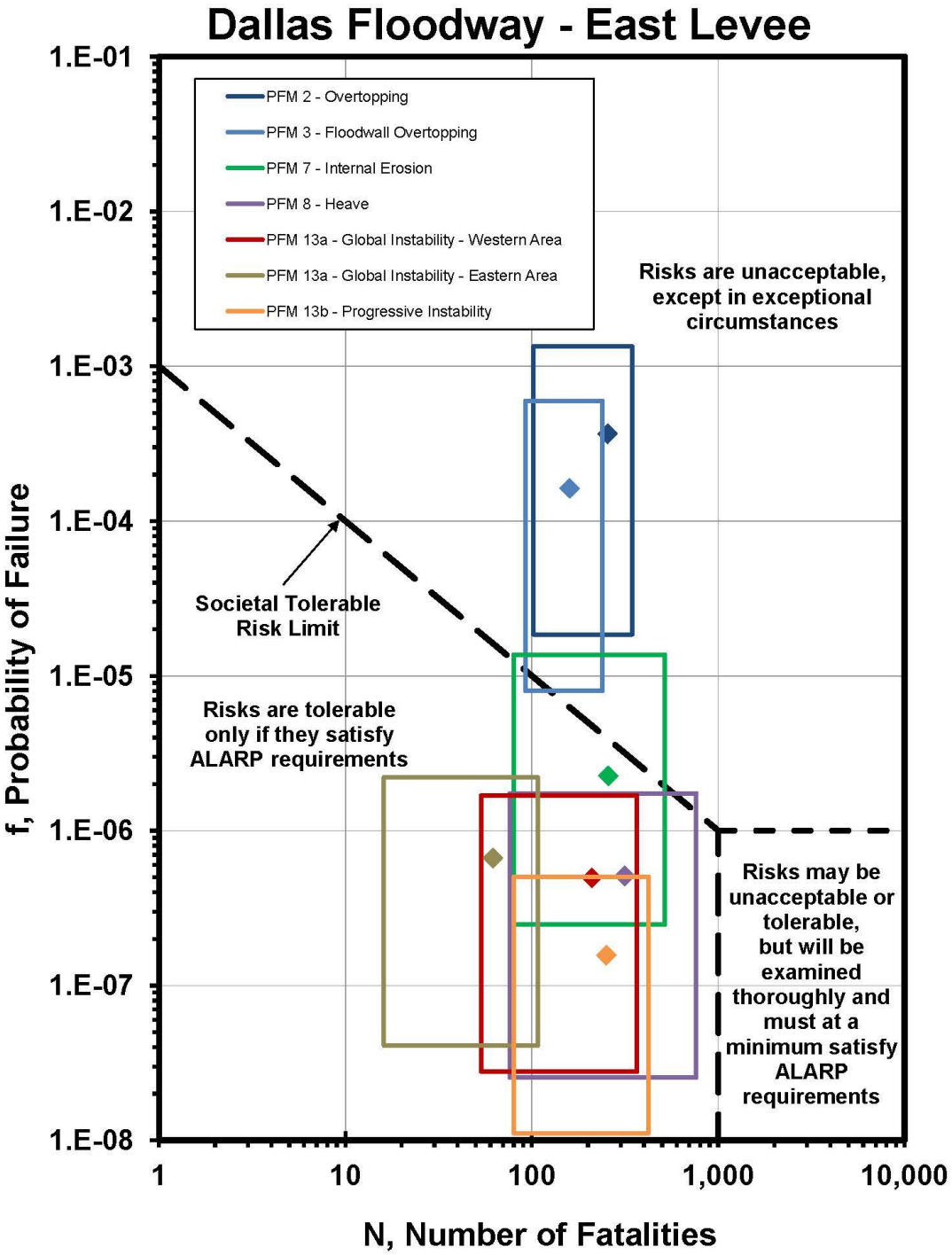
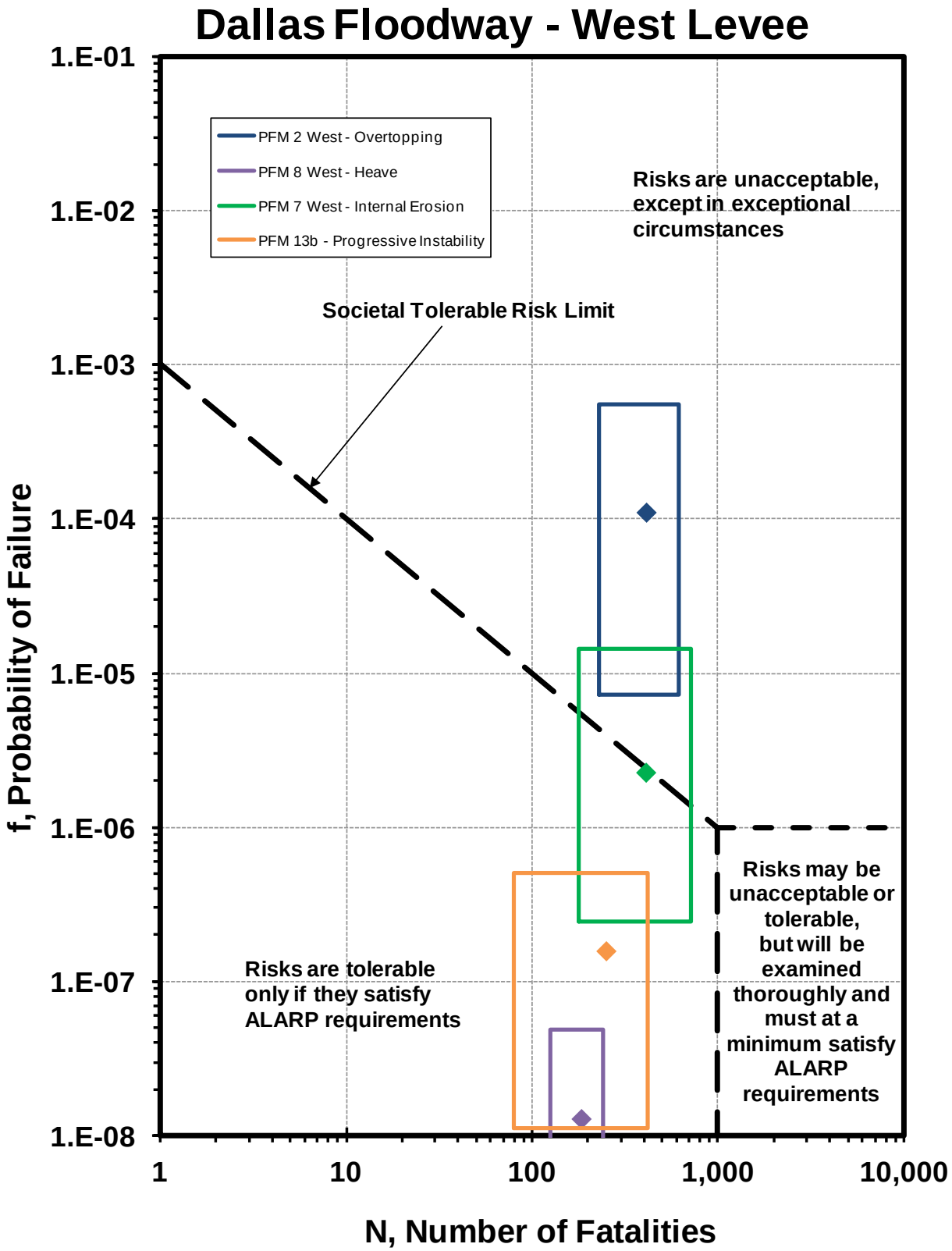


Figure 2-3. Base Condition Risk Assessment f-N Chart for the West Levee



Annualized estimates for probability and loss-of-life shown in Table 2-2 were used as baseline conditions to measure the performance of an alternative or structural/nonstructural measure in the formulation process in Chapter 3. They are presented here to describe the existing and future without-project conditions regarding life-safety risk for the study. Updated probability and consequence estimates due to overtopping and subsequent breach (PFM #2) and internal erosion (PFM #7) are presented in Table 2-2. The update was developed for the unsteady hydraulic modeling conducted for the economic analysis.

Table 2-2. Estimated Failure Probability and Loss-of-Life for Baseline Conditions of Overtopping and Subsequent Breach (PFM #2) and Internal Erosion (PFM #7)*

Annualized Failure Probability – PFM #2	
East Levee	5.42E-04
West Levee	5.42E-04
Annualized Life Loss – PFM #2	
East Levee	1.37E-01
West Levee	4.51E-01
Annualized Failure Probability – PFM #7	
East Levee	5.19E-06
Annualized Life Loss – PFM #7	
East Levee	1.33E-03

*Table uses the revised BCRA estimates

The City of Dallas currently has a flood warning system in place. This flood warning system is described in the City Emergency Action Plan (EAP) for the Trinity River Federal Levee System, dated April 2010 (City of Dallas 2010). In the event of flooding, Police and Fire-Rescue Dispatch would issue a warning to affected residents using Reverse 911. In addition, City of Dallas officials would implement measures such as requesting broadcasters to disseminate Emergency Alert System broadcasts, issue news through cable override, special news advisories to radio, and television and cable news stations.

In the future without-project condition, the PAR in the study area is estimated to remain the same. The risk of an overtopping and breach, and failure due to internal erosion would remain in the future without-project condition; however, the City of Dallas would continue to implement their EAP to reduce the potential loss-of-life in a major flood event.

2.1.5 Interior Drainage

The existing IDS consists of the sumps areas, various pump stations and associated stormwater conveyance structures. The stormwater runoff control system in the City of Dallas consists of a wide array of physical components including overland flow paths, channels, detention storage, floodplains, and larger downstream storage areas. The stormwater control system physical components include the following:

- Sump ponds (natural topographically low areas in the terrain that collect, convey, and store stormwater);
- Major drainage ways (e.g., large concrete-lined surface channels leading toward sumps, and natural channels);
- Streets (part of overland flow, or the flow of stormwater on the surface until it reaches an inlet or a detention facility);
- Storm sewers (e.g., pressure sewers featured as part of the EWLIDS and smaller gravity storm sewers that gather portions of the basin and convey water to major drainage ways);

- Flow control devices (e.g., stormwater gates and gravity sluices (sluice gates) and pumps;
- Trash racks, storm inlets, or grates (e.g., trash racks installed near pumping plants remove large debris from the sump basins prior to pumping); and
- Detention facilities (e.g., water storage sumps and detention ponds that hold stormwater either until it is evaporated or allowed to flow or be pumped elsewhere).

Many of the sump ponds are old river channels that have been cut off from the West Fork, Elm Fork, and Main stem Trinity River by levees. These old channels are natural topographically low areas in the terrain that collect, convey, and store stormwater. In addition, there are storage ponds and levee borrow ditches that run adjacent to the levees that store stormwater. Drainage sumps that are portions of the historic river channels are classified as jurisdictional waters of the United States. In addition, some stormwater runoff is captured higher up the basin in creeks and conveyed to the Floodway via pressure sewers.

The current system was designed to correspond to original (1960s- and 1970s-era) 100-year, 24-hour storm events, which reflected stormwater basin conditions at that time. Primarily due to changes in the stormwater basins, the design storm event water levels no longer reflect current stormwater basin conditions (City of Dallas 2006, 2009).

By design, pumping plants can manage (i.e., eject stormwater to the Floodway) stormwater up to their respective design storm event water levels. Where the predicted 100-year, 24-hour storm event water levels are greater than the original design storm event water levels, it indicates that the associated pumping plant is undersized to handle the predicted volume of stormwater, and flooding is likely. This problem would continue in the future without-project condition.

2.2 RIVERINE ECOSYSTEM

2.2.1 River

Past channelization and clearing in the Floodway, along with urbanization, has significantly degraded the natural terrestrial and aquatic habitat in the Floodway. The Trinity River now reflects little of its historic course, water quality, or habitat. Prior to the 1920s, the Trinity River's morphology through the City of Dallas included significant meandering consistent with a river of geologic age. The construction of the Dallas Floodway Project has essentially eliminated these meanders, and with it, high-value habitat and connections to adjacent ecosystems (USACE 2000). Historic natural meandering of the river created pool and riffle complexes that provided for diverse aquatic habitats. Without meandering, the habitat complexity is limited. In a meandering system, pools typically form in the outside bank of bends and the riffles (sandbars) usually form between the bends. These pools and riffles were an integral part of the historic Trinity River in the mid-1850s that navigation along the river was "often … impeded by snags or sand bars or halted by low water" (Gard 2013). The construction of the Dallas Floodway Project eliminated the meanders thereby inhibiting the formation of pools and sandbars (riffle habitats).

Natural river corridors are comprised of the river, the riverbank, wetlands, and a series of one or more floodplain terraces that eventually connect to the adjacent upland habitats. The vegetation within the riverine corridor along these floodplain terraces provide physical benefits by filtering stormwater runoff before reaching the river and ecological benefits by providing diverse habitats and a travel corridor connecting fragmented habitats. Primary factors affecting these riverine functions are the width of the riverine corridor, the geometry and composition of the edge, and the connectivity of the corridor with adjacent habitats. Given the same riparian vegetation composition, a wider riverine corridor naturally provides more effective filtering than a narrower riverine corridor. Nutrients, sediment, and stormwater

runoff entering the riverine corridor are selectively filtered depending on the shape and composition of the corridor edge. Straight corridor edges provide less effective filtering than a convoluted edge associated with a meandering corridor. In addition, the composition of the corridor edge greatly influences the effectiveness of nutrient and sediment filtering. Areas where there are abrupt transitions from grassland to riparian forest, sediment and nutrient functions concentrate in a narrow area along the transitional boundary, which has multiple adverse impacts on the ecosystem. A more complex system with gradual edges, transitioning naturally among grassland, wetland, shrubland, riparian forest, increases the filtering and spreads sediments and nutrients across a wider ecological gradient.

The width of the riverine corridor and the composition of the corridor edge are also of great importance for fish and wildlife resources. The more diverse and wider the riverine corridor, the greater the capacity for organisms to move within and along the riverine corridor. Gradual corridor edges and connections to adjacent wetland and upland habitats greatly improve the travel corridor functions of the riverine ecosystem.

The original Dallas Floodway Project construction removed natural structure and function from the Trinity River. It also altered the hydrology (with construction of the reservoirs upstream) and vegetation within the Floodway effectively reducing the riverine corridor width, and cut off connections to adjacent wetland habitats. Filtering and buffering functions of the riverine corridor have been greatly disrupted. Aquatic habitats such as cut banks, pools, sandbars, and other habitats have been greatly reduced by the straightening of the river. It is expected that the existing river conditions would prevail in the future without-project condition. Additional information on the environmental resources in the study area can be found in Appendix F (Environmental Resources).

2.2.2 Wetlands

Wetlands within the riverine corridor depend on a constant or recurrent inundation or saturation from flood events. Wetland functions within the riverine corridor benefit the fish and wildlife especially during migration periods. They also provide water storage (flood attenuation), filter sediment and nutrients, improve water quality, and provide a source for groundwater recharge. Wetlands are dynamic ecosystems dependent on seasonal flooding and provide a diverse habitat for fish and wildlife resources, especially when connections with the rest of the habitat and aquatic features are fully functional. Habitat types of concern in the study area include bottomland hardwood and emergent wetlands.

2.2.2.1 Bottomland Hardwood

Bottomland hardwood habitats are wetland areas dominated by deciduous trees, usually along streams, that are occasionally flooded. Located primarily along the Trinity River and its inflows, many of these woodlands are periodically flooded and are predominately composed of cottonwood, cedar elm, green ash, pecan, black willow, and box elder. Other tree species present include bur oak, red mulberry, and sugar hackberry (USFWS 2014). Bottomland hardwoods along the Trinity River are limited to a narrow strip along the main stem and in isolated areas near the confluence. The Great Trinity Forest, located downstream of the AT&SF Railroad Bridge in the DFE Project area represents some of the best remaining bottomland hardwood habitat in the region (USACE 2000).

2.2.2.2 Emergent Wetlands

Currently, wetlands within the Floodway consist of shallow depressions located in the floodplain that are isolated from the riverine habitats of the main river channel. They are also routinely mowed, and when they seasonally dry up, they become overcome by non-native invasive herbaceous vegetation.

Connectivity between the river and floodplain wetlands has been disrupted by the current structure of the channel banks. It is expected that these conditions would prevail in the future without-project condition.

2.2.3 Fish and Wildlife

Historically, the river channels, riparian corridors, and wetlands associated with floodplains of the Trinity River supported a wide variety of wildlife species for cover, food, and nesting areas including migratory songbirds and waterfowl, raptors, wading and shore birds, fish, amphibians, reptiles, and mammals. Predator control, hunting, use of pesticides, and various forms of air, water, and land pollution have affected fish and wildlife populations throughout the area. Dallas County wildlife has been subject to reduction or elimination by habitat destruction through removal, physical alteration, and/or pollution. The surviving fish and wildlife live in a modified natural habitat within the immediate influence of an encroaching urban complex (USACE 1999). Wildlife species occurring in the area are those tolerant of human activity such as rabbits, songbirds, squirrels, and small rodents (USACE 2006). The Great Trinity Forest in the southern end of the study area provides fish and wildlife habitat and is a source area for fish and wildlife to disperse into the rest of the area. The areas upstream in the confluence and along Elm Fork provide higher quality habitats for fish and wildlife than the main stem because the stream and corridor are in more natural conditions.

Multiple fish and wildlife inventories have been conducted over the years around or within the study area. For example, seventy-seven wildlife species were documented in the Great Trinity Forest in 2008 and included 1 amphibian, 49 birds, 20 mammals, and 7 reptiles (City of Dallas 2008). The U.S. Fish and Wildlife Service (USFWS) also published, *Urban Development and Fish and Wildlife Habitat of the Dallas-Fort Worth Metroplex* provided an assessment of fish and wildlife resources of the Dallas area in 1989 (Johnston 1989). At that time, habitats within the Dallas-Fort Worth metropolitan area supported 291 species of birds, 36 species of mammals, 68 species of reptiles, 25 species of amphibians, and 66 species of fish (Johnston 1989). Recently, from February 2009 to December 2009, 280 bird species were observed in Dallas County and 183 bird species were observed at the Trinity River Audubon Center, approximately 5 miles south of the southern edge of the study area (Trinity River Audubon Center 2011). In Dallas County 81 species of reptiles and amphibians have been reported including 4 species of salamanders, 20 species of toads and frogs, 1 alligator, 12 species of turtles, 1 anole, 13 species of lizards, and 30 species of snakes (National Audubon Society 1998; Stebbins 2003; City of Dallas TRCP 2008; Texas A&M University 2009).

Aquatic communities of the Trinity River have been and continue to be impacted by urbanization, loss of riparian zone and floodplain habitats, reduced complexity of instream physical habitat and availability of natural habitats, and elevated nutrient levels and elevated levels of pesticides. In certain areas, the river channel has riffles, runs, and pools, which provide habitat for several species of invertebrates and fish. Studies conducted by TPWD, the University of North Texas' Institute of Applied Sciences and University of Dallas (Dickson et. al. 1989), identified 12 families and 46 species of fish within the Upper Trinity River Basin, which includes the Dallas Floodway study area. These studies verified that stream fisheries have improved since the 1970s and early 1980s, due primarily to improved water quality resulting from improved wastewater treatment. Sport fish present in the study area include largemouth bass, channel catfish, crappie, and white bass. Other species which tend to be more tolerant of moderate levels of nutrients and lower dissolved oxygen content in the area include common carp, river carpsucker, longnose gar, freshwater drum, several species of shiners, and bullhead catfish. Non-sport fish species found in the study area that are less tolerant to pollutants include gizzard shad, mosquito fish, and several sunfish species.

In 2004, the USFWS prepared a report entitled "*Assessment of Trinity River Fisheries within the Dallas Flood Control Project Area, Dallas County, Texas,"* that outlined results of fisheries surveys undertaken in the Dallas Floodway (USFWS 2004). In addition, open water fisheries sampling of Crow Lake, Bart Simpson Lake and DFE Cell D was conducted in 2009 and 2010 to obtain documentation of fisheries open water habitat and fish populations and health. Eleven species of fish were observed during June 2010 sampling and include inland silverside (*Menidia beryllina*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), bluntnose darter (*Etheostoma chlorosoma*), logperch (*Percina caprodes*), spottail shiner (*Notropis hudsonius*), red shiner (*Cyprinella lutrensis*), threadfin shad (*Dorosoma petenense*), western mosquitofish (*Gambusia affinis*), and longnose gar (*Lepisosteus osseus*) (USACE 2010). These species are also likely to occur in the Trinity River.

More than 50 species of freshwater mussels are native to Texas. Freshwater mussels are one of the most imperiled groups of animals in the U.S. The decline of freshwater mussels is due to habitat fragmentation and changes in flow rates in streams and rivers caused by episodes of drought and flooding, ground water pumping, surface diversions, dams, urban and agricultural development; siltation; and contaminants in runoff. Invasive plants and animals also compete with, prey upon, and alter the habitats of native mussels (TPWD 2008). A Phase II presence/absence survey for state listed mussel species was recently performed at the IH-30 and IH-35 crossings of the Trinity River in the Dallas Floodway study area as part of the FHWA/North Texas Tollway Authority (NTTA) Dallas Horseshoe project environmental assessment work efforts. Eleven species of mussels were found, including the Texas pigtoe (*Fusconaia askewi*), a state listed species that was only found at the IH-35 crossing. The USFWS has recently initiated investigation into the status of Texas mussels.

In summary, the existing river ecosystem supports a fair amount of fish and wildlife species; however, the degraded riverine ecosystem could be improved to provide more natural instream and riparian structure and function. It is expected the fish and wildlife that currently utilize the study area would remain the same in the future without-project condition.

2.2.4 U.S. Fish and Wildlife Service Recommendations

The USFWS provided a Planning Aid Report that contains recommendations that could be beneficial for the restoration of natural habitat impacted by urban development in the study area. A Draft Fish and Wildlife Coordination Act Report is included in Appendix G. The recommendations are summarized as follows:

- Widen the riparian woodland corridor along the creeks and their associated tributaries as much as possible;
- Improve the existing riparian corridor and upland forests by thinning portions where it's too dense, and planting mast producing trees and shrubs where they are lacking;
- Provide brush and log piles in all existing habitats to provide cover for small mammals;
- Conduct Hazardous, Toxic, and Radioactive Waste (HTRW) tests where restoration work is proposed;
- Create off-stream wetlands;
- Plant locally available native aquatic plants and shrubs around the water edges;
- Construct proposed waterbodies with shelved floors of variable depths and appropriate substrates for habitat cover and spawning conditions;
- Implement a fish stocking plan, and do not use carp for vegetation control;

- Implement a monitoring program;
- Construct pool, riffle, run sequences where possible;
- Retain canopy cover where possible;
- Create native grasslands where possible;
- Implement a mowing program that promotes tall grass growth, but does not interfere with tall grass nesting birds; and
- Consider Birds of Conservation Concern 2002 during project planning.

CHAPTER 3
PLAN FORMULATION & COMPREHENSIVE ANALYSIS

3.1 PROBLEMS AND OPPORTUNITIES

3.1.1 City of Dallas' Balanced Vision Plan and Interior Drainage Plan

Following Trinity River flooding in 1989 and 1990, the City of Dallas (in conjunction with regional stakeholders) began looking at ways to outline a long-range vision for the entire TRC. The vision aimed to reclaim the Trinity River as a great natural resource in order to create a unique public domain and achieve a model of environmental stewardship. In the subsequent years of planning and community input, the City of Dallas and stakeholders developed concepts for addressing five key issues:

- Flood Risk Management;
- Environmental Restoration and Management;
- Parks and Recreation;
- Transportation; and
- Community and Economic Development (City of Dallas 2003).

The outcome of this effort culminated in "The Balanced Vision Plan" for the TRC (December 2003, amended March 2004). The BVP aims to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the Dallas Floodway Project. The 2004 updates (not depicted) include more sinuosity of the Trinity River, extending and widening the Urban Lake, a larger island downstream of the Natural Lake, and utilizing water from the Central Wastewater Treatment Plant to fill the Natural Lake.

The same levees that provide flood damage benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. The City of Dallas reports entitled, "*The Interior Levee Drainage Study, East Levee – Phase I, Dallas, Texas,*" dated September 2006, and "*The Interior Levee Drainage Study, West Levee - Phase II, Dallas, Texas,"* dated February 2009 (City of Dallas 2006, 2009) identify means to reduce the stormwater flood risk for structures located within the predicted flood area for the 100-year, 24-hour storm event.

3.1.2 Water Resources Development Act (WRDA) 2007 Section 5141 Project

The BVP and IDP Projects were developed by the City of Dallas to address problems and opportunities that are above those normally considered by the Corps. Transportation, community and economic development projects do not align with the traditional Corps missions and are generally the responsibility of locals and other Federal agencies. However, the Corps does have an interest in flood risk management (FRM) and ecosystem restoration and an ancillary interest in providing recreation development. Problems and opportunities were identified and goals and objectives were developed which align with the three identified Corps mission areas of FRM, ecosystem restoration, and recreation. These objectives will be used to measure the success of individual measures, and they will be instrumental in deciding which parts of the BVP and IDP Projects are appropriate for a Recommended Plan for Section 5141 of WRDA 2007.

3.1.3 Flood Risk Management Problems and Opportunities

The RMC developed a BCRA for the Dallas Floodway Project which details perceived vulnerabilities of the Dallas Floodway Project and its components. Using the BCRA to define the baseline risks with the Dallas Floodway Project and the knowledge of the conditions of the existing IDS, the following problem and opportunity statements were developed (Table 3-1).

In addition to the risks associated with the levees themselves, the city is also experiencing frequent inundation due to interior drainage on the protected side of the levees. While interior drainage is normally a local responsibility, the current authorization allows for Corps participation in this problem. FEMA is proposing to remap the floodplain behind the levees not only due to the levee issues identified in PI Report No. 9, but also because there is not currently 100-year level of flood risk levels provided by the IDS associated with the Dallas Floodway Project.

Table 3-1. Flood Risk Management Problems and Opportunities Statements

Problem 1	*Opportunity 1*
There is approximately $12 billion (in structure and content value) in floodplain investment behind the Dallas Floodway Project that is at risk from a failure of the levee system. There is approximately $5 million in remaining equivalent annual damages with the Dallas Floodway Project in place.	Reduce the equivalent annual damages behind the levees.
Problem 2	*Opportunity 2a*
The levee system could overtop, overtop and breach, or breach prior to overtopping and could result in flood damages and loss-of-life.	Prevent the levees from overtopping, overtopping and breaching, and/or breaching prior to overtopping.
	Opportunity 2b
	Improve the City of Dallas' EAP.
Problem 3	*Opportunity 3*
Desiccation cracking on the levees has led to slope failures in the past and will continue to contribute to slope failures in the future. Desiccation cracking has been determined to be low risk; however, they do lead to increased operations and maintenance cost.	Reduce O&M costs due to desiccation cracking.
Problem 4	*Opportunity 4*
Undersized pumps and sumps result in flood damages and general flooding on the protected side of the levees.	Increase pump and sump capacity to handle the 100-year event.
Problem 5	*Opportunity 5*
Pending FEMA rule, updates may result in remapping of 100-year flood zones behind levee systems that are not protected by 100-year interior drainage projects.	Increase pump and sump capacity to handle the 100-year event.
Problem 6	*Opportunity 6*
Several proposals to modify the Dallas Floodway Project have the potential to impact the functioning of the Dallas Floodway Project.	The Corps could take a bigger role in project design and implementation to ensure major project features do not impact the authorized functioning of the Dallas Floodway Project.

3.1.4 Aquatic Ecosystem Restoration Problems and Opportunities

Channelization of the Trinity River led to a number of ecological consequences for the riverine ecosystem. Historically, the Trinity River contained natural channel forming processes that supported the function, structure, and diversity of riparian and aquatic components of the riverine ecosystem. The losses to structure and function of the riverine system resulting from channelization and maintenance include:

- Lack of diverse in-channel habitat complexity due to the current structure of the Trinity River channel;
- Steep, uniform channel bank slopes;
- Riparian vegetation along the existing channel is relatively limited in extent, density, and diversity; and
- Transition from in-channel to floodplain habitat is abrupt and limits habitat quality.

The degradations listed above provide an image of the structurally and functionally homogenous and restrained riverine system which characterizes the existing condition and future without-project condition of the Trinity River. The result is degraded riverine habitat which no longer supports the historic level of organism diversity at any trophic level. The restoration of some of the historic structure, function and dynamic nature of the Trinity River such as those listed above, will capitalize on the opportunity to provide benefits to fish and wildlife in the Dallas Metroplex. Table 3-2 summarizes the aquatic ecosystem restoration problems and opportunities.

Table 3-2. Aquatic Ecosystem Problems and Opportunities Statement

Problem 7	*Opportunity 7*
River function and habitat has been degraded over time due to relocation of the river channel within the Dallas Floodway Project	Restore a more naturally functioning river within the Dallas Floodway Project to benefit fish and wildlife

3.1.5 Water Related Problems and Opportunities

According to a study by the Texas Parks and Wildlife Department (TPWD), the City of Dallas lacks sufficient recreational opportunities for citizens and visitors (TPWD 2005). While some people do enjoy the limited recreational opportunities available in the Floodway (e.g., levee-top trail, Trammel Crow Park), most people do not perceive the Floodway as a desirable destination for active recreation, festivities, or nature observation. There is a strong public need for active recreation facilities in the City of Dallas, in particular playing fields for soccer and other similar activities. In addition, there is inadequate access to the Floodway, which hampers the public's ability to enjoy the limited existing recreational opportunities. Despite being in the top tier for number of TPWD services, the TPWD considers the City of Dallas as "underserved" in terms of recreation opportunities. In a 2005 survey, the TPWD determined that the City of Dallas has a below average supply of almost 70% of the most commonly used facilities and resources (TPWD 2005).

There is a latent recreation demand for open space and water related recreation in the downtown area. While this is not a primary mission area for the Corps, there is an opportunity to modify the Floodway to increase recreational opportunity along the vast areas of the Dallas Floodway Project.

Table 3-3. Water Related Problems and Opportunities Statement

Problem 8	*Opportunity 8*
There is latent recreation demand for open space and water related recreation in the downtown Dallas area.	Modify the Floodway to increase recreational opportunity along the vast areas of the Dallas Floodway Project.

3.2 PLANNING GOALS AND OBJECTIVES

3.2.1 City of Dallas' Balanced Vision Plan and Interior Drainage Plan

The City of Dallas' overall goal is to create an environment that brings residents and development closer to a healthier Trinity River Corridor (TRC) without diminishing the long-term effectiveness of the Dallas Floodway Project.

The objectives prepared during the course of developing the BVP by the City of Dallas results in diverse and potentially conflicting objectives of:

- Providing improved flood risk management for the full length of the TRC in a way that also allows for the achievement of environmental, recreational, mobility, and economic goals;
- Implementing environmental responsibility, restoration, and proper management initiatives in the midst of an urban setting;
- Creating a recreation and urban open space amenity that does not interfere with vehicular traffic or periodic floodwaters;
- Meeting stated regional transportation goals in a way that supports economic development and air quality improvement; and
- Creating community and economic opportunities for the neighborhoods bordering the Trinity River and thus, forming the centerpiece for a major urban region (December 2003, amended March 2004).

3.2.2 Water Resources Development Act 2007 Section 5141 Project Objectives

While the City of Dallas had broad goals for the entire TRC, the Corps goal is somewhat limited to determining what combination of BVP and IDP Projects align with Corps missions. The following are objectives for recommending features of the BVP and IDP Projects to be implemented under Section 5141 of WRDA 2007. The NED analysis used a 50-year period of analysis for the FRM component of the BVP. A 50-year period of analysis was used for the aquatic and riparian ecosystem objective listed below even though formulation for National Ecosystem Restoration (NER) was not required in accordance with the current Implementation Guidance.

- Protect the flood risk reduction function of the Dallas Floodway Project over the life of the project;
- Reduce residual flood risk to property and promote life safety;
- Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project; and
- Provide water-related recreational opportunities within the boundaries of the Dallas Floodway Project.

3.3 PLANNING CONSTRAINTS

The following have been identified as constraints to the planning study:

- Any recommended feature shall not increase risk to life safety; and
- All measures must be technically sound and environmentally acceptable as required by the project authorization.

3.4 PLAN FORMULATION

3.4.1 National Economic Development Analysis on the Flood Risk Management Component of the Balanced Vision Plan

The following planning assumptions were used for the NED planning effort:

- The Locally Preferred Plan for the DFE Project, as authorized and currently under construction, is assumed to be in-place as an existing condition. However, the analysis in the BCRA did not assume the Lamar Levee tied into the East Levee (a "with-project" condition for the DFE Project) and therefore, it identified risk at the floodwall located in the downstream end of the East Levee.
- The City of Dallas' proposed modifications to the existing Dallas Floodway Project to meet FEMA 100-year requirements for flood insurance purposes are not part of the future without-project condition. Possible construction credit for such modifications will be decided upon completion of the Comprehensive Analysis and determination of whether they are integral to the overall levee system upgrades recommended in this feasibility report.
- Remediation efforts by the City of Dallas on the East Bank / West Bank Interceptor tunnel is underway and are considered complete in the future without-project condition.
- The City of Dallas MDCP items are included in the future without-project condition. See Section 3.4.9 of this report for more information. The 21 remaining items related to the following were either addressed or "closed-out" in this feasibility study:
  - Encroachments for bridges, electrical power towers, and a jail;
  - Levee height does not meet original design grade;
  - Extensive cracking due to desiccation;
  - AT&SF Railroad Bridge flow obstructions; and
  - Dallas Floodway Project currently does not meet current Corps design criteria regarding relevant factors of safety for embankment stability and seepage gradients.
- The Dallas Floodway Project will be evaluated as a total project providing for comparable performance on both sides of the river.
- PI Report No. 9 items #34 and #145 (rated Unacceptable) were noted levee height deficiencies of the East and West Levees based on the 2003 crest survey and the 1950s design elevation. The existing height of the levee system is the basis of plan formulation for the NED analysis on the FRM component of the BVP. The project delivery team concluded the levee height (compared to the original design grade) was not necessarily an O&M item that the City of Dallas would be required to restore.
- The levee system baseline condition does not include the Trinity Parkway in the Floodway. During the Comprehensive Analysis alternative alignments for the Trinity Parkway, along with their habitat mitigation requirements are being evaluated for compatibility with the Dallas Floodway Project's primary purpose of flood risk management.
- Indirect (or incidental) damages were not used in the estimate for EAD, and not considered a driver for plan formulation for the NED analysis.

3.4.2 NED Management Measures

The following measures were considered for their potential to meet the FRM objectives of the study. Plan formulation rationale for FRM is to identify a plan that maximizes NED in combination with a plan that reduces risk to life safety to a tolerable level and maintains or improves levee resiliency. Plans that do not

meet these criteria were eliminated from further consideration. The Fort Worth District has run HEC-FDA to estimate the reduction in expected flood damages. The Risk Management Center (RMC) developed the HEC-FIA model to estimate life-safety risk for without and with-project condition. Results of the initial screening of measures are discussed herein.

3.4.2.1 Nonstructural Measures

Floodplain Management

The technique of controlled land use is particularly helpful in planning for future development, but is of limited use in highly developed areas like the area surrounding the Dallas Floodway Levee System. This measure would have the potential to contribute to reducing economic damages in the study area, but has been eliminated from further consideration for plan formulation because the City of Dallas presently participates in the National Flood Insurance Program, has adopted the Trinity River CDC process, and enforces zoning regulations for development in the floodplain.

Flood Forecasting and Warning Systems

The City of Dallas currently has a flood warning system in place. This flood warning system is described in the City of Dallas EAP for the Trinity River Federal Levee System, dated April 2010. In the event of flooding, Police and Fire-Rescue Dispatch would issue a warning to affected residents using Reverse 911. In addition, City of Dallas officials would implement measures such as requesting broadcasters to disseminate Emergency Alert System broadcasts, issue news through cable override, special news advisories to radio, television, and cable news stations. The BCRA identified opportunities to assist the City of Dallas in improving their EAP through reduced response times, increased evacuation rates, or reducing the vulnerabilities of the population that remains during a flood event; therefore, this measure was carried forward for further evaluation to meet the objective to reduce residual flood risk and promote life safety. This measure will be added in combination with other structural and nonstructural measures.

Emergency Response and Public Awareness/Education

Mobilization rate improvement measures include transportation network improvements, utilization of public transportation, and emergency response improvements. Safe haven/zones could be identified and involve facilitation for that portion of the population that cannot mobilize to seek shelter. Measures would also include education of the City of Dallas EAP, overcoming obstacles related to age/language, and implementation of a “good neighbor”/“buddy” system. This measure was carried forward to be implemented in combination with other structural and nonstructural measures to meet the objective to reduce residual flood risk and promote life safety.

Flood Proofing

Typically, flood proofing techniques include water-tight door and window seals, raising floor elevations of structures, installation of check valves on gravity flow water and sewer lines, incorporation of seepage controls, and sandbagging of door openings during emergency situations. This measure would contribute to reducing economic damages in the study area. Such measures are typically implemented by individuals on individual structures. Due to the relatively large number of structures in the damage area and the estimated depths of flooding resulting from catastrophic flood events from levee overtopping with breach, this measure was not considered a viable measure for broad application across the study area and was eliminated from further consideration.

Structure Relocation

Plans for structure relocation would involve moving the existing structures to a more non-flood-prone site. The practicality of this measure depends on the frequency of flooding, the value of the property, its importance to the community, and the need for land use areas that are more compatible with floodplain constraints. This measure would contribute to reducing economic damages in the study area. Considering the performance of the Dallas Floodway Project, relocation of the thousands of structures subject to catastrophic flood events within the City of Dallas (to provide additional flood risk reduction in the event of levee overtopping and breach) would be an impractical and cost prohibitive solution. Based on these findings, relocation was not considered any further.

Permanent Evacuation

Evacuation involves the acquisition and removal or demolition of frequently flooded structures from the floodplain. Floodplain evacuation is normally considered in areas without existing flood risk management projects. One advantage of floodplain evacuation is it generally provides high marginal benefits, because targeted structures are those being damaged at the most frequent events and there are no residual damages because the structures are permanently removed. Floodplain evacuation can also expand open space and enhance natural and beneficial uses and facilitate the secondary use of newly vacated land. In the case of the protected area of the Dallas Floodway Project, which provides a high level of flood risk reduction (approximately 1,500-year), floodplain evacuation in broad application would never be economically justified. Floodplain evacuations would have to be in targeted areas that received high floodwaters if there were a breach and would have to be considered as a life-safety measure. Broad application of this measure would not be cost effective and will not be considered further**.**

Permanent evacuation in an area on Rockefeller Boulevard located adjacent to the Floodway that is not protected by the West Levee or the proposed Cadillac Heights Levee (DFE Project feature) was carried forward as a targeted buyout to meet the economic and life-safety objectives.

Instrumentation

Instrumentation to include installation of piezometers in critical areas is being carried forward for evaluation to inform the technical team as to the continuity of the basal sand layer under the levee. This measure will likely be installed as part of any structural measure or by itself to continue to monitor the levee system in the future.

3.4.2.2 Structural Measures

Structural measures consist of structures designed to control, divert, or exclude the flow of water from the flood prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. Because the Dallas Floodway Project is an existing levee system, the structural measures considered most appropriate in dealing with the residual flood problems are limited.

The structural measures investigated include AT&SF Railroad Bridge modification, river channel widening, vegetation removal, levee raises, a concrete floodwall on top of the existing levee, flattened side slopes, levee armoring, controlled overtopping, and seepage cut-off walls.

AT&SF Railroad Bridge Modification

A historic railroad bridge is located at the downstream end of the Dallas Floodway Project called the AT&SF Railroad Bridge. The modification of the abandoned AT&SF Railroad Bridge has been identified as a measure due to its impact to the SPF water surface profile, its location at the downstream end of the Dallas Floodway Project, and the fact that the bridge is no longer needed for rail traffic. Hydraulic

analysis has shown that the bridge causes a rise in the SPF water surface profile due to its numerous closely spaced piers, low deck height, and large earth embankments within the Floodway. This measure will be carried forward for detailed investigation to determine whether it contributes to the economic and life-safety objectives.

Channel Widening

Based on previous analysis, it was determined that channelization could provide a reduction in the water surface elevations in the upstream portion of the Floodway; however, it was screened out in an initial screening of measures. The screening process used a measure predictive analysis and concluded the channel widening measure would have a low likelihood of reducing the probability or consequences associated with an overtopping event. Therefore, channel widening did not warrant further analysis in this study for reducing flood damages and risk to life.

Vegetation Removal

This involves removing the woody vegetation within the Floodway to reduce the water surface profile to achieve flood damage reduction benefits and contribute to reducing the frequency of overtopping of the levees. Like the channel widening measure, the measure was screened out because it was concluded this measure would have a low likelihood of reducing the probability or the consequences associated with an overtopping event. Therefore, vegetation removal did not warrant further analysis in the plan formulation process.

Levee Floodwalls

This measure would include construction of a concrete floodwall on the levee crest. The specific measure considered in this preliminary analysis was for construction of a floodwall to a height equal to 2 feet above the current SPF water surface elevation. The floodwall measure was only considered for 2 feet or above the current SPF. Based on the preliminary analysis conducted in 1998, it was concluded that this measure was economically justified. In spite of these preliminary findings, it has been subsequently concluded by the project delivery team that this measure is not technically sound. One reason among many is that the levee crest is not of adequate width to allow a floodwall to be installed and also have access for emergencies and flood fighting. As such, this measure will not be carried forward for further consideration.

Levee Height Modification (Levee Raises)

The levee raises are not all-inclusive raise of the entire levee system. The measure involves using earthen fill to raise the low areas of the levee system to a height consistent with a targeted peak flood water surface profile. Measures that raise the levee crest height reduce the frequency of overtopping, and delay initiation of an overtopping levee breach, but may also provide benefits to the protected area by lowering the total volume of water that overtops the levees. Evaluation of this measure is expected to show a reduction in economic damages and loss-of-life estimates, and the measure was carried forward for detailed evaluation.

Levee Armoring

Levee armoring was considered based on the potential to limit the development of a levee breach following an overtopping event. This measure involves armoring the levee crest and the landside levee slope to a crest height consistent with a targeted peak flood water surface profile similar to the levee raise measure described above. The armoring would be placed using articulated concrete block. Two additional materials for armoring were considered, including turf reinforcement mats and scour protection mats.

These two methods provided significant cost savings; however, all materials would require site specific modeling to determine technical viability for their application. Only articulated concrete block was carried forward for analysis during detailed investigations to evaluate reduction in damages and loss-of-life estimates.

Controlled Overtopping

Proposed levee modifications may include what is commonly called "levee resiliency measures." Resiliency measures are expected to reasonably provide cost effective flood risk reduction either alone or in combination with other types of flood risk reduction measures or alternatives. Since the highest risk of flooding from levee failure for the Dallas Floodway Project has been identified as overtopping with levee breaching, resiliency measures are expected to focus on reducing the risk of flooding or depths of flooding associated with overtopping failure of the levees. One of these resiliency measures considered is referred to as "controlled overtopping."

The controlled overtopping measure focuses on design considerations outlined in Engineer Technical Letter 1110-2-299 (1986) entitled "Overtopping of Flood Control Levees and Floodwalls." This guidance deals with designing levee systems to reduce the negative impacts of overtopping of levees since prevention of overtopping can never be absolutely assured. Some considerations for good overtopping design for flood risk reduction outlined in the Engineer Technical Letter are: (1) the measure focuses the overtopping in a reach having the least negative impacts; (2) controls the initial overtopping to reduce the impact of sudden overtopping failure or breach; (3) reduces the chance of overtopping in less desirable areas; (4) reduces project maintenance and replacement costs; (5) reduces the risk associated with flow velocity resulting from overtopping inundation; and (6) reduces the risk to life loss due to extending the timing of flood inundation.

Some types of resiliency measures that may be considered to address these goals for risk reduction are: (1) identify levee reaches for initial overtopping that have the least negative impacts; (2) design levee crest for overtopping to reduce risk of levee breaching using armoring at the crest and interior slopes; (3) use levee superiority design to control the initial overtopping location; (4) use levee flattening or similar methods to reduce the risk of levee breaching; (5) use interior area dikes or similar methods to reduce the rate of flood spreading; and (6) improve levee access for flood fighting. The controlled overtopping resiliency measure was carried forward for evaluation to address the life-safety objective.

Seepage Cut-Off Walls

Problems associated with internal erosion due to seepage and heave at the levee foundation were identified in the BCRA as risks near to exceeding the recommended tolerable risk guideline. Cut-off walls with a clay cap on the riverside of the East and West Levees were carried forward to prevent possible breaches in the levee system prior to overtopping. These measures have potential economic and life-safety risk reduction benefits and were carried forward for further consideration.

Side Slope Flattening

Desiccation cracking in the levee system was not considered to be high risk based on the BCRA results. The desiccation cracking and the number of slope failures has led to increased operation and maintenance cost. Measures to address desiccation cracking have the potential to reduce life-cycle maintenance cost of slope repairs for the City of Dallas. A life-cycle costs analysis would compare the expected costs under two scenarios: (1) continue to fix slides as they occur; or (2) invest in modifications now that reduce the frequency and cost of future slope failures. Side-slope flatting will be considered as a feature to reduce O&M costs and contribute to the economic objective.

3.4.3 Screening of Measures

Based on the conclusions described in the preceding section, the following measures will be carried forward for detailed evaluation due to their ability to contribute to the objectives of the FRM component of the BVP:

- AT&SF Railroad Bridge Modification;
- Levee Height Modification;
- Levee Armoring;
- Controlled Overtopping;
- Seepage Cut-Off Walls;
- Side Slope Flattening;
- Improved Emergency Action Planning;
- Localized Buyouts; and
- Instrumentation.

3.4.4 Key Risks and Uncertainties

Risk and uncertainties related to cost and benefit calculations can affect plan formulation and identification of an NED Plan. The following are key risks and uncertainties related to formulation of the NED Plan.

3.4.4.1 Cost Estimating

The following are some of the risk and uncertainties related to the initial array of alternatives and their cost estimates. It is assumed that all work will be done within the existing Floodway and real estate costs would not be included because the City of Dallas should own all real estate within the existing levee system. There are some bridges within the construction limits but it is assumed that if affected by an alternative, a seal can be placed during construction to prevent future damage that might occur as a result of a levee raise. Houston Street Bridge is an exception; it would only require sand. It is assumed that all borrow material needed to complete the levee work is available within a 12 mile round trip of any place on the levee. Suitable levee material was identified within the West Dallas Lake footprint. West Dallas Lake is a recreation component of the BVP and is described in greater detail in Section 3.5.3.2. Encountering contaminants of concern during construction was considered. Environmental Site Assessment Phase I site visits were conducted and there were no significant concerns noted. Finally, quantity estimate methodologies were considered low risk because they were determined to be at an appropriate level of detail for comparison of alternatives in the initial array. Contingencies were applied to the costs based on these risks inputted into an abbreviated cost risk analysis.

3.4.4.2 Hydrology and Hydraulics

There are Hydrology and Hydraulics (H&H) uncertainties related to levee breaching for the "with-" and "without-" project conditions, but the effects of those uncertainties are minimized to the extent possible by the fact that the same assumptions are being applied consistently for every alternative. For the AT&SF Railroad Bridge modification, one key uncertainty is related to the degree of debris accumulation on the structure and its effect on upstream water surface elevations. Bi-weekly conference calls with review team members from the HEC, RMC, and Mapping and Modeling Center took place during the duration of this analysis to maintain transparency and accountability in the assumptions that were being made.

3.4.4.3 Economics

Uncertainty related to economics can come from several sources. One source is the structure elevation, which has two components: the topographic ground elevation that a structure sits on, and the structure's estimated first floor elevation. Another source is the value of the structure and its contents. The final source of uncertainty is in the inundation depth/percent damage relationship (usually known as depth-damage functions) used to estimate damages to a structure for a given level of flooding. Parameter settings in HEC-FDA account for these uncertainties.

3.4.5 Initial Array of NED Alternatives

The initial array of alternatives will be separable stand-alone alternatives that function independently of each other. The first two alternatives are nonstructural alternatives. It was realized early on that the AT&SF Railroad Bridge modification was easy to add as a first added element for any structural alternative. Therefore, all alternatives are formulated with the bridge modification in place. The initial array of alternatives evaluated include nonstructural, the AT&SF Railroad Bridge modification, levee height modifications considering a variety of flows including the 260,000, 265,000, 269,000, 273,000, 277,000, and 289,000 cfs, levee armoring a variety of flows including the 255,000, 260,000, 265,000, 269,000, 273,000, 277,000, 289,000, and 302,000 cfs, and seepage cut-off walls in select locations. The following sections display the evaluation results of the alternatives.

3.4.5.1 Nonstructural

Additional localized risk reduction measures were evaluated to see whether remaining residual risk not captured by more comprehensive alternatives could contribute to the life-safety objective.

Improved EAP - High Risk Area Identification

The City of Dallas has an existing in-depth EAP that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. In order to make quantifiable changes in the potential for loss-of-life estimates, the high risk areas would be the areas that flood first, deepest, along with those with the special needs. It would be recommended that emergency action personnel would target these structures first. There would likely not be any significant reduction in loss-of-life estimates with this measure implemented due to uncertainties in the model. With-project floodplain inundation maps will be provided to the City of Dallas to update their EAP.

Permanent Localized Buyouts at Rockefeller Boulevard

The permanent evacuation of all or some of 19 structures on Rockefeller Boulevard was evaluated economically for its potential as a stand-alone measure or potentially combined with other measures. These structures were considered for economic evaluation since some of these structures were damaged in the May 1990 flood of record. Based on the hydrologic and hydraulic analysis, which includes the assumption of the completed DFE Project, only three of the 19 structures are located within the 1% AEP (100-year) floodplain. Six structures are located between the 1% AEP floodplain and the 0.4% AEP (250-year) floodplain and ten are located between the 250-year and the 0.2% AEP (500-year) floodplains. These structures are located near the mouth of Cedar Creek which is a small tributary of the Trinity River. During design development for the DFE Project, it was found that it was not practical for the proposed Cadillac Heights Levee component of the DFE Project to be located where these structures would be protected by the levee from Trinity River flooding. Even though these structures are not located where they would be directly protected by the proposed Cadillac Heights Levee, the DFE Chain of Wetlands component of the DFE Project in combination with the DFE Project levee components alters the expected

frequency of flooding sufficiently to provide significant flood risk benefits for these structures that did not exist in 1990. These flood frequency changes resulting from the completed DFE Project as well as any other floodplain impacts that have occurred since 1990 are considered in the current economic analysis for the Rockefeller Boulevard structures.

Estimated values and damages by event are depicted in Table 3-4. The future without-project condition EAD for the area is approximately $1,600 per year. Preliminary estimates for first costs included structure demolition and real estate costs acquisition costs equal to the structure's estimated value. Total costs for evacuating the three structures in the 1% AEP are estimated at $116,600 which annualizes to $5,300. Annual benefits are $1,000 producing approximately -$4,400 annual net benefits with a 0.2 benefit-to-cost ratio. Preliminary first costs for evacuating the six structures in the 0.4% AEP are $233,300, annualizing to $10,600. Annual benefits of $1,500 produce net benefits of -$9,100 with a benefit-to-cost ratio of 0.1. Annualized costs for the ten structures in the 0.2% AEP are $17,700 against $1,600 in annual benefits producing net benefits of -$16,100. Evacuating all nineteen structures would cost at least $622,000 which annualizes to $28,300. Annual benefits are virtually identical to 0.2% AEP evacuation producing -$26,700 in net benefits with a benefit-to-cost ratio of 0.1. The results of all four evacuation scenarios are described in Table 3-5. Evacuating structures along Rockefeller Boulevard would not be economically viable and was therefore removed from further consideration in the NED analysis.

Table 3-4. Number, Value, and Damage of Floodplain Properties and POVs by Event (October 2012 Price Level; $000)

	50% AEP		20% AEP		10% AEP		4% AEP		2% AEP		1% AEP		0.4% AEP		0.2% AEP
Damage Category	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*
Single-Family	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$34.48	3	$96.38	6	$178.90	10	$304.44
POV	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$6.78	3	$20.34	8	$54.24	10	$67.80
Total	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**2**	**$41.26**	**6**	**$116.72**	**14**	**$233.14**	**20**	**$372.24**

Damage Category	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*
Single-Family	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$5.56	3	$25.61	6	$90.73	10	$138.52
POV	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$1.95	3	$12.16	8	$47.05	10	$65.87
Total	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**2**	**$7.50**	**6**	**$37.77**	**14**	**$137.78**	**20**	**$204.39**

Table 3-5. Preliminary Estimates for the Permanent Evacuation of Rockefeller Boulevard (2012 Price Level)

	1% AEP (100-Year)	*0.4% AEP (250-Year)*	*0.2% AEP (500-Year)*	*Total*
INVESTMENT				
Estimated First Cost	$116,600	$233,300	$388,800	$622,000
Annual Interest Rate	3.750%	3.750%	3.750%	3.750%
Project Life (years)	50	50	50	50
Construction Period (months)	12	12	12	12
Interest During Construction	$2,400	$4,700	$7,900	$12,600
Investment Cost	$119,000	$238,000	$396,600	$634,600
Interest	$4,500	$8,900	$14,900	$23,800
Amortization	$800	$1,700	$2,800	$4,500
OMRR&R ($/year)	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	**$5,300**	**$10,600**	**$17,700**	**$28,300**
Without Project EAD	$1,600	$1,600	$1,600	$1,600
Residual EAD	$700	$200	$0	$0
Flood Reduction Benefits	$1,000	$1,500	$1,600	$1,600
TOTAL BENEFITS	**$1,000**	**$1,500**	**$1,600**	**$1,600**
NET BENEFITS	**($4,400)**	**($9,100)**	**($16,100)**	**($26,700)**
BENEFIT-COST RATIO	**0.2**	**0.1**	**0.1**	**0.1**

3.4.5.2 Structural

AT&SF Railroad Bridge Modification

The abandoned AT&SF Railroad Bridge spans the main stem of the Trinity River and is located at the downstream end of the Dallas Floodway Project. The AT&SF Railroad Bridge is at the division between the Dallas Floodway Project and the DFE Project. The removal of portions of the original bridge was identified as a measure since it has a significant impact on the upstream water surface during major flood events due to its closely space piers and wide embankments in the Floodway and is no longer needed for rail traffic. The bridge is a further risk to the levee system due to the potential for the closely spaced piers with cross bracing to cause significant debris accumulation and result in further increased water surface elevations upstream of the bridge during major flood events. The wood trestles on the bridge have approximately 14 foot spacing, instead of the typical 50 foot spacing on most bridge designs.

The AT&SF Railroad Bridge modification plan is for removal of portions of the bridge and includes: (1) removing approximately 1,100 feet of wood trestle bridge on the left bank side of the Floodway from the new Santa Fe Trestle Trail Bridge to the left bridge abutment at the East Levee; (2) removing a 660 foot concrete railroad bridge segment on the right bank side; and (3) removing two embankments on the right bank side of the Floodway.

Hydraulic analysis for an assumed 50% debris accumulation with subsequent levee overtopping of the SPF flood event shows that the effects of modifying the bridge would provide significant economic benefits (Table 3-6). Also shown are the results of an economic analysis for a hydraulic analysis representing an estimated debris accumulation calibrated to the water surface profile for the 1990 Flood. This same debris accumulation for the 1990 flood event was assumed to occur during an SPF flood event with a subsequent overtopping of the levee and the economic analysis (Table 3-6) shows the AT&SF

Railroad Bridge modification remains economically feasible with a lower estimate of debris blockage. Historically, every major flood event has resulted in significant debris accumulations on the bridge, so it would be reasonable to assume there will be debris accumulation during a major flood event. Therefore, all of the formulation includes the AT&SF Railroad Bridge modification as a first added increment. See Section 5.2.3 in Appendix A (Hydrology and Hydraulics) for a detailed discussion of the debris analysis for the AT&SF Railroad Bridge.

Table 3-6. NED Formulation for the AT&SF Railroad Bridge Modification (October 2010 Price Level/4% Federal Interest Rate)

	No Debris	*Debris (50% Blockage)*	*1990 Flood Debris*
INVESTMENT			
Estimated First Cost	$2,221,000	$2,221,000	$2,221,000
Annual Interest Rate	4.000%	4.000%	4.000%
Project Life (years)	50	50	50
Construction Period (months)	12	12	12
Interest During Construction	$48,000	$48,000	$48,000
Investment Cost	$2,268,000	$2,268,000	$2,268,000
Interest	$91,000	$91,000	$91,000
Amortization	$15,000	$15,000	$15,000
OMRR&R ($/year)	$0	$0	$0
TOTAL ANNUAL CHARGES	**$106,000**	**$106,000**	**$106,000**
Without Project EAD	$5,015,000	$6,290,000	$5,697,000
Residual EAD	$4,984,000	$4,984,000	$4,984,000
Flood Reduction Benefits	$31,000	$1,306,000	$713,000
TOTAL BENEFITS	**$31,000**	**$1,306,000**	**$713,000**
NET BENEFITS	**($75,000)**	**$1,201,000**	**$607,000**
BENEFIT-COST RATIO	**0.29**	**12.32**	**6.73**

Levee Height Modifications with AT&SF Railroad Bridge Modification

Levee height modifications were considered for both 4H:1V and 3H:1V levee side slopes on the river side. An initial investigation was performed to determine which flow rates to evaluate. The analysis showed the levee raise for the target flow rate of 269,000 cfs with 4H:1V side slopes, including the AT&SF Railroad Bridge modification was the alternative that had the most net economic benefits. Table 3-7 provides the economic analysis results of the various levee height modifications assuming 3H:1V side slopes. The flow rates evaluated and presented in Table 3-7 are centered on the 269,000 cfs because of its performance economically. A Value Engineering study was performed and recommended use of a 3H:1V side slope, which was adopted by the project delivery team since economic justification for the 4H:1V slope change was not found. The economic analysis demonstrates the 277,000 cfs levee raise with a 3H:1V side slope with the AT&SF Railroad Bridge modification provides the most net benefits of $1,214,000 as a separable element. Table 3-8 and Figures 3-1 and 3-2, show that all levee raises considered resulted in at least a 50% reduction in annualized loss-of-life and failure probability, indicating that they have an overall reduction in risk.

The 4H:1V side slopes was proposed by the City of Dallas to address the cost of repairing levee surface slides since this change was not found to be economically justified. A life-cycle cost analysis was conducted to compare the expected costs of future levee repairs under two scenarios: (1) continue the ad-

hoc approach to fix slides as they occur; or (2) invest in modifications now that reduce the frequency and cost of future slope failures. The City of Dallas currently estimates that it has spent approximately $1,035,000 annually over the last eleven years on repairs caused by slides. Based on these annual expenditures the following analysis determines whether it is more feasible for the City of Dallas to continue the present method of maintenance or if the investment in 4H:1V side slopes will sufficiently reduce annual maintenance expenses to make the investment worthwhile. Currently, the City of Dallas fixes these slides as they occur. A life cycle cost analysis using net present value (NPV) was conducted to determine if flattening the side slopes to 4H:1V is economically advantageous.

Under the current conditions, the NPV of fixing the slides as they occur is $34,304,000 and consists entirely of the discounted annual maintenance for the economic project life of 50 years. Flattening the side slopes to 4H:1V increases the NPV to $65,479,000. This value consists of $41,983,000 of initial construction and annual maintenance costs including the period of construction. The NPV of the total investment is $64,479,000. For this project to break even at the 50-year economic life, the NPV of the current maintenance scenario would have to increase by $31,174,000 or 91% (Table 3-9). Using NPV analysis, the side slope flattening construction is not as economically advantageous to the current maintenance program; however, based on safety concerns, the City of Dallas wishes to pursue construction of the 4H:1V side slopes at 100% non-Federal cost.

Table 3-7. NED Formulation for 3H:1V Levee Height Modifications with AT&SF Railroad Bridge Modification (October 2010 Price Level/4% Federal Interest Rate)

	260K Raise + AT&SF	*265K Raise + AT&SF*	*269K Raise + AT&SF*	*273K Raise + AT&SF*	*277K Raise + AT&SF*	*289K Raise + AT&SF*
INVESTMENT						
Estimated First Cost	$2,360,000	$2,411,000	$2,954,000	$4,205,000	$6,211,000	$11,113,000
Annual Interest Rate	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%
Project Life (years)	50	50	50	50	50	50
Construction Period (months)	12	12	12	13	22	48
Interest During Construction	$51,000	$52,000	$64,000	$97,000	$230,000	$909,000
Investment Cost	$2,411,000	$2,463,000	$3,017,000	$4,301,000	$6,441,000	$12,022,000
Interest	$96,000	$99,000	$121,000	$172,000	$258,000	$481,000
Amortization	$16,000	$16,000	$20,000	$28,000	$42,000	$79,000
OMRR&R ($/year)*	$5,000	$6,000	$8,000	$20,000	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$117,000**	**$120,000**	**$148,000**	**$220,000**	**$330,000**	**$590,000**
Without Project EAD	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Residual EAD	$4,562,000	$4,174,000	$3,881,000	$3,805,000	$3,471,000	$3,243,000
Flood Reduction Benefits	$452,000	$841,000	$1,133,000	$1,210,000	$1,544,000	$1,772,000
TOTAL BENEFITS	**$452,000**	**$841,000**	**$1,133,000**	**$1,210,000**	**$1,544,000**	**$1,772,000**
NET BENEFITS	**$335,000**	**$721,000**	**$985,000**	**$989,000**	**$1,214,000**	**$1,182,000**
BENEFIT-COST RATIO	**3.86**	**7.01**	**7.66**	**5.50**	**4.68**	**3.00**

Note: *Estimate based on net increase in O&M expenses compared to existing conditions.

Table 3-8. NED Formulation Considering Loss-of-Life for Levee Height Modifications with AT&SF Railroad Bridge Modification (October 2010 Price Level/4% Federal Interest Rate)

NED Formulation

Plan	*Without Project**	*260K Raise + AT&SF*	*277K Raise + AT&SF*	*302K Raise + AT&SF*
INVESTMENT				
Estimated First Cost	N/A	$2,360,000	$6,211,000	N/A
Total Annual Charges	N/A	$117,000	$330,000	N/A
Total Benefits	N/A	$452,000	$1,544,000	N/A
Net Benefits	N/A	$335,000	$1,214,000	N/A
Benefit-to-Cost Ratio	N/A	3.86	4.68	N/A

Loss-of-Life for PFM #2

Annualized Failure Probability	**Revised BCRA**			
East Levee	5.42E-04	2.43E-04	1.95E-04	1.44E-04
West Levee	5.42E-04	4.22E-04	1.95E-04	1.44E-04
Annualized Life Loss				
East Levee	1.37E-01	6.56E-02	4.53E-02	3.23E-02
West Levee	4.51E-01	3.66E-01	1.84E-01	1.40E-01

% Change in Loss-of-Life for PFM #2

Annualized Failure Probability				
East Levee	0%	-55.2%	-64.0%	-73.5%
West Levee	0%	-22.3%	-64.0%	-73.5%
Annualized Life Loss				
East Levee	0%	-52.0%	-66.8%	-76.4%
West Levee	0%	-18.9%	-59.2%	-69.0%

* For Loss-of-Life this is the revised BCRA

Table 3-9. Net Present Value for Side Slope Flattening (October 2010 Price Level/4% Federal Interest Rate)

Expense	*NPV of Slope Changes*
Construction	$39,211,000
Maintenance and Repair	$26,267,000
Total	**$65,479,000**
	NPV of Current Conditions
Maintenance and Repair	$34,304,000
Total	**$34,304,000**
% Change	91%

Figure 3-1. Flood Risk Management Risk Assessment f-N Chart for Levee Raises and Levee Armoring (East Levee)

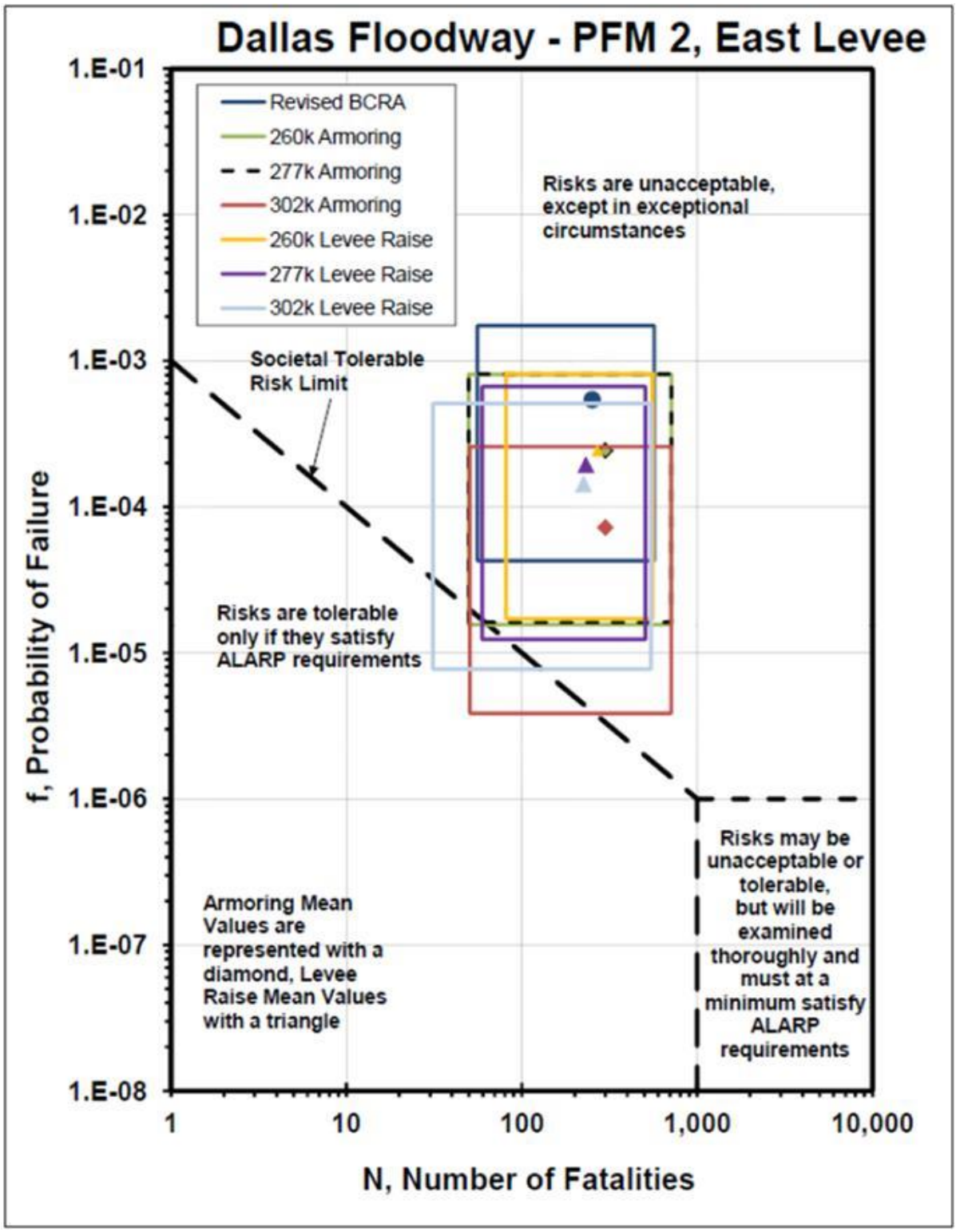
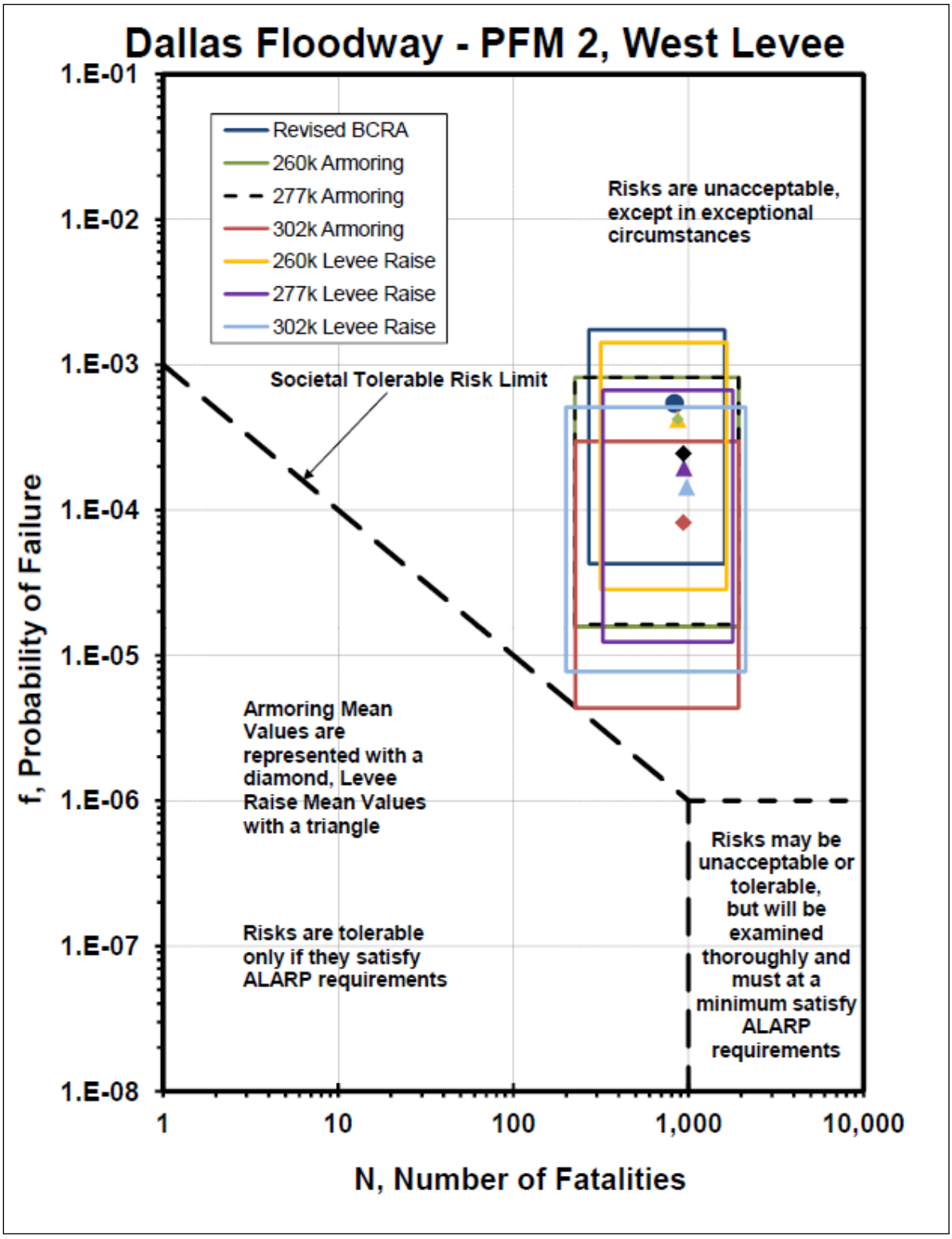


Figure 3-2. Flood Risk Management Risk Assessment f-N Chart for Levee Raises and Levee Armoring (West Levee)



Levee Armoring

This measure involves armoring the levee to designated flow rates similar to the levee raise measure. The armoring would be placed using articulated concrete block. The intent of the armoring alternative is to determine whether a breach following an overtopping event could provide economic benefits and reduce life-safety risk more so than using earthen fill. Based on the economics presented in Table 3-10, the lower level armoring alternatives (up to 265,000 cfs) were justified from an economic perspective. While lower levels of armoring proved to be economically justified, the 277,000 cfs levee raise provided more economic net benefits. Armoring provides benefits by delaying the initiation of an overtopping breach. The levee armoring alternative prevents breach on the armored portions of the levee which correspond to the low areas of the levee system. However, breach can still occur on unarmored portions of the levee at higher flood events. Table 3-11 shows a 50% reduction in the annualized probability failure and life loss from armoring up to the 277,000 cfs. While this alternative provided life-safety benefits, implementing armoring in combination with the 277,000 levee raise would cost approximately $76,000,000 and it would not reduce the overall failure probability and consequences below the recommended tolerable risk guideline for dams; however, levee armoring (as a controlled overtopping technique) was evaluated further for life-safety benefits as described in the final array, Section 3.4.6.

Seepage Cut-Off Walls

This measure was proposed at the toe of the river side of the levee to deal with the potential for under seepage at the toe of the levee leading to breach. This 3 foot wide seepage cut-off wall will be composed of a soil bentonite mixture and would key-into bedrock at a depth of 5 feet. The extent of the cut-off wall was determined through geotechnical evaluation of the borings in the Dallas Floodway Project. Since this is a different probable failure mode than what was used to formulate for overtopping, this required a different baseline condition with different inflow events and breach settings. Because the seepage walls would not prevent damages from events that overtop the levees, an effort was made to separate the economic benefits associated with flood events below the top of the levee versus above the top of the levee. Therefore, two scenarios were modeled: (1) with peak flows ranging from approximately 50% of the levee height to the highest event overtopping the levee; and (2) with peak flows ranging from 50% of the levee height to the highest event not overtopping the levee (Table 3-12). The no overtopping scenario produced without-project EAD of $858,000 and since the seepage cut-off wall is assumed to eliminate under seepage, the residual EAD goes to zero. For the levee overtopping scenario, using the assumption that the without-project condition is additive between the EAD produced for addressing the overtopping PFM and the best estimate for without-project damages that could occur due to under seepage with no overtopping, the without-project EAD is $5,873,000. The benefits to be derived would then be the elimination of the portion of EAD associated with the no overtopping which would be the without-project EAD associated with overtopping. In either scenario, the total benefits are $858,000. Cut-off walls are therefore not economically justified. As indicated in Table 3-13 and on Figure 3-3, seepage cut-off walls provided the most reduction in estimated risk (for PFM #7) of any of the alternatives by providing reductions greater than 90%. In addition, as displayed in Figure 3-3, the reduction in risk dropped the probable failure mode completely into a tolerable range. This alternative would not contribute to NED, but was carried into the final array as a possible combination plan based on its contribution to life safety.

Table 3-10. NED Formulation for Levee Armoring - Articulated Concrete Block (October 2010 Price Level/4% Federal Interest Rate)

	255K Armoring +AT&SF	*260K Armoring* +AT&SF	*265K Armoring* +AT&SF	*269K Armoring* +AT&SF	*273K Armoring* +AT&SF	*277K Armoring* +AT&SF	*289K Armoring* +AT&SF	*302K Armoring* +AT&SF
INVESTMENT								
Estimated First Cost	$4,317,000	$4,580,000	$7,065,000	$32,743,000	$53,634,000	$76,606,000	$166,148,000	$211,279,000
Annual Interest Rate	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%
Project Life (years)	50	50	50	50	50	50	50	50
Construction Period (months)	15	32	52	69	69	69	69	69
Interest During Construction	$112,000	$246,000	$629,000	$3,947,000	$6,465,000	$9,234,000	$20,028,000	$25,468,000
Investment Cost	$4,429,000	$4,827,000	$7,694,000	$36,690,000	$60,100,000	$85,840,000	$186,175,000	$236,747,000
Interest	$177,000	$193,000	$308,000	$1,468,000	$2,404,000	$3,434,000	$7,447,000	$9,470,000
Amortization	$29,000	$32,000	$50,000	$240,000	$394,000	$562,000	$1,219,000	$1,551,000
OMRR&R ($/year)	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	$206,000	$225,000	$358,000	$1,708,000	$2,798,000	$3,996,000	$8,667,000	$11,021,000
Without Project EAD	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Residual EAD	$4,593,000	$4,362,000	$4,183,000	$3,891,000	$3,512,000	$2,469,000	$2,469,000	$2,469,000
Flood Reduction Benefits	$421,000	$653,000	$832,000	$1,123,000	$1,503,000	$2,545,000	$2,545,000	$2,545,000
TOTAL BENEFITS	$421,000	$653,000	$832,000	$1,123,000	$1,503,000	$2,545,000	$2,545,000	$2,545,000
NET BENEFITS	$215,000	$428,000	$474,000	($585,000)	($1,295,000)	($1,451,000)	($6,121,000)	($8,475,000)
BENEFIT-COST RATIO	2.04	2.90	2.32	0.66	0.54	0.64	0.29	0.23

Table 3-11. NED Formulation Considering Loss-of-Life for Levee Armoring - Articulated Concrete Block (October 2010 Price Level/4% Federal Interest Rate)

NED Formulation

Plan	*Without Project**	*260K Armoring + AT&SF*	*277K Armoring + AT&SF*	*302K Armoring + AT&SF*
INVESTMENT				
Estimated First Cost	N/A	$4,580,000	$76,606,000	$211,279,000
Total Annual Charges	N/A	$225,000	$3,996,000	$11,021,000
Total Benefits	N/A	$653,000	$2,545,000	$2,545,000
Net Benefits	N/A	$428,000	($1,451,000)	($8,475,000)
Benefit-to-Cost Ratio	N/A	2.9	0.64	0.23

Loss-of-Life for PFM #2

Annualized Failure Probability	**Revised BCRA**			
East Levee	5.42E-04	2.43E-04	2.42E-04	7.22E-05
West Levee	5.42E-04	4.22E-04	2.45E-04	8.22E-05
Annualized Life Loss				
East Levee	1.37E-01	7.27E-02	7.26E-02	2.16E-02
West Levee	4.51E-01	3.66E-01	2.29E-01	7.68E-02

% Ch. in Loss-of-Life for PFM #2

Annualized Failure Probability				
East Levee	0.0%	-55.2%	-55.3%	-86.7%
West Levee	0.0%	-22.2%	-54.8%	-84.8%
Annualized Life Loss				
East Levee	0.0%	-46.9%	-47.0%	-84.2%
West Levee	0.0%	-18.9%	-49.2%	-83.0%

Note: * For Loss-of-Life this is the revised BCRA.

Table 3-12. NED Formulation for Seepage Cut-Off Walls
(October 2010 Price Level/4% Federal Interest Rate)

	No Overtopping	*W/ Overtopping*
INVESTMENT		
Estimated First Cost	$36,120,000	$36,120,000
Annual Interest Rate	4.000%	4.000%
Project Life (years)	50	50
Construction Period (months)	74	74
Interest During Construction	$4,697,000	$4,697,000
Investment Cost	$40,817,000	$40,817,000
Interest	$1,633,000	$1,633,000
Amortization	$267,000	$267,000
OMRR&R ($/year)	$0	$0
TOTAL ANNUAL CHARGES	**$1,900,000**	**$1,900,000**
Without Project EAD	$858,000	$5,873,000
Residual EAD	$0	$5,015,000
Flood Reduction Benefits	$858,000	$858,000
TOTAL BENEFITS	**$858,000**	**$858,000**
NET BENEFITS	**($1,042,000)**	**($1,042,000)**
BENEFIT-COST RATIO	**0.45**	**0.45**

Table 3-13. NED Formulation Considering Loss-of-Life for Seepage Cut-Off Walls (October 2010 Price Level/4% Federal Interest Rate)

NED Formulation

	Without Project*	Seepage Cut-Off Walls
INVESTMENT		
Estimated First Cost	N/A	$36,120,000
Total Annual Charges	N/A	$1,900,000
Total Benefits	N/A	$858,000
Net Benefits	N/A	($1,042,000)
Benefit-to-Cost Ratio	N/A	0.45

Loss-of-Life for PFM #7

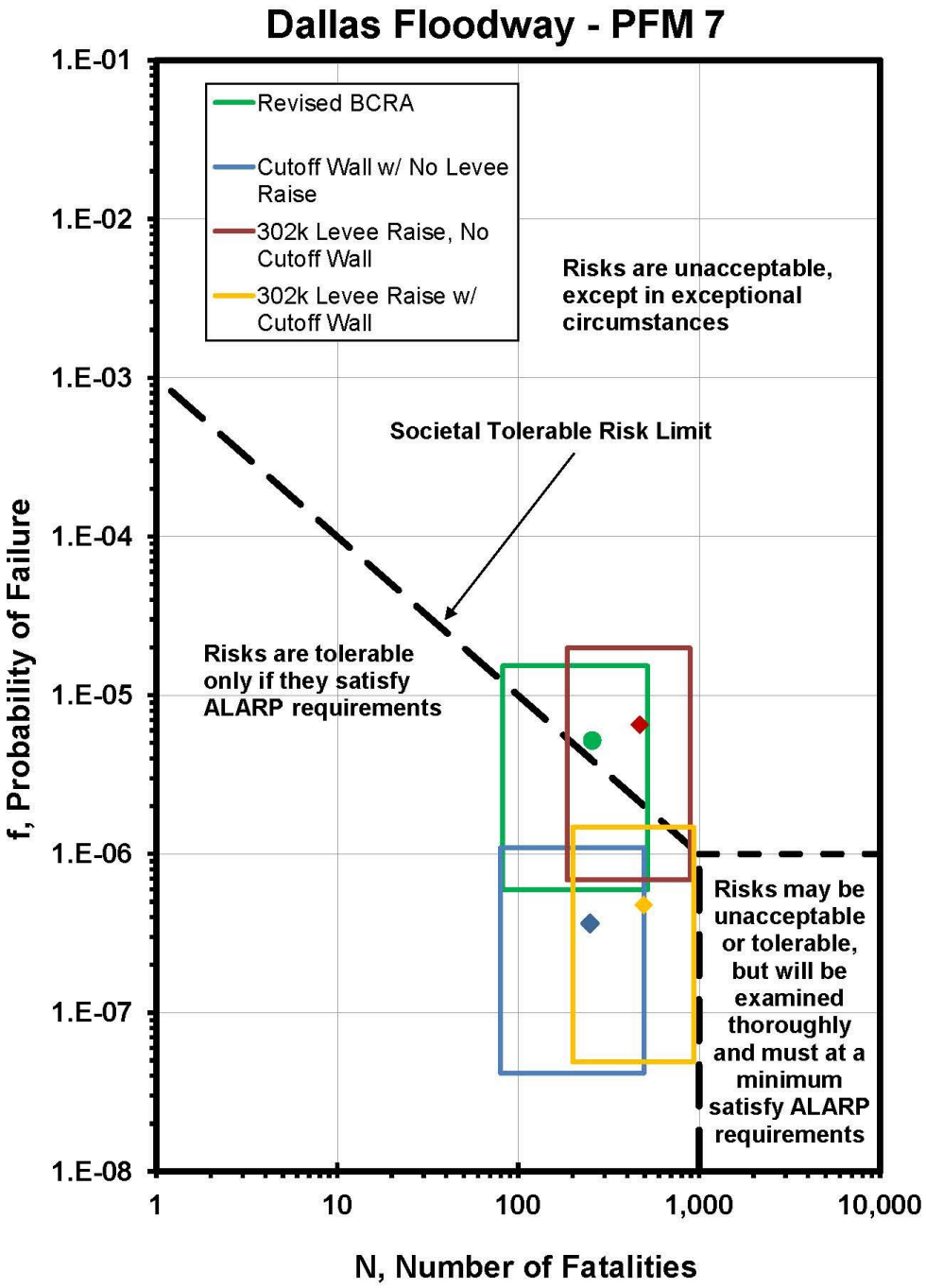
Annualized Failure Probability (P)		
East Levee	5.19E-06	3.66E-07
Annualized Life Loss (L)		
East Levee	1.33E-03	9.12E-05
Annualized Risk (P x L)		
East Levee	6.91E-09	3.34E-11

% Ch. in Loss-of-Life for PFM #7

Annualized Failure Probability (P)		
East Levee	0.0%	-92.9%
Annualized Life Loss (L)		
East Levee	0.0%	-93.2%

Note: * For Loss-of-Life this is the revised BCRA.

Figure 3-3. Flood Risk Management Risk Assessment f-N Chart for Seepage Cut-Off Walls



3.4.6 Evaluation of Final NED Array

The 277,000 cfs levee raise with the AT&SF Railroad Bridge modification proved to be the plan with the most economic benefits as a stand-alone alternative. Two additional plans were analyzed in the final array of alternatives for their ability to complement the 277,000 cfs levee raise and AT&SF Railroad Bridge modification, including the 277,000 cfs levee raise with the AT&SF Railroad Bridge modification with controlled overtopping and the 277,000 cfs levee raise with AT&SF Railroad Bridge modification with cut-off walls.

3.4.6.1 277,000 cfs Levee Raise with the AT&SF Railroad Bridge Modification with Controlled Overtopping

The controlled overtopping measure focuses on design considerations outlined in Engineer Technical Letter 1110-2-299 (1986) entitled "Overtopping of Flood Control Levees and Floodwalls." This guidance deals with designing levee systems to reduce the negative impacts of overtopping of levees since prevention of overtopping can never be absolutely assured. Controlled overtopping analysis presented herein primarily focuses on the potential for reduction of flood damage by means of altering the timing of the overtopping inundation and potentially delaying or preventing the breaching of the levee once it has been overtopped. The HEC-RAS unsteady flow model for the Dallas Floodway Project was used to analyze the effects of controlled overtopping measures at various lengths, levee heights, and locations when combined with the 277,000 cfs levee raise alternative. This controlled overtopping measure could be described as a notch in the levee having armoring on the levee crest and landside slope to prevent breaching of the levee while flow is within the notch. However, similarly to the levee armoring alternatives, if levee overtopping for some flood events exceeds the notch-capacity, then levee breaching may occur at a location on the levee outside the notch.

Out of the notching alternatives evaluated, the most significant benefit occurred with the largest notch size analyzed at 2 feet depth and 3,000 feet weir length. The analysis suggests that a relatively large controlled overtopping notch is required to result in any significant change to inundation depths, and that change only occurs for a relatively narrow range of overtopping flood events. For the highest overtopping flood events the notch would not prevent a breach in the levee and the resulting inundation depth would essentially be unchanged by the notch for these flood events. This further suggests that the economic justification for this measure is unlikely since the potential economic benefit indicated in the hydraulic analysis would be modest if not negative. Such an expected modest benefit would not outweigh the significant cost of a large controlled overtopping notch. Therefore, it was assumed that further detailed economic analysis for this measure was not warranted. Another factor to consider is the area is in an urban environment, and siting a controlled overtopping location would be difficult because there is a lack of an ideal overtopping location.

3.4.6.2 277,000 cfs Levee Raise with AT&SF Railroad Bridge Modification and Seepage Cut-Off Walls

As described previously, the 277,000 cfs levee raise with the AT&SF Railroad Bridge modification in combination with the cut-off walls would not further contribute to NED; however, the Fort Worth District thought it appropriate to display what this type of combination plan would look like if the cut-off walls were required to be part of the NED analysis (Table 3-14).

Table 3-14. 277,000 cfs Levee Raise with the AT&SF Railroad Bridge Modification and Seepage Cut-Off Walls (October 2010 Price Level/4% Federal Interest Rate)

	277K Levee Raise + AT&SF	*Cut-Off Walls*	*Combined*
INVESTMENT			
Estimated First Cost	$6,211,000	$36,120,000	$42,331,000
Annual Interest Rate	0.04	0.04	0.04
Project Life (years)	50	50	50
Construction Period (months)	22	74	74
Interest During Construction	$230,000	$4,697,000	$5,505,000
Investment Cost	$6,441,000	$40,817,000	$47,836,000
Interest	$258,000	$1,633,000	$1,913,000
Amortization	$42,000	$267,000	$313,000
OMRR&R ($/year)	$30,000	$0	$30,000
TOTAL ANNUAL CHARGES	**$330,000**	**$1,900,000**	**$2,257,000**
Without Project EAD	$5,015,000	$858,000	$5,873,000
Residual EAD	$3,471,000	$0	$3,471,000
Flood Reduction Benefits	$1,544,000	$858,000	$2,402,000
TOTAL BENEFITS	**$1,544,000**	**$858,000**	**$2,402,000**
NET BENEFITS	**$1,214,000**	**($1,042,000)**	**$145,000**
BENEFIT-COST RATIO	**4.68**	**0.45**	**1.06**

3.4.6.3 Life-Safety Considerations

To determine whether life-safety risk is fully addressed in the final array evaluation, the 277,000 cfs levee raise, levee armoring, and seepage cut-off walls were evaluated to determine whether "As-Low-As-Reasonably-Practicable" or ALARP considerations were met. The ALARP considerations provide a way to address efficiency with a project proposal to reduce risk. The concept allows risks to be tolerable if there are no practicable ways to address the risk or if further risk reduction costs are grossly disproportional to the risk reduction. Using annualized cost estimates and changes in probabilities of life loss, an estimated cost to save a statistical life was developed for the 260,000 cfs and 302,000 cfs levee armoring plans, the 277,000 cfs levee raise and the seepage cut-off walls as stand-alone alternatives. The net cost per statistical life saved was estimated to be over $1,000,000,000 for the cut-off walls. The estimated number is high because cut-off walls address PFM #7 which has a relatively low estimated probability of occurrence in the future without-project condition. Annual costs divided by low estimated probability of occurrence produce high costs per statistical life saved estimates. The 277,000 cfs levee raise has an estimated net cost per statistical life saved of $920,000 and the levee armoring plans of 260,000 cfs and 302,000 cfs, has approximately $1,500,000 and $31,700,000, respectively. The estimates show that the 277,000 cfs levee raise has the lowest net cost per statistical life saved. The estimated cost to save a statistical life for cut-off walls is disproportionate to the reduction in risk and therefore cut-off walls would not be considered reasonable.

Figure 3-4 shows the total risk for various alternatives including levee armoring and levee raises in combination with seepage cut-off walls. This figure shows the changes in risk by adding seepage cut-off walls to levee raises and levee armoring. Levee armoring is included in this section as a frame of reference and was not considered in the final array as a stand-alone alternative or in combination with cut-off walls. Life-safety risk is reduced for levee armoring and levee raises in combination with cut-off walls, but not below the recommended tolerable risk guideline. Cut-off walls, when evaluated as a stand-alone alternative for risk reduction of PFM #7 reduces risk below the recommended tolerable risk guideline as shown in Figure 3-3. From a total risk perspective, total risk is of the PFM #7 and PFM #2 is dominated by the higher risk failure mode PFM #2 and total risk is located above the recommended tolerable risk guideline. The combined 277,000 cfs levee raise with the cut-off walls as shown in Figure 3-4 does little to reduce the overall total life-safety risk.

3.4.7 Comparison of Final NED Array

The NED Plan is the 277,000 cfs levee raise with 3H:1V side slopes in combination the AT&SF Railroad Bridge modification. Controlled overtopping added to the 277,000 cfs levee raise did not show significant changes in water surface elevations, which would not translate to economic justification, so the Fort Worth District felt that further consideration was not warranted. The seepage cut-off walls provided significant overall reduction in annualized loss-of-life for PFM #7 as a stand-alone alternative for that failure mode; however based on further evaluation, the combined plan did not reduce total risk to a tolerable level. Cut-off walls are also not a cost effective means to reduce life-safety risk based on the estimated net cost of a statistical life saved. The 277,000 cfs levee raise and AT&SF Railroad Bridge modification provides greater economic and life-safety benefits compared to the other alternatives.

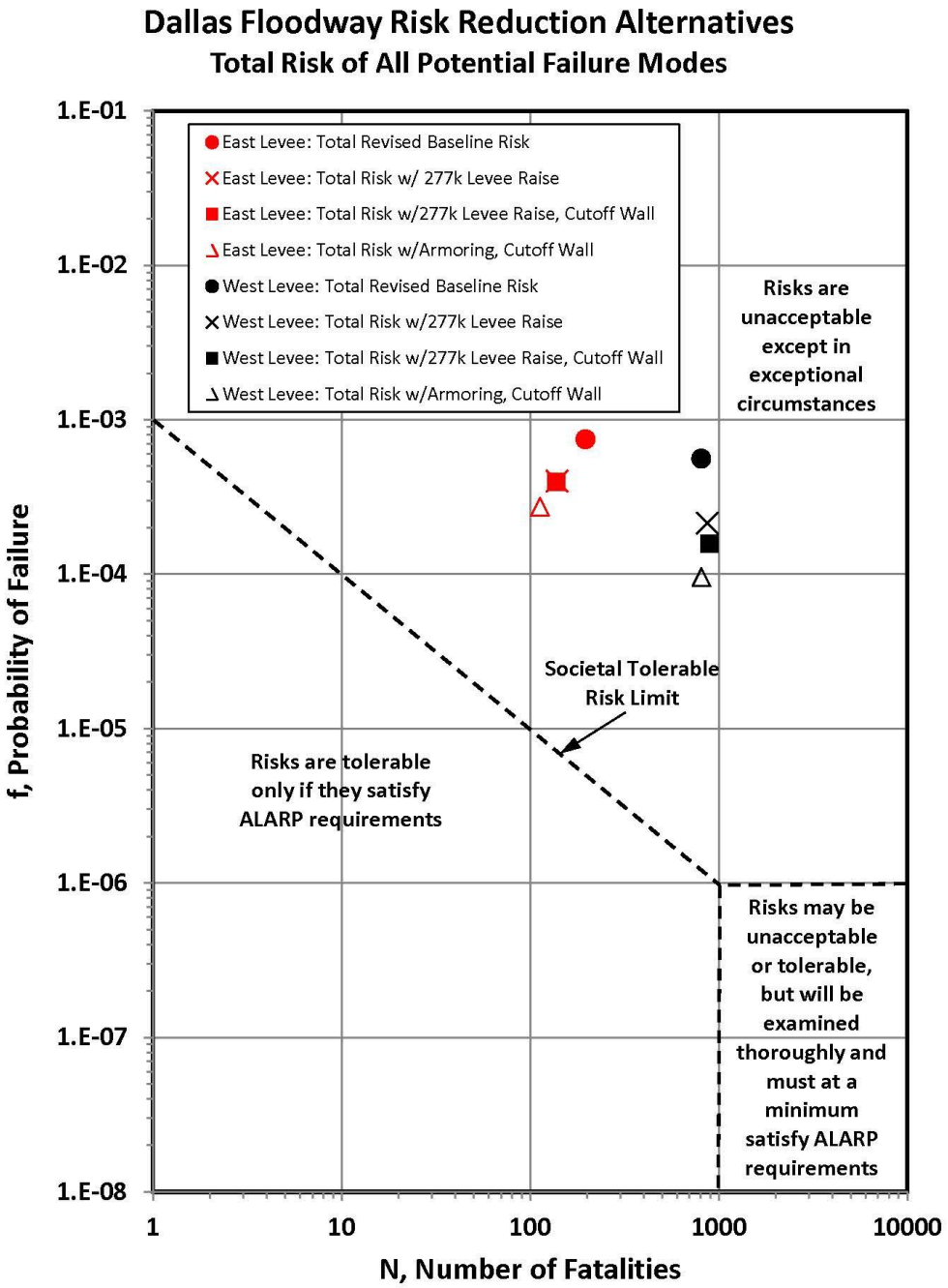
3.4.8 Tentatively Selected Plan - Flood Risk Management Component of the BVP

The BVP included up to a 2-foot levee raise with 4H:1V side slopes. The Implementation Guidance for Section 5141 of the Water Resources Development Act (WRDA) 2007 required the levee system be evaluated per Corps NED guidance. It has been determined through the formulation process that 4H:1V side slopes are not required for the levees to provide increased levels of risk reduction. In addition, a system-wide 2-foot levee raise was not determined to be the NED Plan. The NED – TSP is the 277,000 cfs levee raise with 3H:1V side slopes and the AT&SF Railroad Bridge modification based on their contribution to NED and life-safety benefits. In addition, floodplain inundation maps are available for the City of Dallas to update their EAP. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the local sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, including the forks at 100% non-Federal cost. See Appendix K, Figures K-5 through K-18 of the NED – TSP.

3.4.9 Periodic Inspection No. 9 Considerations

During formulation, all the remaining PI Report No. 9 inspection items were individually addressed and a case made whether: (1) the items should be cleared from the list with no further action; (2) a change in rating in future inspections was warranted; (3) it contributed to a PFM and should be carried forward for potential inclusion in plan formulation for corrective action; or (4) it remain with the City of Dallas as OMRR&R. A path forward for each remaining item is presented in Appendix B (Geotechnical Appendix), Section 17. From further analysis and evaluation performed, several encroachments are now subject to being rated “Acceptable” or “Minimally Acceptable” when the next Annual or PI is conducted with the local sponsor.

Figure 3-4. Flood Risk Management Total Risk for Alternatives Considered



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3.5 COMPREHENSIVE ANALYSIS

Following the NED – TSP identification, the Corps performed the Comprehensive Analysis to ensure that all of the proposed BVP and IDP Project features are technically sound and environmentally acceptable. In addition, all local features were analyzed to ensure they are acceptable and function in combination with the BVP and IDP Projects from a system-wide approach. In order to perform the Comprehensive Analysis and establish a baseline for which alternatives could be compared against, a future without-project condition was developed. In addition, the technical soundness and environmental acceptability for the proposed BVP and IDP Projects is highly dependent on another project currently being considered, the Trinity Parkway. To accommodate this, two potential BVP and IDP Project alternatives were developed; one that assumes the Trinity Parkway in place with BVP in the Floodway and one without. A description of the Trinity Parkway and descriptions of the Comprehensive Analysis alternatives are provided below. This section is followed by a technically sound and environmentally acceptable determination of Alternatives 2 and 3.

3.5.1 Trinity Parkway & Other Local Features

The Trinity Parkway is a proposed nine-mile toll road that would extend from the State Highway (SH) 183/IH-35E juncture to US-175/Spur 310. Several route alternatives are currently being evaluated as part of the FHWA NEPA process (a separate and stand-alone EIS). The FHWA is the lead Federal agency for the Trinity Parkway EIS, with the TxDOT, NTTA as joint lead agencies. The Trinity Parkway would be a tolled route around downtown Dallas, and would assist in managing traffic congestions on IH-30 and IH-35E. As this project has the potential to affect the form and function of the Dallas Floodway Project, the Corps is a cooperating agency in the development of the FHWA Trinity Parkway EIS. The Corps intends to cooperate with the FHWA in considering the FHWA-preferred Trinity Parkway alignment alternative in the Comprehensive Analysis to determine if together they would be hydraulically, geotechnically, and structurally sound with the BVP and IDP Projects.

The other local features evaluated in the Comprehensive Analysis include the Trinity River Standing Wave, Santa Fe Trestle Trail, Pavaho Wetlands, Dallas Horseshoe Project, Sylvan Avenue Bridge, Jefferson Bridge, Dallas Water Utilities Waterlines, Continental Bridge, and the East Bank/West Bank Interceptor Line. These projects have received initial “approval” under Section 408 and are in various stages of design and construction.

3.5.2 Comprehensive Analysis Assumptions

The following assumptions were used in the evaluation of projects in the Comprehensive Analysis:

- The future without-project condition (synonymous with No Action) is the description that is expected to prevail if the BVP and IDP Projects are not implemented. Typically, one future without-project condition is predicted for a study. The Trinity Parkway was considered a part of the “without-” and “with-” project condition in this study as described in the subsequent bullets.
- The Trinity Parkway evaluation compared to the existing condition is contained in the Trinity Parkway 408 package.
- For the environmental acceptability determination for the BVP and IDP Projects, the future without-project condition assumes the Trinity Parkway and other local features are implemented. The environmental acceptability evaluation needed to account for environmental impacts associated with the construction of the Trinity Parkway in order to get an accurate baseline to

evaluate impacts for the BVP and IDP Project alternatives, and assumed the Trinity Parkway implemented in the future without-project condition.

- Following the completion of the NED planning effort, the HEC-RAS model was updated to include projects given preliminary approval under Section 408. This model was used as a new future without-project condition for evaluation. The BVP and IDP Projects were added to the future without-project model and represent the BVP and IDP Projects without Trinity Parkway alternative. Then the Trinity Parkway was added to the model and represents the with Trinity Parkway alternative.

3.5.3 Description of BVP and IDP Project Alternatives

Appendix K (Figures K-19 through K-22) contains a set of figures of Alternatives 2 and 3. Also, Appendix D (Civil and Structural Design) contains design information on the BVP and IDP Projects. The EIS evaluates three alternatives:

- No-Action Alternative (Alternative 1);
- Alternative 2: BVP and IDP Projects with the Trinity Parkway; and
- Alternative 3: BVP and IDP Projects without the Trinity Parkway.

The alternatives described here correspond to the alternatives in the EIS as indicated in parenthesis. The FRM component of the BVP is included in the analysis and consists of the NED – TSP and the City of Dallas' plan to construct 4H:1V levee side slopes. Several reports, documents and drawings were used to present and analyze the alternatives described below. Sources for design are provided in Appendix D (Civil and Structural Design Appendix), Section 6. For the FRM component of the BVP, the feasibility level design was provided by the Corps.

3.5.3.1 The No-Action Alternative (Alternative 1)

The No-Action Alternative is an alternative that assumes the BVP and IDP Projects are not implemented. An analysis of the No-Action Alternative is included to identify the existing baseline conditions against which potential impacts can be evaluated. The analysis and subsequent presentation of the future without-project condition will help the decision maker decide between alternatives.

3.5.3.2 BVP and IDP Projects with the Trinity Parkway (Alternative 2)

This alternative assumes the BVP and IDP Projects are implemented with the preferred Trinity Parkway Alternative 3C (East Levee alignment) identified in the Trinity Parkway Final EIS. The Trinity Parkway proposed action includes excavation of fill material for support and berm building. To maximize construction efficiency, the NTTA, the City of Dallas, and the Corps would coordinate to determine if the Trinity Parkway can use fill material at the BVP Lakes sites for construction purposes. This would reduce the excavation needs of the BVP as the Trinity Parkway would excavate a portion of the BVP Lakes for its use. The excavation efforts by the Trinity Parkway would result in dual purpose for the Trinity Parkway and the BVP Lakes. All wetland mitigation associated with impacts from construction of the Trinity Parkway would occur outside of the Floodway in a mitigation bank.

BVP Lakes

The BVP includes creation of three lakes within the Floodway, the Natural Lake, Urban Lake, and West Dallas Lake. The combined length of the Urban and Natural Lakes is approximately two miles long, ranging between 400 and 800 feet wide. The Urban and Natural Lakes are located at the downstream end of the levee system along the East Levee. The Urban Lake includes recreation features on the perimeter of the lake such as the promenade, skate park, water maze, and white water course. The West Dallas Lake is

approximately 1.5 miles long, 600 to 700 feet wide and located further upstream near the confluence along the West Levee. A clay liner 18 – 30 inches thick will be applied to the bottom of the BVP Lakes to help prevent seepage. The BVP Lakes are designed to withstand the SPF event. The BVP Lakes were also designed to include a water management system with water rights in mind. The three lakes are separated from the Trinity River by fairly narrow earthen berms to ensure proper separation from a hydraulic and geotechnical standpoint. A portion of treated effluent from the CWWTP will be used as a water source for the Urban and Natural Lakes via a pipeline extending from the treatment plant upstream to Natural Lake.

River Relocation

The River Relocation project begins at the confluence, extending downstream approximately 8 miles, merging with the existing river channel near Corinth Avenue. The channel bottom will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain. The designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs and floodplain bench slopes and landscape terrace sides slopes at 20H:1V or flatter. Channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank will be a maximum of 3H:1V side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design is intended to approximately preserve the existing average slope and rely on natural geomorphic processes to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and wildlife habitat diversity. Pools are located in meander bends with preliminary pool design depths averaging depths of approximately 2.6 feet and pool lengths of approximately 375 feet. The Oxbow Lake is located at the downstream end of the study area. The oxbow will only be connected to the Trinity River at flows above 5,740 cfs. The Oxbow Lake is also part of the Corinth Wetlands restoration effort.

Wetlands

Wetlands of varying depths and types are designed across the Floodway including along the shoreline of the BVP Lakes and within the floodplain. Other wetland features include the Cypress Pond, the Corinth Wetlands, and the Hampton Wetlands. Cypress Pond is located just downstream from Natural Lake. Its intent is to provide an enhanced naturalistic environment with cypress trees designed to screen the Trinity Parkway from the opposite side of the park. A design refinement was made and the Cypress Ponds will be wetland ponds planted with native North Texas bottomland hardwood species and other water-tolerant herbaceous plants (as identified in City of Dallas 2009c) capable of high rates of biofiltration.

The Corinth Wetlands extend from Oxbow Lake (a feature of the River Relocation) as part of the BVP, downstream between the relocated Trinity River and the West Levee. There is a boardwalk that borders the wetlands along the West Levee toe that is designed for viewing of the features of the Corinth Wetlands.

The area identified as Hampton Wetlands are proposed as a hydraulic mitigation feature for the Trinity Parkway and will no longer be managed as wetlands. Mitigation for environmental features impacted by the Trinity Parkway is expected to be conducted at a mitigation bank outside the Floodway.

Athletic Facilities

The BVP proposes a substantial amount of managed playing fields, consisting of approximately 115 acres of playing fields for soccer, softball, and groomed “flex” fields for multiple sport usages. Event and concession facilities and amphitheaters are also proposed as part of the BVP. The hub of the active recreation program would be the West Dallas Recreation Fields, an approximately 78-acre area designed

to accommodate up to 17 regulation-size soccer fields, adaptable for lacrosse, field hockey, rugby, cricket, ultimate frisbee, football, and other field sports. This area would also feature two playgrounds. Generally, these areas would be sited at an elevation (25-year to 50-year) to reduce the frequency of maintenance. Water recreation is a major component of the BVP. Water access would be provided in multiple locations.

General Features

General features include parking and public roads, lighting, vehicular access, pedestrian amenities, restrooms, etc. Over 14 miles of roads are proposed. The roads would consist of two lanes, paved in concrete of sufficient thickness to support heavy construction and maintenance vehicles. Approximately 1,900 parking spaces divided between 12 paved lots have been identified. Approximately 500 supplementary roadside parking spaces (parallel) are also proposed along roads. To serve major events and gatherings, an additional 6,200 overflow parking spaces are proposed in 2 separate meadow areas, the majority near the potential West Dallas Amphitheater. The BVP proposes several motorized and non-motorized access points to maximize flexibility, connections, and continuity of access into the Floodway by all users. Access points would provide easy access and linkages to neighborhood parks, facilities and city-wide and region-wide trail systems. Upon implementation, people would be able to access recreational features at numerous points via foot, bike, automobile and public transit.

A system of primary and secondary trails totaling approximately 30 miles in length is proposed to run through the Floodway, meandering between the Oak Cliff and the Downtown sides and crossing the Trinity River at five key points. The primary trail would provide access for all non-motorized users including pedestrians, cyclists, skaters, and wheelchair users. The primary trail would be 20 feet wide at its narrowest, expanding up to 25 feet in places and/or in stretches and becoming divided into 10-foot lanes separated with a planted median. This trail would also serve as a maintenance and emergency access road as a supplement to the roads. An equestrian trail totaling approximately eight miles would be a single-user bidirectional trail except in constrained areas, trail junctions, bridges, and underpasses.

Due to the potential impact of flood events on restroom structures, the BVP proposes that restrooms consist of mobile or removable units, attached to permanent water and sewer utility lines. Both potable water and sewer pipes would be disconnected in preparation for removal of the units to higher ground prior to flood events. The structures would be at a 2-year flood elevation or higher.

Interior Drainage Plan (East and West Levee)

The IDP consists of proposed improvements to the existing East and West Levee Interior Drainage System (EWLIDS). The IDP improvements aim to provide stormwater flood risk management served by the EWLIDS from the 100-year storm event. Table 3-15 presents an overview of all of the proposed IDP improvements.

Table 3-15. Interior Drainage Plan Features (East and West Levee)

Component Action
Able (East Levee)
Construct new Pump Station comprised of four pumps Demolition of two existing pump stations Improvements to the hydraulic connectivity of the sumps Beautification of sump area
Baker (East Levee)
Construct Baker 3 pump station to replace Old Baker Pump Station New Baker to remain Slope protection at the sumps
Hampton (East Levee)
Construct Hampton 3 Pump Station Rehabilitate New Hampton and demolish Old Hampton Pump Stations Install three, 60-inch diameter culverts at Empire Central Drive (Nobles Branch Sump)
Charlie (West Levee)
Demolish existing Charlie Pump Station Construct new Pump Station
Pavaho
Increase capacity of existing Pavaho Pump Station
Install 1, 10-foot by 8-foot culvert under Canada Drive
Delta (West Levee)
Rehabilitate existing Delta Pump Station
Trinity-Portland (West Levee)
Construct new Pump Station
Install 1, 6-foot by 6-foot gated conduit structure between Trinity-Portland and Eagle Ford Sumps.

3.5.3.3 BVP and IDP Projects without the Trinity Parkway (Alternative 3)

While the Trinity Parkway is currently a "reasonably foreseeable" project, there is a possibility that it may never be constructed or the BVP and IDP Projects could be constructed before the Trinity Parkway. The BVP and IDP Projects could be implemented as a stand-alone project, but the Trinity Parkway could potentially be constructed within the TRC at a later date so long as FHWA updated their Final EIS accordingly. Because it is assumed that the Trinity Parkway is not in-place, certain BVP features would be different under this scenario. In addition, there would be additional cost for disposal of excess material off-site to build the BVP features. There would be no change to the NED component of the BVP or IDP improvements for this alternative.

Table 3-16 summarizes some of the notable changes to BVP features without the Trinity Parkway. These modifications are a result of the new Floodway feature geometry, reflecting the absence of the Trinity Parkway.

Table 3-16. Comparison of Notable BVP Features with and without Trinity Parkway

Feature	*With Trinity Parkway*	*Without Trinity Parkway*	*Change*
Bike Path	0 miles	3.4 miles	+ 3.4 miles
Flex Fields	77.8 acres	88.1 acres	+ 10.3 acres
Meadow	1,152.1 acres	1,121.6 acres	- 30.5 acres
Park Road	13.7 miles	15.8 miles	+ 2.1 miles
Planter Boxes (raised vegetation)	4.9 acres	14.7 acres	+ 9.8 acres
Secondary Pedestrian Path	17.5 miles	16.9 miles	- 0.6 miles
Wetlands	301.9 acres	303.8 acres	+ 1.9 acres

3.6 TECHNICAL SOUNDNESS

The evaluation of the BVP and IDP Projects include a technically sound and environmentally acceptable determination. It is based on project constructability, functionality, risk, hydraulic neutrality, compliance with Corps engineering standards at the feasibility level of design. The evaluation also includes a Comprehensive Analysis for all projects in the Dallas Floodway Project from a system-wide approach. It also determines potential conflicts in the integration of the multiple local features (Section 408 projects) and the BVP and IDP Projects.

The feasibility level design documentation listed in Section 6 of Appendix D (Civil and Structural Design Appendix) was provided by the City of Dallas on the BVP and IDP Projects and was the basis for the review for technical soundness. Section 408 project design documentation was provided by their respective project proponents for the Comprehensive Analysis. Feasibility level design of the NED-TSP and the 4H:1V levee side slopes was developed by the Corps. The following sections discuss the Corps technical soundness review of the engineering analysis and designs prepared by the City of Dallas and their contractors as well as the Section 408 projects.

Due to the authorization of the project, the preliminary design was performed by the City of Dallas and did not follow the traditional format for Corps feasibility studies. It does provide a basis to determine technical soundness and conformance to Corps guidance. The overarching goal of the evaluation was to determine technical soundness in order to progress from the current Feasibility Phase to the Pre-construction Engineering and Design (PED) Phase of the project. The following are technical sound criteria for the engineering analysis developed for this study.

3.6.1 Technical Soundness Criteria

A term often used to describe the “technical soundness” as it pertains to the hydraulic performance of the Dallas Floodway Project is “hydraulic neutrality.” In the determination of hydraulic neutrality a process of plan comparison in the Hydrology and Hydraulics (H&H) analysis was used to evaluate if the 1988 Upper Trinity River EIS ROD H&H criteria (ROD criteria) is met. The ROD criteria was originally developed for the purpose of limiting potential increases in flood risk in the TRC due to floodplain developments and has been applied to the Corps Section 404 regulatory process in the Upper TRC since 1988. While the Corps is not constrained by this regulatory process for development of projects that are consistent with Corps mission objectives, it was expected that the study would identify a project that would be a combination of Corps mission objectives (flood risk management, ecosystem restoration, and recreation, etc.), projects by local interests, and other agencies such as the FHWA. These local interest projects on the Trinity River and tributaries have historically been subject to the ROD criteria and all the

local features described herein are evaluated as stand-alone projects using the ROD criteria. Therefore, it was deemed appropriate for the Corps to use the ROD criteria to evaluate these combinations of project components that have varying and sometimes competing hydrologic and hydraulic impacts. This evaluation process is consistent with the original intent of the ROD criteria and ensures that projects that may have significant flood risk management, ecosystem restoration, and recreation benefits for the City of Dallas are designed in such a way that minimizes any potential negative flood risk impacts beyond the limits of the Dallas Floodway Project. The hydraulic modeling results of the Comprehensive Analysis were evaluated on four points from the ROD criteria. These four points are: water surface rise due to the project for the 1% Annual Exceedance Probability (AEP) and SPF flood events and valley storage loss for the 1% AEP and SPF flood events.

Technically sound criteria, for geotechnical purposes, includes compliance with Corps criteria as provided in the USACE ERs, Engineer Manuals, and Engineer Technical Letters. Additional criteria includes the Risk Management Center's reports, "*Risk Assessment Trinity River Corridor Dallas Floodway near Dallas, Texas,"* 7 September 2012, "*Risk Assessment of Proposed Remediation Methods, Trinity River Corridor Dallas Floodway,"* 2 November 2012, and "*Study of the Impact on Risk of the Proposed Balanced Vision Plan and Trinity Parkway, Trinity River Corridor Dallas Floodway,"* June 26, 2013. Fort Worth District Pamphlet (SWFP) 1150-2-1, and "*Preliminary Design Information, Guidelines, and Criteria, Geotechnical Design – City of Dallas Levees*," dated June 6, 2012 by HNTB. The memorandum was developed by the Corps and the City of Dallas' contractor, HNTB.

The Comprehensive Analysis ensures the proposed local features meet Corps engineering and safety standards, are compatible with the proposed BVP and IDP Project features, and would not have significant adverse effects on the functioning of the existing Dallas Floodway Project. A technically sound feature is constructible and positively interfaces with adjacent Dallas Floodway Project features. The feature is designed to meet minimum Corps and all other relevant design criteria. This includes SWFP 1150-2-1, which describes "Criteria for Construction within the Limits of Existing Federal Flood Protection Projects." A technically sound feature is consistent with standard engineering practice. It was determined that in the event the review identified technically sound criteria were not met, a risk based decision was made whether further feasibility level design was required or whether the design could be considered technically sound and the deficiency could remedied in future design phases. A deficiency in this case is a lack of detail in design or potential conflicts in designed features.

3.6.2 No Action (Alternative 1)

The local features that are part of the Comprehensive Analysis (aside from the Trinity Parkway) and considered implemented in the future without-project condition include various bridge modifications intersecting the levee system, utility relocations, recreation projects and other projects within the footprint of the Dallas Floodway Project as described in Section 3.5.1.

A HEC-RAS model was developed to represent a future without-project condition. This model includes all of the projects included in the existing conditions model as well as additional local features that are reasonably foreseeable as part of future conditions. The results of this model serve as the base line for comparison to the "with-project" models for determination of "hydraulic neutrality" by evaluation of the overall project with regard to the ROD criteria.

The comparison of the existing condition and the future without-project condition has indicated very small changes to the water surface profiles for both the 100-year (1% AEP) and SPF flood events. This is as expected since most of the permitted projects are not located in the floodplain or have been designed to

ensure that the project meets the requirements of the ROD criteria. A valley storage comparison has been computed for the future without-project condition compared to the existing condition. The valley storage change for the future without-project is -0.11% for the 1% AEP flood event and -0.45% for the SPF compared to the existing conditions. Not all of the projects included in the future without-project condition model have advanced to a level of development to include design to mitigate for any potential negative floodplain impacts. The future without-project condition is consistent with the current conditions for the geotechnical, civil and structural engineering analysis.

3.6.3 BVP and IDP Projects with the Trinity Parkway (Alternative 2)

The Comprehensive Analysis was conducted on the BVP and IDP Projects with the Trinity Parkway preferred 3C Alternative in place. The BVP and IDP Projects consist of the following three actions:

- FRM Component of the BVP;
- BVP Ecosystem Restoration and Recreation Features; and
- IDP Improvements.

3.6.3.1 Hydrology & Hydraulics

The results of the future without-project condition model serve as the base line for comparison to the "with-project" models for determination of "hydraulic neutrality" by evaluation of the overall project with regard to the ROD criteria. Hydraulic analysis results for the three listed actions in this alternative are as follows.

The with-project NED Plan HEC-RAS model was developed by creating a NED Plan model that encompasses all of the project features of the future without-project condition model with the added NED Plan features. The added features include: (1) the proposed AT&SF Railroad Bridge modification; (2) the levee raise to 277,000 cfs with 3H:1V side slopes on both levees; and (3) the excavated borrow areas within the Floodway needed for the levee raise construction. The 4H:1V side slopes were added to the hydraulic model under the BVP ecosystem restoration and recreation features. The hydraulic modeling results indicate that the AT&SF Railroad Bridge modification causes a loss of valley storage within the Dallas Floodway Project for the 100-year and the SPF flood events. This is caused by a lowering of the water surface due to portions of the bridge being removed. Valley storage is defined as the water volume that occupies the floodplain during passage of the flood event and is measured at the peak of the flood event. When floodplain modifications are made that reduce the peak water surface elevation of the flood event, then a valley storage loss occurs. This in turn may result in a higher peakflow for the same flood event downstream and without compensating downstream floodplain modifications may result in higher peak water surface elevations which may result in a higher flood risk downstream. Refer to Appendix A (Hydrology and Hydraulics), pages A-92 through A-95 for a more detailed discussion of valley storage impacts and computation methodology.

The hydraulic modeling results of the BVP and IDP Projects with the Trinity Parkway in Alternative 2 were evaluated on four points from the ROD criteria. These four points are: water surface rise due to the project for the 1% AEP and SPF flood events and valley storage loss for the 1% AEP and SPF flood events. The results showed that there are no water surface rises due to the project for the SPF flood event but there are some localized areas where a water surface rise occurs for the 1% AEP flood event. These rises occur on the Trinity River main stem where both levees provide risk reduction with levee crest elevations approximately 10 feet above the 1% AEP. No water surface rise occurs for the SPF flood event and the 1% AEP flood event for areas upstream of the project, so there would be no increase in flood risk

for these areas for either flood event. However, since water surface rises occur for the 1% AEP flood event, this plan fails to meet the requirements of the ROD criteria as a stand-alone project.

The loss of valley storage has been computed at more than 6% for the SPF and approximately 2.1% for the 1% AEP compared to the future without-project condition. Since the project results in a valley storage loss for both flood events, the project as currently designed does not meet the ROD criteria for the 1% AEP or SPF event. The unsteady modeling results showed that the decrease in valley storage resulted in a small (less than 1%) increase in peak flow downstream of the Trinity Parkway of 600 cfs for the 1% AEP and 2,200 cfs for the SPF event. This increase in peak discharge resulted in an increase in water surface of about 0.1 feet in the reach downstream of the Dallas Floodway Project. While technically this would be regarded as a potential increase in flood risk, it is considered insignificant with consideration for actual damages that could be realized. The immediate areas downstream of the Dallas Floodway Project are assumed to be protected by the DFE Project levees, and downstream of the DFE Project, there are very few structures subject to flooding by the SPF or 1% AEP flood event.

3.6.3.2 Geotechnical

The NED Plan was developed by the Corps and is technically sound from a geotechnical standpoint. The BVP and IDP Projects at feasibility level design is technically sound and it is expected that any issues with the current design can be remedied in PED and future design submittals. The seepage and stability analyses will need to be updated in future design to include the use of unsteady flow in lieu of the steady state analyses (if appropriate). Deterministic criteria will be confirmed during PED Phase when designing BVP and IDP Project features.

Seepage pathways are shortened by the River Relocation and the risk for heave (PFM #8) increases in the following locations: (1) West Levee, Station 3+00 to 29+00; (2) East Levee, Station 285+00 to 442+00; and (3) East Levee, Continental Avenue to Station 285+00. The City of Dallas has completed construction of seepage cut-off walls as a part of their 100-year FEMA certification effort in these locations except the section on the East Levee from Continental Avenue to Station 285+00. The existing cut-off walls the City of Dallas has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk due to the River Relocation.

There is some concern as to how close the three proposed BVP Lakes are to the levees. The RMC concluded in a risk assessment that placement of the proposed lakes detailed in the BVP will not impact the levee system because the excavation will not advance deep enough to penetrate the basal sand lenses that could cause seepage issues. The clay liner also helps address the seepage concerns.

The Trinity Parkway HNTB Supplemental Geotechnical Report, submitted as a Technical Memorandum dated June 10, 2013, generally addresses the outstanding review comments with respect to data quality issues, and also asserts that a revised geotechnical report (with data “clean-up”) will be provided with the 65% design 408 package.

3.6.3.3 Civil and Structural Design

The NED component of the study was developed by the Corps in coordination with the City of Dallas and is technically sound. The BVP and IDP Projects were evaluated to determine whether the features met the technically sound criteria established for the review. There are several key design issues identified in the BVP and IDP Projects that need to be mitigated in future design: grading plans, bridge pier modifications, earthen berms, clay liner and lake drainage system associated with the BVP Lakes, and River Relocation erosion control.

The BVP grading plans require additional design to remedy low spots and some inconsistencies with other features (including other BVP, IDP, and local features) within the Dallas Floodway Project. This can be fixed in future design by properly grading to drain and positively interfacing all features within the Floodway.

Bridge pier modifications are necessary for the construction of the BVP Lakes and River Relocation to ensure proper scour and erosion protection around the bridges. The current plan covers a majority of the affected bridges, but needs to be expanded to include Section 408 bridges in future design stages.

The three lakes of the BVP all have earthen berms, clay liners, and a lake drain system. The earthen berms, separating the lakes from the Trinity River, need to satisfy Corps criteria. In future design, the earthen berms will be evaluated with Corps criteria. This includes the evaluation of the various utilities and the lake drainage system penetrating the berms. The earthen berms also need to be evaluated for erosion due to storm events with water surface elevations that exceed the height of the earthen berms and protected accordingly. Both the berms and the lining system for the lake must be of suitable material. To date, there has not been any detailed evaluation to determine specific requirements and the quantity of material available within the Floodway. The lake drainage system has not been designed and may conflict with some utility relocations within the Floodway, specifically the pressure sewers. The lake drainage system is currently planned to be gravity flow. This would require drains to have a necessary pressure head differential between the top of lake and outfall structure to achieve flows for drainage.

Finally, River Relocation erosion control needs further evaluation in future design stages. River banks opposite discharge points need increased erosion protection to avoid blow outs, adverse effects to other features within the Floodway including bridge piers, and to limit river migration. An erosion protection plan to include all predicted shear stresses and velocities at high volume areas and confluences of discharge needs to be developed in future design phases to ensure appropriate protection schemes are implemented.

The Trinity Parkway design includes the realignment of a portion of the Trinity River that is not a BVP design feature. This current realignment strategy is to accommodate the footprint of the Trinity Parkway. This strategy may have to be expanded in scope to incorporate larger lengths of the Trinity River in order to allow for proper design and construction of borrow pits in the proposed footprints of the BVP features, Urban and Natural Lakes. In addition, the Parkway may have to include portions of BVP Lake features, such as earthen berms and clay lining material to achieve Section 408 approval. The revised designs would then also have to accommodate any new utility relocation, drainage accommodation, or grading features.

Although, the current design of the Trinity Parkway needs further development, it is believed to have the potential to be constructed in a technically sound manner. Future detailed design submittals for both the BVP and Trinity Parkway will have to be reviewed and evaluated for compliance with Corps design criteria and technical soundness. A high level of coordination between the City of Dallas, Corps, and the Trinity Parkway design team is required to ensure these features are properly designed and constructed.

The design evaluation of the IDP was based on the interface of the IDP with the BVP, Trinity Parkway and the plans to flatten all slopes to 4H:1V. The proposed pump stations increase discharge into existing channels and may require the expansion of the channel and/or additional scour protection, which have not been designed or evaluated. Flow capacities for the outfall channels need to be coordinated between the BVP and IDP Projects during future design. Provided the pump stations are designed in coordination with the NED Plan, Trinity Parkway, BVP and levee side slope flattening plans, these features are considered technically sound.

3.6.4 BVP and IDP Projects without the Trinity Parkway (Alternative 3)

This alternative assumes the BVP and IDP Projects are implemented without the Trinity Parkway Alternative 3C. The BVP and IDP Projects consist of the following three actions:

- FRM Component of the BVP;
- BVP Ecosystem Restoration and Recreation Features; and
- IDP Improvements.

3.6.4.1 Hydrology and Hydraulics

The BVP and IDP Projects without the Trinity Parkway HEC-RAS hydraulic model includes a determination regarding the hydraulic neutrality with reference to the ROD criteria. The criteria are evaluated on water surface rise due to the project for the 1% AEP and SPF flood events and valley storage loss for the 1% AEP and SPF flood events. There are no water surface rises due to the project for the SPF flood event but there is a short reach where a water surface rise occurs for the 1% AEP flood event, which occurs just downstream of the IH-30 Bridge. This rise occurs within the Floodway on the Trinity River main stem where both levees provide risk reduction from flooding for the 1% AEP flood event to the City of Dallas. No rises are indicated upstream of the Elm Fork and West Fork confluence. This analysis indicates that since no water surface rise occurs for the SPF flood event and the 1% AEP flood event for areas upstream of the project, there would be no increase in flood risk for these areas for either flood event. However, since water surface rises occur for the 1% AEP flood event, this plan fails to meet the requirements of the ROD criteria.

The loss of valley storage for the BVP in the without Trinity Parkway condition in Alternative 3 is estimated at -5.1% for the SPF and -0.80% for the 1% AEP compared to the future without-project condition. This means that the project results in a valley storage loss for both flood events. The project as currently designed does not meet the ROD criteria because no valley storage loss is allowed for the 1% AEP and no loss greater than 5% is allowed for the SPF. However, the downstream impacts are expected to be negligible, similar to what was discussed for the with Trinity Parkway alternative. The immediate areas downstream of the Dallas Floodway Project are protected by the DFE Project levees, and downstream of the DFE Project, there are few structures subject to flooding by the SPF or 1% AEP flood event.

3.6.4.2 Geotechnical, Civil and Structural Design

The conclusions of the BVP and IDP Projects technical sound determinations under Alterative 3 are essentially the same as Alternative 2 from a geotechnical standpoint. This is because there is still some benching along the East Levee. Evaluation results are also the same from a civil and structural design perspective for the BVP and IDP Projects for Alternative 3.

3.6.5 Technical Soundness Conclusions

The design completed for the BVP and IDP Projects during this phase is technically sound for the current stage of the projects and will provide a sound basis for future development of engineering products. This applies to Alternative 2 and 3. Future design work needs to follow Corps guidance and format as prescribed in Corps design standards or Section 408 requirements. Typical design submittals at the 35%, 65% and 100% level of development will be submitted and approval is required to advance to the next phase.

The results of the Comprehensive Analysis showed that the alternatives for the BVP and IDP Projects did not meet the ROD criteria in terms of valley storage and water surface rise; however, the potential

negative impacts are insignificant. While additional design refinement efforts may be able to reduce the valley storage losses noted and/or reduce the water surface rises for the 1% AEP flood event within the Dallas Floodway Project on the main stem Trinity River, meeting the ROD criteria on every point and at every location is likely not achievable for such a large and complex combination of projects. Further reducing the negative impacts for valley storage loss to some extent may be achievable, but since these estimated impacts are regarded as insignificant, and efforts to further reduce them are not likely to be cost effective at this level of design. At the current level of design for the various project components considered, the level of compliance with regard to meeting the goals of the ROD criteria is estimated to be very nearly optimal and technically sound from a hydraulic standpoint. As project designs move toward a higher level of detail in the final design stages, continual H&H analysis will be performed to ensure the highest reasonable level of compliance with the ROD criteria.

3.7 ENVIRONMENTAL ACCEPTABILITY

If an action is "environmentally acceptable," it means the action has been determined to be acceptable through the application of the NEPA process, is acceptable to the public as well as other State and Federal agencies, minimizes the extent of environmental mitigation requirements, and meets other environmental laws and regulations. The accompanying EIS presents the impact analysis for all resources in the study area for the BVP and IDP Projects. The following sections discuss the Corps environmental acceptability review of the City of Dallas' BVP and IDP Projects specific to the criteria listed above.

3.7.1 National Environmental Policy Act (NEPA) Process

An Environmental Impact Statement for the BVP and IDP Projects is under development. In accordance with NEPA, the Corps prepared and published a Notice of Intent in the *Federal Register* (Vol. 74, No. 195) on October 19, 2009 and hosted a public scoping meeting on November 17, 2009. The meeting provided the public and resource agencies an opportunity to learn about the project and provide input as to what components of the project are important to them, as well as what environmental resources the Corps should consider in their formulation of plans and impact analysis. The public meeting was also publicized in three local newspapers: the Dallas Morning News on November 7, 8, and 9 2009; Al Día on November 7, 2009; and Dallas Weekly November 12, 2009. The public scoping meeting was intended to solicit input for the EIS. The public scoping meeting also provided an opportunity for interested persons and agencies to gain information about the project and approach to the analysis, and served as an opportunity for the project team to solicit insight regarding issues that potentially could be overlooked otherwise. Thirty-three people attended the scoping meeting. The Corps and the City of Dallas hosted another public meeting January 29, 2013 to provide an update to the public on the on-going feasibility study and outlined the proposed levee system improvements (NED Plan).

3.7.2 Public Acceptability

To date, there is no known public opposition to the alternatives of the BVP or IDP Projects as stand-alone projects, but public opposition is not known for the "with" or "without" Trinity Parkway condition evaluated by the Corps in Alternatives 2 and 3. The City of Dallas developed the entire BVP with stakeholders and community input since the early 1990s. Section 1.6.2 and 2.7 of the accompanying EIS provides the history and planning effort by the City of Dallas that culminated in the development of the BVP.

The BVP was developed after 20 years of coordination with the public, especially the low-income, minority dominated residential neighborhoods within and adjacent to the BVP and IDP Projects. These

neighborhoods will receive the greatest benefit from the recreational amenities proposed, as they have been historically under-served. The designs were modified and refined to meet local demand. Based on the extensive communication with the affected residential communities, the recreational amenities proposed directly reflect the requests of the communities. The Corps has similarly lead public outreach efforts to target these residential communities since the NEPA process and feasibility study were initiated, and continues to receive positive feedback thus far.

3.7.3 Agency Coordination

On November 4, 2008, the Corps sent out letters to over 20 State and Federal agencies notifying them of the Corps intent to conduct a study and prepare an EIS and feasibility report for a proposed project. Pursuant to the *Fish and Wildlife Coordination Act of 1958*, the Corps continues to coordinate with the U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD). The Corps has also conducted resource-specific coordination with the State Historic Preservation Office. The FHWA is a cooperating agency for the EIS. A resource agency meeting was held May 2, 2013 to discuss the development of the proposed project and to invite resource agencies to share any concerns or questions they might have regarding the project so that the project team could proactively address their input in the Draft EIS prior to initiating the public review. The Corps will continue to coordinate with the public, Federal, State and other agencies. To date, there is no known agency opposition to the alternatives of the BVP or IDP Projects as stand-alone projects, but opposition is not known for a "with" or "without" Trinity Parkway condition evaluated by the Corps in Alternatives 2 and 3.

3.7.4 Environmental Impacts

For purposes of environmental acceptability, environmental impacts are assessed in terms of direct impacts to habitat types and quality in the study area for Alternatives 2 and 3. The local features including the Trinity Parkway, various bridge modifications intersecting the levee system, utility relocations, recreation projects and other projects described in Section 3.5.1 are included in the future without-project condition. The area assessed for environmental impacts includes the extent of the FEMA predicted 500-year riverine flood event. This lies within the total study area described in Section 1.4 of this report. An interagency team of Corps, TPWD and USFWS biologists conducted the habitat evaluations for the study. Environmental impacts are expressed in this assessment as changes in acres of habitat type and habitat units. Habitat units (HU) are an indication of habitat quality, and developed using an indicator species that represents the habitat types in the study area.

Table 3-17 and Table 3-18 presents the habitat acres and HU changes that occur by habitat type under the existing condition (year 2013), future without-project condition, Alternative 2 and Alternative 3 (with cumulative projects) at year 50 in the 50 year period of analysis. The year 2029 is the estimated year construction of the environmental features are complete and is the base year for the analysis. Habitat types were subdivided by location into Confluence, Mainstem and Interior Drainage System (IDS) evaluation areas to assess possible differences in project feature impacts in the analysis, but are consolidated here. Appendix F (Environmental Resources) of this report provides additional detail on the environmental resource analysis of Alternatives 2 and 3.

Table 3-17. Estimated Changes to Habitat Units under the No Action, Alternative 2 and Alternative 3 at Year 50

Habitat Type	*Existing Condition*	*Future Without-Project Condition*	*Alternative 2 Cumulative*	*Change*
Bottomland Hardwood	388.92	389.60	449.67	60.75
Emergent Wetland	97.53	94.48	145.55	48.02
Grassland	2,309.00	2,227.24	1,952,33	(356.67)
Aquatic Riverine	345.77	332.84	445.75	99.98
Open Water	143.76	129.90	341.25	197.49
Total	**3,284.98**	**3,174.06**	**3,334.55**	**49.57**
Habitat Type	*Existing Condition*	*Future Without-Project Condition*	*Alternatives 3 Cumulative*	*Change*
Bottomland Hardwood	388.92	389.60	459.89	69.97
Emergent Wetland	97.53	94.48	147.66	50.13
Grassland	2,309.00	2,227.24	1,982.68	(326.32)
Aquatic Riverine	345.77	332.84	445.75	99.98
Open Water	143.76	129.90	341.25	197.49
Total	**3,284.98**	**3,174.06**	**3,376.23**	**91.25**

Table 3-18. Estimated Changes to Habitat Acres under the No Action, Alternative 2 and Alternative 3 at Year 50

Habitat Type	*Existing Condition*	*Future Without-Project Condition*	*Alternative 2 Cumulative*	*Change*
Bottomland Hardwood	1,414	1,431	1,525	111
Emergent Wetland	419	414	368	(51)
Grassland	4,283	3,926	3,380	(903)
Aquatic Riverine	421	388	508	87
Open Water	207	187	464	257
Habitat Subtotal	6,743	6,346	6,245	(498)
Urban	10,400	10,797	10,898	498
Total	**17,143**	**17,143**	**17,143**	**0**
Habitat Type	*Existing Condition*	*Future Without-Project Condition*	*Alternatives 3 Cumulative*	*Change*
Bottomland Hardwood	1,414	1,431	1,547	133
Emergent Wetland	419	414	372	(47)
Grassland	4,283	3,926	3,439	(844)
Aquatic Riverine	421	388	508	87
Open Water	207	187	464	258
Habitat Subtotal	6,743	6,346	6,330	(413)
Urban	10,400	10,797	10,813	413
Total	**17,143**	**17,143**	**17,143**	**0**

Environmental impacts that occur in the future without-project condition are attributed to direct impacts from the local features as well as population increases, continued development, invasive species and climate change. Losses and gains occur for habitat types due to one habitat type converting to another or from local feature construction in the future without-project condition.

Alternative 2 and Alternative 3 with other cumulative projects, as applicable, have similar impacts to habitat types in terms of habitat acres and HUs throughout the 50-year period of analysis. Results suggest that under both Alternative 2 and Alternative 3, habitat quality would increase over time as compared to the "No Action" alternative or future without-project condition. There would be a gain bottomland hardwood for both alternatives primarily because of the River Relocation and associated riverbank tree plantings. Both alternatives have a net loss in acres of emergent wetlands due to construction impacts of the River Relocation; however, emergent wetlands are created at Corinth Wetlands, bottomland hardwood wetlands are created on the river terraces and Cypress Ponds, and fringe marsh along the BVP Lakes edges. The new wetlands in Alternative 2 and Alternative 3 are estimated to have higher value as shown an overall increase in HUs in Table 3-17. The greatest decrease in habitat acreage and value in the study area for both alternatives is to grassland habitat. The grassland in the main stem area of the Floodway would be converted to recreation features or converted to bottomland hardwood habitat. There is an overall improvement in HUs for aquatic riverine habitat from the River Relocation, and they are the same for both alternatives. Open water habitat is increased the same for both alternatives with creation of the Urban, Natural and West Dallas Lakes.

3.7.5 Status of Environmental Compliance

The BVP and IDP Projects may be further developed and refined as the result of public and agency input obtained through the on-going public involvement process. The following is a status for environmental compliance and is applicable to the overarching BVP and IDP Projects. The status of compliance applies to both BVP and IDP Projects for Alternative 2 and 3 unless otherwise indicated.

3.7.5.1 Endangered Species Act

Pending. Due to the lack of suitable habitat and the urbanized character of the project area, it is unlikely that any federally listed threatened or endangered species would become established in any of the study areas. The Trinity River has a high diversity of bird species, and the area is likely to become more popular as an urban park. The interior least tern is the only listed species likely to be found in the area with any regularity. However, given the urban area, breeding populations are not likely to be established. Therefore, adverse effects to federally listed species are not anticipated with implementation of any of the proposed alternatives.

3.7.5.2 Fish and Wildlife Coordination Act

Pending. The USFWS has provided Planning Aid Letters and Reports. The USFWS is currently reviewing information contained in the EIS. The USFWS prepared a Draft Fish and Wildlife Coordination Act Report for the feasibility report and is included in Appendix G. The USFWS recommendations in their Fish and Wildlife Coordination Act Report do not contradict any features of the BVP and IDP Projects. No permanent detrimental effects to aquatic or terrestrial communities within the project area would be expected to occur from the implementation of any of the project alternatives. Long term effects of Alternatives 2 and 3 would result in net benefits to fish and wildlife resources. Therefore, no additional mitigation efforts are recommended.

3.7.5.3 Clean Water Act

Pending. Section 404(b)(1) will be included in the final Draft EIS (Appendix K of the EIS). The Texas Commission on Environmental Quality would review the EIS for the purpose of rendering a decision relative to State Water Quality Certification. The EIS contains all Clean Water Act compliance documentation for Alternatives 2 and Alternative 3.

3.7.5.4 Clean Air Act

Pending. The air quality analysis in the EIS concluded that proposed emissions during construction could temporarily exceed the *de minimis* threshold for Nitrogen Oxide. Project implementation would require additional coordination with the Texas Commission on Environmental Quality (TCEQ) for temporary exceedance authorization. Impacts to air quality are greater for Alternative 3 because the excess material for the BVP Lakes construction would have to be hauled off-site. General conformity compliance documentation was submitted to TCEQ to obtain a temporary exceedance authorization and they have indicated they can approve the temporary exceedance.

3.7.5.5 Migratory Bird Treaty Act

In compliance. Impacts to nesting bird species would be minimized to the greatest extent possible in compliance with the MBTA. If proposed construction activities occur during the avian breeding season (February 15 through August 31), a biologist would check the proposed construction sites, including laydown areas, for active nests (in trees, shrubs, and on the ground) of MBTA-protected species before the construction phase begins. If the biologist finds an active nest, the area surrounding the nest would be marked with flagging and on maps, and construction workers would avoid that area until the biologist determines the nest is no longer active.

3.7.5.6 Executive Order (EO) 11988 – Floodplain Management

In Compliance. Both alternatives take place in the base floodplain (1% AEP). The Corps concluded there are no practicable alternatives to locating the proposed flood risk management and ecosystem restoration features in the base floodplain because they are site specific and require action in the floodplain. Recreation features could be site outside the base floodplain but the desire to locate the recreation features in the Floodway would continue to exist. The changes to the existing urban development would remain on the landward side of the Dallas Floodway Levee System as it exists today, and revitalization of these areas could happen with or without the proposed action. Considerations to fish and wildlife, cultural resources, recreation, and other floodplain resources are considered in the EIS. Avoidance and minimization to existing floodplain resources has been considered in the development of Alternative 2 and Alternative 3. Most of the expected losses or impacts to existing floodplain resources are expected to be compensated by the benefits provided by the BVP and IDP Projects.

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the EO. A response to the eight-step process for Alternative 2 and Alternative 3 is provided in Section 6.5 of the EIS.

3.7.5.7 EO 11990 – Protection of Wetlands

Pending. The overall BVP and IDP Projects would initially impact lower quality wetlands, but ultimately either would increase the size and functional quality of wetlands occurring within the project area.

3.7.5.8 EO 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.

Pending. The EIS considers disproportionately high and adverse effects on minority, low-income, and child populations. Access restrictions during construction would be temporary. In the long-term beneficial recreational opportunities would increase for low-income, minority and child populations. Additional discussion is provided in Section 6.7 of the EIS for compliance with this EO.

3.7.5.9 U.S. Army Corps of Engineers and Federal Aviation Administration Memorandum of Agreement

Pending. The project was coordinated with the Federal Aviation Administration (FAA), Corps, and the City of Dallas to determine if the action would create a potentially hazardous wildlife attractant. Continued coordination with the FAA has alleviated concerns regarding hazardous wildlife impacting air traffic to and from Dallas Love Field.

3.7.5.10 Cultural Resources Compliance

Section 106

In compliance. Section 405(a) of the 2010 Supplemental Disaster Relief and Summer Jobs Act (Public Law 111-212) states that the Army is not required to make determinations of eligibility under the National Historic Preservation Act for the Dallas Floodway Project. The Corps Implementation Guidance dated October 19, 2010 directs the Fort Worth District not to make further determinations under the National Historic Preservation Act.

NEPA

In compliance. The Corps Implementation Guidance dated October 19, 2010 directs the Fort Worth District to examine, describe, and consider the built environment that comprises the Dallas Floodway Project as cultural resources within the context of the scope of impacts that must be analyzed under NEPA. Significant impacts for cultural resources would be mitigated primarily through documenting and recording the resource. During construction, an archeologist will monitor excavation. Should any significant cultural resources be identified, mitigation procedures will take place prior to further excavation.

3.7.5.11 Comprehensive Environmental Response, Compensation, and Liability Act/ Resource Conservation and Recovery Act

In compliance. In 2010, a Phase I Background Database Search was conducted and a report was prepared. The search was updated in 2013 and a total of 34 sites were within the estimated construction limits. A Phase II investigation from 2008 showed presence of contaminants of concern and only 2 out of approximately 200 samples were slightly in excess of the Protective Concentration Levels (PCLs) for a 30-acre source area. All listed facilities have been assessed by the Corps and no additional Phase II investigations are warranted. Contaminated areas could be encountered during demolition or constructed-related activities; however, a soil management plan would contain a contingency plan for encountering material during construction.

3.7.6 Environmentally Acceptable Conclusions

Subject to completion of the NEPA process, public and agency input, issuance of Section 401 Water Quality Certification, the BVP and IDP Projects are environmentally acceptable for the purpose of complying with Section 5141 of WRDA 2007. This determination applies to Alternative 2 and Alternative 3.

3.8 TENTATIVELY SELECTED PLAN – WRDA PROJECT

The Section 5141 of WRDA 2007 authorization directs the Secretary to review the BVP and IDP Projects and if the Secretary determines that the project is technically sound and environmentally acceptable then the Secretary may approve the project for construction. All BVP and IDP Project features have been determined to be technically sound and environmentally acceptable and furthermore it has been determined that with slight modifications during future design, they would all function on a comprehensive system-wide level. However, even though they are technically sound and environmentally acceptable, the Corps needed to determine which features of the BVP and IDP Projects were appropriate for recommendation under Section 5141 of WRDA 2007. A tentatively selected plan (TSP) for Section 5141 of WRDA 2007 is identified in this section is referred to as the WRDA Project – TSP.

3.8.1 Balanced Vision Plan

The BVP has three main missions that have features that are supported for potential inclusion into the WRDA Project – TSP. These missions include flood risk management, ecosystem restoration and recreation. Each mission is described below with the corresponding features and the determination of whether it should be included into the WRDA Project – TSP.

3.8.1.1 Flood Risk Management

The NED Plan was formulated to meet Corps policy and therefore would be recommended as a FRM feature for the BVP. The 4H:1V side slopes improvements were included in the BVP to increase the stability of the levee system. This feature was determined to be not needed for flood risk reduction, but could be beneficial in reducing annual O&M expenses by reducing slides on the levees. A life-cycle cost analysis was conducted to compare the expected costs of future levee repairs to determine whether the investment of the modifications was worthwhile. Using net present value, the side slope flattening construction is not as economically advantageous to the current maintenance program; however, based on safety hazard of mowing steep side slopes, and because it is part of the BVP, the City of Dallas wishes to pursue construction of the 4H:1V side slopes. This feature is part of the WRDA Project – TSP as a "betterment" and will be pursued at 100% non-Federal costs.

3.8.1.2 Ecosystem Restoration

Major BVP ecosystem restoration features include:

- River Relocation;
- Corinth Wetlands;
- Natural Lake; and
- Other various surface treatment wetlands throughout the Floodway.

The River Relocation would restore the sinuosity to the Trinity River and allow the river to naturally form aquatic habitats such as pools, sandbars (riffles), and more diverse variety of instream structures. The channel banks of the existing Trinity River were constructed with uniform 1:1 slopes. The proposed channel design mimics the more natural channel bank conditions observed downstream in the Great Trinity Forest reaches of the river (immediately downstream), with flat terraces situated low in the channel along the insides of meander bends. The milder channel slope banks reduce the abrupt edge condition within the riverine corridor and facilitate greater movement (biotic and abiotic material) within the corridor. The proposed channel design will enhance the existing complex profile by maintaining the average longitudinal profile slope through the project area and facilitating improved, more natural scour

and deposition patterns around the newly created meander bends. Local bedrock controls have also been integrated into the proposed channel design, where possible, as anchors for constructed pool depressions in the profile and as gradient controls. The proposed channel design includes a revegetation plan that will re-establish native vegetation species at elevations on channel banks determined to be most conducive to their establishment and growth. Riparian vegetation will also contribute to bioengineered bank stabilization designed to limit or prevent bank erosion in high energy reaches with sensitive adjacent infrastructure. Because of the steep, uniform nature of existing channel bank slopes, the transition from in-channel to floodplain habitat is abrupt and limited in habitat quality. The proposed channel realignment design improves on this condition in two ways. First, the proposed in-channel addition and the more gradually sloped banks with terraces will improve connectivity through creation of more gradual elevation gradients between the channel and floodplain during high flows. When combined with the Corinth Wetlands, and other wetland projects, the channel realignment design will significantly improve floodplain habitat and connectivity.

Since the River Relocation is also required to implement several of the BVP features, it is also considered a recreation feature. The River Relocation presents the greatest risk to the functioning of the levee system due to the potential to increase seepage under the levees, which could result in levee failure. This risk is mitigated with the installation of cut-off walls, but it still presents engineering challenges. Due to the fact that this feature is required to implement the BVP features, is an engineering challenge, and poses potential risk to the levee system, is located within the Dallas Floodway Project footprint, and it supports all of the objectives, this feature is recommended to be part of the WRDA Project – TSP.

The Natural Lake is one of the primary borrow sources for the Trinity Parkway. Since the Trinity Parkway would likely be issued a 404 Permit as a single and complete project and it needs the borrow sites to minimize hydraulic impacts, it is not recommended to be part of the WRDA Project – TSP. Finally, wetlands are proposed throughout the BVP. If they are associated with the grading of the WRDA Project – TSP features, then they will be implemented through the grading, but the WRDA Project – TSP will not include more wetlands above and beyond the Corinth Wetlands.

3.8.1.3 Recreation

Major recreation features include the Urban and Natural Lakes, West Dallas Lake, and multiple superficial recreational facilities such as parking lots, sports fields, etc. The NED Plan requires suitable borrow material and the West Dallas Lake footprint has been identified as an ideal location for levee borrow material. Since this is also the borrow site of the 4H:1V side slope improvements proposed by the City of Dallas, the construction sequencing would need to be coordinated closely. The proposed 125-acre West Dallas Lake would include several acres of fringe marshlands and would provide recreational opportunities to nearby communities residing on the west side of the Dallas Floodway Project. Notably, the new West Dallas Lake and associated amenities would provide new and enhanced recreation and interpretive opportunities and provide scenic, picnicking, rowing and wildlife viewing opportunities.

The Urban, Natural and West Dallas Lakes are not recommended to be part of the WRDA Project – TSP. While the Corps could recommend additional BVP features as recreation opportunities, they do not add additional risk to the levee system and are generally more than what the Corps would provide for recreation opportunities and are therefore not recommended for implementation under the WRDA Project – TSP.

3.8.2 Interior Drainage Plan

Implementation of the IDP would reduce predicted 100-year, 24-hour storm event water levels to heights at or below the established City of Dallas water levels, resulting in a significant reduction in the number of structures potentially affected by flooding. This risk reduction would serve to reduce potential stormwater flooding impacts to people and property in the City of Dallas.

The IDP includes constructing new pump stations and improving some of the existing sumps for interior drainage behind the East and West Levees. These project features all contribute to the two most important objectives by maintaining the functioning of the Floodway through improving interior drainage and further reducing flood damages through increasing risk reduction behind the levee system. Furthermore, reducing flood risk is a primary mission of the Corps and something that the Corps has a significant stake in. Therefore, it is recommended that these project features be included in the WRDA Project – TSP. Due to specific language in the authorization only the East Levee IDP Phase I features, including Able, Baker, and Hampton pump stations and sump improvements in the Nobles Branch sump area can be implemented under the Section 5141 WRDA 2007 authorization.

3.8.3 The Water Resources Development Act (WRDA) Section 5141 Project – Tentatively Selected Plan

Table 3-19 presents the BVP and IDP Projects and the Recommend Plan for implementation under Section 5141 of WRDA 2007. The TSP for WRDA includes the NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements), levee side slope flattening, the IDP Phase I (Able, Hampton, and Baker pump stations, and the Nobles Branch sump improvements), the proposed River Relocation, and the Corinth Wetlands. Currently, the WRDA Project – TSP assumes the Trinity Parkway is built in the Floodway. Table 3-20 displays how each WRDA Project – TSP proposal meets the WRDA Project Objectives.

Table 3-19. BVP and IDP Projects and the Tentatively Selected Plan for Section 5141 of WRDA 2007

Category	*Description*	*Proposed BVP and IDP*	*WRDA - TSP*
BVP Flood Risk Management			
Levees	Raise to 277,000 cfs Flood Height	✓	✓
AT&SF	Removal of Wood Bridge Segment	✓	✓
	Removal of Concrete Bridge Segment	✓	✓
	Removal of Embankment Segments	✓	✓
Levee Flattening	Flattening the Riverside Levee Side Slopes to 4H:1V	✓	✓
Nonstructural	EAP Improvements	✓	✓
BVP Ecosystem and Recreation			
Lakes	West Dallas Lake	✓	
	Urban Lake	✓	
	Natural Lake	✓	
River	Realignment and Modification	✓	✓
Wetlands	Marshlands	✓	
	Hampton and Biofiltration Wetlands	✓	
	Cypress Ponds	✓	
	Corinth Wetlands	✓	✓

Category	*Description*	*Proposed BVP and IDP*	*WRDA - TSP*
Athletic Facilities	Potential Flex Fields	✓	
	Playgrounds	✓	
	River Access Points	✓	
General Features	Parking and Public Roads	✓	
	Lighting	✓	
	Vehicular Access	✓	
	Pedestrian Amenities	✓	
	Restrooms	✓	
Interior Drainage Outfall Extensions	Extend Pump Station Outfalls	✓	✓
	Extend Pressure Sewer Outfalls	✓	✓
Able Sump Ponds	Recreation and Ecosystem Enhancements	✓	
Interior Drainage Plan Flood Risk Management			
East Levee	Construct Hampton 3 Pump Station, rehabilitate New Hampton and demolish Old Hampton Pump Stations	✓	✓
	Nobles Branch Sump Improvements	✓	✓
	Able Pump Station and Sump Improvement	✓	✓
	Baker Pump Station and Sump Improvement	✓	✓
West Levee	Demolish Charlie Pump Station	✓	
	Construct New Charlie Pumping Station	✓	
	Rehabilitate Existing Delta Pump Station	✓	
	Construct New Delta Pumping Station	✓	
	Eagle Ford and Trinity-Portland Sump Improvements	✓	
	Construct New Trinity-Portland Pumping Plant	✓	

Table 3-20. WRDA – TSP Proposals and WRDA Project Objectives

Objective	*NED Plan*	*4H:1V Side Slopes*	*IDP Phase I*	*River Relocation*	*Corinth Wetlands*
Protect the flood risk reduction function of the Dallas Floodway Project;	✓	✓	✓	✓	✓
Reduce residual flood risk to property and promote life safety;	✓	✓	✓		
Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project; and				✓*	✓*
Provide water-related recreational opportunities within the boundaries of the Dallas Floodway Project.				✓	✓

*Ecosystem Restoration the primary purpose for the River Relocation and Corinth Wetlands features

CHAPTER 4
RECOMMENDED PLAN DESCRIPTION

4.1 RECOMMENDED PLAN FEATURES

The Recommended Plan is the WRDA Project – TSP which includes:

- NED Plan (277K Levee Raise with AT&SF Railroad Bridge Modification and EAP Improvements);
- Levee Side Slope Flattening (at 100% non-Federal cost);
- East Levee IDP Phase I (Able, Hampton, and Baker Pump Stations, and the Nobles Branch Sump Improvements);
- River Relocation; and
- Corinth Wetlands.

The Recommended Plan assumes the Trinity Parkway is built in the Floodway. The Recommended Plan features are described under the primary Corps mission area proposed for implementation below. Not all features associated with a BVP and IDP Projects are proposed in the Recommended Plan and will be pursued as a Section 408 project. Specific features are reflected in the Recommended Plan summaries provided below and the design and cost estimate accompanying this report (Appendices D and I). Figures K-23 through K-25 of Appendix K are figures of the Recommended Plan.

4.1.1 Flood Risk Management

4.1.1.1 NED Plan: 277,000 cfs Levee Raise and AT&SF Railroad Bridge Modification

The NED Plan is comprised of a levee raise to meet the 277,000 cfs water surface elevation and modifications to the AT&SF Railroad Bridge at the downstream end of the Dallas Floodway Project. The AT&SF Railroad Bridge modification will include the demolition and removal of 900 linear feet of wooden trestle ballast-deck bridge, demolition and removal of 100 linear feet of wooden trestle open deck bridge, and demolition and removal of 660 linear feet of concrete ballast-deck bridge. Approximately 53,000 cubic yards of earth forming the railroad embankment will be removed and disposed of outside the levee system.

The levee raises will occur in any location where the effective levee crest height is less than that of the 277,000 cfs water surface elevation. The effective levee height of any levee was determined assuming that the existing access road is approximately eight inches thick based on borings within the crest of the levees. The effective levee height is assumed, therefore, to be eight inches below the surveyed levee height at any point along the levees. Table 4-1 depicts the levee stationing that requires levee raises.

Table 4-1. Stationing of East and West Levee Reaches to be Raised

Reach Number	*East Levee and Elm Fork*		*West Levee and West Fork*	
	Begin Station	*End Station*	*Begin Station*	*End Station*
1	79+95	82+63	50+99	52+00
2	99+70	101+41	66+69	69+48
3	117+04	119+12	70+07	71+60
4	153+63	168+03	154+93	211+35
5	168+79	234+87	211+75	233+70
6	246+90	256+05	241+60	243+88
7	256+77	282+80	244+54	268+25
8	283+31	300+28	280+35	306+54
9	300+72	316+90	314+71	316+90
10	328+10	346+92	325+63	327+88
11	347+61	351+96	331+68	332+45
12	442+28	443+05	338+55	340+95
13	474+29	474+87	365+43	367+88
14	476+10	518+76	409+60	416+75
15	520+85	531+33	417+42	419+19
16	531+73	544+43	423+00	429+95
17	546+04	551+22	431+30	443+46
18	551+93	557+08	452+56	454+98
19	559+25	560+68	476+50	478+55
20	-	-	481+40	482+77
21	-	-	486+20	494+87
22	-	-	495+48	499+75
23	-	-	502+51	516+00
24	-	-	517+74	521+09
25	-	-	522+41	536+61
26	-	-	537+65	541+16
27	-	-	544+55	548+46
28	-	-	553+04	555+65
29	-	-	557+45	558+92
Total Length in Linear Feet	**25,740**		**23,529**	

Levee raises will be constructed by first excavating the top eight inches of the levee and disposing the material. The levee will be scarified to a depth of six inches along flat surfaces. Scarification along the slopes for any levee work will need to be constructed by excavating and benching into the levee at a minimum of 10-foot wide steps. Levee raises will extend from the protected side crest at a 3H:1V slope to the required elevation. The levee crest will be a minimum of 16 feet before tying into the riverside slope of the levee at a 3H:1V slope. A crushed limestone access road will be placed on top of the levee crest to

a depth of eight inches with a Geotextile liner between the levee and the road. Figures 4-1 and 4-2 show a typical levee raise template and the access road template, respectively.

Figure 4-1. 3H:1V Levee Raise Template

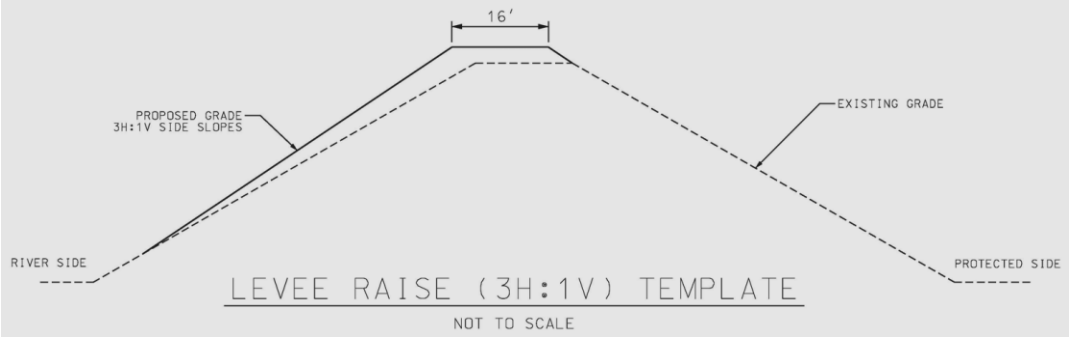
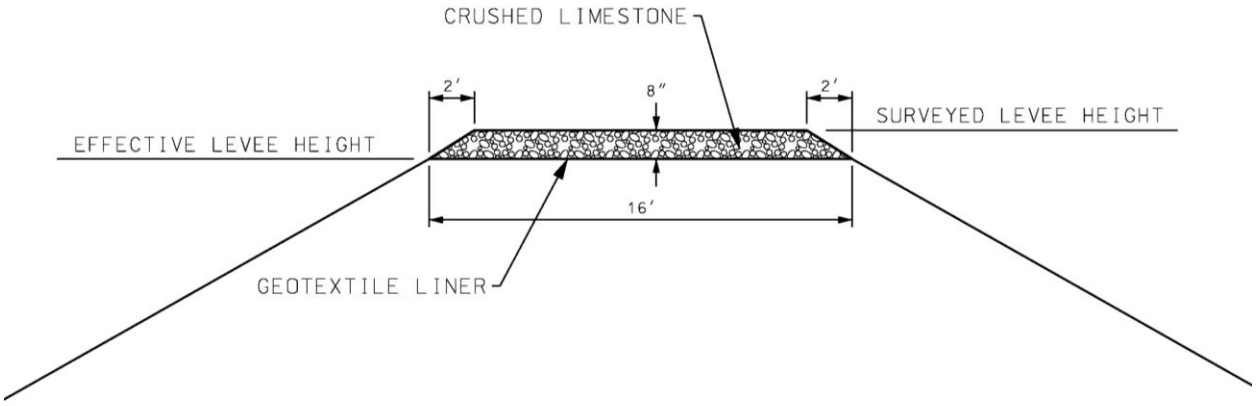


Figure 4-2. New Crushed Limestone Access Road Template



The borrow source for the NED Plan is within the footprint of the proposed West Dallas Lake. An estimated 94,000 cubic yards of material is needed for the construction of the NED Plan. This estimate takes into account compaction.

The NED Plan does not require utility relocation. There are three bridge-levee interfaces that require structural bridge sealing plans including Corinth, Union Pacific, and SH-356 on the East Levee. The Houston Street Bridge on the West Levee requires sandbagging at the 277,000 cfs flow.

4.1.1.2 Economic Summary of the NED Plan

In the development of the NED Plan, several base assumptions were used to generate quantities and to determine scope of work. The road surface template developed showed the road surface imbedded within the height of the levee. The template assumed that the proposed and existing crushed limestone road surface could be considered part of the effective levee height. It was concluded in final analysis that crushed limestone road cannot be considered part of the overall levee height and has been placed on the top of the effective levee. The increase in cost of the NED Plan was $3.2 million. Generally, each alternative considered in the NED plan formulation would have a proportional change in cost. The levee raises analyzed in the NED plan formulation were reanalyzed from a cost perspective to determine whether the formulation would change. The plans to match water surface elevations lower than that of the 277,000 cfs NED Plan were not considered because net benefits for the 277,000 cfs NED Plan with an additional $3.2 million in cost were still greater than the benefits for lower flows. The overall scope and

cost of the 289,000 cfs plan, based on knowledge of the 277,000 cfs scope and cost changes, is expected to increase by 60%. If there was a 60% increase in cost of the 289,000 cfs plan, the net benefits would fall below those of the 277,000 cfs plan. Therefore, the 277,000 cfs remains part of the NED Plan and no additional formulation is required to address the identified increase in quantities for the levee raises. Table 4-2 presents the economic summary of the NED Plan (277,000 cfs levee raise and the AT&SF Railroad Bridge modification) at the current interest rate and OMB interest rate.

Table 4-2. Economic Summary of the NED Plan
(October 2013 Price Level/3.5% Federal Interest Rate)

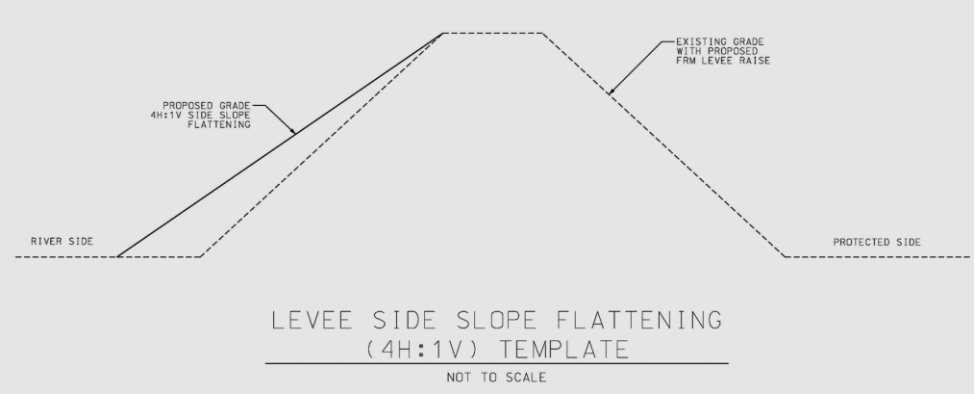
	3.5 Percent	*7 Percent*
INVESTMENT		
Construction	$8,366,000	$8,366,000
PED	$944,000	$944,000
Construction Management	$837,000	$837,000
Estimated First Cost	$10,146,000	$10,146,000
Annual Interest Rate	3.5%	7.0%
Project Life (years)	50	50
Construction Period (months)	22	22
Interest During Construction	$328,000	$659,000
Investment Cost	$10,474,000	$10,805,000
Interest	$367,000	$756,000
Amortization	$80,000	$27,000
OMRR&R ($/year)	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$477,000**	**$813,000**
Without Project EAD	$5,511,000	$5,456,000
Residual EAD	$3,817,000	$3,775,000
Flood Reduction Benefits	$1,695,000	$1,681,000
TOTAL BENEFITS	**$1,695,000**	**$1,681,000**
NET BENEFITS	**$1,218,000**	**$868,000**
BENEFIT-COST RATIO	**3.6**	**2.1**

4.1.1.3 Levee Side Slope Flattening

The current side slopes of the levee system range in grade from approximately 2.8H:1V to 4H:1V. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the local sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, including the forks, where the existing slopes are steeper than 4H:1V. Currently, the City of Dallas has implemented some sections of this plan along the downstream end of the Dallas Floodway Project. The extents of the existing efforts of side slope flattening are not defined; however, a survey prior to design and construction will delineate the full scope of the side slope flattening project. Quantities for the cost estimate of the side slope flattening were developed using a conservative assumption that the entire length of the levees would require flattening. Figure 4-3 displays the 4H:1V side slope template for the East and West Levee. The side slope flattening includes construction of the access roads to match the new contours of the riverward side of the East and West Levee. The borrow source for the side slope flattening is within the footprint of the proposed West Dallas Lake. An estimated 1,400,000 cubic yards

of material is needed for the construction of the 4H:1V side slopes, including the NED Plan levee raise quantities.

Figure 4-3. 4H:1V Typical Levee Side Slope Flattening Template



The outfall structures affected by flattening the side slopes include Old Coombs Creek, Coombs Creek, Turtle Creek, Nobles Branch Sump, and Eagle Ford Sump (Table 4-3). The associated costs and quantities for the extension of the outfall structures for these features is solely related to the proposal to flatten all riverward levee side slopes to 4H:1V. The outfall structures affected by a BVP feature, is accounted for in the respective BVP feature cost. For example, the pressure sewer relocation work on the East Levee is primarily affected by the construction of the Urban or Natural Lake. The side slope flattening plan includes demolition of all existing revetment and riprap and replacement with new concrete underneath bridges using TxDOT standards. This is to create a uniform 4H:1V surface across the entire levee to improve operations and maintenance efforts.

Table 4-3. Utility Relocations for Side Slope Flattening

Project Objective	*Utility Owner*	*Utilities*
Flood Risk Management	City Owned	Storm Pressure – Old Coombs Creek
	City Owned	Storm Pressure – Coombs Creek
	City Owned	Storm Pressure – Turtle Creek
	City Owned	Storm Gravity – Nobles Branch
	City Owned	Storm Gravity – Eagle Ford

This feature is included in the Recommended Plan at 100% non-Federal cost, and has a first cost in October 2010 price levels of approximately $39,000,000. The NED Plan levee raises impact approximately 40% of the linear length of the levees. To avoid disturbing the same sections of the levee multiple times and to reduce cost, it is recommended that the flattening of side slopes be constructed concurrent to the NED Plan construction.

4.1.1.4 East Levee Interior Drainage Plan

The East Levee IDP Phase I consists of the construction of new pump stations or improvements to existing pump stations and sumps. This includes the construction of the new Able Pump Station, new Baker 3 Pump Station, and the new Hampton 3 Pump Station, and modifications to the Nobles Branch Sump at Empire Central Drive. The Baker 3 Pump Station is currently under construction, the new Hampton 3 Pump Station is at a feasibility level design, and Able Pump Station is beyond feasibility level design at approximately 65%.

Able Pump Station will be constructed between Houston Street and Jefferson Street at about station 99+00 on the East Levee with a planned capacity of 875,000 gallons per minute (gpm). Baker 3 Pump Station is proposed to be constructed upstream of Sylvan Avenue at approximately station 241+00 on the East Levee. Baker 3 Pump Station will replace the Old Baker Pump Station and have a maximum capacity of 700,000 gpm. The new Hampton 3 Pump Station will be constructed upstream of Hampton Road at approximately station 315+00 along the East Levee. Hampton 3 Pump Station designs will replace Old Hampton Pump Station and have a maximum capacity of 700,000 gpm. The planned improvements of Nobles Branch Sump increase the connectivity of the sump through the construction of two new 60 inch reinforced concrete culverts and the replacement of one existing 60 inch concrete culvert under Empire Central Drive.

The East Levee IDP Phase I features can be cost shared at 65% Federal and 35% non-Federal based on Section 5141 of WRDA 2007 authorization. The West Levee IDP Phase II is part of the City of Dallas' IDP, but because features were not specifically named in Section 5141 of WRDA 2007, it cannot be included in the Recommended Plan. These features include Charlie Pump Station, Delta Pump Station, Pavaho Pump Station, and the new Trinity Portland Pump Station. These facilities will be constructed by the City of Dallas as Section 408 projects.

4.1.1.5 Emergency Action Plan Improvements

The City of Dallas has an existing in-depth EAP that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. Floodplain inundation maps are available to the City of Dallas to update their EAP and help them target areas with these populations that are flooded the deepest so that they can be evacuated first. The floodplain inundation maps will be developed in PED.

4.1.2 Ecosystem Restoration

4.1.2.1 River Relocation

The River Relocation is proposed for ecosystem restoration in the Recommended Plan. The Corps will participate in vegetation plantings, edge treatments for the river, erosion protection, excavation of the new river channel, and backfill of the existing river channel. The remaining features of the River Relocation are proposed under the Section 408. The existing 7.2 miles of the Trinity River will be relocated between Corinth Street to the confluence of the Elm and West Forks to improve channel diversity and sinuosity. The meanders will add approximately 1,750 linear feet to the existing Trinity River in the Floodway. As part of the River Relocation, an oxbow (Oxbow Lake) will be created upstream from Corinth Street. Oxbow Lake will have a length of approximately 2,400 linear feet. The Oxbow Lake will only be connected to the Trinity River at flows above 5,740 cfs. In order to minimize impacts to state listed threatened and endangered species, some parts of the existing channel will remain intact. The exact areas and extents will be determined during the detailed design.

The channel bottom width will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain park design. The geometry of the designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs, floodplain bench slopes and landscape terrace sides slopes at 20H:1V or flatter, for adequate drainage and transitions, and channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank to be a maximum of 3H:1V side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design is intended to approximately preserve the existing average slope

and rely on natural geomorphic processes to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and bird habitat diversity.

After excavation of the new channel and backfill of the existing channel, the River Relocation and Oxbow Lake there could be up to approximately 1.2 million cubic yards of excess material. In order to mitigate the cost of the disposal of this material, the excess can be used for grading to drain the project features and neighboring features of the West Dallas Lake. The features neighboring West Dallas Lake are not a part of the Recommended Plan; however, providing suitable material for rough grading to meet future BVP goals is recommended.

The relocation of the Trinity River requires relocation or extension of several utilities that either cross the Floodway or drain into the existing Trinity River. Table 4-4 presents the required utility relocations for the River Relocation. The discharges of the new Able Pump Station, Belleview Storm Sewer, Dallas Branch Storm Sewer, and Woodall Rogers Storm Sewer need extensions from their current (or planned) outfalls to accommodate the relocated Trinity River. The initial extension would be provided by the Trinity Parkway.

Table 4-4. Utility Relocations for River Relocation

Project Objective	*Utility Owner*	*Utilities*
Ecosystem Restoration	City Owned	Belleview Storm Sewer Outfall
	City Owned	Dallas Branch Storm Sewer Outfall
	City Owned	Woodall Rogers Sewer Outfall
	City Owned	Houston Street Viaduct Water Line
	City Owned	Hampton Road/Inwood Water Line
	City Owned	Removal of Misc. Pipelines
	City Owned	Able Pump Station Outfall
	Franchise (Atmos Energy)	Gas Main – 16 inches North of Houston Street
	Franchise (Atmos Energy)	Gas Main – 30 inches South of Sylvan Street
	Franchise (Oncor)	Underground Electric North of Commerce Street
	Franchise (Oncor)	Underground Electric South of Houston
	Franchise (Oncor)	Aerial 138kV Elec. Transm. North of Continental Street
	Franchise (AT&T)	Underground Telecomm. South of IH-30
	Franchise (Verizon)	Underground Fiber Optics South of Union Pacific
	Franchise (AT&T)	Underground Fiber Optics Between Sylvan and Continental Ave.
	Franchise (Magellan)	Jet Fuel Pipeline – 6 inches West of Westmoreland

Bridge pier modifications are required for Continental, Commerce Street, Houston Street, Jefferson Boulevard, and the existing IH-35E (southbound and northbound) because the relocated Trinity River will affect the existing bridge piers. The design methodology includes encasing the existing surrounding soil before any excavation of the River Relocation takes place.

The existing cut-off walls the City of Dallas has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk due to the River Relocation. With implementation of the additional cut-off wall, there is no increase in risk due to the River Relocation. The City of Dallas' cut-off wall and the extension of the cut-off wall on the East Levee from approximately Station 170+00 to Station 285+00 are part of the

Recommended Plan as a seepage mitigation measure for the River Relocation. Piezometers will be installed along the East and West Levee for seepage monitoring purposes.

4.1.2.2 Corinth Wetlands

The Corinth Wetlands extend from Oxbow Lake, downstream between the relocated Trinity River and the West Levee. The intent of this feature is to expand the existing wetlands in that area. The Corps will participate in vegetation plantings and excavation of the Corinth Wetlands. The total size of the Corinth Wetlands is approximately 84 acres. All remaining features are provided by the City of Dallas under Section 408 including a boardwalk that borders the wetlands along the West Levee toe that is designed for viewing of the features of the Corinth Wetlands. There are multiple landscape and grading plans for this area that all have varying descriptions and details of the amount and type of work to be completed in this area. Some plans show large amounts of landscape work including riparian woodland plantings. The intent is for the area specified in the environmental analysis for Corinth Wetlands to be emergent wetlands; however, in future design some tree plantings could be incorporated into the design. Upon further design, the final vegetation plan needs to be accounted for within the hydraulics and hydrology model for the Floodway.

4.1.2.3 Changes in Habitat Acreages and Habitat Values of the Recommended Plan

While the project moves into the design and implementation phase, the Corps recommends no net loss of bottomland hardwoods and emergent wetlands as construction occurs. Unavoidable impacts during construction would be offset through implementation of the Corinth Wetlands and River Relocation with the addition of emergent wetlands and riparian/bottomland hardwood plantings with the River Relocation in the Recommended Plan. Tables 4-5 and 4-6 present the changes in habitat acres and habitat units over a 50-year period of analysis. The change indicates there would be a net loss in acres for emergent wetlands, a slight increase in bottomland hardwoods, and a relatively large gain in acres of aquatic riverine. The greatest reduction of habitat value is to grassland habitat. This is not because the habitat value is degrading, but because grassland would be converted to other habitat types upon implementing the Recommended Plan. Overall, the environmental features in the Recommended Plan provide better function and values (considering changes in grassland habitat as a tradeoff for more desirable habitat types) than the future without-project condition as indicated in Table 4-6 over the 50-year period of analysis.

Table 4-5. Estimated Changes to Habitat Acreages within the Study Area under the Recommended Plan at Year 50

Habitat Type	*Acres*			
	Existing Conditions	*Future Without Project Condition (Year 50)*	*Future With Recommended Plan (Year 50)*	*Change*
Bottomland Hardwood	1,412.63	1,431.35	1,434.40	3.05
Emergent Wetland	418.58	414.08	403.77	-10.31
Grassland	4,283.57	3,925.77	3,925.59	-0.18
Aquatic Riverine	421.33	387.71	592.69	204.98
Open Water	206.65	186.69	186.94	.025
Habitat Subtotal	***6,742.75***	***6,345.61***	***6,5443.39***	***197.79***
Urban Area	10,400.01	10,797.16	10,599.37	-197.79
Total	**17,142.76**	**17,142.76**	**17,142.76**	**0.00**

Table 4-6. Estimated Changes to Habitat Units per Habitat Type within the Study Area under the Recommended Plan at Year 50

Habitat Type	*Habitat Units*			
	Existing	*Future Without Project Condition (Year 50)*	*Future With Recommended Plan (Year 50)*	*Change*
Bottomland Hardwood	388.92	389.59	410.64	21.05
Emergent Wetland	97.53	94.48	119.93	25.45
Grassland	2,309.00	2,227.24	1,832.35	-394.89
Aquatic Riverine	345.77	332.84	521.31	188.47
Open Water	143.76	129.90	130.06	0.16
Total	**3,284.98**	**3,174.05**	**3,014.29**	**-159.76**

4.1.2.4 USFWS Recommendations

The Recommended Plan aligns with the USFWS recommendations in their Fish and Wildlife Coordination Act Report, and does not contradict any recommendations provided by the USFWS in their report. A Draft Fish and Wildlife Coordination Act Report is included as Appendix G of this report.

4.2 MONITORING AND ADAPTIVE MANAGEMENT

Section 2039 of WRDA 2007 required monitoring for all ecosystem restoration projects to: (1) assess project performance; (2) determine achievement of success; (3) determine whether adaptive management (adjustments) are needed. A Monitoring and Adaptive Management Plan will be conducted on the River Relocation and the Corinth Wetlands. The Monitoring Plan is estimated to be conducted approximately 10-years post construction.

4.3 VALUE ENGINEERING

A value engineering workshop was performed October 1 – 5, 2012 using the Corps Value Engineering Job Plan. Forty-four items were identified by the Value Engineering team believed to improve project performance and/or cost effectiveness. Items were accepted, rejected or deferred to future design phases as detailed in the final Value Engineering report. The Value Engineering report recommended the levee raise alternatives be 3H:1V and the effective levee crest width be reduced to 14 feet from 16 feet. The project delivery team adopted the 3H:1V recommendation but not the reduction in levee crest. The reduction in crest width was rejected because it was thought to produce a safety hazard for the City of Dallas personnel that routinely drive equipment on the top of the levee for operation and maintenance purposes. The City of Dallas intends to implement the 4H:1V side slopes, and although the risk reduction is not shown in an f-N Chart, 4H:1V is expected to further reduce risk and lower the best estimates of risk in the f-N Charts shown in Section 2.1.4 from the BCRA. An additional Value Engineering workshop would be performed when the project moves to the next phase of design development.

4.4 RISK ANALYSIS

4.4.1 Project Development Risk

The project delivery team and other members of the Corps (Fort Worth District, RMC, Agency Technical Review team) the City of Dallas and other resource agencies identified various risks related to technical soundness and environmental acceptability of proposed features in the BVP and IDP Projects throughout the study process. The causes of the potential risks were identified, along with their consequence, likelihood, and uncertainty. Risks with a high or medium overall risk rating that could affect decisions for technical soundness, environmental acceptability and cost estimating include construction phasing, the River Relocation project, grading plans and the integration of the design of the multiple projects proposed in the Floodway including the Trinity Parkway. The risks were determined to be acceptable for a Feasibility Phase level of design and can be properly managed in design. Cost risks were mitigated with the cost and schedule risk analysis to develop cost contingencies. All project risks were documented in a risk register and will be used as a tool to develop the Project Management Plan (PMP) for design and construction.

4.4.2 Levee Safety Risk

The RMC performed risk assessments during the study process as project features were analyzed and developed (Appendix C). The BCRA identified the potential failure modes to define baseline (current) life-safety risk for the Dallas Floodway Project. A risk assessment was performed to measure the changes in life-safety risk that occur with the measures evaluated for contribution to NED. In a "with-project" condition, the 277,000 cfs levee raise (including the modification to the AT&SF Railroad Bridge) on the East and West Levee, risk of overtopping with a subsequent breach (PFM #2) is reduced but not below the recommended tolerable risk guideline (Figure 4-4). Figure 4-4 shows there is a slight increase in consequences on the West Levee with the 277,000 cfs levee raise. The reduction in probability of overtopping offsets the slight increase in consequences and reduces the overall risk associated with the West Levee raise. Levee armoring was evaluated to see if a breach could be prevented following an overtopping, and seepage cut-off walls were evaluated to address the internal erosion failure modes. Levee armoring or cut-off walls were not cost efficient means to reduce risk because they were high cost features and didn't reduce total risk as discussed in Section 3.4.6.3. Total risk from a flood risk management planning standpoint could not be lowered beyond the recommended tolerable risk guideline because the overall risk is dominated by PFM #2 (Figure 4-5).

A Comprehensive Analysis phase risk assessment was performed on the major features of the BVP (BVP Lakes and River Relocation) and the Trinity Parkway. The risk assessment noted that where the proposed river meanders move closer to the levees, floodwaters moving through the basal sand layer could cause a seepage issue and proposed a cut-off wall as a mitigation feature. It is expected the BVP Lakes construction would not cause a seepage problem, but more robust remediation measures beyond the proposed clay liner in the lake might need to be implemented (e.g. an additional cut-off wall), pending additional analysis. The risk assessment found the Trinity Parkway embankment does no harm "geotechnically" and could have a slight favorable impact of improving consequences by delaying failure times and potential size of breach on the East Levee. An item of note is that the risk assessment only reviewed the general features of the Trinity Parkway using two critical cross-sections; therefore, the results should never be used to completely replace prudent engineering analysis and design. To this end, as the Trinity Parkway progresses to the 65% design phase, the levee system would be analyzed using site-specific geotechnical parameters and more cross-sections.

Figure 4-5 presents the total baseline life-safety risk and the changes that occur with the Recommended Plan. The combined risk is dominated by PFM #2; therefore, the baseline risk is located above the recommended tolerable risk guideline. Total risk is reduced with major Recommended Plan features including the 277,000 cfs levee raise, River Relocation (represented in Figure 4-5 as w/BVP, Cutoff Walls) and the Trinity Parkway.

4.4.3 Residual Risk

Although life-safety and economic risks are reduced with the Recommended Plan, residual risk remains once construction is complete. If the East and West Levees were to overtop and experience a breach, the areas behind the levees would experience significant economic damages to property and the potential for loss-of-life. Controlled overtopping to prevent a breach was evaluated, but the analysis shows if levee overtopping for some flood events exceeds the notch-capacity, then levee breaching may occur at a location on the levee outside the notch and not prevent a levee breach.

Economic residual risk is expressed in an annualized dollar amount. The economic residual risk for the East and West Levee following implementation of the NED Plan is $3,474,000 in annualized damages. Life-safety residual risk can be expressed in terms of loss-of-life estimates for the East and West Levees with the Recommended Plan built. With implementation of the Recommended Plan, the estimated annualized life loss is 1.86E-2 for the East Levee and 1.85E-1 for the West Levee.

HEC-FDA produces project performance reports to display the hydrologic and hydraulic performance of a particular plan. Table 4-7 shows the project performance for the proposed 277,000 cfs levee raise and its impact on risk. The 277,000 cfs reduces the risk of exceeding the levee compared to the future without-project condition by 44.5% on the East Levee and 28% on the West Levee.

Figure 4-4. Levee Raise to Contain the 277,000 cfs Overtopping with Subsequent Breach (PFM #2) f-N Chart

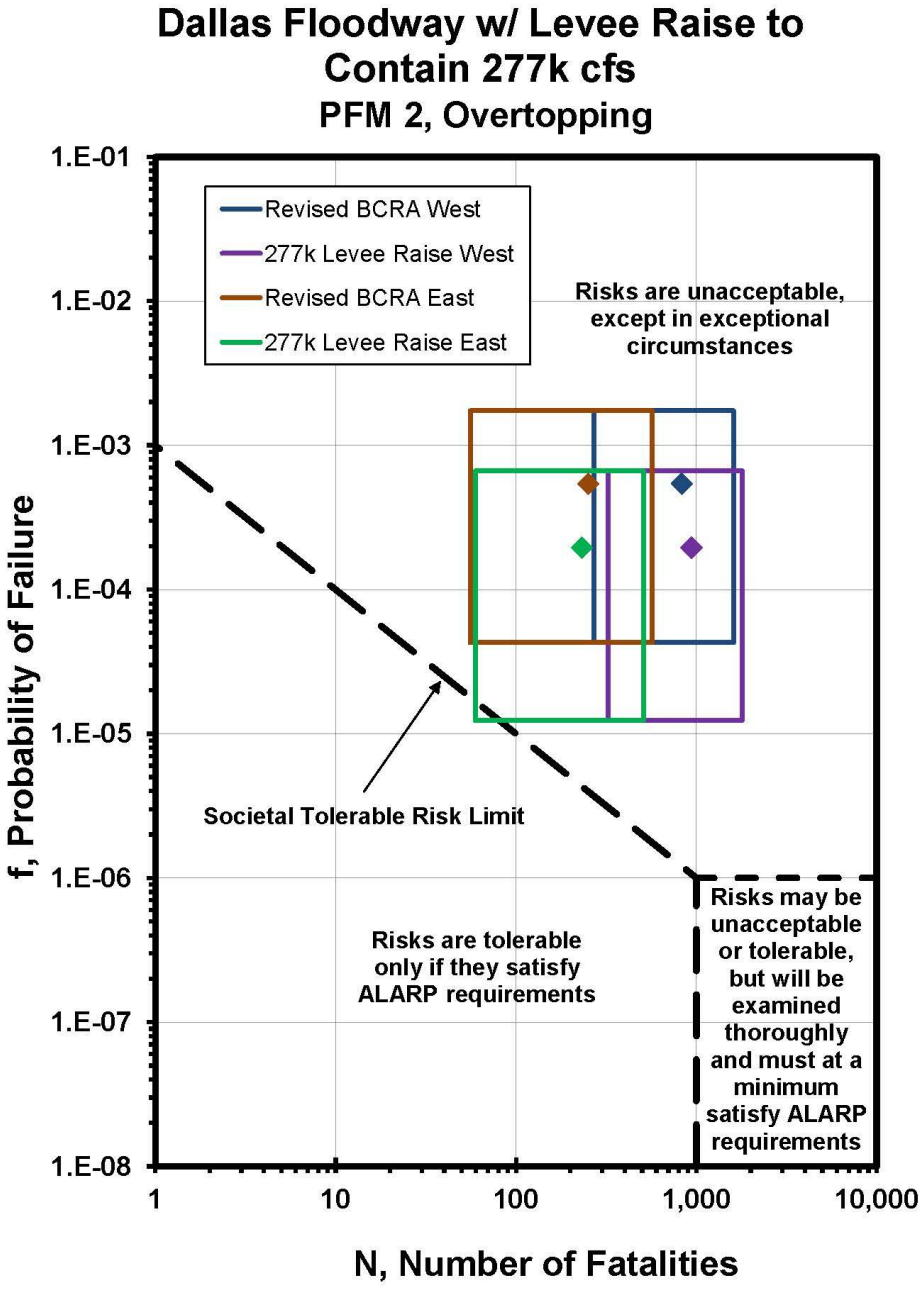


Figure 4-5. Total Risk Chart for the East and West Levee with Recommended Plan Features

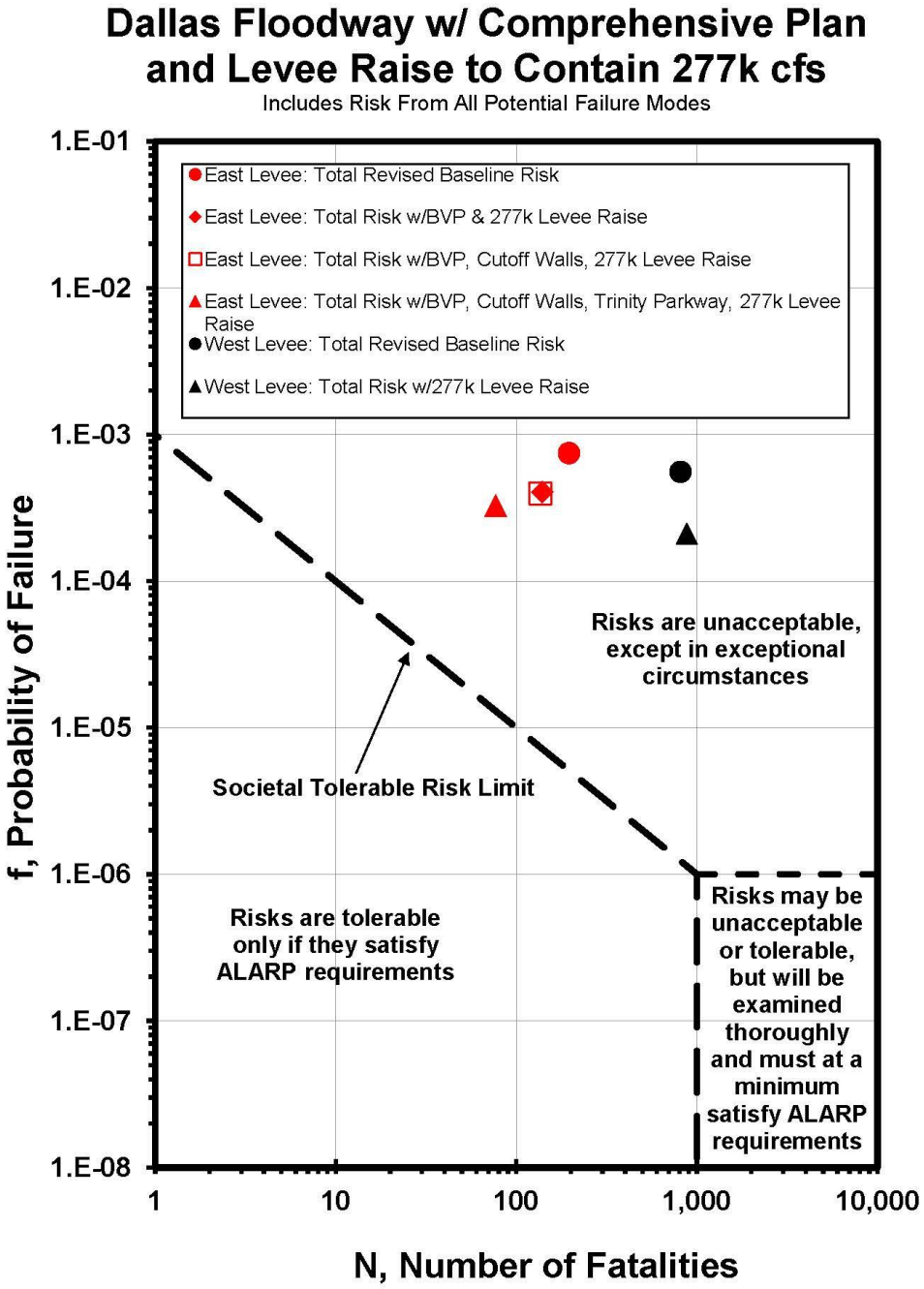


Table 4-7. Risk Performance of Proposed Levee Raise to 277,000 cfs

Without Project

		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	0.1%	0.8%	2.3%	3.8%	100.0%	100.0%	99.9%	99.0%	92.1%	78.8%
West	0.1%	0.6%	1.8%	3.0%	100.0%	100.0%	99.94%	99.3%	93.8%	82.3%

With Project

		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	0.04%	0.4%	1.3%	2.1%	100.0%	100.0%	100.0%	99.6%	95.8%	87.1%
West	0.04%	0.4%	1.3%	2.2%	100.0%	100.0%	99.97%	99.6%	95.8%	86.9%

Change		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	-50.0%	-44.9%	-44.6%	-44.5%	0.0%	0.0%	0.1%	0.5%	4.1%	10.6%
West	-33.3%	-29.0%	-28.3%	-28.0%	0.0%	0.0%	0.03%	0.3%	2.1%	5.6%

1

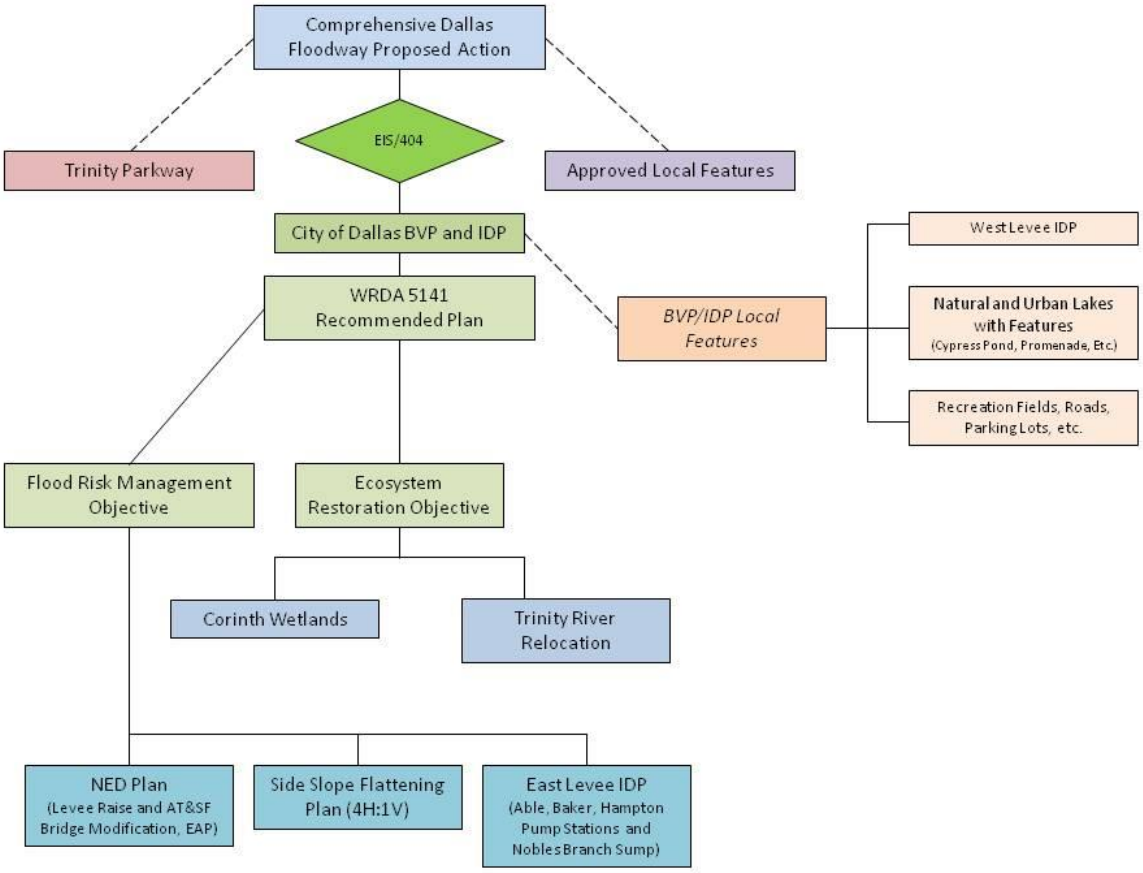
4.5 REMAINING SECTION 408 ACTIVITIES

Figure 4-6 presents the overall framework of the Comprehensive Analysis, Recommended Plan and the related 408 actions taking place or remaining. In the Comprehensive Analysis, the Corps reviewed the City of Dallas' BVP and IDP Projects and found them to be technically sound and environmentally acceptable. The BVP and IDP Projects include several features that are not part of the Recommended Plan, but can be pursued as a Section 408 project. The non-Federal sponsor will be responsible for the construction of remaining features of the BVP and IDP Projects and their associated cost. The City of Dallas and the proponents of the Trinity Parkway will provide separate Section 408 packages for Corps approval that can reference the technical and environmental evaluation presented in this report. The BVP and IDP Projects and the Trinity Parkway 408 packages will be submitted concurrent to the approval of this feasibility report. NEPA compliance and Section 404 for the entire BVP and IDP Projects are provided in the EIS accompanying this report and will be used as supporting documentation for the Section 408 package.

The Trinity Parkway Section 408 submittal will reference the technical and environmental evaluations as needed in this report to obtain the initial Section 408 approval and provide necessary geotechnical, hydraulic, environmental and regulatory documentation in their Section 408 submittal. The Trinity Parkway HNTB Supplemental Geotechnical Report, submitted as a Technical Memorandum dated June 10, 2013, generally addresses the outstanding review comments with respect to data quality issues, and also asserts that a revised geotechnical report (with data "clean-up") will be provided with the 65% design 408 package.

The Corps also evaluated other local features that required Section 408 approval in the Comprehensive Analysis. These projects received initial or construction approval as a major or minor Section 408 while the study was in progress. Some of the Recommended Plan IDP Phase I features have been reviewed and approved as Section 408 projects while the study was in progress and the will seek credit for those features in the future.

Figure 4-6. Comprehensive Analysis Framework



CHAPTER 5
PROJECT IMPLEMENTATION

5.1 STATUS OF ENVIRONMENTAL COMPLIANCE

The status for environmental compliance is applicable to the overarching BVP and IDP Projects and provided in this report under Section 3.7, Environmental Acceptability. The same environmental compliance status applies to the Recommended Plan.

5.2 PROJECT CONSTRUCTION & PROJECT PHASING

Implementation of the BVP and IDP Projects would occur over an approximately 10-year to 12-year period, beginning in 2015. This assumes that capability level funding would be provided. If funds are not provided then construction could extend out to 20-25 years or more. The Recommended Plan is a subset of the BVP and IDP Projects. In order to construct the project efficiently and to be technically sound, appropriate project phasing of the Recommended Plan is imperative.

The Recommended Plan construction will begin with utility relocation, followed by the NED levee raises. Side-slope flattening is recommended to take place concurrent to the levee raises. The River Relocation design could initiate while these features are under construction. The River Relocation design and construction would be split into three phases, and could occur over multiple years. Construction sequencing of all features of the Recommended Plan will be dependent upon the construction schedule of the Trinity Parkway. The Corinth Wetlands would be designed and constructed to compensate for Floodway habitat losses as they occur due to the levee raises and other Recommended Plan features. Any excess borrow material would be utilized as rough grading for BVP features that are not part of the Recommended Plan.

5.3 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION

The non-Federal sponsor is responsible for the Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) of the complete project. The Fort Worth District will update the existing Dallas Floodway Operation and Maintenance (O&M) Plan dated May 1960 upon successful completion of the project. A comprehensive O&M Plan will be created for the entire project. Maintenance will be required throughout project construction. Table 5-1 shows the expected annual OMRR&R costs over and above existing costs associated with the Recommended Plan. The Recommended Plan is expected to increase existing OMRR&R costs by $1,677,000 annually.

The new design grade is 277,000 cfs for the East and West Levee. An updated O&M Plan will specify new design grade and maintenance requirements for the City of Dallas. The new design grade will be specific to the 277,000 cfs flow, not the associated frequency. Targeting a flow instead of a frequency will allow for clear understanding for design grade requirements in the future O&M Plan.

The BVP and IDP Projects have a largely developed O&M Plan that is further discussed in the City of Dallas design submittals. The City of Dallas currently performs mowing operations across the existing

Dallas Floodway Project. These mowing operations will be modified after the construction of all features. Future mowing plans need to be in accordance with landscape preferences for grass length and need to be aware of new wetland features and other vegetation. Additionally, it is important from a hydraulic standpoint that vegetation features be maintained to ensure proper conveyance of water. Debris after a flood event will also be prevalent and will need to be removed to allow for proper water conveyance and hydraulic performance. All BVP features will be inundated on average during the 10 to 25-year storm recurrence intervals.

Routine inspections (annual and periodic) of all elements in the Dallas Floodway Project are required. Features should be inspected on an annual basis prior to the rainy season and after every major flood event, at required periodic intervals. All inspections will be performed by the City of Dallas. Any defects during inspection would be remedied by the City of Dallas to ensure the functionality of the Dallas Floodway Project is not compromised. The estimated increase in annual and periodic inspections for the BVP and IDP Projects is $127,500. The NED Plan and the side slope flattening would not increase existing annual inspection costs. The Recommended Plan features of the East Levee IDP and River Relocation would require the additional cost for inspections of $25,000 as presented in Table 5-1.

The existing level of maintenance performed by the City of Dallas on the levees would increase annually due to additional surface to mow. The increased capacity of the pump stations would require an increase in annual maintenance. Plantings along the relocated Trinity River and Corinth Wetlands would require annual maintenance, especially immediately after planting. The estimated increase in routine maintenance for the plantings is $22,000.

Slides would continue to require repair as they occur, but costs would decrease by 20% based on current estimated annual cost of repairs of $1,000,000. The increased capacity of the pump stations would require an increase in annual repair and replacement costs. Routine repair and replacement cost ($1,500,000) for the River Relocation were estimations derived from a percentage of the total cost to construct bank stabilization features.

Table 5-1. City of Dallas Estimated Change in Annual OMRR&R Costs for the Recommended Plan

Feature	*Annualized Cost*		
	Routine Inspections	*Routine Maintenance*	*Repair & Replacement*
Levees	$0	$30,000	($200,000)
Interior Drainage Plan (East Levee)	$10,000	$50,000	$50,000
River Relocation	$15,000	$22,000	$1,500,000
Total	**$25,000**	**$102,000**	**$1,550,000**

5.4 TOTAL PROJECT COST

The costs associated with the final Recommended Plan are presented in Table 5-2. The Recommended Plan is estimated to cost approximately $579,077,000 at October 2013 price levels. Appendix I (Detailed Cost Estimate and Cost Analysis) contains the cost estimate and Cost and Schedule Risk Analysis for the Recommended Plan. Currently, the total project cost does not exceed the Section 902 cost limit.

Table 5-2. Cost Estimate Summary for the Recommended Plan

Total First Cost Oct 2013 Price Level	
Flood Risk Management	
01 Lands and Damages	$16,672,000
06 Fish and Wildlife	$48,000
08 Roads, Railroads, and Bridges	$1,551,000
11 Levees and Floodwalls	$6,767,000
13 Pumping Plant	$196,675,000
30 Planning, Engineering and Design	$18,800,000
31 Construction Management	$16,717,000
FRM Total	**$257,229,000**
Ecosystem Restoration (ER)	
02 Relocations	$42,706,000
06 Fish and Wildlife	$5,679,000
08 Roads, Railroads and Bridges	$38,982,000
09 Channels	$179,838,000
30 Planning, Engineering and Design	$28,924,000
31 Construction Management	$25,720,000
ER Total	**$321,849,000**
Total	**$579,077,000**

5.5 COST SHARING

Table 5-3 displays what the cost sharing would be for the Recommended Plan if there were no credit available for the project. The Recommended Plan is estimated to cost $579,077,000 that would be cost shared 65% Federal at $376,400,000 and 35% non-Federal at $202,677,000. However, the project authorization allows the City of Dallas to receive credit for implementing project features in advance of signing the Project Partnership Agreement. By the time a Project Partnership Agreement is executed, the City of Dallas is expected to have potential credit in the amount of $165,691,000 or more. This total exceeds the amount of credit that they are eligible to receive. In order to prevent the city from paying 5% cash on the funds that they will not receive credit on, the construction cost had to be adjusted. Table 5-4 displays the cost sharing taking into consideration how much credit the City of Dallas would be eligible for. Table 5-4 is only an estimate and the actual amount of credit would be finalized at the end of the project. Due to the fact that this is a moving target the official cost estimate of the project was not lowered. With the total amount that the City of Dallas has already spent on the project and with credit considerations, the remaining funds to be provided are $343,930,000 Federal and $185,193,000 non-Federal for a total of $529,123,000. Of the $185,193,000, $115,451,000 would be potential credit, $10,364,000 would be the 5% cash required on all Flood Risk Management Projects, and $59,378,000 would be lands, easements, rights-of-ways and relocation requirements. The credit that the city is eligible to receive credit for is primarily in the Flood Risk Management portion of the project. However, the credit is applied to both project features since there will be only one Project Partnership Agreement that will

cover the entire project. Likewise, since credit is applied to both business lines, the Federal dollars proposed for Flood Risk Management would be utilized for Ecosystem Restoration.

The proposed construction of the NED Plan is covered under the project authorization and reconstruction authority is not necessary. One of the City of Dallas' goals was to address flood risk management issues, so their BVP included raising the levees up to 2 feet above the Standard Project Flood (SPF) water surface profile combined with riverside side slope flattening to a 4-to-1, width-to-height ratio (4H:1V). The NED component of the BVP can be constructed as part of the Recommended Plan for Section 5141 of WRDA 2007 without additional authority.

Implementation of the 4H:1V side slopes are a betterment. Under the authority of Public Law 84-99 (Flood Control and Coastal Emergency Act), an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the Federal system owner, and at 20% cost to the eligible non-Federal system owner. If the levees are damaged by a flood event, the City of Dallas would be responsible for the cost to build back to a 4H:1V in excess of the 3H:1V.

Table 5-3. Cost Share Summary of the Recommended Plan Without Credit, October 2013 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$167,198,000		$167,198,000
LERRDs		$16,672,000	$16,672,000
5% Cash		$12,861,000	$12,861,000
Credit			$0
Additional Cash		$60,497,000	$60,497,000
Subtotal	**$167,198,000**	**$90,030,000**	**$257,228,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$209,202,000		$209,202,000
LERRDs		$42,706,000	$42,706,000
Credit			$0
Additional Cash		$69,941,000	$69,941,000
Subtotal	**$209,202,000**	**$112,647,000**	**$321,849,000**
Percentage	**65%**	**35%**	
Subtotal Combined FRM/ER	**$376,400,000**	**$202,677,000**	**$579,077,000**
Combined Percentages	**65%**	**35%**	

Table 5-4. Cost Share Summary of the Recommended Plan With Credit Consideration, October 2013 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$134,728,000		$134,728,000
LERRDs		$16,672,000	$16,672,000
5% Cash		$10,364,000	$10,364,000
Credit		$45,510,000	$45,510,000
Additional Cash			$0
Subtotal	**$134,728,000**	**$72,546,000**	**$207,274,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$209,202,000		$209,202,000
LERRDs		$42,706,000	$42,706,000
Credit		$69,941,000	$69,941,000
Additional Cash			$0
Subtotal	**$209,202,000**	**$112,647,000**	**$321,849,000**
Percentage	**65%**	**35%**	
Subtotal Combined FRM/ER	**$343,930,000**	**$185,193,000**	**$529,123,000**
Combined Percentages	**65%**	**35%**	

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5.6 PROJECT IMPLEMENTATION SCHEDULE

Table 5-5 displays the project implementation schedule and funding for the Recommended Plan. See Section 5.8.5 for additional information on the contract schedule.

Table 5-5. Project Implementation Schedule and Funding Requirements for the Recommended Plan, October 2013 Price Level*

		Fiscal Year													
Flood Risk Management	**Sunk Costs**	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
01 Lands and Damages	$2,466,000					$14,206,000									
06 Fish and Wildlife Facilities			$48,000												
08 Roads, Railroads, and Bridges			$6,767,000												
11 Levees and Floodwalls				$1,551,000											
13 Pumping Plant	$85,094,000*						$61,627,000								
30 Planning, Engineering and Design	$10,928,000	$943,000				$6,930,000									
31 Construction Management	$9,716,000		$737,000	$100,000			$6,164,000								
Ecosystem Restoration															
02 Relocations			$5,193,000	$17,977,000						$19,536,000					
06 Fish and Wildlife Facilities															$5,679,000
08 Roads, Railroads, and Bridges				$363,000	$13,978,000						$24,642,000				
09 Channels	$10,000,000				$53,349,000			$65,078,000				$51,410,000			
30 Planning, Engineering and Design			$6,622,000		$10,910,000				$11,388,000						
31 Construction Management					$5,892,000			$9,702,000				$10,127,000			
Total	**$118,204,000**	**$943,000**	**$19,367,000**	**$19,991,000**	**$84,129,000**	**$21,136,000**	**$67,791,000**	**$74,780,000**	**$11,388,000**	**$19,536,000**	**$24,642,000**	**$61,537,000**			**$5,679,000**

*The Sunk Cost for the Pump Station was reduced from $135,048,000 to $85, 094,000 to account for the adjustment in the total project cost when considering credit.

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5.7 FULLY FUNDED COST ESTIMATE

The fully funded cost estimate is intended to provide an indication of the total project cost when inflation is taken into account. Inflation rates are based on rates developed as part of the Corps budgeting process. The fully funded cost estimate for the Recommended Plan is $687,813,000.00. Details are included in Appendix I (Detailed Cost Estimate and Cost Analysis).

5.8 PRE-CONSTRUCTION ENGINEERING AND DESIGN

5.8.1 Detailed Documentation Report and Plans and Specifications

The PED Phase is cost shared 75% Federal, 25% non-Federal. Prior to initiating the PED Phase, the design team must develop a PMP which defines the scope, work breakdown structure, schedule, and budget to complete PED. Additional items in the PMP are related to value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties of the PED Phase prior to initiation of the PED Phase.

A number of activities are expected to take place during PED Phase. These include the completion of a Design Documentation Report (DDR), plans and specifications (P&S), execution of the Project Partnership Agreement (PPA), and contract award activities. The development of the DDR includes completing the final design of project features. As part of the DDR, the team will complete any ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. Design parameters for all project features will be defined for development of the plans and specifications. P&S includes the development of project construction drawings and specifications, estimation of final quantities, and completion of the Government cost estimate. It is estimated that as many as seven sets of P&S will be developed for the Recommended Plan. Arrangements for on-site archeological monitoring during construction should be documented in the PPA.

5.8.2 Project Partnership Agreement and Items of Non-Federal Responsibility

The PPA is a binding agreement between the Federal Government and the non-Federal sponsor which must be approved and executed prior to the start of construction. The PPA sets forth the obligations of each party. The non-Federal sponsor must agree to meet the requirements for non-Federal responsibilities which will be identified in future legal documents. Some of the likely responsibilities are:

- Provide 35% of the separable project costs allocated to flood risk management and ecosystem restoration. These include, but may not be limited to:
  - provide 25% of design costs allocated by the Government to flood risk management and ecosystem restoration in accordance with the terms of the design agreement entered into prior to commencing the PED Phase for the project;
  - provide all easements and rights of way including suitable borrow and dredged or excavated material disposal areas, necessary for construction, operation, and maintenance of the project;
  - perform, or ensure performance of all utility relocations necessary for construction, operation, and maintenance of the project; and
  - provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including any monitoring features and stilling basins, that may

be required at any dredged or excavated material disposal areas required for construction, operation, and maintenance of the ecosystem restoration features.

- For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project at no cost to the Federal Government in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws, State laws, and specific directions prescribed by the Federal Government.
- Give the Government a right to enter, at reasonable times and in a reasonable manner, property which the non-Federal sponsor owns or controls to gain access to the project for the purposes of inspection, completion, operation, maintenance, repair, replacement, or rehabilitation of the project.
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970 as amended, and Section 103 of the WRDA 1986, Public Law 99-662 as amended, which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.
- Hold and save the United States free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project except for damages due to the fault or negligence of the United States or its contractors.
- Keep and maintain books, records, documents, and other evidence pertaining to the costs and expenses incurred pursuant to the project for a minimum of three years following completion of the project accounting for which such books, records, documents, or other evidence is required, to the extent and in such detail as will properly reflect total project costs, and in accordance with financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20.
- Prevent obstructions or encroachments on the project which might interfere with the proper functioning of the project, hinder operation and maintenance, or reduce the benefits of the project.
- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, Public Law 100-17, and the Uniform Regulations contained in 49 CFR part 24, in acquiring easements, rights of way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said acts.
- Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap Programs and Activities Assisted or Conducted by the Department of the Army."
- Do not use funds from other Federal programs, including any non-Federal contribution required as a matching share, to meet the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that the expenditure of such funds for such purpose is appropriate and authorized.
- Provide and maintain recreation features, access roads, parking areas, and public use facilities open and available to all on equal terms.
- Obtain any and all water rights necessary for the operation of the project.

5.8.3 Real Estate Acquisition

The non-Federal sponsor is responsible for the lands, easements, rights-of-way, relocations, and disposal (LERRD) areas required for project construction, operation, and maintenance of the Dallas Floodway Project. Lands outside the existing interior drainage facilities are identified for Real Estate Acquisition, but there are no lands beyond the existing Dallas Floodway Project that are required for the Recommended Plan. Appendix H contains the Real Estate Plan for the Recommended Plan. Following the Execution of the PPA, the non-Federal sponsor will be provided a right of way map delineating the real estate necessary for construction, operation, and maintenance of the Recommended Plan. Real Estate activities will be coordinated between the City of Dallas Real Estate Office and the Real Estate Office of the Fort Worth District. Also, prior to any solicitation of construction contracts, the Fort Worth District Chief of Real Estate is required to certify in writing that sufficient real property interest is available to support construction of the contract.

5.8.4 Contract Advertisement and Award

Once the PPA is executed, the P&S completed, and the rights of entry provided to SWF, a construction contract will be solicited and advertised. Prior to awarding the contract, the non-Federal sponsor must provide any applicable cash contribution. The contract will be awarded to the lowest responsive bidder and notice to proceed can be expected within 30-45 days from bid opening.

5.8.5 Contract Schedule

After award of the construction contract, the Government will manage project construction. Up to six contracts may be awarded for the Recommended Plan. Inherent with this contract, a warranty period for actual construction items and plantings will be specified. Construction is estimated to take 10-12 years to complete for the Recommended Plan. During construction, an archeologist will monitor excavation. Should any significant cultural resources be identified, mitigation procedures will take place prior to further excavation.

The following contracts are expected to be awarded:

- Contract 1 – 277K Levee Raise and AT&SF Railroad Bridge Modification/Partial 4H:1V Side Slopes;
- Contract 2 – Remainder of the 4H:1V Side Slopes;
- Contract 3 – River Relocation Top;
- Contract 4 – River Relocation Middle;
- Contract 5 – Hampton Pump Station; and
- Contract 6 – River Relocation Bottom.

The exact order of the contracts may shift depending on information developed during the detail design and the availability of funding. In addition, up to five additional contracts may be required for development of vegetation. The Corps has been unsuccessful in the past getting a planting contract in place with the construction contract to establish native vegetative covers. There are typically separate contracts for plantings.

5.9 FINANCIAL PLAN AND CAPABILITY ASSESSMENT

5.9.1 Statement of Financial Capability

The Statement of financial capability is based on information provided by the City of Dallas, and the City of Dallas description of its capability to meet the non-Federal financial obligations for the Recommended Plan. The estimated change in annual OMRR&R costs for the Recommended Plan is $1,677,000.

5.9.2 Financing Plan

In 1998, the City of Dallas passed a bond election that authorized funding in the amount of $246,000,000 for flood control, transportation and storm water projects. From this, the City of Dallas has spent $30,000,000 on feasibility and design efforts for the projects. It is currently estimated that approximately $10,000,000 in credit would be carried over from feasibility into design and construction.

In 2006, the City of Dallas passed another bond program for $371,000,000 for flood control and storm drainage projects. The City of Dallas has spent $11,000,000 in design efforts for Baker, Able and Hampton Pump Stations. In 2012 the City of Dallas awarded a construction contract for Baker Pump Station for $38,000,000 utilizing the 2006 bond money at 100% non-Federal funding. Therefore, approximately $49,000,000 could potentially be applied to the non-Federal share as credit or non-Federal funds for the project.

In 2012, the City of Dallas passed another bond program for $323,000,000 of which $91,200,000 is slated for projects including the Able Pump Station construction. A second construction contract for Able Pump Station estimated at $73,974,000 will be awarded in early fiscal year 2014 utilizing 100% non-Federal funding. If used, all $92,000,000 of the bond money could potentially qualify as non-Federal funds that could be applied to the non-Federal share of the project.

Finally, no earlier than 2016, the City of Dallas will propose including at least $55,000,000 for the Hampton Pump Station.

In total, $158,000,000 of the $203,000,000 is already available or been spent on the project and another $45,000,000 would be required to be funded to complete the project.

5.9.3 Assessment of Financial Capability

Based on the review of the financial capabilities and plan, it is reasonable to expect sufficient resources will be available to satisfy the non-Federal financial obligations of the Recommended Plan.

5.10 VIEWS OF THE LOCAL SPONSOR

The City of Dallas is the non-Federal sponsor for this project. The City of Dallas supports the Recommended Plan and intends to participate in its implementation. A letter of support stating this intent will be provided in Appendix J (Public Comments and Agency Correspondence).

5.11 RESOURCE AGENCY COORDINATION

A summary of the Resource Agency Coordination is provided in the Environmentally Acceptable section of this report, Section 3.7, for the entire BVP and IDP Projects. The Corps will continue to coordinate with the public, Federal, State and other agencies. Documentation on agency coordination can be found in Appendix J.

5.12 PUBLIC INVOLVEMENT

A summary of public involvement for the entire BVP and IDP Projects is provided in Section 3.7, Environmental Acceptability. The Corps will continue to coordinate with the public, throughout the study process. Documentation on public involvement can be found in Appendix J.

5.13 CONCLUSIONS & DISCUSSION

The Recommended Plan meets the City of Dallas' overall goals and objectives of the BVP and IDP Projects. It also achieves the Corps objectives for Section 5141 of WRDA 2007 and aligns with Corps missions of flood risk management, ecosystem restoration, and recreation. All BVP and IDP Projects have been found to be technically sound and environmentally acceptable and function on a comprehensive system-wide level provided key risk and uncertainties are addressed in future design. The modified Dallas Floodway Project addresses the Chief of Engineers Campaign Plan Goal 2 and Objective 2d:

- Goal 2: to deliver enduring and essential water resource solutions using effective transformation strategies.
  - Objective 2d: Deliver reliable, resilient, and sustainable infrastructure systems.

The Recommended Plan reflects the Corps Environmental Operating Principles by incorporating environmental sustainability by returning channelized streams into a more naturally functioning riverine ecosystem to create aquatic habitats and balanced sediment flows. The plan balances flood risk management, ecosystem restoration and recreation within the existing Dallas Floodway Project. A diligent effort was made to coordinate and collaborate with resource agencies, local industry, and environmental interests throughout the study process and public meetings. Environmental resource concerns were addressed early in the study process to assure that adverse impacts were avoided to the maximum extent practicable. The plan is consistent with all applicable laws and policies. The study team used appropriate ways and means to assess cumulative impacts to the environment through the NEPA process.

5.14 RECOMMENDATIONS

I propose the Recommended Plan, which modifies the existing Dallas Floodway Project as described in Chapter 4 of this report, proceed with implementation in accordance with the cost sharing provisions set forth in this report. The Recommended Plan is a subset of the larger BVP and IDP Projects proposed by the City of Dallas.

This recommendation is made with the provision that prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the items of local cooperation, as specified in this document.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and Corps policies governing formulation of individual projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, not the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal

to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

_____

Charles H. Klinge
Colonel, U.S. Army Corps of Engineers
District Engineer

Date _____

5.15 RECORD OF DECISION

To be provided in future drafts.

CHAPTER 6
LIST OF PREPARERS

Discipline	Project Delivery Team Member
Director, Trinity River Corridor Project	Rob Newman
Project Management	Jon Loxley
Lead Planner	Lauren Kruse
Plan Formulation/Economics	Jodie Foster
Lead Engineer	Kathryn White
H&H	David Wilson
H&H	Helena Mosser
Civil Design	Do Dang
Structural Design	Nizar Almasri
Geotechnical	Syed Haneefuddin
Geotechnical	Randal Mead
Cost Estimating	Ninfa Taggart
Economics	Julie Gibbs
Cultural	Joseph Murphey
Environmental	Marcia Hackett
Real Estate	Renee Russell
HTRW	Robert Bowersock
Contracting	Ruby Oringderff
Operations	Mark Sissom
Office of Counsel	Kendra Laffe
Geographic Information System	Lucas Daniels
Electrical	Daren Brown
Landscape Architect	Karen Wright

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CHAPTER 7
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7.1 EXECUTIVE SUMMARY

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