CHAPTER 4
PLAN FORMULATION/ALTERNATIVE DEVELOPMENT

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 and ecosystem problems and needs necessitates the exploration of possible alternative measures, including structural, non-structural, and restoration solutions. Beneficial and adverse outputs of each alternative for the flood damage reduction measures are evaluated against future without project conditions from an environmental perspective. However, for economic evaluation, Year 2010 hydrologic conditions were adopted and utilized during the plan formulation stage. Year 2010 and Year 2060 (baseline and future) hydrologic values were determined to be sufficiently similar. For example, the 1% (100-year) peak flow on Onion Creek at William Cannon Drive would increase from 114,000 cubic feet per second to 125,000 cubic feet per second, an increase of less than 10%. Utilization of baseline conditions for the period of analysis significantly reduces the formulation efforts. The Recommended Plan will, however, be evaluated using both the baseline and future hydrologic conditions in order to fully capture project benefits. The ecosystem restoration measures were evaluated against future without project conditions.

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 period of analysis.

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 or to the National Ecosystem Restoration (NER). 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. Contribution to the NER is achieved by increasing the net value to the nations output of significant habitat, expressed in habitat units.

Plans formulated during this study were evaluated based on their contribution to NED that are consistent with protection of the Nation's environment and their contribution to the NER. In addition to these National objectives, additional planning objectives evolved from meetings with area residents, contact with the local sponsors, 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 this study were identified during the initial stages, and are as follows:

1. Reduce flood damages within the Onion Creek Basin, especially within the known areas of interest identified as Timber Creek, Onion Creek Forest/Yarrabee Bend Subdivision, Bluff Springs/Perkins Valley, Onion Creek Subdivision, Bear/Onion Confluence area, and Williamson Creek.

2. Reduce risk to life, health, and welfare of the residents residing in the Onion Creek Basin by decreasing the risk of flooding to the extent practical.

3. Enhance the quality of life available to residents within the Onion Creek basin, and specifically the portions of the basin within the cities of Austin and Sunset Valley, and

Travis County, by lowering flood risk, returning the area's ecosystem to more natural conditions, and providing increased recreation opportunities

4. Decrease the number of residents who reside in the 4% ACE and 1% ACE floodplain. Ideally, protect all structures in the 1% ACE floodplain from flooding.

5. Reduce emergency costs associated to the occurrence of significant flood events within the Onion Creek Basin.

6. Formulate alternative plans using a holistic approach, where practical. This includes restoration of a naturalistic hydraulic regime by establishment of riparian habitat in headwater streams, reduction of pollutant loads, and preservation of high quality environmental features such as springs, seeps, wetlands, swimming holes, and threatened or endangered species. Restore and maintain natural character of floodplains.

7. Stabilize the geomorphology along the main stem of Onion Creek and Williamson Creek. Current erosion that threatens aquatic and riparian ecosystems and recreational quality of Onion Creek and tributaries should be curtailed. Future channel enlargement by erosive forces should be eliminated.

8. Create a hydrologic model using HEC-HMS over a 50-year period which would reflect ultimate watershed development conditions. Formulate and evaluate alternatives to address water resource problems based over the 50-year period of analysis.

9. Maximize opportunities for public use within floodplains by connecting park facilities through targeted land purchases and easements.

10. "Hard" structural solutions should be avoided, if possible.

PLANNING CONSTRAINTS

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

1. Aquifer Recharge enhancement features must not reduce aquifer water quality.

2. Wetlands must not be constructed near the Austin Bergstrom International Airport.

CRITERIA AND METHODOLOGIES FOR FORMULATION

Consideration was given to economic, social, and environmental impacts for each alternative during the development of long-term solutions to the flood problems and ecosystem degradation within the Onion Creek Watershed.

TECHNICAL CRITERIA

Alternative plans must be feasible, practicable, and soundly engineered to provide a service life, with reasonable maintenance, for at least 50 years (2010-2060). 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. 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, etc., were used in developing alternative plans.

ECONOMIC CRITERIA

The National Economic Development (NED) objective is maximization of the economic worth of alternative plans as set forth in the 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 consistent with protection of the nation's environment. 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 (LPP) 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. In the absence of special legislation, Federal participation in a recommended plan that 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 may 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:

1. The recommended plan must be economically feasible, i.e. the plan's benefits must exceed the cost of the plan.

2. Alternative plans should be evaluated using the current Federal interest rate and price levels over a 50-year period of analysis.

3. Annualized costs must include the cost of operation, maintenance, repair, rehabilitation, and replacements.

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, reduction of economic disruption, and providing recreation opportunity. These project benefits are subsequently annualized to represent an annual benefit applicable for the period of analysis. 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 period of analysis are also annualized to represent an annual project cost applicable for the period of analysis. 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, based on the current applicable 2006 Federal interest rate of 5.125%.

NATIONAL ECOSYSTEM RESTORATION (NER) CRITERIA

Aquatic ecosystem restoration was recognized as a Federal mission upon enactment of the Water Resources Development Act of 1996, thereby allowing investigation of alternatives and implementation of aquatic ecosystem restoration projects to be cost shared between the Federal government and the local sponsor.

Plans formulated for restoration vary from those formulated for flood damage reduction in that 1) it makes environmental improvement an objective, 2) the ultimate design is not of human origin, 3) the ultimate design is self-maintaining, 4) we can facilitate but not dictate restoration, and 5) policy constraints differ. The following policy considerations were taken into account during the selection of the National Ecosystem Restoration (NER) Plan:

1. The project should restore ecosystem structure, functions, and values.

2. The project should result in improved environmental quality.

3. The improvement should be of great enough national significance to justify Federal expenditure.

4. The sum of all monetary and non-monetary benefits should exceed the sum of all monetary and non-monetary costs.

5. The measures taken to improve environmental quality should result in a more naturalistic and self-regulating system.

6. The measures should reestablish to the extent possible a close approximation of predevelopment conditions.

In order to determine the NER, alternative plans are developed, costs are developed and outputs/benefits are defined. Traditional benefit-cost analysis is not possible with non-monetary benefits or outputs. Therefore, cost-effectiveness/incremental cost analysis (CE/ICA) is used to determine the NER, or “are we getting the most for our money”. IWR-Plan software is used as a CE/ICA tool to produce several “Best Buy Plans”. The recommended plan should be the justified alternative and scale having the maximum of monetary and non-monetary beneficial effects over monetary and non-monetary costs. This plan occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated where the extra environmental value is just worth the extra costs. This plan should be called the NER plan.

MULTIPLE PURPOSE PROJECT CRITERIA

In some instances, plans may be formulated to meet several different types of objectives. Given that the list of primary missions of the Corps currently includes flood damage reduction as well as ecosystem restoration, NED and NER plans are commonly combined together along with recreation into one plan known as a Combined Plan.

Combined Plans may not produce the greatest number of benefits in either category, i.e., there are trade-off’s to be considered. However, they do produce benefits to both categories, and are often more efficient than two projects formulated independently for different, single purposes. Also, there may be opportunities to include features to address additional, secondary purposes, such as recreation.

For Combined Plans, costs are allocated to each purpose utilizing accepted procedures such as the Separable Costs, Remaining Benefits (SCRB) method. The costs that are allocated to each purpose are then compared to the benefits to determine the effectiveness of the plan relative to each purpose.

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, non-structural, and restoration 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:

1. Promote the protection and enhancement of areas of natural beauty and human enjoyment.

2. Protect areas of valuable natural resources.

3. Protect quality aspects of water, land, and air resources in the watershed.

4. Protect against possible loss of life and hazards to health.

5. Promote safety.

6. Preserve and enhance social, cultural, educational, and historical values within the project area.

7. Minimize and, if possible, avoid the displacement of people and destruction or disruption of community cohesion.

In Addition, all Corps civil works projects must be in compliance with Engineer Regulation (ER) 200-1-5, Policy for Implementation and Integration Application of the U.S. Army Corps of Engineers Environmental Operating Principles (EOP) and Doctrine dated 30 October 2003. The Corps, as part of the Army, continues to embrace the “four pillars” of the Army’s environmental strategy summarized as follows:

1. Giving immediate priority attention to sustained compliance with environmental laws and regulations.

2. Continuing to restore previously contaminated or impaired sites both within the Defense Complex and for our civil customers, as expeditiously and fully as resources permit.

3. Focusing on preventing pollution and natural resource damage.

4. Conserving, preserving and restoring natural and cultural resources.

When the National Environmental Policy Act was passed in 1969 and signed into law on January 1, 1970, the United States established a national policy to “Encourage productive and enjoyable harmony between man and his environment; promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; enrich the understanding of ecological systems and natural resources important to the Nation.” It

is striking how contemporary this statement is and how well it and the Army's "four pillars" serve as a springboard for the Corps Environmental Operating Principles:

1. Strive to achieve Environmental Sustainability.

2. Recognize the interdependence of life and the physical environment.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

5. Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycles of our processes and work.

6. Build and share and integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

7. Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

All civil works projects must embrace these principles across all programs and projects to make them a reality. This project embraces the EOP throughout the planning process.

BENEFITS METHODOLOGY

Permanent Evacuation (Non-Structural)

As stated in ER 1105-2-100 page E-104, the total benefits of a nonstructural buyout are the total of:

1. The annual benefit of the alternate use of the land.

2. The reduction in annual flood insurance subsidies.

3. The 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.

4. The reduction in Expected Annual Damages that is brought about by the removal of structures.

Identification of a feasible buy-out plan also depends on meeting several criteria. The evaluation only considered residential structures based on topographical location within each targeted exceedence zone, regardless of the finished first floor elevation. Ideally, the BCR for the group of structures should exceed 1.0. However, a BCR between 0.6 and 1.0 would initiate an investigation of the potential for the addition of recreation facilities or ecosystem restoration features, which can provide additional economic benefits for the project. This evaluation considers spatial proximity of the structures and suitability of the neighborhood for a land use change.

Structural Plans

Benefits attributed to a structural plan are expressed on an annualized basis and are calculated by taking the difference between the expected damages under with- and without-project conditions.

The computer program HEC-FDA, developed by the Hydrologic Engineer Center, Davis, California, was used as the primary assessment tool. Inputs to the program include water surface profiles for the spectrum of frequency storms, ranging from the 50% ACE storm event to the 0.2% ACE storm event, as well as a structure database that indicates the elevation, type, and value of each structure. Also, depth vs. percent damage relationships are a required input for each type of structure listed in the database.

More information regarding the computation of benefits for structural plans may be found in Appendix A, Economics.

Ecosystem Restoration

In order to develop benefits for ecosystem restoration alternatives, values of existing habitat, future without-project habitat and future with-project habitat conditions have to be identified. The values of these habitats were quantified using the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP) (FWS 1980). The HEP uses wildlife habitat models to provide a numerical expression known as a habitat suitability index (HSI) of wildlife quality on a scale of 0 to 1, where 0 represents no suitable habitat value and 1 represents optimum habitat conditions for the representative species. This methodology was discussed in detail in Chapter 3 and in Appendix B, Environmental.

Recreation Benefits Methods

Recreation benefits can be calculated in a number of ways. The unit day value (UDV) method, the travel cost method (TCM), and the contingent valuation method (CVM) are all acceptable methods of calculating recreation benefits. In all cases, the number of visitors must be assumed or determined for each center of recreation such that it does NOT take benefits from another similar set of recreation opportunities. Double counting the same set of visitors would result in the over counting of demand and benefits.

The UDV approach, although not necessarily the most accurate, is the most widely used since the values are widely accepted and the methodology is straightforward. This method uses values that are determined at the Institute for Water Resources (IWR) and updated on a yearly basis. Points are assigned to the quality of the recreational features, and from there, the total value of the experience per visitor is calculated by type of activity.

TCM is more difficult as it uses the actual cost of the travel related activities to determine the value of the recreation experience for likely users. Identifying the likely users can cause complications to this approach. For a study such as this, where only local demands are involved, there are few or no travel costs associated with reaching the destination.

CVM can be less difficult than TCM but is more difficult than UDV. Proper use will yield more accurate demand and willingness-to-pay figures than either of the other methods. The CVM does not require origin-destination information to conduct the analysis. CVM requires a survey of persons who are likely users of the feature under investigation. Individuals are asked to place a value on a particular non-market feature and in some cases provide marginal values for varying incremental changes of the feature, which in this case refers to local recreation opportunities. The only thing being valued is the immediate value to the current user. CVM is the methodology chosen to study the recreation needs of Travis County. Even though the CVM does not require

origin destination, only the population within the five-mile radius of the proposed projects will be used to count the number of visits to proposed recreation facilities if they are evaluated.

It is widely known throughout the industry (recreational opportunities) that the residents of Travis County have a higher demand for recreation than many other locations. County and city officials are generally aware of the types and locations where recreation is needed. Until this survey, which served as a backdrop for this study, demand and value of recreational opportunities had never before been quantified for Travis County.

COSTS METHODOLOGY

The standard methodology utilized by the Corps specifies that the implementation cost of each alternative plan be expressed on an annualized basis. While some costs, such as Operation and Maintenance are typically expressed in this manner, most other costs must be converted from a present value first cost to an annualized cost. For purposes of this study, all plans are evaluated using a 50-year period of analysis, and are annualized using the Federal interest rate applicable at the time of evaluation.

Costs used for comparison against potential benefits for the determination of National Economic Development include, but are not limited to, the initial construction, lands, easements, relocations, rights-of-way, disposal areas, mitigation, design, operation and maintenance, and interest during construction.

The level of detail associated with development of cost estimates throughout the course of the study is dependent on the phase. In general, the preliminary screening of alternatives uses estimates that are more general. As the study proceeds, costs become more refined, with the estimate for the final Recommended Plan being the most detailed in nature. Conversely, larger contingencies are used during initial phases, and are usually reduced in subsequent, more detailed estimates. The cost of the Recommended Plan is estimated using the Corps' Micro Computer Aided Cost Estimating Software (MCACES).

The alternatives formulation analyses were performed over a three-year time period, from FY 2002 through FY 2005. As a result, the applicable interest rate during the evaluation ranged from 5.875% in 2003 to 5.125% in Fiscal Year 2006. Since the alternatives evaluation were performed in several independent phases, sufficient consistency was achieved by assuring that all alternatives considered during a specific phase were evaluated using the same interest rate. Phase I, preliminary alternatives analysis, used an interest rate of 5.875%. During the Phase IIA detailed analysis of alternatives, a rate of 5.125% was used for selection and optimization. The Recommended Plan was investigated using the latest applicable Federal interest rate, which is 5.125% for Fiscal Year 2006.

INITIAL SCREENING OF ALTERNATIVES

In selecting initial alternative plans for flood damage reduction and ecosystem restoration, a full range of structural, nonstructural, and ecosystem restoration measures were considered. These were discussed at the Feasibility Scoping Meeting held on August 20, 2003, and described in detail in the *Onion Creek Interim Feasibility Study Phase I Information Paper* (Information Paper) dated January 2003. Detailed graphics of the preliminary designs were discussed within the Information Paper, and are duplicated within this report.

Structural measures consist of structures designed to control, divert, or exclude the flow of water from the flood prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. The structural measures considered most

appropriate in dealing with the character of the flood problems encountered typically include detention lakes, channel modifications, flood flow diversions, and levees.

Nonstructural measures attempt to avoid flood damages by exclusion or removal of damageable properties from the flood prone areas. These measures do not affect the frequency or level of flooding within the floodplain; rather, they affect floodplain activities. The technique of controlled land use is particularly helpful in planning for future development, but is limited in highly developed areas.

Ecosystem restoration measures attempt to restore degraded significant ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restoration should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology. The initial screening of alternatives was primarily focused on flood damage reduction alternatives. Potential ecosystem restoration measures were identified in the areas of interest, but no measures were formulated into a preliminary plan. A detailed analysis of ecosystem restoration measures and alternatives will be analyzed in the detailed investigation of alternatives.

The “No Action” plan is presented because the National Environmental Policy Act requires its consideration and it forms the basis for comparing other alternatives. Adoption of this alternative implies acceptance of the costs and adverse effects of continued flooding and ecosystem degradation. The No Action Alternative would recommend no plan and require no allocation of Federal funds.

Certain alternative plans have been subjected to only preliminary investigations because of their evident economic infeasibility, social unacceptability, or increased adverse impacts on the environment. The more favorable alternative plans have been subjected to more detailed studies to define their costs and benefits. Ecosystem restoration measures and flood damage reduction measures will be combined to formulate comprehensive plans with restoration and NED purposes.

Recreation plans will be evaluated in conjunction with appropriate flood damage reduction and/or ecosystem restoration plans.

ECONOMICS AND PRICE LEVELS

During the Initial Screening of Alternatives, December 2001 price levels and the applicable Federal interest rate of 5.875% were used. Appendix A contains the applicable preliminary depreciated replacement value, single event damages, vehicle damages and expected annual damages for 2001 that was used for the preliminary alternative analysis in Tables A-4 through A-11 in Appendix A, Economics. The No Action Alternative for the initial screening of alternatives is measured against these economics.

NO ACTION ALTERNATIVE

The “No Action” Plan would recommend that no project be implemented. While the No-Action Alternative does not require the expenditure of Federal funds, adoption of this alternative implies acceptance of the existing and future flood damages and other adverse impacts caused by continued potential flooding of the 1,412 structures within the 0.2% ACE floodplain in Onion Creek and another 439 in Williamson Creek for a total of 1,851 structures (2001 data, Appendix A, Table A-8 & A-10). Although flood insurance would partially compensate for flood damages, they would still be incurred at an estimated average rate of $5.1 million annually (2001 data, Appendix A, Table A-9 & A-11). The costs for flood fighting and recovery costs, public damages, the potential loss of life, and the overall threat to health and safety would continue under the no action alternative.

NON-STRUCTURAL ALTERNATIVES

Floodplain Management

Floodplain management is most effective in controlling future development of the floodplain, thereby assuring that the existing flood problems do not become worse. However, floodplain management cannot, by itself, significantly alleviate existing flooding conditions within an existing floodplain. The technique of controlled land use is particularly helpful in planning for future development, but is of limited use in highly developed areas. Effective regulation of the floodplain is dependent on developing enforceable ordinances to ensure that floodplain uses are compatible with the flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building codes. Zoning regulations permit prudent use and development of the floodplain in order to prevent excessive property damage, expenditure of public funds, inconvenience, and most important of all, loss of life due to flooding. Subdivision regulations guide the division of large parcels of land into smaller lots, and typically require the developer to show compliance with subdivision regulations, zoning ordinances, the local land use or master plan, and other regulations. A subdivision ordinance would require installation of adequate drainage facilities, prohibit encroachment into floodway areas, require the placement of critical streets and utilities above a selected flood elevation, and building lots or structures above a selected flood elevation, normally one foot above the 1% ACE floodplain elevation. Building codes specify the building design, materials and construction methods used for both construction of new buildings or repair of flood-damaged structures.

The City of Austin and Travis County currently participate in the National Flood Insurance Program (NFIP), and has been enrolled in NFIP's Regular Program since September 1981. After joining this program, the City has enacted and enforced numerous floodplain land-use restrictions, regulations, zoning ordinances, subdivision regulations, and building codes. While these measures will not reduce flood damages to the majority of the existing structures in the study area, they are important management tools for limiting the continued increase in population and property susceptible to flooding. Given that the vast majority of the areas of interest are located within the FEMA-designated Zone A, or existing 1% ACE floodplain, these floodplain management restrictions will not prevent continued damages within these areas of interest.

Floodplain management does not warrant further evaluation due to its inability to address existing damages that meet the planning objectives. It should be noted that the local sponsor would be required to complete and implement a floodplain management plan within one year of the completion of any flood damage reduction project recommended and implemented by the Corps, in order to protect the benefits gained from the project.

Flood Forecast and Warning

Flood forecasting and warning involves the determination of imminent flooding, implementation of a plan to warn the public, and organization of assistance in evacuation of persons and some personal property. Notification of impending flooding can be by radio, siren, individual notification, or by more elaborate means such as remote sensors to detect water levels and automatically warn residents. These measures normally serve to reduce the hazards to life and damage to portable personal property. Flood warning and emergency evacuation already exist on Williamson Creek and should be considered as part of any flood control plan to prevent loss of life. However, due to the short warning time on Williamson and Onion Creek, a flood forecasting alternative would not represent a viable flood damage reduction measure because there is no time to remove personal property. In addition, effective flood warning depends on public safety respondents and residents actually taking the required action to evacuate. Therefore, floodplain evacuation is not considered further in this study.

Flood proofing

Flood proofing of residential and commercial structures can include providing water tight coverings for door and window openings, raising structures in place, raising access roads and escape routes, constructing levees and floodwalls around individual buildings or groups of buildings, and waterproofing walls of structures. Flood proofing is more easily applied to new construction and more applicable where flooding is of short duration, low velocity, infrequent, and of shallow depths, and is also appropriate in locations where structural flood protection is not feasible or where collective action is not possible. Flood proofing techniques would require major modifications to existing structures. For water levels that are lower than the first floor of a home, flood proofing would certainly be a possibility. However, if a sustained water level in excess of one foot of the first floor elevation, the structural stability of a watertight home becomes a critical factor. A flood proofed structure generally cannot withstand hydrostatic pressures when water rise three feet above the lowest floor. This is especially true in the older, established neighborhoods. Additional shortcomings include not protecting public facilities such as roads, bridges, and utilities, the continued threat of road closures, and the isolation of residents trapped in their homes and businesses. Also, outbuildings and vehicles, which are a significant portion of the damages, continue to be susceptible to the same risk of flooding. While flood proofing would not likely result in any significant or permanent adverse impacts to ecological or cultural resources, and is appropriate under certain conditions, it does not fully address the planning objectives or criteria previously discussed.

Because most of the structures in Timber Creek are not only within the floodplain, but within the FEMA floodway, and are not structurally sound, it is not prudent to pursue flood proofing in this area. Within the Yarrabee Bend/Onion Creek Forest, the homes are closely clustered, slab-on-grade, with significant flooding depths, making flood proofing quite problematic. Flood proofing in combination with other alternatives such as a 4% ACE buyout to reduce residual damages in the 1% ACE floodplain would be possible but not very practical. For example, residents have several hours of lead time to properly install doorstops, but will they be able to find these items that would only be used every 50 years or so. This is further complicated by aging neighborhoods becoming more transient, with many non-resident owners and tenants. The warning time would better be used to move contents higher, save small, non-replaceable keepsake items and evacuate.

For Williamson Creek, low lying structures are scattered along the entire study reach. Due to little warning time for flood events, the structures would need to be raised in place. The homes are slab-on-grade, with sufficient working area so this is possible. It appears that raising structures in place may have sufficient merit to justify further evaluation. Thus, it is recommended that further investigations be undertaken in the detailed formulation phase.

Floodplain Evacuation

Floodplain evacuation, or buyout as it is commonly known, involves the acquisition, demolition, and removal of structures from the floodplain, and the relocation of residents to areas outside the floodplain. The practicality of evacuation depends on several factors, including the frequency and severity of flooding, the willingness of residents to move out of the floodplain, the availability of housing outside the floodplain, the value of the property, and the need for areas for activities more compatible with floodplain use such as parks or nature areas. Permanent evacuation is a very effective means of reducing flood damages, as well as public damages and costs. Ecosystem restoration and recreation measures can be implemented as alternate uses of lands purchased as part of the floodplain evacuation.

Evacuation of the 4% ACE floodplain, or “buy-out” as it is commonly referenced, was the selected measure of choice for the non-structural evaluation being conducted as part of Phase I. The 4% ACE flood level was selected for use as a “measuring stick,” based on prior experiences

with formulation of similar plans. The vacated lands resulting from the evacuation could then be utilized by incorporating an ecosystem restoration measure which would then share in a portion of the land costs to lower the flood damage reduction costs. Costs for implementing recreation features would be added to the flood damage reduction costs, which would raise overall costs, but the benefits generated by recreation features would generate additional benefits above and beyond the costs.

The following paragraphs summarize the preliminary screening performed as part of the non-structural evaluation conducted during Phase I of this Interim Feasibility Study. During Phase I, secondary use of the land was not investigated further, but simply assumed as feasible. It also assumed that FEMA would allow such secondary use to occur.

Estimates for real estate costs were determined in conjunction with a reconnaissance analysis dated December 2003. This report is included as Addendum 1 to Appendix E, Real Estate.

Timber Creek

The 4% ACE evacuation plan, which was analyzed for the Timber Creek subdivision, was essentially an extension of the buy-out program initiated with the FEMA program. However, the proposed plan would focus on eliminating the property gaps left by implementation of the FEMA program. This would then allow a larger, continuous sector of land to be used for more floodplain compatible purposes. To date, 41 structures have been purchased and no more are expected to be purchased under the FEMA program.

Figure 4-1 contains a map of the Timber Creek subdivision, with structures color-coded to represent their current buy-out status. In addition to the structures already proposed for buy-out under the FEMA program, the Corps' plan would require purchase of an additional 63 structures, at an estimated implementation cost of $5,500,000. Preliminary indications are that a feasible multipurpose plan could be formulated in this area of interest. Thus, it will be investigated further during the detailed analysis.

Onion Creek Forest/Yarrabee Bend

Buy-out of the 4% ACE floodplain in this area of interest is illustrated in Figure 4-2. The City of Austin has already initiated a program to buy out the lowest lying residences, which are primarily mobile homes. As of Phase I of this study, the City of Austin had purchased approximately 37 structures within Onion Creek Forest. Those already removed, or in the process of being removed by January 2003, are identified in Figure 4-2 by color-coding. The city continues to buy structures as additional local funding is made available. It is estimated that as of May 2006 an additional 28 have been purchased, bringing the total up to 65. Currently, costs attributable to the advanced buyout are fully non-Federal. The Sponsor is actively pursuing special legislation that would allow credit for their advanced buyout, much of which occurred prior to the start of the feasibility study, provided that it would be identified as part of the recommended Federal project. Also, a letter requesting credit for any additional advanced buyout, as authorized by Section 104 of the Water Resources Development Act of 1986, has been received from the City of Austin. The city is requesting Section 104 credit for approximately 250 houses, but it is expected that they would not purchase this many within the short timeframe before the project is authorized.

The cost associated with implementation of this alternative would easily exceed $70 Million. However, preliminary indications are that a feasible multipurpose plan should be investigated in this area of interest. Thus, this plan will be investigated further during the detailed analysis.

Bluff Springs Road/Perkins Valley

An evacuation of the 4% ACE floodplain in this area would require the buy-out of 15 buildings, including 12 single-family residences. As can be seen in Figure 4-3, which highlights the structures proposed for buyout, the development is scattered. A large portion of the cost associated with a buyout plan would be cost of lands. Alternative land uses such as recreation or ecosystem restoration would be necessary in conjunction with any buyout plan, if a favorable benefit-to-cost ratio is to be achieved.

Implementation of the 4% ACE floodplain evacuation would cost approximately $2,300,000. This cost does not include any conversion to other land uses. This amount is substantial, given it only addresses flooding to 12 residential structures. These findings were discussed with the primary sponsor for this area, Travis County. The County concluded that they were not interested in carrying this plan forward into the detailed analysis, given the need for alternate uses for the land.

Onion Creek Subdivision

Evacuation of the 4% ACE floodplain in the Onion Creek Subdivision would involve the removal of 24 single-family homes and 6 multi-family structures, at an estimated first cost of construction of $6,400,000. This is an average of $200,000 per structure. All of these structures are located within the upper fringes of the 4% ACE flood zone. The specific structures that were identified for possible evacuation are depicted in Figure 4-4.

Given the minimal average annual damages, overall density, return interval, and cost per structure, formulation of a feasible floodplain evacuation project in this area of interest was deemed to be highly unlikely. No additional non-structural formulation will be undertaken in this area.

Bear/Onion Confluence

Buy-out of the 4% ACE floodplain for this area is illustrated by color-coding in Figure 4-5. There were only four structures identified as part of the 4% ACE floodplain evacuation, with an associated cost of approximately $1,100,000. There are also several structures located near the immediate confluence area, which may have buyout potential. It was deemed that further analysis is warranted during detailed analysis. Due to the uncertainty associated with the first floor elevations, a feasible plan could possibly be formulated, when combined with other compatible purposes. This area of interest will be investigated further in Phase IIA, when surveyed first floor elevations will be obtained to more accurately determine the risk associated with these structures.

Williamson Creek

Similar to the areas of interest along Onion Creek, floodplain evacuation of the 4% ACE floodplain was selected as the non-structural measure for evaluation in Phase I. For actual project implementation, this measure would likely be combined with recreational features or ecosystem restoration measures to form a comprehensive, multi-objective plan. Separate analysis of the buy-out portion provides a reference point in terms of the amount of investment required, if a non-structural plan were to be selected as the plan of choice.

Table 4-1 lists the estimated number of structures and probable first cost of construction associated with the selected buyout in each Williamson Creek area of interest (2001 Data, Appendix A, Table A-10). Given the general location, type, and density of the structures, cost, and sponsor interest, the decision was made to carry this alternative forward to the next phase of

study. It should be noted that this was 2001 data and the information was subsequently updated in the detailed investigation of alternatives to reflect a more accurate of 77 structures (Chapter 3) within the 4% floodplain instead of 102 (2 houses in Sunset Valley were not purchased at sponsor's request).

Table 4-1
Williamson Creek
Number of Structures and Investment for 4% ACE Preliminary Buy-out
(December 2001 Prices)

Reach	*# Structures*	*First Cost for Construction*
Heartwood	16	$2,600,000
Radam/Salem Walk	31	$5,400,000
Broken Bow/Buckskin Pass	13	$7,000,000
Westgate Blvd/ Bayton Loop	40	$4,800,000
Total	100	$19,800,000

STRUCTURAL ALTERNATIVES

General

The viability of most structural measures is highly dependent upon the parameters associated with each specific site. Various structural measures were considered on a case-by-case basis for each area of interest. The list of measures considered included channel modifications, levees, floodwalls, and diversions. In addition, a more general assessment of regional detention was made for the entire watershed.

Levee systems traditionally provide high levels of protection to flood prone areas but often require substantial amounts of real estate between the stream and the structures being protected unless an existing levee is in-place, or the height of the levee is relatively small. Floodwalls (usually made of concrete) are used in lieu of levees in situations where the acquisition of real estate for the levee or other topographic problems may be prohibitive. The feasibility of either of these measures is based on the cost and availability of real estate, the number of structures along the levee alignment, and the additional costs necessary to alleviate interior drainage problems to prevent induced damages in adjacent areas. Construction of individual levees or floodwalls around specific structures or small groups of structures is normally considered cost prohibitive unless the individual structure is very valuable, has cultural significance, or is prone to frequent flooding. In addition, costs of environmental mitigation could be substantial.

Channel modifications can be a highly effective measure to address flood damage reduction. This measure consists of modifying an existing channel by either increasing the cross-sectional area of the stream channel and/or an existing bridge (widening and/or deepening), straightening and realigning the stream channel, and/or reducing the friction losses of an existing channel through concrete lining. The design of the channel modification can vary significantly and is primarily based on the topography of the existing stream channel and the existing development of properties within the floodplain. Water surface elevations for the entire frequency range of storms are usually reduced, and right-of-way requirements take full advantage of the existing channel. However, depending on the unique characteristics of each site, many additional side effects and problems may arise as a result of implementation. These include higher, erosive velocities; higher downstream flow rates; disturbance to cultural resources; and in many instances, destruction of the only remaining riparian corridors within an urban area.

Diversions of flood flows can be performed in several ways, depending on whether the flow is diverted completely away from the target stream, or simply diverted to the same stream at a downstream location. Both types can effectively reduce the water surfaces upstream of the diversion intake, thereby reducing water surface levels. If flows are diverted completely away, all areas downstream of the diversion intake receive the benefit of smaller flood flows, and thus a possible reduction in flood damages. If a diversion is used to simply cut off an oxbow, for example, only the reach located upstream of the diversion outlet is likely to benefit. Caution must be used to insure that the diversion is not creating additional problems in the receiving reach (outlet).

Each area of interest was evaluated on a preliminary basis to determine whether any structural measures have sufficient merit to be considered in more detail. In some cases, preliminary layouts were performed along with a preliminary benefit versus cost analysis.

Regional Detention

This alternative consists of constructing one or more structures to provide flood storage to reduce peak flood flowrates and lessen downstream flood damages. Detention is used to temporarily impound floodwaters for later release when the downstream conditions permit. The feasibility of this measure depends heavily on the volume and timing of the flood flows, and the availability of an impoundment site capable of providing sufficient storage. Flood events within this area of the Onion Creek Watershed have high yield volumes of discharges.

Detention has previously been investigated for Williamson Creek in a Preliminary Engineering Report performed by Alan Plummer Associates, Inc., for the City of Austin, dated March 2000. The conclusion of the study was that “the minimal benefits do not justify the large project costs.” Further continued development in the area would require additional relocation costs. For these reasons, detention for Williamson Creek was not found to be a viable option, and therefore, will not be considered further.

Since detention is one of the only measures that would provide regional benefits, it will be investigated during the detailed formulation for Onion Creek. Due to the large volumes of water needing to be controlled, the detention reservoir would need to be fairly large in size. Therefore, it would need to be located in non-residential areas and would need to be located upstream of Onion Creek Subdivision to effectively lower water surface elevations in all downstream areas of interest on Onion Creek.

Timber Creek

Upon consideration of the nature of flooding, the area topography, and above all, the potential environmental impacts, a diversion channel was selected as the structural measure that would have the greatest potential for possible implementation.

As shown in Figure 4-6, the diversion would be located in the right overbank. The diversion increases the flood conveyance in the reach, thereby decreasing the flood event water surface elevations. The proposed diversion channel parameters are:

- channel shape: trapezoidal
- channel lining: grass
- length: 6,500 feet
- side slopes: 3 foot horizontal to 1 foot vertical
- bottom width: 400 feet

Two roadway crossings would need to be reconstructed. A new bridge at the FM 973 crossing and a low water crossing at Pearce Lane would also be required. The diversion channel

would also be very near the future alignment of State Highway 130. Because of this proximity, spoil material from the diversion area could be utilized for future construction of State Highway 130, thus avoiding a lengthy haul distance and costly disposal.

The total first cost of the diversion plan was estimated to be approximately $15,100,000. Using December 2001 prices, the 2003 Federal interest rate of 5.875% and a 50-year period of analysis, this is equivalent to an annualized cost of approximately $942,000. For the purpose of determining a benefit-to-cost ratio, it was assumed that the diversion would eliminate ALL damages, which it would not, and the benefit-to-cost ratio would still be less than 0.2. Thus, any implementation of a structural plan to reduce flood damages appears highly unlikely, and no additional analysis for structural plans is warranted.

Onion Creek Forest/Yarrabee Bend

During Phase I, a significant amount of effort was placed on development of a preliminary structural alternative for the Onion Creek Forest/Yarrabee Bend area of interest. All types of structural measures were initially considered, but upon consideration of the nature of flooding, the area topography, and the potential environmental impacts, a series of diversion channels in combination with levees was developed as a preliminary plan. Initial features of this preliminary structural plan are shown in Figure 4-7, and include the following features:

1. Four levees with a total length of approximately 11,100 feet and average height of 10 feet.

2. Two diversion channels with a total length of approximately 5,050 feet, and an average width of 250 feet.

3. One levee ditch with a length of approximately 900 feet.

4. Two new bridges at William Cannon Road and Pleasant Valley Road. Both bridges would be approximately 450 feet long.

5. Three sump areas totaling about 4.5 acres.

6. Three floodwalls totaling approximately 3500 linear feet, with an average height of 15 feet.

7. Two floodgates (9.5 and 9.0 feet high respectively) for William Cannon Road and Pleasant Valley Road.

The total first cost of the multiple diversion/levee combination plan, excluding utility relocation costs, was estimated to be approximately $21,300,000. Using December 2001 prices, the Fiscal Year 2003 Federal interest rate of 5.875% and a 50-year period of analysis, this first cost is equivalent to an annualized cost of approximately $1,328,000. The diversion would eliminate approximately $1,800,000 in average annual damages, and the resulting benefit-to-cost ratio would be approximately 1.3. These preliminary results were sufficiently favorable to carry forward into detailed formulation.

Bluff Springs Road/Perkins Valley

The scattered development and limited potential benefits in the area limited the possibilities of a structural plan in this area of concern. Channel modifications, for instance, were clearly not supportable from an economic standpoint because the construction cost would be extremely high for very little benefit and there would be substantial environmental mitigation costs. However, a preliminary structural levee plan was developed for the Bluff Springs Road/Perkins Valley area. It

consisted of a combination of the non-structural plan previously discussed and a series of levees and diversions as shown in Figure 4-8. The following describes the measures within the initial alternative:

1. A levee located in the left overbank, with an average height of 10 feet, length of approximately 4,670 feet, and 1 foot vertical to 3 foot horizontal side slopes.

2. A small diversion to take upland drainage flows away from the proposed levee. The average top width and depth of the excavated diversion is 40 feet, and 5 feet, respectively.

3. An excavated swale area located on the left bank, adjacent to the main channel between Bluff Springs Road and Slaughter Lane. This area provides the material needed for levee construction, and it provides additional conveyance area to offset the loss of conveyance as a result of levee construction. Without the swale, water surface elevations upstream of the levied area may be increased for selected frequencies, including the 1% ACE frequency.

This preliminary structural alternative would have to be implemented as an add-on to the non-structural plan described earlier in the non-structural section. Again, this is due to the scattered development. Without the non-structural addition, structures would remain on the creek side of the proposed levee. However, if implemented together, these two measures combined would provide 1% ACE level of protection to the area of interest.

Several structures other than those identified in the non-structural plan, would need to be removed to facilitate building the levee. Estimated first cost of the structural portion of the plan is approximately $1,600,000, excluding utility relocations. Total annual costs would be approximately $175,700 and annual benefits attributable to the structural alternative would be approximately $107,000, resulting in a benefit-to-cost ratio of approximately 0.6. Thus, this was not carried forward into detailed formulation.

Onion Creek Subdivision

A thorough review of this area, including several site visits, was conducted during Phase I. Channelization was deemed cost prohibitive, given the limited amount of damages within the reach. Since a sufficient amount of real estate was not available for consideration of a levee, it was decided to evaluate a floodwall alternative.

Construction of a floodwall would have some major disadvantages. The wall would have to be located between the creek and the closest row of homes adjacent to a golf course. Upon implementation, homes currently having an aesthetically pleasing view of the golf course would then only have a view of a floodwall in their very limited (because of proximity to the floodwall) back yards. The floodwall would have to be located within 15-feet of some of the houses.

The floodwall would generally parallel Pinehurst Drive for approximately 5,000 feet, as shown in Figure 4-9. Additionally, it would be necessary to raise about 800 linear feet of the road to tie into the end of the floodwall. The estimated first cost of this plan, excluding any utility relocation costs, was estimated at $23,800,000. Average annual cost would be $1,900,000. Implementation of this plan would result in average annual flood damage reduction benefits of approximately $881,000, and the removal of approximately 192 homes from the 1% ACE floodplain. The resulting benefit-to-cost ratio for this alternative is approximately 0.4. This low benefit-cost ratio, coupled with the unacceptable visual issues for residences in the area, was sufficient to eliminate this area of interest from any further evaluation, except for regional detention.

Bear/Onion Confluence

Upon consideration of the nature of flooding, the area topography, and the potential environmental impacts, a combination of the proposed nonstructural plan and a structural plan was identified as having the greatest potential for possible implementation.

As shown in Figure 4-10, the structural alternative for this reach consists of a levee placed generally parallel to and on the creek side of Stagecoach Way. Construction of this low level levee would remove an additional four homes from the 1% ACE floodplain. Also, a small runoff diversion would need to be constructed to divert hillside drainage and thus avoid any extensive interior drainage facilities.

The structural alternative, when evaluated as a last added element to the non-structural alternative, has an estimated cost of $150,000, an average annual cost of $15,700, average annual benefits of $22,000, and a benefit-to-cost ratio of 1.4. The first cost takes into account that some of the land cost would be assigned to the non-structural element.

Williamson Creek

Being a highly urbanized smaller tributary of Onion Creek, Williamson Creek has substantially different characteristics than the other areas of interest. Structural barriers such as levees and floodwalls are not practical, primarily due to fairly steep side slopes and overbank areas. There is inadequate open space for the construction of diversion channels, which leaves channel modification as the only viable structural option to investigate.

The City of Austin Phase I Watershed Master Plan was used as a basis for initial selection of a possible channel modification. The conceptual design for channelization blends with existing stream morphology. The modified channel cross-sections have a benched design with grass

seeding on the banks and overbank terraces, stone riprap placed at the toe of slope, and geotechnical stabilization, where required.

For preliminary analysis, the width and length of the various channel modification reaches were based on the 4% ACE storm event. An attempt was made to reduce water surfaces sufficiently to keep this storm event from entering the structures. In some cases where several structures had first floor elevations that were abnormally low, it was assumed that these would be removed. The modification was sized to protect the next lowest group of structures. This initial formulation technique will usually result in a more economically viable plan.

A revised HEC-RAS model was developed from the existing condition model to determine the with-project conditions for the selected improvement alternatives. Floodplain maps were then prepared for the 4% ACE storm event using the revised model output. These are shown in Figures 4-11 through 4-14.

To test the economic feasibility associated with each of the preliminary alternatives, project first costs were developed using many assumptions. These costs were then annualized and compared to the annualized benefits attributed to the project over the 50-year period of analysis. A summary of the first costs, average annual costs, total annual benefits, benefit-to-cost ratio, and remaining annualized damages for each sub-reach is shown in Table 4-2. Based on these results, the channel modification alternative was carried forward into the detailed formulation phase.

Table 4-2
Williamson Creek
Phase I Preliminary Analysis
Summary of Costs and Benefits by Sub-Reach
(December 2001 price levels and 5.875% Interest Rate)

Reach	First Cost	Average Annual Cost	BCR	Total Annual Benefit	Residual Annual Damages
Heartwood	$350,000	$28,100	1.4	$38,000	$149,000
Radam	$820,000	$57,100	2.4	$137,000	$125,000
Broken Bow	$1,245,000	$92,200	1.5	$136,000	$61,000
Bayton Loop	$4,683,000	$319,300	1.2	$376,000	$109,000
Total	**$7,098,000**	**$478,700**	**1.4**	**$687,000**	**$444,000**

PRELIMINARY SCREENING ANALYSIS SUMMARY

Table 4-3 presents a list of the flood damage reduction alternatives to be carried forward into the detailed formulation phase. Both non-structural and structural plans are listed and sorted by areas of interest.

Table 4-3 Phase I Preliminary Analysis Summary of Flood Damage Reduction Measures Identified for Detailed Investigations	
Measure	*Description/Remark*
Regional Detention	Investigate a location upstream of Onion Creek Subdivision
Timber Creek	
Non-Structural Floodplain Evacuation	To be combined with Ecosystem Restoration and/or Recreation
Onion Creek/Yarrabee Bend	
Diversion	Investigate a cut off of a large oxbow and opportunities to assist with localized flows and inducements
Levee	Construction of a levee in combination with two diversions
Non-Structural Floodplain Evacuation	To be combined with Ecosystem Restoration and/or Recreation
Bluff Springs Road/Perkins Valley	
None	No viable alternative except the upstream detention mentioned above
Onion Creek Subdivision	
None	No viable alternative except the upstream detention mentioned above
Bear/Onion Confluence	
Levee	BCR is sufficient, but costs need to be refined
Non-Structural Floodplain Evacuation	To be combined with Ecosystem Restoration and/or Recreation
Williamson Creek	
Channel Modification	To be investigated using geomorphic principles. Potential for high beneficial returns
Non-Structural Floodplain Evacuation	To be combined with Ecosystem Restoration and/or Recreation

Timber Creek

Based on the findings of the initial screening of alternatives, only a non-structural measure was carried forward into more detailed formulation. The performance of the selected structural measure does not warrant further investigations. The non-structural measure must be combined with recreation and/or ecosystem restoration features to attempt to identify a viable, cost effective solution. Consideration will be given to both monetary and non-monetary outputs.

Onion Creek Forest/Yarrabee Bend

Based on the findings of the initial screening of alternatives, both non-structural and structural measures were carried forward into more detailed Phase II formulation. If a structural plan is found to be economically feasible and less costly than the buy-out plan, then recommendation of a non-structural plan is still possible as part of a Locally Preferred Plan; however, Federal participation would be limited by cost sharing associated with the most effective structural plan.

Preliminary analysis indicated that the non-structural measure must be combined with recreation and/or ecosystem restoration features to attempt to identify a viable, cost effective solution. Consideration will be given to both monetary and non-monetary outputs.

Bluff Springs Road/Perkins Valley

Sufficient damages were not identified to support any type of structural solution. Also, the low lying area was sparsely developed. As such, a significant investment for lands and features to support other purposes (ecosystem restoration or recreation) would have been required to remove only a limited number of structures from the floodplain. Jointly, the Corps and Sponsor determined to omit this area of interest from further consideration.

Onion Creek Subdivision

Based on the preliminary findings neither the non-structural buyout nor the floodwall alternative could be considered as excellent candidates for consideration in detailed formulation. Instead, given the type of flooding, the sizable average annual damage estimate, and the shape of the damage-frequency curve, it is concluded that future formulation efforts should pursue the detailed evaluation of possible upstream detention areas, which would decrease the flood peaks of storm events. The intent is to investigate a multipurpose plan that could provide flood damage reduction, ecosystem restoration, water quality, and possibly water supply benefits. There may be sites available that lie within the Barton Springs - Edwards Aquifer recharge zone and flood waters could be retained, and then slowly released to encourage infiltration.

Bear/Onion Confluence

Based on the preliminary findings, both the non-structural as well as structural measures were identified as candidates for detailed formulation of alternatives. Overall, this project is relatively small, but it appears to have potential.

Williamson Creek

Both structural and non-structural solutions were identified as viable options for more detailed studies. Additionally, when sub-reaches within the Williamson Creek area were evaluated, a channel modification measure utilizing geomorphic design features was shown as an economically viable option in each sub-reach.

VALUE ENGINEERING

The Project Study Plan (PSP) for the Wharton and Onion Interim Feasibility Studies were amended in September 2003 to carry the study through the Feasibility Phase. On February 5, 2005, ER 11-1-321 was published after the final array of alternatives were developed and evaluated, which requires feasibility reports to undergo a Value Engineering (VE) Study before the final array of alternatives are evaluated. Realizing that the study would be grandfathered since the final array of alternatives had already been evaluated, but practicing good business the District Value Engineering Officer (VEO) accompanied the Project Manager to Austin to meet with the local sponsors on Feb 17, 2005 to discuss and perform a mini value engineering analysis and a need to revise the PSP if appropriate to conduct a VE Study. The VEO led the Team in identification of issues of concern associated with Onion Creek, Williamson, and Wharton Studies. The VEO explained the VE Process and identified how it is used to resolve issues, clarify expectations, and develop alternatives that best meet the functional requirements of the project. The VEO discussed plans for the expanded VE Study, required by law, planned for the Design Phase of the projects. The study team decided that the mini-analysis would suffice for the

Feasibility Study since the final array of alternatives were already evaluated and that a detailed study should be completed first thing during the Preconstruction, Engineering and Design Phase.

DETAILED INVESTIGATION OF ALTERNATIVES

GENERAL

The preliminary screening and formulation was completed with publication of an Information Paper in January 2003. A summary of the results were shown in Table 4-3 above. Based on these findings, the original Project Management Plan was updated to more accurately reflect the work to be accomplished during the detailed investigation of alternatives. Work efforts on this phase, known as Phase IIA, were initiated in April 2003.

Presentation of the detailed formulation analysis for the flood damage reduction features is organized and presented by area of interest. The ecosystem restoration plans that were investigated were analyzed on a watershed scale, so they have to be described as such. However, when the flood damage reduction plan included ecosystem restoration, the plans are discussed in detail by area of interest. Additionally, evaluation of a regional detention alternative is shown separately, due to its impacts to multiple areas of interest. Furthermore, due to the length of the Incremental Analysis and discussions on ecosystem restoration areas, the plan formulation for the detailed investigations for ecosystem restoration measures is discussed in detail in Appendix B. However, the results of the incremental analysis are summarized below.

UPDATED FUTURE WITHOUT-PROJECT CONDITIONS

Economic data including structure replacement values, single event damages and expected annual damages were updated during the detailed investigation of alternatives from the preliminary screening of alternatives. Some characteristics attributed to structures in the previous phase of the study were assumed rather than measured. This introduced errors in the data that were corrected. Because of the changes including water surface profile refinement, the values and number of structures changed between the 2001 data displayed in Appendix A and the 2004 data displayed in Chapter 3. The economic updates are discussed in detail in Appendix A.

For the detailed investigations of alternatives, December 2004 price levels and 2006 interest rates of 5.125% were used. Single event and expected annual damages for future without project conditions based on December 2004 price levels are contained within Chapter 3. These form the baseline against which all of the flood damage reduction alternatives will be evaluated.

Although construction would continue and it would be expected that acres of riparian woodlands would be reduced overtime, the natural resource agencies requested that the Corps project the future without-project environmental conditions maintaining status quo. Since the future without-project conditions are only projected to increase slightly, this represents a fairly accurate description of what is expected to occur. Slight increases or decreases would not affect formulation. Therefore, the acres and HSI values were not reduced for without-project conditions. However, the shrubland values for Onion Creek were reevaluated as transitional woodlands and those are expected to increase over time. Since habitat units remain constant the existing habitat value equals the annual habitat units. However, since the transitional woodlands increases over time, the annual habitat units equal 65.52 for Transitional Woodlands in Onion Creek Forest/Yarrabee Bend. Table 4-4 has updated overall study area future without-project habitat units, which serve as a baseline from which alternatives can be measured. It should be noted that during alternative development, riparian woodlands were further subdivided to into riparian woodlands and parklands.

ECOSYSTEM RESTORATION

During the detailed investigation of alternatives, ecosystem restoration opportunities were refined to the areas of interest carried forward for detailed investigation. In addition, measures were identified for project specific areas, which are significantly smaller than the study area identified in Chapter 3. Furthermore, the shrubland classification was renamed transitional woodlands. In addition, the woodland category was broken down into a riparian woodland category and a parkland category to capture the appropriate function of the parkland versus the woodland.

Because of the limitations of the IWR-Plan Software that was used for incremental analysis and the amount of measures and scales that were involved in the analysis, Onion Creek and Williamson Creek were analyzed separately. Onion Creek was analyzed as a whole and was later broken out by damage area to determine the annual cost per annual habitat unit gained. A summary of the measures and scales identified for potential implementation and the incremental analysis is described below, for a more detailed description and figures refer to Appendix B.

Table 4-4
Existing Conditions and Future Without Project
Existing Cover Type Habitat Suitability Indices and Habitat Units by Area of Interest

Cover Type	Existing Conditions			Year 1		Year 5		Year 10		Year 25		Year 50	
	Acres	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
TIMBER CREEK													
Woodland	89	0.82	72.98	0.82	72.98	0.82	72.98	0.82	72.98	0.82	72.98	0.82	72.98
Grassland	1042	0.94	979.48	0.94	979.48	0.94	979.48	0.94	979.48	0.94	979.48	0.94	979.48
Shrubland	89	0.8	71.20	0.8	56.96	0.8	45.57	0.8	36.45	0.8	29.16	0.8	23.33
Wetland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ONION CREEK FOREST/YARRABEE BEND													
Woodland	358	0.8	286.40	0.8	286.40	0.8	286.40	0.8	286.40	0.8	286.40	0.8	286.40
Grassland	738	0.71	523.98	0.71	523.98	0.71	523.98	0.71	523.98	0.71	523.98	0.71	523.98
Transitional Woodland	105	0.4	42.00	0.4	42.00	0.45	47.25	0.5	52.50	0.6	63.00	0.7	73.50
Wetland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
BLUFF SPRINGS ROAD/PERKINS VALLEY													
Woodland	54	0.89	48.06	0.89	48.06	0.89	48.06	0.89	48.06	0.89	48.06	0.89	48.06
Grassland	352	0.71	249.92	0.71	249.92	0.71	249.92	0.71	249.92	0.71	249.92	0.71	249.92
Shrubland	17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Wetland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ONION CREEK SUBDIVISION													
Woodland	171	0.55	94.05	0.55	51.73	0.55	28.45	0.55	15.65	0.55	8.61	0.55	4.73
Grassland	641	0.56	358.96	0.56	358.96	0.56	358.96	0.56	358.96	0.56	358.96	0.56	358.96
Shrubland	38	0.85	32.30	0.85	32.30	0.85	32.30	0.85	32.30	0.85	32.30	0.85	32.30
Wetland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 4-4 Continued
Existing Conditions and Future Without Project
Existing Cover Type Habitat Suitability Indices and Habitat Units by Area of Interest

Cover Type	Existing Conditions			Year 1		Year 5		Year 10		Year 25		Year 50	
	Acres	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
BEAR/ONION CONFLUENCE													
Woodland	326	0.76	247.76	0.76	247.76	0.76	247.76	0.76	247.76	0.76	247.76	0.76	247.76
Grassland	93	0.79	73.47	0.79	73.47	0.79	73.47	0.79	73.47	0.79	73.47	0.79	73.47
Shrubland	49	0.83	40.67	0.83	40.67	0.83	40.67	0.83	40.67	0.83	40.67	0.83	40.67
Wetland	4	0.86	3.44	0.86	3.44	0.86	3.44	0.86	3.44	0.86	3.44	0.86	3.44
WILLIAMSON CREEK													
Woodland	145	0.53	76.85	0.53	76.85	0.53	76.85	0.53	76.85	0.53	76.85	0.53	76.85
Grassland	38	0.57	21.66	0.57	21.66	0.57	21.66	0.57	21.66	0.57	21.66	0.57	21.66
Shrubland	73	0.78	56.94	0.78	56.94	0.78	56.94	0.78	56.94	0.78	56.94	0.78	56.94
Wetland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Onion Creek

An ecosystem restoration plan was developed that was never intended to be implemented, but rather was for cost comparison and to perform cost allocation. Because the flood damage reduction alternatives are proposing to be combined with ecosystem restoration and recreation, as discussed in the preliminary screening of alternatives, a combined ecosystem restoration plan was investigated.

Ecosystem Restoration Only

The ecosystem restoration only measures would be to restore eight specific areas, located within the Timber Creek, Onion Creek Forest, and Bear Onion Confluence areas of interest, by converting or restoring the existing vegetation type to riparian woodlands using the scales identified below.

Scale 0: No Action

Scale 1: Restoration to woodlands using seedling trees and shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 300 trees, 150 shrubs, and woodland grass forbs mix per acre
Woodland Conversion: 75 trees, 100 shrubs, and woodland grass and forbs mix per acre
Parkland/Residential Conversion: 200 trees, 250 shrubs, and woodland grass and forbs mix per acre
Urban/Bare Ground Conversion: 300 trees, 150 shrubs, and woodland grass forbs mix per acre
Transitional Conversion: 75 trees, 100 shrubs, and woodland grass and forbs mix per acre

Scale 2: Restoration to woodlands using one-inch caliper trees, one-gallon shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 75 trees, 110 shrubs, and woodland grass forbs mix per acre
Woodland Conversion: 50 trees, 75 shrubs, and woodland grass and forbs mix per acre
Parkland Conversion: 70 trees, 210 shrubs, and woodland grass and forbs mix per acre
Urban/Bare Ground Conversion: 75 trees, 110 shrubs, and woodland grass forbs mix per acre
Transitional Conversion: 50 trees, 75 shrubs, and woodland grass and forbs mix per acre

Scale 3: Restoration to woodlands using two-inch caliper trees, five-gallon shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 50 trees, 80 shrubs, and woodland grass forbs mix per acre
W*oodland Conversion*: 50 trees, 50 shrubs, and woodland grass and forbs mix per acre
Parkland Conversion: 70 trees, 210 shrubs, and woodland grass and forbs mix per acre
Urban/Bare Ground Conversion: 50 trees, 80 shrubs, and woodland grass forbs mix per acre
Transitional Conversion: 50 trees, 50 shrubs, and woodland grass and forbs mix per acre

Under scales 1, 2, and 3 identified above, the restoration would include removing exotic or invasive species, such as ligustrum and Chinaberry, and then restoring a diversity of native species identified in Appendix B, Addendum B-2 with the densities identified above. The removal of invasive species would primarily be completed by mechanical or hand removal methods.

An incremental analysis was conducted using IWR-Plan and 163 cost effective plans were identified. Of the 163, there were 22 best buy plans. Based on the results it was determined that for the conversion to riparian woodland on Onion Creek for the Ecosystem Restoration Only Plan, applying scale 1 in all of the eight areas would be recommended for the Ecosystem Restoration Only Plan. This combination would have a first cost of $2,848,000, allow net habitat gains of + 69.10 units, and have an average annual cost of $175,000. The annual cost per AAHU would be $2,500. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher.

Combined Ecosystem Restoration

The Combined Ecosystem Restoration Alternative would serve to implement ecosystem restoration measures in combination with the non-structural flood damage reduction and recreation features for a multi-purpose plan. The plan would be the same whether a 1% ACE buyout was proposed or a 4% ACE buyout was proposed. The additional lands would be used for recreation, not ecosystem restoration.

The combined ecosystem restoration measures would be to restore the eight specific areas identified under the ecosystem restoration only plan and add three more areas that are being acquired for flood damage reduction for a total of eleven areas, located within the Timber Creek, Onion Creek Forest, and Bear Onion Confluence areas of interest, by converting or restoring the existing vegetation type to riparian woodlands using the scales identified under the ecosystem restoration only plan.

An incremental analysis was conducted using IWR-Plan and 186 cost effective plans were identified. Of the 186, there were 23 best buy plans. Based on the results it was determined that for the conversion to riparian woodland on Onion Creek for the Ecosystem Restoration Only Plan, applying scale 1 (identified above) in all of the eleven areas would be recommended for the Onion Creek Combined Restoration Plan. This combination would have a first cost of $3,289,000 and allow net habitat gains of + 85.28 units at an annual cost of $203,000. The annual cost per AAHU would be $2,400. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher.

Williamson Creek

Similar to Onion Creek, for Williamson Creek an ecosystem restoration plan was developed that was never intended to be implemented, but rather was for cost comparison and to perform cost allocation. Because the flood damage reduction alternatives are proposed to be combined with ecosystem restoration and recreation, as discussed in the preliminary screening of alternatives, a combined non-structural ecosystem restoration plan and a combined structural ecosystem restoration was investigated for a total of three ecosystem restoration plans for Williamson Creek. The Recommended Restoration Plan for Williamson Creek would depend on which type of flood damage reduction plan would be recommended.

Ecosystem Restoration Only

The ecosystem restoration only measures would be to restore eight specific areas, located within the Heartwood, Radam, Broken Bow and Bayton Loop areas, by converting or restoring the existing vegetation type to riparian woodlands using the scales identified under the Onion Creek Ecosystem Restoration Only Plan.

An incremental analysis was conducted using IWR-Plan and 185 cost effective plans were identified. Of the 185, there were 19 best buy plans. Based on the results it was determined that for the conversion to riparian woodland on Onion Creek for the Ecosystem Restoration Only Plan,

applying scale 1 (identified above) in all of the eight areas would be recommended for the Ecosystem Restoration Only Plan. The project first cost is estimated at $2,256,000. This combination would allow net habitat gains of + 60.93 units at an average annual cost of $139,000. The annual cost per AAHU would be $2,900. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher.

Combined Non-Structural Ecosystem Restoration

The Combined Ecosystem Restoration Alternative would serve to implement ecosystem restoration measures in combination with the non-structural flood damage reduction and recreation features for a multi-purpose plan. The combined ecosystem restoration measures would be to restore 15 specific areas, located within the Heartwood, Radam, Broken Bow, and Bayton Loop area of interest, by converting or restoring the existing vegetation type to riparian woodlands using the scales identified under the ecosystem restoration only plan.

An incremental analysis was conducted using IWR-Plan; however, due to 15 measures and 3 scales for each measure and IWR-Plan not able to calculate that large of a volume of combination plans, the measures were broken up into restoration lands (8 areas) and combined use lands (Lands being acquired for flood damage reduction and restored for ecosystem restoration) (7 areas) and run separately. For the restoration only lands, there were 214 cost effective plans identified. Of the 214, there were 18 best buy plans. For the combined lands there were 180 cost effective plans with 18 best buy plans.

Based on the results, it was determined that for the conversion to riparian woodland on Williamson Creek for the restoration lands, applying scale 1 (identified above) in the 8 restoration areas would be recommended for this combined plan. This combination would allow habitat gains of + 50.83 units at an average annual cost of $119,000. In addition, applying scale 1 on the 7 combined area lands would also be recommended for this combined plan. This combination would allow habitat gains of + 13.84 units at an average annual cost of $29,000. This would allow for a total gain for the Combined Non-Structural Ecosystem Restoration Plan of + 64.67 AAHU's at an average annual total cost of $148,000. The total project first cost is estimated at $2,389,000. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher.

Combined Structural Ecosystem Restoration

The ecosystem restoration measures evaluated with this plan would be implemented in combination with the proposed structural flood damage reduction alternative on Williamson Creek. This would include restoring nine areas to riparian woodlands using one of scales 1-3 as well as restoring parkland using one of scales 4-6 on the 13 areas of lands that would be acquired to implement the flood damage reduction measures after the flood damage reduction portion of the study would be constructed. This plan would provide a linear corridor of riparian woodlands throughout the study area from Brodie Lane to below Congress Avenue if all portions were constructed. The only breaks in the corridor would be at existing road crossings and utility lines. A portion of the lowest cost restoration benefits and costs would be allocated towards mitigation requirements as a result of the structural flood damage reduction measure being implemented.

Scale 0: No Action

Scale 1: Acquisition of restoration only land and restoration to woodlands using seedling trees and shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 300 trees, 150 shrubs, and woodland grass forbs mix per acre
Woodland Conversion: 75 trees, 100 shrubs, and no grass and forbs mix per acre.

Parkland Conversion: 200 trees, 250 shrubs, and woodland grass and forbs mix per acre.
Urban/Bare Ground Conversion: 300 trees, 150 shrubs, and woodland grass forbs mix per acre

Scale 2: Acquisition of land and restoration to woodlands using one-inch caliper trees, one-gallon shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 75 trees, 110 shrubs, and woodland grass forbs mix per acre
Woodland Conversion: 50 trees, 75 shrubs, and no grass and forbs mix per acre
Parkland Conversion: 70 trees, 210 shrubs, and woodland grass and forbs mix per acre
Urban/Bare Ground Conversion: 75 trees, 110 shrubs, and woodland grass forbs mix per acre

Scale 3: Acquisition of land and restoration to woodlands using two-inch caliper trees, five-gallon shrubs, and native grass and forbs seed with the following quantities:

Grassland Conversion: 50 trees, 80 shrubs, and woodland grass forbs mix per acre
Woodland Conversion: 50 trees, 50 shrubs, and no grass and forbs mix per acre
Parkland Conversion: 70 trees, 210 shrubs, and woodland grass and forbs mix per acre
Urban/Bare Ground Conversion: 50 trees, 80 shrubs, and woodland grass forbs mix per acre

Scale 4: Acquisition of flood damage reduction land, build structural project, and restore to parkland using seedling trees and native grass and forbs seed mix with the following quantities:

Urban/Bare Ground Conversion: 50 trees and woodland grass forbs mix per acre

Scale 5: Acquisition of flood damage reduction land, build structural project, and restore to parkland using 1” caliper trees and native grass and forbs seed mix with the following quantities:

Urban/Bare Ground Conversion: 25 trees and woodland grass forbs mix per acre

Scale 6: Acquisition of flood damage reduction land, build structural project, and restore to parkland using 2” caliper trees and native grass and forbs seed mix with the following quantities:

Urban/Bare Ground Conversion: 25 trees and woodland grass forbs mix per acre

Under scales 1, 2, and 3 identified above, the ecosystem restoration would include removing exotic or invasive species, such as ligustrum and Chinaberry, and then restoring a diversity of native species identified in Appendix B, Addendum B-3 with the densities identified above. The invasive species removal would primarily be completed by mechanical or hand removal methods with herbicide treatment.

An incremental analysis was conducted using IWR-Plan; however, and again due to IWR-Plan not being able to calculate a large volume of combination plans, the measures were broken up into restoration lands (9 areas) and combined use lands (Lands being acquired for flood damage reduction and restored for ecosystem restoration) (13 areas) and run separately. For the restoration only lands, there were 234 cost effective plans identified. Of the 234, there were 24 best buy plans. For the combined lands there were 118 cost effective plans with 23 best buy plans.

Based on the results, it was determined that for the conversion to riparian woodland on Williamson Creek for the Combined Structural Ecosystem Restoration Plan, applying scale 1 on the nine restoration only areas would be recommended for this combined plan. This combination

would allow habitat gains of + 45.67 units at an average annual cost of $109,000. In addition, applying scale 4 (conversion to parkland) in seven of the thirteen areas would also be recommended for this combined plan. This combination would allow habitat gains of + 5.68 units at an average annual cost of $6,000. This would allow for a total gross gain of + 51.35 AAHU's at an average annual total cost of $115,000 for the Combined Structural Ecosystem Restoration Plan. Approximately 9.3 AAHU's and $13,300 average annual dollars would have to be allocated to mitigation requirements. Therefore, there would be a net gain of 42.05 AAHU's at an average annual cost of $101,000. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher.

Summary of Ecosystem Restoration

Table 4-5 presents a summary of the incremental analysis for each plan that was evaluated.

Table 4-5
Summary of Incremental Analysis

PLAN	FIRST COST FOR CONSTRUCTION	ACRES	TOTAL HU NO ACTION	TOTAL HU GAIN	AAC TOTAL	TOTAL AAC/HU
OC ER ONLY	**$2,848,000**	**217.49**	**112.27**	**69.1**	**$175,000**	**$2,500**
Timber Creek	$232,000	16.03	6.98	5.86	$14,000	$2,400
OCF/Yarrabee Bend	$2,460,000	195.6	96.68	60.97	$151,000	$2,500
Bear/Onion	$155,000	5.86	8.61	2.27	$10,000	$4,000
OC COMBINED PLAN	**$3,289,000**	**256.04**	**121.36**	**85.28**	**$203,000**	**$2,400**
Timber Creek	$232,000	16.03	6.98	5.86	$14,000	$2,400
OCF/Yarrabee Bend	$2,822,000	221.28	105.59	73.26	$174,000	$2,400
Bear/Onion	$234,000	18.73	8.79	6.16	$15,000	$2,400
WC ER ONLY	**$2,256,000**	**148.4**	**58.71**	**60.93**	**$139,000**	**$2,300**
Heartwood	$258,000	16.5	4.5	7.81	$16,000	$2,100
Radam	$667,000	39.05	9.17	20.86	$41,000	$2,000
Broken Bow	$279,000	16.59	4.57	8.46	$17,000	$2,000
Bayton Loop	$1,052,000	76.29	40.47	23.8	$65,000	$2,700
WC COMBINED NS PLAN	**$2,389,000**	**155.61**	**56.15**	**64.67**	**$148,000**	**$2,300**
Heartwood	$232,000	14.35	3.62	7.13	$15,000	$2,000
Radam	$552,000	32.86	7.64	16.86	$34,000	$2,000
Broken Bow	$461,000	27.12	5.24	14.36	$29,000	$2,000
Bayton Loop	$614,000	81.28	39.65	26.32	$71,000	$2,700
WC STRUCTURAL PLAN*	**$1,842,000**	**140.44**	**48.41**	**51.35***	**$115,000***	**$2,200***
Heartwood	$185,000	13.95	2.87	6.04	$12,000	$2,000
Radam	$475,000	30.95	6.27	15.22	$30,000	$2,000
Broken Bow	$170,000	17.13	2.53	6.27	$11,000	$1,700
Bayton Loop	$1,011,000	78.41	36.74	23.82	$63,000	$2,600

Note: * AAC and AAHU gained and AAC/AAHU would change as a result of mitigation requirements of the structural plan.

REGIONAL DETENTION

The regional detention concept for reducing flood flows on Onion Creek has been the focus of several studies in recent years. For example, a study performed for the City of Austin by Loomis and Moore, Inc., in 1997, evaluated detention sites both upstream and downstream of Interstate Highway 35. Findings of this study concluded that detention would be costly, with limited reductions in flow rates for the primary point of interest (Onion Creek Forest/Yarrabee Bend). Nonetheless, this was the only option that would clearly reduce damages throughout the watershed, including those areas in the Onion Creek subdivision and the Bluff Springs Road/Perkins Valley area, where local structural and non-structural plans proved ineffective.

Instead of reevaluating the same locations that were previously analyzed, the decision was made to identify an alternative site that best met selected criteria. It would need to be raw land with little development, have the ability to store sufficient amounts of floodwaters, and located sufficiently close enough to the areas of interest to reduce the peak flows. The site selected for evaluation was located on Onion Creek, immediately south of the Travis-Hays County line, near the town of Buda.

The detention and spillway were sized to maximize its effects on the 1% ACE discharge. The design height was generally limited by the elevation of Interstate 35, located to the east. The location of the dam footprint, and the design flood pool area is shown in Figure 4-15.

As configured, the regional detention was estimated to have a first cost of $77,800,000 (December 2004 prices), and a total investment cost of $84,600,000. Using a 50-year period of analysis and the Fiscal Year 2006 interest rate of 5.125%, the annualized cost was approximately $5,000,000. This compares to average annual benefits of $600,000, resulting in a benefit to cost ratio of approximately 0.12. Based on these findings, further analysis of regional detention was not undertaken, and regional detention was removed from further consideration.

TIMBER CREEK

As discussed in the initial screening of alternatives, a viable structural alternative for the Timber Creek area of interest was not identified. Permanent evacuation of the floodplain combined with ecosystem restoration and/or recreation will be investigated in more detail. The detailed analysis of the non-structural flood damage reduction measures in combination with recreation and restoration are discussed below.

Reduction of flood damages within this area of concern is the primary objective. No standalone ecosystem restoration plan was investigated for possible implementation. However, ecosystem restoration possibilities were evaluated in combination with a nonstructural combined plan.

No Action

In the absence of any flood damage reduction project, the flooding would continue to be experienced in the Timber Creek area. The expected annual damages associated with flooding in this area are estimated at approximately $259,000. Federal funds would also continue to be expended in the flood insurance program and in federal emergency flood assistance and relief efforts. A major portion of the Timber Creek area lies within the FEMA designated floodway and when flooding occurs, it causes substantial damages to the existing structures.

The population within the Onion Creek Watershed is continuing to grow at a rapid rate. Continued urban growth would add to impervious cover within the watershed, which in turn would increase the potential for increased flood damages downstream of the new development. From a hydrologic and hydraulic standpoint, this impact is significantly reduced by the city of Austin's

Watershed Protection Ordinances, which prohibit future increase in the peak 1% ACE discharge from the area being developed. However, direct loss of habitat would continue throughout the watershed as vegetation is removed for construction. In addition to development in the upper watershed, the Austin-Bergstrom International Airport was opened, and SH-130 is under construction within the vicinity of the Timber Creek area. Therefore, commercial and residential developments are being constructed and planned for development in the near future, which would continue to affect habitat within the Timber Creek area. Furthermore, it would be expected that the construction activities would increase sediment load in runoff from soil disturbance. After completion, because of the lack of appropriate vegetative buffers and sediment ponds, the water quality of the creek would be affected by increases in impervious surface area, traffic, lawn fertilizer and other human activities due to increasing nutrient load and pollutant levels in the creek.

Combined Plan

This proposed alternative would combine the permanent evacuation of the 4% ACE Floodplain with ecosystem restoration and recreation features as an alternate use of the vacated lands. Instead of just removing the structures and reseeding the lots, the structures would be removed and recreation facilities or restoration features would be added to gain additional benefits or enhance the value of land as wildlife habitat. The combined plan would recommend removal of 81 structures from the floodplain (90 parcels, total); construction of picnic areas, paved and unpaved trails, multi-use open fields, athletic courts, a playground, and parking areas; and reforestation of approximately 16 acres of riparian woodlands as shown on Figure 4-16. A total of 14 structures that receive damage would remain because even though they are in the economic reach, they are not within the confines of the area of interest. In addition, some structures would be purchased that do not currently receive damages at the 4% ACE event, but would at the 2% or 1% ACE event. These structures are being bought for community cohesion and so that there would not be residual residences scattered around the area of interest. In addition, although the structures do not receive damage because of high first floor elevations, there are safety concerns about being stranded in the floodway.

The exact number of structures and parcels to be acquired continues to be an ever-changing amount. This is due to several factors, including the time elapsed since the last major flood event, and number of structures purchased by the county. Since 1998, Travis County has actively pursued grants from FEMA to remove structures from the Timber Creek area. The County viewed the risk sufficient to take immediate action rather than wait for a total solution. As a result, 41 properties have been purchased using Federal funds provided by FEMA, and are currently owned by the County. For formulation purposes, the value of FEMA buyout properties have been excluded as part of the Corps analysis; the sponsor would not get credit for the purchase of these lands. Further, there are restrictions on these properties that prohibit any structures. It is assumed that these properties could be a part of the overall plan with these restrictions in place.

The design level for this alternative was selected after careful consideration of lower as well as higher levels. Buyout up to the 10% level was considered as an option. However, this left the area with a non-continuous hop-scotch pattern of properties. Additional properties would have to be acquired for continuity purposes, which would make this design level nearly equal to the 4% design level. Higher levels, 2% and 1% ACE, were briefly investigated, but it became apparent that buyout to the higher levels could not be economically justified, even if the lands were utilized for alternative uses. Thus, it was a straightforward decision to adopt the 4% floodplain as the target design level. If a multipurpose plan could be designed at this level to make a positive contribution to NED, as well as provide additional ecosystem restoration benefits, then it would meet all the requirements for designation as a Federal Supportable Plan.

The local sponsors identified facilities they wanted within a recreation facility if one were to be used as an alternate use of the vacated land. Three levels of these plans were then evaluated. These included a low, medium, and high density recreation plan. Optimization of these plans is discussed in Appendix A, Economics. The low density plan was selected as the plan that would be implemented for the Timber Creek area in combination with the proposed evacuation of the floodplain. The selected recreation plan has a first cost of approximately $1,033,000 and produces annual benefits of $438,000.

A summary of costs associated with the Combination Plan is shown in Table 4-6, with a benefit analysis shown in Table 4-7. The total first cost is estimated to be approximately $8,934,000 with $290,000 being associated with the ecosystem restoration measures. It should be noted that the restoration costs include the lands on which the footprint of the ecosystem restoration area is proposed, and this does not include any structure costs, which are allocated to flood damage reduction features.

As discussed earlier in this chapter, incremental analysis was conducted and combined structural ecosystem restoration plan was selected for Onion Creek as a whole. The combined restoration plan can be broken out by damage center using the first cost associated with each measure. The first costs were used to develop cost per benefit and total combined ecosystem restoration costs for this area of interest. For the Timber Creek area of interest, this plan included restoring the area identified on Figure 4-16 to riparian woodlands. This plan would produce 5.9 AAHU at a first cost of approximately $290,000 and an annual cost of $16,000 for an annual cost per AAHU of $2,800.

Environmental Impacts

Only short term adverse impacts to air quality, water quality, and aquatic resources are expected during the Construction phase of the removal of houses. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. Short term, temporary impacts to water quality and aquatic resources would result from stormwater runoff if rainfall events occurred before vegetation was reestablished. These impacts would be reduced by implementing best management practices such as silt fences. There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. The construction area is comprised of a substantial amount of large trees that would be avoided to the extent practical during the removal of the houses and the construction of the recreation facilities. This plan would provide 5.9 average annual habitat units of riparian habitat over the “No Action” in the restored areas. Restoration at this site would improve many more acres than the identified 16 acres due to the fact that residences would be removed and the area would be turned into an open space park. In addition, the restoration area is connected to many acres of riparian areas owned by the Boy Scouts of America. This land is expected to stay in their ownership and remain untouched for the distant future. Therefore, the whole ecosystem in this reach of Onion Creek would be improved by removing residential structures and restoring the restoration areas. The restoration area would not be used for recreation, with the exception of nature trails throughout portions of the restoration area, and would be separated from the recreation area by a road. This alternative is the most environmental friendly cost effective alternative that was considered. A buyout alone with complete restoration of the area would be more environmentally friendly, but the project would not be justified without the recreation. There would be no mitigation required to implement this plan. This plan would reduce county revenue by removing approximately 90 parcels off of the tax roles in Travis County. Additional refinements of this plan, along with slight changes in outputs, will likely occur during the Feasibility design phase.

Cultural Resources

Cultural resources assessments of the Timber Creek floodplain indicate that no Historic Properties are present within the project area of potential effect.

HTRW

Literature reviews and site assessments indicate that there are no hazardous, toxic or radioactive wastes (HTRW) concerns.

Table 4-6
Timber Creek
Summary of Costs for Combination Plan
(December 2004 prices)

Item	***Cost***
Demolition and removal	$705,000
Administrative	$186,000
Structure/Land (fdr portion)	$5,085,000
Engineering and Design	$71,000
Construction S&A	$42,000
25% Contingency	$1,522,000
Subtotal	**$7,611,000**
ECOSYSTEM RESTORATION	
Restoration	$232,000
25% Contingency	$58,000
Subtotal	**$290,000**
RECREATION	
Recreation	$827,000
25% Contingency	$206,000
Subtotal	**$1,033,000**
Total 4% ACE buyout	**$8,934,000**

Table 4-7 **Timber Creek** **Benefit Computations for Combination Plan** (December 2004 Prices and 5.125%)	
FLOOD DAMAGE REDUCTION	
INVESTMENT	
Total First Cost	$8,934,000
Restoration Cost	$290,000
FDR/Recreation Cost	$8,644,000
Interest During Construction	$333,000
Investment Cost	$8,976,000
ANNUAL CHARGES	
Interest	$460,000
Amortization	$41,000
O&M	$50,000
Total Annual Charges	**$551,000**
ANNUAL BENEFITS	
Inundation Reduction	$216,000
Insurance Reduction	$14,000
Recreation	$438,000
Total Annual Benefits	**$668,000**
Net Annual Benefits	**$115,000**
Benefit-to-Cost Ratio	**1.2**
ECOSYSTEM RESTORATION	
INVESTMENT	
Total First Cost	$290,000
Interest During Construction	$11,000
Investment Cost	$301,000
ANNUAL CHARGES	
Interest	$15,000
Amortization	$1,000
Total Annual Charges	$16,000
ANNUAL BENEFITS	
AAHU	5.86
AAC/AAHU	**$2,800**

ONION CREEK FOREST/YARRABEE BEND

As discussed in the initial screening of alternatives, both structural and non-structural alternatives were carried forward for more detailed investigations. The non-structural measure, permanent evacuation of the floodplain, will have to be jointly formulated with recreation, ecosystem restoration, or both in order to develop a justified multipurpose plan. The combination plans as well as the structural plan and No Action are discussed below.

Reduction of flood damages within this area of concern is the primary objective. As such, no standalone ecosystem restoration plan is discussed for possible implementation. However, ecosystem restoration possibilities were evaluated as part of a combination plan.

No Action

In the absence of any type of flood damage reduction project, the flooding problems experienced in the OCF/Yarrabee Bend area would continue. As stated previously, in Chapter 3, the annual damages associated with flooding in this area under future without-project conditions are estimated at approximately $2,088,000. Federal funds would also continue to be expended to support the flood insurance program and in federal emergency flood assistance and relief efforts provided during flood events.

The population within the Onion Creek Watershed is continuing to grow at a rapid rate. This growth would add to impervious cover within the watershed, which in turn would increase the potential for increased flood damages downstream of the new development. From a hydrologic and hydraulic standpoint, this impact is significantly reduced by the city of Austin's Watershed Protection Ordinances, which prohibit any increase in the peak 1% ACE discharge from the area being developed. However, direct loss of habitat would continue throughout the watershed as vegetation is removed for construction. The forested riparian vegetation zone within much of the watershed in this area is already narrow with several grass and shrub openings. The number and size of the openings would increase and there would be fewer acres of forest in the future. The loss of habitat, particularly the bottomland hardwoods, would reduce the numbers of wildlife and bird species within the watershed, especially migratory songbirds, which are particularly susceptible to the loss of habitat along their migration routes. Furthermore, it would be expected that the construction activities would increase sediment load in runoff from soil disturbance. After completion, because of the lack of appropriate vegetative buffers and sediment ponds, the water quality of the creek would be affected by increases in impervious surface area, traffic, lawn fertilizer and other human activities due to increasing nutrient load and pollutant levels in the creek.

The No Action alternative in OCF/Yarrabee Bend would be recommended only if no other solutions are feasible, or when environmental damage associated with other alternatives would be irreparable.

Structural Alternatives: Combination Levee, Floodwall, Diversions, Channel Modifications

The structural alternative formulated during the preliminary screening identified a combination of several levees, floodwalls, diversions, and channel modifications. In addition, some residential structures were identified for acquisition and removal, due to the land being needed to construct the project features such as levees and sumps. Because of the nature of the hydrology and hydraulics of this area, and the extent of the floodplain, the structural alternative was very complex and was comprised of many different measures.

The structural plan, developed in the preliminary analysis is shown on Figure 4-7. The plan includes three major components – two diversions and levees (including a flood wall). As part of the detailed formulation, each component was analyzed incrementally. The most downstream

component, a diversion, was considered to be the most cost effective component. For this reason, and for hydraulic design reasons, it was selected as the first element to be sized to maximize net benefits. An array of sizes ranging from a 100-foot bottom width upwards to a 570-foot bottom width was evaluated. Table 4-8 presents the results of the optimization, with the 100-foot bottom width plan, the smallest evaluated, providing the highest net benefits. No narrower width was evaluated due to the relatively small reduction in water surfaces and overall damages that was being achieved.

Table 4-8
Phase IIA Alternatives Analysis
Onion Creek Forest/Yarrabee Bend
Summary of Costs and Benefits for Various Diversions
(December 2004 Prices and 5.125%)

Size	*First cost*	*Ann. Cost*	*Ann. Ben.*	*Net*	*BCR*
100 foot bottom width	$4,269,400	$304,100	$524,000	$219,900	1.72
200 foot bottom width	$5,257,300	$362,900	$565,000	$202,100	1.56
300 foot bottom width	$6,384,500	$430,000	$593,000	$163,000	1.38

The second element of the plan to be evaluated was the levee. Varying heights and alignments of the levee component were evaluated, with the 200-foot bottom width diversion in place (thought to be the optimal size at the time). As the evaluation progressed, it became apparent that the levee had several critical negative impacts.

1. Despite the presence of the downstream diversion, the levees continued to create a significant rise in water surfaces within the current reach, as well as in the reach upstream of the levees. Note that the second diversion was intended to provide relief for this inducement, but at a significant cost.

2. Additional environmental investigations within this reach confirmed it as an area of high value for habitat. Also, more detailed investigations revealed that the region's largest, most valuable cypress trees were located along the natural creek bank. These factors essentially eliminated any possibility of undertaking channel excavation to counter the increased water surfaces.

After evaluating an array of different levee heights and alignments, the best performing levee plan had a first cost of approximately $18,700,000, with a BCR of approximately 0.5. Even if the inducements were ignored, the BCR was still well below unity. Given these findings, no further analyses of the levee component were undertaken.

The third element of the plan was intended to address the inducements, as well as assist with local drainage issues. Since the levee component was not economically feasible, even with the inducements ignored, evaluation of this element was no longer necessary.

The omission of the levee component left only the first diversion as an economically viable structural alternative. The BCR was above unity, but the construction of the plan would cause significant environmental damages. Further, it reduced the expected annual flood damage by only 26%, leaving an unacceptable amount, approximately $1.5 million in annualized residual damages for the Yarrabee Bend/Onion Creek Forest reach. Larger diversions were evaluated, but the benefits curve remained fairly flat. They did not provide a significant increase in additional benefits, while the costs were substantially higher.

Environmental Impacts

Only short term adverse impacts to air quality and noise levels are expected during the Construction activities. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. There would be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. Normal stream flow would not be affected. During high rain events, the diversion channel would take peak flows and bypass an oxbow in the creek and move water downstream faster. Bypassing the oxbow would have minimal impacts to the aquatic resources as the small events would still flow down the main channel. There would, however, be impacts to the vegetation in the oxbow as a result of not allowing over bank flooding. This would cause the riparian corridor to become narrower over time. The layout of the diversion channel would directly affect several acres of riparian woodlands that would have to be mitigated. The exact acreages of damages due to the layout were not determined. The levee in combination with the diversion channel would cause upstream inducements that would have to be hydraulically mitigated. In order to perform hydraulic mitigation, approximately 50 acres of high quality riparian woodlands would be removed to perform benching. These riparian woodlands are high quality woodlands with some of the regions highest quality cypress trees. Unlike other large trees, large cypress trees are scarce on Onion Creek and are limited to the riparian zone of creeks and rivers. In order to perform in-kind mitigation, it was anticipated that approximately 250-300 acres would be required along Onion Creek. Indirect impacts could occur to the woodlands in the oxbow due to less frequent over bank exposure, but these impacts are expected to be very minimal. Minor downstream impacts would be expected downstream of the discharge of the diversion channel due to increased water velocities. Approximately 310,000 cubic yards of excavation materials would be removed to construct the diversion channel. Traffic would be temporarily affected because the bridges would have to be raised or constructed over the diversion channel and from increased truck traffic hauling the excavated materials. The materials would be disposed of in the landfill.

Cultural Resources

Although no cultural resources were identified during initial site visits, due to the fact that large amounts of excavations would occur next to the creek and a previous archeological site in recorded in the general area, extensive cultural surveys would more than likely be needed. If any cultural sites were found, they would have to be mitigated.

HTRW

Literature reviews and site assessments indicate that there are no hazardous, toxic or radioactive wastes (HTRW) concerns.

Combined Plan A (4%)

During the preliminary investigations, Permanent Evacuation (buyout) was shown to have potential. The 4% ACE floodplain level was used for the initial investigation, based on professional judgment and experience from other studies.

To optimize a buyout plan typically an array of alternatives are analyzed. At the 10% ACE level for the Onion Creek Forest/Yarrabee Bend area, however, only three single family structures, 12 multi-family and eighteen mobile homes have a first floor elevation below the 10% ACE level. Evacuation of these few structures would do little to resolve the significant flooding problems in the reach, which has 360 structures below the 4% ACE level. Thus, the 4% plan was considered to be the minimal level to be evaluated. A higher level plan, a 1% level plan, will also be evaluated as requested by the local sponsor that could possibly be implemented as a locally preferred plan. During the time of formulation, the potential for a 2% ACE level plan was

investigated using several distinguishing metrics. For example, the additional increment of 213 houses (573 2% ACE minus 360 4% ACE) would cost over $20 million (1.2 annualized) with a return of about $250,000 annually. This would result in an incremental benefit-to-cost ratio of about 0.2 for flood damage reduction only, meaning recreation would have to support 80 percent of the costs for the increment to be favorable. This was not a reasonable expectation and thus a full evaluation of the 2% ACE level plan was omitted.

In order to better understand the unusual, non-linear relationship of the number of structures occupying a given floodplain level, one must understand two important influences. First, the majority of the existing structures are constructed in a level, plateau portion of the floodplain, which once had likely been a native pecan grove. As soon as floodwaters exceed bank capacity, the entire plateau is inundated. Second, the subdivision was constructed before the establishment of the City's initial floodplain management ordinances. This ordinance forced builders to set first floor elevations at one foot above the flood profile. Unfortunately, the initial 1970's floodplain determinations were grossly underestimated. The change in the 1% ACE was primarily the result of significant modeling inaccuracies associated with the original 1970's flood insurance study effort, and not by ongoing development. More up-to-date technology was utilized and the official FEMA maps were revised in the mid 1990's, with base flood elevations increasing by as much as six feet. This resulted in the entire neighborhood sharing a similar flood risk that is far greater than the original "one foot above the 1% ACE" that was dictated by the ordinance when the structures were constructed.

The alternative proposed for evaluation would combine a permanent evacuation of the 4% ACE floodplain with ecosystem restoration and recreation features as alternate uses of the vacated lands. Some additional lands adjacent to Onion Creek are also proposed to be acquired for ecosystem purposes. The structures within this area would be removed and recreation facilities or restoration features would be constructed on the project lands to gain additional benefits or enhance the value of land as wildlife habitat. The plan would call for acquiring and removing approximately 410 structures from the floodplain. These structures are highlighted in Figure 4-17. Only 360 of these receive damage at the 4% ACE level; however, the additional 50 are structures that receive damage at the 2% or 1% ACE level, but would need to be acquired for continuity purposes in order to have community cohesion. The vacated lands would be used for construction of picnic areas, paved and unpaved trails, parking areas, playground, multiple use open fields, athletic courts, and vegetative buffers; and reforestation of approximately 221 acres of riparian woodlands as show in Figure 4-18.

The project first costs associated with this alternative would be approximately $45,799,000 and are shown in Table 4-9, and the benefit computations are shown in Table 4-10. Damages within the reach would be reduced by over 75%. Total annual costs would be approximately $2,890,000 and the project would result in $3,890,000 in benefits, which would produce a BCR of 1.4. The combined plan would result in annual net benefits of approximately $1,000,500. This plan would also produce 73 AAHU of riparian habitat.

The local sponsors identified facilities they wanted within a recreation facility if one were to be used as an alternate use of the vacated land. Three levels of these plans were then evaluated. These included a low, medium, and high density recreation plan. Optimization of these plans is discussed in Appendix A, Economics. The plan that was selected to be implemented in the Onion Creek Forest/Yarrabee Bend area in combination with the proposed 4% evacuation of the floodplain has a first cost of approximately $2,513,000 and produces annual benefits of $2,318,000.

As discussed earlier in this chapter, incremental analysis was conducted and combined structural ecosystem restoration plan was selected for Onion Creek as a whole. The combined restoration plan can be broken out by damage center using the first cost associated with each measure. For the Onion Creek Forest/Yarrabee Bend area of interest, the first costs were used

and engineering and design and construction supervision and administration were added to develop a cost per benefit and total combined ecosystem restoration costs for this area of interest (Table 4-10). It should be noted that the costs used during the incremental analysis in Appendix B included land costs that should have been allocated to flood damage reduction, so the total first cost was reduced by $168,000 to account for this discrepancy. The combined plan included restoring the areas identified on Figure 4-18 to riparian woodlands. This plan would produce 5.9 AAHU at a first cost of approximately $3,650,000 and an annual cost of $215,000 for an annual cost per AAHU of $2,900.

Table 4-9
Onion Creek Forest/Yarrabee Bend
Summary of Costs for Combination Plan A
(December 2004 prices)

Item	***Cost***
Demolition and removal	$2,931,000
Administrative	$3,015,000
HTRW	$655,000
Structure/Land (fdr portion)	$27,197,000
Engineering and Design	$494,000
Construction S&A	$335,000
25% Contingency	$8,658,000
Subtotal	**$43,285,000**
ECOSYSTEM RESTORATION	
Restoration including Lands	$2,654,000*
Engineering and Design	$166,000
Construction S&A	$100,000
25% Contingency	$730,000
Subtotal	**$3,650,000**
RECREATION	
Recreation	$2,011,000
25% Contingency	$502,000
Subtotal	**$2,513,000**
Total FDR and REC	**$45,799,000**
Total Project Cost	**$49,448,000**

Note: *Restoration cost was reduced from $2,822,000 to $2,654,000 ($168,000) because of double counted land cost on FDR lands.

Table 4-10 **Detailed Alternative Analysis** **Onion Creek Forest/Yarrabee Bend** **Benefit-Cost for Combination Plan A (4%)** (December 2004 Prices and 5.125%)	
FLOOD DAMAGE REDUCTION	
INVESTMENT	
Total First Cost	$45,799,000
Interest During Construction	$2,367,000
Investment Cost	$48,166,000
ANNUAL CHARGES	
Interest	$2,469,000
Amortization	$221,000
O&M	$200,000
Total Annual Charges	**$2,890,000**
ANNUAL BENEFITS	
Inundation Reduction	$1,458,000
Other	$114,000
Recreation	$2,318,000
Total Annual Benefits	**$3,890,000**
Net Annual Benefits	**$1,001,000**
Benefit-to-Cost Ratio	**1.4**
ECOSYSTEM RESTORATION	
INVESTMENT	
Total First Cost	$3,650,000
Interest During Construction	$189,000
Investment Cost	$3,839,000
ANNUAL CHARGES	
Interest	$197,000
Amortization	$18,000
Total Annual Charges	$215,000
ANNUAL BENEFITS	
AAHU	73
AAC/AAHU	**$2,900**

Environmental Impacts

Only short term adverse impacts to air quality, water quality, and aquatic resources are expected during the Construction phase of the removal of houses. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. Short term, temporary impacts to water quality and aquatic resources would result from stormwater runoff if rainfall events occurred before vegetation was reestablished. These impacts would be reduced by implementing best management practices such as silt fences. There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. No wetlands were present that would be affected from the removal of structures. The construction area is comprised of a substantial amount of large trees that would be avoided to the extent practical during the removal of the houses and the construction of the recreation facilities. This plan would provide 73 average annual habitat units, over the No Action, of riparian habitat in the restored areas. Restoration at this site would improve many more acres than the identified 221 acres of ecosystem restoration due to the fact that residences would be removed and the entire buyout area would be turned into an open space park. In addition, the restoration area is connected to many acres of riparian areas already

owned by the City of Austin. This land is expected to stay in their ownership and remain untouched for the distant future. Therefore, the whole ecosystem in this reach of Onion Creek would be improved by removing residential structures and restoring the restoration areas. The restoration area would not be used for recreation, with the exception of nature trails throughout portions of the restoration area, and would be separated from the recreation area by a road. This alternative is the least environmentally damaging, cost effective alternative that was considered. A buyout alone with complete restoration of the area would be more environmentally friendly, but the project would not be justified without the recreation. This plan would reduce county revenue by removing approximately 410 parcels off of the tax roles in Austin and Travis County. Additional refinements of this plan, along with slight changes in outputs, would occur during the Feasibility design phase.

Cultural Resources

Cultural resources assessments of the OCF/Yarrabee Bend floodplain indicate that no Historic Properties are present within the project area of potential effect.

HTRW

Literature reviews and site assessments indicate that the proposed structure and removal alternatives would present no hazardous, toxic or radioactive wastes (HTRW) concerns. It is likely, however, that some of these residential structures would contain materials for which special handling and disposal would be required. These materials would include asbestos-containing materials (ACM), polychlorinated biphenlyls (PCB), mercury, chlorinated fluorocarbons (CFC), and miscellaneous wastes such as pesticides, paints, solvents, and used oils. Furthermore, although debris from the demolition of residential structures which had previously received applications of lead-based paint (LBP) is exempt from the definition of hazardous wastes, the contractor would be required to perform a lead exposure assessment prior to demolition to ensure workers are properly protected. An assessment of HTRW would have to be performed for every structure, estimated to cost approximately $1,500 per structure. The City of Austin has recently purchased several structures in the neighborhood, and little-to-no materials requiring special handling were found. For cost estimating purposes, an assumption was made that such materials would be found in 5% of the homes, and removal and disposal of the materials was estimated at approximately $20,500 per structure.

Combined Plan B (1%)

This proposed alternative is basically a larger version of Combined Plan A. It would combine Permanent Evacuation of the 1% ACE floodplain with ecosystem restoration and recreation features as alternate uses of the flood damage reduction land. The structures would be removed and recreation facilities or restoration features would be constructed on the project lands to gain additional benefits or enhance the value of land as wildlife habitat. This plan investigated the removal of 700 structures from the floodplain; construction of picnic areas, paved and unpaved trails, parking areas, playground, multiple use open fields, athletic courts, Frisbee disc golf course, and vegetative buffers; and, reforestation of approximately 221 acres of riparian woodlands as shown in Figure 4-19. Restoration of these woodlands would result in the gain of 73 AAHU over the No Action.

Combined Plan B has several advantages over Combined Plan A. These advantages, however, are not necessarily reflected in the key indicators, such as net economic benefits. These advantages include safety benefits to residents as well as emergency responders. Roads leading into the area are generally cut off by flood waters, which have resulted in some daring rescues during previous flood events. The City of Austin, as sponsor for this study, specifically requested that a higher level plan be developed for comparison purposes and possible implementation as a locally preferred plan.

The local sponsors identified facilities they wanted within a recreation facility if one were to be used as an alternate use of the vacated land. Three levels of these plans were then evaluated. These included a low, medium, and high density recreation plan. Optimization of these plans is discussed in Appendix A, Economics. The plan that was selected to be implemented in the Onion Creek Forest/Yarrabee Bend area in combination with the proposed 1% evacuation of the floodplain has a first cost of approximately $2,794,000 and produces annual benefits of $2,559,000.

Potential flood damages within this reach would be reduced by approximately 95%, making this an extremely effective plan. The plan's overriding drawback is its high initial cost, as shown in Table 4-11. Table 4-12 shows the total cost allocated to flood damage reduction and recreation (excludes cost of ecosystem restoration), and then it provides a comparison of the annualized costs to the annualized benefits to be achieved. It is apparent that the overall plan would not provide higher benefits than costs. Thus, Combined Plan B is not eligible for consideration as a recommended plan.

The Combined Plan B would have the same ecosystem restoration as Combined Plan A. This is due to the fact that additional lands that would be acquired would be needed for recreation rather than ecosystem restoration. Therefore, the incremental analysis used for Combined Plan A would stand for this plan also. Table 3-7 and 3-8 provide the economic summary and benefits of the proposed ecosystem restoration.

Environmental Impacts

The impacts of this alternative would be almost identical to the Combined Plan A for Onion Creek Forest/Yarrabee Bend. The ecosystem restoration areas and benefits would be the same for both plans. However, there would be further improvement to the area, because the amount of houses removed would increase and the additional acres of improved land would increase. This would however remove an additional 290 houses from the tax roles.

Cultural Resources

Cultural resources assessments of the OCF/Yarrabee Bend floodplain indicate that no impacts would be expected with implementation of this evacuation alternative, due to a finding of no historic or prehistoric cultural properties in the area of potential effect.

HTRW

HTRW impacts would be the same as the Combined Plan A.

Table 4-11
Onion Creek Forest/Yarrabee Bend
Summary of Costs for Combination Plan B
(1% ACE)
(December 2004 prices)

Item	***Cost***
Demolition and removal	$5,258,000
Administrative	$5,393,000
HTRW	$1,416,000
Structure/Land (fdr portion)	$54,251,000
Engineering and Design	$973,000
Construction S&A	$535,000
25% Contingency	$16,957,000
Subtotal	**$84,783,000**
ECOSYSTEM RESTORATION	
Restoration including Lands	$2,654,000*
Engineering and Design	$166,000
Construction S&A	$100,000
25% Contingency	$730,000
Subtotal	**$3,650,000**
RECREATION	
Recreation	$2,235,000
25% Contingency	$559,000
Subtotal	**$2,794,000**
Total FDR and REC	**$87,577,000**
Total Project Cost	**$91,227,000**

Note: *Restoration cost was reduced from $2,822,000 to $2,654,000 ($168,000) because of double counted land cost on FDR lands.

Table 4-12 **Detailed Alternative Analysis** **Onion Creek Forest/Yarrabee Bend** **Benefit-Cost for Combination Plan B** **(1% ACE)** (December 2004 Prices and 5.125%)	
FLOOD DAMAGE REDUCTION	
INVESTMENT	
Total First Cost	$87,577,000
Interest During Construction	$4,527,000
Investment Cost	$92,103,000
ANNUAL CHARGES	
Interest	$4,720,000
Amortization	$423,000
O&M	$250,000
Total Annual Charges	**$5,393,000**
ANNUAL BENEFITS	
Inundation Reduction	$1,931,000
Other	$135,000
Recreation	$2,559,000
Total Annual Benefits	**$4,625,000**
Net Annual Benefits	**- $768,000**
Benefit-to-Cost Ratio	**0.9**
ECOSYSTEM RESTORATION	
INVESTMENT	
Total First Cost	$3,650,000
Interest During Construction	$189,000
Investment Cost	$3,839,000
ANNUAL CHARGES	
Interest	$197,000
Amortization	$18,000
Total Annual Charges	$215,000
ANNUAL BENEFITS	
AAHU	73
AAC/AAHU	**$2,900**

BEAR/ONION CONFLUENCE

General

Based on the preliminary findings, a non-structural evacuation plan, as well as an add-on structural levee/floodwall plan was carried forward to the detailed analysis phase. It became apparent during the early stages of the detailed analysis that the levee/floodwall portion had many shortcomings. The preliminary cost of the feature was found to have been underestimated by a significant amount. Also, the local drainage design was determined to be inadequate, adding more costs. Given the limited benefits to be attained along with the increase in costs, it became apparent that there was not an economically viable solution. Thus, the decision was made to discontinue the analysis of a structural plan, and focus exclusively on the permanent evacuation element.

Reduction of flood damages within this area of concern is the primary objective of the sponsor. As such, no standalone ecosystem restoration plan was formulated for possible implementation. However, ecosystem restoration possibilities were evaluated as part of a nonstructural combined plan.

No Action

In the absence of any type of flood damage reduction project, the flooding problems experienced in Bear/Onion Confluence would continue. The annual flood losses in this area are estimated at approximately $82,000. Federal funds would also continue to be expended in the flood insurance program and in federal emergency flood assistance and relief efforts. The population within the Onion Creek Watershed would continue to grow at a rapid rate. This growth would add to impervious cover within the watershed, which in turn would increase the potential for increased flood damages downstream of the new development. From a hydrologic and hydraulic standpoint, this impact is significantly reduced by the city of Austin's Watershed Protection Ordinances, which prohibit any increase in the peak 1% ACE discharge from the area being developed. However, direct loss of habitat would continue throughout the watershed as vegetation is removed for construction. Furthermore, it would be expected that the construction activities would increase sediment load in runoff from soil disturbance. After completion, because of the lack of appropriate vegetative buffers and sediment ponds, the water quality of the creek would be affected by increases in impervious surface area, traffic, lawn fertilizer and other human activities due to increasing nutrient load and pollutant levels in the creek.

Permanent Evacuation: 4% ACE Zone

Four structures were targeted for potential buy-out. They are located at the following addresses:

13009 Stagecoach Way
13011 Stagecoach Way
13015 Stagecoach Way
13019 Stagecoach Way

All four structures are single family residential, located within the 4% ACE flood zone, in a continuous area. This type of situation lends itself perfectly to being combined with either recreation or ecosystem restoration features to produce a viable, multi-purpose alternative.

A brief assessment was performed to determine if additional evacuation plans could be developed for both smaller (more frequent) and larger (less frequent) flood zones. It was concluded that since the 10% ACE zone did not contain any structures, the 4% level was the lowest to be evaluated. Conversely, the 2% ACE flood zone contains an additional 4 structures. However, these were not continuous to the area, and thus this level of evacuation had no practical chance of being economically viable. Thus, all remaining formulation efforts on this reach were spent developing a multipurpose plan based on evacuation of the 4% ACE flood zone.

When evaluated as a standalone evacuation plan, the test for economic viability was not passed. The total first cost of the plan was estimated at $780,000 (Table 4-13). When all costs were annualized using a 5.125% interest rate over a 50-year period of analysis, the cost was approximately $45,800 per year. Annualized benefits are estimated to be $29,700 for a benefit to cost ratio of 0.6 (Table 4-14).

Table 4-13 **Detailed Alternative Analysis** **Bear/Onion Confluence** **Permanent Evacuation 4% ACE** **Stand Alone** (December 2004 Prices)	
Flood Damage Reduction	
Item	**Cost**
Demo	$20,000
HTRW	$15,000
Structure/Land	$571,000
E&D	$10,000
S&A	$10,000
25% Contingency	$164,000
FDR Total	**$780,000**

Table 4-14 **Detailed Alternative Analysis** **Bear Onion Confluence** **Permanent Evacuation 4% ACE** (December 2004 Prices and 5.125%)	
FLOOD DAMAGE REDUCTION	
INVESTMENT	
Total First Cost	$780,000
Interest During Construction	$40,000
Investment Cost	$820,000
ANNUAL CHARGES	
Interest	$42,000
Amortization	$4,000
Total Annual Charges	**$46,000**
ANNUAL BENEFITS	
Inundation Reduction	$29,700
Total Annual Benefits	**$29,700**
Net Annual Benefits	**- $16,300**
Benefit-to-Cost Ratio	**0.6**

Environmental Impacts

Only short term adverse impacts to air quality, water quality, and aquatic resources are expected during the Construction phase of the removal of houses. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. Short term, temporary impacts to water quality and aquatic resources would result from stormwater runoff if rainfall events occurred before vegetation was reestablished. These impacts would be reduced by implementing best management practices such as silt fences. There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. This plan would reduce county revenue by removing approximately 6 parcels off of the tax roles in Travis County. Additional refinements of this plan, along with slight changes in outputs, would occur during the Feasibility design phase.

Cultural Resources

Cultural resources assessments of the Bear/Onion Confluence indicate that no Historic Properties are present within the project area of potential effect.

HTRW

Literature reviews and site assessments indicate that the proposed structure and removal alternatives would present no hazardous, toxic or radioactive wastes (HTRW) concerns. It is likely, however, that some of these residential structures would contain materials for which special handling and disposal would be required. These materials would include asbestos-containing materials (ACM), polychlorinated biphenlyls (PCB), mercury, chlorinated fluorocarbons (CFC), and miscellaneous wastes such as pesticides, paints, solvents, and used oils. Furthermore, although debris from the demolition of residential structures which had previously received applications of lead-based paint (LBP) is exempt from the definition of hazardous wastes, the contractor would be required to perform a lead exposure assessment prior to demolition to ensure workers are properly protected. An assessment of HTRW would have to be performed for every structure, estimated to cost approximately $1,500 per structure. The City of Austin has recently purchased several structures in the neighborhood, and little-to-no materials requiring special handling were found.

Combined Plan

Based on the results shown above, a stand alone evacuation plan is not economically feasible. However, if an alternative use of the vacated lands could be found, then the cost allocated to flood damage reduction could be sufficiently reduced to make the permanent evacuation a viable economic option.

Since the Bear/Onion Confluence area of interest is located within Travis County, and the County Government is the local sponsor, the Travis County representative was contacted regarding their interest in supporting either a park or ecosystem restoration as an alternative use of the vacated lands. Travis County responded by expressing the desire to support ecosystem restoration.

The parcels on which the 4 structures were located comprise approximately 5.9 acres. This was deemed to be insufficient to serve as a meaningful restoration alternative. Instead, additional lands were identified adjacent to the original parcels to form a continuous area of approximately 18.7 acres. The area of interest is shown on Figure 4-20.

As discussed earlier in this chapter, incremental analysis was conducted and combined structural ecosystem restoration plan was selected for Onion Creek as a whole. The combined restoration plan can be broken out by damage center using the first cost associated with each measure. For the Bear/Onion Confluence area of interest, the first costs were used to develop a cost per benefit and total combined ecosystem restoration costs for this area of interest (Table 4-15). The combined plan included restoring the areas identified on Figure 4-20 to riparian woodlands. This plan would produce 6.15 AAHU at a first cost of approximately $293,000 and an annual cost of $17,000 for an annual cost per AAHU of $2,700.

A multi-purpose project of this nature generally has costs associated with each purpose that are clearly separable. However, there are costs of other components which are joint in nature, and require segregation in some manner. The joint costs for this project were separated using the Separable Cost Remaining Benefit (SCRB) Method. Required input for use of this method include an annualized cost of a least cost restoration plan providing similar outputs as the multi-purpose project, an annualized cost of a standalone flood damage reduction project, and annualized benefits for each purpose. In this particular instance, the annualized flood damage

reduction benefits equaled the separable costs. This resulted in a unique situation where all the joint costs were allocated to the ecosystem restoration purpose.

It was assumed that the cost of the structure was a separable flood damage reduction cost, and that plantings and additional ecosystem lands were a separable ecosystem restoration cost. All other remaining costs were joint costs. The summary is shown in Table 4-16.

Table 4-15
Detailed Alternative Analysis
Bear/Onion Confluence
Annual Ecosystem Restoration Costs
Before SCRB
(December 2004 Prices and 5.125%)

ECOSYSTEM RESTORATION	
First Cost	$234,000
25% Contingency	$59,000
ER Total	**293,000**
INVESTMENT	
Total First Cost	$293,000
Interest During Construction	$15,000
Investment Cost	$308,000
ANNUAL CHARGES	
Interest	$16,000
Amortization	$1,000
Total Annual Charges	$17,000
ANNUAL BENEFITS	
AAHU	6.15
AAC/AAHU	**$2,700**

Table 4-16
Bear/Onion Confluence
Cost Allocation for Combination Plan
Separable Costs Remaining Benefits Method
(December 2004 Prices and 5.125%)

	FDR	***ER***	***Total***
Average Annual Benefits	$29,700	6.15 AAHU	$29,700+6.15 AAHU
Single Purpose Alternative Annual Cost	$45,800	$16,400	$62,200
Limited Annual Benefits/Costs	$29,700	$16,400	$62,200
Separable Costs	$29,700	$14,300	$44,000
Remaining Benefits	$0	$2,100	$2,100
Percent of Total	0.0%	100.0%	
Joint Costs			$16,100
Allocated Joint Annual Cost	$0	$16,100	
Total Allocation (Annual Costs)	$29,700	$30,400	$60,100
BCR or $/AAHU	**1.00**	**$4,943**	
Net Annual Benefits	**$0**		

The results shown above can be interpreted in several ways. Reduction in flood risk is achieved, but with a marginal benefit to cost ratio. By utilizing a combined plan approach, costs are reduced by $2,100 annually when compared to standalone projects. Additionally, consideration should be given to other incidental benefits (health and safety, for example), which do not enter into the benefit equations.

Environmental Impacts

Only short term adverse impacts to air quality, water quality, and aquatic resources are expected during the Construction phase of the removal of houses. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. Short term, temporary impacts to water quality and aquatic resources would result from stormwater runoff if rainfall events occurred before vegetation was reestablished. These impacts would be reduced by implementing best management practices such as silt fences. There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. This plan would restore approximately 19 acres and provide 6.15 AAHU's of riparian habitat in the restored areas. The restoration area would not be used for recreation. This alternative is the least environmentally damaging, cost effective alternative that was considered for this area. This plan would reduce county revenue by removing approximately 6 parcels off of the tax roles in Travis County. Additional refinements of this plan, along with slight changes in outputs, would occur during the Feasibility design phase.

Cultural Resources

Cultural resources assessments and literature reviews of the Bear/Onion Confluence floodplain indicate that no impacts would be expected with implementation of this evacuation alternative, due to a finding of no historic or prehistoric cultural properties in the area of potential effect. Construction sites would be monitored closely to ensure that no archeological resources are disturbed.

HTRW

Literature reviews and site assessments indicate that the proposed structure and removal alternatives would present no hazardous, toxic or radioactive wastes (HTRW) concerns. It is likely, however, that some of these residential structures would contain materials for which special handling and disposal would be required. These materials would include asbestos-containing materials (ACM), polychlorinated biphenlyls (PCB), mercury, chlorinated fluorocarbons (CFC), and miscellaneous wastes such as pesticides, paints, solvents, and used oils. Furthermore, although debris from the demolition of residential structures which had previously received applications of lead-based paint (LBP) is exempt from the definition of hazardous wastes, the contractor would be required to perform a lead exposure assessment prior to demolition to ensure workers are properly protected. An assessment of HTRW would have to be performed for every structure, estimated to cost approximately $1,500 per structure. The City of Austin has recently purchased several structures in the neighborhood, and little-to-no materials requiring special handling were found.

WILLIAMSON CREEK

General

Both structural and non-structural solutions were carried forward for detailed analysis. The structural plan would utilize a geomorphic channel design to lower water surface profiles for all flood flows, while minimizing the impacts to the natural streambed and other environmental features. This plan has the potential to be combined with ecosystem restoration and recreation to form a multi-objective plan, which has the ability to benefit many residents, as well as other habitat. During the detailed investigations, it would be evaluated as both a standalone, and as a multi-purpose plan combined with ecosystem restoration and recreation.

The non-structural alternative is in the form of a floodplain evacuation, also known as a buyout. This plan was only formulated as part of a multi-objective plan, where recreation and

ecosystem restoration features were designed to utilize the lands that would be vacated by the floodplain evacuation. The sponsor has a history of being partial to non-structural plans, and thus the non-structural plan could serve as a potential locally preferred plan.

No Action

In the absence of any type of flood damage reduction project, the flooding potential experienced in Williamson Creek would continue. As stated previously, the annual costs associated with flooding in this area are estimated at approximately $883,000. Federal funds would also continue to be expended in the flood insurance program and in federal emergency flood assistance and relief efforts.

The population within Williamson Creek is continuing to grow. This growth would add to impervious cover within the watershed, which in turn would increase the potential for increased flood damages downstream of the new development. From a hydrologic and hydraulic standpoint, this impact is significantly reduced by the city of Austin's Watershed Protection Ordinances, which prohibit any increase in the peak 1% ACE discharge from the area being developed. However, direct loss of habitat would continue throughout the watershed as vegetation is removed for construction. The forested riparian vegetation zone within much of the watershed in this area is already narrow with several grass and shrub openings and tremendous amounts of invasive species. The number and size of the openings would increase and there would be fewer acres of forest in the future. The loss of habitat, particularly the bottomland hardwoods, would reduce the numbers of wildlife and bird species within the watershed, especially migratory songbirds, which are particularly susceptible to the loss of habitat along their migration routes. Commercial and residential developments are being constructed and planned for development in the near future, which would continue to affect habitat within Williamson Creek. Furthermore, it would be expected that the construction activities would increase sediment load in runoff from soil disturbance. After completion, because of the lack of appropriate vegetative buffers and sediment ponds, the water quality of the creek would be affected by increases in impervious surface area, traffic, lawn fertilizer and other human activities due to increasing nutrient load and pollutant levels in the creek. In addition, without restoration, there would continue to be decline on the quality of water entering Barton Springs, which will continue to have negative effects on the Barton Springs and Austin blind salamanders. It is not expected that increased water quality degradation would result in the existing vegetation or restored vegetation to be unsustainable.

Flood Proofing

Raising each structure in place was considered for structures within the 4% ACE floodplain. Foundation increases were calculated to raise those structures in the 4% ACE floodplain above the water level of the 4% ACE event. They were then rerun through the HEC-FDA program. The amounts contributed to the EAD by each structure for the with and without-project were calculated to determine the benefits by structure. When compared to the costs of raising each structure, it was found that the benefit cost calculation for all but 8 of the 69 structures examined, was less than 1. Since flood proofing is voluntary, this is no real project solution; therefore, this alternative was therefore eliminated from further consideration.

Environmental impacts

Short term adverse impacts to air quality and noise and traffic levels would be possible during the construction activities, but these impacts would be minimal and would occur during daylight hours. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. There would be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be

minimal. Other than these temporary impacts, this alternative would have no other adverse environmental impacts. However, vehicles and garages would still receive damages and emergency responders would still be at risk if a rescue had to occur during a flood event.

Cultural Resources

Cultural resources would not be an issue with raising structures in place because the ground was previously disturbed during construction of the house.

HTRW

Literature reviews and site assessments indicate that there are no hazardous, toxic or radioactive wastes (HTRW) concerns.

Structural Plan (Standalone)

Preliminary investigations identified the extent of improvements to be limited from upstream of Congress Avenue to below Brodie Lane in Sunset Valley. This encompassed four economic sub-reaches. For purposes of this analysis, from downstream to upstream, these reaches are known as Heartwood, Radam, Broken Bow, and Bayton Loop.

The plan identified during the preliminary analysis was developed in significantly more detail. Additionally, the preliminary plan's concept of a benched channel was utilized to create three plans which provided a range of protection levels, within each sub-reach. This would allow for more detailed economic optimization. For this discussion, these plans are referred to as Plans A, B, and C.

In general, the plans were formulated such that the start of damages in each sub-reach would occur at a set target frequency. However, there were also additional physical and environmental constraints provided to the designer, and these constraints caused some of the targets to remain unmet, especially for the largest of the plans. These constraints included only working on one side of the creek or the other at a time and leaving the baseflow channel intact in order to reduce environmental impacts.

Structural Plan A is an alternative to reduce risk of flooding that used the 10% ACE event as a target storm. It consisted of channel modifications in the Radam, Broken Bow, and Bayton Loop reach areas. There are no flood related damages in the Heartwood reach for a 10% event, so no modifications were proposed. The size and extent of the modifications for Plan A are shown in Figures 4-21B, 4-21C, and 4-21D. The channel modification would consist of excavation of the immediate overbank of one side of the creek on a flat grade for a certain distance and then go to a 3-foot horizontal to a 1-foot vertical slope to natural grade. The first cost of Plan A was estimated to be $1.58 Million, with net annual benefits of $285,500.

Structural Plan B is an alternative to reduce risk of flooding that used the 4% ACE event as a target storm. It consisted of channel modifications in the all four reaches. In addition, a new, larger bridge would have to be constructed at Westgate Boulevard. The size and extent of the modifications for Plan B are shown in Figures 4-22A through 4-22D. The first cost of Plan B was estimated to be $4.81 Million, with net annual benefits of $198,700.

Structural Plan C is an alternative to reduce risk of flooding that used the 1% ACE event as a target storm. However, this level of protection was not achievable in most of the reaches, given the design constraints. In order to achieve 1% ACE protection, both sides of the creek would have to be widened and it would more than likely take a concrete lined or grass lined trapezoidal channel, which was not acceptable from an environmental standpoint. In addition to a new bridge at Westgate Boulevard, a new bridge would have to be constructed at Emerald Forest as well.

The size and extent of the modifications for Plan C are shown in Figures 4-23A through 4-23D. The first cost of Plan C was estimated to be $6.30 Million, with net annual benefits of $195,400.

It was also determined that each reach behaved more or less independently from one another and combinations of Plans A, B and C could be used to develop a optimized plan. Therefore, a final optimized standalone plan was developed that consisted of the optimum size from each reach. Table 4-17 shows the net benefits derived within each reach, broken down by Plan. The table also sums the optimum size in each reach to form an optimal standalone plan. In summary, Plan A provided the best results for Bayton Loop, Plan B provided the best results for Heartwood and Radam, and finally Plan C provided the best for Broken Bow.

Based on this configuration, the optimum standalone plan had an estimated first cost of $2,039,000, annualized costs of $141,000, and total annual benefits of $462,000. Net annual benefits were, therefore $321,000, with a benefit to cost ratio of 3.3 as displayed in tables 4-18 and 4-19.

Table 4-17
Williamson Creek
Net Annual Benefits of Standalone Structural Plans
By Reach
(December 2004 Prices, 50-year analysis period, 5.125%)

Plan	Heartwood	Radam	Broken Bow	Bayton Loop	Total
A	$0	$3,114	$57,423	$224,927	$285,464
B	$15,786	$3,114	$57,423	$122,384	$198,706
C	$8,051	- $58,959	$77,423	$169,750	$196,263
Optimum	**$15,783**	**$3,114**	**$77,423**	**$224,927**	**$321,246**

Table 4-18
Detailed Alternative Analysis
Williamson Creek
Standalone Structural Plan
Summary of Costs
(December 2004 Prices)

Item	Cost
Construction	$916,000
Structure/Land	$204,000
Mitigation	$190,000
E&D	$229,000
S&A	$92,000
25% Contingency	$408,000
Total Cost	**$2,039,000**

Table 4-19 **Detailed Alternative Analysis** **Williamson Creek** **Standalone Structural Plan** **Benefit-Cost** (December 2004 Prices and 5.125%)	
FLOOD DAMAGE REDUCTION	
INVESTMENT	
Total First Cost	$2,039,000
Interest During Construction	$52,000
Investment Cost	$2,091,000
ANNUAL CHARGES	
Interest	$107,000
Amortization	$10,000
O&M	$24,000
Total Annual Charges	**$141,000**
ANNUAL BENEFITS	
Inundation Reduction	$395,000
Municipal and Insurance Cost	$67,000
Total Annual Benefits	**$462,000**
Net Annual Benefits	**321,000**
Benefit-to-Cost Ratio	**3.3**

Environmental impacts

Short term adverse impacts to air quality and noise and traffic levels would be possible during the construction activities, but these impacts would be minimal and would occur during daylight hours. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. There would be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. Approximately 11,720 feet of creek and aquatic resources would be negatively affected. In order to reduce these impacts, the normal low flow channel would be kept intact. No benching would occur below this level (which was estimated at 2-foot above the bottom of the creek or normal water level in the spring pools. In addition, only one bank would be affected and the other bank would be left intact and no benching would occur on that side. Construction equipment would not be allowed within the creek itself as much as possible. The benched area would be returned to a landscape turf and trees would be replanted on 60 foot centers. A storm water pollution prevention plan would be developed and best management practices would be implemented to minimize impacts to aquatic resources. The project area would not be used for restoration or public recreation. This plan would affect approximately 27 acres of riparian habitat and 9.3 AAHU's of habitat and 11,720 feet of Waters of the United States would be impacted and would require mitigation. Several large trees would be lost during construction; however, during final design trees would be surveyed and designs would be slightly altered, to the extent practical, to protect as many of the old growth trees as possible. In addition, protections measures such as inverted wells would also be implemented if practical to protect the trees. Mitigation requirements would be conducted offsite. Approximately 103,000 cubic yards of materials would be removed from the benched areas and disposal materials would be disposed of in landfills to reduce impacts. Increased scour and erosion would be possible downstream of the benched reaches, If this plan were selected as the recommended plan, then during final design, a sediment transport model would be developed to see if measures could be implemented to reduce these impacts. The city of Austin already owns a utility easement that would allow project implementation of most of this alternative; however, a few additional easements would be required. Additional

refinements of this plan, along with slight changes in outputs, would occur during the Feasibility design phase.

Cultural Resources

Initial cultural resources assessments of the Williamson Creek floodplain indicate that further excavations are needed before construction could begin. Deep backhoe trenches would be required during the Preconstruction, Engineering and Design Phase and would be coordinated with SHPO.

HTRW

Literature reviews and site assessments indicate that there are no hazardous, toxic or radioactive wastes (HTRW) concerns.

Combined Plan – Structural

In order to maximize benefits for the structural project, a combined plan was formulated that would add ecosystem restoration measures and recreation facilities for a multi-purpose project. An incremental analysis was conducted and the Structural Combined Plan would implement the structural measures identified in the Optimal Standalone Structural Plan in combination with ecosystem restoration measures identified earlier in this chapter for the Williamson Creek Combined Structural Ecosystem Restoration Plan. In addition, recreation measures would be implemented. The Structural Combined Plan features are shown in Figures 4-25A through 4-25D.

The ecosystem restoration plan would include restoring 114 acres of riparian woodlands along the floodplains of Williamson Creek in the identified areas to improve aquatic habitat. This would include the removal of invasive species and planting of native species. As a result, a greenbelt would be established along most of Williamson Creek that would serve as a corridor and a buffer for wildlife that utilize riparian ecosystems.

The plan would also call for a three foot wide nature trail and trailheads within the project area. The total length of this trail, extending from near Congress Avenue to the Bayton Loop area, would be approximately 19,300 feet. In order to maximize benefits, the trail would have to connect to the existing trials along Williamson Creek. This means that the entire trail length would have to be implemented.

The project first cost of this alternative is approximately $5,535,000 (Table 4-20), of which $2,200,000 would be ecosystem restoration costs. The total expected annual monetary benefits would be approximately $659,000, which would include approximately $462,000 in flood damage reduction benefits and $197,000 in recreation benefits.

Table 4-20 **Detailed Alternative Analysis** **Williamson Creek** **Combined Structural Plan** **Summary of Costs** (December 2004 Prices)	
FLOOD DAMAGE REDUCTION	
Item	**Cost**
Demo	$916,000
Structure/Land	$204,000
Mitigation	$190,000
E&D	$229,000
S&A	$92,000
25% Contingency	$408,000
FDR Total Cost	**$2,039,000**
RECREATION	
First Cost	$768,000
E&D	$192,000
Construction S&A	$77,000
25% Contingency	$259,000
REC Total Cost	**$1,296,000**
ECOSYSTEM RESTORATION	
First Cost	$1,473,000*
E&D	$100,000
Construction S&A	$147,000
25% Contingency	$430,000
RE Admin	$50,000
Total First Cost ER	**$2,200,000**
Total Project Cost	**$5,535,000**
Note: Total of $1,842,000 as shown in Appendix B was reduced by 25% to remove contingency.	

In order to determine the allocation of costs associated to each project purpose, the Separable Costs Remaining Benefits method was used. Use of this method requires that a number of project variations be developed that contain, for example, two of the three purposes. Also, standalone projects were developed for cost allocation purposes. Table 4-21 contains the cost allocation table, and derives the cost associated with each purpose, as well as separable benefit to cost ratios and cost per habitat unit gained.

Annualized Separable Costs for each purpose were derived by subtracting the annualized cost of a project addressing all other purposes from the annualized cost of the complete multi-purpose project. For example, to determine the separable flood damage reduction cost, a theoretical project was developed which contained ecosystem restoration and recreation outputs of similar magnitude as the multipurpose project. The project cost of this theoretical ER/Rec project was subtracted from the multipurpose project to yield the separable FDR cost. This procedure was repeated three times in order to achieve the required combinations.

Methodology rules state that the separable costs are subtracted from the lower value of either the benefits or the single purpose alternative cost to yield “Remaining Benefits.” (Note: In the case of non-monetary benefits, the single purpose alternative cost is always used.) The remaining benefits for each purpose are then divided by the total remaining benefits to produce

an allocation percentage for each purpose. The joint costs are then allocated to each purpose, based on the derived percentages. Finally, these allocated costs are added to the separable costs to determine the total allocation to each purpose.

Key annualized values used for input into the following table include: multipurpose project annual cost of $335,324, theoretical ER/Rec annual project cost of $266,508, theoretical FDR/Rec project annual cost of $229,864, and theoretical FDR/ER annual project cost of $248,100.

Table 4-21
Williamson Creek
Cost Allocation for Combined Structural Plan
(December 2004 Prices and 5.125% Interest Rate)

	FDR	***ER***	***REC***	***Total***
Average Annual Benefits	$462,000	42.1	$197,000	
Single Purpose Alternative Annual Cost	$141,000	$179,000	$94,000	$414,000
Limited Annual Benefits/Costs	$141,000	$179,000	$94,000	
Separable Annual Costs	$107,000	$144,000	$87,000	$339,000
Remaining Annual Benefits	$33,000	$35,000	$6,000	$75,000
Percent of Total	44.4%	46.9%	8.6%	
Annual Joint Costs				$35,000
Allocated Annual Joint Cost	$16,000	$16,000	$3,000	$35,000
Total Allocation (Annual Costs)	$123,000	$161,000	$90,000	$374,000
BCR or $/AAHU				
Net Benefits	3.75	$3,800	2.18	

Environmental Impacts

Short term adverse impacts to air quality and noise and traffic levels would be possible during the construction activities, but these impacts would be minimal and would occur during daylight hours. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. There would be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. Approximately 11,720 feet of creek and aquatic resources would be negatively affected during construction, but the riparian zone would be widened and a diversity of native vegetation would be restored and would improve approximately 16,780 feet of creek and 114 acres of riparian habitat. In order to reduce impacts in the benched areas, the normal low flow channel would be kept intact. Benching would not occur below this level (which was estimated at 2-foot above the bottom of the creek or normal water level in the spring pools. In addition, only one bank would be affected and the other bank would be left intact and no benching would occur on that side. Construction equipment would not be allowed within the creek itself as much as possible. The benched area would be returned to native grasses and trees would be replanted on 60 foot centers. A storm water pollution prevention plan would be developed and best management practices would be implemented to minimize impacts to aquatic resources. This plan would adversely affect approximately 27 acres of riparian habitat and 9.3 AAHU and 11,720 feet of Waters of the United States would be lost and would require mitigation. However, there would be a net gain of 42.1 AAHU of habitat due to the ecosystem restoration measures that would be implemented. Several large trees would be lost during construction. However, protections measures such as inverted wells would also be implemented if practical to protect the trees. Approximately 103,000 cubic yards of materials would be removed from the benched areas and disposal materials would be disposed of in landfills to reduce impacts. Increased scour and erosion would be possible downstream of the benched reaches, If this plan were selected as the recommended plan, during final design, a sediment transport model would be developed to see if measures could be implemented to reduce these impacts. Additional refinements of this

plan, along with slight changes in outputs, would occur during the Preconstruction, Engineering and Design Phase.

Cultural Resources

Initial cultural resources assessments of the Williamson Creek floodplain indicate that further excavations are needed before construction could begin. Deep backhoe trenches would be required during the Preconstruction, Engineering and Design Phase and would be coordinated with SHPO.

HTRW

Literature reviews and site assessments indicate that there are no hazardous, toxic or radioactive wastes (HTRW) concerns.

Combined Plan--- Non-Structural

A Non-Structural plan in the form of a permanent floodplain evacuation was evaluated in the preliminary analysis. While this analysis clearly showed that a structural plan was more cost effective, the sponsor desired to develop a non-structural plan similar in outputs and scope to the structural plan. This plan would provide choices to the local decision makers during the latter portion of the formulation process, and perhaps the non-structural would have intangible benefits that would result in its selection as the locally preferred plan for implementation on Williamson Creek.

As a result, a Non-Structural Combined Plan was formulated to fulfill the objectives of a locally preferred plan. The plan would acquire and remove approximately 58 of the individual residential structures identified in the preliminary screening of alternatives under the Permanent Evacuation of the 4% ACE Floodplain. Also, it would incorporate ecosystem restoration and recreation features to serve as alternative uses of the vacated properties. As discussed earlier in this chapter, an incremental analysis was conducted in order to select an ecosystem restoration plan. The plan that would be implemented would be the Williamson Creek Combined Non-Structural Plan. The philosophy of such a plan would be to reduce the risk of flooding with only minimal invasive construction within the floodplain, increase the environmental value of the Williamson Creek corridor, and open the area for easier access by the general public so it can be enjoyed by all residents instead of only those fortunate enough to have their own direct access.

The Non-Structural Combined Plan is shown on Figures 4-26A through 4-26D. The plan extends the through the entire length of the study area. The first cost of the plan is estimated at $13,567,000 (Table 4-22). This plan includes the restoration of 156 acres of riparian woodlands along the floodplains of Williamson Creek in the identified areas providing 64.67 AAHU of riparian habitat, and it would establish a three foot-wide nature trail, as well as trailheads and playgrounds within the project area. The total length of this trail, extending from near Congress Avenue to the Bayton Loop area, would be approximately 19,300 feet.

The Non-structural Combined Plan contains some items that are a joint cost among the various purposes. Determination of costs attributed to each purpose was performed using a slightly modified version of the Separable Costs Remaining Benefits Method. The modification adjusts for the rule regarding economic justification of non-structural projects, where justification is based on only the total benefit to cost ratio, and not each purpose on its own. The results of the analysis are shown in Table 4-23 below.

Table 4-22 **Detailed Alternative Analysis** **Williamson Creek** **Combined Non-Structural Plan** **Summary of Costs** (December 2004 Prices)	
FLOOD DAMAGE REDUCTION	
Item	**Cost**
Demo	$1,330,000
Structure/Land	$5,810,000
E&D	$40,000
S&A	$69,000
25% Contingency	$1,811,000
FDR Total Cost	**$9,060,000**
RECREATION	
First Cost	$768,000
E&D	$192,000
Construction S&A	$77,000
25% Contingency	$259,000
REC Total Cost	**$1,296,000**
ECOSYSTEM RESTORATION	
First Cost	$1,911,000*
E&D	$200,000
Construction S&A	$191,000
25% Contingency	$576,000
RE Admin	$50,000
Total First Cost ER	**$2,928,000**
Project First Cost	**$13,284,000**
Note: Total of $2,389,000 as shown in Appendix B was reduced by 25% to remove contingency.	

Table 4-23
Williamson Creek
Cost Allocation for Non-Structural Combined Plan
(December 2004 Prices and 5.125%)

	FDR,Rec	*ER*	*Total*
Average Annual Benefits	$695,000	64.67	
Single Purpose Alternative Cost	$622,000	$179,000	$802,000
Limited Benefits/Costs	$622,000	$179,000	
Separable Costs	$624,000	$181,000	$806,000
Remaining Benefits	-$2,000	-$2,000	-$4,000
Percent of Total	50.0%	50.0%	
Joint Costs			-$2,000
Allocated Joint Cost	-$946	-$946	
Total Allocation	$623,000	$180,000	$804,000
BCR or $/AAHU	1.11	$4,000	
Net Benefits	$72,000		$72,000

Environmental Impacts

Only short term adverse impacts to air quality, water quality, and aquatic resources are expected during the Construction phase of the removal of houses. Short term impacts to air quality would be an increase in dust particles and exhaust from construction equipment. Short term, temporary impacts to water quality and aquatic resources would result from stormwater runoff if rainfall events occurred before vegetation was reestablished. These impacts would be reduced by implementing best management practices such as silt fences. There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. This plan would provide approximately 64.67 average annual habitat units of riparian habitat and improve approximately 28,500 feet of creek and approximately 156 acres. The restoration areas are connected to many acres of riparian areas already owned by the City of Austin. This land is expected to stay in their ownership and remain untouched for the distant future. Therefore, the whole ecosystem in this reach of Onion Creek would be improved by removing residential structures and restoring the restoration areas. All project areas would be purchased in fee and taken into public ownership for this alternative. The restoration area would not be used for recreation, with the exception of nature trails. This alternative is the most environmental friendly cost effective alternative that was considered in Williamson Creek. A buyout alone with complete restoration of the area would be more environmentally friendly, but the project would not be justified without the recreation. This plan would reduce city and county revenue by removing land off of the tax roles in Austin and Travis County. Additional refinements of this plan, along with slight changes in outputs, would occur during the Feasibility design phase.

Cultural Resources

Initial cultural resources assessments of the Williamson Creek floodplain indicate that further excavations are needed before construction could begin. Deep backhoe trenches would be required during the Preconstruction, Engineering and Design Phase and would be coordinated with SHPO.

HTRW

Literature reviews and site assessments indicate that the proposed structure and removal alternatives would present no hazardous, toxic or radioactive wastes (HTRW) concerns. It is likely, however, that some of these residential structures would contain materials for which special handling and disposal would be required. These materials would include asbestos-containing materials (ACM), polychlorinated biphenlyls (PCB), mercury, chlorinated fluorocarbons (CFC), and miscellaneous wastes such as pesticides, paints, solvents, and used oils. Furthermore, although debris from the demolition of residential structures which had previously received applications of lead-based paint (LBP) is exempt from the definition of hazardous wastes, the contractor would be required to perform a lead exposure assessment prior to demolition to ensure workers are properly protected. An assessment of HTRW would have to be performed for every structure, estimated to cost approximately $1,500 per structure.

SUMMARY OF FINAL ARRAY OF ALTERNATIVES

A summary of the plans developed during the Detailed Investigation of Alternatives is shown in Table 4-24. These plans are sorted by physical area. Also, since each area is independent from one another, a preferred plan from each area can be selected and combined to form the overall plan of improvement for the Onion Creek project. The plans identified as the tentatively selected plans are highlighted in the table, and constitute the tentative Federally Supportable Plan (FSP). Please note that the No Action plan for each area has been excluded from the table.

Table 4-24
Summarized Final Array of Detailed Alternatives
Grouped by Area of Interest
(December 2004 Prices, 5.125% Interest Rate, 50-Year Period of Analysis)

Alternative	First Economic Cost	Ann. FDR/Rec Cost	Ann. FDR/Rec Total Ben	Ann. FDR/Rec Net Ben	BCR	Ann. ER Cost	Ann. AAHU	$/AAHU
Timber Creek								
No Action Plan	N/A	N/A	N/A	N/A	N/A	N/A	72.98	N/A
Non-Structural	$8,934,000	$551,000	$667,000	$116,000	1.2	$16,000	+5.86	$2,700
Onion Creek Forest/Yarrabee Bend								
No Action Plan	N/A	N/A	N/A	N/A	N/A	N/A	328.40	N/A
100-foot Bottom Diversion	$4,269,000	$304,000	$524,000	$220,000	1.7	N/A	N/A	N/A
Non-Structural Combined Plan A (4%)	$49,448,000	$2,890,000	$3,890,000	$1,000,000	1.4	$215,000	+73.27	$2,900
Non-Structural Combined Plan B (1%)	$91,227,000	$5,393,000	$4,625,000	-$768,000	0.9	$215,000	+73.27	$2,900
Bear/Onion Confluence								
No Action Plan	N/A	N/A	N/A	N/A		N/A	247.76	N/A
Non-Structural Combined Plan	$1,074,000	$30,000	$30,000	$0	1.0	$30,000	+6.15	$4,900
Williamson Creek								
No Action Plan	N/A	N/A	N/A	N/A		N/A	76.85	N/A
Optimum FDR Plan	$2,039,000	$141,000	$462,000	$321,000	3.3	N/A	N/A	N/A
Structural Combined Plan	$5,535,000	$213,000	$659,000	$446,000	3.8	$161,000	+42.05	$3,800
Non-Structural Combined Plan	$13,284,000	$623,000	$695,000	$72,000	1.1	$180,000	+42.05	$4,300
Total Potential FSP	$64,991,000	$3,684,000	$5,246,000	$1,562,000	1.4	$422,000	+127.33	$3,300

Note: Shaded Components comprise the potential Federally Supportable Plan.
* The first costs shown above do not include relocation assistance costs of approximately $9,975,000.
** Includes only the No Action AAHU for Riparian woodlands as that is what the Recommended Plan is measured against. Onion Creek Forest No Action AAHU does include Transitional Woodlands also.

IDENTIFICATION OF THE NED/NER PLAN

The identification of the NED/NER plan depends upon careful consideration of engineering, economic, social, and environmental factors. The following paragraph outlines the process of identifying the NED/NER Plan.

Guidelines for selection of a plan for implementation, as provided by the Water Resources Council's "Principles and Guidelines for Planning Water and Related land Resources Implementation Studies," state that a plan recommending Federal action is to be the alternative plan that reasonably maximizes net national economic development (NED) benefits, i.e. the NED plan, and incrementally justified and cost effective NER Plans, unless the Assistant Secretary of Army (Civil Works) grants an exception. Current Policy allows such exceptions for locally preferred plans. Such locally preferred plans must comply with Federal rules and statutes, most important of which, the project benefits must exceed the project costs. Federal participation in a locally preferred plan is limited to the extent which would have been required by the NED/NER plan. Consequently, the local sponsor is responsible for all additional costs of the larger plan above and beyond the costs of the Federal NED/NER plan.

Upon completion of the plan formulation process, a summary document was prepared and submitted to the Corps' higher headquarters for review. Following this review, an Alternative Formulation Briefing (AFB) was held on May 25, 2006, to discuss the findings with the Corps' higher headquarters. Attendees at this AFB included representatives from the Ft. Worth District; the Southwestern Division; the Corps' Headquarters; the Office of the Assistant Secretary of the Army (Civil Works); and, the local sponsor. Concurrence by Corps' Headquarters and Southwestern Division representatives was received regarding the flood damage reduction and ecosystem restoration components of the proposed NED/NER Plan at the AFB, held on May 25, 2006. As a result of the review and discussions at the AFB it was determined that the proposed NED/NER Plan was the plan that had the highest net economic benefits even though the Corps could not cost share in some of the facilities.

SELECTION OF THE TENTATIVELY SELECTED PLAN

The local sponsors were involved throughout the formulation process. They indicated during the early stages of the feasibility studies that their planning objectives were similar to the Federal objectives. A project of this magnitude would place a substantial burden on the sponsor's financial abilities, but they fully understand the need to provide their citizens with maximum possible relief from future flooding.

Careful consideration was given to all alternatives in the final array, including the No Action plan. Based on the findings cited above, the local sponsors selected the proposed NED/NER as the Tentatively Selected Plan with the understanding that the recreation facilities that are not cost sharable will be funded as a 100% non-Federal cost. The economic summary previously shown in Table 4-24 reflects the Locally Preferred Plan.

TIMBER CREEK

The Tentatively Selected Plan is the NED/NER Plan. The two basketball courts would be cost shared 100% at local expense.

ONION CREEK FOREST/YARRABEE BEND

The Tentatively Selected Plan is the NED/NER Plan. The four basketball courts, two tennis courts, and 19 volleyball courts would be cost shared 100% at local expense.

BEAR/ONION CONFLUENCE

The NED/NER Plan was selected as the Tentatively Selected Plan with no modifications.

WILLIAMSON CREEK

The NED/NER Plan was selected as the Tentatively Selected Plan with no modifications.

COST APPORTIONMENT – TENTATIVELY SELECTED PLAN

Table 4-25 presents a comparison of the total costs and Federal / non-Federal cost apportionments for the NED/NER Plan and the Recommended Plan.

Table 4-25
Cost Apportionment – Tentatively Selected Plan
(December 2004 Prices)

Timber Creek	$6,147,000	$3,627,000	$9,774,000
Onion Creek Forest/Yarrabee Bend	$37,534,000	$20,959,000	$58,493,000
Bear/Onion Confluence	$757,000	$407,000	$1,164,000
Williamson Creek	$3,403,000	$2,132,000	$5,535,000
Total Cost	**$47,841,000**	**$27,125,000**	**$74,996,000**
Percent of Total Cost	**63.8%**	**36.2%**	**100.0%**