CHAPTER 4

PLAN FORMULATION

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This chapter details the steps that were taken to formulate a plan which best meets or exceeds the planning objectives as set forth below. The formulation of a plan to resolve the flood related problems and needs necessitated the exploration of possible alternative measures, including structural and non-structural solutions. Beneficial and adverse contributions of each alternative were evaluated against existing conditions.

As stated previously in this report, the plan formulation process was performed in three phases, each predicated by changes deemed significant enough to necessitate reevaluation and revision of existing conditions hydrology, hydraulic and/or economic models. These changes included, but were not limited to, the availability of more recent technical data, the addition of risk-based analysis requirements, and the passage of legislation providing for inclusion of previous non-Federal construction in the Federal plan. Two of these phases were completed during the development of the NED Plan, while the third was initiated during selection of the Locally Preferred Plan (LPP).

PLANNING OBJECTIVES

Planning objectives are an expression of public and professional concerns about the use of water and related land resources resulting from the analysis of existing and future conditions in the study area. These planning objectives were used in guiding the development of alternative plans and their evaluation for the 1997 to 2047 period of analyses.

Legislation requires that Federal water and related land resources planning be directed at contributing to National Economic Development (NED), consistent with protecting the Nation's environment. Contribution to NED is achieved by increasing the net value of the nation's output of goods and services, expressed in monetary units. NED contributions must also consider the environmental effects of proposed changes on ecological, cultural, and aesthetic attributes of natural and cultural resources.

Plans formulated as part of this study were evaluated based on their contribution to the National Economic Development, and they are consistent with protection of the Nation's environment. In addition to these National objectives, additional planning objectives evolved from meetings with area residents, from contact with the local sponsor, State and Federal agencies, and from observations made in the area. Specific needs, desires, and goals of the community were identified. The planning objectives for the Dallas Floodway Extension General Reevaluation study are as follows:

- Reduce flood damages, provide better health and safety measures, reduce emergency services, reduce potential for loss of life due to high velocity flows, reduce isolations caused by flood waters, reduce overtopping of bridges and roads along the Trinity River, and reduce the loss of jobs and/or wages caused by flooding from the Trinity River within the city of Dallas.

- Preserve and protect existing environmental and aesthetically pleasing areas and maintain, as much as possible, the existing vegetation and wildlife habitat along the Trinity. The channel portion of the Trinity River is possibly the largest remaining natural channel within Dallas.

- Preserve and/or protect historically and culturally significant areas.

PLANNING CONSTRAINTS

In order to provide direction for the plan formulation efforts, maximize good impacts, minimize bad impacts, and reflect restrictions of the General Investigation Program, the following constraints were taken into account:

- Flood control projects which solve problems in one area but compound them in others should be avoided, unless overriding public interest favors implementation of such a plan.

- Total benefits must exceed total costs for a plan to be implemented with the Corps of Engineers as a participant, unless a specific exception is granted to allow such participation.

FORMULATION AND EVALUATION CRITERIA

Consideration was given to economic, social, and environmental impacts for each alternative during the development of long term solutions to the flood problems within the Trinity River watershed. Appropriate Corps of Engineers engineering and design manuals, criteria, and regulations relating to flood control channels, outlet works, embankment, streamflow routing, backwater computation, cost estimates, environmental mitigation, environmental restoration, recreation features, etc., were used in developing alternative plans.

TECHNICAL CRITERIA

Alternative plans must be feasible, practicable, and soundly engineered to provide a project life of at least 50 years. Existing facilities should be utilized to the maximum extent possible. The plan should be complete within itself and not require additional future improvements other than normal operation and maintenance.

ECONOMIC CRITERIA

The NED objective is the maximization of the economic worth of alternative plans as set forth in *Principles and Guidelines for Planning Water and Related Land Resources Implementation Studies*. The NED objective is to increase the nation's output of goods and services and improve national economic efficiency. For flood control projects, this objective relates to a plan's capability to prevent flood damages by comparing the plan's economic benefits with the project cost. The amount that a project's economic benefits exceed the project cost is defined as net benefits. In the plan formulation process, the plan that yields the greatest net benefits best meets the NED objective.

The plan selected as the recommended plan should seek to provide a maximum of net benefits, unless certain provisions can be applied to supercede this criteria. One such provision, stated in Planning Guidance Letter 97-10, allows a locally preferred plan to be selected as the recommended plan if the plan yields greater net benefits than any smaller scale alternative. In such instances, larger scale plans need not be investigated in an effort to identify the NED Plan. The other provision allowing recommendation of a plan other than the NED Plan involves the granting of an exception by the Assistant Secretary of the Army (Civil Works). Such an exception may be granted for an economically justified plan when overriding and compelling reasons favor the selection of such a plan. Recommended plans which are less costly than the NED Plan would be cost shared on the same basis as the NED Plan. Federal participation in a recommended plan which is more costly than the NED Plan would be limited to the Federal share of the NED Plan, unless the increased development is deemed worthy of warranting Federal participation, and is specified as such in the exception. Cost sharing would then be calculated on the same basis as the NED Plan.

To meet the Federal guidelines for planning water resource projects, the following economic criteria were followed:

- The recommended plan must be economically feasible, i.e. the plan's benefits must exceed the cost of the plan.
- Alternative plans must be evaluated using the current Federal interest rate and price levels, and a 50-year period of analysis.
- Annualized costs must include the cost of operation and maintenance.

Economic feasibility of a plan is displayed as a relationship of benefits to costs, expressed in terms of a benefit-cost ratio (BCR). Identified as benefits are the monetary savings or benefits due to damages prevented, reduction in the cost of emergency services, and reduction of economic disruption. These project benefits are subsequently annualized to represent an annual benefit applicable for the life of the project. The project cost, which includes the construction or first cost, the interest on the first cost during construction, the operation and maintenance costs, and the interest to amortize the project cost over the life of the project are also annualized to represent an annual project cost applicable for the analysis period of the project. The annual benefits and the annual costs are then related in a ratio of benefits to costs. To be economically feasible, a plan must have greater benefits than costs or, more specifically, a BCR greater than 1.0.

ENVIRONMENTAL AND SOCIAL CRITERIA

Plans formulated under Federal directives should be consistent with protecting and enhancing the existing environment by the management, conservation, preservation, creation, or improvement of the quality of certain natural and cultural resources and ecological systems in the proposed project area. Structural and non-structural measures must be evaluated in accordance with guidelines established by the National Environmental Policy Act of 1969 (Public Law 91-190), as amended, and the *Principles and Guidelines for Water and Related Land Resources Implementation Studies*, as developed by the U.S. Water Resources Council, dated July 1983. The following environmental and social criteria were considered:

- Promote the protection and enhancement of areas of natural beauty and human enjoyment.
- Protect areas of valuable natural resources.
- Protect quality aspects of water, land, and air resources in the watershed.
- Protect against possible loss of life and hazards to health.
- Promote safety
- Preserve and enhance social, cultural, educational, and historical values within the project area.
- Minimize and, if possible, avoid the displacement of people and destruction or disruption of community cohesion.

IDENTIFICATION OF THE NED PLAN

The following sections provide a chronological review of the plan formulation process for the development of the NED plan for this study. This process included a preliminary analysis of alternatives, an In-Progress Review (IPR) meeting, and a final analysis of NED alternatives.

INITIAL SCREENING OF ALTERNATIVES

An extensive number of non-structural and structural flood damage reduction alternatives were investigated from the study initiation in January 1991 through July 1993. During this time frame, environmental restoration was not a desired project feature of either the local sponsor or special interest groups. During this period, the focus of all environmental concerns was directed primarily toward minimization of impacts to bottomland hardwoods.

Investigated Non-Structural Alternatives

The objectives of non-structural measures are to avoid flood damages by removal of damageable properties from the flood prone areas, and to manage the development of the floodplain in a manner that will minimize flood damage. The full range of non-structural alternatives includes no action, floodplain management, flood warning, flood proofing, structure relocation, and permanent evacuation.

No Action Plan. The fundamental alternative to any flood control plan is the no action plan. Adoption of this alternative implies acceptance of the costs and adverse effects of continued flooding. For the city of Dallas, these estimated costs equate to over $6,500,000 annually. In addition, the residents would continue to suffer from the social and economic stresses associated with repetitive flooding and the potential for loss of life. Although citizens with flood insurance would be partially compensated for future damages, these damages would nonetheless continue to occur and Federal funds would continue to be expended in the flood insurance program and in federal emergency flood assistance and relief. The no action plan is recommended only when no other solutions are feasible or when environmental damage would be irreparable.

Floodplain Management. Effective floodplain management is dependent on the development of enforceable regulations which insure that uses of floodplain lands are compatible with the level of flood hazard. Several means of regulation are available to control future development, including zoning ordinances, subdivision regulations, and building codes.

Zoning ordinances promote prudent use and development of the floodplain to prevent excessive property damage, expenditure of public funds, inconvenience, and loss of life due to flooding. Subdivision regulations guide the division of large land parcels into smaller lots and requires proof of compliance with other regulations and ordinances. A subdivision ordinance with special reference to flood hazards would require installation of adequate drainage facilities, prohibit encroachment in floodway areas, require the placement of critical streets and utilities above a selected flood elevation, and require that building lots be filled or structures be elevated above a selected flood elevation.

Building codes specify the design and construction materials of both new construction and repair of flood damaged structures. The specifications can require proper anchorage of buildings, restrict materials which tend to deteriorate when exposed to water, require water-tightness of exterior walls, placement of valves on sewer lines, and placement of utilities such as heaters and air conditioners at high elevations to reduce flood damages.

Floodplain management is the most effective means to control future development of the floodplain, and insure that existing flood problems do not worsen. This alternative did not require further consideration because the city of Dallas presently participates in the regular phase of the National Flood Insurance Program, and has adopted the Trinity River Corridor Development Certificate (CDC) process.

Flood Warning. Flood forecasting and temporary evacuation involves the determination of imminent flooding, implementation of a plan to warn the public, and organization of assistance in the evacuation of persons and some personal property. Notification of impending flooding can be accomplished by radio, siren, individual notification or by elaborate remote sensor devices. Some type of flood warning and emergency evacuation effort should be a part of any flood control plan. These measures normally serve to reduce the hazards to life and damage to portable personal property. It was not necessary to evaluate this alternative since the city of Dallas currently has a flood warning system in place.

Flood Proofing. Damage to existing structures can be reduced or eliminated through various flood proofing measures. These methods protect damageable property by preventing flood waters from entering the building and/or reaching the contents inside. Flood proofing is most easily applied to new construction, and most applicable where flooding is of short duration, low velocity, infrequent occurrence and of shallow depths. Flood proofing is usually employed in locations where structural flood protection is not feasible or where collective action is not possible. Typically, flood proofing techniques include water-tight door and window seals, raising 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.

Flood proofing of single-family residences within the floodplain would be impractical in frequently flooded zones where flooding depths can easily exceed the window sill heights and the structural integrity is poor. This alternative could be beneficial to commercial and industrial structures. For structures located within less-frequent flood event zones, such measures as sandbagging or altered landscaping adjacent to entryways could be helpful, since flooding depths would be shallow. However, any method requiring personal attendance, such as sandbagging, has a low reliability due to occupant absence and the occurrence of late night floods. The hydrologic characteristics of the Trinity River and the poor structural characteristics of the residential structures makes it impractical to implement the outlined flood proofing techniques.

Raising Structures In-Place. One method of flood proofing evaluated in detail was that of raising the structures at their existing site. This plan is most applicable where a limited number of structures are receiving a large portion of the total flood damages along a given stream reach. However, there is still the potential for loss of life with this alternative, since flooding could easily exceed the level of protection provided and residents are apt to ignore or respond slowly to warnings.

The city of Dallas participates in the Federal Emergency Management Agency (FEMA) floodplain management program. Requirements of the program specify that certain regulations be incorporated into the code of any community participating in the National Flood Insurance Program. One of these regulations stipulates that any substantial improvement made to an existing structure located within the 100-year floodplain should also elevate the structure at least 1 foot above the 100-year flood elevation. Substantial improvement is expressed as the cost of structural repairs equivalent to at least 50 percent of the structure's fair market value. Therefore, structures within the 10-year floodplain would have to be elevated at least 1 foot above the 100-year flood plain, or an average of about 4 feet above their existing finished floor elevations.

Many of the structures in the study area's 10-year floodplain were built in the 1940's or 1950's. Frequent flooding over the structure life has contributed to the dilapidation of these structures. Many of the residential structures do not have the structural integrity required to undergo raising. Furthermore, for those structures which might survive raising in place, the number of feet they would have to be raised is cost prohibitive, could induce damages on adjacent property, and would not be aesthetically pleasing. The majority of the commercial and industrial properties are already elevated 5 feet above ground level and the nature of these businesses makes it impractical to be raised above the 100-year floodplain. Based on the above findings, a raise-in-place plan was determined to be infeasible for this study area.

Relocation. Plans for structure relocation would move the existing frequently flooded structures from the floodplain to a 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.

Each of the structures within the study area was analyzed on an individual basis, with benefits being limited to the average annual losses covered by subsidized flood insurance plus the public damages prevented. All structures within the 10 year-flood zone were evaluated based on this economic criteria. As in the case of raising the structures in-place, either the structural integrity or the type of business made it impractical to consider this alternative further.

Permanent Evacuation. Flood plain evacuation involves the acquisition and removal or demolition of frequently flooded structures from the floodplain. This alternative was evaluated for the evacuation of individual structures within the 10-year flood frequency zone in accordance with the non-structural economic criteria previously outlined. Benefits were also derived for the evacuation of all structures within individual flood zones, including the 2-, 5-, 10-, and 100-year zones. Eligibility under the evacuation alternative rests primarily with the economic criteria and the frequency of flooding. The structural integrity of the structure was not a factor in determining feasibility as is the case in other non-structural plans.

Benefit Methodology. Benefits for removing individual structures from the floodplain are limited to the sum of:

annualized residual value of the vacated land, *or* average annual recreation benefits for the land

plus:

reduction in annual flood insurance subsidy:

agency cost:

average annual damages to the structure and its contents,

plus:

agent fee (at 15 percent of the estimated premium), and other administrative costs (at $131 per policy)

minus:

policy holder's cost:

estimated annual insurance premium (at $0.55 per $100 of structure value for the first $45,000 and $0.17 per $100 thereafter, plus $0.65 per $100 of contents value for the first $15,000 and $0.30 per $100 thereafter),

annual deductible ($500 each for structure and contents per flood occurrence, times the probability of a flood in a typical year), and

annual uninsured losses (5 percent of the structure value per flood occurrence, times the probability of a flood in a typical year)

plus:

average annual public damages prevented (that is, damages to communications and public utilities facilities, and costs for flood fighting and public relief) based on actual FEMA claims.

Analysis Results - Individual Structure Evacuation. Reaches 2 and 5 contain commercial and industrial structures within the 2- to 5-year flood frequency zone which meet this non-structural economic criteria. Table 4-1 presents a summary of the economic analysis for the evacuation of eligible structures in reaches 2 and 5. The investigated alternative yielding the greatest net benefits is shown shaded in the table. The cost estimates include land acquisition, demolition and disposal, and the remediation of asbestos, lead based paint, and other hazardous non-CERCLA contaminants.

In reach 2, about $154,300 in annual damages would be eliminated with the permanent evacuation of 5 commercial structures. The first cost for this plan is estimated at about $874,800. The annual costs and claimable annual benefits are $75,800 and $145,600, respectively, with a resultant benefit-to-cost ratio of 1.9 and excess benefits of $69,800.

In reach 5, an estimated $419,000 in annual damages could be eliminated with the evacuation of only 2 commercial structures. The first cost for this plan is estimated at about $580,300. The annual costs and claimable annual benefits are $50,800 and $410,800, respectively with a resultant benefit-to-cost ratio (BCR) of 8.1 and excess benefits of $360,000. The benefits derived in this reach signal the need for additional investigation to obtain empirical flooding evidence associated with the contents in these structures.

In summary, the permanent evacuation plans were found to be economically feasible for 7 commercial structures. Total damages would be reduced by 12 percent in the immediate study area. The combined plans would have an estimated project first cost of $1,455,100. The total annual costs and benefits would be $126,600 and $556,400, respectively. The resultant BCR would be 4.2, with excess benefits of $429,800.

The Uniform Relocation Assistance Program requires that displaced property owners be compensated for losses attributable to evacuation. A maximum of $22,000 is allowed for residential structures to cover moving expenses, temporary lodging, and the cost to obtain housing in accordance with Federal guidelines. Maximum relocation expenses have not been set for commercial/industrial structures. These costs would be 100 percent non-Federal.

The local sponsor desires recreational facilities; however, a specific recreation design was not considered at this point since the BCR is greater than 1.0, and the structures are randomly located throughout the flood plain. It is recognized that individual structures may be selected for evacuation in conjunction with other flood control measures.

Table 4-1
Economic Analysis of Individual Structure Evacuation Plan
(June 1993 prices, 8.0% interest, 50-year period of analysis)
(Thousands of Dollars)

Reach	Number of Structures	First Costs	Annual Costs	Annual Benefits	Benefit/Cost Ratio	Net Benefits
2	5	$874.8	$75.8	$145.6	1.9	$69.8
5	2	$580.3	$50.8	$410.8	8.1	$360.0
Combined	7	$1,455.1	$126.6	$556.4	4.2	$429.8

Investigated Structural Alternatives

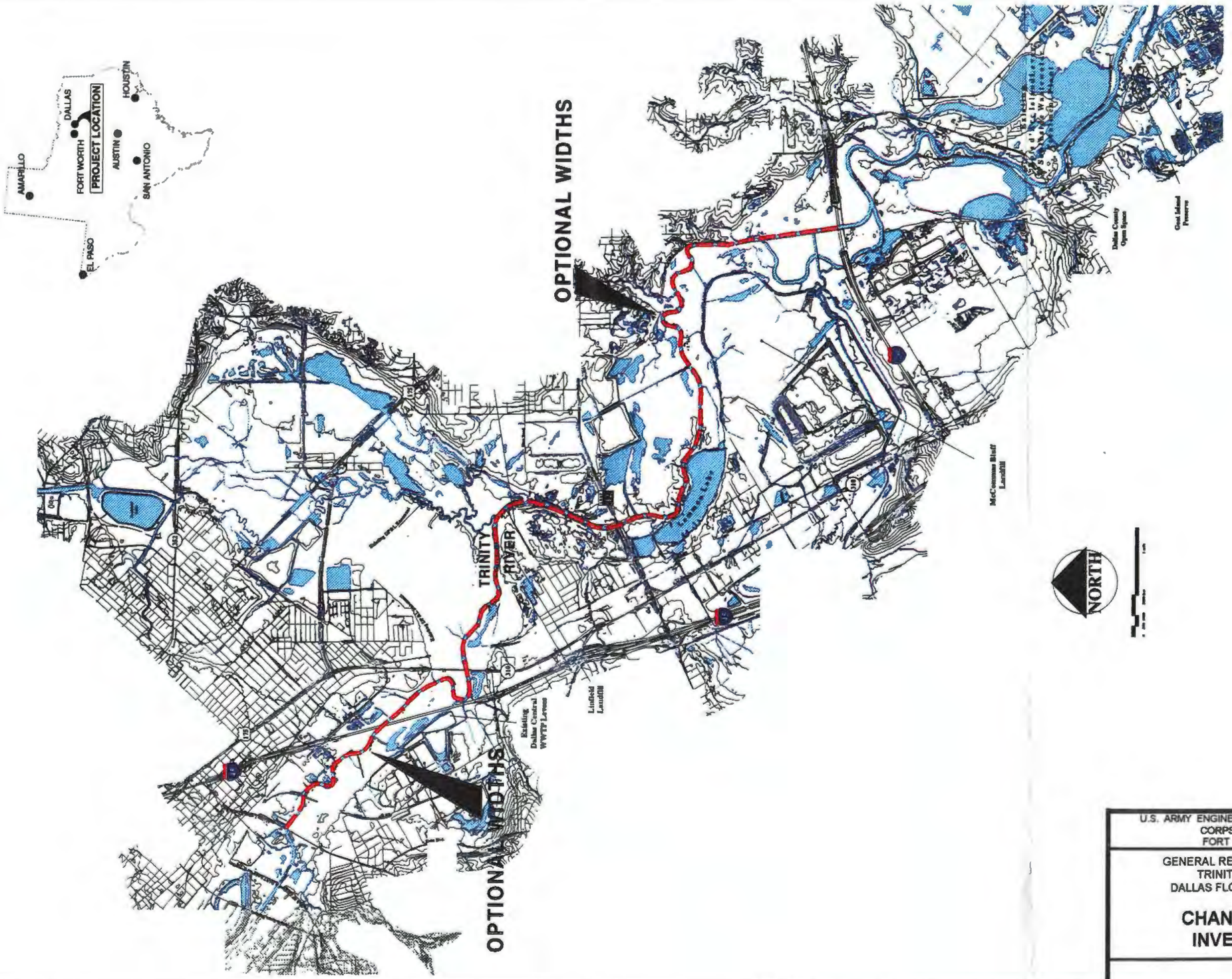
Various structural alternatives were investigated in this study, including construction of channels, levees, swales, and combinations thereof, as well as vegetation management plans. The following paragraphs describe the individual plans investigated.

Channel Plans Investigated. The preliminary design featured a 5-mile channel extending from the downstream end of the existing Dallas Floodway downstream to Loop 12, as shown in figure 4-1. The channel would be a grass-lined trapezoid with 3-foot horizontal to 1-foot vertical side slopes. Between the existing Floodway upstream and continuing to just below IH-45, the channel alignment would be along the west bank of the Trinity River. At IH-45, the channel would veer to the east and cross the river to the east bank, rejoining the natural channel at the center of the large oxbow and continuing along the east bank to IH-20. The channel would be aligned to preserve at least one side of the river bank. Channel sizes investigated for this alignment included 100-, 150-, 200-, and 250-foot bottom widths. Figure 4-2 shows a typical channel section. The results of the analysis are shown in table 4-2.

Project first costs ranged from about $38.9 million to $78.3 million. Each plan was deemed feasible, with benefit-cost ratios ranging from 1.7 to 2.8. The optimum bottom width would be 150 feet. All four designs would increase the level of protection in the primary and secondary study portions of the study area and reduce damages in the unprotected primary study area by 50 to 75 percent. However, due to intense public concern regarding environmental impacts of this plan, other plans with fewer environmental impacts were evaluated.

Table 4-2
Summary of Channel Alternatives
(June 1993 prices, 8.0% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
100' BW	$38.9	$3.6	$11.1	2.8	$6.5
150' BW	$52.1	$5.0	$11.9	2.4	$6.9
200' BW	$74.2	$6.3	$12.5	2.0	$6.2
250' BW	$78.3	$7.6	$13.2	1.7	$5.6



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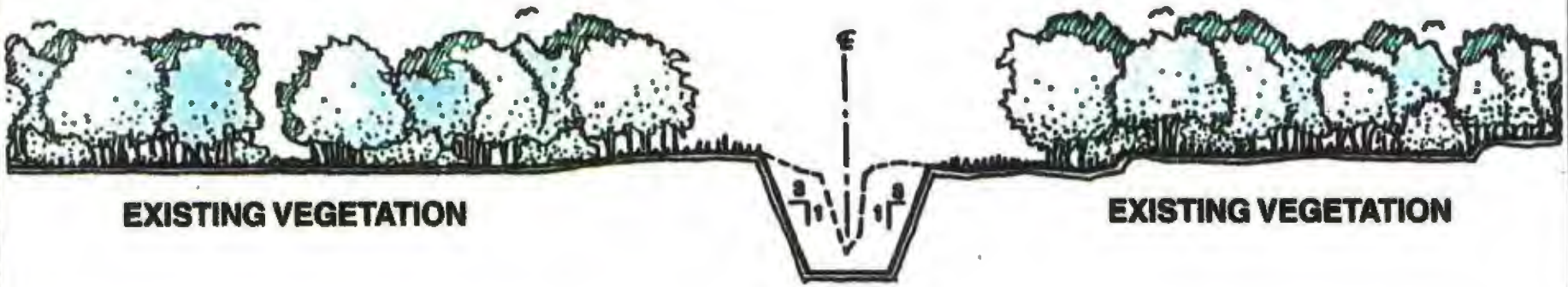
CHANNEL PLANS INVESTIGATED

FIGURE 4-1



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TYPICAL CHANNEL SECTION

FIGURE 4-2

Levee Plans Investigated. Levee designs providing 100-year and SPF levels of protection were investigated for the east and west banks of the Trinity River between the existing Dallas Floodway Levee System and U.S. Hwy. 75 (Central Expressway). Figure 4-3 shows the general layout of these levees.

Lamar Street Levee: This levee would be constructed along the east bank with an average SPF height of about 27 feet, with 1v:3.5h side slopes, and a length of about 2.5 miles. The 100-year levee would consist of a series of small levees with a typical height of about 15 feet including freeboard, and an aggregate length of about 13,200 feet.

Cadillac Heights/Treatment Plant Levees: Constructed along the west bank of the Trinity River between the Cedar Creek confluence and Hwy. 75, these investigated levees are referred to as the Cadillac Heights Levee (Reach 5) and Central Wastewater Treatment Plant (CWWTP) Levee (Reach 6). The average height would be about 25 feet for the SPF levee and 15 feet for the 100-year levee, including freeboard. The total length would be about 1.3 miles.

As shown in table 4-3, individual annual levee costs would be supported by the annual benefits. It was not considered practical to construct single levees along the east or west bank of the Trinity due to induced damages which would occur along the opposite bank. However, as a combined levee system, induced damages to the existing Dallas Floodway produced negative net benefits. Levees providing 100-year levels of protection to the Lamar and Cadillac Heights areas would raise water surface elevations at the downstream end of the existing Floodway by 0.3 feet. Comparatively, SPF levees would raise water surface elevations 0.6 to 2.0 feet, assuming the event occurred within the Floodway. Therefore, the conclusion was reached that construction of levees would require a relief channel or swale to offset the effects to the existing Floodway.

Table 4-3
Summary of Levee Alternatives
(June 1993 prices, 8.0% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
100-Year Lamar	$9.0	$.8	$1.5	1.9	$0.7
100-Year Cadillac	$9.1	$.8	$1.2	1.5	$0.4
SPF Lamar	$14.6	$1.3	$2.2	1.7	$0.9
SPF Cadillac/ CWWTP	$29.3	$2.6	$2.8	1.1	$0.2
All 100-Year	$18.2	$1.6	$2.6	1.6	($1.1)
All SPF	$43.9	$3.9	$1.8	0.5	($2.1)

Vegetation Management Plan Investigated. This plan would clear non-endangered species underbrush from the downstream end of the existing Dallas Floodway to Loop 12. The width of the clearing would extend approximately 1,000 feet from the centerline of the river to both the east and west banks, leaving an overstory of tree cover above 20 foot. Although some selective clearing and pruning would be required, there would be an attempt to leave a 100-foot wide buffer zone for riparian habitat along both sides of the river channel. Small parcels of the understory (shrubs and other vegetation of approximately 3-5 acres in size) would be left in their existing state throughout the 2,000-foot area. All remaining understory vegetation would be removed. Hydraulic performance of this alternative demonstrated the significant impact of vegetation on the water surface elevations. The alternative was removed from consideration due to the requirement for expensive, intense maintenance, and the significant impact to environmental resources

which this plan would cause. However, hydraulic findings regarding the impact of vegetation removal initiated development of the swale alternative.

Swale Plans Investigated. An economic analysis was conducted to ascertain the performance of overbank swales. These grass-lined swales would be divided into lower and upper swales, with the dividing line at the IH-45 river crossing. Various swale sizes were investigated, including average bottom widths (BW) ranging from 300 - 1,500 feet. The swale plan would also include clearing the site of all non-endangered species vegetation. These swales are shown in figure 4-4, and described below. Figure 4-5 shows a typical swale section.

Lower Overbank Swale: This swale would extend from Hwy. 310, beginning at least 100' from the edge of the east bank, downstream to about 2,000 feet below Loop 12, for a total length of 17,300 feet, or 3.3 miles. The lower swale would be designed with a slope of .0005 ft/ft.

Upper Overbank Swale: This swale would be designed to work in conjunction with the lower overbank swale to maximize channel relief. The length of the upper swale would be about 7,800 feet, or 1.5 miles, and would extend from the confluence of Cedar Creek, at the upstream end, to the river crossing of IH-45.

The Multiple Object Management (MOM) approach was incorporated into the design of the swales to avoid and minimize environmental impacts. The wider swales would impact the higher quality habitat to a greater extent than the 300- to 500-foot swales. Fragmentation of habitat would be unavoidable and would require significant mitigation. Approximately 3,200 acres of land would be required to offset the environmental impacts. All swale sizes were economically feasible, with benefits ranging from about $7.8 million to $11.0 million. The results of the analysis of the swale alternatives are shown in table 4-4. As shown, the 1,200-foot BW swale would produce the greatest net benefits among all the swale plans, and among all the alternatives evaluated in the 1991 to 1993 time period.

Table 4-4
Summary of Swale Alternatives
(June 1993 prices, 8.0% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
300' BW	$15.2	$1.4	$ 9.3	6.6	$7.8
500' BW	$21.6	$1.9	$11.5	6.0	$9.5
600' BW	$23.7	$2.3	$11.8	5.2	$9.5
900' BW	$31.9	$3.1	$12.7	4.1	$9.6
1,200' BW	$43.8	$4.4	$15.3	3.5	$11.0
1,500' BW	$54.8	$5.4	$15.7	2.9	$10.2

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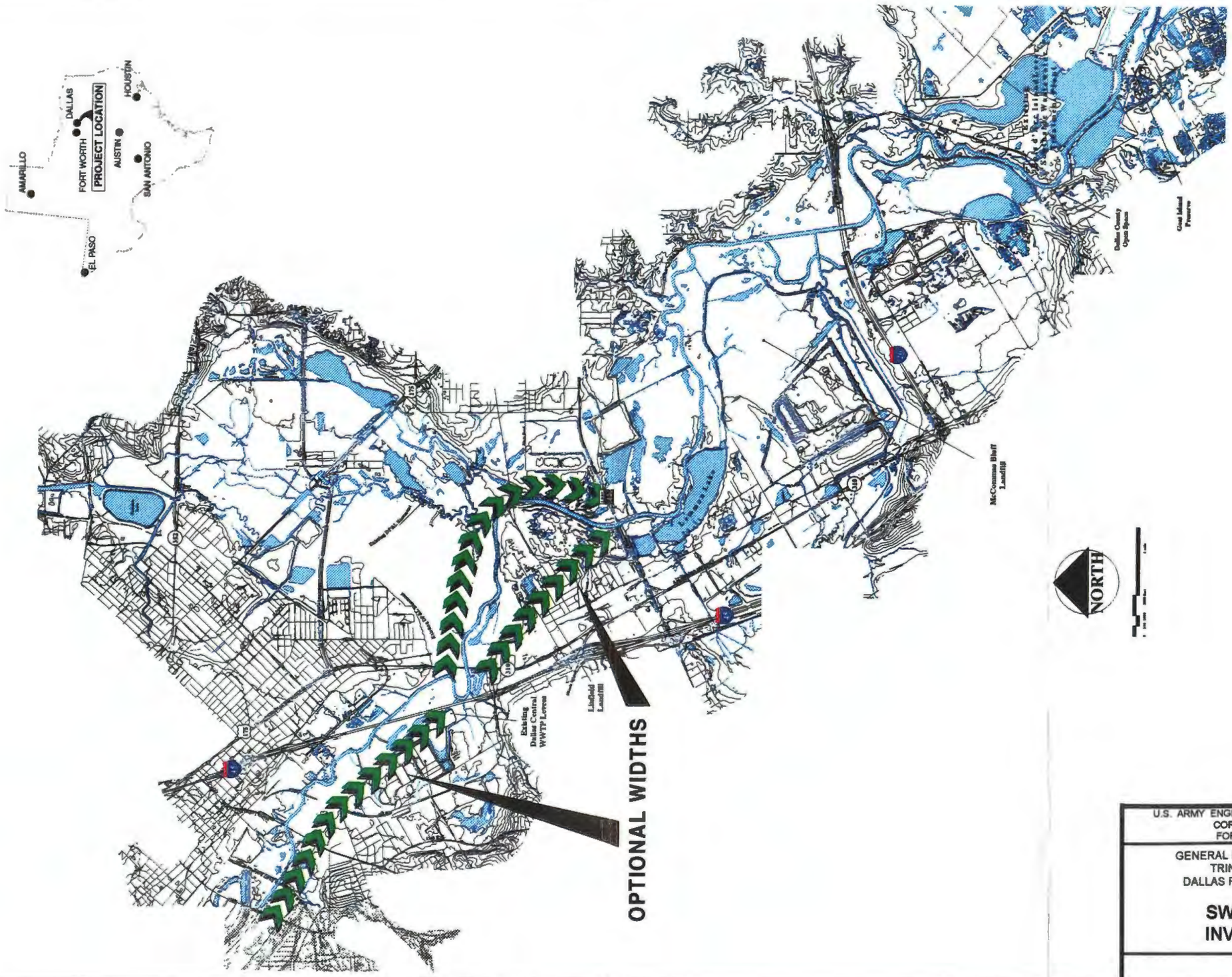
LEVEE PLANS INVESTIGATED

FIGURE 4-3



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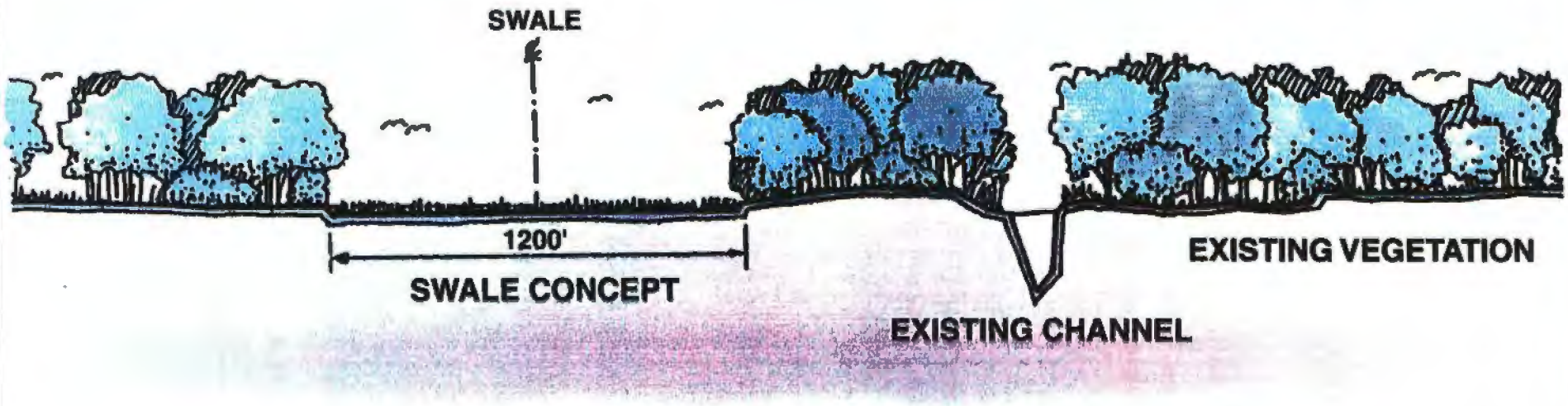
SWALE PLANS INVESTIGATED

FIGURE 4-4



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TYPICAL SWALE SECTION

FIGURE 4-5

Recreation Plan Investigated. Benefits for the initial recreation plan were derived based on Region 4 facility needs and carrying capacity factors extracted from the Texas Outdoor Recreational Plan (TORP). Since the TORP does not identify a net need for picnic facilities, benefits were calculated only for the trail system. This project would generate at least $1.0 million in annual recreation benefits. The total estimated project first cost for the recreation plan would be about $8.9 million, with a resulting BCR of 1.2. These recreation features could be adapted to any of the proposed swale alternatives.

Summary of Initial Alternatives

The costs and benefits associated with the most feasible plans investigated from 1991-1993 are summarized in table 4-5, not including recreation. The results of these analyses served as the basis for identifying the preliminary NED Plan and as an aid to the local sponsor in the selection of a locally preferred plan.

As shown in the table, the 1,200-foot bottom width upper and lower swale alternative was identified as the plan producing the greatest net benefits. The general layout of this plan is shown in figure 4-6. An optimization curve is presented in figure 4-7. The net benefits were calculated at $11.0 million based on a first cost of $43.8 million. Accordingly, this plan was designated as the NED Plan and carried forward in the formulation process.

Table 4-5
Summary of Economic Analyses of Investigated Plans
1991-1993 (Flood Control Only)
(June 1993 prices, 8.0% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
Non-Structural: 7 Individual Structures	$1.46	$0.13	$0.56	4.2	$0.4
Channels: 150' BW	$52.1	$5.0	$11.9	2.4	$6.9
Swales: 1,200' BW	$43.8	$4.4	$15.3	3.5	$11.0

IN-PROGRESS REVIEW MEETING

Subsequent to the preceding analyses and designation of the preliminary NED Plan, an in-progress review (IPR) was held on July 19, 1993, with representatives from Headquarters, U.S. Army Corps of Engineers (HQUSACE), Southwestern Division (SWD), and the Fort Worth District (SWF) in attendance. The major pertinent discussions, concerns, issues, and concurrences included the following:

- Proposed Section 215/104 agreements regarding credit to the local sponsor for non-Federal construction of the Rochester Park Levee and modifications to the CWWTP Levee were deemed invalid due to the timing of the requests and/or lack of prior approval from the Assistant Secretary of the Army (Civil Works). To receive credit, the local sponsor must seek Legislative approval.

- Initial guidance received August 21, 1992, specified a risk-based analysis would be required only for levees. Subsequent guidance, however, directed risk-based analysis be accomplished and integrated into the analysis regardless of the alternatives.

FINAL ANALYSIS OF NED PLAN

Key Revisions and Assumptions.

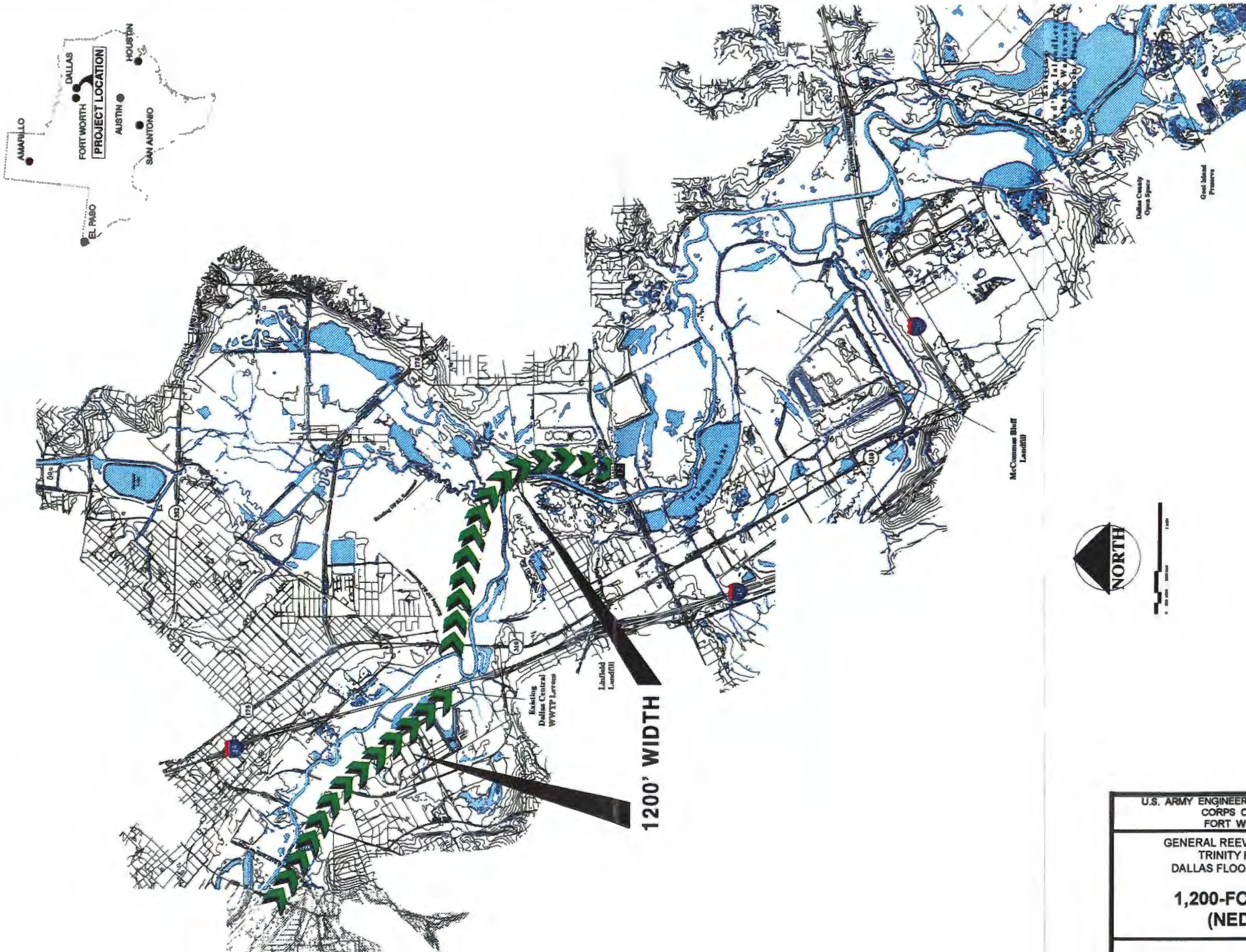
During this phase of the plan formulation process, the following revisions were made regarding engineering and economic parameters:

- The hydrology model developed for the Upper Trinity River Feasibility Study was approved for use in this study, thereby ensuring compatability of the results of this analysis with future Upper Trinity River studies. The revised hydraulic model included computed probability water surface elevations, incorporated the effects of extending the 100-foot benched channel within the existing Floodway, and assumed design grade for the levees in the existing Floodway. In addition, updated aerial photography was used to establish digital topography.

- Current floodplain investment data was gathered through field surveys and from the Dallas County Appraisal District.

- A risk-based analysis was incorporated into all assumptions and benefit calculations. Traditional expression of the frequency of flood events has been in terms of the recurrence interval in years, such as, the "100-Year Flood". The more appropriate expression of the probability of a particular flood magnitude is in terms of "percent chance exceedance", especially as it relates to a risk-based analysis. Therefore, the "100-Year Flood", which is defined as "the magnitude of flooding which has a 1 percent probability of being equaled or exceeded in any given year" would be expressed as the "1 percent chance flood". For comparison purposes, the nine flood events computed for this study, traditionally referred to as the 1-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 500-year, and the Standard Project Flood (SPF), would be referred to, in probabilistic terms, as the 99 percent, 50 percent, 20 percent, 10 percent, 4 percent, 2 percent, 1 percent, 0.2 percent chance flood, and the SPF, respectively. Although the analyses contained herein were performed as risk-based analyses, results of these investigations are expressed in traditional terms for the benefit of the reader.

- Cost data was updated to reflect October 1995 prices and level of development, and the prevailing Federal interest rate of 7.63 percent was applied to the economic analyses.



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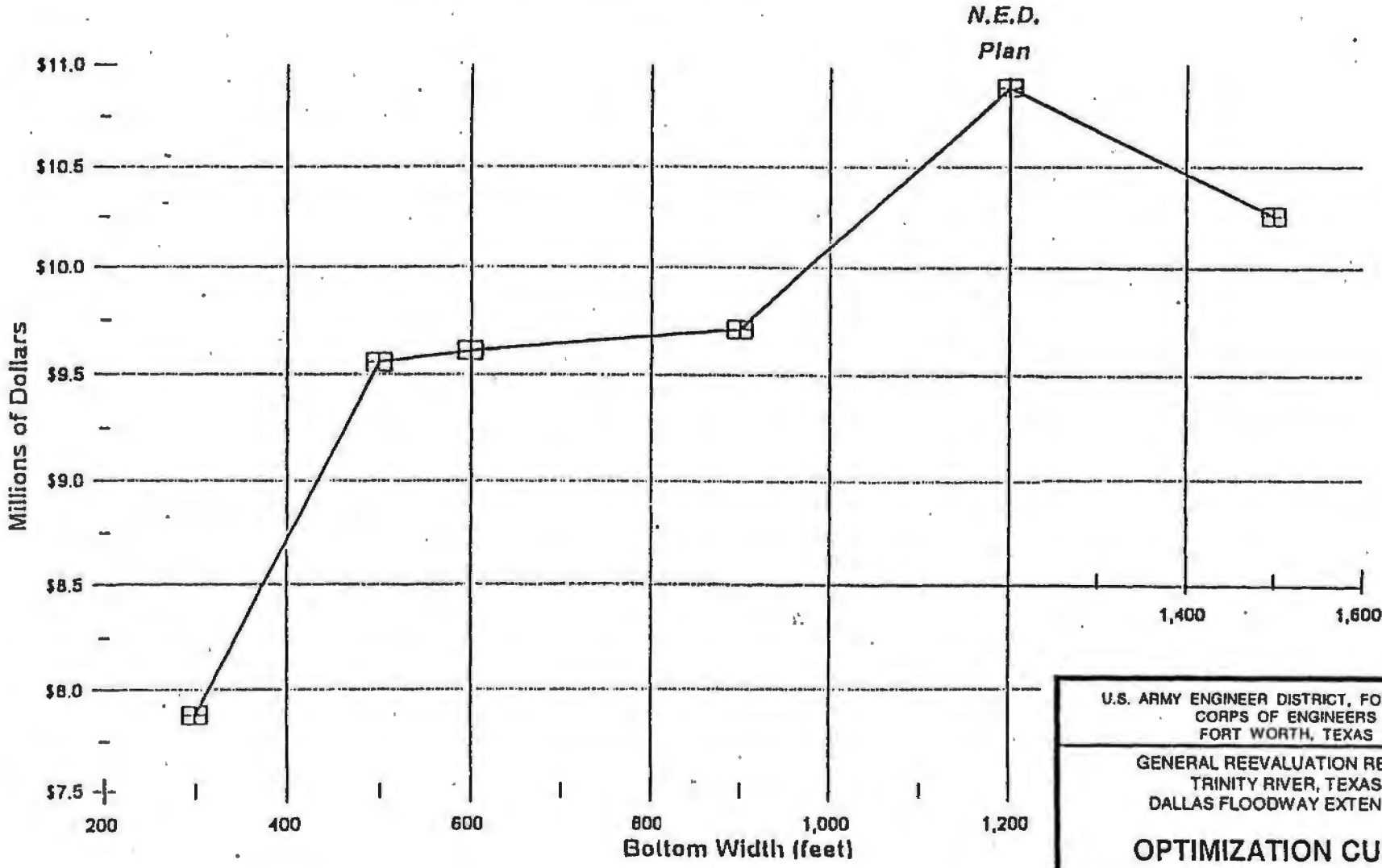
1,200-FOOT SWALE (NED) PLAN

FIGURE 4-6

Dallas Floodway Extension
Swale Alternatives: Net Benefits



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OPTIMIZATION CURVE

FIGURE 4-7

Investigated Structural Alternatives

Revised Swale Plans Investigated. Examination of the results of the preliminary investigations indicated that the majority of benefits for the 1,200-foot swale would be realized in the existing Floodway. Smaller swales, while not providing as many upstream benefits, would yield benefits in the immediate study area at significantly reduced costs, and would cause fewer adverse impacts to environmental resources. Also, in accordance with the request of the local sponsor, a west bank alignment for the lower swale was considered.

The upper swale alignments developed in this phase of the study would be designed to work in conjunction with a lower swale to maximize channel relief and minimize environmental damage. The investigated upper swale would have an approximate 300-foot bottom width and would extend from the Cedar Creek confluence to the oxbow near IH-45. The complementary lower swale would consist of an approximate 500-foot bottom width swale, aligned between Loop 12 and IH-45, and traversing either the Linfield Landfill or the historic Joppa neighborhood, as shown in figure 4-8 and described below:

Linfield Swale: In conjunction with the upper 300-foot swale, this alignment would consist of a 500-foot bottom width channel beginning at Loop 12, at the Sleepy Hollow Golf Course, and extending through the Linfield Landfill. The maximum depth would be about 30 feet, with a minimum depth of about nine feet. Preliminary HTRW investigations indicate manageable levels of contaminants within the landfill. This alignment would reduce damages in the study area and raise the level of protection in the existing Floodway to the 500-year frequency.

Joppa Swale: This plan would consist of a 500-foot bottom width channel beginning at Loop 12, at the golf course, and would pass through the Joppa neighborhood, thereby avoiding the Linfield Landfill. This alignment would displace approximately 17 residents and impact about 68 structures. This alignment would also traverse a large pond previously used as a gravel pit, and a parcel of the Southern Pacific railroad property which has been cited as an illegal dumping area. This alignment would reduce damages in the study area and raise the level of protection in the existing Floodway to the 500-year frequency. This neighborhood, however, is located outside the floodplain.

Adverse environmental impacts would be significantly reduced with either of these west bank alignments when compared to the east bank alignment as proposed in the 1,200-foot swale plan. Flood damage reduction benefits would be similar with either of these west bank alignments, each reducing damages in the study area by more than 30 percent and in the existing Floodway by more than 20 percent. While the preliminary cost estimates for going through the landfill would be comparable with costs associated with relocating and abating contaminated areas within the Joppa neighborhood, the Linfield swale, in conjunction with the 300-foot upper swale, would produce greater net benefits than the Joppa swale. Opposition to disrupting the Joppa neighborhood and the historic, cultural nature of the area prompted the city to request further refinement of the Linfield swale to optimize benefits and to incorporate wetlands and vegetation within the swale. This request was used by the design team to incorporate the chain of wetlands concept into both the upper swale and lower (Linfield) swale.

The Chain of Wetlands alternative would utilize the best identified swale plan (300-foot upper swale and 500-foot Linfield swale), but would also include connected wetlands and pockets of sparsely planted trees within the open grassy areas. The average depth of the swale would be about 2 feet, with the wetland areas approximately 2 - 4 feet deep. The vegetated areas would contain about 10 trees per acre. This plan is shown in figure 4-9.

Comparative costs and benefits for the above mentioned alternatives are presented in table 4-6. As shown, the Chain of Wetlands alternative would provide the greatest amount of net benefits, and was, therefore, carried forward in the formulation process.

Table 4-6
Summary of Revised Swale Alternatives
(October 1995 prices, 7.63% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
300' / 500' Linfield Swale	$34.5	$2.9	$7.2	2.5	$4.4
300' / 500' Joppa Swale	$33.4	$2.8	$6.3	2.3	$3.5
Chain of Wetlands	$50.6	$4.2	$9.4	2.2	$5.2

NED Plan Determination

Due to the revisions to hydrology and economic models in this phase of plan formulation, and due to the similarity of benefits between the 900-foot swale and the 1,200-foot swale in the preliminary formulation phase, both of these alternatives were carried forward for further analysis. The 1,200-foot swale was designated as the preliminary NED plan in 1993. The Chain of Wetlands was carried forward from the more recent studies due to the sponsor's interest in including wetland features. Also included in this array of alternatives was the Chain of Wetlands Plus SPF Levees alternative, due to indications that this plan would be the most likely candidate for being selected as the LPP. This alternative would include the addition of SPF levees on both sides of the river, at Lamar Street and at Cadillac Heights, as shown in figure 4-10. Table 4-7 presents the array of alternatives investigated in the final determination of the NED plan.

Based on applicable criteria, the 1,200-foot swale would produce the greatest net benefits and was designated as the NED plan. As shown, the NED plan would have net benefits of $8.6 million and a first cost of $47.5 million, without recreation.

Table 4-7
Final Array of Alternatives - NED Plan
(October 1995 prices, 7.63% interest, 50-year period of analysis)
(Millions of Dollars)

Investigated Alternative	First Cost	Annual Cost	Annual Benefit	Benefit/Cost Ratio	Net Benefits
1,200' BW Swale	$47.5	$4.3	$12.8	3.0	$8.6
900' BW Swale	$40.7	$3.7	$11.6	3.2	$7.9
Chain of Wetlands	$50.6	$4.2	$9.4	2.2	$5.2
Chain of Wetlands with SPF Levees	$82.6	$7.2	$11.5	1.6	$4.3

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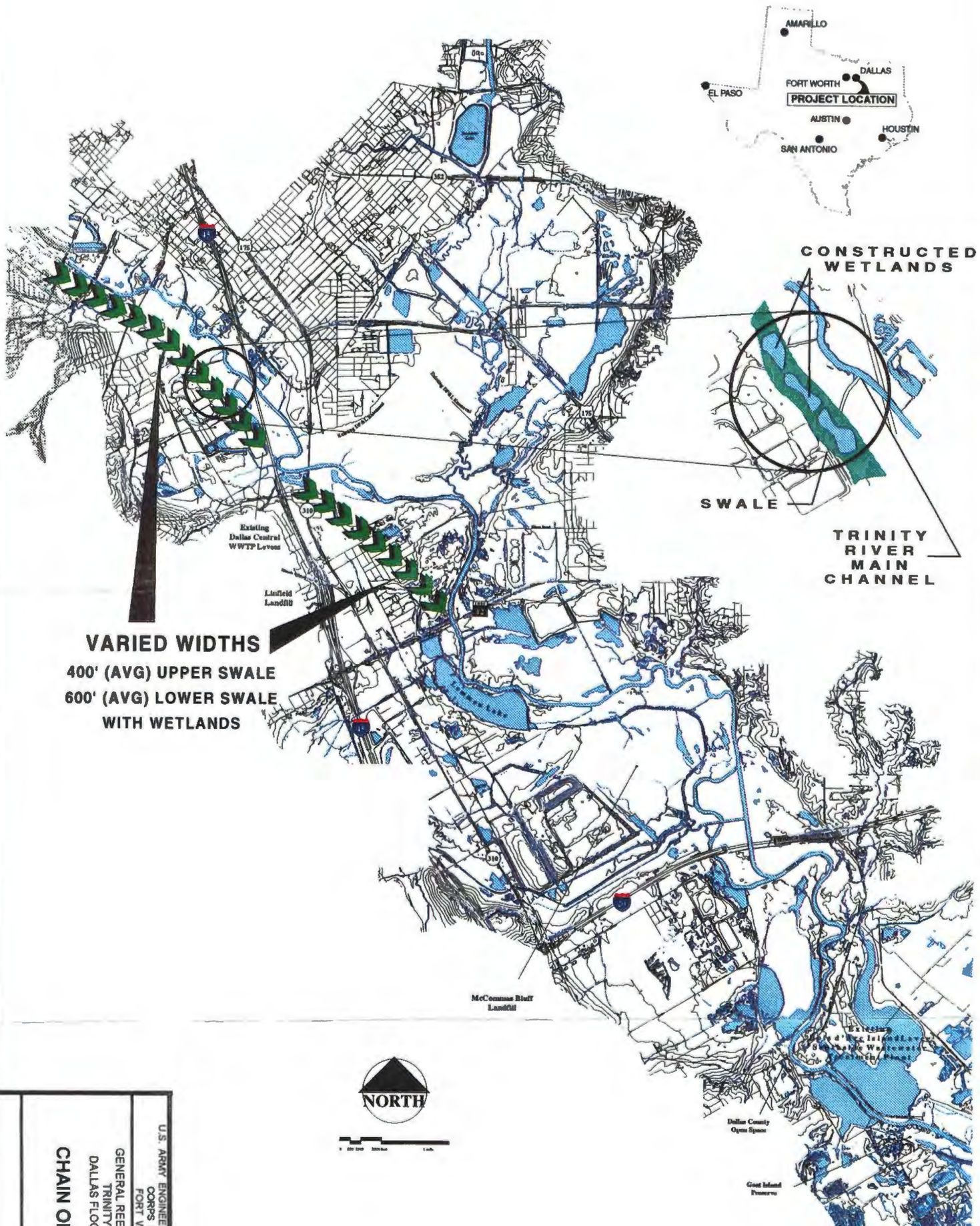
REVISED SWALE ALTERNATIVES

FIGURE 4-8



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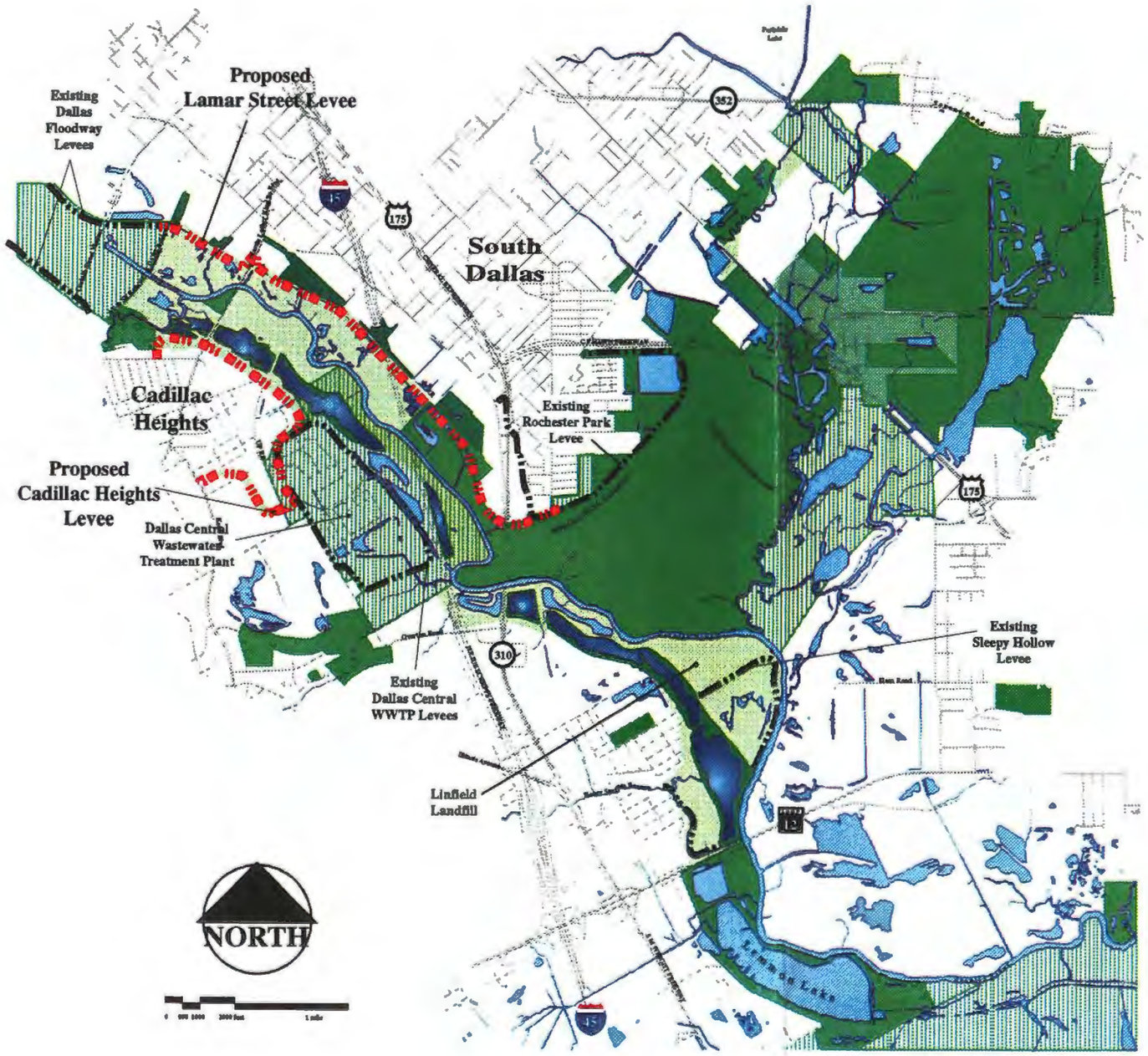
CHAIN OF WETLANDS

FIGURE 4-9



Legend

- Public Park Lands
- Other Public Lands
- Proposed Project Lands
- Proposed Sumps
- Proposed Swale
- Proposed Wetlands
- Existing Levees
- Proposed Levees

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CHAIN OF WETLANDS AND SPF LEVEES

FIGURE 4-10

SELECTION OF THE LOCALLY PREFERRED PLAN

The selection of the Locally Preferred Plan (LPP) began during the development of the NED plan. Many of the alternatives developed by the Corps were deemed worthy of further investigation as potential candidates for the LPP. Following HQUSACE and SWD approval of the preliminary plan formulation process, a series of informal discussions and meetings were held with the city and local interest groups to seek public input for various alternatives. The following issues were deemed worthy of further consideration and resolution:

- Due to the presence of pristine bottomland hardwoods on the east bank in the lower swale area, and the subsequent public input regarding the adverse impacts a 1,200-foot swale would have in this area, further studies were requested by the city.
- The city requested an evaluation of a west bank alignment for the lower swale.
- The city requested that the plans incorporate environmental restoration and recreation features into the flood control options.
- The city sought maximum flood protection for the area residents by construction of SPF levees along Lamar Street and the Cadillac Heights and wastewater treatment plant areas.

NON-STRUCTURAL ALTERNATIVE

The non-structural analysis performed in the preliminary phase of the study investigated the feasibility of evacuation of individual structures within the study area. These investigations revealed only seven structures scattered throughout the floodplain could be economically justified for acquisition. Such a plan was not adopted because it did not adequately address the area's flood problems and did not offer a comprehensive solution. Given these findings, an evaluation of non-structural buyout options from an entire flood zone perspective was performed. Table 4-8 presents a summary of the economic analysis for the evacuation of all structures within various flood zones.

Table 4-8
Economic Analysis of Flood Zone Evacuation Plans
(October 1996 prices, 7.63% interest, 50-year period of analysis)
(Millions of Dollars)

Zone	Number of Structures	First Costs	Annual Costs	Annual Benefits	Benefit/Cost Ratio	Net Benefits
0-2 Year	0	$0.0	$0.0	$0.0	0	$0.0
0-5 Year	13	$13.0	$1.1	$0.9	0.8	($0.2)
0-10 Year	37	$24.0	$2.0	$1.2	0.6	($0.8)
0-100 Year	508	$60.0	$5.8	$1.3	0.2	($4.5)

In the 0 - 5-year flood zone, one residential, five commercial, and seven industrial structures would be removed. The first cost of this plan was estimated at $13,000,000, with a BCR of 0.8.

In the 0 - 10-year flood zone, three residential, 20 commercial, and 14 industrial structures would be removed. The first cost of this plan was estimated at about $24,000,000, with a BCR of 0.6.

In the 0 - 100-year flood zone, 378 residential, 88 commercial, 39 industrial, and three public structures would be removed. The first cost of this plan was estimated at about $60,000,000, with a BCR of 0.2.

These plans would provide unacceptably small impacts on flood damages and were, therefore, screened from further consideration.

The local sponsor decided to focus efforts on the Chain of Wetlands concept, with the possible addition of levees on both sides of the river. The following sections present the development of the LPP, including descriptions of the various features considered, and rationale behind the selections of preferred solutions.

CHAIN OF WETLANDS

The Chain of Wetlands concept was formulated through the iterative process of addressing several issues raised by the city, and from further analysis regarding the hydraulic improvements which could be attained through various vegetation management plans within the area. First, intense concern voiced by citizens and special interest groups over the adverse impacts a 1,200-foot swale would have on important environmental resources in the Trinity River corridor prompted the city to look at smaller swale alternatives, which would provide a reasonable degree of protection in the immediate study area, though providing less benefits to the existing upstream Floodway. Second, the city's desire to add project features which would restore some of the corridor's fish and wildlife habitat qualities shifted the investigations to the examination of a series of connected wetland pools within the open, grass-lined swales.

Swale

Initial Alignment. The original Chain of Wetlands plan would consist of an off-channel swale designed to allow the natural river to retain its meanders, natural banks and bottom, and to preserve the tree canopy along the most ecologically significant vegetation adjacent to the river. The swales would resemble a broad meadow, with side slopes less than the crown of a football field. The centerline of the swales would follow the alignment of the 1,200-foot swale plan. The upper swale would have an average bottom width of approximately 300 feet, and would extend from the upstream end near the Cedar Creek confluence with the Trinity River to the oxbow near IH-45. The complementary lower swale would extend from the State Highway (S.H.) 310 bridge to Loop 12. This swale would have an approximate 500-foot bottom width from S.H. 310 through the Linfield Landfill, but would widen out to a 1,300-foot width through the Sleepy Hollow Golf Course. The maximum depth of the lower swale would be 30 feet through the Linfield Landfill, while the minimum depth would be seven feet.

Revised Alignment. Extensive public involvement revealed continued concerns regarding disturbance of existing environmental resources. Further investigations determined that the higher quality forested zones existed in the areas closest to the river; consequently, it was decided the original alignment of the upper portion of the swale would be shifted to the west to avoid these areas to the extent possible. Downstream of the upstream end of the CWWTP levee, no alignment changes would be necessary. Upstream of this point, the swale would be relocated to the west a distance varying from 200 feet to 500 feet, with an average of approximately 400 feet. Further movement to the west would be prohibited by existing underground utility lines, including three 60-inch diameter and one newly constructed 120-inch diameter pipes. The possibility of locating the swale west of these lines was evaluated, but was considered cost prohibitive. The higher ground elevation west of the utility lines would have required vastly greater excavation quantities, resulting in an estimated $11 million increase in construction costs alone, not

including expected higher costs for real estate and for removal of hazardous, toxic and radiological wastes (HTRW).

When comparing these alignments, it is noted that the initial (eastern) alignment would require acquisition of 940 acres of additional land, at an estimated cost of approximately $4.6 million, to mitigate for impacts to 280 acres of high quality forested areas. The revised (western) alignment would impact 287 acres of lower quality trees, but would require only 635 acres of mitigation, at an estimated cost of approximately $3.1 million. The lower quality forested areas impacted by the western alignment would require significantly less mitigation.

Environmental Restoration (Wetlands)

The proposal to modify the flood swale for restoration of shallow water and emergent wetlands was developed to provide values to fish and wildlife resources, primarily migratory waterfowl, shore and wading birds that utilize the Trinity River corridor as part of the spring and migratory flights. The wetlands would be managed primarily as moist soil units that would optimize production of insects, seeds, tubers and vegetative structures to support several wildlife species during times of critical energy needs. Evaluation of existing constructed wetland features in the area indicated that it was desirable to consider the possibility of using a permanent water source, such as the existing Central Wastewater Treatment Plant effluent, to assure that water for flooding the wetland cells would be available when needed for wildlife usage. An analysis comparing construction of the wetlands with and without a dependable water supply was made.

The design for the proposed restoration plans was developed based upon extensive input from the U. S. Fish and Wildlife Service (USFWS), literature on wetland development in the Trinity River Basin, and from consultation with other biologists within the Corps of Engineers familiar with development of wetlands within this ecoregion for promotion of fish and wildlife benefits. Aside from development of gradual side slopes and provision of a deep permanent water pool, the major characteristics which promote optimized environmental benefits are the ability to regulate water levels with control structures and ability to provide flooding at proper periods during the year. The wetlands as proposed for the chain of wetlands, with control structures and a pumping system designed to deliver water from a continually available source, reflect optimized conditions based upon the available local expertise.

Table 4-9 reflects development of the wetlands without the capability to provide water from a local permanent water source. Based upon existing hydraulic models, it was determined that a flow of approximately 8,000 cubic feet per second would provide overbank flows sufficient to flood the wetlands. Based upon watershed characteristics, it was determined that the overbank flood events would coincide with local rainfall sufficient to fill the wetlands and would thus be a good estimator for frequency of flooding without the use of a pumping system. Hydraulic and hydrologic analyses indicate that approximately 67 % of the time, there would be sufficient water available under natural conditions, during the spring and early summer, to flood the wetlands and stimulate initial growth of emergent and moist soil plants along the perimeter of the wetlands. However, it was found that a flooding event would occur only 5 % of the time during August to irrigate and promote optimum seed production of wetland plants. Flooding would occur approximately 40% of the time during the October to January period, when food and cover produced by the wetlands vegetation would be critical for migratory waterfowl and shorebirds. From these data, the average habitat suitability was adjusted to reflect the effect of reduced flooding on the wetlands. It could additionally be argued that the actual average size of the wetlands would also diminish significantly. Considering suitability values only, there would remain an increase in average annual habitat units in this alternative; however, approximately 83 % of the values would be attributed to the grassland portion of the complex and less than 16 % of the values would be attributable to the wetland portion. The average habitat value of the permanent water feature would be almost totally lost because of the low frequency of flooding that occurs naturally during the summer months.

The wetland complex, as proposed with dependable water supply available (Table 4-10), would provide significant increased fish and wildlife resources values, as indicated by the increases in habitat values of the permanent water, emergent wetlands and grassland portions of the complex. The plan would provide for development of 123 acres of emergent wetland, which would yield over 117 average annual

habitat units, and would more than triple the total resource values over the flood damage reduction swale as it would exist without the proposed emergent wetland complex development alternative. By contrast, the chain of wetlands without a dependable source of water would provide for development of only 83 acres of emergent wetland, providing only 19 average annual habitat units for the priority emergent wetland resources. This analysis shows an increase of 48% in acres and a 516% increase in average annual habitat units of emergent wetlands attributable to a dependable water source.

Cost Effectiveness And Incremental Analysis. While an economic standard has been set that requires a justifiable flood damage reduction plan to have economic costs be no more than the economic benefits, a similar scale does not exist for environmental restoration proposals due to the fact that; although costs are measured in dollars expended, benefits are measured in terms of environmental outputs, such as habitat units, acres, etc., that preclude development of a benefit to cost ratio to eliminate undesirable, non-supportable project alternatives. Cost effectiveness and incremental analysis techniques, as reported by Robinson, et al. 1995, are useful tools for the decision maker to eliminate poor alternatives and to guide the thought process in determining which project alternatives would be supportable when environmental output levels continue to increase with increased expenditure of economic resources.

<u>Cost Effectiveness of Emergent Wetland Restoration.</u> The procedures outlined by Robinson, et al. (1995) were followed to evaluate the environmental benefits and costs of the two broad environmental restoration alternatives for the proposed chain of wetlands. These alternative management plans include providing necessary water when need to optimize fish and wildlife benefits to the proposed emergent wetland complex. This analysis evaluates the benefits that would be derived from the wetland complex relying on naturally occurring weather events versus a pumped supply to provide water for the wetlands. Output information used in the analysis were derived from tables 4-9 and table 4-10. An operation and maintenance cost of $50,000 was estimated for the alternative with a dependable water source, and $35,000 for those without dependable water.

Pertinent information related to the cost effectiveness for the two action alternatives and the no action alternative are displayed in table 9 of Appendix F. Initial analysis indicates that both action alternatives are cost effective in that both provide benefits and that the slightly more expensive plan with dependable water supply provides higher environmental output than the less expensive plan.

The plan without dependable water supply provides a net increase in benefits over the no action alternative, at an average annual cost of $8,678 per average annual habitat unit (AAHU), which appears to be more costly on average than would be expected in this ecoregion. The benefits of adding a dependable water supply are clearly demonstrated by the analysis. For an additional annual cost of $30,503, an additional 130.77 AAHUs can be developed. Furthermore, evaluation of the data indicates that the best buy would the alternative providing dependable water, enabling optimum management of the wetland complex. The no action plan as well as the alternative providing the swale with the wetlands without the capability to provide water when needed provide habitat, the majority of which is associated with the grassland portion of the complex. This scenario, with minimal resource values attributable to the wetlands proper, does not provide restoration of priority habitat and should not be considered further. The emergent wetland restoration plan which includes provision of a dependable water supply appears to be justified based upon the analysis conducted.

Table 4-9
Chain of Wetlands Habitat Evaluation, with Water Supply not available for Management

	Upper Swale						Lower Swale					
	Area (acres)		HSI		Habitat units		Area(acres)		HSI		Habitat Units	
	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands
Grassland/ Forbland	105	65.77	0.25	0.56	26.25	36.83	165.99	114.44	0.25	0.56	41.50	64.08
Permanent Water		3.25		0.2	0	0.65		4.93		0.20	0	0.99
Emergent Wetlands		35.98		0.23	0	8.28		46.62		0.23	0	10.72
Total					26.25	45.76					41.50	75.79
Grand Total											67.75	121.55

Notes: With Flood Control Only reflects on-site conditions if only the flood control portion of the swale were constructed.
Projected with Chain of Wetlands reflects projected conditions with wetland restoration superimposed on flood control project.
Grand Total is the sum of the Upper and Lower Swale values.

Table 4-10
Chain of Wetlands Habitat Evaluation, with Water Supply Available for Management

	Upper Swale						Lower Swale					
	Area (acres)		HSI		Habitat units		Area(acres)		HSI		Habitat Units	
	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands	With Flood Control Only	Projected with Chain of Wetlands
Grassland/ Forbland	105	33.3	0.25	0.90	26.25	29.97	165.99	68.96	0.25	0.90	41.50.	62.06
Permanent Water		18.03		0.95	0	17.13		27.40		0.95	0	26.03
Emergent Wetlands		53.71		0.95	0	51.02		69.59		0.95	0	66.11
Total					26.25	98.12					41.50	154.20
Grand Total											**67.75**	**252.32**

Notes: With Flood Control Only reflects on-site conditions if only the flood control portion of the swale were constructed.
Projected with Chain of Wetlands reflects projected conditions with wetland restoration superimposed on flood control project.
Grand Total is the sum of the Upper and Lower Swale values.

Incremental Analysis of Emergent Wetlands by Cell. Since both action alternatives are considered to be cost effective, further analysis is necessary to determine the optimum extent of environmental restoration through construction of emergent wetlands that is warranted. As in the analysis used to demonstrate that provision of dependable water was desirable and justifiable, an analysis was conduced to determine if the entire chain of wetlands was justifiable or if only a portion of the complex should be constructed and managed. The chain of wetlands, as proposed and evaluated, could contain from one to seven cells (See Figure 2 of Appendix F, and Plates C-21 through C-29 of Appendix C) that would be connected to the water source. A series of water distribution and control structures would be used to manage the emergent wetlands for optimum habitat output. For this analysis, the cells were named in alphabetical order, with the uppermost or northern wetland cell named Cell A, with the most southerly located cell named Cell G. The detailed incremental analyses for each cell is presented in Appendix F, the results of which are shown in table 4-11.

Table 4-11
Incremental Analysis of Environmental Restoration Plan

PLAN	ANNUAL COST	AAHU OUTPUT	INCREMENTAL COST	INCREMENTAL OUTPUT AAHU	INCREMENTAL COST/AAHU
No action	0	68	N/A	N/A	N/A
Cell D	$ 63,349	75	$ 63,349	+ 7	$9,050
Cell C	$ 94,688	99	$ 31,339	+24	$1,306
Cells D and E	$180,927	135	$ 86,239	+36	$2,396
Cells C, D, E and F	$255,615	166	$ 74,688	+31	$2,409
Cells A, B, C, D, E and F	$332,532	196	$ 76,917	+30	$2,564
Cells A, B, C, D, E, F and G	$497,360	252	$164,828	+56	$2,943

Summary - Environmental Restoration Plan. The planning goal for environmental restoration for the proposed project area was to develop a wetland complex providing maximum wetland and related deepwater and grassland habitat gains within the confines of the proposed swale area in a cost effective manner. The proposed restoration plan should not cause additional unacceptable impacts to fish and wildlife resources, nor should it cause impacts to flood damage reduction benefits within the study area, or preclude the development of any additional flood damage reduction actions that might be needed in the future. The seven cells that were designed individually meet all criteria, except they do not maximize total restoration output of important habitat (emergent wetland) that could be achieved. The cost effectiveness and incremental cost analyses was conducted to assist in the determination of whether the plan that does maximize total habitat output (plan with all seven cells) is cost effective and, based upon its incremental cost, should be supported as the recommended environmental restoration plan.

By analysis, it was determined that the plan with all seven cells is cost effective, as were the other five action plans, and these alternatives were carried forward for the final incremental analysis (Table 4-11). All seven of the final alternatives were considered viable alternatives that must be carefully evaluated under the question, "Is this level of output worth the cost?" The analysis conducted shows that for the six action plans that remained after prior screening, environmental benefits increased with each successive increment of wetlands added. Additional increments of wetland restoration, if designed, would likely also continue to

show increased output; however, other planning constraints would be exceeded. For example, additional emergent wetlands could be designed for location off the flood control swale but this could only occur at the expense of bottomland hardwood habitat that is nationally recognized for its importance. Restoration activities should not result in damages that would require environmental mitigation. Studies in the upstream area of the existing Dallas Floodway have only recently begun under separate authorities and it would be imprudent to design emergent wetlands in that area prior to completion of necessary engineering studies to determine needs for that reach of the system.

Therefore, within the constraints of this project and planning area, it appears that the development of the complete chain of wetlands would achieve the goal of maximizing emergent wetland habitat within this area without violating other developed criteria. Going beyond the no action alternative is relatively simple in that a determination has been made that environmental needs are present in the basin that can be obtained by project construction. The output of 68 AAHUs for the no action alternative was based upon the native grassland complex that would result from construction of the flood damage reduction swale, and would essentially provide no benefits attributable to emergent wetlands, the priority output. The next increment, or the first action proposal, construction of Cell D alone, produces only 7 AAHU at a relatively high cost due to the initial high cost of providing the water supply infrastructure and the relatively small size of the Cell. The next measure, construction of Cell C, provides an additional 24 AAHU at a cost of $1306 per AAHU. Additionally, these two increments represent the first in a logical implementation sequence upon which all other cells are dependent.

The remaining alternatives, as listed, continue to provide additional output. Again, the average cost of $2,564 per added AAHU for the plan which includes wetland Cells A through F, and intermediate plans are judged to be worth the additional expense to gain the additional environmental output. The final alternative, which includes all cells, causes need for additional thought in determining whether the additional expense in adding Cell G to provide an additional 56 AAHUs, at an incremental average cost of $2943, is worthwhile. For comparison purposes, an analysis conducted for a similar emergent wetland complex developed on Corps lands for mitigation of another project indicates that the incremental addition of this cell to the plan is warranted.

Following guidance by Robinson, et al., the tendency to select the plan that minimizes average cost, or in other words, is most efficient in production has been bypassed. Instead, a rational decision has been made based upon careful examination of the costs and benefits of all potential combinations of wetland cells. The final array of alternatives was examined in the same manner as if a NED plan were being sought. In our evaluation , the incremental environmental outputs continued to rise with increased expenditure of economic resources. The cap or limit to development of additional alternatives with more wetlands was based upon environmental constraints that precluded development of additional emergent wetlands.

In addition, very few opportunities of this magnitude exist to develop emergent wetlands as proposed in the chain of wetlands, particularly when considering the other non-habitat benefits such as water quality, aesthetics, sightseeing and possibly other recreational benefits that could be attributable to the emergent wetland complex features of this multi-objective plan. The increase in habitat that would be obtained by addition of Cell G appears to environmentally, economically, and socially justifiable. Therefore, the entire wetland complex, with Cells A through G, is included in the environmental restoration plan.

Summary

The Chain of Wetlands Plan is, therefore, defined as the westernmost aligned swale, as described above, into which a connected series of wetlands would be developed and managed utilizing treated effluent from the CWWTP as a source of water, when needed, to supplement overbank flows from the Trinity River. The Dallas City Council, in response to the public opposition voiced against the NED Plan, and in support of the multi-objective outputs of the Chain of Wetlands Plan, voted to adopt the Chain of Wetlands Plan as the initial LPP on August 28, 1996. The total first cost of this plan was estimated at approximately $68.2 million, of which $48.9 million would be for flood control, $10.1 million would be for environmental restoration, and $9.3 million would be for recreation. This plan would yield average annual flood control

benefits of $10.9 million, with a flood control benefit-cost ratio of 1.75. Total net annual flood control benefits for the Chain of Wetlands Plan would be $4.7 million.

However, intense social and public pressure to provide added flood protection in the immediate study area comparable to that provided to the Central Business District by the existing Dallas Floodway levees prompted the city to request additional levee solutions aimed at removing more residents and businesses from flood risk.

CHAIN OF WETLANDS PLUS LEVEES

Public desires to provide greater flood protection to the neighborhoods downstream of the existing Dallas Floodway prompted further, more detailed investigation of plans involving a combination of levees and channels. In order to provide equitable protection to these areas, the city requested that SPF levees be designed on both sides of the river in the Lamar Street and Cadillac Heights areas.

Lamar Levee

Initial Alignment. The initial alignment of the Lamar Levee, located on the east side of the river, would parallel and abut the Southern Pacific Railroad line from Interstate Highway 45 (IH-45) on the upstream end to a point just upstream of S.H. 310 on the downstream side. Upstream of IH-45, the levee alignment would move away from the railroad and connect to the east levee of the existing Dallas Floodway. On the downstream end, from the point upstream of S.H. 310, the levee alignment would shift toward the river, follow a high embankment around and under S.H. 310, and connect to the existing Rochester Park Levee at the east embankment of the Southern Pacific Railroad. This levee alignment, as shown in figure 4-11, would be designed to protect all structures on the east side of the Trinity River.

Secondary (Couplet) Alignment. Concurrent studies conducted by the Texas Department of Transportation (TxDOT) regarding major transportation projects within the downtown Dallas area, including the current study area and the existing Dallas Floodway, yielded preliminary designs which indicated conflicts between roadway alignments and levee alignments within the study area might be minimized by shifting the entire levee closer to the Southern Pacific Railroad. The upstream end of the levee would tie into the east levee of the existing Dallas Floodway, as in the initial alignment, but would shift adjacent to the railroad much further upstream, near Martin Luther King, Jr. (MLK) Boulevard, thereby eliminating flood protection for all businesses in the area. The downstream end of this proposed levee would remain adjacent to the railroad downstream of S.H. 310, and would then roughly parallel the railroad and connect to the Rochester Park Levee at approximately the same location as proposed in the initial alignment. This alignment is also shown in figure 4-11.

The investigation of this proposed alignment revealed several obstacles to feasibility. First, the alignment would eliminate protection to all businesses between the river and the railroad, thereby reducing economic benefits derived from the levee. Second, the placement of the levee adjacent to the railroad would require acquisition of structures along the more densely populated east side of the tracks for construction of sump areas, thereby further reducing economic benefits while increasing project costs. Third, the proposed alignment underneath S.H. 310, on the downstream end, would yield no hydraulic benefit due to the high, existing embankments at this highway, which would restrict conveyance of flood waters to a greater degree than the levee. Vast amounts of excavation and bridge construction would be required to produce hydraulic benefits within this area. For these reasons, the couplet alignment was eliminated from further investigation.

Final Alignment. The next alignment investigated, shown in figure 4-11, would be very similar to the initial alignment, with the exception that the upstream end of the levee would be aligned through the large warehouse structure previously owned and occupied by Proctor & Gamble, but which had essentially been abandoned since the previous analysis. The acquisition of this structure was deemed advantageous for the hydraulic benefits derived from moving the levee further from the river, and for the potential use of this property as a sump area behind the levee.

Summary. As a result of these analyses, the Lamar Street Levee, included in the Chain of Wetlands Plus Levees Plan is defined as a SPF plus 2 foot earthen levee connecting the downstream end of the east levee in the existing Dallas Floodway, at the east abutment of the old Atchison, Topeka and Santa Fe (AT&SF) Railroad bridge, with the existing Rochester Park Levee, at the east abutment of the Southern Pacific Railroad bridge. The levee would have an average height of 21 feet and would be about 3 miles long. This extension would not require raising any portion of the existing Floodway levee, and only about 1,000 feet of the Rochester Park Levee would have to be raised less than one foot. About 4,500 feet of the existing Rochester Park Levee would be made unnecessary by the Lamar Levee. Although the alignment of this levee would be adjacent to several commercial businesses, the majority of these businesses would not require relocation. The Proctor and Gamble storage facility and some smaller commercial structures at the downstream end of the Lamar Levee, near S.H. 310, would require relocation, however.

Cadillac Heights Levee

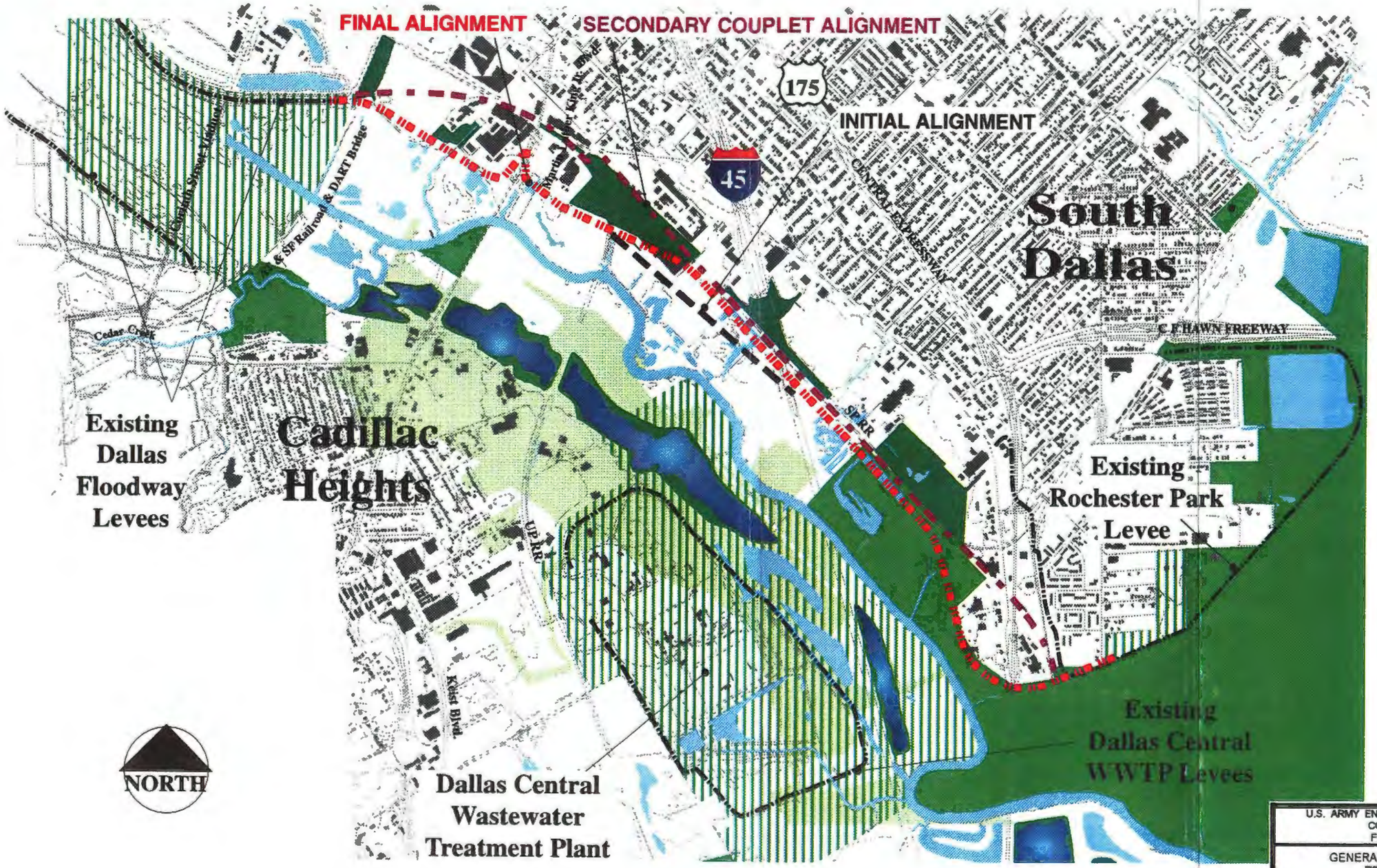
The Cadillac Heights Levee, on the west side of the river, would be composed of new construction and modification of previous construction. Several design iterations were required prior to a final alignment. A proposed new levee would be constructed between Cedar Creek and the CWWTP, a modification to the existing CWWTP Levee would be required, and an extension of the proposed levee behind the CWWTP would be necessary. Two major areas of concern regarding the location of this levee were the possible adverse environmental impacts which this levee might create, and the possible disruption of businesses within the area. Additional obstacles with which the design of this levee had to contend were the presence of large underground sewer lines running parallel with the general flow of the river, and the presence of a utility easement on which large Texas Utilities (TU) towers were located. The underground sewer lines, alluded to previously, included three active 60-inch diameter lines and one 120-inch diameter line, in addition to two abandoned 36-inch diameter lines. The alternatives investigated for this levee are described in the following sections, and are shown in figure 4-12.

New Levee - Eastern Alignment. The initial alignment of the proposed earthen levee would begin upstream near the confluence of Cedar Creek with the Trinity River. Downstream of the MLK Boulevard bridge, the levee would cross over to the east side of the underground sewer lines and TU easement, and then proceed downstream and connect to the CWWTP Levee. Although this alignment would protect a meat packing plant, several potentially insurmountable issues were identified. Foremost, placement of a levee at this location in the floodplain would create significant adverse hydraulic impacts to upstream water surface elevations. In addition, the swale and chain of wetlands would have to be moved closer to the river to accommodate the levee, thereby eliminating the environmental benefits which instigated the realignment of the chain of wetlands as far west as possible. Furthermore, serious concerns were voiced about crossing over major sewer lines with a levee, due to the need for access to the lines and due to potential hazards to the levee in the event of a sewer line break. For these reasons, this "eastern" alignment was eliminated from further consideration.

New Levee - Western Alignment. Several options were investigated for placement of a levee west of the sewer lines, with varying degrees of impact to existing businesses. The upstream end of each levee would match the initial, eastern alignment from Cedar Creek to MLK Boulevard. Downstream of MLK Boulevard, however, each of these "western" alignments would be located on the west side of the sewer lines. These options are described as follows:

<u>Western - Earthen Option.</u> This option would include an entirely earthen levee constructed through the existing meat packing plant, thus requiring acquisition and relocation of the plant. This alignment would cause no impacts to the sewer lines.

<u>Western - Floodwall Option.</u> The alignment of this levee would be the same as the western-earthen option, with the exception that a floodwall would be constructed around the packing plant's main facility, and would require relocation of a barn structure. The floodwall would be required to cross the sewer lines at two locations.



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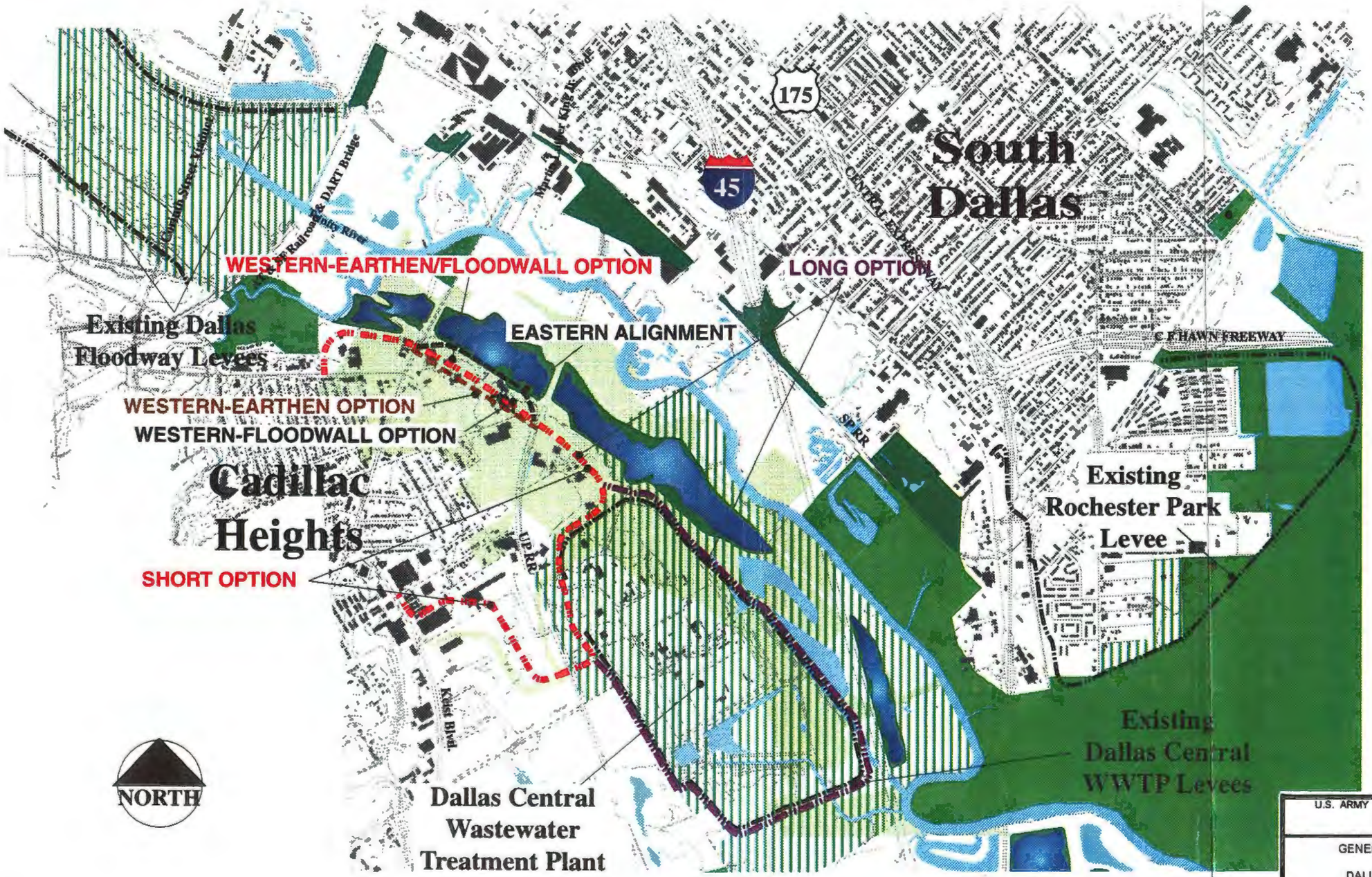
GENERAL REEVALUATION REPORT
TRINITY RIVER, TEXAS
DALLAS FLOODWAY EXTENSION

LAMAR LEVEE ALTERNATIVES

FIGURE 4-11



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FORT WORTH, TEXAS

GENERAL REEVALUATION REPORT
TRINITY RIVER, TEXAS
DALLAS FLOODWAY EXTENSION

CADILLAC HEIGHTS LEVEE ALTERNATIVES

FIGURE 4-12

Western - Earthen/Floodwall Option. The intent of this option would be to minimize the levee footprint to accommodate placement between the westernmost 60-inch sewer line and the 120-inch line, from MLK Boulevard to the Missouri-Kansas-Texas (MKT) Railroad upstream of the CWWTP. Within this area, the earthen levee would require 3:1 side slopes, a 15-foot crest width and a 6-foot high concrete floodwall on top. There would be some overburden placed on the sewer lines within this area. The remaining portions of the Cadillac Heights Levee would consist entirely of earthen embankments with side slopes of 4:1 and crest widths of approximately 20 feet. This alignment would also require relocation of the Dallas City Packing barn facility.

A comparison of direct construction costs, preliminary real estate acquisition and relocation costs, and environmental impacts revealed that these options would be economically and environmentally comparable. However, from an engineering and operation and maintenance standpoint, the risks associated with constructing a floodwall and/or earthen levee on top of sewer lines would make such options much less desirable; therefore, subsequent engineering recommendations endorsed the western-earthen option.

Based on the preceding discussions, decisions were made that further analysis of the Cadillac Heights Levee would be based on an earthen levee located west of the underground sewer lines between Cedar Creek and the CWWTP, thereby requiring acquisition and relocation of several businesses, including the meat packing plant.

CWWTP Levee Tie-In. The proposed new levee, as described above, would be designed to tie into and utilize the existing CWWTP Levee. Two options were investigated for the CWWTP Levee, as shown in figure 4-12, and as described below.

Short Option. In this option, the proposed new levee would tie into the CWWTP Levee, utilize and raise the northwest corner of this levee at the plant entrance to SPF levels, and then extend from the west side of the CWWTP Levee to high ground near the intersection of Kiest Boulevard and McGowan Avenue. This short option, in combination with the Chain of Wetlands and the Lamar Levee, would provide approximately 500-year flood protection to the CWWTP, as opposed to the current 140-year protection. The upstream impacts to the SPF flood elevation at the downstream end of the existing Dallas Floodway for the short option (including the Chain of Wetlands and Lamar Levee) would be an overall reduction of 1.1 feet.

Long Option. The long option would encompass and provide SPF protection to the entire CWWTP. This option would raise the entire CWWTP Levee about 4 feet, except for the northwest corner at the entrance, and would utilize the alignment of the existing levee system. The long option would tie into high ground in the same manner as the short option. The upstream impacts to the SPF flood elevation at the downstream end of the existing Dallas Floodway for the long option (including the Chain of Wetlands and Lamar Levee) would be an overall reduction of 0.45 feet.

The long option was estimated to cost $3.5 million more than the short option, and would yield a loss of benefits in the existing Dallas Floodway of approximately $0.9 million compared to the short option. Due to the increased cost and decreased benefits of the long option, the local sponsor would be responsible for 100% of the increased cost. Based on these findings, the city opted to support the short option.

Summary. The Cadillac Heights Levee to be included in the Chain of Wetlands Plus Levees Plan is defined as a SPF plus 2 foot earthen levee beginning upstream near the confluence of Cedar Creek and the Trinity River and extending on the west side of the underground sewer lines to the CWWTP Levee. The short option, as described above, would be utilized around the CWWTP. The average height of the Cadillac Heights Levee would be about 20 feet, with a length of approximately 2.3 miles.

Interior Drainage

While providing a substantial degree of riverine flood damage reduction to existing properties in the Dallas Floodway Extension study area, the proposed Lamar Street and Cadillac Heights levees would trap a major portion of the surface runoff from about 1,264 and 337 acres of localized subbasin area, respectively. Current Corps policies require that the interior drainage facilities (sumps and sluice outlets)

be designed so as to ensure that this runoff does not contribute to any induced flood damage, and that the interior drainage system be designed to operate in such a way that it does not impair the effective operation of the proposed levee. In addition, current Corps engineering manuals indicate that the minimum facilities from which to begin sump optimization planning procedures should at least meet any minimum design standards established by the local sponsor's drainage ordinance.

The facilities along the proposed levees were initially sized to accommodate collection and/or passage of the 100-year frequency (.01 probability of exceedance) localized runoff event, in accordance with drainage system standards of the local sponsor, the City of Dallas. Along the Lamar Street Levee, this design entailed the proposed implementation of a series of five sumps with related outlet sluice facilities. Areas exhibiting the more low-lying terrain adjacent to the landward side of the proposed levee alignment were chosen for use as sumps. Three of these sites would require extensive excavation, while the existing terrain at the other two sites was found to be adequate in providing the necessary sump storage. Along the Cadillac Heights Levee, this design entailed the proposed implementation of a series of four outlet sluice facilities. Due to the higher terrain along the proposed Cadillac Heights Levee, in contrast with that along the Lamar Street Levee, it is possible to adequately pass the interior runoff design hydrograph without having to temporarily store significant floodwaters. As a result, no specific sump excavations are currently proposed along the Cadillac Heights Levee.

In all instances, any known existing storm sewer lines capable of draining portions of the localized runoff into the Trinity River were assumed to remain in place, and be supplemented with a flap gate, to ensure that the occasionally high river stages do not cause a reversal of flow into the landward side of the proposed levees. Flows capable of being diverted to the river, using the existing storm sewer lines, were subtracted from the total localized runoff in order to develop effective inflow hydrographs at each facility for the design event. The actual sizing of any required sump excavation and the outlet sluice facilities was accomplished by first taking advantage of the mostly vacant real estate pockets along the landward side of the proposed levees, by next varying the size and number of outlet conduits (up to reasonable limits), and by lastly incorporating a degree of surface excavation, to the point that it could be ensured that the 100-year frequency (initial design level) event could be passed without creating a pooling effective on adjacent, non-sump properties.

Summary. The sumps along the proposed Lamar Street Levee would be situated from upstream to downstream as follows, and as shown in figure 4-11. The first would be located immediately southeast of the Dallas Area Rapid Transit (DART) rail line. It would require no excavation, but would inundate 1.68 acres under the design condition. The second would be located at the southwest "dead" end of Forest Avenue. It would require some limited excavation (on the southwest side of an existing commercial activity) and would inundate 1.80 acres under the design condition. The third would straddle the Missouri-Kansas-Texas (MKT) Railway and occupy the long triangular area bounded by that railway, the Southern-Pacific (SP) Railway, and the proposed Lamar Street Levee. It would require extensive excavation and would inundate 17.10 acres under the design condition. The fourth would be located beneath the north end of the Interstate Highway 45 (Julius Schepps Freeway) bridge over the Trinity River valley. It would require no excavation, but would inundate 8.08 acres under the design condition. The fifth would be located along the northeast side of the SP Railway, behind the active commercial entities along the more southeastern end of Lamar Street. It would require substantial excavation and would inundate 12.20 acres under the design condition.

The interior drainage facilities (sluice structures) along the proposed Cadillac Heights Levee, none of which would require significant excavation or would be expected to create a significant area of inundation, would be situated from upstream to downstream as follows. The first would be located west of Martin Luther King Jr. (Cedar Crest) Boulevard. The second would be located adjacent to the west side of the MKT Railway, at the point where it crosses the northeastern leg of the proposed levee alignment. The third would be located several hundred feet east of the MKT Railway. The fourth would be located adjacent to the MKT Railway, at the point where it crosses the southern leg of the proposed levee alignment.

Those sump areas which would be excavated would have three-on-one side slopes, and generally flat bottoms (sloped very slightly to the outlet). The outlet sluice facilities are proposed as simple rectangular

conduits with both a flapgate (at the outlet end) and a manually operated sluice gate. Pertinent data on the sumps and outlet sluice structures, including hydrologic effects, are presented in table A-9 of Appendix A.

Summary

The Chain of Wetlands Plus Levees Plan is defined as the Chain of Wetlands Plan, described previously, in combination with SPF plus 2 foot levees protecting the Lamar and Cadillac Heights areas. Preliminary analyses indicated this plan would impact about 600 acres of environmental resources, including approximately 193 acres of bottomland hardwoods, and would require approximately 1,400 acres of mitigation at an estimated cost of about $6.0 million.

FINAL ANALYSIS OF THE LOCALLY PREFERRED PLAN

As stated previously, the formulation process for this study was comprised of three distinct phases, two of which were completed during identification of the NED Plan. The revisions in the third phase of this process entailed the use of January 1997 price levels and application of the prevailing Federal interest rate of 7.375 percent in all economic analyses, incorporation of Congressional legislation, specifically the Water Resources Development Act (WRDA) of 1996, and inclusion of final revisions to the hydrologic model from the Upper Trinity River Feasibility Study. The following sections reflect the impact these revisions had on overall project cost and benefit analyses.

Impacts of WRDA 1996

On October 12, 1996, during the alternative formulation process and prior to final selection of the LPP, Congress passed WRDA 1996 (Public Law 104-303), which necessitated several revisions in the analysis of alternatives for this project. As stated previously, the local sponsor's request for a Section 215 or Section 104 agreement regarding credit for the non-Federal construction of the Rochester Park Levee and modifications to the CWWTP Levee was denied due to the timing of the request and/or lack of prior approval from the Assistant Secretary of the Army (Civil Works). The sponsor subsequently sought legislation approving the credit. Section 351 of WRDA 1996, quoted in Chapter 3 of this document, is the culmination of that effort.

In summary, Section 351 recognized and acknowledged that the Rochester Park and CWWTP Levees, previously constructed by the non-Federal sponsor (City of Dallas), should be treated as the first element of the project. The actual cost of these levees was $26,958,000 ($14,220,000 for CWWTP, and $12,738,000 for Rochester Park). The legislation stated that costs for the portions of the previously constructed levees compatible with the authorized project, as modified, would be credited toward the non-Federal share of the Federal project. Finally, it specified that the requirement for a 5% cash contribution during construction, stated in WRDA 1986, would remain applicable.

The inclusion of costs for the Rochester Park and CWWTP Levees as part of the overall project costs necessitated revision of the "existing conditions" hydraulic and economic models to reflect pre-1991 conditions in order to capture the benefits derived from these levees. Revised existing conditions damages are presented in table 3-6, in Chapter 3, of this report.

Further guidance received from HQUSACE provided instructions on the implementation of Section 351 in regard to economic justification requirements for the non-Federal levees, and the extent of inclusion of their respective costs and benefits into the various alternatives investigated. This guidance indicated that the portions of the non-Federal levees that are compatible with the authorized project shall be included in the Federal plan, and that if the levees are incrementally economically justified, they shall be included in the NED Plan as well. This guidance, therefore, required incremental analyses of the non-Federal levees, as described in the following paragraphs.

Central Wastewater Treatment Plant Levee

The Central Wastewater Treatment Plant (CWWTP) was previously protected by a levee providing adequate protection from storms with an exceedance probability of 0.02 or greater (50-year). After the flood event in 1990, when access to the plant was curtailed and a near failure occurred, some difficult decisions were made. Dallas Water Utilities estimated $90 million of flood damages would be incurred for any overtopping of its levees, not including costs for clean-up, downstream environmental problems associated with uncontained raw sewage, fines levied by the Environmental Protection Agency, and loss of customer service to the city for the time the CWWTP is down. Due to the amount at risk, both monetary and non-monetary, the city could ill afford to wait for the Federal process. Thus, in 1992-1994, coordination with Corps officials took place to ensure that the levee placement would be physically compatible with the alignment of the Authorized Plan, and the levee protecting the CWWTP was upgraded to its current height. The upgraded levee now provides protection from storms with an exceedance probability of 0.01 (100-year), with a level of confidence of 66%, which indicates an approximate 140-year level of protection.

Table 4-12 contains the benefits and actual costs of the CWWTP levee upgrade. Total investment cost is $14.2 million, with net benefits of $22,000, yielding a BCR of 1.02.

Table 4-12
Benefit Cost Analysis for the CWWTP Levee Upgrade
(January 1997 prices, 7.375% interest, 50-year period of analysis)

Project Alternatives Include Land/Mitigation & HTRW Costs	CWWTP Levee
ESTIMATED FIRST COST	
Non-Federal Levee Cost	$14,220,000
ANNUAL CHARGES	
Interest	$1,048,725
Amortization	$30,765
Operation/Maintenance ($/year)	$75,000
Replacements	$0
TOTAL ANNUAL CHARGES	$1,154,490
ANNUAL BENEFITS	
Inundation Reduction	$1,085,300
Existing Dallas Floodway	$91,208
TOTAL BENEFITS	$1,176,508
NET BENEFITS	$22,018
BENEFIT-COST RATIO	1.02

** The estimated first costs reflect actual expenditures for the CWWTP Levee upgrade in 1993.*

Rochester Park Levee

The Rochester Park Levee was constructed from 1991-1993, following a series of floods that devastated the area. Public outcry resulted in the city taking immediate action to extend protection to the citizens most vulnerable to flooding. Sufficient funds were not available to construct the entire eastern levee (referred to in this text as the Lamar Levee), so the city built only a portion of the system following the

alignment proposed in the Authorized Plan, to the extent possible. In order to provide the maximum protection possible with the funds available, the upstream portion (tail) deviated from the alignment and tied back to high ground in as short a distance as possible. As a stand alone project, the Rochester Park Levee is not economically justified, yielding a BCR of about 0.5.

Construction of the remainder of the Lamar Levee, as proposed in the Chain of Wetlands Plus Levees Plan, would mean that about 4,500 feet of the upstream portion of the Rochester Park Levee would be abandoned, i.e., it would be physically incompatible with the Lamar Levee. The downstream portion of the levee, however, would be fully utilized as part of the system.

Since only a portion of the Rochester Park Levee would qualify for credit under the criteria of physical utilization, economic viability of this piece was tested as part of the Lamar Levee system. An evaluation of the benefits and costs for the Lamar Levee system, with the compatible portion of Rochester Park included, shows the system to be justified as a second added element to the Chain of Wetlands swale. These benefits and costs are provided in table 4-13. Note that the creditable portion of Rochester Park was estimated at approximately $8.9 million, and is shown in the line item entitled "Non-Federal Levee Cost".

Table 4-13
Benefit Cost Analysis for the Lamar Levee System
(Including the Compatible Portion of Rochester Park Levee)
(January 1997 prices, 7.375% interest, 50-year period of analysis)

Project Alternatives Include Land/Mitigation & HTRW Costs	Lamar Levee Incremental
ESTIMATED FIRST COST	$15,631,200
Annual Interest Rate	0.073750
Project Life (years)	50
Construction Period (months)	24
Compound Interest Factor	25.77523
Capital Recovery Factor	0.0759135
Interest During Construction	$1,166,944
Non-Federal Levee Cost	$8,900,000
Investment Cost	$25,698,144
ANNUAL CHARGES	
Interest	$1,895,238
Amortization	$55,598
Operation/Maintenance ($/year)	$181,000
Replacements	$0
TOTAL ANNUAL CHARGES	$2,131,836
ANNUAL BENEFITS	
Inundation Reduction	$1,061,700
Existing Dallas Floodway	$1,450,200
TOTAL BENEFITS	$2,511,900
NET BENEFITS	$380,100
BENEFIT-COST RATIO	1.18

** The estimated first costs reflect actual expenditures for construction of the Rochester Park Levee from 1991 - 1993.*

In accordance with the policy guidance received, and based on Section 351 of WRDA 1996, the total project costs and benefits for all the plans investigated for the LPP were increased to account for the portions of the non-Federal levees deemed compatible for each alternative, as summarized below.

- **NED Plan:** The economic infeasibility of the Rochester Park Levee as a stand alone project preclude the inclusion of the costs and benefits of this levee in the NED Plan. Therefore, only the costs and benefits of the CWWTP Levee upgrade would be added. The cost of this levee upgrade was $14,220,000. Included in this amount was $190,000 in lands, easements, relocations, rights-of-way, and disposal area (LERRD) costs.

- **Chain of Wetlands Plan:** Should the Chain of Wetlands Plan be identified as the final Recommended Plan, the requirements of Section 351 of WRDA 1996 to include the non-Federal levees in the authorized project would allow the costs and benefits of both levees to be included in this alternative. The total cost of both levees was $26,958,000, of which $1,272,000 was defined as LERRD costs.

- **Chain of Wetlands Plus Levees Plan:** The compatible portions of non-Federal levees for this plan would include the entire CWWTP Levee and the portion of the Rochester Park Levee physically utilized in the Lamar Levee system. The estimated cost of the "compatible" portion of Rochester Park was $8,900,000, including $756,000 in LERRD costs. Total non-Federal levee costs added to this alternative would amount to $23,120,000, including $946,000 in LERRD costs.

Table 4-14 presents costs for each of these plans, at January 1997 price levels and level of development. The total cost of the NED Plan, as shown in the table, would be increased to $73.5 million. Should the Chain of Wetlands Plan be designated as the Recommended Plan, it would have an estimated cost of $95.2 million. The Chain of Wetlands Plus Levees Plan would have an estimated cost of $119.2 million. Flood control only costs are presented in the bottom portion of this table.

The residual average annual damages and benefits of each of these alternatives were calculated by reach, and are shown in table 4-15. Table 4-16 presents an economic analysis for each of these plans. It is noted that the estimated first costs shown in this table do not include environmental restoration costs. Outputs for these features are non-monetary and are not included in the benefit-cost ratio. Also, costs for the compatible non-Federal levees are shown separately from estimated first costs of currently proposed components of each plan.

Table 4-14
Costs of Locally Preferred Plan Alternatives
(January 1997 prices, 7.375% interest, 50-year period of analysis)

	PROJECT COSTS		
	NED Plan With CWWTP Levee	Chain of Wetlands With CWWTP and Rochester Park Levees	Chain of Wetlands Plus Levees With CWWTP and Compatible Rochester Park Levees
LERRD (NON-FEDERAL LEVEES)	$190,000	$1,272,000	$946,000
RELOC/UTIL. - FLOOD CONTROL	$5,321,426	$1,525,247	$3,260,902
- ENVIRONMENTAL RESTORATION		$169,472	$169,472
- RECREATION			
EXCAV./DISP. - FLOOD CONTROL	$18,303,092	$16,366,595	$23,949,640
- ENVIRONMENTAL RESTORATION		$8,812,782	$8,812,782
- RECREATION			
FILL - FLOOD CONTROL	$97,854	$72,825	$1,808,192
- ENVIRONMENTAL RESTORATION			
- RECREATION			
HTRW - FLOOD CONTROL	$0	$4,041,908	$4,041,908
- ENVIRONMENTAL RESTORATION			
- RECREATION			
OTHER CONST. - NON-FEDERAL LEVEES	$14,030,000	$25,686,000	$22,174,000
- FLOOD CONTROL	$3,897,441	$16,294,824	$19,759,933
- ENVIRONMENTAL RESTORATION			
- RECREATION	$8,272,400	$8,272,400	$8,272,400
MITIGATION (W/O LAND) - FLOOD CONT.	$2,940,163	$377,800	$626,487
- ENVIRONMENTAL RESTORATION			
- RECREATION			
REAL ESTATE - FLOOD CONTROL	$4,687,800	$2,464,384	$11,779,560
- ENVIRONMENTAL RESTORATION			
- MITIGATION (FLOOD CONT.)	$11,107,200	$3,104,200	$5,140,513
ENG'RING. & DESIGN - FLOOD CONTROL	$1,833,599	$2,320,752	$3,206,824
- ENVIRONMENTAL RESTORATION	$0	$538,935	$538,935
- RECREATION	$496,344	$496,344	$496,344
CONST. MGMT. - FLOOD CONTROL	$1,833,599	$2,320,752	$3,206,824
- ENVIRONMENTAL RESTORATION	$0	$538,935	$538,935
- RECREATION	$496,344	$496,344	$496,344
TOTAL PROJECT COSTS	**$73,607,261**	**$95,172,499**	**$119,225,995**
FLOOD CONTROL COSTS ONLY (WITHOUT LOCAL LEVEES)	$50,022,173	$48,889,267	$76,780,782
LOCAL LEVEE COSTS DEEMED "COMPATIBLE"	$14,220,000	$26,958,000	$23,120,000
TOTAL FLOOD CONTROL COSTS	$64,242,173	$75,847,287	$99,900,782

Table 4-15
Annual Residual Damages and Benefits of LPP Alternatives
(January 1997 prices, 7.375% interest, 50-year period of analysis)

NED PLAN

Reach	Annual Damages			Annual Benefits
	Direct	Incidental	Total	
1	$209,600	$38,986	$248,600	$100,300
2	$20,500	$3,813	$24,300	$35,900
3	$32,300	$6,008	$38,300	$89,200
4A	$524,500	$97,557	$622,100	$979,000
4B	$306,600	$57,028	$363,600	$515,300
5	$384,400	$71,498	$455,900	$831,700
6	$361,100	$34,666	$395,800	$1,463,300
Subtotal	$1,839,000	$309,555	$2,148,600	$4,014,700
7	$2,544,900	$473,351	$3,018,300	$8,906,600
8	$433,300	$80,594	$513,900	$670,300
Subtotal	$2,978,200	$553,945	$3,532,200	$9,576,900
Total	$4,817,200	$863,500	$5,680,800	$13,591,600

CHAIN OF WETLANDS PLAN

Reach	Annual Damages			Annual Benefits
	Direct	Incidental	Total	
1	$269,700	$50,164	$319,900	$29,900
2	$29,800	$5,543	$35,300	$24,900
3	$47,400	$8,816	$56,200	$455,600
4A	$631,200	$117,403	$748,600	$852,500
4B	$420,300	$78,176	$498,500	$380,400
5	$459,200	$85,411	$544,600	$743,000
6	$538,400	$51,686	$590,100	$1,269,000
Subtotal	$2,396,000	$397,200	$2,793,200	$3,754,400
7	$4,449,800	$827,663	$5,277,500	$6,647,400
8	$602,700	$112,102	$714,800	$469,400
Subtotal	$5,052,500	$939,765	$5,992,300	$7,116,800
Total	$7,448,500	$1,336,965	$8,785,500	$10,871,200

CHAIN OF WETLANDS PLUS LEVEES PLAN

Reach	Annual Damages			Annual Benefits
	Direct	Incidental	Total	
1	$269,700	$50,164	$319,900	$29,000
2	$29,800	$5,543	$35,300	$24,900
3	$16,600	$3,088	$19,700	$492,100
4A	$18,400	$3,422	$21,800	$1,579,300
4B	$132,200	$24,589	$156,800	$722,100
5	$13,800	$2,567	$16,400	$1,271,200
6	$688,900	$66,134	$755,000	$1,104,100
Subtotal	$1,169,400	$155,507	$1,324,900	$5,222,700
7	$4,737,000	$881,082	$5,618,082	$6,306,818
8	$873,900	$162,545	$1,036,445	$147,755
Subtotal	$5,610,900	$1,043,627	$6,654,527	$6,454,573
Total	$6,780,300	$1,199,135	$7,979,427	$11,677,273

Table 4-16
Economic Analysis of LPP Alternatives
(January 1997 prices, 7.375% interest, 50-year period of analysis)

	NED Plan		Chain of Wetlands Plan		Chain of Wetlands Plus Levees Plan	
	Flood Control Only	With Recreation	Flood Control Only	With Recreation	Flood Control Only	With Recreation
INVESTMENT						
Estimated First Cost	$50,022,173	$59,287,261	$48,889,287	$58,154,374	$76,780,782	$86,045,870
Annual Interest Rate	0.0738	0.0738	0.0738	0.0738	0.0738	0.0738
Project Life (years)	50	50	50	50	50	50
Construction Period (months)	24	24	24	24	36	36
Compound Interest Factor	25.77523	25.77523	25.77523	25.77523	40.15579	40.15579
Capital Recovery Factor	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759
Interest During Construction	$3,734,394	$4,426,078	$3,649,819	$4,341,502	$8,810,783	$9,873,974
Cost of non-Federal Levees	$14,220,000	$14,220,000	$26,958,000	$26,958,000	$23,120,000	$23,120,000
Investment Cost	$67,976,567	$77,933,339	$79,497,106	$89,453,876	$108,711,565	$119,039,844
ANNUAL CHARGES						
Interest	$5,013,272	$5,747,584	$5,862,912	$6,597,223	$8,017,478	$8,779,189
Amortization	$147,067	$168,609	$171,992	$193,533	$235,197	$257,543
Operation/Maintenance ($/year)	$375,000	$375,000	$175,000	$175,000	$495,000	$495,000
Replacements	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	$5,535,339	$6,291,193	$6,209,904	$6,965,757	$8,747,675	$9,531,731
ANNUAL BENEFITS						
Inundation Reduction	$4,014,700	$4,014,700	$3,754,400	$3,754,400	$5,222,700	$5,222,700
Existing Dallas Floodway	$9,576,900	$9,576,900	$7,116,800	$7,116,800	$6,454,573	$6,454,573
Recreation	$0	$1,000,000	$0	$1,000,000	$0	$1,000,000
TOTAL ANNUAL BENEFITS	$13,591,600	$14,591,600	$10,871,200	$11,871,200	$11,677,273	$12,677,273
NET ANNUAL BENEFITS	$8,056,261	$8,300,407	$4,661,296	$4,905,443	$2,929,598	$3,145,542
BENEFIT-COST RATIO	2.46	2.32	1.75	1.70	1.33	1.33
ENVIRONMENTAL RESTORATION	$0	$0	$0	$10,060,125	$0	$10,060,125
TOTAL PROJECT COSTS	$64,242,173	$73,507,261	$75,847,287	$95,172,499	$99,900,782	$119,225,995
No. of Structures No Longer at Risk from 100-yr Flood Event	403		511		719	
No. of Structures No Longer at Risk from SPF Event	580		241		688	

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To further aid the local sponsor in the LPP selection process, estimated cost apportionment calculations were performed showing approximate Federal/non-Federal cost sharing responsibilities for each plan. These calculations were performed assuming that the cost sharing provisions of WRDA 1986 would be applicable to flood control and recreation costs, while WRDA 1996 cost sharing requirements would be appropriate for environmental restoration features, due to the need for a Congressionally authorized amendment to the original 1965 authorization adding environmental restoration as a project purpose. The non-Federal share of project costs for each of these purposes would be as follows:

- Flood Control: 25 - 50%
- Environmental Restoration: 35%
- Recreation: 50%

Furthermore, Federal cost sharing for recreation features would be limited to 10% of the Federal share of flood control costs.

In order to calculate cost apportionments, the methodology for determining the appropriate amount of credit for "compatible" non-Federal construction was established. The amount of credit applied toward the non-Federal share of project costs for the advanced construction of the Rochester Park and CWWTP Levees would vary for different plans and would not necessarily be equal to the cost added to the plan for these levees. This credit was calculated in the following manner:

- The costs for the compatible portions of these levees applicable to each plan, as previously identified, were added as a flood control project cost.
- Federal and non-Federal project costs were then calculated *as if these levees were being constructed during implementation of the currently proposed project.*
- The required 5% cash contribution was calculated and Federal/non-Federal costs were revised accordingly.
- The non-Federal share was assessed in regard to compliance with the applicable cost sharing percentages, as described above, and Federal/non-Federal apportionments were again revised, as necessary.
- The amount of credit applied toward the non-Federal share of project costs for each plan was calculated as the non-Federal share (as derived above) minus the required 5% cash contribution, with a maximum credit equal to the total cost of the "compatible" non-Federal levees added to that particular plan.

A summary of these calculations is presented in table 4-17.

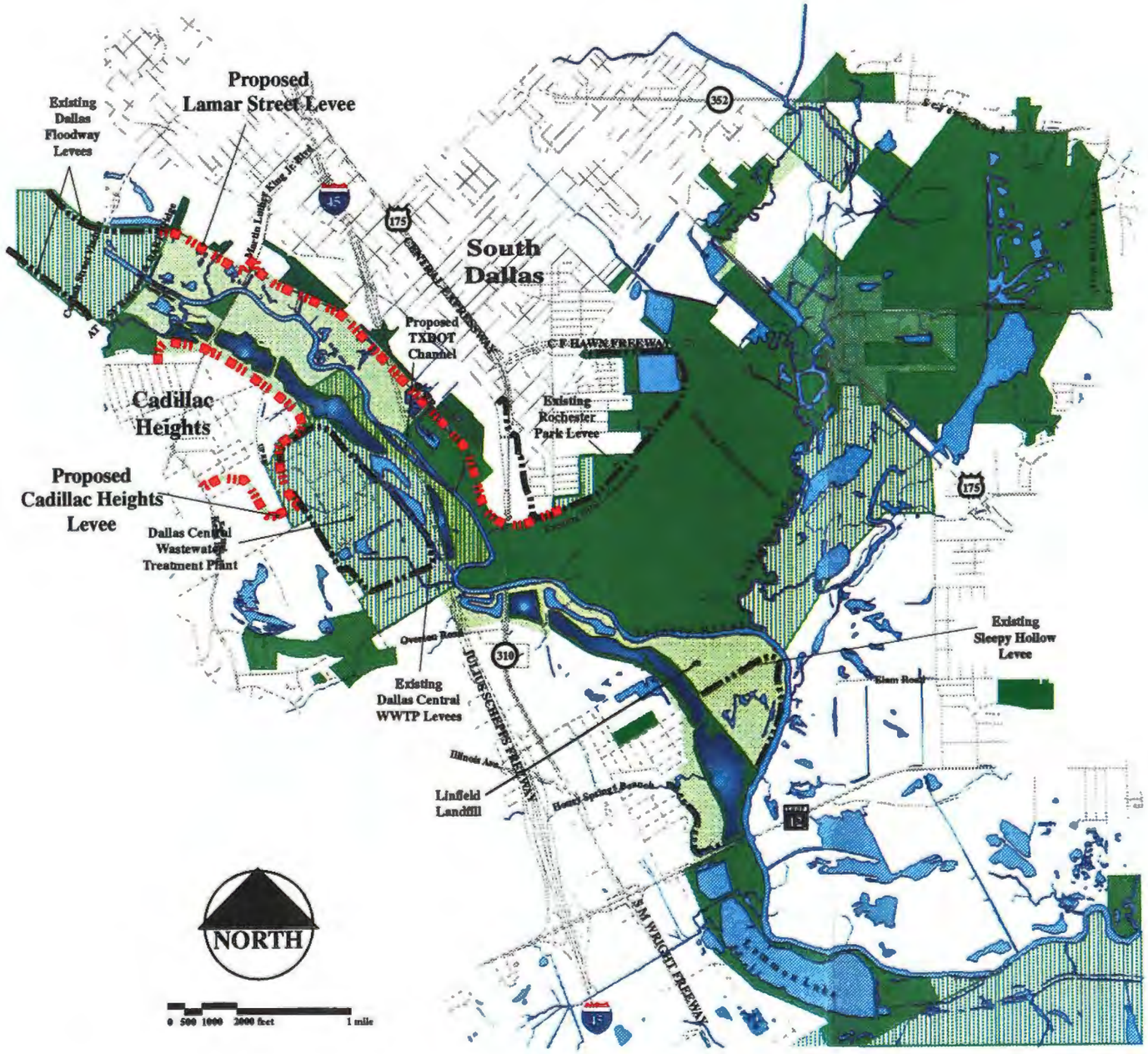
Summary

Based on these analyses, and because the Chain of Wetlands Plus Levees Plan satisfactorily met the city's desire for a multiple objective project providing flood protection to the study area comparable to that provided upstream by the existing Dallas Floodway, this plan was formally adopted by the Dallas City Council as the final LPP on March 26, 1997. Figure 4-13 presents a general layout of the features of this plan.

Table 4-17
Cost Apportionment Data For LPP Alternatives
(January 1997 prices)

Investigated Alternative	Federal Share	Non-Federal Share
NED Plan		
Total Project Cost	$73,507,261	
Share Prior to Levee Credit	$44,356,182	$29,151,079
Percent of Total Project Cost	60.3%	39.7%
Amount of Levee Credit	$14,030,000	($14,030,000)
Remaining Share of Project Cost	$58,386,182	$14,741,079
Uncredited Compatible * Non-Federal Construction	$0	
Chain of Wetlands Plan		
Total Project Cost	$95,172,499	
Share Prior to Levee Credit	$68,057,090	$27,115,410
Percent of Total Project Cost	71.5%	28.5%
Amount of Levee Credit	$15,169,457	($15,169,457)
Remaining Share of Project Cost	$83,226,547	$11,945,952
Uncredited Compatible * Non-Federal Construction	$11,788,543	
Chain of Wetlands Plus Levees Plan		
Total Project Cost	$119,225,995	
Share Prior to Levee Credit	$84,950,393	$34,275,602
Percent of Total Project Cost	71.3%	28.7%
Amount of Levee Credit	$21,126,975	($21,126,975)
Remaining Share of Project Cost	$106,077,368	$13,148,627
Uncredited Compatible * Non-Federal Construction	$1,993,025	

** "Compatible" costs of non-Federal Levees vary with each plan, as defined on pages 4-51 and 4-52 of this document.*



Legend

- Public Park Lands
- Other Public Lands
- Proposed Project Lands
- Proposed Sumps
- Proposed Swale
- Proposed Wetlands
- Existing Levees
- Proposed Levees

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

GENERAL REEVALUATION REPORT
TRINITY RIVER, TEXAS
DALLAS FLOODWAY EXTENSION

LOCALLY PREFERRED PLAN

FIGURE 4-13

FORMULATION OF THE RECOMMENDED PLAN

This section presents the identification of the Tentative Federally Supportable Plan (TFSP), and the final array of alternatives investigated for designation of the Recommended Plan.

Also presented herein are details of a proposal by the Texas Department of Transportation (TxDOT) to include a realignment of a section of the river channel at the IH-45 bridge.

IDENTIFICATION OF THE TENTATIVE FEDERALLY SUPPORTABLE PLAN

The Federally Supportable Plan (FSP) can be defined as the plan which sets the maximum limit for Federal participation in the implementation of a project. Due to maximization of net benefits, the NED Plan is normally denoted as the FSP. However, designation of a plan (larger or smaller) other than the NED Plan is permitted if there are overriding or compelling reasons favoring selection of such a plan. A recommended project which is smaller (less costly) than the NED Plan would, with appropriate approval, be designated as the FSP, thereby establishing lower Federal participation constraints. Should the local sponsor prefer a plan which is more costly than the NED Plan, an exception to the NED requirements may be granted by the Assistant Secretary of the Army for Civil Works (ASA(CW)), should the increased development warrant full Federal participation. Such an exception would be cost shared the same as the NED Plan and would become the Federally Supportable Plan. This section provides comparative data between the final array of alternatives investigated, prior to any decisions by the ASA(CW) regarding an exception, and presents rationale for designation of a plan other than the NED as the Tentative Federally Supportable Plan (TFSP). The final Federally Supportable Plan (FSP) will be designated following the decision of the ASA(CW).

Due to the significant adverse environmental impacts associated with implementation of the NED Plan, an incremental analysis of the separable flood control elements of the LPP was performed to determine whether a Tentative Federally Supportable Plan could be established which would complement the LPP. These separable elements include the swale (with incorporated chain of wetlands), the SPF Lamar Levee, and the SPF Cadillac Heights Levee. In accordance with Section 351 of WRDA 1996, the costs and benefits of the CWWTP Levee and the "compatible" portion of the Rochester Park Levee are included in this analysis, shown in table 4-18. Note that the benefits for the chain of wetlands *increment* of the LPP are different than the benefits for the Chain of Wetlands Plan presented in table 4-16. The reason for this difference is that the Chain of Wetlands Plan would include the costs and benefits of the CWWTP Levee upgrade and the *entire* costs and benefits for the Rochester Park Levee. However, the LPP would only include the costs and benefits for the CWWTP Levee upgrade and the *portion* of the Rochester Park Levee which would be compatible with the LPP. Since the Rochester Park Levee would be an integral part of the Lamar Levee system, the costs and benefits of its "compatible" portion were included in the Lamar Levee increment, while the CWWTP Levee was included in the chain of wetlands increment.

Given the three separable flood control features, it was assumed that the chain of wetlands swale must be the first added element. It would achieve benefits from all reaches, the net benefits would be far greater than the other elements, and it is the only feature which would not adversely impact adjoining areas due to increased water surfaces for given storms. The chain of wetlands swale and CWWTP Levee, when analyzed as an increment of the LPP, would have a flood control first cost of $63.1 million ($48.9 million for the chain of wetlands and $14.2 million for the CWWTP Levee), a BCR of 2.05, and net annual flood control benefits of $5.4 million. Comparatively, the NED Plan would have estimated flood control costs of $64.2 million ($50.0 million for the 1,200-foot swale and $14.2 million for the CWWTP Levee), net annual flood control benefits of approximately $8.1 million, and a BCR of 2.46. From an environmental standpoint, the NED Plan was estimated to directly impact over 725 acres of environmental resources, including 504 acres of mature bottomland hardwoods, and would require the purchase of 3,200 acres of mitigation land. The chain of wetlands portion of the LPP was preliminarily estimated to directly impact only 287 acres of lower quality terrestrial, including 114 acres of bottomland hardwoods, requiring only 635 acres of mitigation.

As shown, the Chain of Wetlands Plan would yield fewer net benefits than the NED Plan, but would have a lower estimated first cost. Based on these findings, and on the expected difficulty in implementing the NED Plan from a public acceptability standpoint, general consent, by ASA(CW) and HQUSACE representatives, for designation of the chain of wetlands as the first increment of the Tentative Federally

Supportable Plan, in lieu of the NED Plan, was given during the Alternative Formulation Briefing, held June 19, 1997. Furthermore, policy guidance allows for the addition of incrementally justified elements of the LPP to the Tentative Federally Supportable Plan, with full cost sharing provisions. The levees were analyzed as separate increments for possible inclusion in the Tentative Federally Supportable Plan.

The SPF Cadillac Heights Levee was analyzed as the second added element by combining it with the swale. Results showed this increment would have a negative contribution, with a BCR of 0.81.

The SPF Lamar Levee system, however, fared much better as a second added element, with an incremental BCR of 1.36. Combined with the swale, net annual benefits of $6.1 million would be achieved. This levee was, therefore, incorporated into the Tentative Federally Supportable Plan.

Finally, both levees were evaluated as a system to determine overall economic efficiency. As a total system, the LPP would have net annual flood control benefits of $2.9 million, with a BCR of 1.33.

Due to the incremental infeasibility of the SPF Cadillac Heights levee, further analysis was performed to determine whether or not a 100-year levee could be economically justified. This analysis, shown in table 4-19, revealed that a 100-year levee would be incrementally justified, and can be added to the Tentative Federally Supportable Plan.

Summary

The identified Tentative Federally Supportable Plan, as shown in figure 4-14, would consist of the following elements:

- **Chain of Wetlands:** The chain of wetlands increment would consist of upper and lower swales, separated at Interstate Highway (IH) 45. The upper swale would have an average 400-foot bottom width and would extend from Cedar Creek to the oxbow lake at IH-45, a distance of about 1.5 miles. The lower swale would have an average 600-foot bottom width, would extend between IH-45 and Loop 12, a distance of about 2.2 miles, and would be aligned through the Linfield Landfill and Sleepy Hollow Golf Course to minimize impacts to forested areas and nearby residential areas. Excavated wetlands and vegetative plantings would be added as environmental restoration features within the footprint of the swales to form a "chain of wetlands."

- **SPF Lamar Levee:** This increment would include construction of an earthen levee providing SPF protection (.00125 probability of exceedance) for the Lamar Street area and. This levee would extend from the existing Dallas Floodway East levee to the previously constructed Rochester Park Levee, a distance of 2.9 miles.

- **100-Year Cadillac Heights Levee:** This increment would include a levee / floodwall system providing 100-year protection (.01 probability of exceedance) for the Cadillac Heights area. This levee would extend from near Cedar Creek to the Central Wastewater Treatment Plant (CWWTP), a distance of 1.1 miles.

- **Non-Federal Levees:** In addition to the levees described above, the Tentative Federally Supportable Plan would also include the costs and benefits of the portions of the previously constructed non-Federal levees. The total cost for the compatible portions of these levees was estimated at $23.1 million ($14.2 million for the CWWTP Levee upgrade and $8.9 million for the compatible portion of the Rochester Park Levee).

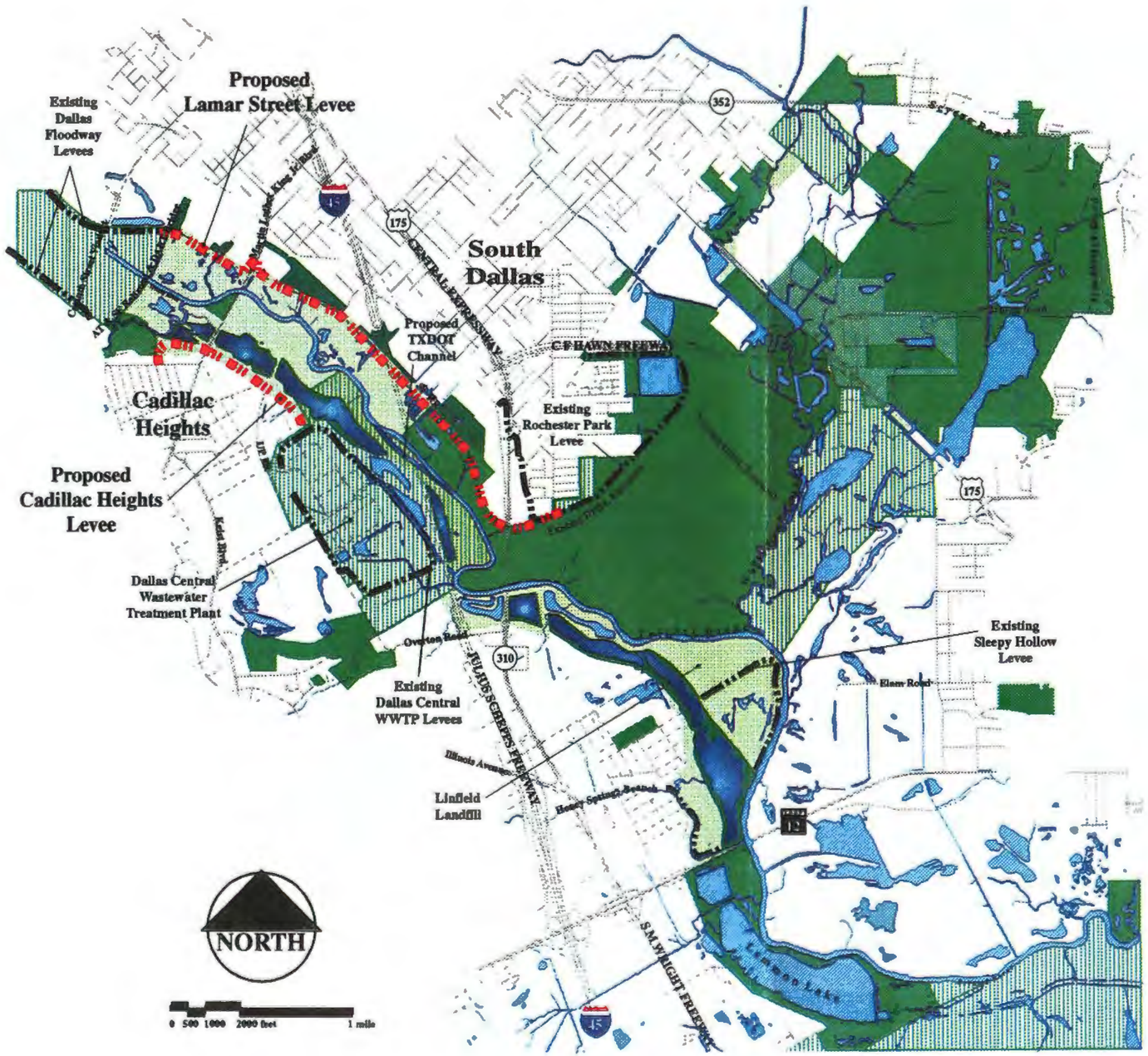
- **Recreation Features:** The Tentative Federally Supportable Plan would include recreation amenities compatible with the regional recreation master plan, including hike/bike trails, equestrian trails, canoe launches and pavilions.

Table 4-18
Incremental Analysis of the LPP - Flood Control Only
(January 1997 prices, 7.375% interest, 50-year period of analysis)

Description	Chain of Wetlands	Chain of Wetlands Plus SPF Cadillac Heights	SPF Cadillac Heights Incremental	Chain of Wetlands Plus SPF Lamar	SPF Lamar Incremental	Chain of Wetlands Both SPF Levees
INVESTMENT						
Estimated First Cost	$48,889,287	$61,149,587	$12,260,300	$64,520,487	$15,631,200	$76,780,782
Annual Interest Rate	0.073750	0.07375	0.07375	0.073750	0.073750	0.073750
Project Life (years)	50	50	50	50	50	50
Construction Period (months)	24	24	24	24	24	36
Compound Interest Factor	25.77523	25.77523	25.77523	25.77523	25.77523	40.15579
Capital Recovery Factor	0.0759135	0.0759135	0.0759135	0.0759135	0.0759135	0.0759135
Interest During Construction	$3,649,819	$4,565,109	$915,290	$4,816,763	$1,166,944	$8,810,783
Cost of Non-Federal Levees	$14,220,000	$14,220,000	$0	$23,120,000	$8,900,000	$23,120,000
Investment Cost	$66,759,106	$79,934,696	$13,175,583	$92,457,250	$25,698,144	$108,711,565
ANNUAL CHARGES						
Interest	$4,923,484	$5,895,184	$971,700	$6,818,722	$1,895,238	$8,017,478
Amortization	$144,433	$172,939	$28,505	$200,031	$55,598	$235,197
O&M ($/year)	$50,000	$189,000	$139,000	$231,000	$181,000	$495,000
Replacements	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	$5,117,917	$6,257,123	$1,139,204	$7,249,753	$2,131,836	$8,747,676
ANNUAL BENEFITS						
Inundation Reduction	$3,370,100	$4,289,800	$919,700	$4,816,100	$1,443,000	$5,222,700
Existing Dallas Floodway	$7,116,800	$7,116,800	$0	$8,567,000	$1,450,200	$6,454,578
TOTAL ANNUAL BENEFITS	$10,486,900	$11,406,600	$919,700	$13,383,100	$2,893,200	$11,677,273
NET ANNUAL BENEFITS	$5,368,983	$5,149,477	($219,504)	$6,133,347	$761,364	$2,929,598
BENEFIT - COST RATIO	2.05	1.82	0.81	1.85	1.36	1.33

Table 4-19
Incremental Analysis of the
100-Year Cadillac Heights Levee - Flood Control Only
(January 1997 prices, 7.375% interest, 50-year period of analysis)

Description	Chain of Wetlands Plus SPF Lamar	Chain of Wetlands, SPF Lamar and 100-Year Cadillac Heights Levees	100-Year Cadillac Heights Incremental
INVESTMENT			
Estimated First Cost	$64,520,487	$67,224,987	$2,704,500
Annual Interest Rate	0.073750	0.073750	0.073750
Project Life (years)	50	50	50
Construction Period (months)	24	24	24
Compound Interest Factor	25.77523	25.77523	25.77523
Capital Recovery Factor	0.0759135	0.0759135	0.0759135
Interest During Construction	$4,816,763	$5,018,668	$201,904
Cost of Current Levees	$23,120,000	$23,120,000	$0
Investment Cost	$92,457,250	$95,363,654	$2,906,404
ANNUAL CHARGES			
Interest	$6,818,722	$7,033,069	$214,347
Amortization	$200,031	$206,319	$6,288
O&M ($/year)	$231,000	$370,000	$139,000
Replacements	$0	$0	$0
TOTAL ANNUAL CHARGES	$7,249,753	$7,609,389	$359,635
ANNUAL BENEFITS			
Inundation Reduction	$4,816,100	$5,272,300	$456,200
Existing Dallas Floodway	$8,567,000	$8,567,000	$0
TOTAL BENEFITS	$13,383,100	$13,839,300	$456,200
NET ANNUAL BENEFITS	$6,133,347	$6,229,911	$96,565
BENEFIT - COST RATIO	1.85	1.82	1.27



Legend

- Public Park Lands
- Other Public Lands
- Proposed Project Lands
- Proposed Sumps
- Proposed Swale
- Proposed Wetlands
- Existing Levees
- Proposed Levees

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

GENERAL REEVALUATION REPORT
TRINITY RIVER, TEXAS
DALLAS FLOODWAY EXTENSION

TENTATIVE FEDERALLY SUPPORTABLE PLAN

FIGURE 4-14

The flood control first cost of the Tentative Federally Supportable Plan would be $67.2 million, plus $23.1 million for the non-Federal levees, for a total of $90.3 million. Total annual flood control benefits would equal $13.8 million, net annual flood control benefits would be $6.2 million, and the BCR would be 1.82.

CHANNEL REALIGNMENT PROPOSAL AT IH-45 BRIDGE

During the Environmental Impact Statement (EIS) scoping process, the Texas Department of Transportation (TxDOT) submitted a proposal to realign the Trinity River at IH-45 as a part of the Dallas Floodway Extension project. TxDOT provided documentation that the bridge at IH-45 was constructed in 1972 to complement the authorized navigation channel of the Dallas Floodway Extension portion of the Trinity River Project. The bridge, which consists of 23 spans, varying in length from 78 feet to 480 feet, was constructed such that the longer spans would be located over the proposed navigation channel. The navigation channel, however, was never built. Currently, three of the shorter 78-foot spans span the existing Trinity River. In the years following construction, the constricted flows through the existing 78-foot spans have resulted in blockage and subsequent damage to the existing piers, due to debris accumulations. This proposal cited a 1984 flood event in which massive accumulations of driftwood precipitated a fracture in one of the bridge columns supporting the section spanning the river. The narrow bridge span at this crossing was deemed the cause of the debris blockage.

IH-45 has been designated as a major transportation corridor for national defense, and TxDOT has considered replacement of the bridge spans over the existing channel as a solution to the on-going maintenance costs and to provide long-term integrity of the structure. Alternatively, TxDOT has proposed a plan to relocate the existing river channel to pass normal river flow beneath the existing 320-foot bridge span that is located nearest the river channel. A plan to relocate a portion of the existing river channel has been designed to accomplish these goals at a significantly lower cost than replacement of the short bridge spans. The plan calls for realignment of about 3,300 feet of existing river channel. The proposed channel would have a trapezoidal cross section with a 30-foot bottom width, 3H:1V side slopes, and a top width of approximately 180 feet. The existing river channel in the reach where the realignment is proposed has an average bottom slope that is nearly zero. Therefore, the proposed channel realignment section has been designed with a zero bottom slope from beginning to end. The proposed channel has an average depth of 15 feet and has been designed to closely approximate the channel flow capacity and the flow velocities of the existing river channel. The proposed channel alignment would be centered between the nearest 320-foot span of the IH-45 bridge which has a face-to-face clearance distance between the piers of about 200 feet normal to the flow. Excavation around the piers would not be required. The proposed realignment will result in the channel being moved laterally a maximum distance of about 350 feet. The existing channel would be filled to the existing top of bank elevation 396.0 to prevent further collection of debris. Relocation of the channel would result in modifications to the existing Central Mitigation Swale, which would be reduced in size by filling of the portion of the swale near the proposed channel realignment. A minimum of 150 feet from the top of bank of the proposed river channel realignment to the top of the bank of the Central Mitigation Swale would be required.

Several alternatives regarding filling of the old river channel have been investigated. The investigated alternatives accomplish the primary goals of the IH-45 bridge channel realignment project to some degree, but the proposed plan for the channel realignment accomplishes these goals with a minimal risk to the bridge structure and a minimal filling of the old channel. The primary objective of the project is to reduce the risk of damage to the bridge piers from floating debris and reduce or eliminate the cost of continual maintenance to remove the debris and periodically repair the structure. The proposed plan to fill the old channel is to fill from the upstream diversion of the river channel to the downstream side of the bridge. The fill will be placed up to the level of the existing overbank areas at the approximate elevation of 398.0 and will be placed around the existing bridge piers located within the old channel. This is the only partial channel fill plan that will ensure complete diversion of channel confined flows and minimize the risk to the existing bridge piers. The channel fill will terminate at the downstream end with a very gradual slope of the fill to the streambed of the old channel just downstream of the bridge piers. A portion of the old channel downstream of the IH-45 bridge is to remain unfilled as existing. This unfilled portion of the old channel will provide a slack water area for use as a possible river access point and may provide some

habitat diversity near the river. However, slack water areas such as this have a tendency to collect trash and debris both from flood events and from the ease of public access. Therefore, additional maintenance to remove trash may be required for the unfilled portion of the old river channel. The filled portion of the old river channel will maximize the diversion of channel confined river flows to the new channel alignment, stabilize the bridge piers in the old channel, and minimize the risk of floating debris collecting on the bridge piers. The Texas Department of Transportation (TXDOT) maintains an access road directly beneath the IH-45 bridge which provides access to the river channel from either side of the river. Filling of the old river channel beneath the bridge as proposed will provide continued access to the river channel within the TXDOT right-of-way for inspection and maintenance. A plan view of the proposed relocation of the Trinity River channel at IH-45 may be found in Appendix C.

TxDOT's proposal included relocation of a section of the existing Trinity River to an adjacent span, beneath a 1,120-foot plate girder unit structure that was originally designed and constructed to span the river. This continuous plate girder unit, which consists of two 320-foot end spans and a 480-foot center span, has considerably stronger columns and drill shafts designed specifically for lateral forces, in anticipation of possible boat or debris impacts.

Alternatives for IH-45 Proposal

Three alternatives were investigated to determine the economic feasibility of a solution to the problem. The alternatives included the following:

- No Action
- Column/Pier Armoring
- River Realignment

In the absence of a project to reroute the Trinity River, the "No Action" alternative, TxDOT indicated that the 78-foot bridge spans spanning the river, in its existing location, would be replaced by a single 320-foot span, which would span the existing river in its entirety. This work effort would be accomplished at a future data, either in a planned replacement scenario, or as a reaction to a catastrophic or partial failure of the bridge during a flood event. This larger span would reduce the risk of loss of life due to bridge failure, prevent extensive and expensive repairs due to partial failure of the bridge in a flood event, reduce routine maintenance costs associated with removal of accumulated debris around the bridge columns, and reduce the possibility of significant costs associated with rerouting of traffic and loss of potential wages due to delays should this major thoroughfare between Dallas and Houston catastrophically fail. The first cost of this reconstruction was estimated to be $12.5 million, with an annualized cost of $1.1 million.

The second alternative would involve armoring the six sets of columns in the existing Trinity River with concrete to protect them against impacts similar to those which caused the 1984 column failure. The first cost of this alternative was estimated to be $4.9 million, with an annualized cost of $0.5 million. However, an element of risk exists with this alternative. It would still be possible to have a large flood event carrying sufficient debris to cause the bridge to fail.

The third alternative investigated would involve rerouting a portion of the existing Trinity River to a new site beneath the adjacent 1,120-foot plate girder structure. This location would follow the original authorized navigation channel project location and would provide the needed cross-sectional area under the bridge to avert potential damage from high debris flows. This alternative was estimated to have a first cost of $1.9 million, and an annualized cost of $0.2 million.

Economic Analysis of IH-45 Proposal

An economic analysis of this proposal was performed, using the "No Action Plan" as the basis for project benefits. This analysis assumes that in time, with no changes in annual maintenance of the existing bridge, the bridge would fail or be damaged to such an extent as to require complete replacement. The

results of this analysis are presented in table 4-20. As shown, the alternative which involved armored protection of the existing columns was economically feasible, with net benefits of $0.6 million, and a BCR of 2.30. The alternative providing maximum net benefits, however, was determined to be the rerouting of the river to an adjacent span. This alternative yielded $0.9 million in net benefits, with a BCR of 6.69. The general layout of this plan is shown in Appendix C.

Table 4-20
Economic Analysis of IH-45 Proposal
(January 1997 prices, 7.375%, 50-year period of analysis)

Project Alternatives Include	No-Action Plan	Column/Pier Armoring	River Realignment
INVESTMENT			
Estimated First Cost	$12,449,000	$4,874,000	$1,935,000
Annual Interest Rate	0.0738	0.0738	0.0738
Project Life (years)	30	30	50
Construction Period (months)	6	6	6
Compound Interest Factor	6.09295	6.09295	6.09295
Capital Recovery Factor	0.0836	0.0836	0.0759
Interest During Construction	$224,093	$87,738	$34,831
Investment Cost	$12,673,225	$4,961,870	$1,969,831
ANNUAL COSTS			
Interest	$934,650	$365,938	$145,275
Amortization	$125,379	$49,089	$4,262
Operation/Maintenance	$10,000	$50,000	$10,000
Replacements	$0	$0	$0
Total Annual Costs	$1,070,000	$465,000	$160,000
Annual Cost Reduction	$1,070,000	$1,070,000	$1,070,000
Total Annual Benefits	$1,070,000	$1,070,000	$1,070,000
Net Benefits	$0	$605,000	$910,000
Benefit-Cost Ratio	1.00	2.30	6.69

Summary of IH-45 Proposal

The investigations performed to evaluate the feasibility of rerouting the Trinity River at the IH-45 bridge indicate that such a proposal is warranted. As indicated on page A-25, Appendix A, the proposed realigned channel has been designed to closely approximate the channel flow capacity and flow velocities of the existing channel. The new channel length would also be almost identical to the existing length. Reestablishment of streambank riparian vegetation would also be accomplished. With these factors considered, the proposal would have no hydraulic effect on the project, either upstream or downstream, and no inundation reduction benefits have been included for this proposal. Due to the independent nature of this work effort, from a flood damage reduction standpoint, this proposal can be implemented in conjunction with any of the plans included in the final array of alternatives. Therefore, the costs and benefits of this proposal are not included in the economic comparisons of these alternatives, but will be added to the final Recommended Plan.

FINAL ARRAY OF ALTERNATIVES

In accordance with Section 102 (2) of the National Environmental Policy Act (NEPA) of 1969, as amended, a final alternative incorporating non-structural measures was evaluated and included in the final array of alternatives, which includes the following:

- No Action Plan
- NED Plan
- Combination Non-Structural / Structural Plan
- Tentative Federally Supportable Plan
- Locally Preferred Plan

In addition, for comparison purposes, the 1965 Authorized Plan was analyzed to ascertain the economic viability of this plan under current conditions. All plans in the final array are compared against the No Action Plan.

Combination Non-Structural / Structural Plan

The combination non-structural / structural plan investigated for the final array of alternatives would involve the acquisition and removal of homes in the Cadillac Heights area (Reach 5), in lieu of the construction of a Cadillac Heights Levee, as the last-added increment of an overall plan also including the construction of the chain of wetlands and the SPF Lamar Levee. This buyout was analyzed for the 2-, 5-, 10-, 25-, 50-, and 100-year flood zones. The economic analysis of this non-structural increment of the overall combination structural / non-structural plan is shown in table 4-21. For comparative analysis, also included in this table are the incremental costs and benefits of constructing a last-added 100-year levee in the Cadillac Heights area.

The table reveals that the greatest incremental net benefits of a non-structural plan in the Cadillac Heights area would occur for a buyout of the 10-year flood zone. This alternative would have an estimated first cost of $2.5 million, would produce incremental benefits of $179,700, and would include the acquisition of seven structures. Comparatively, the 100-year Cadillac Heights Levee would have an estimated first cost of $2.7 million, would produce incremental net benefits of $96,600, and would protect 158 structures. From the perspective of desiring to remove people and property from the risk of flood damage, the levee alternative would be much more cost effective.

Table 4-21
Economic Analysis of Non-Structural Increment in Final Array of Alternatives
(January 1997 prices, 7.375% interest, 50-year period of analysis)

Flood Zone	Chain of Wetlands Plus Lamar Levee Plus Buyout of Cadillac Heights Area (Buyout Increment Only)	Chain of Wetlands Plus Lamar Levee Plus 100-Yr. Cadillac Heights Levee (Levee Increment Only)
0 - 2 Year Zone		
No. of Structures	0	0
0 - 5 Year Zone		
No. of Structures	3	0
Total Costs	$1,176,000	$0
Annual Costs	$79,100	$0
Annual Benefits	$194,100	$0
Net Benefits	$115,000	$0
BCR	2.5	N/A
0 - 10 Year Zone		
No. of Structures	7	0
Total Costs	$2,463,100	$0
Annual Costs	$165,300	$0
Annual Benefits	$345,000	$0
Net Benefits	$179,700	$0
BCR	2.1	N/A
0 - 25 Year Zone		
No. of Structures	24	0
Total Costs	$5,052,700	$0
Annual Costs	$334,900	$0
Annual Benefits	$365,900	$0
Net Benefits	$31,000	$0
BCR	1.1	N/A
0 - 50 Year Zone		
No. of Structures	126	0
Total Costs	$12,851,600	$0
Annual Costs	$823,600	$0
Annual Benefits	$401,100	$0
Net Benefits	($422,500)	$0
BCR	0.5	N/A
0 - 100 Year Zone		
No. of Structures	160	158
Total Costs	$19,388,000	$2,704,500
Annual Costs	$1,311,200	$456,200
Annual Benefits	$404,900	$522,800
Net Benefits	($906,300)	$96,600
BCR	0.3	1.3

ENVIRONMENTAL IMPACTS OF ALTERNATIVES

Overview

Table 4-22 shows the current status of studies in relation to requirements for environmental policy compliance. The report is in compliance for most of these requirements for this phase of the study process.

The most positive impacts that would result from the decision to develop a flood damage reduction project with restoration of emergent/deepwater wetlands would be that the flooding that threatens lives, damages residential and business properties and causes general disruptions to traffic and economic vitality of the area would not continue to occur. The economic benefits of the project would extend well beyond the area of proposed construction to include the downtown Central Business District (CBD). The environmental restoration aspect of the chain of wetlands would develop emergent wetlands that would be managed to provide important feeding and winter cover for migratory waterfowl, shorebirds and wading birds, in addition to supporting neotropical songbirds. Negative impacts resulting from development of either the combination non-structural / structural plan, the TFSP or the LPP include the loss of bottomland hardwood forest values, including fish and wildlife habitat and potential loss of archeological resources.

Four environmental and cultural resource items were identified by state, local and federal agencies and the public during the EIS scoping process as important in the overall decision-meking process. These resources include emergent wetlands, aquatic resources, forested areas and cultural/historic resources. The comparative impacts of the investigated alternatives to these key resources are discussed below and shown comparatively in table 4-23. During review of the Draft EIS, a number of other concerns were identified which required additional analysis and discussion. Among those concerns were land use impacts, visual and aesthetic impacts, and impacts on utilities. Discussion of the proposed project impacts on these and other resources is contained in the following sections.

Emergent Wetlands

Emergent wetlands in the study area are currently lacking. Some areas of permanent and semi-permanent water exist, primarily resulting from past excavations. However, these areas do not provide appropriate conditions for development of emergent wetland vegetation. An area adjacent to IH-45, between IH-45 and Highway 310 on the south side of the river, has been excavated to provide mitigation for impacts associated with a previous Section 404 permitted activity associated with the Central Wastewater Treatment Plant. Emergent and wetland vegetation occasionally dominate approximately 11.25 acres of this excavation. This area would not be impacted by any of the proposed project alternatives. The only alternative feature considered that could be constructed as a single component that provides an impact to emergent wetlands is the chain of wetlands. The combination non-structural / structural plan, the TFSP, or the LPP alternative, with the environmental restoration features included, would provide an additional 123 acres of emergent wetland that would be managed by providing a dependable water source and appropriate water elevation control structures. None of the alternatives (the NED Plan, the TFSP, the LPP, or the combination non-structural / structural plan) would result in a negative impact to emergent wetlands.

Aquatic Resources

It is envisioned that only minor changes in the aquatic resources would occur without the project, as sedimentation fills excavated ponding areas during the 50-year period of analysis. The NED Plan would cause the largest negative impact to aquatic resources by removing 16 acres of aquatic area. The chain of wetlands would provide a positive impact by adding eight acres of permanent water area as a part of the environmental restoration plan. The Lamar Levee would impact five acres of ponded water and the Cadillac Levee would impact an additional one acre. The proposed realignment of the Trinity under the IH-45 bridge would result in the loss of approximately eight acres of existing river channel. As part of the combination non-structural / structural plan, the TFSP, or the LPP, this area would be restored within the diversion channel, resulting in no net loss of channel area. The impact from construction activities to the aquatic environment of the channel would be temporary. Additional information related to the temporary nature of these impacts is addressed in the Section 404(b)(1) guidelines analysis in Appendix F, and in the following sections.

Table 4-22
Extent of Plan Compliance with Environmental Requirements

Federal Policies	NED Plan	TFSP / LPP (By Increment)			Non-Structural / Structural Plan	IH-45 Diversion
		Chain of Wetlands	Lamar Levee	Cadillac Levee		
Fish and Wildlife Coordination Act	All plans in full compliance					
Endangered Species Act	All plans in full compliance					
National Historic Preservation Act of 1966	All plans in full compliance					
Archaeological and Historic Preservation Act	All plans in full compliance					
Wild and Scenic Rivers Act	Not applicable					
National Environmental Policy Act	Full compliance					
Clean Water Act	All plans in full compliance					
Clean Air Act	All plans in full compliance					
Coastal Zone Management Act	Not applicable					
Coastal Barrier Resources Act	Not applicable					
Floodplain Management (E.O. 11988)	All plans in full compliance					
Protection of Wetlands (E.O. 11990)	All plans in full compliance					
Farmland Protection Policy Act/EPA Policy to protect environmentally significant agricultural lands	No prime or environmentally significant agricultural lands in study area					
Wilderness Act	Not applicable					
Sections 9 and 10 of Rivers and Harbors Act	All plans in full compliance. Only temporary navigation obstructions would occur.					
Land and Water Conservation Fund Act	All plans in full compliance.					
Native American Graves Protection and Repatriation Act	All plans in full compliance.					
Environmental Justice, E.O. 12898	All plans in full compliance.					

Table 4-23
Comparative Impacts of Alternatives
Future condition with feature in place exclusive of mitigation
(Indicates net gain or losses)

	Emergent Wetlands (Acres)	Aquatic Resources (Acres)	Forested Area (Acres)	Cultural/Historic Sites
Existing Conditions	11.25	233	5,956	41 known archaeological and 748 architectural sites
MEASURES				
Chain of Wetlands	(+123)134.25	(+8) 241	(-90*) 5,866	unknown
IH-45 Diversion Channel	(0) 11.25	(+1) 234	(-9*) 5,947	No known added sites or structures; survey required
Lamar Levee Increment	(0)11.25	(-5) 228	(-53*) 5,903	unknown
100-Yr. Cadillac Heights Levee/ Floodwall Increment	(0) 11.25	(0) 233	(-2.4*) 5,954	unknown
SPF Cadillac Heights Levee Increment	(0) 11.25	(-1) 232	(-9.4*) 5,947	unknown
ALTERNATIVES				
No-Action Plan (Future Without)	11.25	minor change	minor change	unknown
NED Plan	(0) 11.25	(-16) 217	(-504**)5,452	not evaluated
Combination Non-Structural / Structural	(+123)134.25	(+3) 236	(-143*) 5,813	unknown
TFSP	(+123)134.25	(+3) 236	(-155*) 5,801	27 archaeological and 699 architectural sites
LPP	(+123)134.25	(+2) 235	(-162*) 5,794	27 archaeological and 699 architectural sites

** Approximately 50% of bottomland hardwood forests in area are forested wetlands*
*** Approximately 90% of bottomland hardwood forest in NED footprint are forested wetlands*

Forested Areas

The most significant resource issue raised by the public was the concern about loss of bottomland hardwood forest within the project area. The forest has developed during the past three to four decades around a remnant stringer of mature trees along the river bank and on isolated high grounds that had minimal disturbance in the past. The forested area has filled in most of the old field areas that have been abandoned, so it is believed that little additional forest would accrue in the future without-project condition. No decreases in forested area are expected to occur without the project.

The NED Plan would cause the most significant impacts, resulting in a direct loss of 504 acres through clearing and grading, and cumulative impacts through fragmentation of habitat to an additional 99 acres of bottomland hardwood. Because of the adverse impacts of the NED, additional planning was conducted to design a project which would be economically favorable and produce less negative

impacts. The chain of wetlands would negatively impact bottomland hardwoods by removal of approximately 90 acres of forest by clearing, of which approximately 50%, or 45 acres, are forested wetlands. The Lamar Levee would provide an additional impact of 53 acres by removal of trees within the footprint and temporary work area along the levee and within the proposed sumps. Construction of the Cadillac Heights Levee would impact through removal of approximately nine acres of bottomland hardwood forest. The levees, by design, would reduce overbank flow to some small areas of forest; however, the bottomland forests that would be protected from overbank flow are along relatively high elevations and would not be adversely impacted by the reduction in flows from overbank conditions. In addition, tributary flows would not be impacted and the riparian stringers within the protected zone of the levees would not be adversely impacted. The combination of these three measures as part of the LPP would negatively impact 153 acres of bottomland hardwoods, of which approximately 81 acres are forested wetlands. The proposal to realign the river under the IH-45 bridge would result in nine acres of impact to bottomland hardwoods. Furthermore, the realignment would necessitate encroachment into the riparian buffer containing mature forest along the river bank. This total impact of 162 acres would be significantly less than that caused by the NED Plan; however, this loss was considered significant and required development of a compensatory environmental mitigation plan.

The combination non-structural / structural plan would impact approximately nine fewer acres of forest than the LPP. In addition to evaluation of the loss of forested area per se, evaluation of the effect of those losses on local climate, air quality and other resource issues are discussed in the following sections.

Water Quality

With no action, water quality in the Trinity River, within the segment of the Dallas Floodway Extension (DFE), would continue to improve. In addition to more stringent Federal and state regulations aimed at reducing water pollution, comprehensive watershed management programs in the upper watershed of the Trinity River are being initiated by local governments and municipalities. An objective of the these programs is to restore the river and floodplain back to its natural condition. A functional benefit and output of this program has been an overall improvement in all aspects of water quality throughout the entire Trinity River system, including the DFE segment. This trend is expected to continue without the project.

Any and all of the project alternatives considered which would include Corps of Engineers participation would require preparation of a comprehensive floodplain management plan by the project sponsor. This management plan is a requirement of Section 202 of the Water Resources Development Act of 1996, which requires that project sponsors develop plans within one year of entering into a Project Cost Sharing Agreement with the Corps of Engineers. The comprehensive floodplain management plan, at a minimum, must conform to the requirements of the Federal Emergency Management Agency's requirements for participation in the National Flood Insurance Program. But more than that, the plan must consider watershed management strategies which will not worsen flood runoff conditions in the future. This requirement has implications for both future flood elevations and runoff water quality with implementation of a Federal project. These plans must be reviewed and approved by the Corps prior to completion of construction and must be implemented within one year of completion of construction.

The water quality of the Trinity River would not be altered as a result of implementing the combination non-structural / structural alternative. Future development adjacent to the project or utilization of the areas included in the non-structural measures would be consistent with a comprehensive floodplain management plan, and could positively influence water quality in the DFE segment of the Trinity River. Sump areas, project lands, and the emergent wetlands of the chain-of-wetlands would all have a positive effect on retention times and nutrient and pollutant uptake prior to local runoff entering the Trinity River. During high flow events, these project features should have a slight positive effect on water quality.

Water quality impacts resulting from the NED alternative, development of a 1,200-foot bottom width overland swale, would occur from the removal of trees and soil disturbances. A reduction in the number of trees within the floodplain would temporarily increase water turbidity and nutrient loads from rain events during construction. This impact would be temporary and would cease after turfing. Water temperature of temporarily stored waters in the off-channel swales could increase slightly because of reduced canopy shading, and the possible decrease in dissolved oxygen levels could temporarily impact water quality in the river during the first minutes of a flushing event. Over the long term, adverse impacts associated with loss of woody vegetation should be offset by the establishment of grasslands and some emergent wetlands within the swale, and by implementation of a floodplain management plan by the City of Dallas.

Placement of levees in the DFE area with the TFSP or the LPP could increase the velocity of river water during flood events; however, the levees would not be constructed without a compensating swale with chain-of-wetlands, which would tend to balance velocities. The levees would only function during extreme flooding events, in which case the velocity increases would be negligible. Sump areas would extend water retention times of storm water runoff, allowing for turbidity reduction and possible contaminant removal prior to entering the Trinity River. During non-flood and no rainfall periods, the levees and sumps would not affect water quality in the Trinity River. Temporary impacts to turbidity from runoff during construction could occur. The chain of wetlands would provide both beneficial and adverse impacts to the water quality of the Trinity River. As proposed, the wetlands would beneficially impact the water quality of the river by assimilating nitrogen, phosphorus, and any heavy metals from the Central Wastewater Treatment Plant stream which would be used to hydrate the wetlands. The wetlands would also provide beneficial filtration and cleanup of wastewater prior to groundwater recharge. The net effect would be similar to tertiary cleaning of some of the Central Wastewater Treatment Plant's treated effluent prior to it being reintroduced into the Trinity River. During rare conditions of low sunlight, high water temperature, no wind, and low wetland exchange rate, dissolved oxygen concentrations in the chain of wetlands could be low and the Biochemical Oxygen Demand (BOD) of the water high from the organic matter generated. During the early stages of flushing events under these conditions, water flowing from the wetlands into the Trinity River might cause temporary adverse impacts to the water quality of the river at the point of entry and downstream from oxidation of wetland organic matter. Should adverse conditions develop as described, pumpage of water through the wetlands could be altered as necessary to improve water quality within the wetland effluent. It is anticipated that over time, management of the wetlands can be fine tuned to the point that adverse impacts from the wetlands can be eliminated. It is also anticipated that the wetland water quality, vegetational assemblages and use by local and migratory wildlife would benefit from use of the wastewater effluent. Currently, the entire effluent passes through an existing lake prior to discharging into the Trinity River. The lake supports largemouth bass and channel catfish according to locals who have been observed fishing when access is available. It is not anticipated that water quality would adversely impact the proposed wetlands. During construction of the wetland outflow points on the river channel, there would be temporary increases in the turbidity of Trinity River.

During construction and initial stabilization of the Trinity River realignment at the IH-45 bridge, a short-term increase in river turbidity would occur in and immediately downstream of the project. A temporary increase in Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD) could also occur depending upon the molecular composition of the disturbed river sediment. The reduction in light transmittal from elevated turbidity would temporarily shade oxygen-producing phytoplankton and cause lower dissolved oxygen levels.

Aquatic Habitat, Aquatic Invertebrates, and Fisheries

Under without-project conditions, the development of comprehensive watershed management plans in the upper watershed would allow the aquatic habitat of the mainstem of the Trinity River, within the project area, to continue to improve corresponding to the improvement in the water quality. The diversity and number of aquatic invertebrate and fish species would continue to increase in the DFE segment of the river as the pollution-sensitive aquatic organisms return to occupy former niches.

The condition of the aquatic habitat and fisheries resources following implementation of the combination non-structural / structural alternative would not be significantly changed in the DFE segment of the Trinity River from conditions without the project. Beneficial or negative impacts to the aquatic habitat, aquatic invertebrates and fishes would be dependent on future land use changes and development of areas adjacent to the proposed project. The project could be expected to intensify adjacent development, resulting in some increased imperviousness. It is anticipated, however, that such land use changes induced by the economic stimulus of the project would result in less litter, oil and grease, and general debris, and no significant degradation of runoff water quality. Furthermore, sumps provided inland of the levee would increase retention time for storm water runoff and project lands, and the created emergent wetlands would serve to further reduce loadings to the river, thereby resulting in slight positive impacts to aquatic habitat and fisheries resources.

Impacts resulting from the development of a 1,200-foot bottom width overland swale would occur from the changes in water quality associated with tree removal and soil disturbances. Decreases in aquatic habitat quality would occur under environmental conditions incurred from the implementation of the NED alternative. There could be some loss in fisheries spawning areas that could result in overall reduction of fish production as the smooth nature of the swale area, when flooded, would not provide the spawning habitat associated with tree stumps, roots, and other structure in the forested area. However, the swale would not alleviate flooding conditions on other forested areas of the floodplain and, therefore, it is not anticipated that there would be a significant corresponding reduction in the species diversity of aquatic invertebrates and fish.

Placement of levees in the DFE area, as part of the TFSP or LPP, would provide no appreciable positive or negative impacts to aquatic habitat or fisheries resources. Sump areas would improve the water quality characteristics of storm water runoff entering the Trinity River and subsequently enhance the aquatic habitat for aquatic invertebrates and fish. The chain of wetlands would provide both beneficial and negative impacts to the aquatic habitat and fisheries resources of the Trinity River. Effluent from the Central Wastewater Treatment Plant currently enter the Trinity River near the IH-45 bridge after flow through a small lake. Diversion of some of the water through the proposed chain of wetlands would result in some loss of water due to infiltration and transpiration and evaporation. The improvement in water quality provided by the chain of wetlands would enhance the aquatic habitat and beneficially impact fish and aquatic invertebrate communities. The resultant overall improvement of water quality that ultimately would reach the river would offset any losses in quantity. The chain of wetlands would provide new habitat for fish and aquatic invertebrate species which prefer water velocities lower than the flow rates which occur in the mainstem of the river. Riprap armoring at wetland discharge points on the river would provide substrate for colonization by communities of aquatic invertebrates, and food, refuge, and spawning areas for fish. Rock placement to protect the stream bank at the outfalls would produce a structural bottom feature which would benefit fish by providing a congregational point for bait fish and higher predatory fish species. Aquatic habitat in the wetlands and the river would be adversely impacted if environmental conditions (low sunlight, high water temperatures, no wind, and low wetland exchange rates) which generate poor water quality prevail. Management of the wetlands would occur to minimize any impacts to the mainstem of the river. Construction of the wetland outflow points on the river channel would cause temporary negative impacts to aquatic species not tolerant of elevated turbidity levels.

As previously discussed in terms of water quality, inducement of more intensive use or redevelopment of lands adjacent to the proposed project as a result of the economic stimulus of the project would not be expected to have any negative effect on aquatic organisms. These development activities within the watershed would have no direct effect on the physical component of aquatic habitats. Likewise, the increased utilization of the project area and project lands for recreation pursuits would not be anticipated to result in any net negative impacts to aquatic organisms and fisheries habitats. In fact, use of project lands for recreation should result in less loading of trash and debris as a result of controls on illegal dumping. Any adverse impacts resulting from adjacent land use redevelopment and projected recreation use planned for the project should be more than offset by the

positive effects of project features, increased operation and maintenance of the resource base, and by the comprehensive floodplain management plan developed and implemented by the City of Dallas.

Realigning the Trinity River at the IH-45 bridge would result in a short-term increase in river turbidity and decrease in dissolved oxygen concentrations, which would adversely impact the aquatic habitat. This would temporarily impact aquatic invertebrate and fish species not tolerant of elevated turbidity levels or reduced dissolved oxygen concentrations. Recolonization of the new channel and the impacted area downstream should begin immediately after completion of construction, and diversity should be restored within a one- to two-year time period. Moving the river channel to avoid bridge pilings would adversely impact the aquatic habitat by removing a feature which would provide structure for colonization by aquatic invertebrate communities, and a feeding area and congregational focal point for fish. The removal of the small area of habitat associated with the pilings would not be significant.

Micro-Climate Effects

One of the concerns raised by citizens and environmental groups was the impact that removing trees would have on micro-climate conditions of adjacent areas. McPherson, Nowak, and Rowntree (1994) (See Appendix F), in a report for the U.S. Forest Service document that, by transpiring water, blocking winds, shading surfaces, and modifying storage and exchanges of heat among urban surfaces, trees affect local climate and human thermal comfort. These benefits are also documented in Mapping Micro-Urban Heat Islands Using Satellite Imagery (Lowry and Aniello 1993) (See Appendix F) for Dallas County, but it must be understood that the micro-climate effects of trees to conserve energy and lower temperature are very localized in nature. Without directly being covered by the shade provided by trees, or close enough to take advantage of the benefits provided by trees as natural windbreaks, micro-climate effects are negligible. Therefore, the removal of trees in conjunction with any of the potential alternatives for the proposed DFE flood control project is expected to have little or no impact on micro-climate effects of those trees to surrounding residential, industrial and business neighborhoods. It is also important to remember that none of the potential alternatives call for the addition of any impervious surfaces which might be expected to add radiant heat and thereby increase local temperatures. The replacement of trees by herbaceous vegetation would not have this effect.

Implementation of the TFSP or the LPP is expected to create an economic stimulus within the project area. This economic stimulus, combined with the flood damage reduction afforded by the project will no doubt result in redevelopment and land use intensification on lands adjacent to project features. Some of the types of redevelopment which are being considered might include a police station, reuse of industrial areas for condominium apartments, along with along with residential and commercial services redevelopment, and possibly some light industry. There is also the possibility that commercial services in support of new recreation opportunities could be part of the projected redevelopment. Given the past uses of lands on both the Lamar Street and Cadillac Heights sides of the project, it could be anticipated that most redevelopment projects will incorporate existing vegetation into their landscapes to the extent feasible. Further, it is highly probable that any industrial redevelopment that may be induced will be "cleaner" in terms of physical presence as well as products and waste by-products produced. The net effect of these changes on micro-climate should be negligible from the without project condition.

The economic development of adjacent neighborhoods would be further spurred on by the portion of TxDOT's proposed Trinity Parkway which would extend from Hwy 175 along the proposed Lamar Street Levee alignment. This proposed project could have an effect, on it's own, to the micro-climate of the project area. Those effects will have to be considered and ameliorated to the extent that they can by TxDOT as they move forward with their own compliance under the National Environmental Policy Act. The cumulative effect of this proposed highway project on the micro-climate would likely be some measurable increase in ambient temperatures immediately adjacent to the highway due to increased reflective surface, and some reduction in shading due to some slight loss of tree or other

vegetative cover. It is important to note, however, that neither the TFSP nor the LPP is dependent upon TxDOT's proposed roadway, that the effects of the TFSP or LPP on their own are not significant, and that TxDOT will be required to address the impacts of it's actions, and to mitigate any adverse effects to the extent practicable.

Air Quality

The "Future Without-Project (No Action) Alternative" would cause no significant adverse impacts to air quality within the proposed project area. Regional trends in air quality indicate that regulated pollutant levels are slightly increasing. Flooding episodes and floodplain regulations imposed by the city of Dallas within the project area would restrict further urban and commercial development. In the absence of urban and commercial growth, mobile and stationary pollution emitting sources would decrease as would their associated pollutants. Construction of the portion of the Trinity Parkway along the proposed Lamar Levee alignment, as proposed by TxDOT, could result in increases in pollutant levels, regardless of whether or not the proposed levee was built.

The development of some additional tree canopy in the area, without the project, would provide beneficial impacts through biogenic removal of regulated gaseous air pollutants. UFORE estimates of pollution removal capabilities with this alternative indicate trees in the entire DFE area would have the capacity to assimilate 13.85 tons/year of carbon monoxide, 12.23 tons/year of sulfur dioxide, 34.30 tons/year of nitrogen dioxide, 80.37 tons/year of PM10, and 151.23 tons/year of ozone, or approximately 10.1% of the total capacity of trees in the Dallas, Texas, area. The additional tree canopy that would develop would provide a slight improvement of approximately 4.1% in air pollutant removal capability above the existing conditions (Table 1, Appendix F).

Implementation of the NED alternative would cause minor adverse impacts to the quality of air within the proposed project area. Utilization of diesel-fueled heavy equipment would result in minimal amounts of exhaust fumes, smoke, and dust during construction activities. There would be no stationary emitting sources and no on site storage of petroleum or petroleum based by-products to cause additional negative impacts to air quality. Disposal of cleared vegetation or other debris by burning during construction would be accomplished only as permitted by the TNRCC. Required maintenance activities required for the NED alternative would contribute little additional mobile air emissions. The reduction in tree canopy area from clearing activities for swale development would result in negative impacts through removal of biogenic sources which extract regulated gaseous air pollutants. UFORE estimates of pollution removal capabilities by trees in the entire DFE project area with this alternative implemented indicate there would be a vegetation assimilation capacity of 12.07 tons/year of carbon monoxide, 10.66 tons/year of sulfur dioxide, 29.89 tons/year of nitrogen dioxide, 70.03 tons/year of PM10, and 131.78 tons/year of ozone, or approximately 8.8% of the total capacity of trees in the Dallas, Texas, area. The reduction in tree canopy would decrease the air pollutant removal capability below the existing conditions by 9.2% (Table 1, Appendix F). The NED Plan would call for revegetation of the cleared swale area. The planted vegetation would provide a small amount of air pollutant assimilative capacity and to a limited extent, ameliorate the air quality impacts caused from tree removal.

The implementation of the TFSP alternative would cause minor adverse impacts to the quality of air within the proposed project area. Utilization of diesel-fueled heavy equipment, would result in minimal amounts of exhaust fumes, smoke, and dust during construction activities. There would be no stationary emitting sources and no on-site storage of petroleum or petroleum based by-products to cause negative impacts to air quality. Disposal of cleared vegetation or other debris by burning during construction would be accomplished only as permitted by the Texas Natural Resources Conservation Commission (TNRCC). Maintenance activities required for the TFSP alternative would contribute few additional mobile air emissions. The reduction in tree canopy area from clearing activities for wetlands and levee development would result in negative impacts through removal of biogenic sources which extract regulated gaseous air pollutants. UFORE estimates of pollution removal capabilities of trees in the detailed project area under future conditions as listed in table 1,

Appendix F, indicated there would be an vegetation assimilation capacity of 2.02 tons/year of carbon monoxide, 1.78 tons/year of sulfur dioxide, 4.99 tons/year of nitrogen dioxide, 11.70 tons/year of PM10, and 22.02 tons/year of ozone, or approximately 1.5% of the total capacity of trees in the Dallas, Texas, area. Impacts of tree removal to assimilative capacities as a result of implementing elements of the TFSP are delineated in table 4-24.

As can be seen from Table 4-24, impacts to all parameters are minimal. In addition, acquisition and preservation of the proposed fish and wildlife mitigation area would greatly exceed the losses from implementation of the project features. The proposal to implement mitigation features of hastening the conversion of existing grasslands within the mitigation areas to bottomland hardwood forest by intensive tree plantings would result in more gains in air quality purification than would be lost by the project features, individually or cumulatively. The TFSP plan would call for re-vegetation of the cleared swale and levee areas. The new vegetation would provide a small amount of air pollutant assimilative capacity and, to a limited extent, ameliorate the air quality impacts caused from tree removal.

Air quality impacts associated with implementing the combination non-structural / structural alternative would be very similar to those impacts previously described for the TFSP. The only differences in air quality impacts between the TFSP and the non-structural alternative would result from the reduction in construction activity associated with the Cadillac Heights Levee. Not building this levee as part of the project would reduce the use of heavy equipment for earth moving activities which may cause minor adverse impacts to the air quality through emission of exhaust fumes, dust, and smoke. This alternative would also allow the tree canopy to remain and develop in the areas where the levee construction would have impacted. The remaining tree canopy would provide air quality benefits through air pollutant removal. The tree canopy in the areas delineated for mitigation would provide beneficial impacts through removal of regulated gaseous air pollutants. The addition of the tree canopy in the mitigation areas to that of the canopy area in the TFSP would increase the total pollutant removal capability over each area individually.

The impacts of the LPP alternative would be similar to those of the TFSP, as described above. The difference between the two alternatives would be the size of the Cadillac Heights Levee. Neither of the Cadillac Heights Levee alternatives would impact large areas of existing forest and, therefore, their impacts to air quality would be minimal.

Land use changes adjacent to the project area, which would likely be an indirect result of the project, would have some effect, though likely unmeasurable, on air quality of the study area. Given that lands outside the immediate project area are already mostly urbanized, consisting of residential, commercial strip development, and some industrial, it is projected that most changes will be in the form of redevelopment and reuse of already developed lands. These land use changes would likely be an intensification of current uses adjacent to the proposed project. Acreage changes from one land use to another should not be significant as a result of project implementation. Reduction of recurring flood damages, combined with an economy stimulated by construction dollars, is projected to increase real estate sales, renovations, and reuse. Effect of this redevelopment on vegetation and natural processes controlling air quality parameters is expected to be minimal.

Bottomland Hardwood Forests

One of the main concerns of citizens and environmental groups has been the impacts of the various potential alternatives on the bottomland hardwood forests located within the proposed DFE project area. Table 4-25 shows the impacts for the construction alternatives in terms of tree quality and numbers. Pecan-Oak bottomland hardwoods (BLH) would be considered high quality, while Elm-Ash BLH would be considered medium quality. These designations were taken from data derived from vegetation cover and land use maps. The average number of trees per acre was estimated from data collected on-site. These figures were then used to estimate the number of trees impacted by the various alternatives.

Table 4-24
Annual Removal Rates of Regulated Air Pollutants By Trees
(Tons / Year)

Site	Carbon Monoxide	Sulfur Dioxide	Nitrogen Dioxide	Particulate Matter (10um)	Ozone
Chain of Wetlands, Upper Swale	-0.15	-0.14	-0.38	-0.89	-1.67
Chain of Wetlands, Lower Swale	-0.09	-0.08	-0.21	-0.49	-0.93
Cadillac Heights Levee (TFSP)	-0.01	-0.01	-0.01	-0.03	-0.06
Cadillac Heights Levee (LPP)	-0.02	-0.02	-0.06	-0.13	-0.25
Lamar Street Levee	-0.13	-0.11	-0.32	-0.76	-1.42
IH-45 Channel Realignment	-0.02	-0.02	-0.05	-0.13	-0.24
Total Impact for TFSP	-0.40	-0.36	-0.97	-2.30	-4.32
Total Impact for LPP	-0.41	-0.37	-1.02	-2.40	-4.51
Total Impact for Combination Non- Structural / Structural Alternative	-0.37	-0.33	-0.91	-2.14	-4.02
Preservation Value of Proposed Mitigation Area	+2.24	+1.99	+5.58	+13.09	+24.60
Conversion of Grasslands to Forest in Mitigation Area (TFSP)	+0.55	+0.48	+1.36	+3.18	+5.98
Conversion of Grasslands to Forest in Mitigation Area (LPP)	+0.57	+0.50	+1.41	+3.30	+6.21

Table 4-25
Bottomland Hardwood For st Impact Analysis

	NED Plan	Chain of Wetlands	Lamar Levee	SPF Cadillac	100-Yr Cadillac	Combination Plan	IH-45	TFSP	LPP
Total Acres of Trees	503.9	89.9	53.3	9.4	2.4	143.2	9.0	154.6	161.6
Total Acres - Pecan-Oak BLH	146.6	5.9	10.6	0.0	0.0	16.5	4.1	20.6	20.6
Total Acres - Ash-Elm BLH	357.3	84.0	42.7	9.4	2.4	126.7	4.9	134.0	141.0
Avg. Number of Trees per Acre - Pecan-Oak BLH	196	196	196	196	196	196	196	196	196
Avg. Number of Trees per Acre - Ash-Elm BLH	218	218	218	218	218	218	218	218	218
Total Number of Trees Impacted - Pecan-Oak BLH (000's)	28.7	1.1	2.0	0.0	0.0	3.2	0.8	4.0	4.0
Total Number of Trees Impacted - Ash-Elm BLH (000's)	77.9	18.3	9.3	2.0	0.5	27.6	1.1	29.2	30.7
Total Number of Trees Impacted (000's)	106.6	19.4	11.3	2.0	0.5	30.8	1.9	33.2	34.7

Long-term survivability of the bottomland hardwood forest within the proposed project area, without a project, would depend on the City of Dallas' Floodplain Management Plan and any future development, natural disturbances (e.g., prolonged flood events, tornados) and encroachment by human activities. Current regulations and public concern indicate, however, that the bottomland hardwood forest will increase in size and quality over time without the project.

Approximately nine fewer acres of trees would be impacted by the federal project if the combination non-structural / structural alternative were implemented instead of the LPP. Unless this area is protected through other regulatory means, however, they could be impacted by any future development.

The NED alternative would have major adverse impacts on the bottomland hardwood forest ecosystem now found in the proposed project area. One hundred forty seven acres of Pecan-Oak BLH and 357 acres of Ash-Elm BLH would be lost and the quality of the surrounding bottomland hardwood habitat would be greatly compromised. Fragmentation of forested habitat often eliminates its suitability for certain species which need a more continuous range in order to survive. It also opens up more fringe area to be inhabited by species who would not normally be found in a bottomland hardwood system, which could also lead to losses in bottomland hardwood dwelling species who are then not able to adequately compete against the new invader species.

The TFSP alternative would impact a portion of the bottomland hardwood forest found within the study area, but the impacts would be located in that portion of the proposed project area that has already seen significant impact by human activities such as gravel, dirt, and topsoil mining, landfills, and years of illegal dumping activities. Another consideration is that the bottomland habitat impacted by the TFSP would, for the most part and by design, be located in an area which is of lesser habitat quality than the NED Plan. Implementing the TFSP rather than the NED Plan would save over 73 percent of the bottomland hardwood acres that have been identified as being within the NED project area. Perhaps more importantly, over 90 percent of the bottomland hardwood forest acres determined to be Pecan Oak (high quality) habitat within the study area would be protected through public ownership. Roughly 50 percent of the forested land that would be impacted by the TFSP would be considered forested wetlands by U.S. Army Corps of Engineers determinations. The impact of the LPP would be very similar to that of the TFSP, as described above, but would impact seven acres more bottomland hardwoods than the TFSP.

Fish and Wildlife Habitat

The plan formulation process carefully followed a step-wise progression leading to minimization of impacts to bottomland hardwoods and other significant resources. Planning leading to the determination of the NED Plan eliminated channelization plans for flood damage reduction from further consideration due to adverse environmental effects. A vegetative management plan was considered, but eliminated, because it would have seriously diminished stream aquatic, riparian and bottomland hardwood habitats that have high national priority for protection. An array of swale alternatives, including the NED Plan, although causing significant losses to bottomland hardwoods, was developed. These swales were aligned to avoid the highest quality forested habitats to the extent possible. The swale plans did not receive endorsement by the entire environmental community, but appropriate mitigation plans were found to be feasible for the proposals.

The Chain of Wetlands alternative alignment was developed from a smaller swale plan around desires expressed by the sponsor following extensive public involvement. A major planning objective by the Corps and sponsor included the commitment to continued avoidance of Pecan-Oak forested areas and minimization of impact to any bottomland hardwood forested areas. The alignment within the upper reach was moved to the west as far as technically and economically justifiable. The alignments of the Cadillac Heights and Lamar Levees have also been extensively considered, and it has been determined that no other reasonable alignments would produce less impacts to important resources. Alignment of the Cadillac Heights Levee was adjusted during plan formulation to avoid direct impacts to an existing rookery located adjacent to Rector Street. Additional investigations would be done during future detailed planning to adjust the alignment if possible should the rookery expand into existing woodlands that the levee would remove.

Based upon experience, and lessons learned dealing with other levees in the area, it has been determined that the more gradual slope of the proposed levees, although causing slight additional impact due to a widened footprint, would be necessary to reduce slumping, possible failure and otherwise high operation and maintenance costs. Any additional adjustments to the proposed project features that would reduce environmental impacts to significant resources have been judged to have immediate or long term costs that are not warranted.

Table 4-26 provides a breakdown by project feature indicating the extent of impacts (losses of acres of habitat) to important resources that would occur if the project or feature were implemented.

Table 4-26
Impacts to Significant Resources
(Acres)

Resource	NED Plan	Chain of Wetlands	Lamar Levee	SPF Cadillac	100-Yr Cadillac	Combination Plan	IH-45	TFSP	LPP
Pecan-Oak Bottomland Hardwood	*175.6	5.9	10.6	0.0	0.0	16.5	4.1	20.6	20.6
Ash-Elm Bottomland Hardwood	*427.7	84.0	42.7	9.4	2.4	124.9	4.9	134.0	141.0
Mixed Grass Forblands	196.7	125.5	44.5	41.7	10.6	170.0	0.0	180.6	211.7
Open Water	24.3	37.8	4.9	1.0	0.0	42.7	7.6	50.3	51.3

**Includes area affected by habitat fragmentation caused by NED project within White Rock Creek floodplain.*

Using these assumptions, the Corps of Engineers and the U.S. Fish and Wildlife Service modeled future with- and without-project conditions to determine impact to fish and wildlife habitat. The losses in habitat are directly related to losses in wildlife species that utilize the specific habitat. The Habitat Evaluation Procedures (HEP) were used to evaluate several plans to determine impacts to wildlife resources and to satisfy mitigation requirements for bottomland hardwood forest habitats impacted by the proposed project. A basic assumption of the HEP is that species habitat requirements can be modeled and that selection of representative species for analysis can better account for impacts to the numerous species of wildlife that utilize various components of the habitat than trying to discuss the individual species requirements. According to these studies, the project features of the LPP, including the IH-45 channel realignment would result in impacts to 21 acres of pecan/oak forest (High Quality), 141 acres of ash/elm (Medium Quality) forest, and 212 acres of mixed grass forbland. Details of the HEP analysis are provided in Appendix G (USFWS Coordination Act Report). The HEP indicated that these impacts would result in losses of 14 Average Annual Habitat Units (AAHU) to pecan/oak forest and 91 AAHU to ash/elm forest over a 50-year period of analysis, when compared to the future without-project conditions. Alternative mitigation plans were developed to provide no net loss of bottomland hardwood habitat. The recommended mitigation plan would impact the area by setting aside a specific area for long term management for fish and wildlife resources. There would also be positive impacts of the mitigation plan, as evidenced not only by meeting policy of no net loss of bottomland hardwood habitat values, but also by providing long-term stability of the structural and functional values of what has been termed the Great Trinity Forest, including air pollutant removal capacity, and fish and wildlife resource values.

Forest Mitigation Plan

Three potential mitigation tracts, which remain in private ownership, were identified in coordination with the U.S. Fish and Wildlife Service (USFWS), and evaluated for their potential to offset the losses to fish and wildlife habitat that would result from implementation of the plan which would have the largest footprint, and therefore, the largest impact to important resources. This plan was identified as the LPP and the IH-45 Diversion. These tracts are located within the Trinity River floodplain near the proposed project (See figure F-3 in Appendix F). These tracts contain grasslands that have potential for conversion to bottomland hardwoods and areas of Ash-Elm BLH and Pecan-Oak BLH habitat.

Using the models for species evaluated, measures were developed to optimize habitat conditions on these tracts through conversion of existing grasslands to bottomland hardwoods and the improvement of existing forest stands. While the largest gains in habitat values over the life of the analysis would occur from grassland conversion, the cost associated with this conversion, including land acquisition, would be the most expensive per acre. Also, within the tracts identified there is a limited amount of grassland available for conversion. Table 4-27 presents the costs and average annual benefits associated with the three mitigation plans evaluated. Target mitigation values were based on habitat losses of 14 Average Annual Habitat Units (AAHU) to pecan/oak forest and 91 AAHU to ash/elm forest.

Table 4-27
Incremental Mitigation Analysis
USFWS Plan

Mitigation Plan Alternative	Average Annual Habitat Units		Average Annual Mitigation Cost	Annual Cost / AAHU
	Pecan-Oak Bottomland Hardwood (HQ)	Ash-Elm Bottomland Hardwood (MQ)		
No Mitigation	0	0	0	--
Plan A	+9	+43	$307,589	$5,915
Plan B	+9	+55	$330,347	$5,162
Plan C	+14	+92	$444,472	$4,193

Mitigation Plan A would consist of modifying existing habitat at a tract located east of the Trinity River, in a corridor adjacent to Loop 12. The management plan to develop bottomland hardwood habitat would consist of conversion of 86 acres of grassland to bottomland hardwood, preservation of 10 acres of grassland, and improvement to habitat quality on 753 acres of existing bottomland hardwood.

Plan B would consist of adding an additional 34-acre tract located on the west side of the Trinity, adjacent to the proposed lower chain of wetlands. This site was identified as potentially multi-purpose, and would serve as a surplus soil disposal and mitigation area. The management proposal would be to convert the entire tract to bottomland hardwood.

Plan C would be a combination of Plan B and addition of a 271-acre tract near IH-635, within the floodplain near the southern end of the Dallas city limits boundary. Management in this tract would include conversion of 88 acres of grassland to bottomland hardwood, improvement of habitat quality on 173 acres and preservation of an additional 10 acres of grassland. Plan C would consist of a total of 1,154 acres with prescribed management practices that would fully mitigate projected losses to bottomland hardwoods attributable to the LPP and the IH-45 river realignment. In addition to providing full mitigation of these resources, Plan C presents the best buy in terms of cost per gain in habitat value. Plans A and B would be more costly per gain and would not provide the mitigation required to offset losses.

Subsequent evaluations by the Corps of Engineers indicated a more cost effective management approach for conversion of grasslands to forest would entail planting of bare-root seedlings in lieu of containerized trees and shrubs, as recommended by the USFWS, even though

additional acreage would be required to satisfy the mitigation requirements. A detailed description of this Corps analysis is included in Appendix F.

Table 4-28 indicates the mitigation requirements by project feature, including the NED, for this revised mitigation plan, as proposed by the Corps. The analysis is another indicator of the relatively larger impacts that would be caused by the NED Plan as opposed to the TFSP or LPP.

Table 4-28
Required Mitigation by Alternative
(Acres)

Alternative	Mitigation Required
Chain of Wetlands	649
IH-45 Channel Realignment	71
Lamar Levee	400
Cadillac Heights Levee (TFSP)	15
Cadillac Heights Levee (LPP)	59
Tentative Federally Supportable Plan	1,135
Locally Preferred Plan	1,179
Combination Non-Structural / Structural	1,027
NED	3,200

Impacts to Threatened and Endangered Species

Following review of available information, including that provided by the U.S. Fish and Wildlife Service, it has been determined that the endangered black-capped vireo and interior least tern are the only federally listed species known to actively occupy suitable habitat for substantial periods of time other than as pure migratory birds. Both species are know to actively nest in Dallas County. Mountain plover is a candidate species of potential occurrence. There is no preferred habitat for the vireo or tern within the proposed project area. In addition, there is a lack of suitable habitat within the area for the mountain plover during its spring and fall migratory movements. Therefore, it has been concluded that the federally listed and candidate species are unlikely to be adversely affected by the proposed project.

Geology and Soils

Fluvial terrace deposits and alluvial deposits of the Quaternary Age occupy the floodplain area of the Trinity River within the study area. These deposits consist of gravel, sand, silt, and clay deposits. There has been no significant channel migration, bank stability problems or erosion document in the last fifty years within the project reach in spite of many man induced alterations from sand gravel operations, modifications associated with the Central Wastewater Treatment Plant or numerous other intrusions into the floodway. The construction of the project features would utilize soil derived from the project area and would be stabilized to reduce erosion during in-channel and overbank flows. During overbank flow events, much of the water would be routed through the chain

of wetlands, which would resist erosion due to the nature of the established vegetation and construction design. The realignment of the river channel through the IH-45 bridge would result in a channel segment of equivalent length, depth and width as the existing channel. The bank of the channel would be stabilized with turf grasses and replanted with woody vegetation that would work together to stabilize the new segment. The levees and sumps would also be stabilized to reduce erosion. The combined effect of chain of wetlands, levees and sumps, and realignment of Trinity River channel would result in some increases in water velocity along the right over bank during the larger, but more rare events, such as the 100-year and SPF events; however, these flows would not substantially increase erosion within the project area.

Cultural Resources

Eight of the archaeological sites identified in the project footprint are considered eligible for the National Register of Historic Places (NRHP). They appear to retain the intact deposits that return data valuable in scientific research. Although additional work will be necessary to make a determination of eligibility, they will be treated as eligible rather than eligibility unknown until the additional investigations are completed. Seven of the sites are buried prehistoric occupations exposed in banks or cut profiles. They are covered with approximately 5 - 10 feet of alluvium. These resources will require additional study through data recovery prior to construction. One of the sites is historic. Four of the prehistoric sites would be in the chain of wetlands project element and three others would be impacted by the Cadillac Heights Levee construction. The single historic site would be in the western portion of the Lamar Levee element and is identified as a City of Dallas dump in use between 1890 and 1940. In addition, brief analyses of several historic maps, such as Sam Street's Map of Dallas County dated 1900 and U.S.G.S. Soil Survey of 1920, indicate numerous additional historic sites would be impacted by the project.

Six of the historic buildings and structures identified in the project footprint as potentially eligible for the NRHP will require additional evaluation, including documentation by an archivist and a historic architect. Five of the six structures would be in the Cadillac Heights Levee and chain of wetlands elements. The sixth would be adjacent to a proposed sump near the southern end of the proposed Lamar Levee element.

The potential for additional buried prehistoric sites is high. As noted above, extrapolation from the historic maps indicate the potential for historic sites throughout the project footprint is also considered high. Consequently, a two stage program has been designed for the project footprint which addresses the differences in the proposed undertakings. In the Cadillac Heights Levee and Lamar Street Levee elements, the work would be oriented to an intensive survey of the upper 2.5 feet, since excavation would be minor. By contrast, the Lamar sump areas and the chain of wetlands would require some sampling using probes, cores and backhoe trenches to identify and expose buried sites, as well as an intensive survey for historic period components. However, since the central channel in the chain of wetlands would extend to between 8 - 10 feet below surface, construction would be monitored and impacts to any uncovered or exposed sites would be mitigated in consultation with the Texas State Historic Preservation Officer (SHPO). Finally, the depth and width of the proposed river realignment under the IH-45 bridge would preclude deep trenching as a survey strategy. Although the upper one meter of deposit would be intensively surveyed for historic period sites, the remaining deposits would be initially investigated using probes and cores. The recovered data would be used to guide the more intensive oversight monitoring and possible mitigation during construction. Consultation with the SHPO is ongoing and would continue throughout the project.

Transportation Impacts

A detailed description of traffic corridors including railroads that would be impacted by construction and during operation of the project is described in Appendix C, beginning on page C-5. Implementation of the alternatives investigated would result in short term use of local streets for access to the construction locations and for access to major routes leading to disposal sites for material

excavated from the project area or from removal of building materials associated with the non-structural plan. In addition, transportation would be impacted directly during construction of the levees and appurtenant features. The Lamar Levee would intersect with the Union Pacific Railroad owned lines in the area (MKT and and Southern Pacific). Rail traffic would be shifted between the two railroads as work was being conducted that interfered with traffic on the other. The Cadillac Heights Levee would cross the MKT line at two separate locations. Transportation impacts to IH-45 would not occur as a result of the channel realignment under the IH-45 bridge; however, allowing the threat to the major transportation corridor to continue would ultimately result in substantial impacts to use of the bridge. Also, other alternatives considered, such as strengthening the piers or refurbishing the bridge by shifting structural support locations would result in extensive periods of time when the structure would be unusable.

The Cadillac Heights Levee, as proposed in the TFSP, would not result in need for a closure across Martin Luther King (MLK) Blvd; however, the LPP would require a closure. The Lamar Levee would not require a closure at MLK for either plan. Central Expressway would not be impacted, provided the owner raises abutments as currently planned. No alteration to the IH-45 bridge is expected for any project alternative. The southern end of Sargent road would be abandoned with implementation of the LPP, requiring a permanent rerouting of traffic to other routes. The eastern terminus of the existing Rector Road, which has only occasional traffic, would be eliminated during the construction of the LPP, but would not under the TFSP, since the levee segment through this area would not be required for the TFSP. At locations where levees would cross through streets, traffic would have to rerouted during periods of flooding, since the gates would have to be closed to prevent flood damage to structures. However, these areas are already subject to closure when flooding occurs. Therefore, the impacts to traffic are negligible other than those caused by the permanent closing of Sargent Road. Traffic flow through this area is normally light and other streets should be sufficient to offset the losses.

Land Use Impacts

Each project alternative considered which would include Corps of Engineers participation would, by law, require preparation of a comprehensive floodplain management plan by the project sponsor. Section 202 of the Water Resources Development Act of 1996 requires that project sponsors develop comprehensive floodplain management plans for implementation within one year of completion of construction. The plans must not only conform to the requirements of the Federal Emergency Management Agency's requirements for participation in the National Flood Insurance Program, which had been a requirement prior to 1996, but the plans must also give consideration to watershed management strategies as they relate to future flooding and water quality.

The economic stimulus associated with development of the TFSP or LPP, combined with the reduction in frequency and intensity of flood damages, will result in economic development of lands adjacent to the project. The area of secondary or induced impact will not be limited to those lands immediately adjacent to the project but will be most visible there. Since most of this area is already in residential and light commercial and industrial development, the most obvious changes will be more in the form of redevelopment and reuse than outright land use changes. This redevelopment will likely be more gradual than abrupt, but noticeable over several years. Based upon the current state of development of these lands, the intensification of use should be minor. It cannot be determined with any degree of certainty at this time what specific, or even what general type of development may occur in any given area. Because the City of Dallas would be required to prepare a floodplain management plan addressing land uses within the watershed, it is likely that there will be opportunity for public input to any potential zoning changes.

Some of the developments which are currently being considered include a police station, reuse of industrial buildings and complexes for condominium apartments and attendant commercial services, refurbishing of residential neighborhoods within and adjacent to the Cadillac Heights, Rochester Park, and Joppa neighborhoods, along with residential and commercial services redevelopment, and

possibly some light industry. There is also the possibility that commercial services in support of new recreation opportunities could be part of the projected redevelopment.

Prior to any new development or any redevelopment of currently developed lands, liability requirements for any environmental contamination must be addressed. This would include compliance with both Environmental Protection Agency and Texas Natural Resources Conservation Service requirements, as well as consistency with such programs as the "Brownfields" initiatives administered by those agencies. Although no specific proposals have been identified, it is probable that any industrial redevelopment that may be induced will be "cleaner" than former industrial development in the study area.

Redevelopment of adjacent neighborhoods could be further induced by the portion of TxDOT's proposed Trinity Parkway, which would extend from Hwy 175 along the Lamar Street Levee alignment. This proposed project could have an effect, depending upon number and location of access ramps, on the type of development adjacent to the project. In general, it would seem intuitive that light commercial and industrial developments might be more likely to occur at the access points, as opposed to both high and low density residential development being more appropriate away from major highway access points. Those effects will be considered by TxDOT as they move forward with their own compliance under the National Environmental Policy Act. One certain cumulative effect of the proposed roadway project on land uses in the project vicinity would be an additional economic stimulus. There would be some economic effect of the TxDOT project on land use, whether or not the TFSP or LPP proposal is constructed, but the two together would have a combined effect. It should be noted again, however, that neither the TFSP nor the LPP is dependent upon TxDOT's proposed highway project. TxDOT will be required to plan for, and to mitigate, any adverse impacts of it's actions on land use to the extent practicable, regardless of the ultimate fate of the DFE project.

Increased utilization of the project area and project lands for recreation pursuits is anticipated and, in fact, is designed into the project. The Corps of Engineers would participate in certain types of low density recreation activities such as hike and bike trails and day use facilities, which would result in a slight land use change on project lands which are currently within the floodplain. These lands will remain in the floodplain as open space but would be available for compatible public uses with the project. Corps policy provides for compatible low density recreation to occur on lands acquired and managed for habitat mitigation, provided that it is consistent with the wildlife management purpose. Recreation trails through the habitat mitigation area, therefore, are considered to be consistent with that land use. Development of more intensive recreation facilities is planned by the project sponsor for certain areas within the lands required for the project. This would include such facilities as athletic fields and a community center. Direct land use changes caused by the proposed project would be compatible with floodplain functions and should have no negative effects on floodplain uses without the project.

Noise Impacts

Implementation of any of the alternatives investigated in this study is not expected to adversely impact the noise-environment over the long-term. However, analysis of the alternatives in regards to temporary noise levels during the construction phase of the project was conducted, especially given the proximity of some of the proposed features to residential areas, specifically the Cadillac Heights and the Joppa neighborhoods.

Of concern are impacts on people near the construction sites who are performing activities which are totally unrelated to construction activities (e.g., area residents, office workers, schoolchildren, etc.). Important factors in determining noise levels that would potentially impact such populations include distance from the noise source; natural or man-made barriers between the source and the impacted population; weather conditions which could potentially absorb, reflect or focus sound (such as wind speed and direction and temperature inversions); and the scale and intensity of the particular construction phase (e.g., excavation, building or finishing).

The Noise Control Act of 1972, one of the earliest legislative bills to address noise concerns, directed the Environmental Protection Agency (EPA) to promote an environment for all Americans that is free from noise that jeopardizes their health and welfare. Several key federal agencies, including the EPA, Department of Transportation (FAA and FHWA), Department of Defense, and Department of Housing and Urban Development (HUD) agreed to a joint effort to incorporate noise considerations in development planning. This cooperation resulted in noise-impact-related data such as noise-zone classifications and land-use compatibility guidelines.

The most frequently used measure currently in general use to describe noise level impacts is the day night average sound level system, abbreviated as DNL and symbolized mathematically as L_{dn}. The day night average sound level is the 24 hour average sound level, expressed in decibels (dB), obtained after the addition of a 10 decibel penalty for sound levels which occur at night between 10PM and 7AM. This nighttime penalty is based on the fact that many studies have shown that people are much more disturbed by noise at night than at any other time. According to general guidelines established by the EPA, residential land use is deemed acceptable for noise exposures up to 65 L_{dn}. The noise exposure at this level may be of some concern but common building construction will make the indoor environment acceptable, and the outdoor environment will be reasonably pleasant for recreation and play.

The noise levels associated with heavy, earth moving equipment such as would be used in construction of levees and swale and wetland excavations range between 72 and 96 dBA (decibel readings weighted to average frequencies heard by the human ear) at a distance of 50 feet. Since sound travels through the air in waves, as the wave spreads (moves away from the sound source) the intensity of the sound at any given point diminishes. Because of the relatively large distances between the proposed construction sites and the nearest residential neighborhoods, most of the alternative plans investigated in this study were readily eliminated from consideration for significantly adverse noise impacts.

Two exceptions to this elimination from consideration were the alternatives proposing construction of either the 100-year or SPF levee around Cadillac Heights and the alternatives proposing the construction of a swale, with or without wetlands, adjacent to the Joppa neighborhood. In the Cadillac Heights neighborhood, more detailed noise analysis of the proposed levee alignments revealed that the only location where the noise levels from construction activities rise above the acceptable 65 L_{dn} would be in the residential area immediately across 11th Street from the end of the levee. The distance between the edge of the levee construction site and the nearest homes in this area is approximately 200 feet which means that construction noise levels outside these homes could vary between 60 and 80 dBA. The distance between the edge of the construction zone and the nearest residences in the Joppa neighborhood is approximately 400 feet. The construction noise levels outside the homes in this area varies between 54 and 76 dBA. Noise levels from earth moving equipment would not remain at a constant level but would fluctuate up and down as the equipment moves closer or farther away, so none of the nearby residents would be subjected to constant high noise levels for extended periods of time. Even though this is the case, it has been determined that where noise levels would consistently extend above the 65 L_{dn}, limits would be placed on the hours of construction operations. Work would not start before 7 AM and would be shut down by 6PM in these areas of concern.

Long-term adverse impacts to the noise environment in the areas adjacent to the proposed project site would not be significant upon completion of the construction phase of the project. Operations and maintenance (O&M) activities, such as mowing, would be conducted on a periodic basis, but the noise from these activities is not expected to reach levels above 65 L_{dn}. In addition, the topographic variations in land as a result of the construction of the proposed swales, wetlands and levees would serve as man-made barriers to noise in the areas surrounding project lands.

Visual Impacts

Visual and aesthetic resources and the interpretation of impacts to resources is varied due to the differences of opinions in what constitutes non-quantifiable elements, such as beauty or pleasantness of the surrounding vista. The proposed chain of wetlands would provide flood damage reduction by removal of forests that impede flow. This could be determined by some to be an adverse visual impact. However, the emergent wetlands would encourage various shore birds, wading birds, waterfowl and other wildlife to utilize the area. The grasslands surrounding the wetland complexes blending into the remaining woodlands should constitute a desirable visual quality even if not preferred by some. The levees would intrude visually into area due to their height. At the same time, development of the entire area as open space providing access to the area, the ability to observe the floodplain resources from atop the levees would be a benefit. Recently considerable growth of wildflowers has been observed on the existing Dallas Floodway levees. The natural propagation of wildflowers along the levees could also develop on the proposed levee extension. The realignment of the river under the IH-45 bridge would initially have adverse visual qualities, but over time as the banks stabilize and the forest is re-established on the banks, the new segment would take on the appearance of the existing channel through the area.

Utility Impacts

The linear levees, as proposed, would cross a number of utilities, such as sanitary sewers, storm drains, water lines, electric transmission towers, fiber optic or other communication cables. A detailed analysis of the known relocations of utilities that would be required is described in Appendix C, beginning on page C-8. The impacts associated with the utilities relocations would be minor. Only temporary disruptions in service would be expected. The utility relocations would be isolated to the immediate area near the construction site, and no additional impacts to important resources would occur. In addition, safeguards would be added to the relocated utilities as a means to lessen problems associated with operation of the project. For example, closure valves would be included for sewer pipelines reconstructed under the levees to be utilized in the event of a rupture. Storm drains would be equipped with emergency closure valves at each levee crossing to prevent flooding in the event of a malfunction of the flap gates. Water supply lines would be relocated to the upper surface of the levees, buried a minimum of two feet deep.

Hazardous, Toxic and Radioactive Waste (HTRW) Impacts

The goal of any design for a flood damage reduction project is to avoid construction in HTRW-contaminated areas and in areas where impact to an HTRW-contaminated site would occur. Avoidance of construction in these areas prevents releases to the environment from occurring. Should it be determined that a project feature must be constructed within an HTRW-contaminated area, or within an area which would have an impact on an HTRW-contaminated site, then a response action is taken to remediate or remove the site in order to eliminate the potential for a release and subsequent impact. This response action would be undertaken in accordance with applicable EPA and state regulations, with the total cost for the response borne by the local sponsor. Therefore, every effort is made to identify potential HTRW-contaminated areas as early as possible during the development of any flood control project design, so that project features can be adjusted to avoid these areas.

The no action alternative for this project would result in no HTRW environmental impact because no construction would occur. The regulatory community would continue to address HTRW-contaminated sites in accordance with the appropriate policies, and liability for environmental releases and impacts would remain with the responsible parties. All other alternatives could result in a potential for HTRW impact due to the construction which must occur for project features, which could result in a hazardous substance release to the environment. Alternatives allowing for the most flexibility in adjusting project features to avoid HTRW-contaminated sites would have the least potential for HTRW impact. The NED Plan is the alternative which would allow the least flexibility for avoiding HTRW-

contaminated sites due to the large width and extent of the swale areas to be constructed. The other alternatives (Combination non-structural / structural plan, TFSP, and LPP) would allow the most flexibility for avoiding HTRW-contaminated sites due to its variety of project features and their various locations which allow for adjustments with minimal cost or project impacts.

The potential for HTRW impact from past and current activities within the study area is extensive. However, efforts to identify, investigate, and adjust project features will continue, with the intent of creating no environmental impact for the project due to HTRW-contaminated areas.

Disposal Impacts

The impacts of placement of excavated material along the alignment of the proposed levees have been addressed as part of the evaluation of these project features. The disposal site for surplus, non-contaminated material was selected because it had been previously approved as a disposal site and would cause not adverse impacts to environmental or cultural resources. The disposal site for contaminated, non-hazardous materials, as described in Appendix J, was tentatively selected because of its known capability to handle the type of wastes identified. The most significant impacts would be related to the hauling of material to these sites, including temporary increases in air pollutants, and the irretrievable commitments of non-renewable resources such as fuel for the hauling equipment.

ECONOMIC ANALYSIS FOR FINAL ARRAY OF ALTERNATIVES

Table 4-29 presents the comparative economic analysis of the flood control features for the final array of alternatives.

The 1965 Authorized Plan, as shown, was analyzed with the original interest rate of 3.25%, and with the January 1997 interest rate of 7.375%. This plan would no longer be economically justified, with current flood control first costs of $199.2 million, annual food control first costs of $17.1 million, negative annual net flood control benefits of $4.1 million, and a BCR of 0.76.

The NED Plan would have an estimated flood control first cost of $50.0 million, annual flood control first costs of $5.5 million, annual net flood control benefits of $8.1 million, and a BCR of 2.46.

The combination non-structural / structural plan reflects the costs and benefits of a plan which would include the chain of wetlands, the SPF Lamar Levee, and the 10-year buyout of the Cadillac Heights area. For equitable comparison of the non-structural plan with the NED and LPP, the costs and benefits of the economically justified CWWTP Levee upgrade and "compatible" Rochester Park Levees are also included in this plan. This plan has estimated flood control first costs of $67.0 million, annual flood control first costs of $7.6 million, annual net flood control benefits of $5.3 million, and a BCR of 1.70.

The TFSP would have estimated flood control first costs of $67.2 million, annual flood control first costs of $7.6 million, annual net flood control benefits of $6.2 million, and a BCR of 1.82.

The LPP would have estimated flood control first costs of $76.8 million, annual flood control first costs of $8.7 million, annual net flood control benefits of $2.9 million, and a BCR of 1.33.

Table 4-29
Economic Analysis of Final Array of Alternatives - Flood Control Only
(January 1997 prices, 7.375% interest, 50-year period of analysis)

	Authorized Plan		NED Plan	Combination Plan *	TFSP	LPP
	Original Rate	Current Rate				
INVESTMENT						
Estimated First Cost	$199,214,200	$199,214,200	$50,022,173	$66,983,587	$67,224,987	$76,780,782
Annual Interest Rate	0.0325	0.0738	0.0738	0.0738	0.0738	0.0738
Project Life (years)	100	50	50	50	50	50
Construction Period (months)	36	36	24	24	24	36
Compound Interest Factor	37.75981	40.15579	25.77523	25.77523	25.77523	40.15579
Capital Recovery Factor	0.0339	0.0759	0.0759	0.0759	0.0759	0.0759
Interest During Construction	$9,870,297	$22,860,317	$3,734,394	$5,000,645	$5,018,668	$8,810,783
Cost of non-Federal Levees			$14,220,000	$23,120,000	$23,120,000	$23,120,000
Investment Cost	$209,084,497	$222,074,517	$67,976,567	$95,104,232	$95,363,654	$108,711,565
ANNUAL CHARGES						
Interest	$6,795,246	$16,377,996	$5,013,272	$7,013,937	$7,033,069	$8,017,478
Amortization	$289,268	$480,458	$147,067	$205,758	$206,319	$235,197
Operation/Maintenance ($/year)	$250,000	$250,000	$375,000	$405,000	$370,000	$495,000
Replacements	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	$7,334,515	$17,108,454	$5,535,339	$7,624,695	$7,609,389	$8,747,675
ANNUAL BENEFITS						
Inundation Reduction	$13,016,900	$13,016,900	$4,014,700	$4,134,600	$5,272,300	$5,222,700
Existing Dallas Floodway			$9,576,900	$8,789,500	$8,567,000	$6,454,573
TOTAL ANNUAL BENEFITS	$13,016,900	$13,016,900	$13,591,600	$12,924,100	$13,839,300	$11,677,273
NET ANNUAL BENEFITS	$5,682,400	(4,091,600)	$8,056,261	$5,299,405	$6,229,911	$2,929,598
BENEFIT COST RATIO	1.77	0.76	2.46	1.70	1.82	1.33
No. of Structures No Longer At Risk From a SPF Event		Unknown	580	504	504	688

** Combination plan includes the chain of wetlands, the SPF Lamar Levee, and a 10-year buyout of the Cadillac Heights area*

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SUMMARY

Due to the environmentally controversial nature of the NED Plan, implementation of this plan was deemed unfavorable by the local sponsor. The Tentative Federally Supportable Plan would yield greater net benefits than any of the other alternatives investigated, and will be considered in further detail in Chapter 5 of this document. In addition, due to the sponsor's desire to implement the LPP, more detailed designs and costs will be developed for this plan, as well.