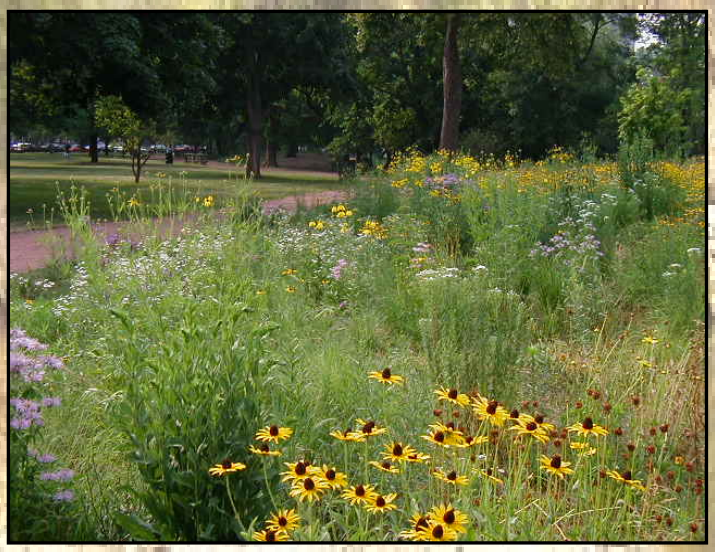
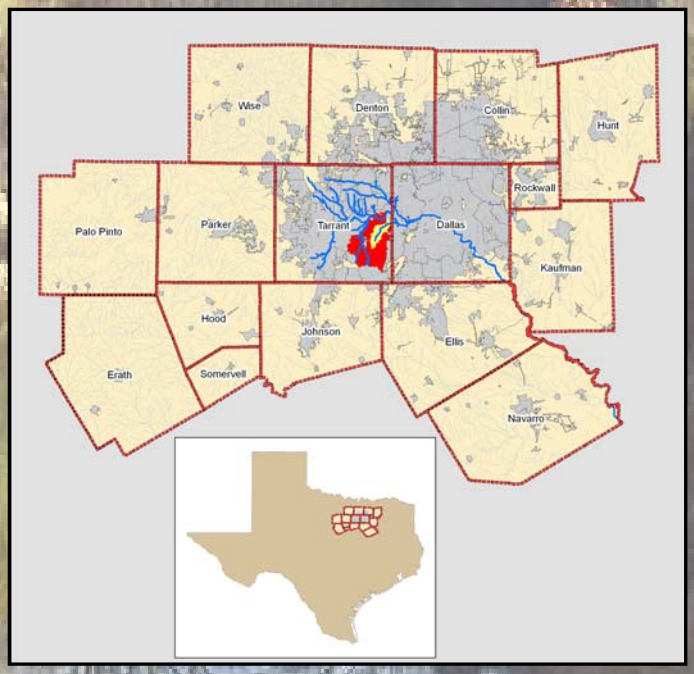
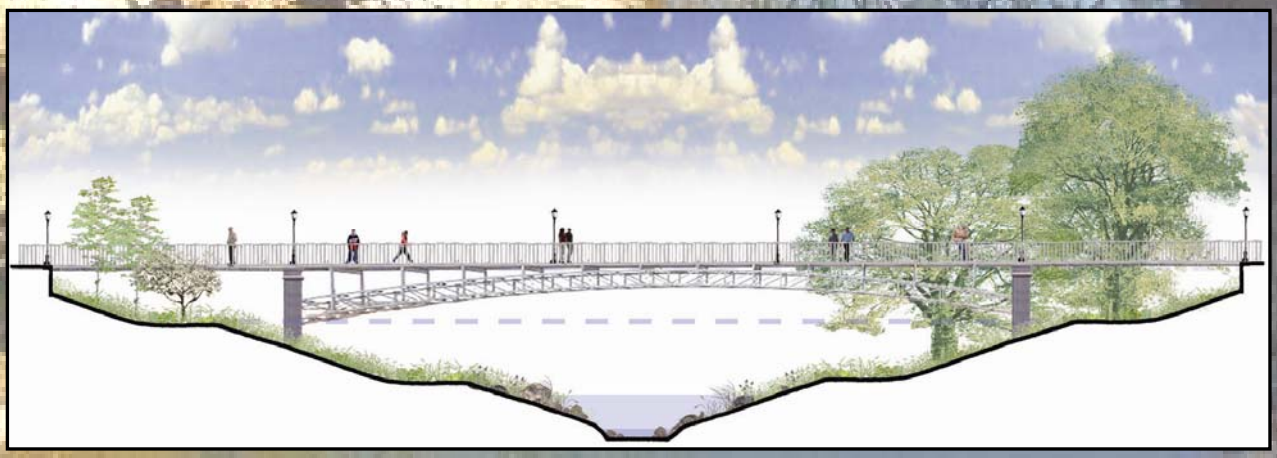
Johnson Creek: A Vision of Conservation

Arlington, Texas

March 30, 2006







Applied Ecological Services, Inc.™

Prepared for the City of Arlington, Texas
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EXECUTIVE SUMMARY

Johnson Creek, a tributary of the Trinity River, flows 14.3 miles north/northeast from its headwaters near Interstate 20 and Cooper Street in Arlington to its outlet at the West Fork of the Trinity River in Grand Prairie. The study area for this plan consists of the most southerly reach (approximately 9 miles) of Johnson Creek and its contributing 10,174-acre watershed within City of Arlington limits.

Johnson Creek has been the topic of extensive study by the Corps of Engineers (Corps) and the City of Arlington (City) since the early 1980s due to a history of flooding, extensive erosion and sedimentation, recreational challenges and opportunities, and important wildlife habitat.

In 1990, the Corps proposed to address flooding by planning and allocating funds to channelize and line with concrete substantial stretches of Johnson Creek. The City rejected this plan in 1995 on the grounds that it provided flood relief at the expense of recreational opportunities, wildlife habitat and economic development. The City adopted in 1997 a more holistic alternative called the Johnson Creek Corridor Plan that received wide community support. However, funding to implement the Johnson Creek Corridor Plan has been difficult to obtain.

In 1999, the Corps prepared an Interim Feasibility Report and Integrated Environmental Assessment for Johnson Creek in Arlington (USACE 1999). The document recommended a National Economic Development (NED) Plan for flood damage reduction that also addressed the City's desires for enhanced wildlife habitat and recreation in the Johnson Creek corridor. In 2000, the City adopted the Corps' 1999 plan to purchase homes within the floodplain of Johnson Creek, create linear parks with trails, and acquire and restore open space for wildlife habitat and recreation.

In 2004, subsequent to the City's contract with the Corps to implement the 1999 corridor plan, the City entered into a partnership with the Dallas Cowboys to build a new football stadium adjacent to the Texas Rangers' venue and land purchased and restored as part of the Corps' 1999 plan. In 2005, the Corp's 1999 plan was amended to remove approximately 90 acres of City owned land north of Union Pacific Railroad tracks.

During ecological investigations associated with design and master plan development of the stadium, a number of critical ecological issues arose that the authorized plan, hereafter referred to as the 1999/2005 plan, only partially addressed:

Flooding.-- Flooding remains a serious threat along Johnson Creek due to floodplain development, lack of detention and retention, and poor channel maintenance. The 1999/2005 plan included acquisition of flood prone structures within a portion of the 25-year and 5-year floodplain. Even with these acquisitions, at least nine bridges and several dozen private properties remain flood problem areas.

Poor Water Quality and Unstable Streambanks.-- Sedimentation and erosion leading to poor water quality and unstable streambanks is the most serious threat to the ecological integrity of the Johnson Creek corridor. Erosion and sedimentation is widespread, active, and severe,

particularly north of Division Street. It threatens public and private property, and prevents active or passive use of land set aside in City parks for wildlife habitat and recreation.

Lack of Passive Recreation.-- Most green space in Arlington is set aside for picnicking and active recreation such as baseball, tennis, and swimming. The few passive recreation opportunities along Johnson Creek are limited by erosion and overgrown streambanks. Portions of existing trails have already become undercut and have fallen into the creek. Under the 1999/2005 plan, all of the resources allocated for improved recreation were in areas between Collins Street and Park Row Drive. The modified plan, which includes open space north of Union Pacific Railroad, helps achieve a City goal for expanded recreation opportunities linking Arlington's entertainment district with central and south-central Arlington neighborhoods and businesses.

Unsuitable Habitat for Wildlife.-- The greatest threat to wildlife habitat in Johnson Creek is bank and bed erosion and in-stream sedimentation. The 1999/2005 plan emphasizes the creation of woody riparian habitat to the exclusion of in-stream and bank restoration which will reconnect the stream to its floodplain while also providing new wildlife habitat. The modified plan emphasizes the restoration of historic ecological communities and the systems that sustain them.

Of the four environmental threats, flooding is the catalyst for continued degradation of water quality, wildlife habitat, and passive recreational opportunities. 25-year and larger storm events are occurring more frequently, and as a result, are causing irreversible damage to homes, businesses, bridges, roads, and other infrastructure. With new economic opportunities looming, the City desires a long-term solution to flooding that will protect historic structures, private homes, and new business opportunities such as the proposed Dallas Cowboys football stadium and Arlington town center. Our challenge is that the Corps' 1999/2005 plan is very specific in scope, and deviations from the plan to further address flooding and other environmental threats require explicit authorization and financial support from Congress.

Through this document, the City modifies the 1999/2005 plan and requests federal funding to 1) implement and modify, if necessary, unfinished components of the 1999/2005 plan; 2) design and construct new bank stabilization, flood control, recreation, and habitat restoration projects on public lands and easements along Johnson Creek; and 3) allow for reimbursement and/or acquisition of an additional 90 acres in Trinity River and/or Rush/Village Creek floodplain; and 4) obtain reimbursement for new acquisitions, if desired, and the use of Vandergriff and Meadowbrook parks for funded federal projects.

Unfinished projects the City desires to complete under the modified plan include demolition of three homes between Collins Street and Park Row Drive, acquisition of 100-year floodplain at 1225/1223 Pecan Street, and re-design and implementation of passive recreational features and park amenities such as pedestrian crossings over Johnson Creek, 12' concrete trails, retaining walls as necessary for trails placed near the top of restored streambank, trail lighting, shelters, drinking fountains, park benches, flagstone paving, and adjustments to the quantity, type, or placement of plant material to accommodate new stream alignment and relocated trails; and bank stabilization.

New Johnson Creek projects are prioritized on the basis of feasibility, cost, and ability to meet multiple watershed goals. Desired projects are divided into two phases.

Phase 1 includes property between the Union Pacific railroad tracks between Division and Abram to the northerly Rangers' Pond. Phase 1 was selected for a variety of reasons as follow: 1) There is adequate open space for regional flood control; 2) the riparian corridor has high potential for restoration to improve wildlife habitat, water quality, and recreational opportunities; 3) the property is owned by the City; 4) a significant portion of existing environmental stresses, particularly erosion and sedimentation, occur within this area; 4) the City has identified this area as an entertainment district; and 5) this area includes the future Dallas Cowboys stadium, the existing Texas Rangers stadium, and a future Arlington town center. These developers have all agreed to provide matching money for the City to improve the green space within this corridor for environmental benefits listed above. Phase 1 work will provide the catalyst and inspiration for future work throughout the remainder of the watershed.

Phase 1 work is all new work and includes constructing a major flood control detention basin between the Union Pacific railroad tracks and Division Street; constructing a detention/sedimentation basin just west of the Stone Gate Mobile Park; restoring the south Rangers' pond to a stream; bank stabilization and creek restoration; modifying the north Rangers' ponds to maximize detention; installing two pedestrian bridges across Johnson Creek; providing trails and other passive recreational amenities; and enhancing remaining green space for wildlife habitat.

Phase 2 includes the Johnson Creek corridor between Union Pacific railroad tracks and Vandergriff Park, and 90 acres of environmental land within Trinity River and/or Rush/Village Creek floodplain. Within the Johnson Creek corridor, Phase 2 work will occur within three main areas. At Vandergriff and Meadowbrook Parks, proposed activities include creating a detention/sedimentation basin; restoring eroded creek banks and creek restoration; enhancing passive recreational opportunities using trails and other amenities; and enhancing wildlife habitat. The third area includes the restoration of two tributaries of Johnson Creek on either side of the main stem, between Sanford Street and the proposed Rogers Street crossing. Possible acquisition of three homes between Collins and Park Row may also occur as part of Phase 2.

Estimated costs of all components of the modified plan, except for sunk costs from the 1999/2005 authorized plan, are based on conceptual and/or master plan drawings of modified and new Johnson Creek projects. All drawings are subject to change during subsequent phases of design. Adjustments to unit costs and quantities of specific plan components are anticipated during subsequent phases of design. The City requests that these costs be allowed to change with the design process, understanding that the total project cost for any given phase cannot exceed the total project cost.

Total project cost is estimated at $79,997,666, including contingency. This includes $30,000,000 in sunk costs for completed Johnson Creek projects, $12,523,879 for new Phase 1 projects, and $27,474,255 for new Phase 2 projects.

1.0 INTRODUCTION

A universal challenge for local governments today is to find a balance between land development and environmental protection. The City of Arlington, Texas is no different. Contained within city limits is an approximate 9-mile stretch of Johnson Creek and contributory 10,174-acre watershed whose long-term sustainability is threatened by direct and indirect effects of urban development. This historic channel, a tributary of the Trinity River, is one of Arlington's most precious remaining natural resources, and has been described by citizens as "an important thread in their city's fabric" (Johnson Creek Consortium 1997). Yet, poorly regulated floodplain development, improper channel maintenance, and limited funds for restoration have prevented the City from fully embracing and integrating Johnson Creek into land use decisions.

1.1 HISTORY

Johnson Creek has been the topic of extensive study and planning by the Corps of Engineers (Corps) and the City of Arlington (City) since the early 1980s due to a history of flooding, extensive erosion and sedimentation, recreational challenges and opportunities, and important wildlife habitat. In the last 16 years, the City has initiated or been a key stakeholder in flood protection and ecological corridor planning for Johnson Creek. Recent efforts have included coordination with the Corps on flood protection projects using more natural methods. The following summarizes work associated with the corridor over the last 16 years:

- In 1990, the U.S. Army Corps of Engineers (Corps) proposed to channelize and line with concrete substantial stretches of Johnson Creek.
- In 1995, the City rejected this plan on the grounds that it provided flood relief at the expense of recreational opportunities, wildlife habitat, and economic development.
- In 1997, the City adopted a more holistic alternative called the Johnson Creek Corridor Plan, which received wide community support, but was not fundable.
- In 1999, the Corps prepared an Interim Feasibility Report and Integrated Environmental Assessment for Johnson Creek in Arlington (USACE 1999). The document recommended a National Economic Development (NED) Plan for flood damage reduction that also addressed the City's desires for enhanced wildlife habitat and recreation in the Johnson Creek corridor.
- In 2000, the City adopted the 1999 Corps-sponsored plan to purchase homes within the 25-year and 5-year floodplain of Johnson Creek, create linear parks with trails, and acquire and restore open space for wildlife habitat. The 1999 plan partially met the City's goals for flood control, linear park systems, and wildlife habitat, but it could not address all flooding problem areas, nor could it fund streambank restoration to reduce erosion and sedimentation.
- In 2004, the City entered into contract with the Dallas Cowboys to build a new stadium adjacent to Johnson Creek.
- In 2005, the 1999 plan was amended to remove approximately 90 acres of City owned land north of Union Pacific Railroad tracks.

1.2 PURPOSE

The purpose of this plan is to 1) provide sufficient background information on the major environmental threats that continue to worsen Johnson Creek; 2) outline the holistic strategy and feasible approach developed to address each threat; 3) prioritize and cost all completed, unfinished, and newly proposed Johnson Creek projects for inclusion in the modified plan; and 4) request federal funding for all components of the plan as described in subsequent chapters. This plan modifies the Corps' authorized plan, hereafter referred to as the 1999/2005 plan, to the extent that it enables the City to redesign and construct unfinished components of the 1999/2005 plan while also expanding the project scope to include bank stabilization, flood control, recreation, and habitat restoration on additional public lands or within public easements along Johnson Creek. The modified plan also allows for the reimbursement and/or acquisition of an additional 90 acres of environmental land preserved in Trinity River and/or Rush/Village Creek floodplain. Specifically, this plan includes the following:

- Finished components of the Corps' 1999 plan as amended in the fall of 2005.
- Unfinished components of the 1999/2005 plan the City still desires to complete, including demolition of three structures between Collins Street and Park Row Drive, and acquisition of 100-year floodplain at 1225/1223 Pecan Street.
- Modified, unfinished components of the 1999/2005 plan, including acquisition of three floodplain structures, and streambank stabilization and upgraded park amenities between Collins Street and Park Row Drive.
- New flood control, water quality, and wildlife habitat/recreation improvement projects on public lands or easements throughout the Johnson Creek corridor as described in this document.
- Reimbursement and/or acquisition of an additional 90 acres of environmental land preserved in Trinity River and/or Rush/Village Creek floodplain.

Conceptual plans included in this document are consistent with regional environmental planning efforts the City supports. These efforts include three programs developed by the North Central Texas Council of Governments (NCTCOG), known as the *Trinity River Common Vision Program*, the *Sustainable Environmental Excellence* (SEE) program, and the *Integrated Stormwater Management Program* (*i*SWM). The *Trinity River Common Vision Program*, established in 1989, is a cooperative effort among local governments in the region to ensure a safe, clean, enjoyable, natural, and diverse river corridor (Promise and Tidwell 2005). As a tributary to the Trinity, Johnson Creek plays a vital role in meeting these goals in the region. The more recent *Sustainable Environmental Excellence* (SEE) program, is a vision for achieving "Safe, Clean, and Green" environmental corridors throughout the region by integrating flooding, safety, and water quality issues with greenway planning. SEE is an example of a multiple-objective approach to corridor planning. The *Integrated Stormwater Management Program*, referred to as *i*SWM, is NCTCOG's most recent regional effort developed to specifically address the effects of poorly managed stormwater on water features and wildlife habitat.

The vision of these programs – to identify and provide solutions to common environmental problems that all cities in the region face – depends on local governments adopting and

implementing strategies developed cooperatively with all members. For the City of Arlington, which is already active in the planning and development of these programs, this means taking the Corps' 1999/2005 plan one step further in terms of expanding the project area, scope, and securing funding from multiple sources. Essentially, the City needs a modified and fundable watershed approach developed using a holistic approach that, when implemented, will fit into the context of larger, regional watershed efforts and meet Arlington's goals and objectives for Johnson Creek.

The authors, collaborators, and reviewers of this plan seek to resolve specific environmental threats that, in past plans, were overlooked, partially addressed, difficult to fund or lacked public support. Specific threats that plague the long-term viability of the Johnson Creek watershed include flooding, poor water quality and unstable streambanks, lack of passive recreation opportunities, and unsuitable habitat for wildlife.

Flooding.-- Flooding remains a serious threat along Johnson Creek due to floodplain development, lack of detention and retention, and poor channel maintenance. The 1999/2005 plan included acquisition of flood prone structures and parcels within a portion of the 25-year and 5-year floodplain. Even with these acquisitions, at least nine bridges and several dozen private properties remain flood problem areas.

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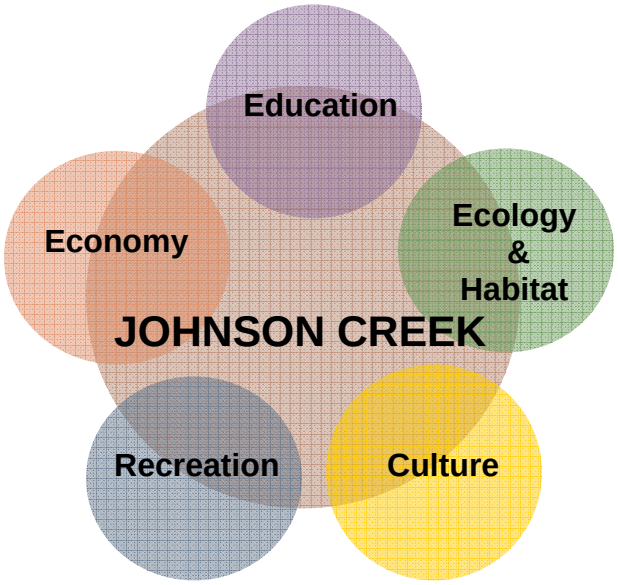
Of the four environmental threats, flooding is the catalyst for continued degradation of water quality, wildlife habitat, and passive recreational opportunities. Twenty-five year and larger storm events are occurring more frequently, and as a result, are causing irreversible damage to homes, businesses, bridges, roads, and other infrastructure. With new economic opportunities looming, the City desires a long-term solution to flooding that will protect historic structures, private homes, and new business opportunities such as the proposed Dallas Cowboys football stadium and Arlington town center. Our challenge is that the 1999/2005 plan is very specific in scope, and deviations from the plan to further address flooding and other environmental threats require explicit authorization and financial support from Congress.

1.3 Goals and Objectives

The primary goal this plan is to turn Johnson Creek into an asset to the community. By merging watershed improvement projects with other City projects, such as sculpture gardens, environmental education programs, and heritage centers, the City will ultimately transform Johnson Creek into an asset on five levels: Economy, Culture, Recreation, Ecology and Habitat, and Education.



Economy.-- integrate Johnson Creek in to economically viable development and utilize its assets to enhance property values.

Culture.-- protect, celebrate, display, and educate the public about historic cultural resources associated with Johnson Creek.

Recreation.-- provide unique, multiple-use passive recreation opportunities for all ages.

Ecology and Habitat.-- conserve, enhance, and properly maintain natural functioning ecological systems associated with and supported by Johnson Creek.

Education.-- encourage the long-term viability of Johnson Creek for future generations through environmental education and responsible stewardship.

With these goals in mind, this multi-objective vision of conservation for Johnson Creek seeks to:

- Build detention basins to reduce flooding and enhance public safety.
- Build sedimentation basins and restore Johnson Creek to promote natural sediment conveyance, reduce flooding, and improve water quality.
- Build additional trails, linear parks, and connected green corridors to improve wildlife habitat and passive recreation.
- Support regional integrated stormwater management and environmental corridor initiatives.
- Phase and prioritize multi-objective watershed improvements to meet plan goals as well as realistic funding and implementation schedules.
- Raise awareness through a public process.
- Obtain federal support to implement the highest priority projects having multiple watershed benefits.
- Leverage economic development within the corridor to stimulate environmental benefits such as flood control, water quality, and wildlife habitat.
- Develop public-private partnerships to plan, implement, and steward the proposed Vision of Conservation for Johnson Creek.

1.4 GEOGRAPHIC LIMITS

The geographic limits of this plan are defined by the Johnson Creek watershed boundary (Figure 1), with the exception of an additional 90 acres of floodplain to be identified in the Trinity River and/or Rush/Village Creek watersheds. Johnson Creek, a tributary of the Trinity River, flows 14.3 miles north/northeast from its headwaters near Interstate 20 and Cooper Street in Arlington to its outlet at the West Fork of the Trinity River in Grand Prairie. The study area for this plan consists of the most southerly reach (approximately 9 miles) of Johnson Creek and its contributing 10,174-acre watershed within City of Arlington limits. Most of the recommended watershed improvement projects are within or adjacent to the 100-year floodplain between Vandergriff Park and Randol Mill Road.

1.5 USING THIS DOCUMENT

The document begins in Chapter 2.0 with a description and relevant mapping of the Johnson Creek watershed and its four primary environmental threats. Specific components, features, and projects of the modified plan, including unfinished City projects authorized by the 1999/2005 plan, are located, described, prioritized, and phased in Chapter 3.0. The document concludes in Chapter 4.0 with a summary and request for funding for two phases of project implementation. Figures and appendices are attached to the end of the document.

2.0 WATERSHED DESCRIPTION AND ENVIRONMENTAL THREATS

2.1 STUDY AREA

Johnson Creek, a tributary of the Trinity River, flows north/northeast 14.3 miles from its headwaters near Interstate 20 and Cooper Street in Arlington, Texas to its outlet at the West Fork of the Trinity River in Grand Prairie (Figure 1). The creek and several tributaries drain an 11,697-acre watershed. Just within City limits, Johnson Creek extends 9 miles and its watershed drains 10,174 acres.

2.2 PHYSICAL FEATURES

Natural Communities
Johnson Creek is physiographically bound on the east by the West Coastal Plain and on the west by the Great Plains (Hunt 1974). Upstream of Arkansas Lane, the creek runs through the Blackland Prairie. This feature is underlain by the Eagle Ford Group of the Upper Cretaceous System, which historically consisted of rolling, upland grasslands. Downstream of Arkansas Avenue, the creek runs through the East Cross Timbers underlain by the Woodbine Formation (Winton and Adkins 1919). Like the Black Prairie this formation is also of the Upper Cretaceous System. Prior to urbanization, the East Cross Timbers were noted for thick timberlands of black jack oak and post oak (Hunt 1974).

Topography
Topographic features of the Johnson Creek Watershed outside of the channel are nearly level to gently rolling (0 to 8%; Ressell 1979). The overall drainage pattern for the watershed is angular dendritic, and appears to follow bedrock joint patterns. This pattern is particularly evident downstream of Arkansas Avenue. The channel slope of the creek from Matlock Road to Randol Mill Road is approximately 0.0033 (1/3 of 1%).

Geology
Reaches of Johnson Creek upstream of Arkansas Avenue run through and over bedrock of the Upper Cretaceous System Eagle Ford Group (Barnes 1972). This group consists of black to blue shales with seams of arenaceous to fossiliferous limestone. The shales tend to be bentonitic. The rocks weather to a "black, waxy, carbonaceous, treeless, rolling upland soil" (Winton and Adkins 1919). Outcrops of the weathered shales of the Eagle Ford Group are observable along banks of Johnson Creek in Vandergriff Park.

Reaches of Johnson Creek downstream of Arkansas Avenue run over and through the Upper Cretaceous System Woodbine Formation, which conformably underlies the Eagle Ford Group (Barnes 1972). The formation consists primarily of sandstone with seams of clay and shale. The sandstone is fine-grained and well-sorted, and the unweathered shale is gray and fissile. The formation typically weathers to a red, acidic sandy soil, and is part of the Eastern Cross Timbers. The acidic sandy soil developed, in part, due to pyrite (FeS_2) in the shale.

Outcrops of intact Woodbine Formation sandstone are observable at numerous locations along Johnson Creek. The orientation of Johnson Creek is affected by the joint sets within this formation, especially in the sharp meanders between Sanford Street and Randol Mill

Road. Attitudes of the joint sets seen in the sandstone and shale units were measured at several locations and are presented in the following table.

Table 1. Attitudes of joint sets observed in sandstone and shale rock along Johnson Creek.

Location	Rock	Attitude (strike/dip)*
Approximate mid-section between Arkansas Avenue and Park Row Drive	Sandstone	N80°E/nv, N65°E/nv, N15°E/nv, N0°E/nv, N10°W/nv, N45°W/nv, N80°W/nv
Upstream of Abram Street near Meadowbrook Park	Sandstone	N80°E/nv, N60°E/nv, N15°E/nv, N0°E/nv, N50°W/nv, N80°W/nv
Approximate mid-section between Sanford Street and Randol Mill Road in sharp meanders segment	Shale	N75°E/82°S, N50°W/80°S

*nv: near vertical dip

Joint sets presented in Table 1 indicate the presence of conjugate fractures in the Woodbine Formation. The overall dip for the bedrock formations within Tarrant County is 2° to the southeast (Winton and Adkins 1919).

Soils

Soil along the banks of Johnson Creek upstream of Arkansas Avenue is of the Houston Black-Navo-Heiden Soil Complex (Ressell 1979). These soils are dark gray to brown highly plastic clays to moderately plastic silty clays (CH to CL). Soils in this map unit are moderately well drained to well drained, with very slow permeability (less than 0.06 inches per hour). These soils are known for their moderate to very high shrink-swell potential from soil moisture fluctuation. These soils are derived from the shales and, to a lesser extent, the limestones of the Eagle Ford Group, and are therefore bentonite-bearing. The presence of this clay explains the very high shrink-swell potential. Further, these soils are found primarily along the southeast half of the watershed.

Downstream of Arkansas Avenue, soils along the banks of Johnson Creek are of the Crosstell-Gasil-Rader Soil Complex (Ressell 1979). This map unit consists of moderately well drained to well drained red-brown to yellow silty sands to sandy clays (SM, SP, SC, ML CL and CH). Permeability of these soils is very low to moderate (less than 0.06 to 2 inches per hour). The shrink-swell potential of these soils is low to high. These soils are derived from the underlying sandstones and, to a lesser extent, shales of the Woodbine Formation. Overall, this soil complex occupies the northwest half of the watershed.

Channel Geometry

For most of its length through Arlington, Johnson Creek is a two-stage meandering channel, severely incised, and unstable. The base of the channel ranges from concrete slab to sandstone/shale to shale. Bank heights range from 2-16 feet, and bank crests range from 50

to 160 feet. Between Randol Mill Road and Ballpark Way, Johnson Creek consists of two online detention ponds.

2.3 LAND USE

The Johnson Creek watershed is nearly 86% developed. Land use is a mixture of commercial, residential, and recreational. Open space is occupied by streams, ponds, lakes, golf courses, and several types of City parks including: neighborhood parks with water features; community parks with playgrounds; linear parks and trails; and natural areas.

2.4 ENVIRONMENT THREATS

2.4.1 Flooding

Background

Information on the flooding history of Johnson Creek is limited to a 1990 Corps study which is incorporated into the Corps' feasibility study of Johnson Creek (USACE 1999). The Corps' study documents the occurrence of fifteen damaging floods in the Johnson Creek watershed since 1949, not including the most recent 2004 flood event. The 1989 flood is considered the flood of record, and it was estimated to have a recurrence interval of 25 years.

Existing Conditions and Past Efforts

Flood problem areas in the Johnson Creek corridor through Arlington include specific reaches, streets, residential and commercial sites, and other structures that were damaged in most if not all of the reported flood events. Approximately 200 homes are predicted to flood during a 100-year event, although observed damage to structures begins with less than a 2-year event (Johnson Creek Consortium 1997). The primary residential flood zone is between Mitchell Street and Park Row Drive, where most homes lie within the 2-year floodplain.

Past efforts to reduce flooding in the watershed include the following:

- Gateway Park Design/Construction: In 1998, the City developed Gateway Park into a multi-functional land use for recreation and flood control. The pond is an open water landscape feature that also serves as a detention pond for the headwaters region of Johnson Creek.
- Bridge repairs: The City has conducted bridge repairs and associated erosion control projects at Mesquite Street, Center Street, Park Row Drive, Division Street, Mitchell Street, Abram Street, and Copeland Road. Most bridges are still unable to adequately convey the 100-year event.
- Online pond construction: West of Vandergriff Park on the west side of Matlock Road, the City and a private developer constructed online ponds, an associated bridge, and repaired erosion. Two online ponds created on Rangers' property provide detention and flood control.

- Corps' 1999/2005 plan: This plan included a non-structural buy-out program to include the acquisition and removal of 138 structures in the 25-year floodplain and 2 structures within the 5-year floodplain between Collins Street and Park Row Drive.

Despite these efforts, specific areas and structures remain flood problem areas today. They are shown on Figure 2 and include:

- Bridges at Arkansas Lane, Pioneer Parkway, Park Row Drive, Mitchell Street, 2nd Street, Abram Street, Union Pacific Railroad, Division Street, and Sanford Street.
- Stone Gate Mobile Home Park north of Sanford Street.
- Apartments at Pioneer Parkway and Arkansas Lane.
- Eroded streambanks north of Abram Street near the Union Pacific Railroad.
- Sediment deposits (clogged pipes or bridge openings) under bridges at Division Street, Abram Street, and just south of Randol Mill Road.

Floods that may not have destroyed or damaged property in the past could potentially result in extensive damage or property loss today. The watershed is almost completely developed (approximately 86%), which has increased runoff into Johnson Creek. Urbanization combined with channelization and loss of bottomland floodplain has decreased the creek's ability to handle stormwater without overtopping its banks. This situation can cause flooding of structures located in the floodplain during lower flow events.

Goals and Objectives

Based on the history and effects of flooding to date, the following goals are established for flood control and flood damage reduction:

- Reduce the frequency of damaging flood events.
- Reduce rates and volumes of runoff from already developed areas.
- Prevent increases in rates and volumes of runoff from new development.
- Maintain natural conveyance systems (streams/tributaries/ditches/swales) to minimize flooding due to debris obstructions.
- Reconnect entrenched tributaries to the historic floodplain.
- Provide flood hazard protection for up to the 100-year flood.
- Maximize the use of floodplain of Johnson Creek for natural retention and sediment removal.
- Utilize natural solutions for erosion control.
- Address flood control management with a multi-objective approach that meets goals of both the City and Corps to enhance aesthetics, recreational opportunities, and wildlife habitat.

The following objectives will achieve the proposed goals:

- Establish and adopt zoning or development ordinances that reduce or restrict development in the 100-year floodplain.

- Buy out and remove structures in the 100-year floodplain.
- Replace or retrofit bridges to accommodate the 100-year flood where possible; otherwise reconstruct bridges to reduce potential for debris obstructions and sedimentation.
- Utilize Best Management Practices (BMPs) in new development and retrofit into existing developments.
- Re-create, enhance, and maintain bottomland floodplain forest or other riparian habitat along as much of the Johnson Creek corridor as possible.
- Increase the bankfull width of the creek to accommodate the 2-year storm without degrading stream structure.
- Restore eroded reaches of Johnson Creek with a combination of soil bioengineering and hard engineering techniques where necessary.
- Create detention basins in large available expanses of open space.

2.4.2 Poor Water Quality and Unstable Streambanks

Background

Sediment scour and deposition is a significant problem throughout much of the Johnson Creek watershed. The primary source of sediment in the creek is streambank destabilization and subsequent failure during significant storm events. This results in a highly dynamic system in which the configuration of the creek undergoes significant changes over short periods of time. If this condition persists, it is likely creek alignment will begin to encroach on and impact private and public properties throughout the watershed (Figure 3). Land use types ranging from single-family residential to industrial could potentially be impacted by this phenomenon. Predicting the evolution of alignment changes in Johnson Creek is complex, thus an approach emphasizing stabilization and restoration is most prudent.

Existing Conditions and Past Efforts

Sediment and erosion control measures in the watershed have been limited to emergency bank armoring and the Rangers' pond detention facilities. Bank armoring has primarily consisted of temporary measures including concrete filled bags and gabion mattresses. The Rangers' ponds, which are on-channel lakes built in 1993-1994, were designed as flood storage facilities but also function as sediment traps. Required sediment removal in the Rangers' ponds has been sporadic, with large sediment deposits occurring as a result of large, infrequent rain events. Provide more history and background of those ponds.

The existing unstable condition of the creek has resulted in ecological degradation through the destruction of streambank habitat and reduced water quality. Streambank habitat is destroyed as large sections of streambank slough into the stream during flooding events. Large sediment deposits bury aquatic habitat. The advance of the streambank (channel widening) destroys overbank habitat through erosion. The primary impact to water quality is increased turbidity, but other problems can arise as well. Chemical constituents residing in the soil matrix can be liberated, the overall Biochemical Oxygen Demand (BOD) of the creek can increase through organic material in and on top of the soil, and the interstitial spaces of the creek bed can become clogged (spawning and macroinvertebrate habitat). Also, cobble habitat structure can be buried by sediment.

Field Review
Site evaluations were performed from February 14-18, 2005 to evaluate existing conditions. The investigation concluded that erosion and mass wasting of the creek from Matlock Road to Randol Mill Road were the major sources of sediment deposition in the upper portions of Rangers' ponds. Subsequent field visits performed during low flow conditions, assumed to represent baseflow conditions, focused on this stream section to determine the dominant hydraulic and geomorphologic processes of the creek. Baseflow conditions include groundwater and surface irrigation contributions.

Representative cross sections were measured using the angle/cord technique at locations along Johnson Creek. These cross sections were located at or near cross sections surveyed previously, with survey dates ranging from 1968 to 1999/2005. Most of the historic cross sections were surveyed in 1984. Local residents report the majority of erosion in and along the creek occurred after a shopping mall was completed upstream of the site. It is assumed that the historic cross sections are a valid reference, because the majority of them were recorded after completion of the shopping mall. Locations of historic cross sections were obtained from HEC-2 hydraulic models provided by Graham Associates, Inc. The locations of the most recent cross sections, measured during the period of February 16-17, 2005, were superimposed on historic cross sections and adjusted to bank crests as much as practicable. Historic and existing conditions cross sections are compared in Appendix A.

Soil samples obtained from the banks and channel were submitted to a geotechnical testing laboratory to determine grain size and other soil properties. A pocket penetrometer was used to take shear strength readings. Baseflow conditions were assumed during field reconnaissance, therefore the maximum soil saturation elevations along the creek were assumed to reflect groundwater elevations. These elevations were measured and recorded.

Engineers and scientists produced an inventory of erosion hotspots throughout the watershed (Figure 4). These locations were identified through field inspection, historical review of bank stability problems, and extensive interaction with residents in the vicinity of the creek.

Reach Descriptions
Erosion and sedimentation analyses for the Johnson Creek watershed focused on six reaches from Matlock Road to Randol Mill Road (Figure 6). Reach descriptions are based on field reconnaissance, measurement of channel cross sections by Applied Ecological Services, Inc. (AES), and cross section data collection from the previous 30 years.

<u>Reach A-B: Matlock Road to Arkansas Lane</u>
The upstream end of Reach A-B is within Vandergriff Park. The park is considered an open space land use and surrounds the creek for roughly the entire upstream half of the reach. Downstream of Vandergriff Park areas west of the creek consist of commercial and light industrial land uses, while development east of the creek is single-family residential. Though development is significant in the downstream half of Reach A-B, it is lined with open space for several hundred feet on either side.

The first 200 feet of Reach A-B is a stable two-stage channel. The bankfull/dominant discharge width of the lower channel is 6 feet, and the bankfull/dominant discharge height is

approximately 2 feet above the channel bottom. The bank crest height ranges from 5 to 6 feet above the bankfull/dominant discharge height, and the bank crest width is approximately 90 feet. The overbanks are covered with turf grass and the lower limit of vegetation is at or below the bankfull/dominant discharge height.

Within Vandergriff Park, downstream of the first 200 linear feet of Reach A-B, erosion of creek banks alternates from one bank to the other. Several knick points in the channel are apparent. This portion of the reach is unstable, as it appears to be incising and widening, which is substantiated by historic data for cross section 60960 (Appendix A). In this section the bankfull/ dominant discharge width of 10 feet, and the height of the bankfull/dominant discharge is 3 to 4 feet above the channel bottom. The bank crests are 6 to 7 feet above the bankfull/dominant discharge height, and the crest width is approximately 50 feet. Banks experiencing erosion have little to no vegetation over most of their face, and their soil makeup consists of yellow-brown to gray clay to shaly clay. Slumping of eroded banks is common. Banks that are not eroded are vegetated with turf grass and have a lower limit of vegetation at one foot below the bankfull/dominant discharge height.

Downstream of Vandergriff Park the creek returns to a stable two-stage channel. The bankfull/dominant discharge width is approximately 8 feet with a height of 3 to 4 feet above the channel bottom. The bank crest width is over 100 feet wide with crests at least 5 feet above the bankfull/dominant discharge. The banks below the bankfull/dominant discharge level are vegetated with turf grass nearly to base flow water surface, while the upper banks consist of turf grass and scattered trees.

The base of the channel throughout the reach is primarily shale. The channel slope through the reach is approximately 0.005 feet/foot. The channel under Arkansas Lane is reasonably free of sediment, indicating sufficient sediment conveyance through the crossing.

<u>Reach B-C: Arkansas Lane to Park Row Drive</u>
Land uses adjacent to the creek are multi-family residential from Arkansas Lane to Pioneer Parkway. The west bank of the creek is bordered on one side by a golf course for approximately 1,700 linear feet downstream of Pioneer Parkway. All remaining land uses throughout the reach are single-family residential with minor amounts of open space.

The upstream portion of the reach between Arkansas Lane and Pioneer Parkway is reasonably stable but may have been relocated according to historic cross Section 57140 (Appendix A). The bankfull/dominant discharge width of the channel in the section is 15 feet, and the height of the bankfull/dominant discharge is approximately 1.5 to 2 feet above the channel bottom. Bank crest height is approximately 14 feet above the bankfull/dominant discharge level, and the bank crest width is approximately 80 feet. The banks are covered with haphazardly placed riprap primarily consisting of concrete slabs. Medium to small trees and brush are found growing between the pieces of riprap. Some woody vegetation roots are exposed but are barked over.

Stream degradation from incision and widening downstream of Pioneer Parkway is considerable. This is substantiated by review of historic cross sections 53730 and 50920 (Appendix A). Instability near Pioneer Parkway is likely due to incision, while that near Park Row Drive is likely due to channel widening. Local residents suggested much of the

downcutting and widening occurred after the completion of shopping malls in tributary areas upstream of Reach B-C. From Pioneer Parkway to Park Row Drive, the bankfull/dominant discharge width is 21 feet, while the height of the bankfull/dominant discharge level is 2 to 4 feet above the channel bottom. The bank crests are 12 to 14 feet above the bankfull/dominant discharge height, and the crest width ranges from 50 to 120 feet. Bank cover ranges from bare soil with exposed roots to sparse vegetation. Overbank areas are vegetated with turf grass and contain tree populations of varying density. Bank face erosion is apparent nearly to the bank crest elevation. Exposed soils along the banks range from brown silty sand to brown-gray clay. Downstream of the golf course, 1 to 2 feet thick seams of sandstone outcrops were found along both banks.

The base of the channel between Arkansas Lane and Pioneer Parkway is covered with haphazard, concrete slab riprap. From Pioneer Parkway to Park Row Drive, the channel bottom is shale to sandstone. At several locations exposed sandstone seams provide grade control, abating incision migration upstream. Overall, the slope of this channel is approximately 0.004 feet/foot. Little if any sediment deposition was observed under the crossings at Pioneer Parkway and Park Row Drive, indicating sufficient sediment conveyance through these crossings.

Reach C-D: Park Row Drive to Collins Street

This entire reach is within Julia Burgen Park. Land use along this reach is primarily single family residential. One exception is approximately 400 bank feet of school property along the east side of the creek, downstream of Center Street. A second exception is approximately 1,000 bank feet of cemetery property along the west side of the creek, upstream of Collins Street. Additionally, home relocations were conducted in support of two distinct flood mitigation zones adjacent to the creek. The first mitigation zone covers approximately 1,000 bank feet along the east side the creek, upstream of Center Street. The second location consists of approximately 2,000 bank feet west and east of the creek, between Center Street and Mitchell Street.

This reach is primarily characterized by alternating eroding banks through meander migration, possibly in conjunction with widening. An exception is a 100-foot section downstream of the Center Street bridge where the channel was widened and stabilized with riprap and willows. A second exception is a 200-foot section upstream of Mitchell Street, which indicates stability through a backwater condition during higher flows. Historic cross sections through this reach indicate some downcutting, though the most significant impacts are from widening. This phenomenon suggests that the channel bottom in the downstream portion of the reach is harder than that of the upstream portion.

The channel bankfull/dominant discharge width ranges from 18 to 25 feet, and the height of the bankfull/dominant discharge is approximately 2 to 3 feet above the channel bottom. The crest height is approximately 9 to 15 feet above the bankfull/dominant discharge height, and the bank crest width ranges from 40 to 100 feet. The banks alternate from being bare to covered with turf grass, forbs and small to large trees. The eroded portions of the bank often extend up to the bank crests. Soils exposed along the bare banks vary from brown silty sand to brown-gray clay. Surfer and undercut trees were observed but are not prevalent. The channel base between Park Row Drive and Collins Street is shale to sandstone. Some sand and gravel sediment lines the channel bottom but appears very mobile. Overall the

slope of this channel is approximately 0.003 feet/foot. Little if any sediment deposition was observed under the crossings at Center Street or Collins Street. The crossing at Mitchell Street was too deep to traverse but significant deposits of sediment were not observed upstream or downstream of this crossing. Based on observations, sediment is sufficiently conveyed through these crossings.

Reach D-E: Collins Street to Abram Street

Land use adjacent to the creek for the entire reach is primarily single family residential. The main exception is Meadowbrook Park, which covers approximately 1,400 bank feet along the east bank, upstream of Abram Street.

The upstream half of this reach is reasonably stable. The bankfull/dominant discharge width is 24 feet, and the bankfull/dominant discharge height is approximately 2 feet above the channel bottom. Bank crest height is approximately 10 to 12 feet above the bankfull/ dominant discharge height, and the bank crest width is 50 feet. The banks are covered with turf grass, forbs and medium to large trees. The lower limit of vegetation is at or below the bankfull/dominant discharge height.

The downstream half of the reach, which fronts Meadowbrook Park, shows signs of erosion and slumping banks. Much of the instability appears to have resulted from the removal of deep-rooted woody vegetation. In Meadowbrook Park, the historic cross section at 41040 has been widened and incised (Appendix A). In this section the bankfull/dominant discharge width is 25 feet, and the height of the bankfull/dominant discharge level is 3 feet above the channel bottom. Bank crest ranges from 12 to 14 feet above the bankfull/dominant discharge height, and crest width ranges from 50 to 100 feet. Banks range from bare and highly degraded to sparsely vegetated. In the upstream portion of this half of Reach D-E bare, eroded banks are more prevalent on the outside of channel bends, while sparse vegetation populates banks along the inside portion of channel bends. In the downstream portion of this half of Reach D-E the previously described alternating bank erosion is replaced with bare, highly-degraded banks on both sides of the creek. This is especially the case just upstream of Abram Street. The soil exposed along the banks is primarily brown silty sand with lesser amounts of brown-gray clay. Within the portion of the creek 200 feet upstream of Abram Street, 1 to 2 foot-thick sandstone seams are present along the banks.

The base of the channel between Collins and Abram streets is shale. Sand and gravel sediment overlies the channel bottom but appears very mobile. Overall the slope of this channel is approximately 0.005 feet/foot. Little if any sediment deposition was observed under the crossings at the Meadowbrook Park access road, pedestrian bridge, or Abram Street. Site investigations suggest sufficient sediment conveyance exists through each of these crossings.

Reach E-F: Abram Street to Sanford Street

From Abram Street to the railroad bridge, land uses adjacent to the creek are commercial and light industrial. Downstream of the railroad bridge to Division Street, land use west of the creek is light to heavy industrial. One of the industrial uses includes a waste hauler. The adjacent land to the east contains undeveloped forest and open space. From Division Street to Sanford Street, the adjacent land use is commercial to heavy industrial.

The stretch of Reach E-F from Abram Street to the railroad bridge is reasonably stable with some historic incision as indicated by cross section 39400 (Appendix A). The bankfull/ dominant discharge channel width is 23 feet, and the bankfull/dominant discharge height is approximately 4 feet above the channel bottom. The crest height ranges from approximately 12 to 13 feet above the bankfull/dominant discharge height, with a bank crest width of 65 feet. The banks are covered with turf grass, forbs, and medium to large trees. Roots, which are exposed along the banks, are barked over. The lower limit of vegetation is at or below the bankfull/dominant discharge height.

From the railroad bridge to Division Street, the historic cross section at 38220 and current visual observations indicate that the creek has been relocated and graded into a large radius of curvature. This segment is somewhat stable. From the railroad bridge to Division Street, the bankfull/dominant discharge width is 23 feet with a bankfull/dominant discharge height of 4.5 to 5 feet above the channel bottom. Bank crest heights are approximately 10 feet with widths of approximately 65 feet. The banks are primarily covered with turf grass, forbs, and scattered small trees. Erosion along the west bank extends up to mid-height along the bank. The soil exposed along the eroded bank varies from brown to yellow brown sandy clay to clayey sand.

The segment between Division and Sanford streets is stable with little or no downcutting, as suggested by historic cross section 36450 (Appendix A). Bank cover in this section is similar to that of the segment upstream of the railroad bridge. The bankfull/dominant discharge width is approximately 25 feet, and the bankfull/dominant discharge height is 3 feet above the channel bottom. Bank crest height is approximately 11 feet above the bankfull/ dominant discharge height, and bank crest width is approximately 60 feet.

The base of the channel between Abram Street and Sanford Street is shale. Some sand and gravel sediment lines the channel bottom but appears very mobile. Overall the slope of this channel is approximately 0.002 feet/foot. Field observation suggests the channel has been relocated in the section between the railroad bridge and Division Street. Localized instability due to channel and bank scour has resulted from debris collection on a remnant utility pole support in the center of the creek. Little if any sediment deposition was observed at the railroad bridge, the pedestrian bridge upstream of Division Street, Division Street, and Sanford Street. It appears that sediment is sufficiently conveyed through each of these crossings.

<u>Reach F-G: Sanford Street to Randol Mill Road</u>
Land use adjacent to the first 2,000 linear feet of the reach consists of woodland to the west and residential mobile homes and open space to the east. The undeveloped open space is a former sewage disposal plant. The remainder of the reach is bound by single family residential land uses to the west and Ameriquest Field to the east.

The first 400 linear feet of the reach is reasonably stable. The bankfull/dominant discharge width of the channel is 23 feet, with bankfull/dominant discharge heights 5 to 6 feet above the channel bottom. The bank crest heights are approximately 11 feet above the bankfull/dominant discharge level, and bank crest width is approximately 150 feet. The banks, which have exposed plant roots, are covered with turf grass, forbs, and medium to

large trees. The lower limit of vegetation is at or below the bankfull/dominant discharge height.

Over the next 1,500 linear feet of the reach the banks and channel bottom are lined with concrete slab riprap. The placement of riprap is haphazard and erosion is quite active. Review of historic cross sections 35560 and 34280 (Appendix A) suggests the channel has been relocated. The bankfull/dominant discharge width is 25 feet, with a bankfull/dominant discharge height approximately 4 feet above the channel bottom. Bank crest heights range from 10 to 12 feet above the bankfull/dominant discharge height, and bank crest width is approximately 50 feet. Vegetation is absent to sparse and plant roots are exposed along the west banks over most of the bank face. Concrete slab riprap has been placed haphazardly along the east bank. Exposed soil along the eroded banks resembles brown silty sand.

The creek begins to meander sharply in the downstream portion of the reach, where the banks and channel are severely eroded through incision and widening. This assessment is supported by historic cross section 33820 (Appendix A). The sharp meanders in this segment consist of three tight bends with meander amplitudes of 200 to 300 feet. The bankfull/dominant discharge width is approximately 41 feet, with a bankfull/dominant discharge height of 4 to 5 feet above the channel bottom. The bank crests heights extend approximately 10 to 11 feet above the bankfull/dominant discharge height, and the bank crest width is approximately 60 feet. Vegetation is absent to sparse on both sides of the reach, with exposed shale near the bank toe and silty sand over the remaining bank.

Downstream of the sharp meanders, the creek is eroded and considerably wider. This portion is in the vicinity of historic cross section 31970 (Appendix A). Widening of the channel in this portion is possibly due to the rapid flow expansion as the creek leaves the section with sharp meanders. Width of the bankfull/dominant discharge is 144 feet, with a bankfull/dominant discharge height of 5 feet above the channel bottom. The bank crests extend 16 to 24 feet above the bankfull/dominant discharge height, and bank crest width is approximately 160 feet. Vegetation along both banks is absent to sparse, and exposed soil is primarily brown silty sand.

Effects of bedrock joint sets on stream alignment are most evident in this reach. These impacts are particularly apparent in the section with the sharp meanders. Upstream of the segment with sharp meanders the base of the channel appears to be shale. Some sand and gravel sediment lines the channel bottom but appears very mobile. The channel bottom is sandstone within the segment with sharp meanders and extending downstream to Randol Mill Road. Overall, the slope of this channel is approximately 0.003 feet/foot. Little to no sediment deposition was observed under the crossing of Randol Mill Road. Sediment deposition occurs in the water body immediately downstream of the Randol Mill Road crossing.

Hydrologic Information

Discharges for each stream reach were established with several sources of hydrologic information. The approved FEMA 100-Year floodplain elevation throughout the site was approximated through HEC-2 analyses by the Corps (Appendix B). Cross sections and corresponding study reaches used in the hydraulic analysis do not correspond spatially with reaches established for the erosion and sedimentation analysis (Figures 5 and 6). Discharges

used in the FEMA approved study and their corresponding translation to stream reaches established in the erosion and sedimentation analysis appear in Table 2.

Table 2. USCOE hydraulic study discharges and their translation to reaches established for the erosion and sedimentation analysis.

Recurrence Interval (yr)	Matlock (XS 61610)	Arkansas (XS 57500)	Park Row (XS 49250)	Collins (XS 42860)	Abram (XS 39590)	Sanford (XS 35101)
2	n/a	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a	n/a
10	2540	2540	6160	7940	7940	8760
25	3070	3070	7410	9530	9530	10690
50	3470	3470	8390	10730	10730	12170
100	3890	3890	9500	11970	11970	13710
500	n/a	n/a	n/a	n/a	n/a	n/a

The Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) is a second source of hydrologic information in support of the erosion and sedimentation analysis. Discharges established in the Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) appear in Table 3. Though not approved by FEMA, the discharges in the 1997 study are more conservative, so they were used in the erosion and sedimentation analysis.

Table 3. Johnson Creek discharges at street crossings with FEMA cross sections in parentheses.

Recurrence Interval (yr)	Matlock (XS 61610)	Arkansas (XS 57500)	Park Row (XS 49250)	Collins (XS 42860)	Abram (XS 39590)	Sanford (XS 35101)
2	1554	1449	3611	4061	4666	4618
5	2312	2407	5977	6880	7619	7565
10	2601	2840	7363	8665	9573	9586
25	2974	3381	8747	10462	11481	11566
50	3329	3816	9878	11905	12953	13106
100	3775	4273	11064	13383	14482	14687
500	5281	5766	14624	17701	18751	19049

Both the Corps hydraulic study and the Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) provide discharges for storm events with recurrence intervals ranging from the 1 year to 100 years. Storm events with the more frequent recurrence intervals are critically important to the process of scour, erosion, and sedimentation in streams. Discharges described in the Corps hydraulic study and the Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) follow an annual series distribution. Discharges approximated with an annual series must be converted to a partial series to accurately approximate discharges for storms with recurrence intervals of less than 2 years (Appendix C). Discharges from the Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) were converted to partial series discharges and appear in Table 4.

Table 4. Annual series discharges from the Johnson Creek Corridor Plan converted to partial flow series.

Recurrence Interval (yr)	Reach A-B	Reach B-C	Reach C-D	Reach D-E	Reach E-F	Reach F-G
0.25	640	640	750	767	967	967
0.5	957	957	1605	1718	2069	2069
1	1343	1343	2867	3179	3701	3701
2	1742	1782	4287	4873	5545	5545
5	2256	2414	6148	7150	7976	7976
10	2629	2874	7458	8784	9698	9698
25	3100	3454	9028	10770	11773	11773
50	3443	3872	10095	12133	13189	13189
100	3775	4273	11064	13383	14482	14482
500	4516	5150	12987	15889	17065	17065

AES and Graham Associates, Inc. collaborated to provide additional hydrologic and hydraulic analysis that determined floodwaters overtop the bank crest of the creek every three to twelve months. Additionally, areas tributary to the site provide little attenuation of runoff, which results in flow periods of two hours or less for storms with recurrence intervals below the 10-year event.

Erosion and Sedimentation Analysis

Johnson Creek sediment generation due to erosion and mass wasting was estimated for existing conditions and several development alternatives. These estimates are based on creek flows and their associated recurrence intervals. Creek management and stabilization alternatives were developed and evaluated using existing conditions as the baseline condition. The Conservation Channel Evolution and Pollutant Transport System (CONCEPTS) was used to estimate sediment loads for this comparison.

The CONCEPTS program was developed in 1997 by the US Department of Agriculture – Agricultural Research Service National Sedimentation Laboratory (Langendoen 2000). It has undergone a number of updates, with the latest being May 31, 2005. The governing equations of the program include St. Venant's conservation of mass and equilibrium dynamic wave analysis for unsteady flow. The Manning friction slope equation is used to calculate friction the flow imparts on the channel. The program uses sediment grain size as input in calculating sediment transport and erosion in the channel. The Laursen Equation is used for silt, The Yang Equation is used for sand, and the Meyer-Peter and Mueller Equation is used for gravel. The program approximates bank erosion by simulating exceedance of bank shear stresses and quantifying the resulting mass wasting due to slope instability. Slope stability is calculated using the Culmann Equation for planar failure and beam analysis for bank undercutting and cantilever failure. The resulting failed soil mass is then incorporated into the total estimate of eroded soil.

Total annual sediment production for each recurrence interval was approximated by multiplying the sediment yield for a given storm by weighting factors appearing in Table 5.

This technique is an adaptation of sediment yield calculation models used by the Corps (USACE 1989; Copeland et al. 2001).

Table 5. Weighting factors used to approximate annual sediment generation.

Discharge Recurrence Interval	Weighting Factor
3 months	4
1 year	1
2 Year	0.5
5 Year	0.2
10 Year	0.1

Sedimentation Modeling

Existing conditions were modeled to estimate the potential volume of sediment production for a given storm event. Cross sections and groundwater levels taken during field reconnaissance were used as input to the modeling (Appendix A). Cross sections were generated and included in the analysis to enhance model stability. The material properties of the soil and rock conditions found along the banks and channel used in the model appear in Table 6.

Crossings data were not incorporated into the model, because field observations indicated full sediment conveyance at each location. Further, crossings data would be inappropriate for a model of such large scale. If model scale is decreased and more data becomes available crossings data should be added to the model to simulate localized grade controls and back-pooling; an example of where this is occurring is upstream of Mitchell Street.

The design flow rates presented in the existing conditions section were used for the model and the duration for each of the flows was 2 hours to simulate a plug flow for 3-month, 1-year, 2-year, 5-year and 10-year events. Model stability was maintained for most of the events, especially those in the upstream reaches. When discharges were too large to maintain model stability a hydrograph synthesized by Graham Associates, Inc. was substituted to allow the program to run to completion. Though this hydrograph was more gradual, the majority of flow occurred during a 2-hour period. Synthesized hydrographs were used to increase model stability in the following reaches: Park Row Drive to Collins Street (10-year), Collins Street to Abram Street (10-year), Abram Street to Sanford Street (5-and 10-Year) and Sanford Street to Randol Mill Road (10-year).

Modeling sediment generation up to the 10-year recurrence interval provided sufficient data to estimate annual sediment generation. Sediment deposition in the channel bottom was not considered as part of the total sediment generated. This was done because field observation suggested sediment on the channel bottom was very mobile and would inevitably be transported downstream. The primary sediment generation mechanism was erosion of the channel and banks, however significant sediment was generated through mass wasting (bank failure). This mechanism occurred for larger recurrence intervals (5 year or larger) in the following reaches: Park Row Drive to Collins Street, Collins Street to Abram Street, Abram Street to Sanford Street, and Sanford Street to Randol Mill Road. Existing conditions sediment generation amounts for each reach and storms of varying recurrence intervals appear in Tables 7 and 8.

Each reach was ranked based on sediment generation on a per linear foot basis, and results from this analysis appear in Figure 7.

Table 6. Material properties of soil and rock conditions found along Johnson Creek.

		Silty SAND		Sand & Silt Sediment		Shaley CLAY		Clayey SAND		Sandy CLAY		SAND, Silt & Gravel Sediment		CLAY	
		English	Metric	English	Metric	English	Metric	English	Metric	English	Metric	English	Metric	English	Metric
Density (pcf - N/m^3)		115	18000	115	18000	125	20000	115	18000	120	19000	115	18000	120	19000
Internal Friction (^{o})[1,2]		32	32	30	30	28	28	30	30	28	28	30	30	27	27
Cohesion (psf - Pa)*		0	0	0	0	300	48000	0	0	100	15000	0	0	150	24000
Matric Suction Friction (^{o})[3]		15	15	15	15	15	15	15	15	15	15	15	15	15	15
Shear Threshold (psf - Pa)[5]		0.006	0.09	0.006	0.09	0.14	22	0.008	1.2	0.14	22	0.005	0.7	0.14	22
Grain Size.															
in.	Mm	% Passing	% Retained	% Passing	% Retained	% Passing	% Retained	% Passing	% Retained	% Passing	% Retained	% Passing	% Passing	% Retained	% Passing
0.0004	0.01	16	16	2	2	47	47	36	36	34	34	6	6	50	50
0.001	0.025	17	1	3	1	55	8	39	3	38	4	7	1	58	8
0.0025	0.065	18	1	4	1	72	17	43	4	54	16	8	1	66	8
0.01	0.25	83	65	28	24	96	24	93	50	92	38	40	32	85	19
0.03	0.841	100	17	54	26	98	2	97	4	100	8	59	19	94	9
0.08	2	100	0	67	13	99	1	97	0	100	0	67	8	96	2
0.013	3.364	100	0	78	11	99	0	98	1	100	0	80	13	98	2
0.22	5.656	100	0	84	6	99	0	99	1	100	0	88	8	99	1
0.37	9.514	100	0	92	8	100	1	100	1	100	0	96	8	100	1
0.63	16	100	0	97	5	100	0	100	0	100	0	100	4	100	0
1.05	26.909	100	0	100	3	100	0	100	0	100	0	100	0	100	0
1.5	38.055	100	0	100	0	100	0	100	0	100	0	100	0	100	0
2.0	50	100	0	100							0	100	0	100	0

* Derived from pocket penetrometer readings

[1] Winterkorn, Hans F. and Hsai-Yang Fang, 1975, *Foundation Engineering Handbook*, Van Nostrand Reinhold Company, New York, NY.
[2] Lambe, William T. and Robert V. Whitman, 1969, *Soil Mechanics*, John Wiley and Sons, New York, NY.
[3] US Department of Agriculture – Agricultural Research Service National Sedimentation Laboratory.

Table 7. Annual sediment generation in Johnson Creek (short ton).

Reach	3-month	6-month	1-year	2-year	5-year	10-year
A-B	<1	<1	4	14	<1	<1
B-C	2679	3933	2717	2134	1227	1346
C-D	1415	1640	1584	3393	6782	1357
D-E	<1	7	15	22	<1	<1
E-F	2	1272	292	150	238	130
F-G	1157	1456	1780	2081	11143	949

Table 8. Annual sediment generation in Johnson Creek normalized for length of reach (short ton/linear foot).

Reach	3-month	6-month	1-year	2-year	5-year	10-year
A-B	0.00004	0.00009	0.00091	0.00313	0.00000	0.00000
B-C	0.34364	0.50440	0.34844	0.27367	0.15741	0.17262
C-D	0.21890	0.25376	0.24505	0.52496	1.04936	0.21002
D-E	0.00007	0.00222	0.00474	0.00717	0.00001	0.00000
E-F	0.00052	0.40030	0.09186	0.04726	0.07504	0.04103
F-G	0.22911	0.28828	0.35264	0.41208	2.20695	0.18802

Goals and Objectives

This plan establishes the following goals and objectives for sediment and erosion control efforts within the watershed:

- Protect property through stabilization of creek alignment and development of sediment handling facilities.
- Enhance biotic integrity of watershed through restored creek overbank environments and improved water quality.
- Provide more natural sediment conveyance by minimizing the impact of development on the hydrologic regime of the watershed and maintaining stable creek embankments.
- Identify primary sources of sediment through frequent field visits and updated computer modeling.
- Reduce total sediment load through the restoration of a more natural sediment conveyance regime.
- Restore unstable creek reaches through bio-engineering of stream banks and minimization of destructive hydrologic inputs to the system.
- Exhaust all sustainable bio-engineering solutions and possibilities prior to installation of sedimentation basins.

2.4.3 Lack of Passive Recreation

Background

The City has a vision to provide residents with a high quality of life through great parks and exceptional recreational opportunities. These services provide a foundation for the physical, social, economic and environmental viability and well-being of the community. The Parks

and Recreation Department (Department) is the City department assigned to achieve this vision. Its mission is to provide quality facilities and services that are responsive to a diverse community and sustained with a focus on partnerships, innovation and environmental leadership. As the City continues to grow, both in population and geographically, this mission becomes more important, and more difficult to achieve.

The City, once a pre-eminent address in the region, has lost ground to other affluent suburbs. But Arlington is not a suburb anymore, it is a city, and the strengths that made it such a desirable location in the recent past, such as access to parks and natural resources, still exist. It has the building blocks from which to reposition itself as a "community of choice" in the Metroplex.

Historically the City has invested wisely in its park system, and as a result, the current park system is cited as an important reason why residents choose to live in Arlington. But the park system, much like the City, is at a turning point. The community desires more parks, better access to parks, better protection and use of the City's natural resources, and stronger focus on establishing a sustainable environment for future generations. This is challenging for a city that is fast approaching build-out. With each year of growth there is less suitable land available for park development and often less funding for capital improvement projects.

Residents continue to express a desire for linear parks that provide multiple benefits. Since 1987, Arlington's linear park system has increased five-fold in terms of acreage, and has added 22 trail miles. There are numerous additional opportunities in Arlington to continue this trend, particularly along Johnson Creek, where recreational improvements can contribute other watershed benefits and raise awareness of Johnson Creek as a natural resource to protect.

Existing Conditions and Past Efforts

Arlington's park system is widespread and diverse, with amenities ranging from the most active sports facilities to the most passive natural areas. The Department's efforts to expand and better Arlington's park system have been just as widespread, including substantial additions of linear park acres, neighborhood parks and playgrounds, swimming pools, recreation centers, and outdoor courts over the last fifteen years.

Expanding trails and linkages has been an important goal of the Department for several years. Trails are offered at over 30 Arlington parks, including four of the six existing parks along Johnson Creek: Gateway Park, Founders Park, Meadowbrook Park, and Richard Greene Linear Park. A new trail system was also constructed by the Texas Department of Transportation near Johnson Creek between Sanford Street and Randol Mill Road (an area formerly referred to as Johnson Creek Linear Park). More trails are planned for the proposed Julia Burgen Park between Collins Street and Park Row Drive, Vandergriff Park, Meadowbrook Park, as well as in planned open space near Arlington's sports venues.

A primary recreational feature lacking in the Johnson Creek watershed is a continuous trail corridor along Johnson Creek that connects existing parks to each other and to other recreational opportunities and population hubs outside of the watershed, such as the University of Texas at Arlington, downtown Arlington, and entertainment venues in

northern Arlington. Land ownership and issues with crossing of the Union Pacific railroad tracks has delayed development of a continuous linear park system with appropriate linkages to other amenities. Most of Johnson Creek is bound on either side by private residential or commercial development, which limits opportunities for park development and maintenance of riparian vegetation. Acquisition of properties in the floodplain is a strategy that was used in the past to obtain land for flood control and ecosystem restoration. Maintenance easements, which allow the City to clear vegetation, repair eroded banks, and develop trails, will likely be the preferred strategy for linear park development and habitat enhancement.

Efforts to provide other types of passive recreation, such as designated wildlife and natural areas and interpretive education, have in the past been few and far between. Only four of Arlington's current park properties are designated as natural areas (City of Arlington 2004), but the Department is beginning to place greater emphasis on natural areas by developing amenities such as nature centers and native plant gardens.

Despite challenges to create a continuous linear park system with greater emphasis on natural areas, the Department has made noteworthy efforts to become an environmental leader for the City. In its 2004 Master Plan (City of Arlington 2004), the Department has developed policies to utilize and promote sustainable management and design practices, conserve natural resources, develop parks specifically for natural area preservation, and pursue linear park development to promote non-vehicular transportation.

Goals and Objectives

Recreation goals have been developed and revisited on numerous occasions, most recently in the late 1990s and again in the early 2000s. Goals written into the Johnson Creek Corridor Plan (Johnson Creek Consortium 1997) addressed community desires for passive educational opportunities on park lands, safe and controlled public access to a greenbelt or existing network of trails through the Johnson Creek corridor, and better preservation and conservation of the City's natural resources. The 2004 Master Plan refined goals and objectives for recreation based on phone interviews and public meetings with residents. Master Plan goals that are most supportive of a multi-objective approach to conservation in the Johnson Creek watershed include the following:

- To wisely use natural resources to create a healthful place to live, work, and play.
- To provide easy pedestrian access to a system of parks, open spaces, trails and gathering places promoting interactions within and among neighborhoods.
- To foster pride through an aesthetically pleasing environment.
- To conserve natural resources and green spaces that add beauty and value to the surrounding development.
- To preserve environmentally sensitive areas that protect ecosystems and provide for sustainable living.

Objectives required to meet these goals include the following:

- Identify a system of connected trails along the entire length of Johnson Creek.
- Develop a system of trail hierarchy based on use type and use volume.

- Identify recreational corridor connections to parks outside of the Johnson Creek corridor, such as River Legacy Park and the Fish Creek Linear Park.
- Provide additional passive recreation opportunities along the Johnson Creek corridor.
- Provide safe, controlled public access to the Johnson Creek corridor.
- Develop interaction zones where visitors can physically interact with Johnson Creek.
- Identify visual occupation opportunities.

2.4.4 UNSUITABLE HABITAT FOR WILDLIFE

Background

Habitat available to wildlife in the Johnson Creek corridor covers substantially less area and is less protected from human influences than it once was. The corridor, which now rests in an 86% developed watershed was historically a distinctive transitional zone between two unique ecological zones: Cross Timbers to the west and Blackland Prairie to the east. Pristine oak-dominated forests and mixed grassland forests lined the creek to the east while expansive, nearly treeless prairies approached the creek from the east. Today's corridor is flanked by steep and narrow riparian forest, dense in places with invasive species, along most of its length. Remnants of the oak-dominated bottomland riparian forests and grasslands are present but not common; prairie remnants are practically non-existent due to urban development.

Upland and bottomland riparian forests and grassland are still the dominant plant communities, but they are substantially smaller and greatly modified from their original condition. In general these communities are believed to be narrower, more linear, less diverse, and more fragmented compared to past conditions. They lack community characteristics that promote wildlife diversity, such as a diverse native herbaceous understory, hollows and nesting cavities, natural debris (logs, brush) in the understory, and snags or dead limbs (USFWS unpublished data). As a result, the keystone species are typical of disturbed environments, and include: fox squirrel, raccoon, opossum, eastern cottontail rabbit, coyote, armadillo, and various species of small rodents (USFWS unpublished data).

Aquatic habitat in Johnson Creek supports approximately 17 species of fish and shellfish. As compared to the Trinity River watershed, the fishes and various invertebrates in Johnson Creek are not particularly unique, and they are indicators of poor water quality.

There are four threatened, endangered, or special concern species in Tarrant County that could migrate through or utilize Johnson Creek habitat, but urban development surrounding the corridor makes Johnson Creek an unlikely home for any of the listed species, even under restored conditions. These species include the federally and state endangered interior least tern (*Sterna antillarum*) and whooping crane (*Grus americana*), the federally and state threatened bald eagle (*Haliaeetus leucocephalus*), and the federal candidate species, mountain plover (*Charadrius montanus*).

Existing Conditions and Past Efforts

Only ten of the sixty-nine parks currently built in Arlington are advertised in the Guide to Arlington Parks (2004) as having nature areas or nature areas with trails. These include: Clarence Thompson Park, River Legacy Parks, California Lane Park, Mary & Jimmie Hooper Park, Randol Mill Park, Veterans Park, Bob McFarland Park, Cliff Nelson Park, Gene Schrickel, Jr. Park, and Martin Luther King Sports Center. Although riparian corridors typically support more wildlife species than any other habitat (USFWS 2002), none of Arlington's ten parks with advertised natural area (excluding those with hike/bike trails) are located along Johnson Creek or within its riparian corridor.

There are few efforts to date that focus specifically on reestablishing wildlife habitat in the Johnson Creek watershed. This is not due to lack of interest in the Arlington community, but rather to challenges with funding and implementation of habitat corridor plans, which prioritize natural habitat over active recreation.

The most noteworthy effort to date for on-the-ground green corridor development along Johnson Creek is implementation of the Corps' 1999/2005 plan. The plan restored bottomland and riparian forest by thinning non-native or aggressive trees and shrubs, planting native, hard-mast trees (oaks, pecan, black walnut, red mulberry, and persimmon) and fruiting shrubs (holly, yaupon, coralberry, plum, dogwood, blackhaw, hawthorn, elderberry, sumac, and redbud), converting old fields and shrubby grasslands to riparian forest, and creating mature forest elements such as snags, cavities, and dead limbs.

Another good example of green corridor development within city limits (but outside of the Johnson Creek watershed) is River Legacy Park in north Arlington. This park was created as part of a NCTCOG regional initiative to establish a greenbelt connecting Dallas and Fort Worth along the Trinity River. The park is an asset to the City on many levels: it is managed to maximize biological diversity while also providing active and passive recreation opportunities; its natural communities protect valuable floodplain functions and improve water quality; and it enhances the quality of life for visitors from the entire Metroplex. However, park development did not incorporate bank stabilization or vegetation management that would provide additional wildlife habitat benefits.

Using River Legacy Park as an example, efforts to create and enhance natural parks for passive recreation lend opportunities for simultaneously improving habitat for wildlife.

Goals and Objectives

Goals to provide, enhance, and protect wildlife habitat in the Johnson Creek watershed should be broad enough to accommodate the holistic, multi-objective approach to conservation.

- Provide healthy and sustainable ecosystems for wildlife.
- Improve native species diversity.
- Educate and involve the public in wildlife preservation.

- Continuously develop new goals to acquire, expand, and improve open space for wildlife preservation.

The following objectives, applied primarily within existing open space such as City parks adjacent to Johnson Creek, will achieve these goals:

- Expand/create streambank buffers using native vegetation.
- Replace turf grass with native vegetation where feasible.
- Control or eliminate non-native plant species.
- Thin existing woodlands to open the canopy for understory native vegetation.
- Maximize the use of soil bioengineering bank stabilization methods.
- Continuously monitor plant and animal populations.
- Properly maintain native plant communities and landscapes.
- Develop partnerships and education programs with local environmental groups, schools, churches, businesses, and neighborhoods.
- Develop and implement a volunteer stewardship program for clean-ups, workdays, and other maintenance activities.
- Build nature centers and/or provide interpretive signage at City parks and along trails.
- Acquire and preserve for wildlife additional parcels in the 25-year floodplain.
- Assess feasibility of acquiring 100-year floodplain property for specific multiple-use needs including flood protection, wildlife habitat, and linear park/green corridor development.

3.0 FEATURES OF THE MODIFIED PLAN

It is the intent of this modified plan to: 1) include finished components of the 1999/2005 authorized plan; 2) implement and modify, if necessary, all desired unfinished projects authorized by the 1999/2005 plan; 3) design and implement new projects to better address the four environmental threats and meet multiple watershed goals; and 4) allow for reimbursement and/or acquisition of an additional 90 acres of environmental land in Trinity River and/or Rush/Village Creek floodplain.

Components of the modified plan are described below and followed, where appropriate, by a cost estimate. Conceptual and/or master plan drawings have been prepared for modified and new Johnson Creek projects. All drawings are subject to change during subsequent phases of design as a result of technical studies, feasibility studies, public needs, and City Council approvals. Cost estimates of all components of the modified plan, with the exception of projects completed as part of the 1999/2005 plan, are based on conceptual and master plan drawings included in this document. We anticipate needing to refine unit costs and quantities of specific components of the modified plan during subsequent design phases, particularly for park amenities yet to be designed. The City requests that these costs be allowed to change with the design process, understanding that the total project cost cannot exceed the amount shown in Table 11.

3.1 FINISHED COMPONENTS OF THE 1999/2005 PLAN

Total project costs to date for demolition of floodplain structures, land reimbursement, administration, design, construction, and related costs has been estimated at $30 million.

3.2 UNFINISHED COMPONENTS OF THE 1999/2005 PLAN

Unfinished projects authorized by the 1999/2005 plan that the City still desires to complete, either as originally planned or as modified by this document, include the following:

- Demolition of three houses within the 25-year floodplain of Johnson Creek (Figure 21).
- Acquisition of 100-year floodplain at 1225/1223 Pecan Street for streambank restoration and recreation (Figure 21).
- Passive recreation features and park amenities at the buyout area between Collins Street and Park Row Drive such as pedestrian crossings over Johnson Creek, 12' concrete trails, retaining walls as necessary for trails placed near the top of restored streambank, trail lighting, shelters, drinking fountains, park benches, flagstone paving, and adjustments to the quantity, type, or placement of plant material to accommodate new stream alignment and relocated trails. All park amenities will be designed according to Johnson Creek greenway standards.
- Stream restoration of Johnson Creek between Collins Street and Park Row Drive, including but not limited to, pulling back the banks to the top-of-bank limit shown on Figures 22 and 23.

The City prefers to implement unfinished components of the 1999/2005 plan simultaneously with new Phase 2 Johnson Creek projects described below. Estimated costs of unfinished projects are included in Table 10.

3.3 NEW JOHNSON CREEK PROJECTS

A phasing strategy was developed for new projects to include in the modified plan on the basis of feasibility, cost, and ability to meet multiple watershed goals. Criteria used to determine feasibility included funding opportunity, proximity to planned economic development, proximity to planned City ecological restoration projects, land ownership (private vs. public), adjacent land uses, existing conditions (such as degree of sediment accumulation), accessibility, location in watershed, and long-term maintenance requirements. Desired projects were divided into two phases.

3.3.1 Phase 1: Rangers' Ponds South to Union Pacific Railroad Tracks

Phase 1 includes property from the northerly Rangers' pond south to the Union Pacific railroad tracks between Division and Abram. Phase 1 was selected for a variety of reasons as follow: 1) There is adequate open space for regional flood control; 2) the riparian corridor has high potential for restoration to improve existing wildlife habitat, water quality, and recreational opportunities; 3) the property is owned by the City; 4) a significant portion of existing environmental stresses, particularly erosion and sedimentation, occur within this area; 4) the City has identified this area as an entertainment district; and 5) this area includes the future Dallas Cowboys stadium, the existing Texas Rangers stadium, and a future Arlington town center. These developers have all agreed to provide matching money for the City to improve the green space within this corridor for environmental benefits listed above.

Phase 1 of the plan will be the highest profile region along the corridor and will serve as the catalyst and inspiration for restoration in the remainder of the watershed. Phase 1 projects are categorized as Flood Control, Water Quality/Public Health/Bank Stabilization, and Wildlife Habitat/Recreation Improvements.

Flood control

Of the four environmental threats, flooding was determined to be the single most important issue in Arlington for several reasons: it threatens public safety, property values, and long-term stability of infrastructure; it contributes to the degraded channel and bank conditions along most of Johnson Creek, and as a result, limits recreation and wildlife habitat. Flooding is also the most complicated technical issue for the City to address, because complete resolution would require extensive acquisition of private properties and structures in the 100-year floodplain. Past efforts to control flooding have focused on acquisition and infrastructure repairs; this plan recommends a long-term solution for flooding without necessitating immediate acquisition.

Flood control benefits within Phase 1 will result primarily from additional flood storage from a new, regional detention basin between Division Street and the Union Pacific railroad tracks and improvements to north and south Rangers' ponds to maximize detention. Bank stabilization and a sedimentation/detention basin west of the mobile home park described as water quality improvement projects will also contribute to flood control. Bank stabilization in particular will improve channel conveyance and capacity, thereby controlling flooding.

1) Flood detention basin south of Division.-- There is a large open space parcel along Johnson Creek south of Division Street and north of the Union Pacific railroad tracks that is owned by the City. This area is an ideal location for a large, regional flood detention basin, which will be designed to reduce flow rate and volume downstream. A conceptual layout of this basin is presented in Figures 8 and 9 with a corresponding cross section shown in Figure 10. This basin will be designed as offline storage to capture water as the stream stage is rising. The basin will retain water for a specified time and regulate the rate at which it reenters the creek. The conceptual basin layout shown in Figure 9 has a surface area of approximately 10.8 acres. With a maximum water surface fluctuation of up to five feet, this would provide over 50 acre-feet of storage, which is felt to be significant in this watershed, although hydraulic modeling is not yet complete.

2) Flood storage retrofit project in Rangers' ponds.-- The two Rangers' ponds, located between Randol Mill Road and Ballpark Way, will be retrofitted to provide flood storage benefits, along with secondary benefits to the watershed. This area, shown in plan on Figures 8 and 11, and in cross section on Figure 12, will be altered to provide additional flood storage in both pools. The dam and outlet control structure for the north pond will be modified to provide approximately two additional feet of storage, which would correspond to approximately 11.5 acre-feet of additional storage in the north pond (the surface area is approximately 5.75 acres). Between the two ponds an additional outlet control structure will be installed, which will provide an increased detention volume of a similar magnitude in the south pond. The south pond will be restored to the historical stream that formerly meandered through this area. The proposed stream and wetland complex will provide stormwater management, flood control, and habitat quality benefits such as sediment and pollutant filtration, infiltration, and high interspersion of plant community types.

Water Quality/Public Health/Bank Stabilization

Poor water quality related to erosion, unstable streambanks, and sedimentation was determined to be the second most critical environmental threat due to its negative impacts on wildlife, public safety, aesthetics, and recreation opportunities.

Water quality and public health benefits within Phase 1 will result from bank stabilization and a new sedimentation/detention basin west of the mobile home park. Benefits include reduced sedimentation, repaired streambanks, new trails, and permanent erosion control from native vegetation.

1) Bank stabilization between Randol Mill and Division.-- According to CONCEPTS modeling, the most significant sediment generation in the Johnson Creek watershed occurs in Reach F-G between Sanford Street and Randol Mill Road. This finding, combined with the need to provide flood control south of Division, necessitates bank stabilization between the Union Pacific railroad tracks and Randol Mill Road to reduce sediment generation in this portion of the stream (Figure 8). Under restored conditions, unstable banks will generally be graded to a stable slope (Figure 13). Soil bioengineering techniques will be employed to re-vegetate sloped channel banks with native grasses, forbs, trees and shrubs. Areas of high shear stress will be reinforced with crushed rock grade controls to stabilize and maintain the channel bottom. Existing and proposed conditions for the four cross sections used in sediment modeling for Reach F-G appear in Appendix D.

2) New sedimentation basin west of mobile home park.-- A critical component of the restoration of Reach F-G is minimizing the amount of sediment entering the reach from upstream. A sedimentation basin will be constructed alongside Reach F-G near an existing trailer park (Figure 8). The basin is sized to not exceed available surface area, to enhance the recreational character and ecological integrity the riparian area, and to provide a reasonable sediment removal schedule while bank stabilization occurs in Reach F-G. Less frequent removal of sediment will be required as bank stabilization occurs upstream. Eventually this sedimentation basin will function primarily as additional floodplain storage. A rendered cross section of the proposed sedimentation basin is shown in Figure 14.

Wildlife Habitat and Recreation Improvements

Wildlife habitat and recreation issues are closely linked to each other and are dependent on the availability of green space along the Johnson Creek corridor. These threats are of lesser priority than flood control or water quality improvements, primarily because they do not provide as many readily observable multiple watershed benefits when compared to flood control or bank stabilization.

Wildlife habitat and recreation benefits within Phase 1 will result from woodland restoration including invasive species control and native re-vegetation; the addition of new parkland and continuous green space along the Phase 1 corridor; and the addition of passive recreation amenities.

1) *New and enhanced green space from Rangers' ponds to Division*.-- Approximately 43 acres of new or enhanced parkland and open space will be developed between north Rangers' pond to Division (Figure 8). North of Randol Mill Road, the proposed open space will include re-creating Johnson Creek and expanding its native riparian corridor in the south Rangers' pond (Figure 11), naturalizing shoreline in the north Rangers' ponds to accommodate lower water levels for flood control (Figure 11), and enhancing existing green space in Richard Greene Linear Park north of Randol Mill Road to incorporate more native vegetation (Figure 11). South of Randol Mill Road, the existing overgrown riparian corridor along Johnson Creek will be restored and developed into usable green space with new trails and passive recreation amenities (Figure 8). The most southerly green spaces in Phase 1, adjacent to proposed sedimentation and detention basins, will be more wild and natural than the green spaces proposed north of Rogers Street.

2) *Passive recreation features and park amenities in new green space*.-- New passive recreation features and new park amenities such as 12' trails, two pedestrian crossings over Johnson Creek, park benches, trash receptacles, drinking fountains, restroom facility or other covered structure, trail lighting, flagstone paving, and interpretive signage will be added to new green space. All park amenities will be designed to meet City standards for Johnson Creek greenways.

3) *Restoration of existing woodlands between Randol Mill and Division*.-- The riparian corridor along Johnson Creek is overgrown with non-native species and will not be suitable as recreation space or wildlife habitat without invasive species control. Bottomland forest communities will be cleared of invasive species, thinned of aggressive trees and shrubs, and re-vegetated where feasible to make the woodlands more inviting to people, plants, and animals.

4) *Native vegetation along restored streambanks, in restored woodlands, and around Rangers' ponds*.-- With the exception of planned turf grass spaces, only native species will be used to re-vegetate restored streambanks and woodlands. Native species beautify the landscape for passive recreation experiences, provide numerous benefits to wildlife as food and shelter, help protect the soil from eroding, and are low maintenance.

5) *In-stream features for aquatic wildlife*.-- New channel bedding, riffles, pools, and natural boulder features will be installed in Johnson Creek between Randol Mill Road and Division Street to reduce shear stress (Figure 15). These structures will also function as aquatic wildlife habitat. The substrate and in-stream features of Johnson Creek will provide diverse structure for aquatic wildlife to attach, feed, rest, and reproduce.

Table 9 estimates the cost of new Phase 1 Johnson Creek projects.

Table 9. Estimated cost of new Phase 1 Johnson Creek projects.

ITEM	QUANTITY	UNIT	UNIT COST	COST
RANGERS' PONDS				
Fill	83,400	cy	$ 11	$ 917,400
Topsoil Stockpiling and Replacement	11,700	cy	$ 8	$ 93,600
Channel Bedding (18" - 24" diam.)	1,860	cy	$ 85	$ 158,100
Boulder Toe (24" - 36" diam.)	860	sf	$ 100	$ 86,000
Concrete Apron/Boulder Transition	500	sy	$ 50	$ 25,000
Seeding	4.7	ac	$ 3,000	$ 14,130
Plantings	2.0	ac	$ 175,000	$ 350,000
Geotextile Slope Fabric	7,000	sy	$ 10	$ 70,000
Erosion Control Blanket	14,000	sy	$ 3	$ 42,000
Temporary Silt Fence	1,005	lf	$ 5	$ 5,025
Outlet Crest Modification	1	ls	$ 100,000	$ 100,000
Structure Between Ponds	1	ls	$ 250,000	$ 250,000
Subtotal Rangers' Ponds				**$ 2,111,255**
DETENTION BASIN SOUTH OF DIVISION				
Excavation (Includes Berm)	300,000	cy	$ 9	$ 2,700,000
Soil Retention Blanket	7,500	sy	$ 2	$ 15,000
Seeding	4	ac	$ 3,000	$ 12,000
Temporary Silt Fence	2,300	lf	$ 5	$ 11,500
Outlet Area Erosion Control	1	ls	$ 5,000	$ 5,000
Subtotal Detention Basin				**$ 2,743,500**
BANK STABILIZATION RANDOL MILL TO RAILROAD TRACKS				
Excavation (Includes Hauling)	50,724	cy	$ 11	$ 557,964
Topsoil Replacement	8,454	cy	$ 8	$ 67,632
Channel Bedding	6,341	cy	$ 85	$ 538,985
Channel Grade Controls	12	ea	$ 6,000	$ 72,000
Seeding	8.24	ac	$ 3,000	$ 24,720
Plantings	50584	ea	$ 5	$ 252,920
Geotextile Slope Fabric	27,155	sy	$ 10	$ 271,552
Temporary Silt Fence	4,227	lf	$ 5	$ 21,135
Subtotal Bank Stabilization				**$ 1,806,908**
SEDIMENTATION BASIN				
Excavation (Includes Hauling)	36,000	cy	$ 11	$ 396,000
Rock Berms	1,900	cy	$ 50	$ 95,000
Topsoil	2,140	cy	$ 8	$ 17,120
Erosion Control Fabric	6,486	sy	$ 3	$ 19,458
Seeding	1	ac	$ 3,000	$ 3,000
Grade Controls (Inlet/Outlet)	2	ea	$ 15,000	$ 30,000
Grasspave Access Point	0.15	ac	$ 260,000	$ 39,000
Subtotal Sedimentation Basin				**$ 599,578**

ITEM	QUANTITY	UNIT	UNIT COST	COST
WILDLIFE HABITAT AND RECREATION				
Site Preparation	43	ac	$ 1,200	$ 51,600
Straw Mulch	20	ac	$ 400	$ 8,000
Large Trees (2.5 - 3")	34	ea	$ 450	$ 15,300
Medium Trees (1.5 - 2")	732	ea	$ 250	$ 183,000
Ornamental Trees (1 - 1.5"; or 6 ft tall)	732	ea	$ 350	$ 256,200
Shrubs	1,391	ea	$ 70	$ 97,370
Perennials (quart)	120,570	ea	$ 7	$ 843,990
Mulch (3" deep)	540	cy	$ 85	$ 45,900
Turf Seed	11,519	sy	$ 1	$ 11,519
Pedestrian Bridge Crossings	2	ea	$ 150,000	$ 300,000
Boardwalk (5 ft width)	1,200	lf	$ 125	$ 150,000
Park Bench	5	ea	$ 1,300	$ 6,500
Waste Recepticle	5	ea	$ 750	$ 3,750
Drinking Fountains	5	ea	$ 1,500	$ 7,500
Restroom Facility	1	ea	$ 200,000	$ 200,000
Trail Signage	1	ls	$ 26,000	$ 26,000
Trail Lighting	5,785	lf	$ 25	$ 144,625
Concrete Trail (12')	5,785	lf	$ 60	$ 347,100
Subtotal Wildlife Habitat and Recreation				**$ 2,698,354**
Miscellaneous				
Construction Staking	1	ls	$ 50,000	$ 50,000
QA/QC (Construction Oversight)	2,080	hrs	$ 100	$ 208,000
Subtotal Miscellaneous				**$ 258,000**
SUBTOTAL PHASE 1				**$ 10,217,595**
Administration (3%)				$ 306,528
Technical Studies, Design & Permitting (15%)				$ 1,532,639
5-year Warranty and Establishment (5%)				$ 467,116
TOTAL PHASE 1				**$ 12,523,879**

3.3.2 Phase 2: Union Pacific Railroad Tracks South to Vandergriff Park and 90 Acres

Phase 2 includes new projects proposed in the Johnson Creek corridor between Union Pacific railroad tracks and Vandergriff Park, and 90 acres of environmental land within Trinity River and/or Rush/Village Creek floodplain.

1) Phase 2 Johnson Creek corridor projects.-- Flood control, water quality, and wildlife habitat/recreation improvements similar to Phase 1 projects will occur at two City parks, Vandergriff Park and Meadowbrook Park, and additionally along two tributaries of Johnson Creek between Sanford Street and proposed Rogers Street (Table 10; Figures 8 and 16). Flood control basins in Phase 2 will provide an additional estimated 31 acre-feet of flood storage. Conceptual plan views of City parks are shown on Figures 17 and 19. Cross sections of proposed flood detention basins, sedimentation/detention basins, and bank stabilization are provided for Meadowbrook and Vandergriff parks on Figures 18 and 20.

2) 90 Acres.-- The City will preserve, and obtain reimbursement for, an additional 90 acres of environmental land within Trinity River or Rush/Village Creek floodplain. The City will not encumber mineral rights associated with the 90 acres that is to be acquired; however, all surface rights will be encumbered so as to ensure the environmental integrity of the property.

The City desires to complete unfinished projects authorized by the 1999/2005 plan simultaneously with new Phase 2 Johnson Creek projects. Table 10 estimates the cost of new Phase 2 Johnson Creek projects as well as unfinished components of the 1999/2005 plan that the City desires to complete.

Table 10. Estimated cost of new Phase 2 Johnson Creek projects.

ITEM	QUANTITY	UNIT	UNIT COST	COST
MEADOWBROOK PARK				
Real Estate				
Reimbursement for City owned land	15	ac	$ 12,000.00	$ 180,000
Detention Basins (2)				
Excavation (Includes Hauling)	58,320	cy	$ 11	$ 641,520
Clearing/Grubbing	2	ac	$ 8,000	$ 16,000
Soil Retention Blanket	2,160	sy	$ 2	$ 4,320
Temporary Silt Fence	1,945	lf	$ 5	$ 9,725
Outlet Area Erosion Control	1	ls	$ 10,000	$ 10,000
Grade Controls (Inlet/Outlet)	4	ea	$ 15,000	$ 60,000
Bank Stabilization				
Excavation (Includes Hauling)	15,038	cy	$ 11	$ 165,418
Clearing/Grubbing	5	ac	$ 8,000	$ 36,823
Topsoil Replacement	7,018	cy	$ 8	$ 56,144
Channel Bedding	7,018	cy	$ 85	$ 596,530
Channel Grade Controls	3	ea	$ 6,000	$ 18,000
Seeding	0.12	ac	$ 3,000	$ 360
Plantings	0.40	ac	$ 175,000	$ 70,000
Geotextile Slope Fabric	17,822	sy	$ 10	$ 178,220
Temporary Silt Fence	2,005	lf	$ 5	$ 10,025
Toe Boulder	13,576	sf	$ 100	$ 1,357,600
Sedimentation Basin				
Excavation (Includes Hauling)	14,197	cy	$ 11	$ 156,167
Clearing/Grubbing	1.8	ac	$ 4,000	$ 7,040
Soil Retention Blanket	1,278	sy	$ 2	$ 2,556
Temporary Silt Fence	1,150	lf	$ 5	$ 5,750
Outlet Area Erosion Control	1	ls	$ 10,000	$ 10,000
Grade Controls (Inlet/Outlet)	2	ea	$ 15,000	$ 30,000
Grasspave Access Point	0.20	ac	$ 260,000	$ 52,000
Wildlife Habitat and Recreation Improvements				
Seeding	10	ac	$ 3,000	$ 30,000
Plantings	2	ac	$ 175,000	$ 350,000
Trees	320	ea	$ 350	$ 112,000
Temporary Watering Allowance	1	ls	$ 60,000	$ 60,000
Park Bench	6	ea	$ 1,300	$ 7,800
Waste Recepticle	6	ea	$ 750	$ 4,500
Drinking Fountains	2	ea	$ 1,500	$ 3,000
Trail Signage	1	ls	$ 26,000	$ 26,000
Trail Lighting	680	lf	$ 25	$ 17,000
Concrete Trail (12')	680	lf	$ 60	$ 40,800
Sidewalk	8,773	sf	$ 20	$ 175,460
Subtotal Meadowbrook Park				**$ 4,500,758**

ITEM	QUANTITY	UNIT	UNIT COST	COST
VANDERGRIFF PARK				
Real Estate				
Reimbursement for City owned land	14.5	ac	$ 20,000.00	$ 290,000
Detention Basins (3)				
Excavation (Includes Hauling)	60,500	cy	$ 11	$ 665,500
Clearing/Grubbing	3.4	ac	$ 4,000	$ 13,720
Soil Retention Blanket	3,628	sy	$ 2	$ 7,256
Temporary Silt Fence	3,265	lf	$ 5	$ 16,325
Outlet Area Erosion Control	1	ls	$ 30,000	$ 30,000
Grade Controls (Inlet/Outlet)	6	ea	$ 15,000	$ 90,000
Bank Stabilization				
Excavation (Includes Hauling)	4,828	cy	$ 11	$ 53,108
Topsoil Replacement	2,575	cy	$ 8	$ 20,600
Channel Bedding	1,912	cy	$ 85	$ 162,520
Channel Grade Controls	3	ea	$ 6,000	$ 18,000
Seeding	0.92	ac	$ 3,000	$ 2,760
Plantings	0.32	ac	$ 175,000	$ 56,000
Geotextile Slope Fabric	11,587	sy	$ 10	$ 115,870
Temporary Silt Fence	1,738	lf	$ 5	$ 8,690
Toe Boulder	2,058	sf	$ 100	$ 205,800
Sedimentation Basin				
Excavation (Includes Hauling)	15,972	cy	$ 11	$ 175,692
Soil Retention Blanket	817	sy	$ 2	$ 1,634
Temporary Silt Fence	1,470	lf	$ 5	$ 7,350
Outlet Area Erosion Control	1	ls	$ 10,000	$ 10,000
Grade Controls (Inlet/Outlet)	2	ea	$ 15,000	$ 30,000
Grasspave Access Point	0.10	ac	$ 260,000	$ 26,000
Other Wildlife Habitat and Recreation Improvements				
Seeding	10	ac	$ 3,000	$ 30,000
Plantings	2	ac	$ 175,000	$ 350,000
Trees	400	ea	$ 350	$ 140,000
Temporary Watering Allowance	1	ls	$ 60,000	$ 60,000
Park Bench	5	ea	$ 1,300	$ 6,500
Waste Recepticle	5	ea	$ 750	$ 3,750
Drinking Fountains	2	ea	$ 1,500	$ 3,000
Trail Signage	1	ls	$ 26,000	$ 26,000
Trail Lighting	2,678	lf	$ 25	$ 66,950
Concrete Trail (12')	3,200	lf	$ 60	$ 192,000
Demolition of existing structures	1	ls	$ 125,000	$ 125,000
Subtotal Vandergriff Park				**$ 3,010,025**

ITEM	QUANTITY	UNIT	UNIT COST	COST
90 ACRES				
Real Estate				
Reimbursement and/or acquisition	90	ac	$ 15,000.00	$ 1,350,000
Subtotal 90 Acres				**$ 1,350,000**
COLLINS TO PARK ROW				
Buyouts				
100-yr. floodplain at 1225/1223 Pecan St.	2.8	ac	$ 15,000	$ 42,000
721 College Oaks, 704 Mitchell, 702 Mitchell	1	ls	$ 389,000	$ 389,000
Demolition				
Floodplain structures	6	ea	$ 50,000	$ 300,000
Bank Stabilization				
Excavation (Includes Hauling)	51,473	cy	$ 11	$ 566,203
Clearing/Grubbing	16	ac	$ 8,000	$ 126,042
Topsoil Replacement	24,021	cy	$ 8	$ 192,168
Channel Bedding	24,021	cy	$ 85	$ 2,041,785
Channel Grade Controls	6	ea	$ 6,000	$ 36,000
Plantings	34,315	ea	$ 5	$ 171,575
Seeding	13	ac	$ 3,000	$ 37,813
Geotextile Slope Fabric	61,004	sy	$ 10	$ 610,040
Temporary Silt Fence	6,863	lf	$ 5	$ 34,315
Wildlife Habitat and Recreation Improvements				
Park amenities - 1999/2005 plan	1	ls	$ 4,000,000	$ 4,000,000
Upgraded Johnson Creek greenway park amenities such as trail lighting, retaining walls, flagstone paving, shade structures	1	ls	$ 1,200,000	$ 1,200,000
Trail Signage	1	ls	$ 50,000	$ 50,000
Additional Bridge Costs (longer span)	1	ls	$ 500,000	$ 500,000
Seeding	20	ac	$ 3,000	$ 60,000
Plantings	2	ac	$ 175,000	$ 350,000
Turf (Seed)	4,840	sy	$ 1	$ 4,840
Trees	420	ea	$ 350	$ 147,000
Subtotal Collins to Park Row				**$ 10,858,781**
BANK STABILIZATION TRIBUTARIES N OF SANFORD				
Excavation (Includes Hauling)	38,808	cy	$ 11	$ 426,888
Clearing/Grubbing	6	ac	$ 8,000	$ 44,830
Topsoil Replacement	6,468	cy	$ 8	$ 51,744
Channel Bedding	4,852	cy	$ 85	$ 412,420
Channel Grade Controls	8	ea	$ 6,000	$ 48,000
Seeding	4.3	acre	$ 3,000	$ 12,902
Geotextile Slope Fabric	13,246	sy	$ 10	$ 132,460
Temporary Silt Fence	2,441	lf	$ 5	$ 12,205
12' Concrete Trail	908	lf	$ 60	$ 54,480
Trail Lighting	908	lf	$ 25	$ 22,700
Subtotal Tributary Bank Stabilization				**$ 1,218,629**

ITEM	QUANTITY	UNIT	UNIT COST	COST
MISCELLANEOUS				
Construction Staking	1	ls	$ 100,000	$ 100,000
QA/QC (Construction Oversight)	4,160	hrs	$ 100	$ 416,000
Fees	1	ls	$ 882,600	$ 882,600
Subtotal Miscellaneous				**$ 1,398,600**
SUBTOTAL PHASE 2				**$ 22,336,792**
Administration (3%)				$ 670,104
Technical Studies, Design & Permitting (15%)				$ 3,350,519
5-year Warranty & Establishment (5%)				$ 1,116,840
TOTAL PHASE 2				**$ 27,474,255**

3.4 TOTAL PROJECT COST

The total project cost for completed 1999/2005 plan components, unfinished and/or modified 1999/2005 plan components, new Johnson Creek corridor projects, and identification and reimbursement and acquisition of an additional 90 acres in the Trinity River and/or Rush/Village Creek watersheds is $79,997,666 (Table 11).

Table 11. Total project cost.

ITEM		COST
1999/2005 Plan "Sunk" Costs	$	30,000,000
MODIFIED PLAN PROJECTS		
Phase 1	$	12,523,879
Phase 2	$	27,474,255
Subtotal	$	39,998,133
Contingency (25%)	$	9,999,533
TOTAL PROJECT COST	$	79,997,666

3.5 WARRANTY AND ESTABLISHMENT PROGRAM

The success of all proposed watershed improvement projects, particularly those restored with native vegetation, depends largely on long-term maintenance and monitoring. The modified plan will require the development of a long-term maintenance and monitoring plan, and a five-year warranty and establishment period in which the selected Contractor(s) will perform repairs and maintenance as needed to ensure long-term success of the project. Examples of anticipated maintenance items include removal of accumulated material in sedimentation basins, routine observation and removal, if necessary, of channel obstructions in Johnson Creek, and mowing or herbicide application in native plant communities.

4.0 CONCLUSION AND REQUEST FOR FUNDING

4.1 SUMMARY OF THE MODIFIED PLAN

The previous chapter outlined, prioritized, and estimated the cost of all completed, unfinished, and newly proposed Johnson Creek projects. With this plan, the City modifies the Corps' 1999/2005 plan to allow redesign and construction of unfinished components of the 1999/2005 plan, design and construction of new bank stabilization, flood control, recreation, and habitat restoration on public lands and easements along Johnson Creek, and reimbursement and/or acquisition of an additional 90 acres of environmental land within City floodplain. Specifically, this plan includes the following:

- Finished components of the 1999/2005 authorized plan.

- Implementation of unfinished components of the 1999/2005 authorized plan, including demolition of three structures between Collins Street and Park Row Drive; and acquisition of 100-year floodplain at 1225/1223 Pecan Street.

- Re-design and implementation of unfinished components of the 1999/2005 authorized plan between Collins Street and Park Row Drive, including bank stabilization and stream restoration, and park amenities such as pedestrian crossings over Johnson Creek, 12' concrete trails, retaining walls as necessary for trails placed near the top of restored streambank, trail lighting, shelters, drinking fountains, park benches, flagstone paving, and adjustments to the quantity, type, or placement of plant material to accommodate new stream alignment and relocated trails.

- New Johnson Creek projects including possible future acquisition and demolition of two homes between Collins Street and Park Row Drive, and design and implementation of new flood control, water quality, and wildlife habitat/recreation improvement projects between Division Street and the north Rangers' Pond, and at Vandergriff and Meadowbrook Parks.

- Reimbursement and/or acquisition of an additional 90 acres within Trinity River and/or Village/Rush Creek floodplain. The City will not encumber mineral rights associated with the 90 acres that is too be acquired; however, all surface rights will be encumbered so as to ensure the environmental integrity of the property.

4.2 BENEFITS OF THE MODIFIED PLAN

Arlington has long recognized that the ecological health of Johnson Creek and its contributing watershed are inextricably tied to the quality of life of its residents. In this light, Arlington hopes to develop a stronger link between its residents and its natural surroundings by restoring the watershed specifically to resolve flooding, habitat, and recreation issues, and, in doing so, revitalizing the community.

Immediate local benefits of the modified plan include flood damage protection, habitat restoration, improved water quality and public health, increased access to Johnson Creek for

passive recreation, elevated community pride, and economic redevelopment opportunities. Each of the proposed projects complements larger, regional efforts to improve water quality and maximize the function of floodplain communities in the Trinity River watershed. Nearly all local benefits also contribute to statewide water quality, stormwater management, flood control, and environmental planning efforts by the North Central Texas Council of Government, US Environmental Protection Agency, US Fish and Wildlife Service, Corps of Engineers, Texas Parks and Wildlife, and Texas Commission on Environmental Quality.

This project is an excellent model for local governments across the nation to utilize in resolving environmental issues through an integrated, holistic process geared toward improving and sustaining natural ecosystem functions, while promoting full engagement of natural systems into economic development. Various federal agencies such as the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service resolve to sustain our nation's aquatic resources and the biological life these resources support, including human life. Inherent in this resolve are actions such as flood protection, water quality, public health, and wildlife habitat improvements, and recreation opportunities. By supporting this project the federal government ensures a high quality of life for residents of Arlington and furthers the ecological integrity of Johnson Creek.

4.3 REQUEST FOR FUNDING

The City respectfully requests funding for 65% of the total project cost in the amount of $51,998,483, to be appropriated on an annual basis as requested. The City is prepared to provide a 35% match for each appropriations request, for a total match of $27,999,183.

4.4 FUTURE PHASES

The largest component excluded from the modified plan is acquisition of parcels and structures within the 25-year and/or 100-year floodplain. Although 140 structures will be acquired and converted to open space uses by the time the plan is complete, additional acquisition and restoration is necessary to maximize flood control efforts, complete bank stabilization at all erosion hotspots, establish a continuous green corridor along all of Johnson Creek and its tributaries for recreation and wildlife habitat.

Property acquisition is a very controversial and politically charged issue. Local representatives should still pursue property acquisition to enable implementation of projects beneficial to the watershed. Figure 24 shows desirable parcels to acquire in the watershed. It depicts areas that are predicted to be acquired by the City with some degree of certainty, along with other parcels judged to be beneficial for accomplishing the multiple benefits explained in this plan. There are approximately 49 parcels shown in this figure, with a total surface area of approximately 115 acres. It is recommended that parcels be acquired on a prioritized basis, with those that will accomplish significant multiple benefits being the highest priority. This will be a long term process (10-50 years), where contiguous segments of parcels will be "bridged" to provide a continuous corridor along the creek.

Recommended projects for future phases of watershed restoration include the following:

- Bank stabilization, prioritized by reach to reduce sediment mobilization and increase channel carrying capacity.
- Bridge repair, bank stabilization, and trail connection at the Union Pacific railroad bridge over Johnson Creek.
- Construction of additional flood detention basins.
- Conversion of sediment basins constructed during Phases 1 and 2 to flood detention basins for long-term benefit.
- Implementation of dispersed detention (BMPs) within new development or retrofitting existing developments to incorporate these practices.
- Development of a public outreach program to foster stewardship of the watershed restoration efforts.
- Establishment of a non-profit agency that can continually monitor and maintain restored streams and parklands.
- Continued development of a continuous linear park/green corridor system within 100-year floodplain.

5.0 LITERATURE CITED

Barnes, Virgil E. 1972. *Geologic Atlas of Texas, Dallas Sheet*, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

The City of Arlington. 2004. Great Parks: A Foundation of a Great Community. City of Arlington Park, Recreation and Open Space Master Plan. Arlington, Texas.

Copeland, Ronald R., et al. 2001. Hydraulic Design of Stream Restoration Projects, US Army Corps of Engineers, Engineer Research and Development Center, Coastal and Hydraulics Laboratory, ERDC/CHL TR-01-28.

Hunt, Charles B. 1974. Natural Regions of the United States and Canada, W.H. Freeman and Company, San Francisco, California.

Johnson Creek Consortium. 1997. Johnson Creek Corridor Plan. Graham Associates/James Richards Studio, Arlington, Texas.

Lambe, William T. and Robert V. Whitman. 1969. Soil Mechanics, John Wiley and Sons, New York, New York.

Langendoen, Eddy J., 2000, CONCEPTS – Conservation Channel Evolution and Pollution Transport System, Stream Corridor Version 1.0, US Department of Agriculture – Agricultural Research Service National Sedimentation Laboratory, Oxford, MS.

Promise, J. and J.E. Tidwell, Jr. 2005. From reclamation to restoration: Trinity River COMMON VISION for the 21st Century. Presented at the 3rd International Symposium on Flood Defense, City of Nijmegen, The Netherlands.

Ressell, Dennis D. 1979. Soil Survey of Tarrant County, Texas, US Department of Agriculture, Soil Conservation Service and the Texas Agricultural Experiment Station.

USACE (U.S. Army Corps of Engineers). 1989. Engineering and Design, Sedimentation Investigations of Rivers and Reservoirs, EM-1110-2-4000.

USACE (U.S. Army Corps of Engineers). 1999. Interim Feasibility Report and Integrated Environmental Assessment. Forth Worth District of the US Army Corps of Engineers, Fort Worth, Texas.

USDA (U.S. Department of Agriculture). Agricultural Research Service National Sedimentation Laboratory.

USFWS (U.S. Fish and Wildlife Services). 2002. Wildlife habitat management recommendations for the Clear and West Forks of the Trinity River and Their Tributaries in Tarrant County. Compiled by C.S. Hale, U.S. Fish and Wildlife Service.

Winterkorn, Hans F. and Hsai-Yang Fang. 1975. Foundation Engineering Handbook, Van Nostrand Reinhold Company, New York, New York.

Winton, W.M. and W.S. Adkins. 1919. The Geology of Tarrant County, University of Texas Bulletin No. 1931, Division of Economic Geology, Bureau of Economic Geology and Technology, University of Texas, Austin, Texas.

FIGURES

Figure 1.pdf Johnson Creek Watershed Map

Figure 2.pdf Flood Problem Areas

Figure 3.pdf Public and Private Parcels

Figure 4.pdf Erosion Hotspots

Figure 5.pdf Johnson Creek Reaches

Figure 6.pdf Reaches Used for Erosion and Sedimentation Analysis

Figure 7.pdf Ranked Reaches

Figure 8.pdf Phase 1 Restoration Plan

Figure 9.pdf Phase 1 Flood Detention Basin

Figure 10.pdf Phase 1 Sections – Detention Basin

Figure 11.pdf North and South Rangers' Pond

Figure 12.pdf Phase 1 Sections – North and South Rangers' Pond

Figure 13.pdf Phase 1 Sections – Bank Stabilization

Figure 14.pdf Phase 1 Sections – Sedimentation Basin

Figure 15.pdf Longitudinal Sections of Cross Vane and Detention Outlet

FIGURES – Continued

Figure 16.pdf Phase 2 Overall Concept Restoration Plan

Figure 17.pdf Vandergriff Park Restoration Plan

Figure 18.pdf Vandergriff Park Sections – Bank Stabilization and Flood Detention Basin

Figure 19.pdf Meadowbrook Park Restoration Plan

Figure 20.pdf Meadowbrook Park Sections – Sedimentation Basin and Bank Stabilization

Figure 21.pdf Julia Burgen Park

Figure 22.pdf Julia Burgen Park – Relocated Trails – 1 of 2

Figure 23.pdf Julia Burgen Park – Relocated Trails – 2 of 2

Figure 24.pdf Desired Parcels for Future Acquisition

Figure 25.pdf Overall Concept Restoration Plan – Phases 1 and 2

APPENDIX A

HISTORIC AND EXISTION CROSS SECTIONS

Appendix A-1 EH-61420-60960.pdf

Appendix A-2 EH-58890-57140.pdf

Appendix A-3 EH-53730-50920.pdf

Appendix A-4 EH-48240-45100.pdf

Appendix A-5 EH-43420-41580.pdf

Appendix A-6 EH-41040-39400.pdf

Appendix A-7 EH-38220-36450.pdf

Appendix A-8 EH-35560-34280.pdf

Appendix A-9 EH-33820-31970.pdf

APPENDIX B

HEC-2 MODELING

Appendix B-1.pdf - 16 pages including cover letter

Appendix B-2.pdf - 18 pages including cover letter

APPENDIX C

JOHNSON CREEK DISCHARGES

Appendix C-1.pdf

Appendix C-2.pdf

Appendix C-3.pdf

Appendix C-4.pdf

Appendix C-5.pdf

Appendix C-6.pdf

Appendix C-7.pdf

Appendix C-8.pdf

Appendix C-9.pdf

Appendix C-10.pdf

Appendix C-11.pdf

Appendix C-12.pdf

Appendix C-13.pdf

Appendix C-14.pdf

APPENDIX D

EXISTING AND MODELED PROPOSED CROSS SECTIONS

Appendix D-1 EMP-61420-60960.pdf

Appendix D-2 EMP-58890-57140.pdf

Appendix D-3 EMP-53730-50920.pdf

Appendix D-4 EMP-48240-45100.pdf

Appendix D-5 EMP-43420-41580.pdf

Appendix D-6 EMP-41040-39400.pdf

Appendix D-7 EMP-38220-36450.pdf

Appendix D-8 EMP-35560-34280.pdf

Appendix D-9 EMP-33820-31970.pdf