

## **APPENDIX B ENVIRONMENTAL RESOURCES**

### **HABITAT EVALUATION**

The United States Fish and Wildlife Service's Habitat Evaluation Procedure (HEP) was used to evaluate habitat conditions that would result from alternative plans. A habitat suitability index (HSI) for indicator species is derived by aggregating suitability indices (SIs) critical for habitat variables. These SIs are based on field measurements for existing conditions and on professional judgment for future conditions under alternative plans. The index ranges from 0.0 to 1.0, with 1.0 representing the highest habitat quality possible. A habitat unit (HU) is the product of the HSI multiplied by an area (acre) of available habitat. HSIs and HUs were developed for different times during the period of analysis (at year 1, 5, 15, 25, and 50), and HUs are annualized to estimate an average annual habitat unit (AAHU). Therefore, HEP provides information for two general types of wildlife habitat comparisons. The first is the relative value of different areas at the same point in time. The second is the relative value of the same area at future points in time. Therefore, the impact of land and water use changes on wildlife habitat can be estimated.

#### **EVALUATION OF RIPARIAN HABITAT**

For central Texas, the wooded uplands, prairie uplands, and riparian corridors work in unison to provide the habitat needs for many species of wildlife that call this unique part of Texas home. Upland areas in this part of the state are mostly prairie with some woodland consisting of legumes and other small and/or short-lived species. These wooded uplands do not typically progress to late successional woodlands because the climate of the area is not favorable for late successional species except where associated with riparian corridors. Therefore, many species of birds and other wildlife, which occupy upland habitats exclusively in other areas of the U.S., occupy the riparian areas of central Texas exclusively or in conjunction with the upland habitats. For many species, the riparian areas of central Texas are needed to meet the needs of their circadian and circannual rhythms. However, riparian areas of the region are small and less diverse than their northeastern counterparts; therefore, connection to upland woodlands is also important to provide the full range of habitat requirements of a species. Additionally, due to fragmentation of upland habitats, a riparian corridor serves as the only travel conduit for species to migrate to other habitats needed to complete their life requisites.

The USFWS, with assistance from the TPWD and the Fort Worth District, completed HEP for the without- (existing and future) and with-project condition of riparian natural resources. Because the resource agencies are most concerned in the restoration of lost aquatic and riparian habitat functions, the focus was to use models containing variables measuring important components of riparian corridor structure. A review of the available models providing the variables necessary to build quality riparian habitat was undertaken. The team decided it was appropriate to measure the existing habitat value of the current vegetation state even though the restoration measures were for converting or restoring existing vegetation to riparian woodlands. The following indicator species were utilized for the habitat evaluations indicative of the mostly urban mammalian and avian species found within the Onion and Williamson Creek Watersheds. The species by cover type are as follows:

- Riparian Woodlands: raccoon, barred owl, fox squirrel, downy woodpecker
- Grasslands: red-tailed hawk, scissor-tailed flycatcher, eastern meadowlark
- Transitional Woodland: raccoon, scissor-tailed flycatcher, eastern cottontail
- Wetlands: raccoon, green heron, wood duck

It is important to understand that while these species are relatively common, their HSI models serve as good indicators of a healthy, functioning ecosystem and therefore provides a good basis for comparing outputs from alternatives plans. They should not be used to judge the importance or significance of those outputs in terms of habitat scarcity, connectivity or contribution to regional restoration planning.

An overall habitat evaluation was performed and the results are shown in a Planning Aid Letter dated October 11, 2002, in Appendix D, Fish and Wildlife Coordination Act, of the Onion Creek Report. A summary of the existing conditions by area of interest is provided below. In addition, the riparian woodland vegetative cover type was further broken down into parkland and riparian woodlands. These cover types generally are missing the needed understory to function as a high quality habitat. In order to assign habitat suitability to it, the team evaluated the models and decided that a parkland habitat exhibited about one half the value of the existing woodland value next to the parkland habitat. Therefore, one half of the riparian habitat suitability index was assigned to the existing value of parklands. Finally, residential cover types were assigned a value because they functioned much like a parkland cover type. There are large trees that provide minimal habitat without understory.

See Addendum 5 for a general HSI and HU by cover type. In the Alternative Analysis Section, tables of existing HSI and future without-project projections for the existing vegetation that were used for evaluation for each measure to establish the amount of HU that would be converted to riparian woodlands are given.

## EXISTING ECOSYSTEM DEGRADATION

Riparian woodlands occur in the transition zone between aquatic and upland ecosystems. Riparian woodland systems are considered to be Texas' most diverse ecosystem. Prior to European settlement, Texas had approximately 16 million acres of bottomland hardwood riparian habitat. Today, the state has less than 5.9 million acres (Texas Center for Policy Studies 1995).

Riparian woodlands serve several important functions. They contribute to the state's biodiversity. According to the Texas Environmental Almanac (1995), 189 species of trees and shrubs, 42 woody vines, 75 grasses, and 802 herbaceous plants occur in Texas' bottomlands. They are also known to support 116 species of fish, 31 species of amphibians, 54 species of reptiles, 273 bird species and 45 mammals. At least 74 species of threatened and endangered animals depend directly on bottomland hardwood systems and over 50 percent of neotropical songbirds are associated with these systems. Besides providing critical wildlife and bird habitat, riparian woodland systems 1) serve as catchments and water retention areas in times of flooding; 2) help control erosion; 3) contribute to the nutrient cycle, and 4) play a vital role in maintaining water quality by serving as a depository for sediments, wastes and pollutants from runoff. Despite these important functions, riparian woodland ecosystems are one of the most endangered ecosystems in the United States (MacDonald et al. 1979). For all of these reasons, the riparian woodland vegetation system is of great environmental concern in the analysis of the project area.

According to the Texas State Almanac (1995), interior wetlands which include bottomland hardwood forests, riparian vegetation, inland freshwater marshes, and the playa lakes of west Texas account for 80 percent of the total wetland acreage in Texas and the vast majority are

located on private property. In the last 200 years, Texas has lost over 60 percent of these inland wetlands due to agriculture conversion, timber production, reservoir construction and urban and industrial development. Therefore, there is a need to restore as many of these wetlands, including riparian woodlands, as possible. This is especially true in urban areas where a large portion of the riparian zone has been lost and only small fragmented portions of low quality exist today. Much of the land within the proposed project area, especially Williamson Creek, has been highly disturbed by human activities that have altered the topography of the landscape. These include construction of roads and instream sewer lines, mining of gravel by commercial business enterprises, and construction activities associated with encroaching industries, commercial businesses, residential neighborhoods, and parklands.

There has been a large amount of urban and rural development in the Onion and Williamson Creek watersheds within the last fifty years. This has tremendously reduced the overall width and quality of the riparian corridor in the watersheds degrading wildlife habitat and aquatic resources. Riparian woodlands improve the aquatic habitat and overall aquatic resources in a riverine system. They serve as buffer zones to help remove harmful pollutants and nutrient loading of an aquatic system, serve as depositories for sediments, help stabilize the banks of creeks to prevent scour and erosion and decrease sedimentation and turbidity of aquatic resources, provide shade which lowers water temperatures which in turn helps keep dissolved oxygen levels higher serve as spawning and rearing habitat for fisheries, and serve as corridors for other wildlife resources.

In addition to the direct loss of riparian woodland habitat, there is has been a further degradation to riparian habitat due to proliferation of invasive species such as ligustrum, Chinese tallow, and chinaberry. Nonnative species typically occur in disturbed areas where native species take longer to reestablish. Once established, they proliferate and result in monotypic stands of vegetation, which leads to a decrease in diversity and richness.

The quality of the water and the quantity of water that is recharging the Barton Springs segment of the Edwards Aquifer has been degrading over time. Williamson and Onion Creeks both contribute recharge to the Edwards Aquifer and to Barton Springs, the only known habitat of the Barton Springs salamander and water quality is an issue in both of those creeks. Water quality is the main factor in the species decline of the Barton Springs and Austin blind salamanders. Since these species rely on high water quality to survive and are very sensitive to changes in water quality, water quality is the most degraded niche of their habitat.

## **FUTURE WITHOUT PROJECT CONDITIONS**

In order to effectively evaluate changes to the environment of Onion and Williamson Creeks if proposed projects were implemented, it is necessary to forecast likely future environmental conditions if it were not.

In the absence of any type of flood damage reduction project, the problems experienced in some Austin and Travis County neighborhoods as a result of Onion and Williamson flooding would continue. It is anticipated that growth and development in the watersheds would continue. As a result, there would be additional construction and increased amounts of impervious surfaces such as roads, parking lots, and structures. As mentioned earlier, the increase in future impervious would increase from 6.6% to 18.1% for Onion Creek and 21% to 31% for Williamson Creek. These factors would add to the runoff within the creeks and would typically increase the severity and/or frequency of the flood problems within those neighborhoods currently affected by flooding problems and possibly add to the numbers of structures inundated; however, the city of Austin has a extensive storm water management ordinance which would reduce the impacts from future impervious cover. According to the Onion Creek Soil Erosion Assessment, it is estimated that with proper stormwater management and that the instream erosion potential averaged 13%

over existing conditions and 50% without it. This would however lead to continued degradation of the aquatic resources of Onion and Williamson Creeks. Although the peak flows would be reduced, increased construction and increase of impervious cover would contribute to increases in sediment transport and turbidity from construction activities. These increases are not expected to affect the existing riparian zone to the point that riparian woodland restoration activities would not be sustainable. To the contrary, riparian woodland restoration would help offset some of these impacts from future impervious cover. Riparian woodlands serve as buffer zones to construction sites to help filter pollutants that enter the waterways. In addition, they help attenuate flooding, although this would be expected to be very minor on Onion and Williamson Creeks.

It would be expected that without restoration measures and probably even with restoration measures to a certain extent, water quality in Onion and Williamson Creeks would degrade slightly to moderately in the future as the Travis County continues to develop. The construction phase of new residences and businesses would produce additional sediment load from runoff from construction sites. After completion, the increases in impervious surface area, traffic, lawn fertilizing and other human activities would have an adverse impact on the creeks. Degradation of the water quality would reduce the numbers of aquatic biota in the creeks. The overall diversity of fishes and other aquatic species is already low according to USFWS; the further loss of aquatic biota would therefore be damaging to the aquatic ecosystem.

Encroaching urban and rural development activities would also be expected to negatively impact the watershed's existing vegetation. As mentioned earlier, the existing forested riparian vegetation zone within much of the watershed is already very narrow with several grass and shrub openings. The number and size of the openings would continue to 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. This is especially true for migratory songbirds listed in Addendum 4, which are particularly susceptible to the loss of habitat along their migration routes.

The City of Austin has a Water Quality Ordinance that protects lands that have not been platted for development prior to 2001. This ordinance requires a 400-foot setback from the center of the creek where no vegetation can be removed. Areas that were previously platted are not required to have the setback, but this should protect vegetation in areas that have not been platted along creeks and streams.

The only other scenario that can be reasonably foreseen in the Onion and Williamson Creek watersheds should implementation of the proposed plan fail to occur is that the cities of Austin and Sunset Valley and Travis County would choose to implement a non-structural buyout project sometime in the future. This would allow for the structures to be removed and the lots be maintained in their current vegetative state. Large trees would still exist, but the wildlife habitat gains would not be seen as the areas would continue to be mowed if they are located in subdivisions because of Texas nuisance ordinances. The areas would function similar to the parkland habitat and would improve habitat quality in the area if large continuous blocks were purchased because of the lack of human presence. If large segments were bought, they could also be turned into parks or greenbelts and allowed to return to a more natural state with underbrush, which would significantly improve habitat quality. For purposes of analysis, it was assumed that vegetation would be maintained in its current condition if this were to happen due to the fact that the local parks department has not taken control of existing lands that were bought out in the area for flood damage reduction purposes several years ago. This process would continue over decades as the cities and counties are only budgeted a small amount of money and the proposed project is an approximately \$70 million dollar buyout project. If the city of Austin allocated 100% of their funds to this area and neglected other parts of the city, it would take approximately 20 years to complete the buyout without special bond elections. Projections of future without project conditions are shown later in this document.

The increased impervious cover and increased residential subdivisions would continue to impact the Edwards Aquifer and the Barton Springs. Increased impervious cover limits infiltration into the aquifer and reduces storage capacity of the watershed. Barton Springs would see increased periods of low flows, which would further endanger the Barton Springs salamander and the Austin blind salamander. In addition, water quality would be reduced as mentioned above and therefore the quality of water in the aquifer and Barton Springs would continue to be degraded. Degraded water quality and quantity is the primary factor affecting the Barton Springs and Austin Blind salamanders. The Barton Springs/Edwards Aquifer Conservation District is directed to conserve, protect and enhance the groundwater resources of the Barton Springs segment of the aquifer. They help limit impacts to these resources, but impacts are occurring non-the-less and would continue under the future without project conditions. There are impervious cover regulations over the recharge zone to help reduce these impacts, but continued degradation is still projected over time.

## **ENVIRONMENTAL RESOURCE NEEDS AND OPPORTUNITIES**

### **ENVIRONMENTAL RESOURCE NEEDS**

Since the riparian woodlands of Williamson and Onion Creeks have been severely degraded due to residential development and urbanization, there is a need to restore this valuable riparian woodland habitat to improve the overall aquatic habitat of both creeks. Furthermore, since the existing riparian habitat is being even further degraded by proliferation of invasive species such as ligustrum, Chinese tallow, and chinaberry, there is a need to remove these invasive species to the extent practical. Finally, with water quality being the main reason factor in the species decline of the Barton Springs and Austin blind salamanders, there is a need to improve water quality in both of these creeks.

### **ECOSYSTEM RESTORATION OPPORTUNITIES**

There are multiple ecosystem restoration opportunities in the Onion and Williamson Creek watersheds. They range from riparian ecosystem restoration to endangered species habitat improvement. It was decided that proposed restoration opportunities for Williamson Creek should be concentrated on lands along Williamson Creek that connect other city owned lands to provide connectivity for an extensive riparian corridor or greenbelt. Due to cost constraints, the assumption was made for both creeks that houses would not be bought specifically for restoration purposes. However, if a proposed non-structural alternative is a preferred alternative as part of the Federal plan, then the excess land could be utilized as restoration areas to provide a wider riparian corridor. Currently the existing houses are a limiting factor for restoration opportunities since they extend well into the 25-year floodplain and most of the time homeowners maintain the existing riparian corridor as lawn all the way to the creek. Ecosystem Restoration Opportunities are provided below.

- Restore riparian woodland habitat along Onion Creek and Williamson Creek on public property where it has been completely lost
- Purchase lands adjacent to the creeks and perform riparian woodland habitat restoration to improve the aquatic habitat in the creek
- Restore habitat for the Barton Springs and Austin blind salamanders and well as other karst species by increasing water quantity and restoring water quality being recharged into the aquifer

- Protect existing water quality within the Onion and Williamson Creek watershed by purchasing existing open space and preventing development

## **PLAN FORMULATION**

To effectively formulate an ecosystem restoration plan for Onion and Williamson Creek it was necessary to understand not only the existing natural resources, but the needs and constraints of the riparian ecosystem as a whole. It was also necessary to formulate suitable ecosystem restoration opportunities which could meet the needs of the ecosystem, increase and improve the quality and quantity of wildlife habitat given the system's constraints, and still be cost effective in terms of costs per habitat unit gained.

## **ALTERNATIVE ANALYSIS**

There is a never ending supply of restoration opportunities in the Onion and Williamson Creek Watersheds. Restoring existing riparian woodland habitat is one of the most important ecosystem restoration projects within an urban environment. Riparian woodlands and riparian vegetation in general provide the basis for aquatic life within a creek or river. Without functioning riparian woodlands there would be insufficient shade to keep temperatures suitable for fisheries, benthos and other macroinvertebrate; detritus and other organics.

Both flood damage reduction and ecosystem restoration measures were developed to meet their related needs. Flood damage reduction measures take priority over the ecosystem restoration measures in the areas of interest because the study is primarily a flood damage reduction study. However, ecosystem restoration measures were identified independent of flood damage reduction measures for purposes of cost allocation for combined multipurpose alternatives in the areas of interest. In addition, an ecosystem restoration plans were developed for Onion Creek Combined plans and for Williamson Creek Combined Non-structural and Structural Plans in the areas of interest.

Because of the enormous amount of measures that could be implemented and the limitations of software capable of determining cost effective and incrementally justified projects, the study team elected to use areas as "measures" with fully developed restoration plans. Different planting densities were used as "scales" of the measures. Additionally, in the Williamson Creek and Onion Creek Forest/Yarrabee Bend areas of Interest, goals and objectives were to expand or create a connected riparian corridor as a greenbelt throughout the areas of interest.

In addition, due to the complexity of the Williamson Creek flood damage reduction portion of the study, it was analyzed separately from the other Onion Creek areas of interest. Williamson Creek flood damage reduction and recreation measures were combined in the NED/NER sections for one recommended plan alternative.

## **PRELIMINARY SCREENING OF ALTERNATIVES**

### **Environmental Setting of Areas of Interest**

A vegetation classification of each area of interest was developed using ArcMAP and a vegetation classification provided from the city of Austin. Acreages by vegetative cover were determined for the 1% ACE floodplain. The habitat suitability indices (HSI's) from the habitat evaluation and the acres of each vegetative cover were then used to determine the existing habitat units within each cover type (Table B-1). The overall indices were of high quality except in certain areas of interest where there has been substantial degradation of the riparian zone due to existing development. Each area of interest is described in detail below.



Area of Interest	Riparian Woodland		Grassland		Shrubland		Wetland	
	HSI	HU	HSI	HU	HSI	HU	HSI	HU
<b>Timber Creek</b>	0.82	73	0.94	979	0.80	64	NA	NA
<b>OCF/YB</b>	0.80	286	0.71	524	0.93	55	NA	NA
<b>Perkins Valley/Bluff Springs</b>	0.89	47	0.71	250	NA	NA	NA	NA
<b>Onion Creek CC</b>	0.55	94	0.56	359	0.85	32	NA	NA
<b>Bear/Onion Confluence</b>	0.76	248	0.79	73	0.83	42	0.86	3.4
<b>Williamson Creek</b>	0.53	77	0.57	22	0.78	57	NA	NA
<b>Total</b>		<b>825</b>		<b>2061</b>		<b>250</b>		<b>3.4</b>

### **Timber Creek**

#### General

The Timber Creek area of interest is located in the lower end of Onion Creek Watershed east of Highway 183 from about Burleson Road northeast to State Highway 71. Farm Road 973 runs right through the middle of the area. The Timber Creek Subdivision also falls totally within the flood plain. This reach has been extensively farmed/grazed and has little forest cover except along the riparian zone of Onion Creek. This reach has high soil/clay banks typical of the blackland prairie ecoregion and a large deciduous canopy where it has been left alone. There are several sections of this stream where row-crops have been cut right up to the edge of the stream and there is virtually no riparian zone. In other areas the riparian zone is large (more than 200 meters), dense and intact. The Bergstrom International Airport is also within this reach. The airport lands are managed mostly as grasslands. These grasslands as like the rest on Onion Creek, have relatively high SIs, but are comprised mostly of non-native invader species. In general this reach is highly degraded from agricultural and grazing activities and appears to have areas susceptible to erosion due to a non-continuous and low-quality riparian zone. The Timber Creek area of interest contains approximately 18,000 feet of Onion Creek.

#### Riparian Resources

The Timber Creek area of interest covers about 1,466 acres within the 100-year flood plain and contains several habitat and non-habitat land use types as follows:

- Riparian Woodlands: 89 acres (6%)
- Grasslands: 1,042 acres (71%)
- Shrublands: 89 acres (6%)
- Wetlands: 5 acres (0.3%)
- Urban/bare soil: 241 acres (16%)

The riparian zones in this reach are mature stands of mast producing deciduous trees. The canopy has a high-density closure with very dense understory. The overall riparian woodland HSI value for the Timber Creek area of interest is 0.82 with 73 habitat units providing good habitat. The majority of the trees in these riparian areas were greater than twenty inches in diameter and that improved the overall habitat rating for raccoon cover and reproduction. Barred owl habitat was fair, though the relatively thick understory reduces cover and reproductive values. Similarly fox squirrel habitat value for cover and reproduction was reduced by the relatively thick understory. Barred owls and fox squirrels require a more open under story.

Most of the grasslands along the creeks in Timber Creek have very high HSI values with an overall HSI value of 0.94, with 979 habitat units. The grasslands generally had dense ground cover and a mixture of grasses and forbs. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching. A pair of nesting red-tailed and red-shouldered hawks was observed during site visits. Meadowlark habitat value was very good (0.82) because of the higher percentage of grass present in the areas. Scissor-tailed flycatcher habitat was high at all three sites. Habitat diversity in these areas was good; however, nonnative invasive plant species dominate the grassland area and limit the habitat potential of these sites. Removing nonnative species and restoring native grasses and forbs into the area could improve the habitat.

The shrubland sampled in Timber Creek had very good habitat for scissor-tailed flycatchers and eastern cottontails. There was good ground cover and a good mixture of forbs and grasses (above reference to grasses applies here also). There was a paucity of suitable denning habitat for raccoons, which lowered the habitat value for that species. Removing some of the nonnative invasive species and restoring native vegetation to the area could improve the overall diversity of the area.

#### Aquatic Resources

This reach of Onion Creek also retains water throughout the year. There are several deep pools that retain water throughout even most drought years. Several different species of fish have been observed during site visits of this segment. Large mouth bass, perch, and minnows species were all observed. The large floods have disturbed the habitat along and inside the creeks by leaving the trash from previous flood events in place. This is mainly because the habitat along the creek is densely vegetated in some areas. According to local residents, the creek has also been filled in from construction activities associated with the new bridge and underground storm water discharge lines. This area also incurs slumping from flood events due to high cutbanks comprised of sandy soils. The vegetation has been completely removed from past agricultural and with the sandy soil, the banks erode.

#### Ecosystem Restoration Opportunities

The Timber Creek area of interest is limited due to the proximity of the Austin Bergstrom International Airport. However, opportunities exist for riparian woodland restoration and stream bank stabilization. The stream bank stabilization was removed from consideration because of the large cost, and it is primarily on the edges of the area of interest. Riparian woodland restoration will be evaluated in the detailed investigation of alternatives.

#### ***Onion Creek Forest/Yarrabee Bend***

##### General

The Onion Creek Forest/Yarrabee Bend area of interest is East of I-35 and William Cannon Drive runs almost through the middle of the area. This area has experienced a high density of residential and commercial development within the 500, 100 and 25-year flood plains, which has reduced the width of the riparian corridor. However, this segment of Onion Creek has average quality riparian areas with very mature cypress trees due to the fact it contains the Onion Creek Greenbelt. There are invasive species, such as Chinese Tallow, ligustrum and chinaberry, within the area of interest, which leaves room for improvement for fish and wildlife species. In addition, the cut bank side of the creek in this area is experiencing erosion. This is primarily due to the vegetation being removed from the tops of the banks. Reestablishing vegetation on these banks would help stabilize the banks, which would benefit the overall aquatics in the area.

However, even with the state of degradation, due to the very large, water dependant cypress trees, this area should be protected to the extent possible and would require substantial mitigation if impacted. This segment contains approximately 20,000 feet of creek.

#### Riparian Resources

The Yarrabee Bend area of interest covers about 1414 acres within the 100-year flood plain and contains several habitat and non-habitat land use types as follows:

Riparian Woodlands: 358 acres (25%)  
Grasslands: 738 acres (52%)  
Transitional Woodlands: 105 acres (7%)  
Wetlands: 3 acres (0.2%)  
Urban/bare soil: 210 acres (15%)

The overall HSI value for riparian woodlands in Onion Creek Forest/Yarrabee Bend is 0.80 with 286 Habitat Units providing good habitat. However, the majority of the trees in these riparian areas were less than ten inches in diameter, which lowered the overall habitat rating for raccoon cover and reproduction. The barred owl habitat was fair, and the relatively thick understory reduced cover and reproductive values. Similarly, fox squirrel habitat value for cover and reproduction was reduced by the relatively thick understory. Barred owls and fox squirrels require a more open understory. Mast producers greater than or equal to 6 inches dbh were fairly common throughout the woodlands producing good food value for fox squirrels. Downy woodpecker habitat rated very well with an HSI value of 1.00.

The grasslands along the creeks in Onion Creek Forest/Yarrabee Bend are in good condition with an overall HSI value of 0.71, with 524 habitat units. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the percent of herbaceous canopy and the lower amount of grass within the sample areas depresses red-tailed nesting success; therefore, these areas only provide fair habitat for red-tailed hawks. Meadowlark habitat value was similarly lower because of the lower herbaceous cover of grass present in the areas. The lower herbaceous cover also impacted scissor-tailed flycatcher habitat. Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles.

The transitional woodland sampled in Onion Creek Forest/Yarrabee Bend had good habitat for raccoons, scissor-tailed flycatchers, and eastern cottontails. There was good ground cover and a good mixture of forbs and grasses. There are also many suitable refuge sites for raccoons.

#### Aquatic Resources

The aquatic resources in Onion Creek Forest/Yarrabee Bend are of pretty fair quality. The creek in this area retains water throughout the year in most all of the segment. There are many deep pools that retain permanent water throughout most drought years. The creek as well as the deep pools, as seen during site visits, provides habitat for catfish, bass, sunfish, frogs, and water snakes. Most of the creek habitat in this are is protected from the Onion Creek Greenbelt, which flows the creek on one or both sides throughout most of the area. The main problem associated with water quality and habitat in this area is from flood events that cause the banks to slump off into the water causing increased sediment loading and destruction of fish habitat.

#### Ecosystem Restoration Opportunities

Ecosystem restoration opportunities in this area are abundant. They included: wetland restoration in the abandoned gravel mine; riparian woodland restoration, buyout of houses and return to riparian woodland, and improvement of existing riparian woodlands by removal of invasive species.

The gravel mines are proposed to be used by the city of Austin as a BMX course and therefore are not available for restoration as wetlands. Buyouts, improvement of existing woodland and riparian woodland restoration will be considered in the detailed investigations of alternatives.

### ***Bluff Springs Road/Perkins Valley***

#### General

The Bluff Springs Road/Perkins Valley area of interest is in the middle of the Onion Creek Country Club and the Onion Creek Forest/Yarrabee Bend Areas of Interest. It is directly east of I-35 and Slaughter Lane runs right through the middle of the area.

#### Riparian Resources

Bluff Spring Road/Perkins Valley covers about 475 acres within the 100-year flood plain and contains several habitat and non-habitat land use types as follows:

Riparian Woodlands: 54 acres (6%)  
Grasslands: 352 acres (71%)  
Shrublands: 17 acres (6%)  
Urban/bare soil: 52 acres (16%)

This small stretch of Onion Creek is dominated by agricultural, rural residential, and some commercial land use. The riparian zone is continuous, but ranges from less than 30 meters to greater than 200 meters, with some areas that are mowed and/or cleared up to one bank of the stream. Since there is no dense residential development, the only activity within the riparian zone is row cropping and cattle grazing, which directly contributes to erosion and sedimentation from the steep soil banks where riparian vegetation has been removed. In general the riparian zone in this area is poor to fair with many areas that are dominated by newer invasive species (most of the lower section) with some higher quality older communities interspersed (primarily in the upper end).

The overall HSI value for the riparian woodlands at Bluff Springs Road/Perkins Valley is 0.89 with 47 Habitat Units providing very good habitat. The raccoon and barred owl require large diameter trees, which were fairly common throughout the woodlands. The trees in these riparian areas were large (many over 20 inches dbh) which increased the overall habitat rating for raccoon cover and reproduction and barred owl habitat. Mast producing trees greater than or equal to 6 inches dbh were fairly common throughout the woodlands producing good food value for fox squirrels. Downy woodpecker habitat also rated very high overall 0.97 HSI (FWS 2002). The riparian woodlands that are established are of high quality; however, there are several areas along the creek where the riparian zone has been reduced due to agricultural practices. The fish and wildlife habitat would benefit from extending the riparian zone and creating a larger buffer zone.

The grasslands along the creeks in Bluff Springs Road/Perkins Valley are in fair condition with an overall HSI value of 0.71, with 250 habitat units. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the percent of herbaceous canopy and the lower amount of grass within the sample areas

depresses red-tailed nesting success and therefore these areas only provide fair habitat for red-tailed hawks. Meadowlark habitat value was similarly lower (fair) because of the lower herbaceous cover of grass present in the areas. The lower herbaceous cover also impacted scissor-tailed flycatcher habitat. Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles. As with many other grassland areas within the Onion Creek watershed, the herbaceous species were mostly nonnative invasive species.

#### Aquatic Resources

The aquatic resources in Bluff Springs Road/Perkins Valley are limited by the intermittent nature of stream flow throughout the area. Throughout the area of interest there are several deep pools that retain permanent water throughout most years. These pools act as refuges for fish and aquatic macroinvertebrates. These creeks have evolved with this flow regime. The deep pools and the creeks when flowing provide habitat for catfish, bass, sunfish, frogs, and water snakes. The Slaughter Road Bridge has caused some adverse impacts to the stream. There are gullies underneath the bridge caused by soil erosion of the bare soil surface during rain events. This leads to increased sediment loading of the creek during rain events. Planting vegetation or placing rock rubble under the bridge could minimize erosion and provide habitat for fish and wildlife species.

#### Ecosystem Restoration Opportunities

The Bluff Springs Road/Perkins Valley area of interest has fair quality existing habitat, but much of the riparian woodlands have been cleared or convert to other uses such as cattle grazing and row cropping. Riparian woodlands could be restored.

USACE and Travis County agreed that the Bluff Springs Road/Perkins Valley area of interest would be omitted from consideration for flood damage reduction. Since the area had fairly good existing habitat, it was decided to remove the area of interest completely for the detailed investigation of alternatives.

### ***Onion Creek Subdivision***

#### General

The Onion Creek Subdivision Area of Interest begins at Interstate 35 (I-35) and ends just above Slaughter Creek. The area downstream of I-35 includes a large residential development and 3 golf courses that dominate this section of Onion Creek. The riparian zone in this reach is extremely narrow (less than 30 meters) and relatively non-functional, particularly within Onion Creek Subdivision, where the understory and much of the canopy cover has been cleared. This area needs an active riparian management strategy to reclaim the high potential value for riparian species.

Several raw banks have developed along the stream with little protective vegetation. The golf course has sustained major erosion and has stability problems throughout the floodplain. This area has been greatly altered and provides minimal habitat for fish and wildlife resources.

Restoration potential here is great, but there would more than likely be great opposition to the restoration as the golf course would have to be closed to properly implement ecosystem restoration. The fairways and greens are within 10-20 feet from the creek in many places. In order to provide for valuable ecosystem restoration a minimum of a 50-foot buffer would be recommended with over 300-feet being optimal.

### Riparian Resources

The Onion Creek Subdivision covers about 971 acres within the 100-year flood plain and contains several habitat and non-habitat land use types as follows:

Riparian Woodlands: 171 acres (18%)  
Grasslands (includes golf course): 641 acres (66%)  
Shrublands: 38 acres (4%)  
Urban/bare soil: 121 acres (12%)

The riparian woodlands of Onion Creek Subdivision are probably the most degraded of all of the Onion Creek areas of interest. According to local residents, the Onion Creek Country Club Golf Course cuts down and removes trees when they show signs of distress. This along with the management of the area as a golf course has caused there to be very little true native riparian woodlands along the country club. Along the South side of the creek, the riparian zone is relatively native riparian woodland with large stands of mature deciduous trees composed of pecan, cypress, and cedar elm trees. However, agricultural fields are directly adjacent to the riparian zone offering very little wildlife edge effect. Directly downstream of the Onion Creek Subdivision there is a very good reference reach that shows what the undisturbed riparian zone should look like. There is a large riparian buffer zone even though residential development has extended right to the edge.

The grasslands along the creeks in the Onion Creek Subdivision are in poor condition with an overall HSI value of 0.56, with 359 habitat units. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the interspersed urban impacts severely depresses red-tailed nesting success and therefore these areas did not provide good habitat for red-tailed hawks. Meadowlark habitat value was similarly lower (fair) because of the lower herbaceous cover of grass present in the areas. The lower herbaceous cover also impacted scissor-tailed flycatcher habitat. Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles (FWS 2002).

### Aquatic Resources

Onion Creek in this stretch of river is intermittent at times, but several large pools of water remain throughout most years. During site visits, several different species of fish were observed in the large pools including: large mouth bass, sunfish, and various species of minnows. Turtles, cricket frogs, leopard frogs, and snakes were also observed during the site visits.

The clearing of riparian habitat, especially the bottomland hardwoods, has effected the aquatic environment by raising water temperatures in some parts of the stream. Large growths of algae were noted along the stream. The management of the area as a golf course may be acting synergistically with the cleared canopy to promote high levels of algae growth. In other areas where the trees have not been cleared, habitat for fish is fair in value. Aquatic vegetation is established and fish communities are using the areas as spawning and rearing grounds.

### Ecosystem Restoration Opportunities

Ecosystem main restoration opportunity in Onion Creek Subdivision includes removal of the existing golf course and restoration of the riparian woodlands. The golf course is within a few feet of Onion Creek and the vegetation has been removed completely from the bank on the golf course side of the creek in some areas.

While this would provide for outstanding restoration potential and provide large amounts of habitat gains, the repercussions from adjacent landowners would be enormous. Large

amounts of money were spent on the adjacent houses because of the proximity of the house to the golf course. There is insufficient room to move the golf course away from the creek and still be located behind the houses. Since the Onion Creek Subdivision was removed from consideration from detailed investigation of alternatives for flood damage reduction purposes and the ecosystem restoration would not be locally supported, the Onion Creek Subdivision was removed completely from consideration in the detailed investigation of alternatives.

### ***Bear/Onion Confluence***

#### General

The Bear/Onion Confluence area of interest is located near the confluence of Bear Creek and Onion Creek west of Interstate Highway 35. There are several older neighborhoods built on the isthmus between these two streams and on the banks of both streams.

#### Riparian Resources

Bear/Onion Confluence covers about 476 acres within the 100-year flood plain and contains several vegetation cover types as follows:

Riparian Woodlands: 326 acres (68%)  
Grasslands: 93 acres (20%)  
Shrublands: 49 acres (10%)  
Wetlands: 4 acres (0.8%)  
Urban/bare soil: 4 acres (0.8%)

The riparian zone here is starting to take on more of an eastern character with flatter topography, soil/clay banks and large deciduous trees. The understory for at least 20 meters on either side of Onion Creek in this area is well established and diverse. The canopy is dense, primarily pecan, walnut, cypress, and cedar elm. The extent of the riparian zone for both streams is about 75 meters on either side of the stream (150 meters total), but is encroached upon regularly by residential development. Outside the 75 meter riparian zone there is a mix of upland juniper and live oak, residential development and light agriculture and grazing. The habitat in this area is fair (Table B-1).

The bottomland hardwoods in this area had an HSI value of 0.76 with 248 habitat units providing good habitat. A limiting factor in this area is the lack of trees over ten inches at diameter at breast height (dbh). In order to increase habitat units in this area, trees should be protected to allow them to grow in size. Extension of the riparian zone would also provide for better habitat diversity.

Most of the grasslands along the creeks in this area are in good condition with an overall HSI value of 0.79, with 73 habitat units. The grasslands generally had good ground cover and a fair to good mixture of grasses and forbs (FWS 2002). However, the mixtures of grasses and forbs were primarily nonnative invader species. One grassland site was a heavily grazed pastureland. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching. Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles. It is believed that some of these grasslands are cleared riparian woodland communities and should be restored back as such.

Wildlife in this area is consistent of normal wildlife species in the Texas Hill Country. There is habitat that supports normal rodent and non-game species as well as game species. This area of interest is on the edge of the city of Austin where there is a substantial deer

population utilizing the riparian zones. Non-game species include but are not limited to skunks, rabbits, opossums, raccoons, snakes, turtles and various birds.

### Aquatic Resources

A couple of low water dams in this area of Interest have altered the natural channel of Onion Creek. Above the upstream dam the channel is flat and filled in with cobble and gravel. The gradient of Onion Creek from the top of the area of interest to the dam is very low. Water willow and other emergent vegetation are dominant in this wide flat section of the stream. Stream flow through this section typically goes subsurface by July with water found only in several deep pools throughout the area.

The second low water dam in this area is formed by the old low water crossing of the original San Antonio road. This old bridge is just upstream from the confluence of Bear Creek and Onion Creek. Onion Creek is a bedrock channel in this section of stream. The bridge creates a deep pool upstream and is a popular fishing spot. The pool holds water throughout most years. The bridge does act to back water up and the culverts beneath the bridge routinely clog with woody debris.

The aquatic resources in Bear/Onion Confluence are limited by the intermittent nature of stream flow throughout the area. This area lies directly below the recharge zone of the Barton Springs segment of the Edwards Aquifer. The streams crossing the Edwards aquifer recharge zone tend to go dry during the summer months because much of the flow is infiltrated into the aquifer through recharge features in the streambeds. Throughout the area of interest there are several deep pools that retain permanent water throughout most years. These pools act as refuge for fish and aquatic macroinvertebrates. These creeks have evolved with this flow regime. The deep pools and the creeks when flowing provide habitat for catfish, bass, sunfish, frogs, and water snakes.

One wetland site was sampled on Onion Creek. The Site is just downstream of Old San Antonio Road and just upstream of Interstate Highway 35. According to the landowner, this wetland was enhanced by excavation 30 to 50 years ago. There is permanent water year round in this wetland. The overall HSI for this four-acre wetland was 0.86 with 3.4 habitat units (FWS 2002). This area is really outside of the area of interest and would not be affected by any of the proposed alternatives.

### Ecosystem Restoration Opportunities

Ecosystem restoration in this area is limited by the size of the area and the relatively good habitat that is present. Residential houses have been built in close proximity to the creek and the main restoration opportunity would be to purchase the houses, remove them, and restore the area back to riparian woodland. This would not be cost effective unless performed in combination with flood damage reduction. Since the flood damage reduction alternative includes a non-structural buyout, this measure will be carried forward into the detailed investigation of alternatives.

### ***Williamson Creek***

#### General

The identified areas of interest on Williamson Creek are densely developed with residential and commercial land uses with an impervious cover of the entire watershed at 21 percent. It is expected that by year 2040, there will be 31 percent impervious cover of the watershed (Chan & Associates 1997). The upper portion of the area of interest is located in the recharge zone for the Barton Springs segment of the Edwards Aquifer. A small area downstream

of the recharge zone is classified as a contributing zone because water flowing from this area actually flows into the recharge zone. The lower portion of the area of interest is in the artesian zone and does not contribute water to the Edwards Aquifer.

Within the areas of interest, Williamson Creek is an intermittent stream that routinely goes dry in the summer months and is typical of a hill country recharge zone stream. However, the lower end of the creek does retain water throughout most, if not all, of the year. According to local residents, the stream retained water further upstream in the past than it does today. The riparian habitat quality throughout this area of interest is poor to average. The riparian zone through Williamson Creek is narrow (less than 50 meters) and very disturbed. A sewer line runs through most of the area of interest and is located in the bottom of the streambed. There are numerous streambank erosion problems through this channel. The majority of the erosion within the active channel is related to the sewer line. However, there are several large raw banks that are actively eroding that are not related to the sewer line.

### Riparian Resources

The Williamson Creek area of interest covers about 428 acres within the 100-year flood plain and contains several habitat and non-habitat land use types as follows:

Riparian Woodlands: 145 acres (34%)  
Grasslands: 38 acres (9%)  
Shrublands: 73 acres (17%)  
Urban/bare soil: 172 acres (40%)

The riparian vegetation in this area is dominated by mostly young invasive species of low habitat quality. Chinaberry, ligustrum, and Chinese tallow, three invasive species, were dominant along the floodplain throughout the area. Other tree species present included willow, pecan, sycamore, cottonwood, Ashe juniper, cedar elm, hackberry, and live oak.

Several of the smaller tributaries in this area have no riparian zone, while some of the headwaters are in their natural state with relatively large undisturbed and forested areas. In general the riparian zone along this portion of Williamson Creek is of low quality and of minimal benefit to stream integrity. The habitat quality for wildlife resources is poor. There is potential for habitat restoration within this area; however, given the current density of urban development, restoration would be difficult. The area does provide habitat for typical urban riparian species. Signs of armadillos, raccoons, and opossum were fairly numerous throughout the area. Cricket frogs and leopard frogs were observed during site visits. The area could provide some habitat for white-tailed deer. Bird species included neotropical migrants, which are listed in Addendum B-4.

Riparian woodland habitat was assessed at five sites along Williamson Creek. The overall HSI value for Williamson Creek is 0.53 with 77 habitat units providing fair habitat. However, the majority of the trees in these riparian areas were less than ten inches in diameter and mostly invasive species and that lowered the overall habitat rating for raccoon cover and reproduction. However, there are significant size trees throughout Williamson Creek. Barred owl habitat was fair, and the relatively thick understory reduces cover and reproductive values. Similarly fox squirrel habitat value for cover and reproduction was reduced by the relatively thick understory. Barred owls and fox squirrels require a more open understory. Mast producers greater than or equal to 6 inches dbh were fairly common throughout the woodlands producing good food value for fox squirrels.

The grasslands along the creeks in Williamson Creek are in fair condition with an overall HSI value of 0.57, with 22 habitat units. The grasslands were adjacent to wooded riparian areas providing good red-tailed hawk nesting and perching habitat. However, the interspersions of urban impacts severely depresses red-tailed nesting success and therefore these areas did not provide

good habitat for red-tailed hawks. Meadowlark habitat value was similarly lower (fair) because of the lower herbaceous cover of grass present in the areas. The lower herbaceous cover also impacted scissor-tailed flycatcher habitat. Habitat diversity in these areas could be improved by establishing a few native tall grassland areas along the floodway grassland boundary with scattered shrubs and scattered brush piles.

The shrublands in the area had good habitat for scissor-tailed flycatchers and eastern cottontails. There was ground cover and a good mixture of forbs and grasses. There was a paucity of suitable denning habitat for raccoons, which lowered the habitat value for that species.

### Aquatic Resources

This area lies upon the recharge zone of the Barton Springs segment of the Edwards Aquifer. The streams crossing the Edwards Aquifer recharge zone tend to go dry during the summer months because much of the flow is infiltrated into the aquifer through recharge features in the streambeds. This stream section typically goes dry throughout the area, but retains water throughout the lower portions of the stream near the confluence. This area probably serves as a migration area for fish that are spawning and rearing. Fish and aquatic insects are quick to populate the area when stream flows are present. These fish and insects either move upstream from perennial water sources or move downstream from deep pools that may hold water throughout the year. Frogs and toads are fairly common throughout this area; however, these species do not need permanent water throughout the year.

In the past, there have been some water quality problems with the sewer lines running down the streambed. During times of high water, the stream flows over the top of the manholes and the pressure from the current removes the covers and raw sewage leaks into the stream. According to the City of Austin, this problem has been corrected to the best of their knowledge by fastening the covers down with screws. Williamson Creek was removed from the 2002 TNRCC Impaired Stream List.

## **DETAILED INVESTIGATION OF ALTERNATIVES**

During the detailed investigations of alternatives, the areas of interest were further broken down into project areas. These project areas were then evaluated and ecosystem restoration only plans and combined plans with the proposed flood damage reduction and recreation were investigated. Onion and Williamson Creeks were evaluated separately and discussed separately below.

### **ONION CREEK**

Two different plans were developed for Onion Creek. An ecosystem restoration only plan was developed in order to perform cost allocations and to set restoration limits. The plan was never intended to be implemented. In addition, a combined plan was developed taking into consideration the flood damage reduction portion of the study. Some of the land that would be purchased for flood damage reduction would be restored as fish and wildlife habitat.

### **Ecosystem Restoration Only Plan Measure**

The ecosystem restoration only measure would be to purchase the areas listed in Table B-2 and described below and implement one of the proposed scales in order to restore riparian woodlands within the areas of interest on Onion Creek. The scales are discussed below in a separate section because they are the same for each area of interest.

TABLE B-2 Acres Within Each Vegetation Classification, Ecosystem Restoration Only Plan, Onion Creek									
AREA/ Measure	Seg	VEGETATION CLASSIFICATION							
		Grass	Wood	Residential	Transitional	Park	Utility/ Water	Bare	TOTAL
A	TC	2.34		6.04		7.65			16.03
B	YB		29.48	1.24	32.65				63.37
E	YB		3.16	1.45	12.09				16.70
F	YB	14.16	15.93		25.43			21.22	76.74
H	YB	8.50		0.71		5.77	1.46		16.44
I	YB		7.75			2.37			10.12
J	YB		2.39			9.81			12.20
L	BO		10.23			2.19	0.45		12.87

### **Timber Creek**

Travis County, the local sponsor for this area of interest, is not interested in participating in ecosystem restoration projects unless it is in combination with a flood damage reduction study. Therefore, only measures that are located in the immediate vicinity of where the flood damage reduction projects would be located were analyzed.

Area A (Addendum B-2, Figure B-1), the only area identified in Timber Creek because of the limitations within the area of interest, would be restored to bottomland hardwoods. The area has a fair amount of existing hardwoods; however, when the area was developed as a residential development, many of the trees were removed and most of the understory was as well. Area A is approximately 16 acres and is comprised of a mix of vegetation (Table B-2).

### **Onion Creek Forest/Yarrabee Bend**

Areas Identified on Figure B-2 in Addendum B-2 and shown in Table B-2 are located within the Onion Creek Forest/Yarrabee Bend area of interest. These areas are comprised of approximately 196 acres of a mix of vegetation types. These areas would be restored as riparian habitat using native species. Habitat values would be expected to increase over time as the plantings mature.

### **Bear/Onion Confluence**

Area L (Addendum B-2, Figure B-3) is located within the Bear/Onion Confluence. This area is comprised of approximately 13 acres of a mix of vegetation types (Table B-2). These areas would be restored as riparian habitat using native species. Habitat values would be expected to increase over time as the plantings mature.

### **Ecosystem Restoration Scales Analyzed**

Scale 0: No Action

Scale 1: Acquisition of 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 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

The quantities above were selected for several reasons. For the grassland and urban restoration back to riparian woodlands, the limiting factor in trying to restore these areas to functional habitat is the lack of mature trees, no understory, and limited, if any, forbs. Therefore, high quantities of each category needed to be used. Higher quantities of trees were used because it was estimated that understory would develop over time, but some were planted to accelerate the successional stages and provide transitional habitat while undergoing succession to a mature riparian woodland. This would involve planting the trees on 12-foot centers and the shrubs on 17-foot centers of clumping under the trees. Next, the limiting factor in the transitional and woodlands is primarily lack of diversity and invasion of exotics. Therefore exotics would be removed and tree would be added on 25-foot centers and the understory shrubs would be placed in clumps or on 20-foot centers. Finally, parklands normally have large trees, but the limiting factor is density of trees and the complete lack of mid-story and understory trees. Therefore, higher quantities of shrubs would be needed. Trees would be placed on 15-foot centers and shrubs would be put on 13-foot centers, or clumped under existing trees.

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 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

The quantities of one-inch caliper trees and 1-gallon shrubs above were selected to accelerate early successional stages of the trees and shrubs. Because the plants would be larger and of better quality, the quantities that were used for seedlings would not be needed as more of these species would be expected to reach maturity. For Grasslands and Urban classifications, the trees would be planted on 25-foot centers and the shrubs on 19-foot centers or clumping under the trees. Next, in the transitional and woodland classification, trees would be added on 30-foot centers and the understory shrubs would be placed in clumps or on 25-foot centers. Finally, parklands would be restored by trees being placed on 25-foot centers and shrubs would be put on 14-foot centers, or clumped under existing trees.

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 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

The quantities of two-inch caliper trees and 5-gallon shrubs above were selected to accelerate early successional stages of the trees and shrubs. Because the plants would be larger and of better quality, the quantities that were used for seedlings would not be needed as more of these species would be expected to reach maturity. For Grasslands and Urban classifications, the trees would be planted on 25-foot centers, but the shrubs would be planted on

23-foot centers or clumped under the trees. Next, in the transitional and woodland classification, the trees would continue to be planted on 25-foot centers, but the shrubs would be planted on 30-foot centers or clumped under the trees. Finally, parklands would continue to be restored by trees being placed on 25-foot centers and shrubs would be put on 14-foot centers, or clumped under existing trees.

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

### **Combined Ecosystem Restoration Plan Measure**

The Combined Ecosystem Restoration Plan 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 Plan for Onion Creek would be to purchase the areas listed in Table B-3 and described below and implement one of the proposed scales in order to restore riparian woodlands within the areas of interest on Onion Creek. The scales are discussed below in a separate section because they are the same for each area of interest.

TABLE B-3 Acres Within Each Vegetation Classification, Combined Ecosystem Restoration Plan Measures, Onion Creek									
AREA	SEG	VEGETATION CLASSIFICATION							
		Grass	Wood	Residential	Transitional	Parkland	Utility/ Water	Bare	TOTAL
A	TC	2.34		6.04		7.65			16.03
B	YB		29.48	1.24	32.65				63.37
C	YB		4.00	15.16					19.16
D	YB			6.55					6.55
E	YB		3.16	1.45	12.09				16.70
F	YB	14.16	15.93		25.43			21.22	76.74
H	YB	8.50		0.71		5.77	1.46		16.44
I	YB		7.75			2.37			10.12
J	YB		2.39			9.81			12.20
K	BO			4.54		0.47		0.85	5.86
L	BO		10.23			2.19	0.45		12.87
Total		25	72.94	35.69	70.17	28.26	1.91	22.07	
NOTE:									

**Timber Creek**

The Combined Ecosystem Restoration Plan for Timber Creek would include the same restoration areas and scales considered under the Ecosystem Restoration Only Plan.

**Onion Creek Forest/Yarrabee Bend**

The Combined Ecosystem Restoration Plan for Onion Creek Forest/Yarrabee Bend would include the same measures as the Ecosystem Restoration Only Plan, but would add Areas C and D (Addendum B-2, Figure B-4). The vegetation classification of these areas is shown on Table B-3. These areas are predominately residential housing developments consisting of maintained yards and large trees consisting primarily of pecan, elms and hackberry. The residential areas currently provide little habitat, however, if the houses were removed, the area could be restored to a high quality riparian area, since most of the area lies within the 100-year floodplain.

**Bear/Onion Confluence**

The Combined Ecosystem Restoration Plan for Bear/Onion Confluence would include the same restoration measures considered under the Ecosystem Restoration Only Plan, but it would add area K for an additional 5.86 acres (Addendum B-2, Figure B-3). The vegetation classification of these areas is shown on Table B-3.

**WILLIAMSON CREEK**

Three different plans were developed for the Williamson Creek area of interest. An ecosystem restoration only plan was developed in order to perform cost allocations and to set restoration limits. The plan was never intended to be implemented. In addition, a combined non-structural plan was developed taking into consideration the buyouts for the flood damage reduction portion of the study. Some of the land that would be purchased for flood damage reduction would be restored as fish and wildlife habitat. Finally, a combined structural plan was

developed that would add ecosystem restoration to the flood damage reduction project to create a multi-purpose project, which would benefit the entire basin.

The Williamson Creek area of interest was further broken down into four additional segments for flood damage reduction purposes. Ecosystem restoration opportunities were also limited to these reaches for Williamson Creek during plan formulation. The most effective restoration would be to remove houses to restore the width of the riparian woodland habitat. As mentioned throughout the report, this would require extensive amounts of capital and would be too expensive from a cost per habitat perspective. The next best opportunity would be to restore the existing lawns to a more natural, native riparian woodland/riverine aquatic ecosystem. The reaches are described as follows:

#### ***Heartwood***

This reach begins a few hundred yards east of Congress Avenue and goes upstream to the lowest 1<sup>st</sup> Street Bridge. This reach includes approximately 5,300 feet of Williamson Creek.

#### ***Radam***

This reach continues upstream from the lowest 1<sup>st</sup> Street Bridge upstream to Manchaca Road. This reach includes approximately 9,300 feet of Williamson Creek.

#### ***Broken Bow***

This reach continues upstream from Manchaca Road and goes upstream to Jones Road. This reach includes approximately 4,100 feet of Williamson Creek.

#### ***Bayton Loop***

This reach extends upstream from Jones Road to Brodie Lane. This reach includes approximately 9,800 feet of Williamson Creek.

### **Ecosystem Restoration Only Plan Measures**

Eight areas were identified for riparian woodland restoration along Williamson Creek. These eight areas should provide an increase of wildlife habitat that could be utilized by neotropical migratory birds, migratory waterfowl, and resident animal species. There should also be an overall benefit to water quality by improving or widening the riparian buffer strip, which would reduce sediment transport, erosion, and nutrient loading since the areas would not be maintained as residential yards anymore.

All areas identified for restoration under the Ecosystem Restoration Only Plan would be restored to riparian woodlands with thick understory. There are four existing habitat types or vegetation classifications that are found on Williamson Creek: grasslands, woodlands, urban, and parklands. Different management techniques and different planting densities are required to restore these different existing habitat types back to riparian woodlands. In addition, different sizes of plants can be used. Therefore, planting densities for each habitat type and scales of plant sizes were developed for each habitat type.

The ecosystem restoration measures evaluated with this plan did not take flooding considerations into account. This alternative was developed to meet the environmental needs of Williamson Creek. This would include restoring all vegetation classifications within the identified areas to riparian woodlands in segments 1-4. This plan would provide a linear corridor of riparian woodlands throughout the study area from Brodie Lane to below Congress Avenue. The only breaks in the corridor would be at existing road crossings and utility lines.

### **Heartwood**

This reach contains two areas comprised of approximately 16.5 acres that are suitable for restoration. Areas EA and EB are 3.81 acres and 12.69 acres respectively (Addendum B-2, Figure B-5A). These areas contain a mix of poor quality woodland and parkland and average quality grasslands (Table B-4). These areas would all be restored to high quality riparian woodlands.

### **Radam**

This reach contains two areas comprised of approximately 39 acres that are suitable for restoration. Areas EC and ED are 12.69 and 25.09 acres respectively (Addendum B-2, Figure B-5B). These areas contain a mix of average quality woodlands, parklands, and grasslands (Table B-4). These areas would all be restored to high quality riparian woodlands.

### **Broken Bow**

This reach contains area EE, which is comprised of approximately 16.59 acres (Addendum B-2, Figure B-5C). Area EE contains a mix of average quality woodlands and parklands (Table B-4). This reach contains some of the larger live oak trees in the Williamson Creek watershed, but there is a limiting factor of no understory present within the parkland classification. This area would be restored to high quality woodlands.

### **Bayton Loop**

This reach contains three areas comprised of approximately 76.29 acres suitable for restoration. Areas EF, EG, and EH are 20.04, 11.89, and 44.36 acres respectively (Addendum B-2, Figures B-5C & B-5D). This reach contains some of the better quality woodlands within Williamson Creek. However, they still can only be classified as average to medium quality habitat. These areas contain a mix of vegetation that is shown in Table B-4. The areas would be restored to higher quality riparian woodlands that would have existed prior to urbanization in the Williamson Creek watershed.

Table B-4 Acres Within Each Vegetation Classification Ecosystem Restoration Only Plan, Williamson Creek						
AREA	SEG	VEGETATION CLASSIFICATION				
		GRASSLAND	WOODLAND	URBAN	PARKLANDS	TOTAL
EA	1		3.01		0.8	3.81
EB	1	0.56	4.73		7.4	12.69
EC	2	2.29	4.5		18.3	25.09
ED	2		3.14	0.63	10.19	13.96
EE	3		4.14		12.45	16.59
EF	4	3.08	16.96			20.04
EG	4		9.57		2.32	11.89
EH	4	2.99	35.78		5.59	44.36

Note:

### Ecosystem Restoration Scales Analyzed

Scale 0: No Action

Scale 1: Acquisition of 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

The justification for these scales remains consistent with what was described under the Onion Creek Ecosystem Restoration only Plan. Under scales 1, 2, and 3 identified above, the restoration would include removing exotic or invasive species, such as ligustrum, and then restoring a diversity of native species identified in Addendum B-3 with densities identified above. The removal would primarily be completed by mechanical or hand removal.

### **Combined Non-Structural Ecosystem Restoration Plan Measures**

The ecosystem restoration measures evaluated with this plan takes into consideration the proposed non-structural flood damage reduction alternative. This would include restoring all vegetation classifications (Table B-5) within the identified areas to riparian woodlands in as well as restoring riparian woodlands as an alternate use of the lands purchased for flood damage reduction thus providing a greater width riparian corridor. This plan would provide a linear corridor of riparian woodlands throughout the study area from Brodie Lane to below Congress Avenue. The only breaks in the corridor would be at existing road crossings and utility lines.

#### ***Heartwood***

For the Combined Non-Structural Ecosystem Restoration Plan in this reach, Areas NA, NB, and NK would be restored using the scales identified under the Ecosystem Restoration Only Plan (Addendum B-2, Figure B-6A).

#### ***Radam***

For the Combined Non-Structural Ecosystem Restoration Plan in this reach, Areas NC, ND, and NL would be restored using the scales identified under the Ecosystem Restoration Only Plan (Addendum B-2, Figure B-6B).

#### ***Broken Bow***

For the Combined Non-Structural Ecosystem Restoration Plan in this reach, Areas NE, NI, NM, and NN would be restored using the scales identified under the Ecosystem Restoration Only Plan (Addendum B-2, Figure B-6C).

#### ***Bayton Loop***

For the Combined Non-Structural Ecosystem Restoration Plan in this reach, Areas NF, NG, NH, NJ, and NO would be restored using the scales identified under the Ecosystem Restoration Only Plan (Addendum B-2, Figure B-6C & 6D).

Table B-5 Acres Within Each Vegetation Classification Combined Non-Structural Ecosystem Restoration Plan, Williamson Creek						
AREA/ Measure	SEG	VEGETATION CLASSIFICATION				TOTALS
		Grass	Wood	Urban	Park	
NA	1		2.08	0.09	0.80	2.97
NB	1		2.32	0.61	7.49	10.42
NC	2	2.29	4.50	1.46	11.99	20.24
ND	2				6.31	6.31
NE	3		2.32	0.14	9.42	11.88
NF	4	3.09	16.16	1.37		20.62
NG	4		8.63		2.19	10.82
NH	4	2.99	35.78		5.59	44.36
NI	3		1.82	0.36	3.01	5.19
NJ	4		1.02		0.12	1.14
NK	1		0.96			0.96
NL	2		3.66	2.65		6.31
NM	3			7.37	0.43	7.80
NN	3		1.59	0.66		2.25
NO	4		0.33	3.79	0.22	4.34

Note: Areas NA - NH = Restoration Only Areas. NI - NO = areas where structures would be removed and the lands would be restored.

### Ecosystem Restoration Scales Analyzed

The ecosystem restoration scales utilized would be the same as those identified in the Ecosystem Restoration Only Plan identified above. However, since there are additional lands, table B-5 shows the vegetation classification of the Non-structural combined plan measures as well as which reach the area is in. Areas NA-NH would be bought for restoration only. Areas NI-NO would be acquired for flood damage reduction, the structures would be removed and the land would be restored to woodlands.

### Combined Structural Ecosystem Restoration Plan Measures

The ecosystem restoration measures evaluated with this plan takes into consideration the proposed structural flood damage reduction alternative. This plan would include restoring all vegetation classifications in Areas SA-SI to riparian woodlands as well as restoring parkland on the lands that would be bought for flood damage reduction (areas SJ-SV) 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 restoration benefits and costs would be allocated towards mitigation requirements as a result of the structural flood damage reduction measure being implemented.

#### **Heartwood**

For the Combined Structural Ecosystem Restoration Plan in this reach, Areas SA and SB would be restored using the scales 0-3 identified below. In addition, Areas SJ and SQ would be restored using scales 0 and 4-6 (Enclosure B-2, Figure B-7A) Table B-6.

**Radam**

For the Combined Structural Ecosystem Restoration Plan in this reach, Areas SC, SD, and SE would be restored using the scales 0-3 identified below. In addition, Areas SK, SL, SR, and SS would be restored using scales 0 and 4-6 (Enclosure B-2, Figure B-7B).

**Broken Bow**

For the Combined Structural Ecosystem Restoration Plan in this reach, Area SF would be restored using the scales 0-3 identified below. In addition, Areas SM, SP, and ST would be restored using scales 0 and 4-6 (Enclosure B-2, Figure B-7C).

**Bayton Loop**

For the Combined Structural Ecosystem Restoration Plan in this reach, Area SG, SH, and SI would be restored using the scales 0-3 identified below. In addition, Areas SN, SO, SU, and SV would be restored using scales 0 and 4-6 (Enclosure B-2, Figure B-7C & 7D).

Table B-6 Acres Within Each Vegetation Classification Combined Structural Ecosystem Restoration Plan Measures, Williamson Creek						
AREA	SEG	VEGETATION CLASSIFICATION				TOTALS
		GRASSLAND	WOODLAND	URBAN	PARKLANDS	
SA	1		3.01		0.80	3.81
SB	1		1.09	0.24	5.64	6.97
SC	2	2.31	4.55	1.46	12.58	20.90
SD	2				3.81	3.81
SE	2		2.09	0.64		2.73
SF	3	0.38	2.79		5.21	8.38
SG	4	2.28	13.95	1.39		17.62
SH	4		6.75		2.02	8.77
SI	4	2.99	35.78		5.59	44.36
SJ	1		0.91	0.32	1.94	3.17
SK	2				2.21	2.21
SL	2		1.01		0.29	1.30
SM	3		1.43	0.35	4.77	6.55
SN	4	0.71	3.62	0.29		4.62
SO	4		2.74		0.30	3.04
SP	3				2.20	2.20
SQ	1		2.44			2.44
SR	2				0.15	0.15
SS	2			0.73		0.73
ST	3				0.57	0.57
SU	4	0.09				0.09
SV	4		0.11			0.11

Note: Areas SA - SI = Restoration only areas. SJ - SV = Areas where structural alternatives would occur and restoration would be on top of the structural alternatives.

### **Ecosystem Restoration Scales Analyzed:**

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 Addendum B-3 with densities identified above. The invasive species removal would primarily be completed by mechanical or hand removal methods with herbicide treatment.

## **INCREMENTAL COST ANALYSIS OF ECOSYSTEM RESTORATION**

There are straight forward decision rules set forth in the Principles and Guidelines (P&G) for selecting a recommended plan for a flood damage reduction project based on economics where both outputs and benefits are measured in dollars. A similar standard does not exist for environmental proposals because the outputs are not measured in dollars, but in outputs such as habitat units, acres, etc., that preclude development of a benefit-to-cost ratio to eliminate undesirable, non supportable project alternatives. Cost effectiveness and incremental analysis techniques are useful tools for the decision maker. They help to eliminate poor alternatives and to guide the thought process in determining which project alternatives are supportable when environmental output levels continue to increase with increased expenditure of economic resources.

Cost effectiveness and incremental cost analyses techniques were used to determine the most cost effective levels of restoration efforts in terms of costs per habitat units gained. For ease of analysis, the study area was broken down into three areas of interest for Onion Creek and four for Williamson Creek based on some of the major road crossings that transected the watershed and the areas. These reaches were further delineated by the vegetation coverage (grassland, woodland, urban, or parkland) of developed and undeveloped acres identified for ecosystem restoration. Separate cost effectiveness and incremental cost analyses were then run for ecosystem restoration utilizing woodland conversion for the ecosystem restoration only plan and non-structural combined plan for Onion Creek and for the ecosystem restoration only plan, non-structural combined plan, and the structural combined plan for Williamson Creek. All the plans were evaluated using annualized habitat unit gains versus annualized cost estimates including the real estate costs for land acquisition and those for yearly operations and maintenance.

Due to the complexity of the analyses, the software program IWR-Plan was used. Costs that were put into the program for use were annualized first costs of the construction only. This included restoration costs and estimated land costs of \$7,500 per acre. In addition, the Williamson Creek costs have a 25% contingency added to the costs. A summary table is provided later in this section for the results of the incremental analysis. Values used in the main report include additional costs such as engineering and design, construction management, interest during construction, real estate costs from the gross appraisal and other costs which cause the costs per habitat unit to be higher in the main report than in this appendix. The incremental analysis was used to screen measures and scales for the "best buy" plan that could be implemented as a Recommended Plan. The differences in costs would not affect the plan formulation, so the numbers reflected in this incremental analysis are merely for screening purposes.

### **COMBINATIONS FOR FINAL INCREMENTAL ANALYSIS**

Based on cost effectiveness and incremental cost analyses techniques and model analyses, steps prior to the combinations for final incremental analysis eliminated from consideration all combinations of segments and woodland conversion measures that were not cost effective and incrementally justified. The combinations of the remaining cost effective action and the no action plans represented in the tables below are cost effective and incrementally justified. The plans are sorted and shown by increasing annual cost. It should be noted that each successive plan also shows continually increasing environmental outputs. The decision as to which combination to recommend has to be based on whether the incremental cost of the next increase in habitat units is worth the cost of the habitat units gained.

**Onion Creek Ecosystem Restoration Only**

Table B-7 presents the summary statistics of the cost effectiveness and incremental cost analysis models for the final alternatives for the ecosystem restoration measures for the Ecosystem Restoration Only Plan for Onion Creek. IWR-Plan analyzed over 65,536 combinations of the alternatives and there were 163 cost effective plans. Of the 163, there were 22 best buy plans.

<b>Table B-7 Incremental Analysis, Final Array of Alternatives Ecosystem Restoration Ecosystem Restoration Only Plan, Onion Creek</b>					
<b>Measures</b>	<b>Total Annual Cost (AAC)</b>	<b>Total Output (AAHU's) Minus No Action</b>	<b>Incremental Cost Per Unit of Output</b>	<b>Incremental Output (AAHU's)</b>	<b>Average Cost AAC/AAHU</b>
No Action	0	N/A	N/A	112.27	N/A
F1	61,203	33.79	1,811	33.79	1,811
F1, J1	71,754	39.41	1,877	5.62	1,821
A1, F1, J1	86,101	45.27	2,448	5.86	1,902
A1, F1, H1, J1	99,517	50.43	2,600	5.16	1,973
A1, F1, H1, I1, J1	107,323	52.72	3,408	2.29	2,036
A1, E1, F1, H1, I1, J1	119,700	56.19	3,566	3.47	2,130
A1, E1, F1, H1, I1, J1, L1	129,334	58.45	4,262	2.26	2,213
<b>A1, B1, E1, F1, H1, I1, J1, L1</b>	<b>175,195</b>	<b>69.1</b>	<b>4,306</b>	<b>10.65</b>	<b>2,535</b>
A1, B1, E1, F3, H1, I1, J1, L1	243,376	69.79	988,13	.69	3,487
A1, B1, E1, F3, H2, I1, J1, L1	251,365	69.86	114,128	.07	3,598
A1, B1, E1, F3, H2, I1, J2, L1	257,856	69.91	129,820	.05	3,688
A1, B1, E3, F3, H2, I1, J2, L1	274,172	70.03	135,966	.12	3,915
A1, B1, E3, F3, H2, I1, J2, L2	279,696	70.07	138,100	.04	3,992
A2, B1, E3, F3, H2, I1, J2, L2	288,554	70.13	147,633	.06	4,115
A3, B1, E3, F3, H2, I1, J2, L2	301,448	70.21	161,675	.08	4,294
A3, B1, E3, F3, H3, I1, J2, L2	310,005	70.26	170,340	.05	4,412
A3, B1, E3, F3, H3, I1, J2, L3	317,190	70.3	179,625	.04	4,512
A3, B3, E3, F3, H3, I1, J2, L3	376,902	70.6	199,040	.30	5,339
A3, B3, E3, F3, H3, I2, J2, L3	381,485	70.61	458,300	.01	5,403
A3, B3, E3, F3, H3, I2, J3, L3	391,433	70.63	497,400	.02	5,542
A3, B3, E3, F3, H3, I3, J3, L3	397,508	70.64	607,500	.01	5,627

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

Based on the results presented in the table above, 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 areas A, B, E, F, H, I, J, and L (Enclosure B-2, Figures B-1, 2, & 3) would be recommended for the Ecosystem Restoration Only Plan. This combination would allow net habitat gains of + 69.10 units at an average annual cost of \$175,195.00. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-8 represents the future with and without project conditions for the Onion Creek Ecosystem Restoration Only Plan used during the incremental analysis runs for the selected alternatives. Figure A shows graphically the results from the final incremental analysis for the Onion Creek Ecosystem Restoration Only Plan.

**Economic Summary**

As mentioned above, the costs that were used during the incremental analysis did not include construction management, construction design, and interest during construction, etc. All of these prices are across the board contingencies so it would not affect formulation. The project first cost was used during formulation of the overall project costs when combined with the other project features. These costs are reflected in Chapter 4. Table B-9 lists the first cost and economics of each recommended restoration measure.

<b>Table B-8 Future With and Without Project AAHU's for Onion Creek Ecosystem Restoration Only Plan Alternatives</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area A)	6.98	12.84	5.86
Riparian Woodlands (Area B)	43.11	53.76	10.65
Riparian Woodlands (Area E)	10.34	13.81	3.47
Riparian Woodlands (Area F)	25.98	59.77	33.79
Riparian Woodlands (Area H)	6.25	11.41	5.16
Riparian Woodlands (Area I)	6.53	8.82	2.29
Riparian Woodlands (Area J)	4.47	10.09	5.62
Riparian Woodlands (Area L)	8.61	10.87	2.26
<b>Total</b>	<b>112.27</b>	<b>181.37</b>	<b>69.10</b>

<b>Table B-9 Economic Summary Onion Creek Ecosystem Restoration Only Plan December 2004 Prices, 5.375%, 50-Year</b>	
<b>MEASURE</b>	<b>First Cost</b>
A	\$232,435
<b>Subtotal Timber Creek</b>	<b>\$232,435</b>
B	\$748,007
E	\$200,212
F	\$998,990
H	\$217,210
I	\$125,427
J	\$170,327
<b>Subtotal OCF/YB</b>	<b>\$2,460,173</b>
L	\$155,332
<b>Subtotal Bear/Onion</b>	<b>\$155,332</b>
<b>Total First Cost ER Only Plan</b>	<b>\$2,847,940</b>
Interest During Construction	\$154,445
<b>Total Investment Cost</b>	<b>\$3,002,385</b>
<b>Incremental Analysis</b>	
Interest During Construction 5.375%	\$161,375
Amortization	\$12,700
Operation and Maintenance	\$1,120
<b>Total Annual Charges</b>	<b>\$175,195</b>

**FIGURE A:  
INCREMENTAL ANALYSIS FOR ONION CREEK ECOSYSTEM RESTORATION ONLY PLAN  
Best Buy Plans - OC ER Only  
Onion Creek ER Only Plan**



**Onion Creek Combined Non-Structural Ecosystem Restoration Plan**

Table B-10 presents the summary statistics of the cost effectiveness and incremental cost analysis models for the final alternatives for the ecosystem restoration measures for the Combined Non-Structural Ecosystem Restoration Plan for Onion Creek. IWR-Plan analyzed over 177,147 combinations of the alternatives and there were 186 cost effective plans. Of the 186, there were 23 best buy plans.

Table B-10 Incremental Analysis, Final Array of Alternatives Onion Creek, Ecosystem Restoration Combined Non-Structural Ecosystem Restoration Plan					
Measures	Total Annual Cost (AAC)	Total Output (AAHU's) Minus No Action	Incremental Cost Per Unit of Output	Incremental Output (AAHU's)	Average Cost AAC/AAHU
No Action	0	N/A	N/A	121.35	
K1	4,970	3.89	1277	3.89	1,278
D1, K1	10,915	7.44	1,674	3.55	1,467
D1, F1, K1	72,118	41.23	1,811	33.79	1,749
D1, F1, J1, K1	82,669	46.85	1,877	5.62	1,765
C1, D1, F1, J1, K1	99,118	55.59	1,882	8.74	1,783
A1, C1, D1, F1, J1, K1	113,465	61.45	2,448	5.86	1,846
A1, C1, D1, F1, H1, J1, K1	126,881	66.61	2,600	5.16	1,905
A1, C1, D1, F1, H1, I1, J1, K1	134,687	68.9	3,408	2.29	1,955
A1, C1, D1, E1, F1, H1, I1, J1, K1	147,064	72.37	3,566	3.47	2,032
A1, C1, D1, E1, F1, H1, I1, J1, K1, L1	156,698	74.63	4,262	2.26	2,100
A1, B1, C1, D1, E1, F1, H1, I1, J1, K1, L1	<b>202,559</b>	<b>85.28</b>	<b>4,306</b>	<b>10.65</b>	<b>2,375</b>
A1, B1, C1, D1, E1, F1, H1, I1, J1, K2, L1	203,141	85.33	11,640	.05	2,381
A1, B1, C1, D1, E1, F1, H1, I1, J1, K2, L2	208,665	85.41	69,050	.08	2,443
A1, B1, C1, D1, E1, F2, H1, I1, J1, K2, L2	276,846	86.1	98,813	.69	3,215
A1, B1, C1, D1, E2, F2, H1, I1, J1, K2, L2	293,162	86.22	135,966	.12	3,400
A1, B1, C1, D1, E2, F2, H2, I1, J1, K2, L2	309,668	86.34	137,550	.12	3,587
A2, B1, C1, D1, E2, F2, H2, I1, J1, K2, L2	331,460	86.48	155,657	.14	3,833
A2, B2, C1, D1, E2, F2, H2, I1, J1, K2, L2	391,172	86.78	199,040	.30	4,508
A2, B2, C1, D1, E2, F2, H2, I1, J2, K2, L2	407,611	86.85	234,842	.07	4,693
A2, B2, C1, D2, E2, F2, H2, I1, J2, K2, L2	417,100	86.89	237,225	.04	4,800
A2, B2, C2, D2, E2, F2, H2, I1, J2, K2, L2	442,790	86.99	256,900	.10	5,090
A2, B2, C2, D2, E2, F2, H2, I2, J2, K2, L2	453,448	87.01	532,900	.02	5,211

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

Based on the results presented in the table above, it was determined that for the conversion to riparian woodland on Onion Creek for the Combined Non-Structural Plan, applying measure 1 (identified above) in areas A-L would be recommended for the Combined Structural

Ecosystem Restoration Plan (Enclosure B-2, Figures B-1, B-3 & 4). This combination would allow net habitat gains of + 85.28 units at an average annual cost of \$202,559. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-11 represents the future with and without project conditions for the Onion Creek Combined Non-Structural Ecosystem Restoration Plan used during the incremental analysis runs for the selected alternatives. Figure B shows graphically the results from the final incremental analysis for the Onion Creek Combined Non-Structural Ecosystem Restoration Plan.

**Economic Summary**

As mentioned above, the costs that were used during the incremental analysis did not include construction management, construction design, and interest during construction, etc. All of these prices are across the board contingencies so it would not affect formulation. The project first cost was used during formulation of the overall project costs when combined with the other project features. These costs are reflected in Chapter 4. Table B-12 lists the first cost and economics of each recommended restoration measure.

<b>Table B-11 Future With and Without Project AAHU's for Onion Creek Combined Non-Structural Ecosystem Restoration Plan</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area A)	6.98	12.84	5.86
Riparian Woodlands (Area B)	43.11	53.76	10.65
Riparian Woodlands (Area C)	7.13	15.87	8.74
Riparian Woodlands (Area D)	1.77	5.32	3.55
Riparian Woodlands (Area E)	10.34	13.81	3.47
Riparian Woodlands (Area F)	25.98	59.77	33.79
Riparian Woodlands (Area H)	6.25	11.41	5.16
Riparian Woodlands (Area I)	6.53	8.82	2.29
Riparian Woodlands (Area J)	4.47	10.09	5.62
Riparian Woodlands (Area K)	0.18	4.07	3.89
Riparian Woodlands (Area L)	8.61	10.87	2.26
<b>Total</b>	<b>121.35</b>	<b>206.63</b>	<b>85.28</b>

<b>Table B-12</b>	
<b>Economic Summary</b>	
<b>Onion Creek Combined Non-Structural Ecosystem Restoration Plan</b>	
December 2004 Prices, 5.375%, 50-Year	
<b>MEASURE</b>	<b>First Cost</b>
A	\$232,435
<b>Subtotal Timber Creek</b>	<b>\$232,435</b>
B	\$748,007
C	\$266,820
D	\$94,975
E	\$200,212
F	\$998,990
H	\$217,210
I	\$125,427
J	\$170,327
<b>Subtotal OCF/YB</b>	<b>\$2,821,968</b>
K	\$79,020
L	\$155,332
<b>Subtotal Bear/Onion</b>	<b>\$234,352</b>
<b>Total First Cost Combined Plan</b>	<b>\$3,288,755</b>
Interest During Construction	\$178,351
<b>Total Investment Cost</b>	<b>\$3,467,106</b>
<b>Incremental Analysis</b>	
Interest During Construction 5.375%	\$186,354
Amortization	\$14,664
Operation and Maintenance	\$1,540
<b>Total Annual Charges</b>	<b>\$202,559</b>

**FIGURE B:**  
**INCREMENTAL ANALYSIS ONION CREEK COMBINED ECOSYSTEM RESTORATION PLAN**  
**Best Buy Plans - OC Combined 1**  
Onion Creek Combined Plan



**Williamson Creek Ecosystem Restoration Only Plan**

Table B-13 presents the summary statistics of the cost effectiveness and incremental cost analysis models for the final alternatives for the ecosystem restoration measures for the Ecosystem Restoration Only Plan for Williamson Creek. IWR-Plan analyzed over 65,536 combinations of the alternatives and there were 185 cost effective plans. Of the 185, there were 19 best buy plans.

<b>Table B-13</b> <b>Incremental Analysis, Final Array of Alternatives</b> <b>Williamson Creek, Ecosystem Restoration</b> <b>Ecosystem Restoration Only Plan</b>					
Measures	Total Annual Cost (AAC)	Total Output (AAHU's) Minus No Action	Incremental Cost Per Unit of Output	Incremental Output (AAHU's)	Average Cost AAC/AAHU
No Action	0	N/A	N/A	58.71	N/A
C1	26,475	13.7	1,932	13.70	1,932
B1, C1	39,138	20.02	2,003	6.32	1,955
B1, C1, E1	56,352	28.48	2,034	8.46	1,979
B1, C1, D1, E1	70,938	35.64	2,037	7.16	1,990
A1, B1, C1, D1, E1	74,321	37.13	2,270	1.49	2,002
A1, B1, C1, D1, E1, H1	111,988	51.27	2,663	14.14	2,184
A1, B1, C1, D1, E1, G1, H1	122,193	55.06	2,692	3.79	2,219
<b>A1, B1, C1, D1, E1, F1, G1, H1</b>	<b>139,027</b>	<b>60.93</b>	<b>2,867</b>	<b>5.87</b>	<b>2,282</b>
A1, B1, C1, D3, E1, F1, G1, H1	162,732	61.8	27,247	0.87	2,633
A1, B1, C1, D3, E2, F1, G1, H1	173,637	62.2	27,262	0.40	2,792
A1, B1, C1, D3, E3, F1, G1, H1	191,301	62.84	27,600	0.64	3,044
A1, B1, C3, D3, E3, F1, G1, H1	233,758	64.26	29,899	1.42	3,638
A1, B1, C3, D3, E3, F2, G1, H1	244,644	64.59	32,987	0.33	3,788
A1, B1, C3, D3, E3, F3, G1, H1	256,744	64.95	33,611	0.36	3,953
A1, B3, C3, D3, E3, F3, G1, H1	276,920	65.48	38,067	0.53	4,229
A1, B3, C3, D3, E3, F3, G1, H3	332,375	66.48	55,455	1.00	5,000
A1, B3, C3, D3, E3, F3, G3, H3	347,939	66.75	57,644	0.27	5,213
A3, B3, C3, D3, E3, F3, G3, H3	352,968	66.83	62,862	0.08	5,282

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

Based on the results presented in the table above, it was determined that for the conversion to riparian woodland on Williamson Creek for the Ecosystem Restoration Only Plan, applying scale 1 (identified above) in areas EA – EH in all the segments would be recommended for the ecosystem restoration plan (Addendum B-2, Figures B-5A-D). This combination would allow net habitat gains of + 60.93 units at an average annual cost of \$139,027.00. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-14 represents the future with and without project conditions for the Williamson Creek Ecosystem Restoration Only Plan used during the incremental analysis runs for the selected

alternative. Figure C shows graphically the results from the final incremental analysis for the Ecosystem Restoration Only Plan.

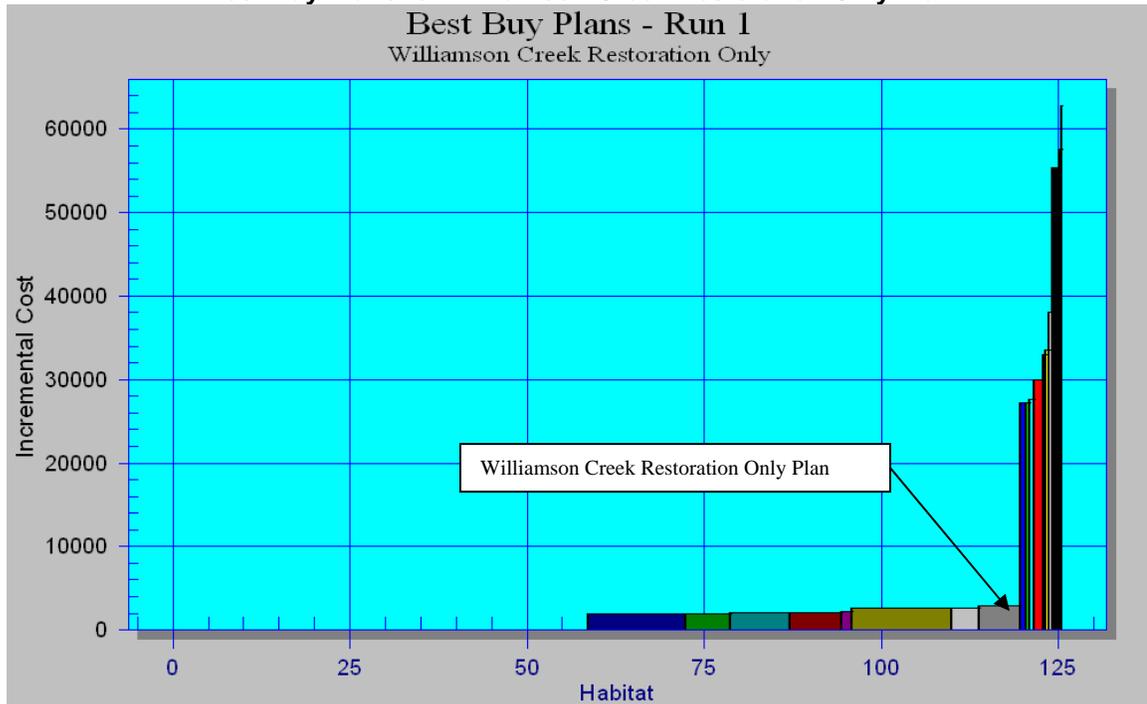
**Economic Summary**

As mentioned above, the costs that were used during the incremental analysis did not include construction management, construction design, and interest during construction, etc. All of these prices are across the board contingencies so it would not affect formulation. The project first cost was used during formulation of the overall project costs when combined with the other project features. These costs are reflected in Chapter 4. Table B-15 lists the first cost and economics of each recommended restoration measure.

<b>Table B-14</b>			
<b>Future With and Without Project AAHU's for Williamson Creek Ecosystem Restoration Only Plan</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area EA)	1.30	2.79	1.49
Riparian Woodlands (Area EB)	3.20	9.52	6.32
Riparian Woodlands (Area EC)	5.52	19.22	13.70
Riparian Woodlands (Area ED)	3.65	10.81	7.16
Riparian Woodlands (Area EE)	4.57	13.03	8.46
Riparian Woodlands (Area EF)	10.60	16.47	5.87
Riparian Woodlands (Area EG)	6.43	10.22	3.79
Riparian Woodlands (Area EH)	23.44	37.58	14.14
<b>Total</b>	<b>58.71</b>	<b>119.64</b>	<b>60.93</b>

<b>Table B-15</b>	
<b>Economic Summary</b>	
<b>Williamson Creek Ecosystem Restoration Only Plan</b>	
December 2004 Prices, 5.375%, 50-Year	
<b>MEASURE</b>	<b>First Cost</b>
EA	\$53,065
EB	\$204,878
EC	\$430,850
ED	\$236,344
EE	\$279,341
EF	\$273,125
EG	\$164,666
EH	\$613,944
<b>Total First Cost ER Only Plan</b>	<b>\$2,256,212</b>
Interest During Construction	\$122,355
<b>Total Investment Cost</b>	<b>\$2,378,567</b>
<b>Annual Costs</b>	
Interest During Construction 5.375%	\$127,847
Amortization	\$10,060
Operation and Maintenance	\$1,120
<b>Total Annual Charges</b>	<b>\$139,027</b>

**Figure C:  
Best Buy Plans for Williamson Creek Restoration Only Plan**



**Williamson Creek Combined Non-Structural Ecosystem Restoration Plan**

Due to the limitations of the IWR-Plan Software, the combined Non-Structural Plan had to be broken out into two separate parts for analysis. The most meaningful way to perform this was to analyze areas that were being bought for restoration only separately from areas that were being bought for flood damage reduction and then being utilized for ecosystem restoration as an alternate use of the land.

Tables B-16 and B-17 present the summary statistics of the cost effectiveness and incremental cost analysis models for the final alternatives for the ecosystem restoration measures for the Non-Structural Combined Ecosystem Restoration Plan for Williamson Creek. For the restoration only lands, IWR-Plan analyzed over 65,536 combinations of the measures and there were 214 cost effective plans. Of the 214, there were 18 best buy plans. For the combined use lands, IWR-Plan analyzed over 16,384 combinations of the measures and there were 180 cost effective plans. Of the 180, there were 18 best buy plans.

<b>Table B-16</b>					
<b>Incremental Analysis, Final Array of Alternatives</b>					
<b>Williamson Creek, Ecosystem Restoration Restoration Only Lands</b>					
<b>Combined Non-Structural Ecosystem Restoration Plan</b>					
<b>Measures</b>	<b>Total Annual Cost (AAC)</b>	<b>Total Output (AAHU's) Minus No Action</b>	<b>Incremental Cost Per Unit of Output</b>	<b>Incremental Output (AAHU's)</b>	<b>Average Cost AAC/AAHU</b>
No Action	0	N/A	N/A	50.96	N/A
D1	7,130	3.74	1,906	3.74	1,906
B1, D1	18,060	9.33	1,955	5.59	1,936
B1, C1, D1	39,162	19.96	1,985	10.63	1,962
B1, C1, D1, E1	51,710	26.19	2,014	6.23	1,974
A1, B1, C1, D1, E1	54,465	27.42	2,239	1.23	1,986
A1, B1, C1, D1, E1, F1	72,202	33.91	2,732	6.49	2,129
A1, B1, C1, D1, E1, F1, G1	81,526	37.27	2,775	3.36	2,187
<b>A1, B1, C1, D1, E1, F1, G1, H1</b>	<b>119,193</b>	<b>50.83</b>	<b>2,777</b>	<b>13.56</b>	<b>2,345</b>
A1, B1, C1, D1, E3, F1, G1, H1	139,101	51.56	27,271	.73	2,698
A1, B1, C3, D1, E3, F1, G1, H1	169,981	52.68	27,571	1.12	3,227
A1, B1, C3, D1, E3, F3, G1, H1	193,479	53.45	30,516	.77	3,620
A1, B1, C3, D3, E3, F3, G1, H1	204,906	53.81	31,8741	.36	3,808
A1, B1, C3, D3, E3, F3, G2, H1	210,971	53.99	33,694	.18	3,908
A1, B3, C3, D3, E3, F3, G2, H1	227,876	54.49	33,810	.50	4,182
A1, B3, C3, D3, E3, F3, G2, H3	282,819	56.03	35,677	1.54	5,048
A1, B3, C3, D3, E3, F3, G3, H3	290,776	56.24	37,890	.21	5,170
A3, B3, C3, D3, E3, F3, G3, H3	294,742	56.32	49,575	.08	5,233

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

<b>Table B-17</b>					
<b>Incremental Analysis, Final Array of Alternatives</b>					
<b>Williamson Creek, Ecosystem Restoration Combined Use Lands</b>					
<b>Combined Non-Structural Ecosystem Restoration Plan</b>					
<b>Measures</b>	<b>Total Annual Cost (AAC)</b>	<b>Total Output (AAHU's) Minus No Action</b>	<b>Incremental Cost Per Unit of Output</b>	<b>Incremental Output (AAHU's)</b>	<b>Average Cost AAC/AAHU</b>
No Action	0	N/A	N/A	5.19	N/A
M1	8,781	4.61	1,904	4.61	1,904
I1, M1	14,079	7.31	1,962	2.7	1,925
I1, M1, O1	18,920	9.75	1,984	2.44	1,940
I1, J1, M1, O1	19,991	10.22	2,278	.47	1,956
I1, J1, L1, M1, O1	25,933	12.71	2,386	2.49	2,040
I1, J1, L1, M1, N1, O1	28,049	13.53	2,580	.82	2,073
<b>I1, J1, K1, L1, M1, N1, O1</b>	<b>28,940</b>	<b>13.84</b>	<b>2,874</b>	<b>.31</b>	<b>2,091</b>
I1, J2, K1, L1, M1, N1, O1	29,560	13.91	8,857	.07	2,125
I1, J2, K1, L1, M1, N2, O1	30,819	14.01	12,590	.10	2,199
I1, J2, K1, L3, M1, N2, O1	37,857	14.48	14,974	.47	2,614
I1, J2, K1, L3, M3, N2, O1	46,350	15.02	15,727	.54	3,085
I1, J2, K1, L3, M3, N2, O3	51,100	15.3	16,964	.28	3,339
I1, J2, K1, L3, M3, N3, O3	52,384	15.37	18,342	.07	3,408
I2, J2, K1, L3, M3, N3, O3	55,676	15.52	21,946	.15	3,587
I3, J2, K1, L3, M3, N3, O3	60,333	15.71	24,510	.19	3,840
I3, J3, K1, L3, M3, N3, O3	61,119	15.73	39,300	.02	3,885
I3, J3, K2, L3, M3, N3, O3	61,624	15.74	50,500	.01	3,915

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

Based on the results presented in the tables B-16 and B-17 above, it was determined that for the conversion to riparian woodland on Williamson Creek for the Combined Non-Structural Plan, applying scale 1 (identified above) in areas NA-NH in all the reaches would be recommended for this combined plan. This combination would allow habitat gains of + 50.83 units at an average annual cost of \$119,193.00. In addition, applying scale 1 in areas NI-NO would also be recommended for this combined plan (Addendum B-2, Figures B-6A-D). This combination would allow habitat gains of + 13.84 units at an average annual cost of \$28,940.00. This would allow for a total gain of 64.67 AAHU's at an average annual total cost of \$148,133.00 for the Combined Non-Structural Ecosystem Restoration Plan. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-18

displays the future with and without project conditions for the Williamson Creek Non-Structural Ecosystem Restoration Plan used during the incremental analysis runs for the selected alternative. Figure D and E show graphically the results from the final incremental analysis for the Williamson Creek Combined Non-Structural Ecosystem Restoration Plan runs.

**Economic Summary**

As mentioned above, the costs that were used during the incremental analysis did not include construction management, construction design, and interest during construction, etc. All of these prices are across the board contingencies so it would not affect formulation. The project first cost was used during formulation of the overall project costs when combined with the other project features. These costs are reflected in Chapter 4. Table B-19 lists the first cost and economics of each recommended restoration measure.

<b>Table B-18 Future With and Without Project AAHU's for Williamson Creek Non-Structural Ecosystem Restoration Plan</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area NA)	0.94	2.17	1.23
Riparian Woodlands (Area NB)	2.30	7.89	5.59
Riparian Woodlands (Area NC)	4.50	15.13	10.63
Riparian Woodlands (Area ND)	1.20	4.94	3.74
Riparian Woodlands (Area NE)	3.05	9.28	6.23
Riparian Woodlands (Area NF)	10.10	16.59	6.49
Riparian Woodlands (Area NG)	5.39	8.75	3.36
Riparian Woodlands (Area NH)	23.48	37.04	13.56
Riparian Woodlands (Area NI)	1.29	3.99	2.70
Riparian Woodlands (Area NJ)	0.42	0.89	.47
Riparian Woodlands (Area NK)	0.38	0.69	.31
Riparian Woodlands (Area NL)	1.94	4.43	2.49
Riparian Woodlands (Area NM)	0.08	4.69	4.61
Riparian Woodlands (Area NN)	0.82	1.64	0.82
Riparian Woodlands (Area NO)	0.26	2.70	2.44

<b>Table B-19 Economic Summary Williamson Creek Combined Non-Structural Ecosystem Restoration Plan December 2004 Prices, 5.375%, 50-Year</b>	
<b>MEASURE</b>	<b>First Cost</b>
NA	\$42,781
NB	\$176,538
NC	\$342,944
ND	\$114,369
NE	\$203,000
NF	\$287,888
NG	\$150,266
NH	\$613,944
NI	\$84,400
NJ	\$15,244
NK	\$12,300
NL	\$94,925
NM	\$141,375
NN	\$32,334
NO	\$76,909
<b>Total First Cost Combined NS Plan</b>	<b>\$2,389,216</b>
Interest During Construction	\$129,568
<b>Total Investment Cost</b>	<b>\$2,518,784</b>
<b>Annual Costs</b>	
Interest During Construction 5.375%	\$135,384
Amortization	\$10,655
Operation and Maintenance	\$2,100
<b>Total Annual Charges</b>	<b>\$148,140</b>

**Figure D**  
**Best Buy Plans for Williamson Creek Combined Non-Structural Ecosystem Restoration Plan Ecosystem Only Lands**



**Figure E**  
**Best Buy Plans for Williamson Creek Combined Non-Structural Ecosystem Restoration Plan Combined Use Lands**



### **Williamson Creek Combined Structural Ecosystem Restoration Plan**

Again, due to the limitations of the IWR-Plan Software, the combined Structural Plan had to be broken out into two separate parts for analysis. The most meaningful way to perform this was to analyze areas that were being bought for restoration only separately from areas that were being bought for flood damage reduction and then being utilized for ecosystem restoration as an alternate use of the land.

Tables B-20 and B-21 present the summary statistics of the cost effectiveness and incremental cost analysis models for the final alternatives for the ecosystem restoration measures for the Combined Structural Ecosystem Restoration Plan for Williamson Creek. For the restoration only lands, IWR-Plan analyzed over 262,144 combinations of the measures and there were 234 cost effective plans. Of the 234, there were 24 best buy plans. For the combined use lands, IWR-Plan analyzed over 1,594,323 combinations of the measures and there were 118 cost effective plans. Of the 118, there were 23 best buy plans.

<b>Table B-20</b> <b>Incremental Analysis, Final Array of Alternatives</b> <b>Williamson Creek, Ecosystem Restoration</b> <b>Conversion to Woodlands</b> <b>Restoration Only Lands</b> <b>Combined Structural Ecosystem Restoration Plan</b>					
Measures	Total Annual Cost (AAC)	Total Output (AAHU's) Minus No Action	Incremental Cost Per Unit of Output	Incremental Output (AAHU's)	Average Cost AAC/AAHU
No Action	N/A	N/A	N/A	48.41	N/A
C1	21,817	11.24	1941	11.24	1941
C1, D1	26,178	13.46	1964	2.22	1945
B1, C1, D1,	33,686	17.27	1970	3.81	1951
B1, C1, D1, F1	42,204	21.39	2067	4.12	1973
A1, B1, C1, D1, F1	45,587	22.84	2333	1.45	1996
A1, B1, C1, D1, F1, H1	53,251	25.65	2727	2.81	2076
A1, B1, C1, D1, F1, G1, H1	68,382	31.15	2751	5.5	2195
A1, B1, C1, D1, E1, F1, G1, H1	70,867	32.05	2761	.90	2211
<b>A1, B1, C1, D1, E1, F1, G1, H1, I1</b>	<b>108,534</b>	<b>45.67</b>	<b>2765</b>	<b>13.62</b>	<b>2376</b>
A1, B1, C1, D1, E2, F1, G1, H1, I1	110,043	45.82	10060	.15	2402
A1, B1, C1, D1, E2, F2, G1, H1, I1	115,394	46.06	22295	.24	2505
A1, B1, C1, D1, E2, F3, G1, H1, I1	123,339	46.37	25629	.31	2660
A1, B1, C1, D1, E3, F3, G1, H1, I1	125,095	47.57	26980	.06	2630
A1, B1, C1, D3, E3, F3, G1, H1, I1	131,994	47.63	29266	.22	2771
A1, B1, C1, D3, E3, F3, G2, H1, I1	141,677	47.85	31359	.30	2961
A1, B1, C1, D3, E3, F3, G3, H1, I1	153,156	48.15	32276	.35	3181
A1, B3, C1, D3, E3, F3, G3, H1, I1	164,973	48.5	32797	.35	3402
A1, B3, C1, D3, E3, F3, G3, H1, I2	189,595	48.85	33762	.68	3881
A1, B3, C1, D3, E3, F3, G3, H2, I2,	194,553	49.53	36208	.13	3928
A1, B3, C1, D3, E3, F3, G3, H2, I3	153,156	49.66	38138	.35	3084
A1, B3, C1, D3, E3, F3, G3, H3, I3	164,973	50.52	38436	.35	3265
A3, B3, C1, D3, E3, F3, G3, H3, I3	189,595	50.7	39333	.68	3740
A3, B3, C3, D3, E3, F3, G3, H3, I3	194,553	50.78	64825	.13	3831

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

<b>Table B-21</b> <b>Incremental Analysis, Final Array of Alternatives</b> <b>Williamson Creek, Ecosystem Restoration</b> <b>Conversion to Parklands</b> <b>Combined Use Lands</b> <b>Combined Structural Ecosystem Restoration Plan</b>					
Measures	Total Annual Cost (AAC)	Total Output (AAHU's) Minus No Action	Incremental Cost Per Unit of Output	Incremental Output (AAHU's)	Average Cost AAC/AAHU
No Action	N/A	0	N/A	N/A	N/A
M1	1,641	1.61	1,019	1.61	1,019
M1, N1	2,839	2.75	1,050	1.14	1,032
J1, M1, N1	3,705	3.53	1,110	.78	1,050
J1, M1, N1, O1	4,541	4.28	1,114	.75	1,061
J1, K1, M1, N1, O1	5,183	4.82	1,188	.54	1,075
J1, K1, M1, N1, O1, P1	5,827	5.36	1,192	.54	1,087
<b>J1, K1, L1, M1, N1, O1, P1</b>	<b>6,264</b>	<b>5.68</b>	<b>1,365</b>	<b>.32</b>	<b>1,103</b>
J1, K1, L1, M1, N1, O1, P1, Q1	15,414	6.64	9,531	.96	2,321
J1, K1, L1, M1, N1, O1, P1, Q1, R1	15,976	6.68	14,050	.04	2,392
J1, K1, L1, M1, N1, O1, P1, Q1, R1, S1	18,713	6.86	15,205	.18	2,728
J1, K1, L1, M1, N1, O1, P1, Q1, R1, S1, T1	20,850	7.00	15,264	.14	2,979
J1, K1, L1, M1, N1, O1, P1, Q1, R1, S1, T1, U1	21,187	7.02	16,850	.02	3,018
J1, K1, L1, M1, N1, O1, P1, Q1, R1, S1, T1, U1, V1	22,046	7.05	28,633	.03	3,127
J1, K1, L1, M1, N1, O2, P1, Q1, R1, S1, T1, U1, V1	23,672	7.08	54,200	.03	3,344
J2, K1, L1, M1, N1, O2, P1, Q1, R1, S1, T1, U1, V1	25,368	7.11	56,533	.03	3,568
J2, K1, L1, M2, N1, O2, P1, Q1, R1, S1, T1, U1, V1	28,871	7.17	58,383	.06	4,027
J2, K1, L1, M2, N1, O2, P2, Q1, R1, S1, T1, U1, V1	30,047	7.19	58,800	.02	4,179
J2, K2, L1, M2, N1, O2, P2, Q1, R1, S1, T1, U1, V1	31,233	7.21	59,300	.02	4,332
J2, K2, L1, M2, N2, O2, P2, Q1, R1, S1, T1, U1, V1	33,704	7.25	61,775	.04	4,649
J2, K2, L1, M2, N2, O2, P2, Q1, R1, S1, T2, U1, V1	38,692	7.26	498,800	.01	5,329
J2, K2, L1, M2, N2, O2, P2, Q2, R1, S1, T2, U1, V1	60,042	7.30	533,750	.04	8,225
J2, K2, L1, M2, N2, O2, P2, Q2, R1, S2, T2, U1, V1	66,430	7.31	638,800	.01	9,088

NOTE: Average Cost does not include No Action AAHU's. Numbers reflect the various riparian woodland conversion restoration measures noted above. Costs reflect annualized costs including and estimated real estate land acquisition or \$7,500/acre and operations and maintenance.

Based on the results presented in tables B-20 and B-21 above, it was determined that for the conversion to riparian woodland on Williamson Creek for the Combined Structural Ecosystem Restoration Plan, applying scale 1 (identified above) in areas SA - SI would be recommended for this combined plan. This combination would allow habitat gains of + 45.67 units at an average annual cost of \$108,534.00. In addition, applying scale 4 (conversion to parkland) in areas SJ-SP would also be recommended for this combined plan (Addendum B-2, Figures B-7A-D). This combination would allow habitat gains of + 5.68 units at an average annual cost of \$6,264. This would allow for a total gross gain of + 51.35 AAHU's at an average annual total cost of \$114,798.00 for the Combined Structural Ecosystem Restoration Plan. Approximately 9.3 AAHU's and \$13,309 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 \$101,489.00. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-22 represents the future with and without project conditions for the Onion Creek Ecosystem Restoration Only Plan used during the incremental analysis runs for the selected plan. Due to the flood damage reduction portion of the study, some of the future without project AAHU's would be completely lost, and restoration would be performed to mitigate the losses. Negative numbers represent a net loss in habitat units in that area even after the area is restored and additional mitigation would be required for those losses. The alternatives with the lowest cost per habitat unit would be allocated towards mitigation requirements and the remainder of the benefits would be allocated towards restoration benefits. Figures F and G show graphically the results from the final incremental analysis for the Combined Structural Ecosystem Restoration Plan runs.

### ***Economic Summary***

As mentioned above, the costs that were used during the incremental analysis did not include construction management, construction design, and interest during construction, etc. All of these prices are across the board contingencies so it would not affect formulation. The project first cost was used during formulation of the overall project costs when combined with the other project features. These costs are reflected in Chapter 4. Table B-23 lists the first cost and economics of each recommended restoration measure.

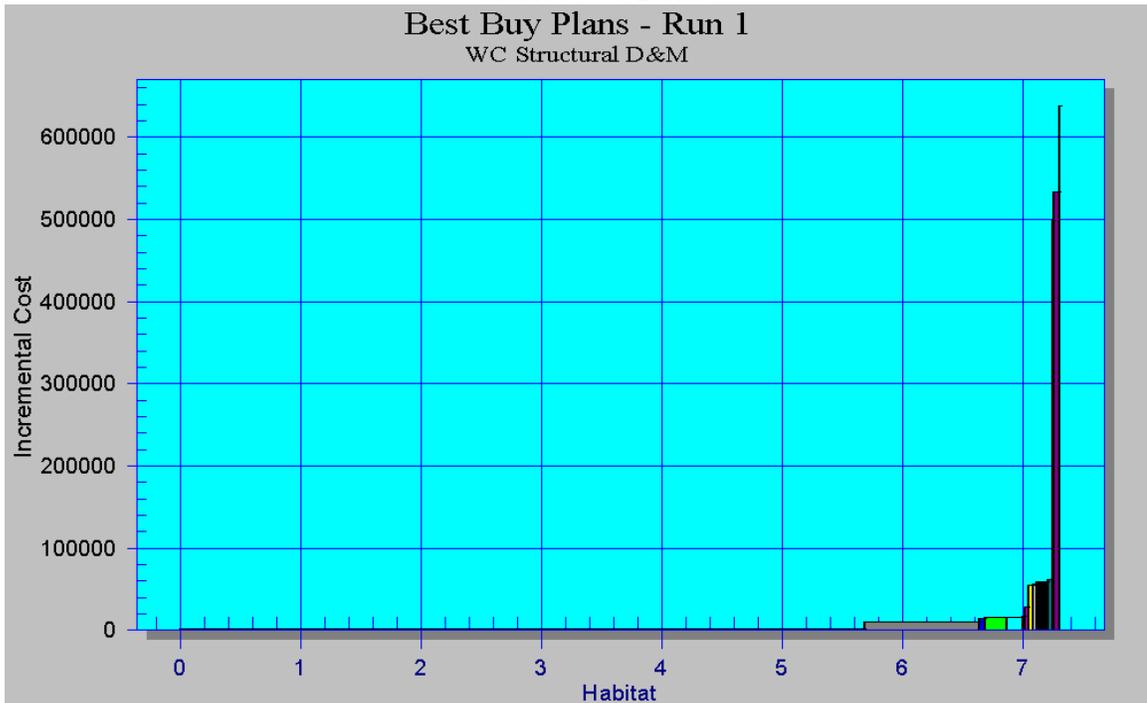
<b>Table B-22 Future With and Without Project AAHU's for Williamson Creek Structural Ecosystem Restoration Plan</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area SA)	1.34	2.79	1.45
Riparian Woodlands (Area SB)	1.53	5.34	3.81
Riparian Woodlands (Area SC)	4.40	15.64	11.24
Riparian Woodlands (Area SD)	0.76	2.98	2.22
Riparian Woodlands (Area SE)	1.11	2.01	3.12
Riparian Woodlands (Area SF)	2.53	6.65	4.12
Riparian Woodlands (Area SG)	8.72	14.22	5.5
Riparian Woodlands (Area SH)	4.60	7.41	2.81
Riparian Woodlands (Area SI)	23.42	37.04	13.62
Riparian Woodlands (Area SJ)*	0.72	0.78	0.06
Riparian Woodlands (Area SK)*	0.42	0.54	0.12
Riparian Woodlands (Area SL)*	0.45	0.32	-0.13
Riparian Woodlands (Area SM)*	1.68	1.61	-0.07
Riparian Woodlands (Area SN)*	2.26	1.14	-1.12
Riparian Woodlands (Area SO)*	1.77	0.75	-1.02
Riparian Woodlands (Area SP)*	0.88	0.54	-0.34
Riparian Woodlands (Area SQ)**	0.93	0.00	-0.93
Riparian Woodlands (Area SR)**	0.03	0.00	-0.03
Riparian Woodlands (Area SS)**	0.00	0.00	0.00
Riparian Woodlands (Area ST)**	0.11	0.00	-0.11
Riparian Woodlands (Area SU)**	0.00	0.00	0.00
Riparian Woodlands (Area SV)**	0.04	0.00	-0.04
NOTE: * Areas would be destroyed and parkland habitat would be restored. AAHU's were normalized to represent woodland value. ** Areas would not be restored, but the existing woodland/parkland habitat would be lost			

<b>Table B-23</b>	
<b>Economic Summary</b>	
<b>Williamson Creek Combined Structural Ecosystem Restoration Plan</b>	
December 2004 Prices, 5.375%, 50-Year	
<b>MEASURE</b>	<b>First Cost</b>
SA	\$53,066
SB	\$120,541
SC	\$354,641
SD	\$69,056
SE	\$38,378
SF	\$137,066
SG	\$245,253
SH	\$123,097
SI	\$613,944
SJ	\$11,888
SK	\$8,288
SL	\$4,875
SM	\$24,563
SN	\$17,325
SO	\$11,400
SP	\$8,250
<b>Total First Cost Combined Structural Plan</b>	<b>\$1,841,628</b>
Interest During Construction	\$99,872
<b>Total Investment Cost</b>	<b>\$1,941,500</b>
<b>Annual Costs</b>	
Interest During Construction 5.375%	\$104,350
Amortization	\$8,210
Operation and Maintenance	\$2,240
<b>Total Annual Charges</b>	<b>\$114,800</b>

**FIGURE F**  
**Best Buy Plans for Williamson Creek Combined Structural Ecosystem Restoration Plan**  
**Restoration Only Lands**



**FIGURE G**  
**Best Buy Plans for Williamson Creek Combined Structural Ecosystem Restoration Plan**  
**Combined Use Lands**



## **SUMMARY OF INCREMENTAL ANALYSIS**

Table B-24 presents the findings of all of the incremental analysis runs with a combined project wide average annual cost per average annual habitat unit. An average cost per acre was used for the land costs. Mitigation requirements for the Williamson Creek Combined Structural Plan are shown in Table B-25 due to the fact that the overall restoration benefits were reduced and the cost per habitat unit was raised due to the fact that mitigation requirements were allocated the most inexpensive habitat units gained. The final Recommended Plan as discussed in Chapter 5 will have a higher average annual cost per average annual habitat unit due to the land costs rising after the gross appraisal is done, engineering and design, construction management, interest during construction and other expenses not counted for in this analysis. However, this would not affect the incremental analysis because an average cost or an across the board percentage is still used in the development of the Recommended Plan. Mitigation requirements were not taken into consideration while running this incremental analysis; therefore if the same lands are used for mitigation, the average annual cost per average annual habitat units would go up and the total gain in habitat units would decrease.

<b>Table B-24 Summary of Incremental Analysis</b>						
<b>PLAN</b>	<b>FIRST COST FOR CONSTRUCTION</b>	<b>ACRES</b>	<b>TOTAL HU NO ACTION</b>	<b>TOTAL HU GAIN</b>	<b>ACC TOTAL</b>	<b>TOTAL ACC/HU</b>
<b>OC ER ONLY</b>	<b>2,847,942</b>	<b>217.49</b>	<b>112.27</b>	<b>69.1</b>	<b>175,200</b>	<b>2,535</b>
Timber Creek	232,435	16.03	6.98	5.86	14,347	2,448
OCF/Yarrabee Bend	2,460,175	195.6	96.68	60.97	151,218	2,480
Bear/Onion	155,332	5.86	8.61	2.27	9,635	4,244
<b>OC COMBINED PLAN*</b>	<b>3,288,757</b>	<b>256.04</b>	<b>121.36</b>	<b>85.28</b>	<b>202,563</b>	<b>2,375</b>
Timber Creek	232,435	16.03	6.98	5.86	14,347	2,448
OCF/Yarrabee Bend	2,821,970	221.28	105.59	73.26	173,612	2,370
Bear/Onion	234,352	18.73	8.79	6.16	14,604	2,370
<b>WC ER ONLY</b>	<b>2,256,212</b>	<b>148.4</b>	<b>58.71</b>	<b>60.93</b>	<b>139,027</b>	<b>2,282</b>
Heartwood	257,943	16.5	4.5	7.81	16,046	2,054
Radam	667,193	39.05	9.17	20.86	41,062	1,968
Broken Bow	279,340	16.59	4.57	8.46	17,214	2,034
Bayton Loop	1,051,733	76.29	40.47	23.8	64,707	2,718
<b>WC COMBINED NS PLAN</b>	<b>2,389,215</b>	<b>155.61</b>	<b>56.15</b>	<b>64.67</b>	<b>148,133</b>	<b>2,290</b>
Heartwood	231,618	14.35	3.62	7.13	14,577	2,044
Radam	552,236	32.86	7.64	16.86	34,175	2,026
Broken Bow	461,109	27.12	5.24	14.36	28,745	2,002
Bayton Loop	613,943	81.28	39.65	26.32	70,642	2,684
<b>WC STRUCTURAL PLAN*</b>	<b>1,841,628</b>	<b>140.44</b>	<b>48.41</b>	<b>51.35*</b>	<b>114,798*</b>	<b>2,192*</b>
Heartwood	185,492	13.95	2.87	6.04	11,758	1,947
Radam	475,236	30.95	6.27	15.22	29,748	1,955
Broken Bow	169,877	17.13	2.53	6.27	10,803	1,723
Bayton Loop	1,011,017	78.41	36.74	23.82	62,498	2,624
<b>TOTAL NED/NER*</b>						

NOTE: Shaded denotes NED/NER Plan elements. \* This plan requires mitigation which would change the benefits and cost if AAHU's were taken from mitigation requirements. Average Annual Costs per habitat unit will be different in the recommended plan due to increases in land price from gross appraisal; however it would not change the results of the incremental analysis as the land costs would still be averages.

Table B-25 Summary Results of Mitigation And Resulting Restoration Benefits									
PLAN	ACRES IMPACTED BY FDR	MIT HU'S REQ	MIT TOTAL ACC	MIT ACC/HU	ACRES OF MIT AREAS	REST HU GAIN	REST TOTAL AAC	REST ACC/HU	REST ACRES
<b>WC STRUCTURAL PLAN</b>	<b>27.18</b>	<b>9.3</b>	<b>13,309</b>	<b>1,429</b>	<b>26.17</b>	<b>42.05</b>	<b>101,489</b>	<b>2413</b>	<b>114.27</b>
Segment 1	5.61	1.65	2357	1,429	N/A	N/A	N/A	N/A	N/A
Segment 2	4.39	.90	1286	1,429	N/A	N/A	N/A	N/A	N/A
Segment 3	9.32	2.67	3815	1,429	N/A	N/A	N/A	N/A	N/A
Segment 4	7.86	4.08	5830	1,429	N/A	N/A	N/A	N/A	N/A
NOTE: Mitigation HU's required were taken from the Habitat Evaluation Procedures. The mitigation AAC for each segment were derived by multiplying \$1,429 by the required Habitat Units.									

## SELECTION OF THE ECOSYSTEM RESTORATION ONLY/NATIONAL ECOSYSTEM RESTORATION (NER) PLAN

The National Ecosystem Restoration Plan (NER) would be to implement the identified ecosystem restoration only plans at Timber Creek, Onion Creek Forest/Yarrabee Bend, Bear/Onion Confluence, and Williamson Creek. This plan would not be implemented, because the flood damage reduction portion of the study is being conducted on portions of the lands identified for restoration. However, this plan will be used in order to perform cost allocations and to set restoration limits for Federal participation on the combined plans.

### DESCRIPTION

#### Timber Creek

The Ecosystem Restoration Only Plan would be to restore Area A identified on Figure B-1 in Addendum B-2 to riparian woodlands. This would be done by planting a mix of native species identified in Addendum B-3 and using 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.

The Timber Creek Ecosystem Restoration Only Plan would restore approximately 16 acres and produce 5.86 AAHU's of habitat at an average annual cost per habitat unit of \$2,448.

#### Onion Creek Forest/Yarrabee Bend

The Ecosystem Restoration Only Plan would be to restore Area B, E, F, H, I, and J identified on Figure B-2 in Addendum B-2 to riparian woodlands. This would be done by planting a mix of native species identified in Addendum B-3 and using 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.

The Onion Creek Forest/Yarrabee Bend Ecosystem Restoration Only Plan would restore approximately 196 acres and produce 60.97 AAHU's of habitat at an average annual cost per habitat unit of \$2,480.

### **Bear/Onion Confluence**

The Ecosystem Restoration Only Plan would be to restore Area L identified on Figure B-3 in Addendum 2 to riparian woodlands. This would be done by planting a mix of native species identified in Addendum 3 below and using 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.

The Bear/Onion Confluence Ecosystem Restoration Only Plan would restore approximately 13 acres and produce 2.26 AAHU's of habitat at an average annual cost per habitat unit of \$4,244 wrong combination of a plan.

### **Williamson Creek**

The Ecosystem Restoration Only Plan would be to restore Areas EA, EB, EC, ED, EE, EF, EG, and EH identified on Figures B-5A-D in Addendum 2 to riparian woodlands. This would be done by planting a mix of native species identified in Addendum 3 and using 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.

The Williamson Creek Ecosystem Restoration Only Plan would restore approximately 148 acres and produce 60.93 AAHU's of habitat at an average annual cost per habitat unit of \$2,282.

## **MULTI-OBJECTIVE PLAN (NED/NER)**

The Multi-Objective Plan is a combination of structural and non-structural measures in each area of interest. The plan is described by reach below.

### **TIMBER CREEK**

The Multi-Objective Ecosystem Restoration Plan would be to restore Area A to riparian woodlands. This would be done by planting a mix of native species identified in Addendum B-3 using 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

The Timber Creek Combined Non-Structural Ecosystem Restoration Plan would restore approximately 16.03 acres and produce 5.86 AAHU's of habitat at an average annual cost per habitat unit of \$2,448.

### **ONION CREEK FOREST/YARRABEE BEND**

The Multi-Objective Ecosystem Restoration Plan would be to restore Area B, C, D, E, F, H, I, and J to riparian woodlands. This would be done by planting a mix of native species identified in Addendum B-3 using 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.

The Onion Creek Forest/Yarrabee Bend Multi-Objective Ecosystem Restoration Plan would restore approximately 221 acres and produce 73.26 AAHU's of habitat at an average annual cost per habitat unit of \$2,370.

### **BEAR/ONION CONFLUENCE**

The Multi-Objective Ecosystem Restoration Plan would be to restore Areas K and L to riparian woodlands. This would be done by planting a mix of native species identified in Enclosure 3 using the following quantities:

*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

The Bear/Onion Confluence Multi-Objective Ecosystem Restoration Plan would restore approximately 18.73 acres and produce 6.15 AAHU's of habitat at an average annual cost per habitat unit of \$2,370.

### **WILLIAMSON CREEK**

The Multi-Objective Plan would be to restore Areas SA - SI to riparian woodlands by planting a mix of native species identified in Addendum B-3 using 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

In addition, Areas SJ-SP (Figure B-12A-D) would also be restored to parklands by planting a mix of native species identified in Enclosure 3 using the following quantities:

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

The Williamson Creek Combined Structural Ecosystem Restoration Plan would restore approximately 114.27 acres and produce approximately 42.05 AAHU's of Habitat at an average annual cost per habitat unit of \$2,413. As mentioned earlier, approximately 9.3 AAHU's would be required for mitigation and would be 1,429 average annual cost per habitat unit. The lowest cost measures were used for mitigation requirements.

## **SELECTION OF THE RECOMMENDED PLAN**

The Recommended Ecosystem Restoration Plan for Onion Creek would be the same as the Multi-objective NED/NER Plan with a few minor modifications.

### **RECOMMENDED PLAN FOR TIMBER CREEK**

The NED/NER was selected as the Recommended Plan with no modifications (Figure B-9).

### **RECOMMENDED PLAN FOR ONION CREEK FOREST/YARRABEE BEND**

The NED/NER was the Recommended Plan; however, the city decided to reduce the size of the restoration area so that a BMX course could be constructed instead implementing restoration in that area. This reduced the total number of acres to be reduced the total number of acres from 221 to 190. The reduced area is shown on Figure B-10 in Addendum 2.

### **RECOMMENDED PLAN FOR BEAR/ONION CONFLUENCE**

Bear Onion was removed from consideration after the flood damage reduction was omitted (Figure B-11).

### **RECOMMENDED PLAN FOR WILLIAMSON CREEK**

The Williamson Creek portion of the study was delayed until the next interim feasibility report.

### **UPDATE OF THE INCREMENTAL ANALYSIS FOR THE RECOMMENDED PLAN**

After the more detailed review of the draft Integrated Report, higher Corps review members suggested that the Incremental analysis be updated with the current land cost, construction

management, engineering and design, adaptive management, and operations and maintenance. This is to ensure that the recommended plan is still justified and that the increases in cost did not affect plan formulation. Since the recommended plan was revised after the public and higher Corps review there is only a need to update the measures within the currently proposed restoration. The Bear/Onion Confluence was removed from consideration and the Williamson Creek Project was delayed until the next interim feasibility report. Therefore, the following represents the updated incremental analysis run for the restoration in the Yarrabee Bend and Timber Creek areas of interest in combination with the non-structural flood damage reduction plans. The measures and scales are still applicable as described above in the original incremental analysis.

Table B-26 displays the updated analysis for the final alternatives for the Recommended Plan. IWR-Plan analyzed over 262,144 combinations of the alternatives and there were 215 cost effective plans. Of the 215, there were 26 best buy plans.

Based on the results presented in the table above, it was determined that for the conversion to riparian woodland applying measure 1 (identified above) in areas A-J would be recommended for the Recommended Plan (Enclosure B-2, Figures B-1 and B-4). This combination would allow net habitat gains of + 62.62 units at an average annual cost of \$303,706. Other plans showed small additional habitat gains but at incremental costs that would be substantially higher. Table B-27 represents the future with and without project conditions for the Recommended Plan used during the incremental analysis runs for the selected alternatives. Figure H shows graphically the results from the final incremental analysis for the Recommended Plan.

### ***Economic Summary***

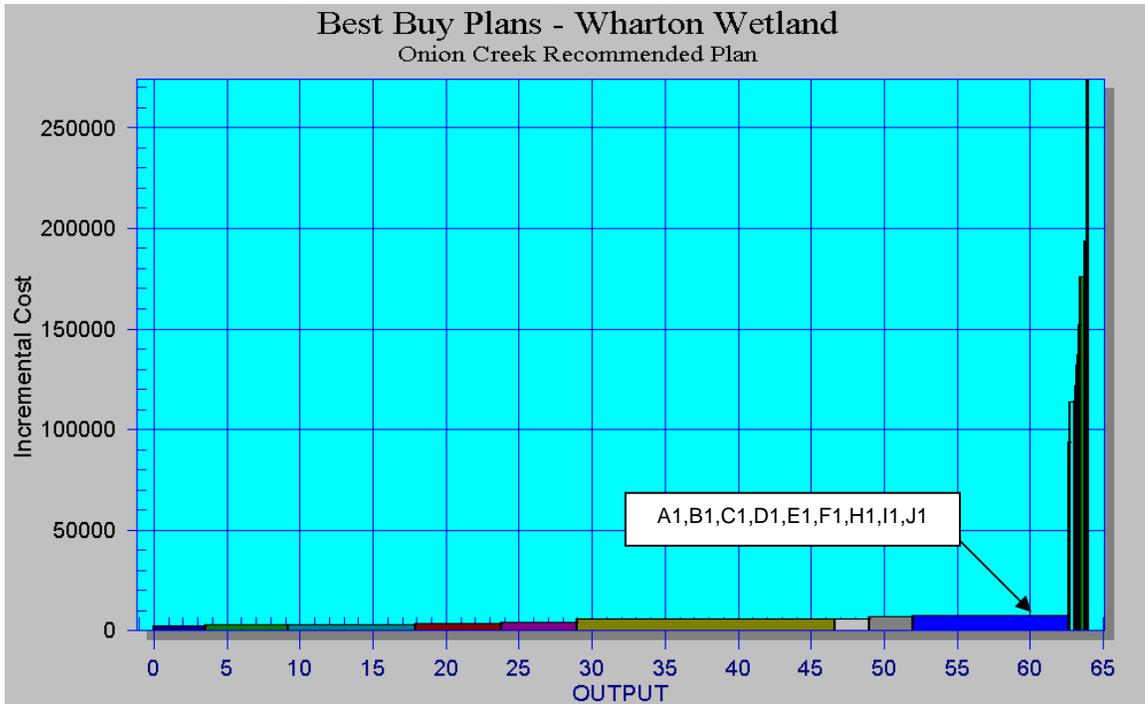
An economic summary of the Recommended Plan is provided in Table B-28. The Recommended Plan has a total first cost of \$4,592,015 with a total average annual cost of 310,924.

Table B-26 Incremental Analysis, Recommended Plan					
Measures	Total Annual Cost (AAC)	Total Output (AAHU's) Minus No Action	Incremental Cost Per Unit of Output	Incremental Output (AAHU's)	Average Cost AAC/AAHU
No Action	0	N/A	N/A	106.36	0
D1	9,268	3.55	2,610	3.55	2,610
D1, J1	25,970	9.18	2,966	5.63	2,828
C1,D1,J1	52,919	17.92	3,083	8.74	2,953
A1,C1,D1,J1	74,527	23.78	3,687	5.86	3,134
A1,C1,D1,H1,J1	96,013	28.93	4,172	5.15	3,318
A1,C1,D1,F1,H1,J1	195,686	46.65	5,624	17.72	4,194
A1,C1,D1,F1,H1,I1,J1	209,547	48.94	6,052	2.29	4,281
A1,C1,D1,E1,F1,H1,I1,J1	231,087	51.98	7,085	3.04	4,445
<b>A1,B1,C1,D1,E1,F1,H1,I1,J1</b>	<b>310,919</b>	<b>62.62</b>	<b>7,503</b>	<b>10.64</b>	<b>4,965</b>
A1,B1,C1,D1,E1,F1,H2,I1,J1	318,402	62.70	93,537	.08	5,078
A1,B1,C1,D1,E1,F2,H2,I1,J1	353,629	63.01	113,635	.31	5,612
A1,B1,C2,D1,E1,F2,H2,I1,J1	361,619	63.08	114,142	.07	5,732
A1,B1,C2,D2,E1,F2,H2,I1,J1	365,050	63.11	114,366	.03	5,784
A1,B1,C2,D2,E1,F2,H2,I1,J2	371,131	63.16	121,620	.05	5,876
A1,B1,C2,D2,E3,F2,H2,I1,J2	385,651	63.27	132,000	.11	6,095
A2,B1,C2,D2,E3,F2,H2,I1,J2	393,896	63.33	137,416	.06	6,219
A3,B1,C2,D2,E3,F2,H2,I1,J2	406,035	63.41	151,737	.08	6,403
A3,B3,C2,D2,E3,F2,H2,I1,J2	458,913	63.71	176,260	.30	7,203
A3,B3,C2,D2,E3,F3,H2,I1,J2	486,026	63.85	193,664	.14	7,611
A3,B3,C2,D2,E3,F3,H3,I1,J2	494,004	63.89	199,450	.04	7,732
A3,B3,C2,D2,E3,F3,H3,I2,J2	498,296	63.90	429,200	.01	7,798
A3,B3,C3,D2,E3,F3,H3,I2,J2	512,843	63.93	484,900	.03	8,021
A3,B3,C3,D3,E3,F3,H3,I2,J2	518,300	63.94	545,700	.01	8,106
A3,B3,C3,D3,E3,F3,H3,I3,J2	523,991	63.95	569,100	.01	8,193
A3,B3,C3,D3,E3,F3,H3,I3,J3	533,309	63.96	931,800	.01	8,338

<b>Table B-27</b> <b>Future With and Without Project AAHU's for Onion Creek</b> <b>Combined Non-Structural Ecosystem Restoration Plan</b>			
<b>Habitat Types</b>	<b>Future W/O AAHU's</b>	<b>Future With AAHU's</b>	<b>Difference Between With and W/O</b>
Riparian Woodlands (Area A)	6.98	12.84	5.86
Riparian Woodlands (Area B)	43.11	53.76	10.65
Riparian Woodlands (Area C)	7.13	15.87	8.74
Riparian Woodlands (Area D)	1.77	5.32	3.55
Riparian Woodlands (Area E)	8.20	11.24	3.04
Riparian Woodlands (Area F)	21.91	39.63	17.72
Riparian Woodlands (Area H)	6.25	11.41	5.15
Riparian Woodlands (Area I)	6.53	8.82	2.29
Riparian Woodlands (Area J)	4.47	10.09	5.62
<b>Total</b>	<b>106.36</b>	<b>168.98</b>	<b>62.62</b>

<b>Table B-28</b>									
<b>Economic Summary</b>									
<b>Recommended Restoration Plan</b>									
December 2004 Prices, 5.125%, 50-Year Period of Analysis									
<b>Measure</b>	<b>Timber Creek</b>	<b>Onion Creek Forest/Yarrabee Bend</b>							
	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>H</b>	<b>I</b>	<b>J</b>
Construction Cost	\$129,000	\$357,852	\$149,030	\$54,650	\$108,162	\$525,680	\$119,840	\$63,397	\$95,152
Lands including Cont.	\$98,000	\$610,740	\$189,540	\$63,180	\$157,950	\$716,040	\$33,810	\$105,300	\$115,830
E&D	\$40,000	\$23,200	\$7,200	\$2,400	\$6,000	\$27,200	\$147,420	\$4,000	\$4,400
Construction Mgmt	\$8,000	\$21,460	\$6,660	\$2,220	\$5,550	\$25,160	\$5,600	\$3,700	\$4,070
Construction Cont.	\$44,000	\$118,320	\$36,720	\$12,240	\$30,600	\$138,720	\$5,180	\$20,400	\$22,440
Adaptive Management	\$6,000	\$34,800	\$10,800	\$3,600	\$9,000	\$40,800	\$8,400	\$6,000	\$6,600
<b>Total First Cost</b>	<b>\$325,000</b>	<b>\$1,166,372</b>	<b>\$399,950</b>	<b>\$138,290</b>	<b>\$317,262</b>	<b>\$1,473,600</b>	<b>\$320,250</b>	<b>\$202,797</b>	<b>\$248,492</b>
Interest During Const.	\$8,258	\$29,638	\$10,163	\$3,514	\$8,061	\$37,445	\$8,137	\$5,153	\$6,314
<b>Total Investment Cost</b>	<b>\$333,258</b>	<b>\$1,196,010</b>	<b>\$410,113</b>	<b>\$141,804</b>	<b>\$325,324</b>	<b>\$1,511,045</b>	<b>\$328,387</b>	<b>\$207,950</b>	<b>\$254,806</b>
Interest	\$17,079	\$61,295	\$21,018	\$7,267	\$16,672	\$77,441	16,829	\$10,657	\$13,058
Amortization	\$1,529	\$5,487	\$1,881	\$650	\$1,492	6,932	1,506	\$954	\$1,169
O&M	\$3,000	\$13,050	\$4,050	\$1,350	\$3,375	\$15,300	\$3,150	\$2,250	\$2,475
<b>Total Annual Cost</b>	<b>\$21,608</b>	<b>\$79,832</b>	<b>\$26,949</b>	<b>\$9,268</b>	<b>\$21,540</b>	<b>\$99,673</b>	<b>\$21,486</b>	<b>\$13,861</b>	<b>\$16,702</b>
<b>Grand Total Ann. Cost</b>	<b>\$21,608</b>	<b>\$289,316</b>							

**FIGURE H:**  
**INCREMENTAL ANALYSIS RECOMMENDED PLAN**  
**Best Buy Plans - Wharton Wetland**  
Onion Creek Recommended Plan



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**ADDENDUM B 1  
THREATENED AND ENDANGERED SPECIES**

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## HAYS COUNTY

	Federal Status	State Status
<b>*** AMPHIBIANS ***</b>		
<b>Blanco Blind Salamander (<i>Eurycea robusta</i>)</b> - troglobitic; water-filled subterranean caverns of the Edwards Aquifer; may inhabit deep levels of the Balcones aquifer to the north and east of the Blanco River		T
<b>Blanco River Springs Salamander (<i>Eurycea pterophila</i>)</b> - subaquatic; springs and caves in the Blanco River drainage in Blanco, Hays, and Kendall counties		
<b>Edwards Plateau Spring Salamanders (<i>Eurycea</i> sp. 7)</b> - troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
<b>San Marcos Salamander (<i>Eurycea nana</i>)</b> – headwaters of the San Marcos River downstream to ca. ½ mile past IH-35; water over gravelly substrate characterized by dense mats of algae ( <i>Lyng bya</i> ) and aquatic moss ( <i>Leptodictyum riparium</i> ), and water temperatures of 21-22 ° C; diet includes amphipods, midge larve, and aquatic snails	LT	T
<b>Texas Blind Salamander (<i>Eurycea rathbuni</i>)</b> – troglobitic; water-filled subterranean caverns along a six mile stretch of the San Marcos Spring Fault, in the vicinity of San Marcos; eats small invertebrates, including snails, copepods, amphipods, and shrimp	LE	E
<b>*** BIRDS ***</b>		
<b>Arctic Peregrine Falcon (<i>Falco peregrinus tundrius</i>)</b> - potential migrant	DL	T
<b>Black-capped Vireo (<i>Vireo atricapilla</i>)</b> - oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, & required structure; nests mid April-late summer	LE	E
<b>Golden-cheeked Warbler (<i>Dendroica chrysoparia</i>)</b> juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	LE	E
<b>Mountain Plover (<i>Charadrius montanus</i>)</b> – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
<b>Whooping Crane (<i>Grus americana</i>)</b> - potential migrant; winters in and around Aransas National Wildlife Refuge and migrates to Canada for breeding; only remaining natural breeding population of this species	LE	E
<b>*** CRUSTACEANS ***</b>		
<b>Balcones Cave Amphipod (<i>Stygobromus balconis</i>)</b> – A small subterranean amphipod. Found in cave pools		
<b>Ezell's Cave Amphipod (<i>Stygobromus flagellatus</i>)</b> – known only from artesian wells		
<b>Texas Cave Shrimp (<i>Palaemonetes antrorum</i>)</b> – subterranean sluggish streams and pools		

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\*\*\* FISHES \*\*\*

- |  |    |   |
|--|----|---|
| <b>Blue Sucker (<i>Cyprinella longatilis</i>)</b> – larger portions of major rivers in Texas; usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles |    | T |
| <b>Fountain Darter (<i>Etheostoma fonticola</i>)</b> – known only from the San Marcos and Comal rivers; springs and spring-fed streams in dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding mostly diurnal; spawns year-round with August and late winter to early spring peaks                                     | LE | E |
| <b>Guadalupe Bass (<i>Micropterus treculii</i>)</b> – introduced in Nueces River system; endemic to perennial streams of the Edwards Plateau region  |    |   |
| <b>Guadalupe Darter (<i>Percina sciera apristis</i>)</b> - spawns January to June; typically over gravel or gravel and sand raceways of medium streams and rivers, and pools; feeds mainly on larval insects in riffles  |    |   |
| <b>San Marcos Gambusia (<i>Gambusia georgei</i>)</b> (extinct) – endemic; formerly known from upper San Marcos River; restricted to shallow, quiet, mud-bottomed shoreline areas without dense vegetation in thermally constant main channel   | LE | E |

\*\*\* INSECTS \*\*\*

- |   |    |  |
|---|----|--|
| <b>Comal Springs Diving Beetle (<i>Comalidessus stygius</i>)</b> - known only from the outflows at Comal Springs; aquatic; diving beetles generally inhabit the water column  |    |  |
| <b>Comal Springs Dryopid Beetle (<i>Stygoparnus comalensis</i>)</b> - dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night; most dryopid larvae are vermiform and live in soil or decaying wood | LE |  |
| <b>Comal Springs Riffle Beetle (<i>Heterelmis comalensis</i>)</b> - Comal and San Marcos Springs  | LE |  |
| <b>Edwards Aquifer Diving Beetle (<i>Haideoporus texanus</i>)</b> - habitat poorly known; known from an artesian well in Hays County  |    |  |
| <b>Flint's Net-spinning Caddisfly (<i>Cheumatopsyche flinti</i>)</b> - very poorly known species with habitat description limited to "a spring"   |    |  |
| <b>San Marcos Saddle-case Caddisfly (<i>Protoptila arca</i>)</b> - known from an artesian well in Hays County; locally very abundant; swift, well-oxygenated warm water about 1-2 m deep; larvae and pupal cases abundant on rocks  |    |  |

\*\*\* MAMMALS \*\*\*

- |  |  |  |
|--|--|--|
| <b>Cave Myotis Bat (<i>Myotis velifer</i>)</b> - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow ( <i>Petrochelidon pyrrhonota</i> ) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore |  |  |
| <b>Plains Spotted Skunk (<i>Spilogale putorius interrupta</i>)</b> – catholic in habitat; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie   |  |  |



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\*\*\* VASCULAR PLANTS \*\*\*

- Canyon mock-orange (*Philadelphus ernestii*) - solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodland; flowering April-May, fruit maturing in September
- Hill Country wild-mercury (*Argythamnia aphoroides*) - shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May; fruit persisting until midsummer
- Texas wild-rice (*Zizania texana*) – perennial, emergent, aquatic grass known only from the upper 2.5 km of the San Marcos River in Hays County      LE      E
- Warnock's coral-root (*Hexalectris warnockii*) - leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

Status Key:	
LE, LT	- Federally Listed Endangered/Threatened
PE, PT	- Federally Proposed Endangered/Threatened
E/SA, T/SA	- Federally Listed Endangered/Threatened by Similarity of Appearance
C1	- Federal Candidate for Listing, Category 1; information supports proposing to list as Endangered/Threatened
DL, PDL	- Federally Delisted/Proposed for Delisting
NL	- Not Federally Listed
E, T	- State Listed Endangered/Threatened
"blank"	- Rare, but with no regulatory listing status

*Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.*

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## TRAVIS COUNTY

	Federal Status	State Status
<b>***AMPHIBIANS***</b>		
<b>Austin Blind Salamander (<i>Eurycea waterlooensis</i>)</b> – mostly restricted to subterranean cavities of the Edwards Aquifer; dependent upon water flow/quality from the Barton Springs segment of the Edwards Aquifer; only known from the outlets of Barton Springs [Sunken Gardens (Old Mill) Spring, Eliza Spring, and Parthenia (Main) Spring which forms Barton Springs Pool]; feeds on amphipods, ostracods, copepods, plant material, and (in captivity) a wide variety of small aquatic invertebrates	C1	
<b>Barton Springs Salamander (<i>Eurycea sosorum</i>)</b> - dependent upon water flow/quality from the Barton Springs segment of the Edwards Aquifer; only known from the outlets of Barton Springs; spring dweller, but ranges into subterranean water-filled caverns; found under rocks, in gravel, or among aquatic vascular plants & algae, as available; feeds primarily on amphipods	LE	E
<b>Edwards Plateau Spring Salamanders (<i>Eurycea</i> sp. 7)</b> - endemic; springs and waters of some caves of this region		
<b>Jollyville Plateau Salamander (<i>Eurycea tonkawae</i>)</b> - known from springs and waters of some caves of Travis and Williamson counties north of the Colorado River		
<b>Pedernales River Springs Salamander (<i>Eurycea</i> sp. 6)</b> - endemic; known only from springs		
<b>***ARACHNIDS***</b>		
<b>A Cave Spider (<i>Cicurina cueva</i>)</b> - Subterrestrial, subterranean obligate; cave-adapted spider		
<b>Bandit Cave Spider (<i>Cicurina bandida</i>)</b> - very small, cave-adapted spider		
<b>Bee Creek Cave Harvestman (<i>Texella reddelli</i>)</b> - small, blind, cave-adapted harvestman endemic to a few caves in Travis and Williamson counties	LE	
<b>Bone Cave Harvestman (<i>Texella reyesi</i>)</b> - small, blind, cave-adapted harvestman endemic to a few caves in Travis and Williamson counties; weakly differentiated from <i>Texella reddelli</i>	LE	
<b>Tooth Cave Pseudoscorpion (<i>Tartarocreagris texana</i>)</b> - small, cave-adapted pseudoscorpion known from small limestone caves of the Edwards Plateau	LE	
<b>Tooth Cave Spider (<i>Neoleptoneta myopica</i>)</b> - very small, cave-adapted, sedentary spider	LE	
<b>Warton's Cave Spider (<i>Cicurina wartoni</i>)</b> - very small, cave-adapted spider	C1	
<b>*** BIRDS ***</b>		
<b>Arctic Peregrine Falcon (<i>Falco peregrinus tundrius</i>)</b> - potential migrant	DL	T
<b>Bald Eagle (<i>Haliaeetus leucocephalus</i>)</b> - found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	LT- PDL	T
<b>Black-capped Vireo (<i>Vireo atricapilla</i>)</b> - oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer	LE	E

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	Federal Status	State Status
<b>Golden-cheeked Warbler (<i>Dendroica chrysoparia</i>)</b> - juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests are placed in various trees other than Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees and shrubs; nesting late March-early summer	LE	E
<b>Henslow's Sparrow (<i>Ammodramus henslowii</i>)</b> - wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles; a key component is bare ground for running/walking; likely to occur, but few records within this county		
<b>Interior Least Tern (<i>Sterna antillarum athalassos</i>)</b> – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
<b>Mountain Plover (<i>Charadrius montanus</i>)</b> – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
<b>Whooping Crane (<i>Grus americana</i>)</b> - potential migrant; winters in and around Aransas National Wildlife Refuge and migrates to Canada for breeding; only remaining natural breeding population of this species	LE	E

\*\*\*CRUSTACEANS\*\*\*

- An Amphipod (*Stygobromus russelli*)** - subterranean waters, usually in caves & limestone aquifers; resident of numerous caves in ca. 10 counties of the Edwards Plateau
- Balcones Cave Amphipod (*Stygobromus balconis*)** – A small subterranean amphipod. Found in cave pools
- Bifurcated Cave Amphipod (*Stygobromus bifurcatus*)** - found in cave pools

\*\*\*FISHES\*\*\*

- American Eel (*Anguilla rostrata*)** - most aquatic habitats with access to ocean; spawns January-February in ocean, larva move to coastal waters, metamorphose, then females move into freshwater; muddy bottoms, still waters, large streams, lakes; can travel overland in wet areas; males in brackish estuaries
- Guadalupe Bass (*Micropterus treculii*)** – introduced in Nueces River system; endemic to perennial streams of the Edwards Plateau region
- Smalleye shiner (*Notropis buccula*)** - endemic to upper Brazos River system and its tributaries; apparently introduced into adjacent Colorado River drainage; medium to large prairie streams with sandy substrate and turbid to clear warm water; presumably eats small aquatic invertebrates

\*\*\*INSECTS\*\*\*

- Kretschmarr Cave Mold Beetle (*Texamaurops reddelli*)** - small, cave-adapted beetle found under rocks buried in silt; small, Edwards Limestone caves in of the Jollyville Plateau, a division of the Edwards Plateau

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	Federal Status	State Status
<b>Tooth Cave Blind Rove Beetle (<i>Cylindropsis</i> sp. 1)</b> - one specimen collected from Tooth Cave; only known North American collection of this genus		
<b>Tooth Cave Ground Beetle (<i>Rhadine persephone</i>)</b> - resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson counties	LE	

\*\*\* MAMMALS \*\*\*

- Cave Myotis Bat (*Myotis velifer*)** - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore
- Plains Spotted Skunk (*Spilogale putorius interrupta*)** – catholic in habitat; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie

\*\*\* MOLLUSKS \*\*\*

- Creeper (Squawfoot) (*Strophitus undulatus*)** - small to large streams, prefers gravel or gravel and mud in flowing water; Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins
- False Spike Mussel (*Quincuncina mitchelli*)** - substrates of cobble and mud, with water lilies present; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins
- Pistolgrip (*Tritogonia verrucosa*)** - stable substrate, rock, hard mud, silt, and soft bottoms, often buried deeply; east and central Texas, Red through San Antonio River basins
- Rock-pocketbook (*Arcidens confragosus*)** - mud, sand, and gravel substrates of medium to large rivers in standing or slow flowing water, may tolerate moderate currents and some reservoirs, east Texas, Red through Guadalupe River basins
- Smooth Pimpleback (*Quadrula houstonensis*)** - small to moderate streams and rivers as well as moderate size reservoirs; mixed mud, sand, and fine gravel, tolerates very slow to moderate flow rates, appears not to tolerate dramatic water level fluctuations, scoured bedrock substrates, or shifting sand bottoms, lower Trinity (questionable), Brazos, and Colorado River basins
- Texas Fatmucket (*Lampsilis bracteata*)** - streams and rivers on sand, mud, and gravel substrates; intolerant of impoundment; broken bedrock and coarse gravel or sand in moderately flowing water; Colorado and Guadalupe River basins
- Texas Fawnsfoot (*Truncilla macrodon*)** - little known; possibly rivers and larger streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins
- Texas Pimpleback (*Quadrula petrina*)** - mud, gravel and sand substrates, generally in areas with slow flow rates; Colorado and Guadalupe river basins

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Status    Status

\*\*\* REPTILES \*\*\*

- Spot-tailed Earless Lizard (*Holbrookia lacerata*)** - central & southern Texas & adjacent Mexico; moderately open prairie-brushland; fairly flat areas free of vegetation or other obstructions, including disturbed areas; eats small invertebrates; eggs laid underground
- Texas Garter Snake (*Thamnophis sirtalis annectens*)** - wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August
- Texas Horned Lizard (*Phrynosoma cornutum*)** - open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September T
- Timber/Canebrake Rattlesnake (*Crotalus horridus*)** - swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto T

\*\*\* VASCULAR PLANTS \*\*\*

- Basin bellflower (*Campanula reverchonii*)** - endemic; dry gravels and very shallow sandy soils derived from Precambrian igneous and metamorphic rocks, on open slopes and rock outcrops; flowering May-July, September-October
- Bracted twistflower (*Streptanthus bracteatus*)** - endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May
- Canyon mock-orange (*Philadelphus ernestii*)** - endemic; solution-pitted outcrops of Cretaceous limestone in mesic canyons, usually in shade of mostly deciduous slope forest; flowering April-May
- Correll's false dragon-head (*Physostegia correllii*)** - wet soils including riverbanks, streambanks, in creek beds, roadside ditches and irrigation channels; flowering June-July
- Texabama croton (*Croton alabamensis* var. *texensis*)** - mostly deciduous or evergreen deciduous woodlands in duff-covered loamy clay soils on rocky slopes in comparatively mesic limestone ravines, often locally abundant on deeper soils on small terraces in canyon bottoms; flowering late February-March; fruit maturing and dehiscing by early June

<p>Status Key:</p> <p>LE, LT - Federally Listed Endangered/Threatened</p> <p>PE, PT - Federally Proposed Endangered/Threatened</p> <p>E/SA, T/SA - Federally Listed Endangered/Threatened by Similarity of Appearance</p> <p>    C1 - Federal Candidate for Listing, Category 1; information supports proposing to list as Endangered/Threatened</p> <p>DL, PDL - Federally Delisted/Proposed for Delisting</p> <p>    NL - Not Federally Listed</p> <p>    E, T - State Listed Endangered/Threatened</p> <p>    "blank" - Rare, but with no regulatory listing status</p>
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*Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.*



Notes for  
County Lists of Texas' Special Species



The Texas Parks and Wildlife (TPWD) county lists **include**:

**Vertebrates, Invertebrates, and Vascular Plants** on the special species lists of the TPWD, Non-game and Rare Species Program, Natural Diversity Database (NDD) (formerly the Biological and Conservation Data System). These special species lists are comprised of all species, subspecies, and varieties that are federally listed; proposed to be federally listed; have federal candidate status; are state listed; or carry a global conservation status indicating a species is imperiled, very rare, vulnerable to extirpation; and some species ranked rare or uncommon.

**Colonial Waterbird Nesting Areas and Migratory Songbird Fallout Areas** are included on the county lists for coastal counties only.

The TPWD county lists **exclude**:

**Natural Plant Communities** such as Little Bluestem-Indiangrass Series (native prairie remnant), Water Oak-Willow Oak Series (bottomland hardwood community), Saltgrass-Cordgrass Series (salt or brackish marsh), Sphagnum-Beakrush Series (seepage bog).

**Other Significant Features** such as non-coastal bird rookeries, comprehensive migratory bird information, bat roosts, bat caves, invertebrate caves, and prairie dog towns.

**These lists are not all inclusive for all rare species distributions.** The lists were developed and are updated based on field guides, staff expertise, scientific publications, and the TPWD Natural Diversity Database (NDD) (formerly the Biological and Conservation Data System) occurrences data. Historic ranges for some state extirpated species, full historic distributions for some extant species, accidentals and irregularly appearing species, and portions of migratory routes for particular species are not included. Species that appear on county lists do not all share the same probability of occurrence within a county. Some species are migrants or wintering residents only. Additionally, a few species may be historic or considered extirpated within a county.

TPWD includes the Federal listing status for your convenience and makes every attempt to keep the information current and correct. However, the US Fish and Wildlife Service (FWS) is the responsible authority for Federal listing status. The TPWD lists do not substitute for contact with the FWS and federally listed species county ranges may vary from the FWS county level species lists because of the inexact nature of range map development and use.

This information is for your assistance only; due to continuing data updates, **please do not reprint or redistribute the information, instead refer all requesters to our office to obtain the most current information available.**

Last Revision: 14 Feb 2006



### The Natural Diversity Database



The Texas Parks and Wildlife Department (TPWD), Natural Diversity Database (NDD) (formerly the Biological and Conservation Data System), established in 1983, is the Department's most comprehensive source of information on rare, threatened, and endangered plants and animals, exemplary natural communities, and other significant features. Though it is not all-inclusive, the NDD is constantly updated, providing current or additional information on statewide status and locations of these unique elements of natural diversity.

The NDD gathers biological information from museum and herbarium collection records, peer reviewed publications, experts in the scientific community, organizations, qualified individuals, and on-site field surveys conducted by TPWD staff on public lands or private lands with written permission. TPWD staff botanists, zoologists, and ecologists perform field surveys to locate and verify specific occurrences of high-priority biological elements and collect accurate information on their condition, quality, and management needs.

The NDD can be used to help evaluate the environmental impacts of routing and siting options for development projects. It also assists in impact assessment, environmental review, and permit review.

**Given the small proportion of public versus private land in Texas, the NDD does not include a representative inventory of rare resources in the state. Although it is based on the best data publicly available to TPWD regarding rare species, these data cannot provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in any area. Nor can these data substitute for on-site evaluation by qualified biologists. The NDD information is intended to assist the user in avoiding harm to species that may occur.**

Please use the following citation to credit the source for this county level information:

Texas Parks and Wildlife Department, Wildlife Division, Diversity and Habitat Assessment programs. County Lists of Texas' Special Species. [county name(s) and revised date(s)].

*For information on obtaining a project review form or a site-specific review of a project area for rare species, and for updated county lists, please call (512) 912-7011.*

Last Revision: 14 Feb 2006

**ADDENDUM B 2  
FIGURES**

### ADDENDUM B 3 VEGETATION LIST FOR RESTORATION

VEGETATION LIST FOR RESTORATION			
Species	Zone 1 (waters edge)	Zone 2 (stream bank)	Zone 3 (above bank)
<b>Canopy Species</b>			
Big (>0.3m diam.) = 60% Cover			
Cedar Elm			X
Pecan			X
Black Walnut			X
Bur Oak			X
Green Ash	X	X	X
Live Oak			X
Bald Cypress	X	X	
Shumard Oak (Southern Red Oak)		X	X
Small (<0.3m diam.) = 25% Cover			
Little Walnut		X	
Roughleaf Dogwood	X	X	
Wafer Ash (Hop Tree)			X
Mulberry			X
Shin Oak			X
Cherry Laurel			X
Redbud			X
Mexican Plum			X
Texas Persimmon			X
Burmelia			
<b>Understory ((0.5-5m high)</b>			
Woody Shrubs = 50% cover			
Fragrant Sumac		X	X
Flameleaf Sumac		X	X
Evergreen Sumac		X	X
Buttonbush	X		
False Indigo	X		
Cat Claw Mimosa			X
Deciduous Holly	X	X	X

Texas Buckeye		X	X
Mexican Buckeye		X	X
Non-Woody Herbs			
Yaupon	X	X	X
American Beautyberry		X	X
Coral berry		X	X

**Ground Cover (<0.5m high)**

Woody Shrubs = <10% cover

Non-Woody Herbs, Grasses = 50% cover

Sedges ( <i>Cyperus</i> spp., <i>Carex</i> spp., etc)	X		
<i>Juncus</i> spp. ( <i>J. americanus</i> , <i>effusus</i> , etc.)	X		
Spikerushes	X		
Smartweed	X		
Horsetail	X		
Reedgrass	X		
Bulrush	X		
Switchgrass	X	X	
Eastern Gammagrass	X	X	
Big Bluestem		X	X
Indiangrass		X	X
Canada Wildrye		X	X
Purpletop			X
Little Bluestem		X	X
Buffalograss			X
Southern Wild Rice	X		
Rice Cutgrass	X		
Bushy Bluestem		X	
Big Muhly	X	X	
Inland Seoats	X	X	
Sideoats grama			X
Alkali Sacaton		X	X
Goldenrod			X
Horsemint		X	X
Salvia		X	X
Spiderwort		X	
Ludwigia	X	X	
Ruellia		X	X
Partridge Pea		X	X
Maximillian Sunflower		X	X
Illinois Bundleflower		X	X
Fleabane ( <i>Pluchea</i> spp.)	X		

*Lower Colorado River Basin  
Phase I, Texas*

*Interim Feasibility Report and  
Integrated Environmental Assessment*

Butterfly Bush		x	
Shield Fern	x		
Maidenhair Fern	x		
American Water Willow	x		
frostweed		x	x
Turks cap		x	x

## ADDENDUM B 4 POTENTIAL SPECIES OF ONION AND WILLIAMSON CREEKS

Species	Potential Birds of Onion Creek					*
	Riparian Woodland	Parkland	Shrubland	Grassland	Wetland	
Magnolia Warbler	x					M
Cape May Warbler	x					M
Black-throated Blue Warbler	x					M
Yellow-rumped Warbler	x					
Blue-winged Warbler	x					M
Golden-winged Warbler	x					M
Tennessee Warbler	x					M
Orange-crowned Warbler	x					M
Nashville Warbler	x					M
Northern Parula	x					M
Tropical Parula	x					M
Yellow Warbler	x					M
Chestnut-sided Warbler	x					M
Golden-cheeked Warbler	x					
Black-throated Green Warbler	x					M
Townsend's Warbler	x					M
Blackburnian Warbler	x					M
Yellow-throated Warbler	x					M
Pine Warbler	x					M
Prairie Warbler	x					M
Palm Warbler	x					M
Bay-breasted Warbler	x					M
Blackpoll Warbler	x					M
Cerulean Warbler	x					M
Black-and-white Warbler	x	x				
American Redstart	x	x				M
Prothonotary Warbler	x				x	
Worm-eating Warbler	x					M
Swainson's Warbler	x					M
Ovenbird	x					M
Northern Waterthrush	x					M
Louisiana Waterthrush	x					M
Kentucky Warbler	x					M
Connecticut Warbler	x					M
Mourning Warbler	x					M
MacGillivray's Warbler	x					M
Common Yellowthroat	x				x	

Hooded Warbler	x					M
Wilson's Warbler	x					M
Canada Warbler	x					M
Yellow-breasted Chat		x	x	x		
Summer Tanager	x	x	x			
Scarlet Tanager	x	x	x			
Olive Sparrow					?	
Spotted Towhee	x	x	x			
Eastern Towhee	x	x	x			M
Cassin's Sparrow		x			x	
Rufous-crowned Sparrow		x	x	x		
Chipping Sparrow		x			x	
Clay-colored Sparrow		x			x	
Field Sparrow		x			x	
Vesper Sparrow		x	x		x	
Lark Sparrow		x	x		x	
Black-throated Sparrow		x	x		x	
Lark Bunting						
Savannah Sparrow					x	
Grasshopper Sparrow					x	
Baird's Sparrow					x	
Henslow's Sparrow					x	
Le Conte's Sparrow					x	
Fox Sparrow		x	x		x	
Song Sparrow		x	x		x	
Lincoln's Sparrow		x	x		x	
Swamp Sparrow		x	x		x	
White-throated Sparrow			x		x	
Harris's Sparrow						
White-crowned Sparrow						
Golden-crowned Sparrow						
Dark-eyed Junco	x	x	x		x	
Northern Cardinal	x	x	x			
Rose-breasted Grosbeak	x					M
Blue Grosbeak	x	x	x		x	
Indigo Bunting	x	x	x		x	
Painted Bunting		x	x		x	
Dickcissel					x	
Bobolink					x	
Red-winged Blackbird						x
Eastern Meadowlark					x	
Western Meadowlark					x	
Yellow-headed Blackbird					x	
Rusty Blackbird		x			x	
Brewer's Blackbird		x			x	
Common Grackle	x	x	x			M

Great-tailed Grackle	x	x	x	x	
Brown-headed Cowbird		x	x	x	
Orchard Oriole	x	x			
Bullock's Oriole	x	x			
Baltimore Oriole	x				M
Purple Finch		x	x	x	
House Finch		x	x	x	
Red Crossbill					
Pine Siskin	x				M
Lesser Goldfinch		x	x	x	
American Goldfinch		x	x	x	
Evening Grosbeak	x	x		x	
Black-bellied Whistling-Duck				x	x
Fulvous Whistling-Duck				x	x
Greater White-fronted Goose					x
Snow Goose					x
Ross's Goose					x
Canada Goose		x			x
Wood Duck	x				x
Gadwall					x
American Wigeon					x
Mallard	x				x
Blue-winged Teal					x
Cinnamon Teal					x
Northern Shoveler					x
Northern Pintail					x
Green-winged Teal					x
Canvasback					x
Redhead					x
Ring-necked Duck					x
Greater Scaup					x
Lesser Scaup					x
Bufflehead					x
Common Goldeneye					x
Hooded Merganser					x
Red-breasted Merganser					x
Ruddy Duck					x
Wild Turkey	x	x	x	x	
Northern Bobwhite		x	x	x	
Common Loon					x
Least Grebe					x
Pied-billed Grebe					x
Eared Grebe					x
Western Grebe					x
American White Pelican					x
Neotropic Cormorant	x				x
Double-crested	x				x

Cormorant							
Anhinga	x						x
American Bittern							x
Least Bittern							x
Great Blue Heron							x
Great Egret							x
Snowy Egret							x
Little Blue Heron							x
Tricolored Heron							x
Cattle Egret					x		x
Green Heron	x						x
Yellow-crowned Night- Heron	x						x
Glossy Ibis					x		x
Wood Stork							x
Black Vulture		x			x		
Turkey Vulture		x			x		
Osprey							x
Hook-billed Kite					x		
Swallow-tailed Kite					x		
White-tailed Kite					x		
Mississippi Kite					x		
Bald Eagle		x			x		x
Northern Harrier		x			x		x
Sharp-shinned Hawk	x	x		x	x		
Cooper's Hawk	x	x		x	x		
Harris's Hawk					x		
Red-shouldered Hawk	x	x		x			
Broad-winged Hawk					x		
Swainson's Hawk					x		
White-tailed Hawk					x		
Red-tailed Hawk					x		
Ferruginous Hawk					x		
Crested Caracara					x		
American Kestrel					x		
Merlin		x			x		
Peregrine Falcon					x		
Prairie Falcon							
King Rail							x
Virginia Rail							x
Sora							x
Purple Gallinule							x
Common Moorhen							x
American Coot							x
Sandhill Crane					x		
Whooping Crane					x		x
American Golden- Plover					x		
Killdeer					x		x
Mountain Plover					x		x

Black-necked Stilt					X
American Avocet					X
Greater Yellowlegs					X
Lesser Yellowlegs					X
Solitary Sandpiper					X
Willet					X
Spotted Sandpiper					X
Upland Sandpiper			X		
Long-billed Curlew			X		
Marbled Godwit					X
Red Knot			X		X
Semipalmated Sandpiper					X
Western Sandpiper					X
Least Sandpiper					X
White-rumped Sandpiper					X
Baird's Sandpiper					X
Pectoral Sandpiper					X
Dunlin					X
Stilt Sandpiper					X
Buff-breasted Sandpiper					X
Short-billed Dowitcher					X
Long-billed Dowitcher					X
Wilson's Snipe			X		X
American Woodcock	X				X
Wilson's Phalarope					X
Franklin's Gull					X
Bonaparte's Gull					X
Ring-billed Gull					X
Herring Gull					X
Least Tern					X
White-winged Dove		X		X	
Mourning Dove		X		X	
Inca Dove		X		X	
Common Ground-Dove	X	X		X	
Black-billed Cuckoo	X				
Yellow-billed Cuckoo	X				
Greater Roadrunner		X	X	X	
Groove-billed Ani			X		
Barn Owl		X		X	
Western Screech-Owl	X	X	X		
Eastern Screech-Owl	X	X	X		
Great Horned Owl	X	X	X	X	
Barred Owl	X	X			
Common Nighthawk		X		X	
Chuck-will's-widow	X	X	X	X	
Whip-poor-will	X	X	X	X	
Chimney Swift		X		X	

M

Ruby-throated Hummingbird	x	x	x	x	
Black-chinned Hummingbird	x	x	x	x	
Anna's Hummingbird	x	x	x	x	
Belted Kingfisher	x				x
Red-headed Woodpecker	x	x			
Golden-fronted Woodpecker	x	x			
Red-bellied Woodpecker	x	x			
Yellow-bellied Sapsucker	x	x			
Red-naped Sapsucker	x	x			
Ladder-backed Woodpecker	x	x			
Downy Woodpecker	x	x			
Northern Flicker	x	x			
Pileated Woodpecker	x	x			
Eastern Wood-Pewee	x				
Acadian Flycatcher	x	x			
Alder Flycatcher	x				M
Willow Flycatcher	x				M
Least Flycatcher	x				M
Eastern Phoebe	x	x			
Say's Phoebe	x	x			
Vermilion Flycatcher		x	x	x	
Ash-throated Flycatcher	x	x			
Great Crested Flycatcher	x				M
Western Kingbird		x	x	x	
Eastern Kingbird		x	x	x	
Scissor-tailed Flycatcher		x		x	
Loggerhead Shrike		x	x	x	
White-eyed Vireo	x				
Bell's Vireo	x	x	x	x	
Black-capped Vireo			x		
Yellow-throated Vireo	x				M
Blue-headed Vireo	x				M
Warbling Vireo	x				M
Philadelphia Vireo	x				M
Red-eyed Vireo	x	x			
Blue Jay		x	x		
Western Scrub-Jay	x	x	x		
American Crow	x	x	x	x	
Common Raven	x	x	x	x	
Purple Martin		x			
Tree Swallow		x		x	
Violet-green Swallow		x		x	

Northern Rough-winged Swallow		x		x		
Bank Swallow		x		x		
Cliff Swallow		x		x		
Cave Swallow		x		x		
Barn Swallow		x		x		
Carolina Chickadee	x	x	x			
Tufted Titmouse	x	x	x			
Black-crested Titmouse	x	x	x			
Verdin		x	x	x		
Bushtit		x	x	x		
Carolina Wren	x	x	x			
Bewick's Wren	x	x	x			
House Wren		x				
Winter Wren	x					M
Sedge Wren				x	x	
Marsh Wren				x	x	
Golden-crowned Kinglet	x		x			
Ruby-crowned Kinglet	x	x	x			
Blue-gray Gnatcatcher	x	x	x			
Eastern Bluebird		x		x		
Western Bluebird		x		x		
Veery	x					M
Gray-cheeked Thrush	x					M
Swainson's Thrush	x					M
Hermit Thrush	x					M
Wood Thrush	x					M
American Robin		x		x		
Gray Catbird	x		x			M
Northern Mockingbird		x	x			
Brown Thrasher	x					M
American Pipit				x	x	
Sprague's Pipit				x	x	
Cedar Waxwing	x	x		x		
Phainopepla	x	x	x	x		

\* M= Migrant only less than one week

Source: Birds and Other Wildlife of South Central Texas by Edward A. Kutac and S. Christopher Caran

**Potential Bat Species of Onion Creek**

Scientific Name	Common Name	Historic Range	Actual Account	
<i>Myotis velifer</i>	Cave Myotis	x	x	
<i>Lasionycteris noctivagans</i>	Silver-haired Bat	x		
<i>Pipistrellus subflavus</i>	Eastern Pipistrelle	x	x	
<i>Eptesicus fuscus</i>	Big Brown Bat	x		
<i>Lasiurus borealis</i>	Eastern Red Bat	x	x	
<i>Lasiurus cinereus</i>	Hoary Bat	x	x	Migrant only
<i>Lasiurus intermedius</i>	Northern Yellow Bat	x	x	
<i>Nycticeius humeralis</i>	Evening Bat	x	x	
<i>Tadarida brasiliensis</i>	Brazilian Free-tailed Bat	x	x	
<i>Nyctinomops macrotis</i>	Big Free-tailed Bat	x		

Source: The Mammals of Texas by William B. Davis and David J. Schmidly 1994 TPWD Publication

**Common Mammals of Onion Creek**

Species	Scientific Name	Riparian Woodland	Parkland	Shrubland	Grassland	Wetland
White Tailed Deer	<i>Odocoileus virginianus</i>	X	X	X	X	
Virginia Opossum	<i>Didelphis virginiana</i>	X				
Armadillo	<i>Dasypus novemcinctus</i>	X	X	X	X	
Eastern Cottontail	<i>Sylvilagus floridanus</i>	X		X	X	
Coyote	<i>Canis latrans</i>					
Red fox	<i>Vulpes vulpes</i>	X		X	X	
Gray fox	<i>Urocyon cinereoargenteus</i>	X		X	X	
Raccoon	<i>Procyon lotor</i>	X	X	X	X	
Striped skunk	<i>Mephitis mephitis</i>	X	X	X	X	
bobcat	<i>Lynx rufus</i>	X		X		
Fox squirrel	<i>Sciurus niger</i>	X	X	X		
American Beaver	<i>Castor Canadensis</i>	X				X
nutria	<i>Myocastor coypus</i>	X				X
Fulvous harvest mouse	<i>Reithrodontomys fulvescens</i>	X		X	X	
White-footed mouse	<i>Peromyscus leucopus</i>	X				
Deer mouse	<i>Peromyscus maniculatus</i>			X	X	

Source: The Mammals of Texas by William B. Davis and David J. Schmidly 1994 TPWD Publication

**ADDENDUM B-5--HEP EVALUATION SUPPLEMENTAL INFORMATION**











**Existing Conditions and Future Without Project  
Existing Cover Type Habitat Suitability Indices and Habitat Units by Area of Interest  
Williamson Creek Ecosystem Restoration Only Plan**

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
<b>HEARTWOOD/SEGMENT 1</b>													
Grassland	0.56	0.57	0.32	0.57	0.32	0.57	0.32	0.57	0.32	0.57	0.32	0.57	0.32
Woodland	7.74	0.38	2.94	0.38	2.94	0.38	2.94	0.38	2.94	0.38	2.94	0.38	2.94
Parkland EA	0.8	0.4	0.32	0.4	0.32	0.4	0.32	0.4	0.32	0.4	0.32	0.4	0.32
Parkland EB	7.4	0.38	2.81	0.38	2.81	0.38	2.81	0.38	2.81	0.38	2.81	0.38	2.81
<b>RADAM/SEGMENT 2</b>													
Grassland	2.92	0.57	1.66	0.57	1.66	0.57	1.66	0.57	1.66	0.57	1.66	0.57	1.66
Woodland EC	4.5	0.44	1.98	0.44	1.98	0.44	1.98	0.44	1.98	0.42	1.89	0.4	1.80
Woodland ED	3.14	0.53	1.66	0.53	1.66	0.53	1.66	0.53	1.66	0.53	1.66	0.53	1.66
Parkland	28.49	0.4	11.40	0.4	11.40	0.4	11.40	0.4	11.40	0.4	11.40	0.4	11.40
<b>BROKEN BOW/SEGMENT 3</b>													
Woodland	4.1	0.53	2.17	0.53	2.17	0.53	2.17	0.53	2.17	0.53	2.17	0.5	2.05
Parklands	12.45	0.4	4.98	0.4	4.98	0.4	4.98	0.4	4.98	0.39	4.86	0.38	4.73
<b>BAYTON LOOP/SEGMENT 4</b>													
Grassland	6.07	0.57	3.46	0.57	3.46	0.57	3.46	0.57	3.46	0.57	3.46	0.57	3.46
Woodland	62.31	0.65	40.50	0.65	40.50	0.65	40.50	0.65	40.50	0.65	40.50	0.65	40.50
Parkland	7.91	0.4	3.16	0.4	3.16	0.4	3.16	0.4	3.16	0.39	3.08	0.38	3.01

**Existing Conditions and Future Without Project**  
**Existing Cover Type Habitat Suitability Indices and Habitat Units by Area of Interest**  
**Williamson Creek Combined Non-Structural Ecosystem Restoration Only Plan**

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
<b>HEARTWOOD/SEGMENT 1</b>													
Urban	0.7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Woodland	5.36	0.38	2.04	0.38	2.04	0.38	2.04	0.38	2.04	0.38	2.04	0.38	2.04
Parkland	8.29	0.38	3.15	0.38	3.15	0.38	3.15	0.38	3.15	0.38	3.15	0.38	3.15
<b>RADAM/SEGMENT 2</b>													
Grassland	2.29	0.57	1.31	0.57	1.31	0.57	1.31	0.57	1.31	0.57	1.31	0.57	1.31
Woodland NC	1.98	0.44	0.87	0.44	0.87	0.44	0.87	0.44	0.87	0.42	0.83	0.4	0.79
Woodland NL	3.66	0.53	1.94	0.53	1.94	0.53	1.94	0.53	1.94	0.53	1.94	0.53	1.94
Urban	4.11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Parkland NC	11.99	0.44	5.28	0.44	5.28	0.38	4.56	0.38	4.56	0.38	4.56	0.38	4.56
Parkland ND	6.31	0.38	2.40	0.38	2.40	0.38	2.40	0.38	2.40	0.38	2.40	0.38	2.40
<b>BROKEN BOW/SEGMENT 3</b>													
Woodlands NE, NN	7.82		0.00		0.00		0.00		0.00		0.00		0.00
Woodland NI	1.82	0.53	0.96	0.53	0.96	0.53	0.96	0.53	0.96	0.53	0.96	0.5	0.91
Urban	8.53	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Parklands	12.6	0.4	5.04	0.4	5.04	0.4	5.04	0.4	5.04	0.4	5.04	0.4	5.04
<b>BAYTON LOOP/SEGMENT 4</b>													
Grassland	8.27	0.57	4.71	0.57	4.71	0.57	4.71	0.57	4.71	0.57	4.71	0.57	4.71
Woodland	61.92	0.65	40.25	0.65	40.25	0.65	40.25	0.65	40.25	0.65	40.25	0.65	40.25
Parkland	5.93	0.4	2.37	0.4	2.37	0.4	2.37	0.4	2.37	0.39	2.31	0.38	2.25



**ADDENDUM B-6  
404 (b)(1) ANALYSIS**

## Section 404 (b)(1) Analysis Flood Damage Reduction Onion Creek, Austin, Texas

### Project Description

#### LOCATION

The proposed flood damage reduction project is located on Williamson Creek, a tributary to Onion Creek, and on Onion Creek itself, a tributary to the Colorado River, within the city of Austin and Travis County, Texas. There are four specific project areas, Timber Creek, Onion Creek Forest/Yarrabee Bend, Bear/Onion Confluence, and Middle Williamson Creek. Middle Williamson Creek was further broken down into Heartwood, Radam, Broken Bow, and Bayton Loop Reaches. The extents of the reaches are listed in the table below.

<b>Project Reaches</b>	
<b>Onion Creek</b>	
<b>Reach Name</b>	<b>Description</b>
Timber Creek	Colorado River to US 183
Onion Creek Forest/Yarrabee Bend	US 183 to William Cannon Drive
Bluff Springs/Perkins Valley	William Cannon Drive to Slaughter Lane
Onion Creek Subdivision	Slaughter Lane to I-35
Bear/Onion Confluence	I-35 to Hays County Line
<b>Williamson Creek</b>	
Heartwood	South Congress Avenue to Jeffburn Cove
Radam/Salem Walk	Jeffburn Cove to Manchaca Road
Broken Bow/Buckskin Pass	Manchaca Road to Remuda Trail
Westgate Blvd/Bayton Loop	Remuda Trail to Westgate Boulevard

#### GENERAL DESCRIPTION OF RECOMMENDED PLAN

A complete description of the proposed project including maps and figures that augment the description are included in the main text of the report to which this analysis is appended. A summary of project features is provided below.

#### Timber Creek

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 flood damage reduction land. 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 call for removal of 82 structures from the floodplain (91 parcels, total); construction of picnic areas, paved and unpaved trails, multi-use open fields, athletic courts, a playground, restroom, and parking areas; and reforestation of approximately 16 acres of riparian woodlands. This plan is the identified Multi-Objective Plan shown on Figure B-9 in Addendum B-2. No dredge or fill activities should occur in Waters of the U.S.

### **Onion Creek Forest/Yarrabee Bend**

This proposed alternative would combine a partial Permanent Evacuation of the 4% ACE Floodplain with ecosystem restoration and recreation features as alternate uses of the vacated parcels (Addendum B-2, Figure B-10). 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 397 structures from the floodplain; construction of picnic areas, paved and unpaved trails, parking areas, playscapes, multiple use open fields, restrooms, athletic courts, and vegetative buffers; and reforestation of approximately 221 acres of riparian woodlands. A Jurisdictional Determination was performed on this area and it was determined that although there were Waters of the United States present in the project area, no impacts to Waters of the United States would occur as a result of this alternative.

### **Bear/Onion Confluence**

This proposed alternative would combine a partial Permanent Evacuation of 4 houses with ecosystem restoration as an alternate use of the land. Four structures would be removed and 6 parcels would be purchased. Areas K and L would be restored to riparian woodlands to gain additional benefits or enhance the value of land as wildlife habitat. Approximately 18.7 acres would be restored producing 6.15 AAHU's of habitat. This alternative would not impact Waters of the United States. This alternative was subsequently removed from consideration for implementation.

### **Williamson Creek**

The proposed alternative is the Combined Structural Plan, which is broken into the four segments identified earlier. The Combined Structural Plan is a multi-purposed flood damage reduction and ecosystem restoration plan. This plan would implement the optimal structural alternative and ecosystem restoration measures would be constructed on the structural alternative lands in Heartwood, Radam, and Bayton Loop after the structural alternative is constructed and on other areas along Williamson Creek and would establish a connected greenbelt along large portions of Williamson Creek (Addendum B-2, Figure B-13 A-D). The optimal plan would consist of excavation of the immediate overbank area along one side of Williamson Creek to increase flood conveyance of the main channel. No restoration would occur within the Broken Bow reach due to public opposition of the need for all project land associated with ecosystem restoration to be bought in fee title. Approximately 8,500 feet of creek and aquatic resources would be negatively affected. In order to reduce these impacts, the normal low flow channel would be kept in tact. 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 40 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 15 acres and 6 AAHU's of riparian woodland habitat would be lost and would require mitigation. The remaining project lands would be bought in fee title and Broken Bow would be constructed using an existing utility easement. This alternative would implement the Locally Preferred Ecosystem Restoration Plan identified earlier. This plan would provide partial flood damage reduction benefits for approximately 254 structures. This plan would include restoring as many vegetation classifications within the identified areas to riparian woodlands in segments 1-4 as possible, as well as restoring parkland on the lands that would be bought for flood damage reduction purposes. This plan would provide a linear corridor of riparian woodlands

throughout the study area from Brodie Lane to below Congress Avenue. The only breaks in the corridor would be in the Broken Bow Reach and at existing road crossings and utility lines.

## **AUTHORITY AND PURPOSE**

The authority for the study of Onion Creek is contained in a resolution by the Committee on Transportation and Infrastructure, United States House of Representatives, adopted May 6, 1998, as quoted below:

*“Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Colorado River, Texas, published as House Document 361, 71st Congress, 2nd Session, and other pertinent reports, with a view to determine if improvements to the Onion Creek watershed in the interest of flood damage reduction, environmental restoration and protection, and other related purposes are advisable at the present time.”*

The primary purpose of the Onion Creek Interim Feasibility Study (OCIFS) is to investigate the water resource problems, needs, and opportunities within the Onion Creek watershed.

## **GENERAL DESCRIPTION OF DREDGED OR FILL MATERIAL**

### **General Characteristics of Material**

The material excavated would be derived from the channel banks along Williamson Creek. There should be no fill except incidental spill from construction equipment. The exposed construction areas would be covered with composted mulch with seed or sod to allow for revegetation.

### **Quantity of Material**

Approximately 72,180 cubic yards of soil and rock would be excavated in order to form the benched area. The materials would be removed from the project area and placed in a non-environmentally sensitive area such as a landfill or predisturbed construction site to be used as fill in the uplands.

### **Source of Material**

The source of the excavated materials would be from the immediate overbank on one side of the creek. Additional erosion control materials would be obtained offsite from commercial sources.

## **DESCRIPTION OF THE PROPOSED DISCHARGE SITE(S)**

### **Location**

Discharge into waters of the United States would occur along 8,500 feet of Williamson Creek in Austin, Texas and from approximately 15 acres of immediate overbank as show on the proposed plan figures identified above if rain events occurred. In addition, there would be additional discharge from incidental spills from construction equipment while construction is implemented along the banks of Williamson Creek.

### **Size**

The proposed project would impact approximately 8,500 feet of one side of the bank of the creek and approximately 15 acres of overbank woodland areas on Williamson Creek. A breakdown by reach is as follows:

Heartwood Reach	1,200 feet
Radam Reach	1,400 feet
Broken Bow Reach	2,900 feet
Bayton Loop	3,000 feet

**Type of Site**

The type of site would be a riparian area adjacent to Williamson Creek.

**Type(s) of Habitat**

The excavation would remove approximately 15 acres of average quality habitat and would impact 8,500 feet of fairly stable creek bank. Approximately 0.5 acres of grasslands, 8.0 acres of riparian woodlands, and 6.5 acres of parklands would be impacted by the proposed project. The table below shows the breakdown by reach.

<b>Acres of Impacted Vegetation on Williamson Creek from Implementation of the Recommended Plan</b>					
<b>Vegetation Type</b>	<b>Heartwood</b>	<b>Radam</b>	<b>Broken Bow</b>	<b>Bayton Loop</b>	<b>Total</b>
Grassland	0.0	0.0	0.0	0.5	<b>.5</b>
Woodland	1.4	0.0	0.9	5.7	<b>8.0</b>
Parkland	0.8	2.4	3.3	0.0	<b>6.5</b>
<b>Total</b>	<b>2.2</b>	<b>2.4</b>	<b>4.2</b>	<b>6.2</b>	<b>15</b>

**Timing and Duration of Discharge**

Discharges would be limited to occurring during storm water discharges for approximately 15 months or until the vegetation is fully established. Minor discharges would occur from construction equipment while the immediate adjacent bank is being excavated. The stream is an intermittent stream in all reaches except the Broken Bow Reach.

**DESCRIPTION OF DISPOSAL METHOD**

Equipment used to excavate the benched area would be backhoes, front end loaders, bulldozers, dump trucks and other heavy construction equipment as needed. The Recommended Plan would be to excavate the materials and take the excavated materials to an appropriate disposal site so as not to impact additional Water of the U.S.

## FACTUAL DETERMINATIONS

### PHYSICAL SUBSTRATE DETERMINATIONS

#### Substrate Elevation and Slope

The existing profile slope of Williamson Creek is 25 feet/mile. The proposed project would not affect the slope on Williamson Creek.

#### Sediment Type

The lower portion of the project area is predominately bed rock. Significant levels of sediment within the channel bottom occur within the upper portion of the project area. The sediment is cobble with fine gravel. Below is a classification of the Stream type and sediment composition by reach taken from the Williamson Creek Soil Erosion Assessment:

Heartwood:	Rock Bed
Radam:	Rock Bed
Broken Bow	Alluvial consists of cobble and fine gravel
Bayton Loop:	Alluvial consists of cobble and fine gravel

The excavated materials would consist of limestone rock, cobble, and soils located adjacent to the creek.

#### Dredged/Fill Material Movement

Excavated materials would be removed from the project area so as not to further affect Waters of the U.S. during disposal. Backhoes would be used to the extent possible to limit discharge and movement of materials. During construction and prior to reestablishment of vegetation, sediment from the construction site would be transported downstream as a result of storm water discharges in the form of sheet flow for minor rains or as a result from overbank flow from the creek as a result of a larger rainfall event. Only minor to no movement of fill material would occur after vegetation would get established. A sediment transport model is currently being developed so that the proposed project can be refined during the Preconstruction, Engineering, and Design Phase if it is determine that the proposed project would affect the sediment continuity of the creek.

#### Physical Effects on Benthos

Since Williamson Creek is an intermittent stream, the effects on Benthos would be limited to temporary impacts from sediment transport during construction and until vegetation is reestablished. According to the city of Austin, Williamson Creek already has an impaired benthos community.

#### Other Effects

No other effects are anticipated.

### **Actions Taken to Minimize Impacts**

Alternatives that are normally considered as structural alternatives (i.e. concrete lined channels, and trapezoidal grass lined channels) for flood damage reduction projects were not even considered as alternatives for this project. In addition, construction impacts were limited to one side of the creek. Finally, design efforts were utilized to keep the base flow channel intact by limiting the start of construction to two foot above the bottom of the channel. A Storm Water Pollution Prevention Plan would be developed to implement best management practices to minimize sediment transport and sedimentation. The area would be revegetated as soon as possible to limit temporary impacts from storm water discharges.

### **WATER CIRCULATION. FLUCTUATION AND SALINITY DETERMINATIONS**

#### **Water, Consider effects on:**

##### ***Salinity***

The project would not impact salinity in Williamson Creek.

##### ***Water Chemistry (pH.etc.)***

No current water quality data is available for this creek in the project area; however, no long term impacts to water chemistry are anticipated from project implementation.

##### ***Clarity***

Temporary disruption to water clarity is expected during construction as a result of sediment transport and increased turbidity. After the channel is completed and stabilized, water clarity would be similar to that found in the stream now.

##### ***Color***

No changes in color are anticipated following construction.

##### ***Odor***

No changes in odor would occur following construction.

##### ***Taste***

The stream is not used as a potable water source within any portion of the area that would be impacted by the project.

##### ***Dissolved Gas Levels***

Only minor changes are expected to dissolved gas levels. The removal of trees from one side of the adjacent bank would allow increase light penetration into the creek, which would result in slight increase in temperatures, which could decrease dissolved oxygen in the channel. However, the construction was limited to one side of the creek to minimize these impacts. In addition, trees would be replanted on the bench to attempt to prevent long term impacts from temperature increases. In addition, the proposed restoration measures that would be

implemented as part of the Recommended Plan would restore approximately 16,000 feet of Williamson Creek.

### ***Nutrients***

The project as proposed could increase nutrient loading to the stream as a result of the compost mulch used in erosion control measures and revegetation; however, these would be temporary impacts. In addition, the proposed restoration portion of the Recommended Plan would establish a buffer zone of native species for approximately 16,000 feet of Williamson Creek, which would result in an overall decrease in nutrient loading over time.

### ***Eutrophication***

Eutrophication is not evident in the project reach and there would be no factors changed that would impact eutrophication of the aquatic system in Williamson Creek.

## **Current Patterns and Circulation**

### ***Current Patterns and Flow***

The Williamson Creek watershed is largely urban and the stream is intermittent until it nearly reaches the confluence with Onion Creek, except for a spring feed perennial pools in the Broken Bow Reach. Patterns of flow are dependent on the distribution and intensity of rainfall over this area. The normal patterns of precipitation result in minor to major fluctuations of flow intensity through the system. Heavy thunderstorms can induce large flows and high water surface elevations very quickly. Current flows and projected flows and velocities are provided in H&H Appendix within Appendix G. Circulation basically does not change as the system has no braids or large instream detention.

### ***Velocity***

There would be increases in velocity for most flow events due to increasing channel storage of the stream. The hydraulic design would be reviewed during Preconstruction, Engineering and Design to detect any areas where velocities might induce scour would so that they can be protected with suitable erosion control techniques.

### ***Stratification***

Stratification in these shallow or intermittent reaches of the stream does not occur now in the stream nor would it following project implementation.

### ***Hydrologic Regime***

Within the project area the existing flows varies from an approximate 9,710 cubic feet per second in the upper reach and 11,050 cubic feet per second in the lower reach for the 10-year flood to approximately 21,060 cubic feet per second in the upper reach to 23,630 cubic feet per second in the lower reach for the 100-year event. More frequent events were not computed but vary from essentially no flows during and following dry summer conditions to a few cubic feet per second for several days following local rainfall.

Projected flows with the project would vary from an approximate 9,760 cubic feet per second in the upper reach and 11,390 cubic feet per second in the lower reach for the 10-year flood to approximately 21,060 cubic feet per second in the upper reach to 24,120 cubic feet per second in the lower reach for the 100-year event.

### ***Normal Water Level Fluctuations***

Under existing conditions water surface elevation fluctuates from the channel bottom at 643.6 msl to 662.81 msl for the 100-year event at the Westgate Bridge and from 589.6 msl to 609.11 msl at the most downstream 1<sup>st</sup> Street Bridge. After completion of the described benching, water surface elevation would decrease to 659.92 msl at the Westgate Bridge and 608.74 msl at the 1<sup>st</sup> Street Bridge for the 100-year event.

### ***Salinity Gradients***

No changes to salinity gradient would occur.

### ***Actions That Will Be Taken to Minimize Impacts***

These impacts were minimized as a result of the minimization of the channel reach impacted and to the minimization of channel width.

## **SUSPENDED PARTICULATE/TURBIDITY DETERMINATIONS**

### **Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site**

Only temporary increases in suspended particulates and turbidity levels would occur as a result of construction and until vegetation is reestablished on the benches. The excavations would mostly occur in the uplands during dry periods. There would be movement of these materials downstream of the construction zone should high flow events occur prior to revegetation.

### **Effects (degree and duration) on Chemical and Physical Properties of the Water Column**

#### ***Light Penetration***

Changes to light penetration would occur during construction associated with minor turbidity increases. After project completion and stabilization, the clarity of the stream would return to preconstruction levels.

### ***Dissolved Oxygen***

No testing was performed to establish existing Dissolved Oxygen concentrations. Temporary lowering of dissolved oxygen would occur during construction and until trees provide appropriate shading. These effects have been minimized to the extent practical by only performing construction on one side of the creek.

### ***Toxic Metals and Organics***

No water testing was conducted in the immediate proposed project area and no data was identified to provide information on Toxic Metals and Organics. The area is primarily urban with most of the run-off coming from residential homes and businesses. No significant indications of organic loading were observed in the project area. No adverse effects are anticipated in the project area

### ***Pathogens***

No pathogens would be added to the water column as a result of this project.

### ***Aesthetics***

The aesthetics of the creek would be altered by the proposed project. Instead of currently wooded parklands or densely vegetated riparian woodlands riparian zones, the benched area would be a flat bench vegetated with grass cover and trees on 40-foot centers. Existing vegetation including several large live oak trees would be removed.

### ***Others as Appropriate***

No other effects to water column are anticipated

### **Effects on Biota**

No measurable effects on biota within the water column are anticipated from construction or operation of the project.

### ***Primary Production, Photosynthesis***

No measurable effects on biota within the water column are anticipated from construction or operation of the project.

### ***Suspension/Filter Feeders***

No measurable effects on biota within the water column are anticipated from construction or operation of the project.

### ***Sight Feeders***

No measurable effects on biota within the water column are anticipated from construction or operation of the project.

### **Actions taken to Minimize Impacts**

Construction was limited to one side of the creek and the baseflow was left intact to reduce impacts. Limiting the construction on one side keeps the riparian habitat intact on opposite side to provide shading and filtering of pollutants. A Storm Water Pollution Prevention Plan would be implemented using best management practices such as silt fences, composted mulch, and other erosion control measures to reduce sedimentation and increased turbidity.

### **CONTAMINANT DETERMINATIONS**

No known contamination exists within the area that would be directly affected by the project.

### **AQUATIC ECOSYSTEM AND ORGANISM DETERMINATIONS**

#### **Effects on Plankton and Nekton**

Williamson Creek is an intermittent stream throughout most of the creek. The Broken Bow Reach has perennial pools that are spring fed. Since there are perennial pools, plankton populations, although low, would be temporarily impacted by the project.

#### **Effects on Benthos**

No additional effects other than those previously discussed were identified.

#### **Effects on Aquatic Food Web**

Temporary disruptions to food web would occur during construction. However, it is anticipated that all trophic levels would return to preconstruction levels shortly after construction is completed. Predatory fish, mammals and birds that utilize the energy produced by this system would be able to utilize the food sources of adjacent aquatic reaches and riparian woodlands.

#### **Effects on Special Aquatic Sites**

##### ***Sanctuaries and Refuges***

Not Applicable

##### ***Wetlands***

No wetlands were identified within the area to be impacted by the project.

##### ***Mud Flats***

No mud flats were observed within the study area to be impacted by the project

### **Vegetated Shallows**

No vegetated shallows were observed in the area to be impacted by the project.

### **Coral Reefs**

Not applicable

### **Riffle and Pool Complexes**

Since the baseflow channel is going to be left intact, no effect to riffle pool sequences would occur. A sediment transport model would be developed during Preconstruction, Engineering and Design to determine if there would be changes in sediment continuity, which could cause aggradations or degradation. If it is determined that sediment continuity would change, measure would be taken to try and reduce these effects.

### **Threatened and Endangered Species**

The project would not affect any federally listed threatened or endangered species.

### **Other Wildlife**

The project would impact riparian and aquatic habitat as indicated in the project report. Those riparian species that occupy manicured park-like areas would be temporarily displaced during construction activities. Revegetation with native grasses and forbs would take place following construction. Approximately 6.02 AAHU of habitat would be fully mitigated.

### **Actions to Minimize Impacts**

## **PROPOSED DISPOSAL SITE DETERMINATIONS**

### **Mixing Zone Determination**

Most fill would occur within areas of the channel while in a dry state and only minimal mixing would occur, if any. Best Management Practices will be implemented such as silt curtains to lower impacts. Disposal of surplus material would occur at an offsite location that is not within waters of the United States.

### **Determination of Compliance with Applicable Water Quality Standards**

Williamson Creek is a tributary to Onion Creek. Williamson Creek is identified as Segment 1427B on the Texas Water Quality Inventory put out by the Texas Commission of Environmental Quality. Williamson Creek is fully supporting for all criteria. The section of Onion Creek that Williamson Creek flows into is identified as Segment 1427. The uses and criteria listed for surface waters in Segment 1427 were reviewed to determine compliance. The segment from US 183 to the confluence with the Colorado River currently does not meet state water quality standards for dissolved oxygen. Temporary construction impacts within the immediate area of construction could at times impact dissolved oxygen and reduce this criteria below the lower limit of 5.0 mg/l however the zone impacted would be small and would not reach downstream to Segment 1427. Temperature (maximum 90) is likely exceeded for short times during the day within the existing

channelized reach during maximum heating of summer conditions and would likely be exceeded during similar periods with the new channel. Temperature in the receiving segment 1427 would not be significantly impacted. No other criteria are likely to be exceeded as a result of the project.

### **Potential Effects on Human Use Characteristic**

#### ***Municipal and Private Water Supply***

NA

#### ***Recreational and Commercial Fisheries***

Recreational fisheries are limited to fishing for pan fish or crawfish, most likely by youth living in the area adjacent to the channel. No signs of recreational fisheries activities were identified. No significant impact to recreational fisheries is anticipated. No commercial fisheries were identified within the project area

#### ***Water Related Recreation***

No additional effects to water related recreation are anticipated

#### ***Aesthetics***

Aesthetics from construction of the project would not be aesthetically pleasing at first. The area would be transformed from a park setting to an open area in the short term. Trees would be replanted on 40-foot centers to help offset this, but they would take several years to establish.

#### ***Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves***

Slight effects would occur to channel banks adjacent to city parks. No other sites of the types listed occur in the project area.

#### ***Determination of Cumulative Effects on the Aquatic Ecosystem***

The cumulative effects of the reasonably foreseeable projects would be slightly adverse due to the cumulative sediment introduced through runoff from the various construction activities. However, it is anticipated that the sediments that could cumulate from these activities would be very low with the implementation of storm water control features and best management practices required during construction.

#### ***Determination of Secondary Effects on the Aquatic Ecosystem***

No secondary effects on the aquatic ecosystem were identified

**FINDING OF COMPLIANCE**  
**FOR**  
**ONION AND WILLIAMSON CREEK, AUSTIN, TEXAS**

1. No significant adaptations of the guidelines were made relative to this evaluation.
2. Three different channel widths alternatives were reviewed in the final array. Upstream detention sites were not economically justified.
3. The planned disposal of dredged material within the construction area would not violate established State water quality standards for Williamson Creek. The disposal operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.
4. Use of the selected disposal sites will not harm any endangered species or their critical habitat.
5. The Proposed disposal of dredged material will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic and economic values will not occur. Possible riparian forest impacts were identified that required development of a compensatory riparian forest mitigation plan. The plan was developed and will be implemented.
6. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include use of suitable erosion control technologies including the implementation of procedures to protect against erosion and sedimentation during and after construction.
7. On the basis of the guidelines the proposed disposal site for the discharge of dredged material is specified as complying with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.