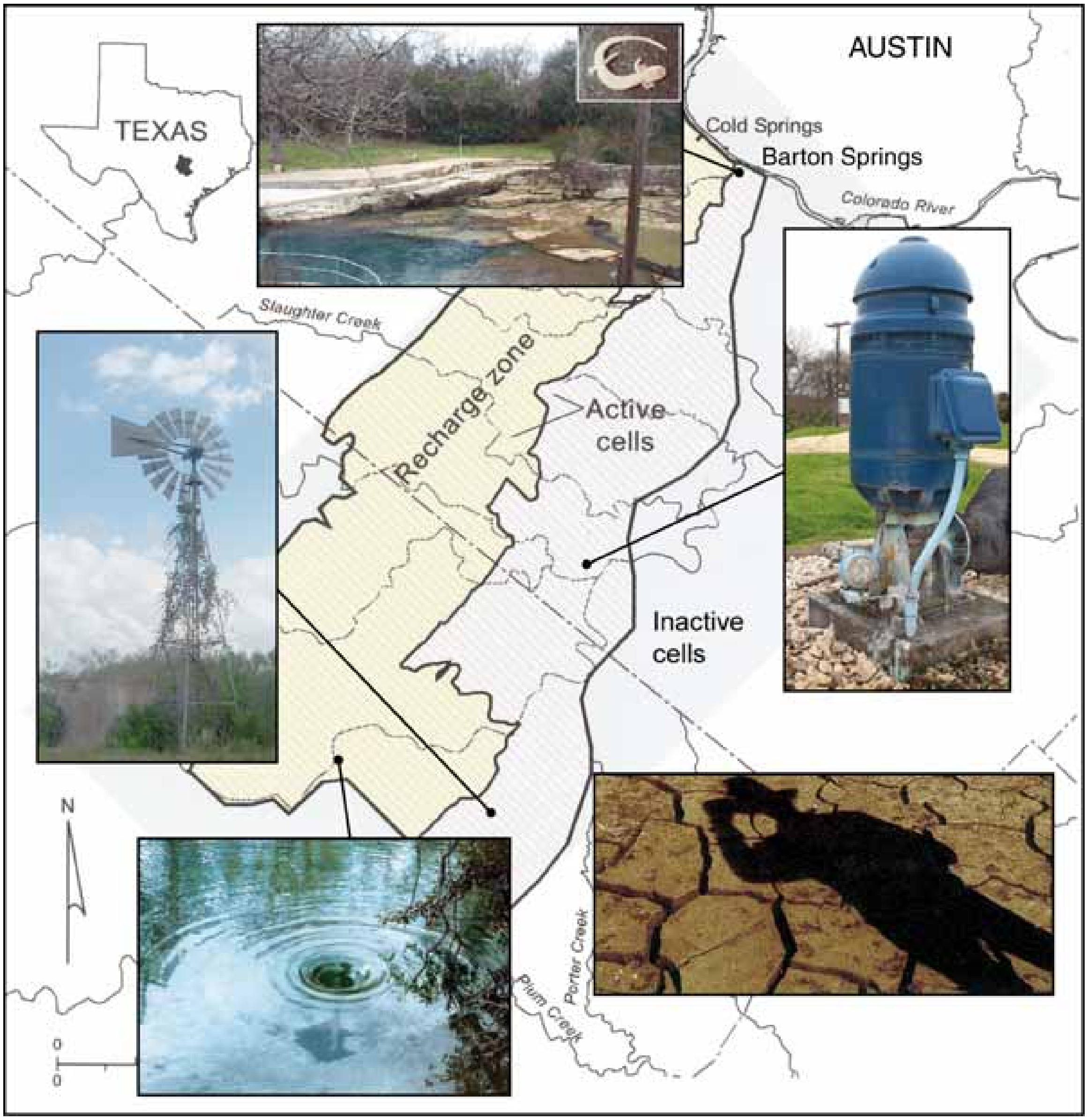
DRAFT HABITAT CONSERVATION PLAN AND PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STUDY
Volume One



Prepared By

Barton Springs/Edwards Aquifer Conservation District

For

U.S. Fish & Wildlife Service

August 2007

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Pursuant to Issuance of a Permit to Allow Incidental Take of An Endangered Species in South Central Texas

August 2007

Executive Summary

The Barton Springs/Edwards Aquifer Conservation District (District) has developed the Barton Springs/Edwards Aquifer Conservation District Draft Habitat Conservation Plan (DHCP) that is intended to protect and conserve two species and their habitats associated with the Barton Springs/Edwards Aquifer system. The DHCP has been prepared pursuant to section 10(a) of the Endangered Species Act (ESA) of 1973, as amended, and is established and evaluated as a combined Draft HCP/Preliminary Draft Environmental Impact Study (DHCP/PDEIS), both of which are required for issuance of a permit by the U.S. Fish and Wildlife Service (Service). Integrated into a sustainable groundwater management program, the DHCP identifies and implements those actions necessary to maintain the viability of the aquifer and natural spring ecosystem habitats for an endangered species, the Barton Springs salamander (*Eurycea sosorum*). The Austin blind salamander (*Eurycea waterlooensis*), a candidate for listing that inhabits portions of the Barton Springs/Edwards Aquifer system, is also included in the HCP and will be covered under the section 10(a)(1)(B) Incidental Take Permit (ITP) if listed in the future. These species proposed for coverage in this DHCP are subject to the standards set forth in section 10(a)(1)(B) of the ESA and 50 Code of Federal Regulations (CFR) 17.32(b) and 17.22(b).

The PDEIS evaluates three groundwater management alternatives, including a No Action Alternative (Alternative 1: No Action—Aquifer Management Strategies and Growth of Pumping Demand with No Protection Under an ITP), and two other HCP alternatives with measures to reduce and mitigate incidental take resulting from low spring discharge from the Barton Springs segment of the Edwards Aquifer. These two other alternatives include: Alternative 2—Regional Permit for Best Practicable and Attainable Measures; and Alternative 3—Regional Permit for Maximum Measures with Highest Costs and Increased Implementation Uncertainty. The PDEIS also contains considerable background information and data on the species, their habitats, and the surrounding region; and it assesses the impacts and consequences of the three alternatives on the affected environment.

Under Alternative 1 (No Action), there would be no HCP and no coverage provided by an ITP. This alternative would result in aquifer pumpage that would be higher than currently exists (to an estimated 13–16 cubic feet per second [cfs]), with the least number of measures to encourage demand reduction or water supply enhancement. There would be smaller adverse economic impacts than for Alternatives 2 and 3, but Alternative 1 does not assure any springflow if aquifer conditions occur that would be similar to the drought of record. Consequently, there would be little protection for the species during low aquifer conditions. Similarly, under Alternative 1 there would be little protection for groundwater users from failure of well production due to declining water tables in the unconfined zone of the aquifer during prolonged, extreme drought periods.

Conversely, the greatest positive impacts to the Barton Springs ecosystem would be associated with Alternative 3—Regional Permit for Maximum Measures with Highest Costs and Increased Implementation Uncertainty. This alternative provides the greatest level of protection to the Barton Springs ecosystem and the Barton Springs salamander and Austin blind salamander by reducing the amount of water pumped from the aquifer during extreme drought, to an estimated 7–10 cfs, thereby sustaining a higher level of water flow through the spring ecosystems and probably assuring some springflow during aquifer conditions that would duplicate the drought of record. (The lowest flow recorded at the Barton Springs complex was approximately 10 cfs, which occurred during the drought of record of 1951–56.) At the same time, this alternative has the greatest uncertainty in its efficacy, because the implementation of its water management policies requires new and politically problematic state legislative action, cooperation of other entities not under the District's control, and/or relatively large capital outlays with uncertain funding sources. It also would be accompanied by the highest level of negative impacts on economic resources, as it would require greater reliance on higher cost alternative water supplies reflected in higher development costs that could affect many economic sectors, primarily housing and suburban development.

As with Alternative 3, the DHCP Alternative 2—Regional Permit, Best Practicable and Attainable Measures includes an array of measures to reduce groundwater demand, enhance supply of alternative water sources, and adapt management strategies to future changing conditions, differing from Alternative 3 primarily in degree of benefit. Alternative 2 implements progressively more stringent pumpage withdrawal limits during Alarm (less than 38 cfs springs discharge) and then Critical Stage (less than 20 cfs springs discharge) Drought conditions. This would also include an Emergency Drought Response Period deep within a Critical Stage Drought, when springflow drops to 14 cfs or lower. As originally formulated, Alternative 2 would have resulted in total aquifer pumpage during extreme drought between 10 and 13 cfs, but little to no springflow.

The proposed DHCP measures that form the basis for the associated ITP are generally similar to those of Alternative 2. However, some additional demand-reduction and supply-conversion measures that were originally conceived, defined and evaluated as part of Alternative 3 are now able to be included in the proposed DHCP as adaptive management measures. Every one of the measures is designed to benefit the salamander habitat; and taken together, these measures provide the District and its regulated pumpers with compliance under the ESA. Under conditions similar to a repeat of the drought of record, the frequency distribution of discharge of Barton Springs is predicted to be intermediate between the most optimistic effects of Alternatives 2 and 3. The total cumulative pumpage from the aquifer should be no greater than 8.5 cfs. A comparison of direct impacts indicates that the proposed DHCP measures comprise the maximum practicable and currently most feasible alternative, considering biological, economic, and legislative/statutory realities.

The ultimate goal of the DHCP is to develop a long-term plan that will optimize use of the Barton Springs segment of the Edwards Aquifer while aggressively protecting federally listed species dependent upon the aquifer and springflow from Barton Springs, and minimizing the negative impact of the plan on the economy and the economic interests of all of the stakeholders. The associated water management plans and policies developed by the District under the prospective DHCP would provide significant additional protection of springflows during drought periods, so that a modest amount of springflow will persist during a repeat of the drought of record. This protection is the aggregate result of numerous measures that collectively reduce demand, enhance groundwater supplies, foster conversion of use of the Edwards Aquifer to alternative water supplies, and institute short-term drought management measures, as described in Alternative 3. However, the District may be statutorily prevented, for now, from further reducing levels of pumpage from the Edwards Aquifer beyond those in the proposed DHCP, notwithstanding the desire to "guarantee" springflows that are demonstrably associated with ecological health of the covered species. Nevertheless, the proposed measures offer the highest possible probability of survival of the species with respect to springflow quantity and composition. Mitigation measures necessary to provide protection for covered species would also be implemented, including measures to assist in the recovery of the covered species, an adaptive management program, and the financial and legal commitments to implement the proposed DHCP.

This PDEIS and integrated DHCP will be subject to review and comment by any citizen, organization, or public entity, upon notice of its availability by the Service, and that review will result in revisions to be published in the succeeding months as a Draft EIS (DEIS) and revised Draft HCP. The DEIS and revised Draft HCP will again be submitted for public review and comment before any actions are taken by the Service on the proposed ITP. If the Service ultimately approves the final HCP, the agency would authorize incidental take of the listed species covered by the plan through the issuance of an ITP and the production of the Final EIS. The ITP would evidence and ensure compliance under the ESA for the District and permitted well users, provided that the District consistently implements the final HCP.

Comments on the DHCP/PDEIS are due 45 days from the date the notice of availability is published in the *Federal Register*. (As of August 2007, no date has yet been set for publication in the *Federal Register*.) Once the publication date has been set, comments should be sent to the Service at the address below at right.

Additional information regarding the HCP process can be obtained from the following:

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Chapter 1
Purpose and Need for Action

1.1 Purpose of Proposed Action

The proposed federal action is the issuance of an Incidental Take Permit under section 10(a) of the Endangered Species Act. The purpose of the proposed action is to develop a long-term regional habitat conservation plan (HCP) that will enable continued regulated use of groundwater from the Barton Springs segment of the Edwards Aquifer in support of a regional economy while protecting the Barton Springs ecosystem and the federally listed species that it supports.

1.2 Need for Proposed Action

The Barton Springs segment of the Edwards Aquifer is dependent on rainfall for recharge, especially creek flow in streams that cross the recharge zone. Discharge from the aquifer is through springflow and wells. Only the discharge from wells is controllable. At current pumping levels and future levels anticipated by the Barton Springs/Edwards Aquifer Conservation District (District, also BSEACD in citations), withdrawals from the Edwards Aquifer under extended and severe drought conditions could adversely impact listed species. Without the proposed action, the District could face significant difficulty in balancing its state-mandated management functions and goals of regulating the water resources of the Barton Springs segment of the Edwards Aquifer.

Compliance with the Endangered Species Act, as amended (ESA), is necessary inasmuch as water withdrawals from the Barton Springs segment of the Edwards Aquifer are regulated by the District under provisions of Chapter 36 of the Texas Water Code. Without the proposed action (issuance of an Incidental Take Permit [ITP] under section 10(a) of the ESA), the District could face significant risks in meeting its mandated functions and goals under Chapter 36, if reduced or no springflows resulting directly from District actions led to unauthorized "take" of the listed species. Section 9 of the Act prohibits "take" of any federally listed endangered or threatened species that has not been authorized through a permit issued under section 10(a)(1)(B). Take, as defined by the

Act, means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Harm is further defined as “significant habitat modification or degradation where it actually kills or injures wildlife by significantly interfering with essential behavioral patterns including breeding, feeding and sheltering” (50 CFR 17.3). Disturbing or destroying endangered species habitat, in areas where those species occur, could potentially be in violation of the Act if the species are prevented from breeding, feeding, or sheltering and ultimately leads to the death or injury to a member of the species. If it is not possible to change a proposed action to avoid take of a listed species, a non-federal entity may request a permit under section 10(a)(1)(B) that would authorize take of the species. The U.S. Fish and Wildlife Service (Service, also USFWS in citations), under the limited circumstances described in section 10(a), may issue permits to take endangered wildlife species incidental to otherwise lawful activities.

The ESA further provides in sections 11(a) and (b) civil and criminal penalties for violation of the provisions of the ESA, including fines and imprisonment. Without the issuance of an ITP under section 10(a), those entities withdrawing water from the aquifer would be potentially exposed to these provisions of the ESA.

1.3 Background

1.3.1 Federally Listed Species

The Barton Springs salamander (*Eurycea sosorum*), federally listed as endangered, is supported by springflow from the Barton Springs segment of the Edwards Aquifer (Figure 1.1-1). It is limited to specific locations of the Barton Springs ecosystem including the Main (Parthenia) Spring, Barton Springs Pool, Eliza Spring, Old Mill (Sunken Garden or Zenobia) Spring, and Upper Barton Spring.

The Austin blind salamander (*Eurycea waterlooensis*), a candidate for federal listing, inhabits subterranean locations of the Barton Springs segment of the aquifer but has also been found sporadically at the spring discharge locations of the Main Spring, Eliza Spring, and Old Mill Spring.

In 1992, two University of Texas scientists filed an emergency petition with the Service seeking federal protection for the Barton Springs salamander. The Service has authority to list wildlife under the ESA and enforce provisions of the ESA to protect those species that are listed. In 1997, the Service listed the Barton Springs salamander as an endangered species.

The primary threats to the salamanders include loss of springflow, degradation of water quality, modification of surface habitat, lack of regulatory mechanisms to protect water quality and quantity in the Barton Springs watershed, and increased vulnerability due to a

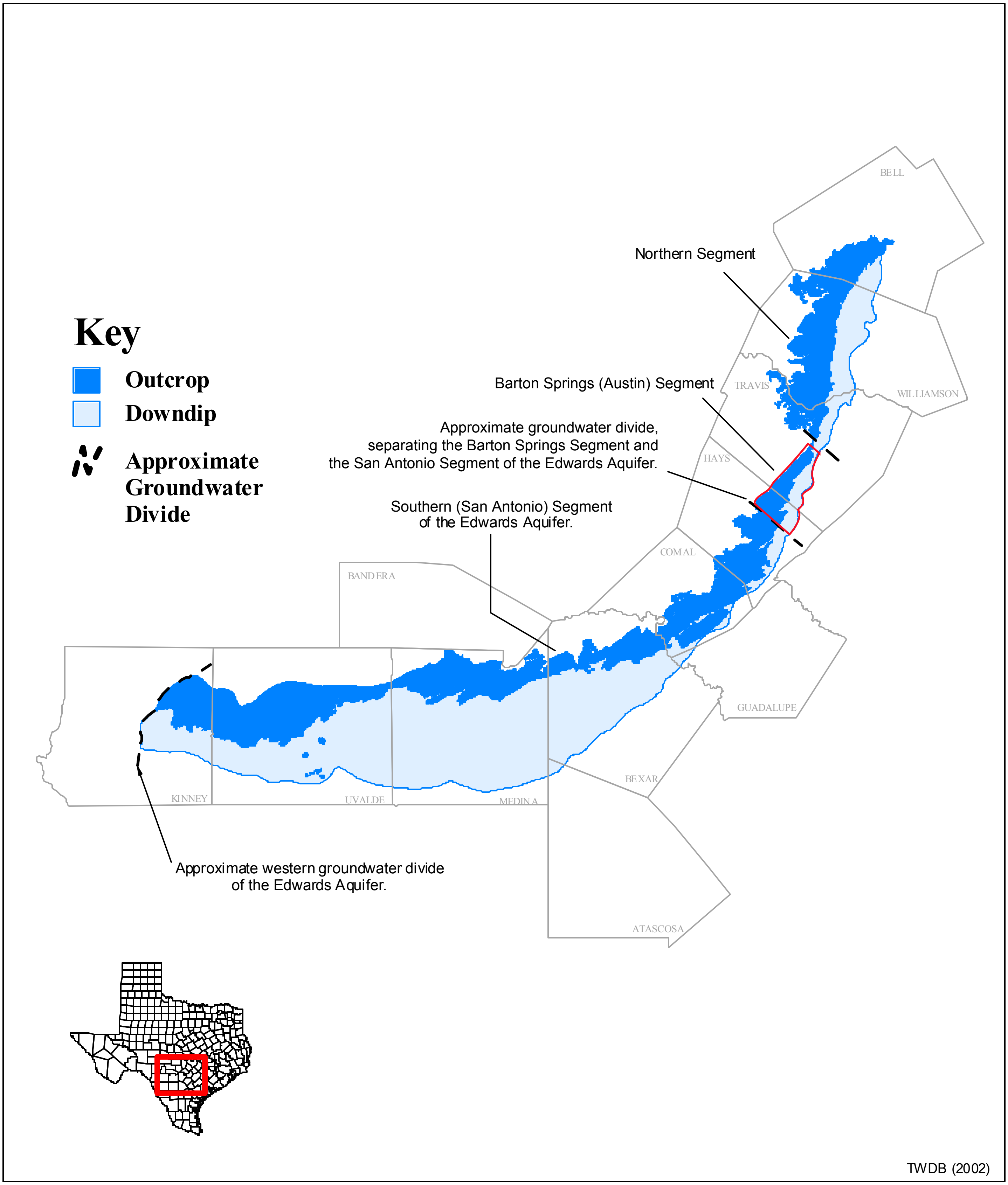

Figure 1.1-1
Map of the Edwards Aquifer

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AND PLANNING
CONSULTANTS

range restricted to an entirely aquatic environment (USFWS 2005a). Springflow loss is the combined result of naturally fluctuating rainfall patterns that affect recharge and of regional pumping, with its associated temporal drawdown of the aquifer. Taken in aggregate across the region, groundwater pumpage is continuous and varies only within the upper end of the pumpage range. At a pumping level of 10 cubic feet per second (cfs), which is only slightly more than current levels of pumpage, springflow has been predicted to substantially decline to flows of 4 cfs or lower (well below long-term average flows), if a drought equivalent to the drought of record should occur.

The Edwards Aquifer is that portion of an arcuate belt of porous, water-bearing, predominantly carbonate rocks known as the Edwards and Associated Limestones in the Balcones Fault Zone. It is a major aquifer in Texas that currently serves more than two million people with their primary source of water (BSEACD 2005a).

The HCP Planning Area (Figure 1.1-2) relates only to that small part of the Edwards Aquifer designated as the Barton Springs segment. The Planning Area includes both the area of the aquifer itself and upstream areas that contribute recharge to the segment. This area includes rapidly increasing amounts of urban and suburban land use in addition to substantial undeveloped land. The Barton Springs segment of the Edwards Aquifer covers approximately 155 square miles (Slade et al. 1985) and extends over parts of Travis, Hays, Bastrop, and Caldwell Counties. The aquifer provides municipal, industrial, agricultural, and domestic uses for about 50,000 people (BSEACD 2005a). Approximately 80 percent of the aquifer is unconfined; the remainder is confined (Slade et al. 1985). The population within the five most populous counties in the HCP Planning Area—Bastrop, Blanco, Caldwell, Hays, and Travis—is expected to increase by more than 96 percent, or nearly one million people, between the years 2000 and 2040, with a concurrent increase in overall water demand. However, an appreciable amount of this water demand will be met by surface-water sources (Texas Water Development Board [TWDB] 2004a).

Before the District was created in 1987, there was no authority or ability to manage the amount of pumpage from the Barton Springs segment of the Edwards Aquifer. Not until the District adopted a Groundwater Management Plan and rules were promulgated, a permit program was fully operational, and meters were placed on the permitted wells in 1990 did the District have any actual way to manage groundwater production. The District's scientific, regulatory, and educational programs have been a positive force for sound groundwater management in its jurisdictional area since then. Pursuant to continued excellence in groundwater stewardship and management, the District has now applied for the ITP and prepared the HCP and its preliminary draft Environmental Impact Study (PDEIS) voluntarily, and it is proposing to implement its provisions in a proactive manner.

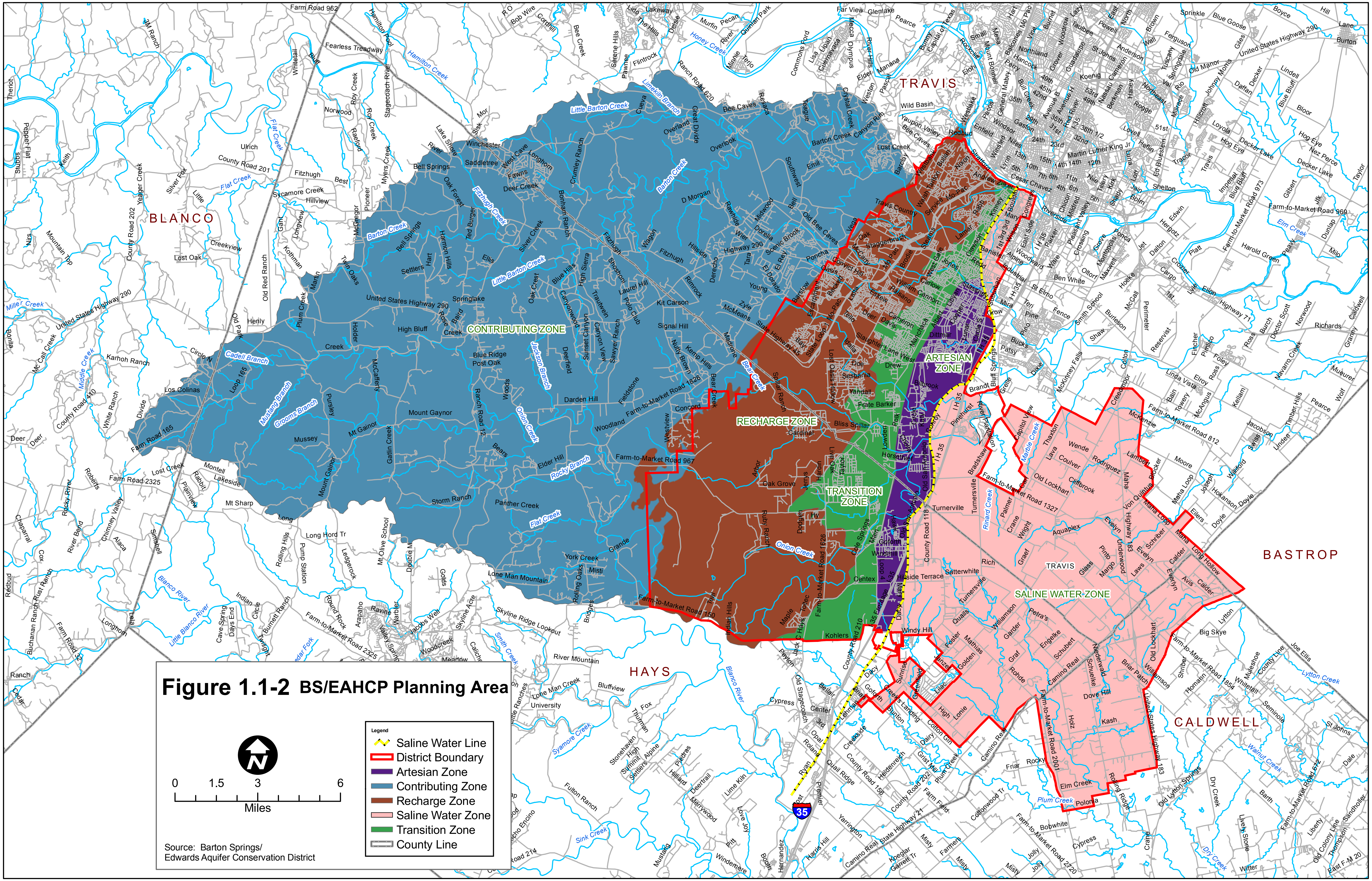


Figure 1.1-2 BS/EAHCP Planning Area

1.3.2 Administration of Rights to Withdraw Water from the Barton Springs Segment of the Edwards Aquifer

1.3.2.1 The Rule of Capture

In Texas, the administration of water rights is dependent on the type of water in question—surface water or groundwater. Surface water is governed by the "appropriation doctrine." According to this doctrine, the State of Texas owns all water in streams and rivers and grants permission to use it through an administrative process. An important feature of the appropriation doctrine is seniority, determined by the date on which the user first began drawing the water.

Since 1904, administration of groundwater has basically occurred in Texas under the common law "Rule of Capture." Under this rule an owner of land may drill a well to seek groundwater, withdraw any groundwater that may be encountered, and place the water to beneficial use without limitation as to amount, place, or purpose of use without incurring any liability to the owner of an adjacent well.

Although the Rule of Capture remains in effect, groundwater conservation districts may through rulemaking modify the operation of the Rule of Capture within their boundaries. Districts may limit aquifer withdrawals under the specific authorities provided by Chapter 36, Subsection 36.101 of the Texas Water Code in order to conserve, preserve, and protect groundwater or groundwater recharge.

1.3.2.2 Organization and Function of the Barton Springs/Edwards Aquifer Conservation District

The Barton Springs/Edwards Aquifer Conservation District was created in 1987 by the 70th Texas Legislature as a groundwater conservation district under Chapter 36, with a directive to conserve, protect, and enhance the groundwater resources of the Barton Springs segment of the Edwards Aquifer, which currently serves as either a sole source or a primary source of drinking water for more than 50,000 people. It also provides water for Barton Springs, Barton Springs Pool, and their associated spring-dependent species. A confirmation election was held on August 8, 1987, with about 80 percent of the voters casting favorable ballots, thus affirming the District.

Under its enabling legislation, the general jurisdiction of the District wherein it asserts its water quantity management authority for the Barton Springs segment of the Edwards Aquifer extends to the unconfined (recharge) zone and the confined zone of the segment. The District's jurisdictional area is bounded on the west by the western edge of the Edwards Aquifer outcrop and on the north by the Colorado River. The eastern boundary is generally formed by the easternmost service area limits of the Creedmoor-Maha, Aqua-

Texas Water Services, and Goforth Water Supply Corporations. The District's southern boundary is generally along the established groundwater divide or "hydrologic divide" between the Barton Springs and the San Antonio segments of the Edwards Aquifer. This area includes the locations of all wells in the Barton Springs segment and also the locations of the natural outlets of the aquifer at Barton Springs and several other smaller springs along the Colorado River. While the jurisdictional area is defined by boundaries of the Edwards Aquifer, the District regulates groundwater from all aquifers in this area. This is a multicounty jurisdiction and includes parts of Bastrop, Caldwell, Hays, and Travis Counties; most Edwards groundwater production is in northern Hays and southern Travis Counties. The HCP Planning Area includes these areas but also includes the contributing zone upstream of the jurisdictional area. However, the area to be covered by the ITP is only the District's jurisdictional area, not the entire HCP Planning Area.

The District has the authority to undertake various studies and implement structural facilities and non-structural programs to achieve its statutory mandate. The District has rule-making authority under Chapter 36 of the Texas Water Code as specified above to implement its policies and procedures and to help ensure the management of the groundwater resources.

A five-member Board of Directors, elected by the population in the jurisdictional area, for staggered four-year terms, oversees the District's work. Under state law, only two of the directors can represent incorporated areas of the City of Austin. Three directors must reside in rural areas of the District. The board meets at least bimonthly. All board and advisory committee meetings are open to the public. Directors hire a general manager, who acts as the chief operating officer. The general manager employs a technical staff to administer programs, monitor and manage the aquifer, and carry out research in support of the District's programs. The board sets policies and adopts rules and bylaws to operate the District. The Board also appoints *ad hoc* advisory committees to review various activities and procedures and make recommendations to the District. These committees are made up of local citizens who are knowledgeable about environmental and economic concerns within the District as well as technical specialists in various fields.

Wells drilled inside District boundaries must follow the rules and regulations outlined in the District's *Well Construction Standards Manual*. The manual details generally accepted drilling procedures, practices, and construction specifications for Edwards Aquifer wells and for wells that penetrate the Edwards Aquifer for production in other aquifers.

Wells in the District may be either exempt from permitting or non-exempt and therefore require permits. Non-exempt use is further classified according to whether it is historical use or conditional use. These classifications of the groundwater user community, including how each of them is defined and generally how they are regulated, are described in detail below in Section 1.2.3.4. A hydrogeologic report (or pump test) may be required as part of the application for a pumping permit, increase in pumping in a permit, or when constructing, drilling, or modifying non-exempt wells. Planning and implementation of the aquifer test is closely coordinated with District staff; however, the groundwater professional conducting the investigation is solely responsible for the accuracy and validity of the test.

In accordance with District rules, non-exempt well owners may only withdraw groundwater from wells under a current permit and must develop both a User Conservation Plan (UCP) and User Drought Contingency Plan (UDCP) as part of the permit. The UCP outlines daily usage guidelines that, when followed, will maximize the utility of water withdrawn from the aquifer. The guidelines are to be implemented at all times and may only be replaced by more restrictive requirements during declared drought periods, as outlined in the UDCP. The UDCPs must be prepared and adopted consistent with applicable District Rules. The UCPs and UDCPs are described in detail in Section 6.1.3.

The District has adopted a Groundwater Management Plan (BSEACD 2003) in partial fulfillment of the requirements of SB 1, SB 2, and TWDB rules, specifically Texas Administrative Code (TAC_1), Chapter 356 (Title 31 TAC_1 Section 356). There are 13 specific planning elements required in the Groundwater Management Plan, and goals, objectives, performance standards, and tracking methods are required to be established for seven management goals. These requirements are detailed in the plan. The Groundwater Management Plan also incorporates relevant regional water management strategies outlined in the Regional Water Plan developed by the Lower Colorado Regional Water Planning Group. All rulemaking by the District must be based on its statutory authority and its prevailing Management Plan. Once the HCP is finalized, as evidenced by issuance of an ITP, the District's Management Plan will be revised, as necessary, to incorporate all measures to be implemented by the HCP.

1.3.2.3 Sustainable Yield Policy on Aquifer Withdrawals

Based on the findings of a District report entitled *Evaluation of Sustainable Yield of the Barton Springs Segment of the Edwards Aquifer, Hays and Travis Counties, Central Texas* (BSEACD 2004), the District's Board of Directors accepted a sustainable yield estimate of 10 cfs for periods of severe drought in October 2004 (BSEACD 2005a). The District Management Plan states that 10 cfs of pumping will be the aquifer pumping limit on which the District will base its policies. Pending the results of future studies by the District, including those under the HCP, revisions to this pumping limit may be made. The establishment of the sustainable yield in the course of the HCP development triggered the promulgation and implementation of the interruptible-supply conditional permitting program, as described in the following section.

1.3.2.4 Groundwater User Community

More than one thousand water wells exist in the jurisdictional area of the District, and hundreds more exist in the HCP Planning Areas outside the District boundaries. The large majority of wells in the District only draw water from the Edwards Aquifer. Moreover, usage of other aquifers in the District is currently very small. Nearly all of the known wells in the District are registered with the District, and most are small-volume users, typically individual households.

The District classifies the registered wells into several categories of users, and the category classification determines whether and how the District regulates its groundwater use.

Exempt Wells and Users

An exempt well is exempt from the District's permitting program and therefore has no authorized pumpage level set by the District. There are more than 900 exempt wells in the District. Exempt wells generally use only small volumes of groundwater, but they are subject to District Rules concerning avoidance of waste, pollution, and excessive use. By definition, an exempt well has the following restrictions on its usage:

A. Domestic supply – 1) may only be used to supply the domestic use needs of 5 or fewer households (where a person who is a member of each such household is either the owner of the well, a person related to the owner, a member of the owner's household within the second degree by consanguinity, or an employee of the owner); 2) must be either drilled, completed or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day (0.0155 cfs); and 3) must be located on a tract larger than 10 acres; or

B. Livestock or poultry supply – 1) may only be used for providing water for livestock or poultry; 2) must be drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day; and 3) must be located on a tract of land larger than 10 acres.

Exempt wells are mostly used as water supplies for livestock (including windmill-powered wells) and for residences on ranch or farm lands. Most current exempt wells existed at the time the District was formed in 1987. Exempt wells are generally equipped with pumps of less than 1 horsepower, which produce no more than about 6 to 7 gallons per minute (0.02 cfs). These wells usually are not metered and are not charged for their water at any time. Most new wells will not meet the criteria to be exempt.

Non-exempt Domestic Use Wells and Users

A non-exempt domestic use (NDU) well is a well used by, and connected to, a household for personal needs or for household purposes such as drinking, bathing, heating, cooking, sanitation or cleaning, and landscape irrigation. NDUs operate under a "general permit by rule" and apply to wells that were drilled and completed on or after August 14, 2003.

These wells must be on a single-ownership plot smaller than 10 acres in size that contains a household and not use more than 500,000 gallons per year (0.002 cfs). NDUs must have meters, and the owners must report water usage monthly. No water use fee is charged to NDUs for water withdrawals, but the District does charge their users a permit fee. NDUs have UCPs and UDCPs as well. The District has about 30 NDUs.

Non-exempt Wells and Users

All other wells are classified as non-exempt wells. These wells are required to have permits from the District, are metered, and report water use monthly. In 2006, users of non-exempt wells paid a water use fee of $0.17 per 1,000 gallons of water used. The District had about 90 non-exempt permittees, not including NDUs. It is estimated that in 2006, almost 90 percent of all the groundwater withdrawn in the District was by non-exempt wells.

Non-exempt wells are categorized by usage: agricultural, commercial, industrial, irrigation, and public water suppliers. The permittees include churches, office parks, quarry operations, schools, community athletic fields, municipalities, and water supply companies. By far, the largest use is for public water supplies. The type of use is one determinant of the provisions that the District Board considers when it examines the permittees' UCPs and UDCPs.

An important distinction among non-exempt wells is based on whether or not they were registered with the District and had authorized groundwater production permits approved by the District as of September 9, 2004. Wells that meet these criteria are classified as historic-use wells. Historic-use wells are required to curtail their authorized monthly pumpage by 20 and 30 percent during Alarm and Critical Stage droughts, respectively. Wells that received permits after September 9, 2004, are classified as conditional-use wells. The distinction is important because conditional-use wells are authorized only on an interruptible supply basis. They have UDCPs that provide for pumpage curtailments of 50, 75, or 100 percent of their authorized monthly usage during declared droughts. Any permit amendments after September 9, 2004, that authorize an increase in the volume of groundwater, including amendments of historic-use permits, are also subject to conditional-use rules for the increase.

1.3.3 Incidental Take Permit and Habitat Conservation Plan

The District is applying for an ITP from the Service to allow incidental take of the previously described federally listed endangered species and one candidate species, under section 10(a)(l)(B) of the ESA. This take will be incidental to otherwise lawful activities that would occur as a result of water withdrawals within the jurisdiction of the District. These withdrawals are necessary for domestic and livestock, irrigation, municipal, industrial, and monitoring well uses, within the Barton Springs portion of the Edwards Aquifer (Figure 1.1-1).

The ITP application includes documentation, contained in this PDEIS, that complies with the application requirements of Title 50 of the *Code of Federal Regulations* (50 CFR) 17.22(b)(l) for an ITP under section 10(a)(1)(B) of the ESA. This documentation identifies the impacts of the proposed take; describes how the impacts will be minimized, monitored, and mitigated through the District's DHCP; and demonstrates that measures identified in the District's DHCP will not appreciably reduce the likelihood of the survival and recovery of the species in the wild. The DHCP is contained in Chapter 6 of this PDEIS. It is supported by various technical appendices, comprising Volume Two of the PDEIS documentation.

1.4 Scoping Issues and Concerns

1.4.1 Scoping Process

The process to identify the scope and contents of the Preliminary Draft EIS (PDEIS) and Draft HCP was formally initiated on August 9, 2005, with publication of the Notice of Intent to prepare an EIS and HCP in the *Federal Register* (Volume 70, number 152, page 46186). A scoping meeting was held in Austin, Texas, on August 23, 2005.

1.4.2 Public Involvement

1.4.2.1 Public Scoping Meetings

The public scoping meeting held on August 23, 2005, produced two letters and a total of 40 comments. Table 1.5-1 contains a summary of the issues raised by these comments, with the corresponding number of comments received on each issue. The list is useful in identifying common issues of concern and the general level of concern for each issue.

Table 1.4-1. Summary of results from public scoping meeting of August 23, 2005 and letters received

Issue Categories	Number of Comments
Groundwater flow routes need study	1
Need to protect prey species in aquifer; uncertainty as to how flow changes will impact species and food base	2
Biodiversity unknown, evidence of genetic links between Barton Springs and San Marcos salamander species	3
Consider 1950's drought impacts; restrict water usage during times of drought; CAC should help revise District's Drought Trigger Methodology	4
More outreach needed to make process understandable, alternatives should be described early in HCP process; initial CAC meeting and scoping meeting of the Service on August 23, 2005 were designed to inhibit and manage discussion, as well as information flow; facilitation of communication between the members of the CAC needed; facilitate communication between BAT and CAC; input of the CAC and the BAT is already improperly constrained	7
Investor-owned water utility must balance limiting aquifer pumping against obligation to serve demand under state law	1
Role of conjunctive use in HCP	1
New road and water infrastructure in aquifer contributing and recharge zones needed to serve growth is too expensive, better to use money to buy land and preserve	4
County land regulation authority needed; conservation development emphasis needed	2
Sprawl development subsidizes growth; acquisition of open space needed over the recharge zone and within the service area of the District; address growth served by groundwater	3
Economic impact of pumping limits needs study	1
Sustainable population concept should be considered	1
District should use pricing to manage groundwater via market; greater water conservation from District customers needed	2
Expand scope to address synergistic effects of pollution and water quantity/quality in more detail	1
Pesticides and sedimentation are main threats to species; habitat stressors also include reduced springflows, oxygen content, toxic pollutants including petroleum by-products	2
To the maximum extent practicable, minimize and mitigate the impacts of taking and assure that the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; over-reliance on adaptive management to make up for inadequate up-front planning does not meet the legal requirements of the ESA	2
EIS should examine in detail the stochastic risk of species extinction; impact of any authorized take should be minimized by establishing minimum springflows that are clearly sufficient to ensure the continued survival and recovery of the species	2
Captive breeding and off-site refugia are not reliable or legally adequate means of ensuring the continued survival of the species in the wild	1
TOTAL	40

CAC = Citizens' Advisory Committee
HCP = Habitat Conservation Plan
BAT = Biological Advisory Team
ESA = Endangered Species Act
EIS = Environmental Impact Study
Source: Service, draft comments from BSEACD HCP EIS scoping, 09/07/05

1.4.2.2 Advisory Bodies

Two ad hoc advisory bodies were employed during the development of the Draft HCP. The passage of Senate Bill 1272 during the 76th Texas Legislature in 1999 requires the District to appoint a citizens' advisory committee (CAC) to assist in preparing the regional HCP and the application for an ITP. The purpose of the CAC is to assist in determination of the scope of the HCP, advise the District in development of the HCP, review and recommend mitigation measures and other HCP conditions, provide a forum for public discourse and conflict reconciliation, help meet public disclosure requirements, oversee HCP progress and development, and build consensus among diverse organizations and interests. Accordingly, a panel was appointed by the District in a manner to assure representation by a cross section of affected interests in the Edwards Aquifer region. Participants include private landowners; irrigators; water purveyors; private consultants; representatives of conservation and environmental organizations; representatives from major cities; federal, state, and local governmental agencies; and universities.

Senate Bill 1272 also requires the District

> …together with the [Texas] Parks and Wildlife Commission (commission) and the landowner members of the citizens advisory committee, to appoint a biological advisory team (BAT). Requires at least one member to be appointed by the commission and one member by the landowner members of the citizens advisory committee. Provides that the member appointed by the commission serves as presiding officer of the team. Requires the team to assist in certain studies [the calculation of harm to the endangered species and the sizing and configuring of habitat preserves].

The District appointed a committee to fulfill this function, comprising scientific and technical specialists with knowledge of the ecosystems and endangered species of interest.

A complete listing of the CAC and BAT members is included in Appendix A, Participating Individuals and Organizations.

1.4.3 Scope of the Draft Environmental Impact Study

Issues and concerns raised through the public involvement and scoping process contributed to the development of the overall scope of this PDEIS, in conjunction with an evaluation of the potential for significant impacts on the affected environment. After assessing the potential for adverse impacts to federally listed species and other environmental resources (described in Chapter 3 of this PDEIS), the Service has determined that the following areas could potentially be adversely affected by the proposed action: biological resources; water quality/resources; agricultural resources; cultural resources; land use; recreation; social and economic resources; and air quality. All of these issues are analyzed in depth in this PDEIS.

Chapter 2
Alternatives Including the Proposed Action

This chapter describes the three major alternatives considered in the development of this DHCP and PDEIS. It is divided into four sections. Section 2.1 outlines the process used to formulate the alternatives. Section 2.2 outlines alternatives that were considered and ultimately eliminated from further consideration. Section 2.3 presents a description of each alternative considered in detail, including the proposed action. Section 2.4 compares the impacts and potential mitigation for each of the alternatives. This chapter includes the information needed to comply with 50 CFR 17.22(b)(I)(iii), which requires that the Service determine: "What alternative actions to such taking the applicant considered and the reasons such alternatives are not proposed to be utilized."

2.1 Process Used to Formulate the Alternatives

In 2004 the District Board of Directors created an HCP subcommittee composed of two board members to guide and supervise development of the HCP in order to secure a regional ITP under the ESA. In early 2005, stakeholder groups including a CAC and BAT were formed to assist in the HCP development. These groups have been involved in the process of formulating alternatives.

The District's proposed HCP represents an implementable program to attain maximum practicable protection of the endangered species of concern while allowing for continuing utilization of the water resources of the Barton Springs segment of the Edwards Aquifer. It establishes a combination of regulatory and mitigation measures to protect and sustain natural flows from Barton Springs.

The proposed action (reflected in the District's HCP, contained in Chapter 6 of this PDEIS) and a set of alternatives, including mitigation measures and monitoring requirements, were developed to meet the purpose, need, and the stated project objectives, to address issues raised by the public during the scoping process, to resolve Service concerns related to the issuance of a permit, and to take advantage of existing opportunities to implement some measures of the District's HCP in advance of the ITP. The proposed action has been developed within the framework of the water management planning process required by Chapter 36, Texas Water Code, and is also consistent with the State of Texas's regional water planning process.

2.2 Alternatives Eliminated from Further Consideration

In developing the District's proposed HCP for the Barton Springs segment of the Edwards Aquifer, several potential alternatives were considered but not carried forward as viable alternatives in this analysis, because they 1) overlapped or were redundant with existing alternatives identified and evaluated in this PDEIS; 2) required enforcement or other regulatory actions beyond the statutory authority of the District; or 3) did not meet the purpose and need identified in Chapter 1. Alternatives eliminated from further consideration are discussed in Sections 2.2.1 through 2.2.3 below.

2.2.1 Regional Water Quantity or Quality Protection Plans Proposed by Local Entities and Conservation Groups

2.2.1.1 Edwards Aquifer Protection Plan

This plan was developed in 2003 by the Greater Edwards Aquifer Alliance and has been endorsed by a number of conservation and aquifer protection groups. The plan addressed protection of water quantity and quality over the entire Edwards Aquifer. Protection measures in this plan focused on recommendations for land acquisition and incentives to discourage development over the aquifer. Many of the provisions of this plan require implementation and enforcement of regulatory measures involving land use restrictions and impervious cover limits, water conservation measures, prohibition of interbasin transfer of water, and limitations in extending water lines to rural and low density areas over the recharge and contributing zones. Portions of this plan were not feasible for further evaluation because implementation and enforcement of many of these measures were beyond the regulatory authority and jurisdiction of the District.

2.2.1.2 Regional Water Quality Plan for the Barton Springs Segment of the Edwards Aquifer and its Contributing Zone

A water quality protection plan for the Barton Springs segment of the Edwards Aquifer was developed in 2005 by a consulting team led by Naismith Engineering Inc. for a number of local governmental entities (Naismith Engineering 2005), in cooperation with a citizen committee. These included the cities of Dripping Springs, Austin, Buda, Kyle, Rollingwood, Sunset Valley, Village of Bee Cave; counties of Blanco, Hays, and Travis; and the Barton Springs/Edwards Aquifer Conservation District, Hays Trinity Groundwater Conservation District, and Blanco-Pedernales Groundwater Conservation District.

The principal goal of this plan is the protection of water quality. Protection measures identified by this plan include natural area conservation; transferable development rights; comprehensive site planning and pre-development review; establishment of buffer zones adjacent to sensitve areas; establishment of impervious cover limits; greater control of stormwater runoff including structural Best Management Practices (BMPs) for discharges from developed land; enforcement of construction site controls; water conservation; restrictions on use, storage; and disposal of hazardous materials; proper vegetative management and agricultural practices; protection of endangered species; and public outreach. This regional plan was not carried forward as an alternative because water quantity was not a major focus of the plan, many of the water quality protection measures either were beyond the legal authority of the District or were redundant with alternative measures that are evaluated in this PDEIS, and the geographical coverage of the plan did not correspond with the District's jurisdictional area.

2.2.2 Extending the Existing City of Austin Habitat Conservation Plan to Cover Actions of the District

The City of Austin (City) has implemented an approved HCP for the City's management of the Barton Springs Pool as part of the conditions for obtaining a section 10(a) ITP for the Barton Springs salamander (City 1998a). The goal of this plan is to improve salamander habitat, increase population size, and increase life history information over the term of the permit. The City's HCP was not included in the alternatives to be evaluated in this PDEIS because many of the factors creating the incidental take (from the City's operation of Barton Springs Pool) are different from the District's activities. The City's activities under this ITP are more direct and localized in nature, they are beyond the legal authority of the Distrrict to implement, and they require different mitigation measures to lessen impacts than the District's management of the Barton Springs segment of the Edwards Aquifer. However, there are opportunities for cooperative efforts between the City and the District in the implementation of specific measures within the respective HCPs that could mutally benefit the listed species. However, there are also cumulative impacts that must be recognized and accommodated between the two HCPs, as discussed further in Section 4.11.2.5.

2.2.3 Conservation Agreements, Land Acquisition, or Other Management Strategies Not Requiring Consultation Under the Endangered Species Act

Chapter 83 of the Texas Parks and Wildlife Code was amended in 1999 by the 76th Texas Legislature (Senate Bill 1272) to provide for "Conservation Agreements for Protection of Species." Subsection 83.005, paragraph (b) provides that a Conservation Agreement "includes an agreement between the state or political subdivision of the state and the United States Department of the Interior under the federal act that does *not* relate to a federal permit." Subsection 83.012, paragraph (2) encourages governmental entities to develop and implement HCPs (defined as a plan that does not require acquisition or regulation of land) rather than regional HCPs (defined as a plan requiring acquisition or regulation of land) to avoid acquisition or regulation of land or interests in land not owned by the plan participant or sponsor. Development of an HCP for endangered or threatened species under the state guidelines provided by Chapter 83 of the Texas Parks and Wildlife Code does not account for the need to also address requirements and provisions of the federal ESA.

The ESA provides civil and criminal penalties for violation of the provisions of the ESA, including fines and imprisonment. Without the issuance of an ITP under section 10(a), entities or individuals withdrawing water from the aquifer would be potentially exposed to violations of the ESA. In light of this potential federal liability under the ESA, alternatives involving conservation agreements, land acquisition, or implementation of management strategies that are not protected by a section 10(a) ITP do not meet the purpose and need for the proposed action. Either these alternatives have been eliminated from further consideration, or certain selected measures have been incorporated into the HCP.

2.2.4 Other Alternative Measures

Several other specific HCP measures or actions were initially considered, but later dropped from consideration in the alternatives analysis. These are discussed below.

2.2.4.1 Acquisition of Land to Protect the Edwards Aquifer

This action was initially considered as a measure to protect the contributing and recharge zones of the Barton Springs segment of the Edwards Aquifer by designating the acquired land for preservation and management in its natural state. This would have precluded future development and conversion of the acquired land into urban and residential use and resulting adverse effects on groundwater quality and recharge. However, the District cannot legally purchase land outside its jurisdictional boundaries for any reason, and the entire contributing zone is outside the District boundary. Further, the District does not have sufficient funding for the purchase of enough land within the recharge zone to provide appreciable protection benefits. However, the District's provision of technical assistance to other entities in their acquisition of land within the recharge zone and within its jurisdictional boundaries remains as an alternative measure for consideration in the PDEIS.

2.2.4.2 Brackish Water Desalination

The use of brackish water desalination to augment existing water sources was determined not to meet the purpose and need as an HCP alternative measure. Even if adaptive management studies prove that desalination is feasible, desalination projects could not be completed in time to be considered as HCP measures and would not have any beneficial impact for many years.

2.2.4.3 Initiation of an Emergency Response Period Triggered by a Declaration from United States Fish and Wildlife Service

Early consideration was given to limiting aquifer pumping during a declared emergency response period (ERP) that would be triggered by actions of the Service at such time that it believed springflows were reaching critical levels. This alternative approach did not meet the HCP purpose and need, as such action would conflict with statutorily mandated aquifer management responsibilities of the District and would be redundant with current or proposed aquifer pumping limitation alternative measures considered in this PDEIS/HCP.

2.3 Alternatives Considered Including the Proposed Action

Three alternatives are analyzed in detail in this chapter and in other sections of this PDEIS document: no action (Alternative 1), a preferred action using best practicable and attainable measures (Alternative 2), and a regional permit with maximum conservation measures (Alternative 3). These alternatives are described in detail below. Each alternative incorporates measures identified by numbers that correspond with the measures in Table 2.3-1, HCP/PDEIS Alternative Measures. Each of these measures is more fully described in Appendix B.

The proposed action (represented by the DHCP) is contained in Chapter 6 of the PDEIS documentation. After the three alternatives were developed and evaluated as described in the PDEIS documentation (see, in particular, Chapters 2 and 4 for an evaluation of the alternatives), the proposed action measures were then refined and developed in greater detail over the course of several more months, culminating in the completion of the DHCP (see Chapter 6).

Table 2.3-1. DHCP/PDEIS alternative measures

Existing or Potential Alternative HCP Measures	Alternative[1]		
	1	2	3
1.0 MEASURES UNDERTAKEN DURING ALL CONDITIONS			
1.1 Establish and Implement a Permitting Program in the District to Maintain and Improve an Extreme Drought Withdrawal Limitation ("Aquifer Cap")		X	X
1.2 Ongoing/Continuing Demand Reduction Measures			
1.2.1 Implement a new database of registered wells that contains estimates of groundwater withdrawal for a subset of exempt (i.e., non-permitted) wells to better gauge location and amount of pumpage from all exempt wells. [2]	X	X	X
1.2.2 Institute a new, voluntary metering and water use monitoring program for non-permitted (exempt) wells. [2]	X	X	X
1.2.3 Require nonexempt users (permittees) to identify and encourage them to employ measures in their adopted User Conservation Plans (UCPs) and User Drought Contingency Plans (UDCPs) so that they may voluntarily achieve at least a 10% reduction during the summertime Water Conservation Period, and encourage all other groundwater users to implement similar conservation measures. [2]	X	X	X
1.2.4 Require permittees to identify and commit to mandatory measures in UDCPs to achieve specified levels of curtailment during District-declared drought. [2]	X	X	X
1.2.5 Conduct a continuing water conservation and demand reduction education program with a specified minimum budget directed at all groundwater users in the District. [2]	X	X	X
1.2.6 Seek authority for, and if successful implement, higher water use fees for non-exempt groundwater users as necessary to promote conservation and substitution of alternative water supplies for Edwards Aquifer water. [2,3]		X	X
1.2.7 Seek conformance, to the maximum extent legally possible, of the requirements of "Managed Available Groundwater" limits, as established by TWDB, with the limits imposed under this ITP.[4]	X	X	X
1.2.8 Seek authority for, and if successful implement, programs to limit groundwater production by all permittees under certain prescribed conditions. [2,3]		X	X
1.2.9 Work with public water utilities and other governmental entities to enhance plans and regulations that protect both the quantity and quality of Edwards groundwater.[2,4]		X	X
1.2.10 Adopt authorized production limits on a monthly as well as annual basis for all District permittees under all aquifer conditions. [2]		X	X
Subtotal – Continuing Demand Reduction Measures (cfs)	0.5	1.2	1.7

Table 2.3-1. DHCP/PDEIS alternative measures (continued)

Existing or Potential Alternative HCP Measures	Alternative[1] 1	2	3
1.3 Ongoing/Continuing Water Supply Enhancement Measures			
1.3.1 Provide support to recharge enhancement projects of all types, if they are deemed effective and have minimal negative ecological impacts.	X	X	X
1.3.2 Provide support to clean, maintain and protect recharge features in natural drainage-ways in the District.[2]	X	X	X
1.3.3 Provide technical assistance and cooperation in the acquisition of open space in the recharge zone of the Edwards Aquifer.[2,4]		X	X
1.3.4 Promulgate programs to prevent waste, including contamination and excessive use, of groundwater. ***(Note:*** These measures serve to implement those actions described in Measure 1.2.8 above).[2]		X	X
Subtotal – Continuing Supply Enhancement Measures (cfs)	0.4	0.8	1.8
1.4 Ongoing/Continuing Water Supply Conversion Measures			
1.4.1 The District will initiate, support, and participate in conjunctive use initiatives to increase use of surface water supplies with existing Edwards groundwater providers in the District.[2,3,4]		X	X
1.4.2 The District will initiate planning and assess feasibility of long-range plans, policies and programs concerning designation of defined water management zones with different hydrogeologic and water availability/use situations and incorporate them in a revised Groundwater Mangement Plan.[2,3,4]	X	X	X
1.4.3 Initiate, support, and participate in policies and plans to increase use of *other alternative water supplies (e.g., units of the Trinity Aquifer, other aquifers, desalinated water, harvested rainwater)* with existing Edwards groundwater providers in the District.[2,4]		X	X
1.4.4 Seek authority for, and if successful implement, a new regulatory program element that requires existing groundwater users, under certain prescribed conditions, either to convert from Edwards groundwater to alternative water supplies, and/or to encourage such conversion using higher water usage fees and longer term permits as an economic incentive.[2, possibly 3,4]		X	X
1.4.5 Encourage and facilitate the construction of excess pumpage and storage capacity within alternative water supply systems by District permittees, to promote the use of alternative water supplies during drought conditions in lieu of groundwater.[2, possibly 3,4]		X	X
Subtotal – Continuing Supply Conversion Measures (cfs)	0.3	0.8	2.3
ESTIMATED CUMULATIVE EFFECT OF CONTINUING MEASURES DURING NON-DROUGHT (cfs)	1.2	2.8	5.8

Table 2.3-1. DHCP/PDEIS Alternative Measures (continued)

Existing or Potential Alternative HCP Measures		Alternative[1]		
		1	2	3
2.0 ADDITIONAL MEASURES EMPLOYED AFTER DECLARING ALARM STAGE DROUGHT				
2.1	Develop a drought trigger methodology that can be effectively used to signal timely curtailment of groundwater withdrawals.[2]	X	X	X
2.2	Define trigger conditions that require a mandatory 20% reduction in monthly groundwater withdrawals by permittees.[2] ***Alarm Stage*** = 20% reduction when Lovelady Well level is equal to or greater than 180.8 feet from the Land Surface Datum (LSD) or when a 10-day average discharge of Barton Springs is equal to or less than 38 cfs.	X	X	X
2.3	Define additional reductions that will be required of certain conditional production permittees under certain conditions.[2]	X	X	X
2.4	Seek legislation, and if successful implement, authority to apply additional enforcement measures for ensuring/improving drought period compliance with withdrawal restrictions.[2, possibly 3]		X	X
NET EFFECT OF MEASURES EMPLOYED DURING ALARM STAGE DROUGHT (cfs)		2.0	2.8	3.8
3.0 ADDITIONAL MEASURES EMPLOYED AFTER DECLARING CRITICAL STAGE DROUGHT				
3.1	Define trigger conditions that require a mandatory 30% reduction in monthly groundwater withdrawals by permittees.[2] ***Critical Stage*** = 30% reduction when Lovelady Well level is equal to or greater than 192.1 feet from Land Surface Datum (LSD) or when a 10-day average discharge of Barton Springs is equal to or less than 20 cfs.	*X*	*X*	*X*
3.2	Pumping reductions beyond those of Measure 2.3 above and based on drought triggers will be applied to certain (currently undefined) Historic Exempt Users.[3]			X
3.3	Define additional reductions that will be required of certain conditional permittees under certain conditions.[2]		X	X
3.4	Define an Emergency Response Period, deep within the Critical Stage drought period, in which both a) water withdrawals under certain conditional permits may be further curtailed or prohibited, and b) if legislative authority is granted, certain historic use permits not directly essential to human health and welfare may be curtailed.[2]		X	X
3.5	An ***Emergency Response Period*** will begin when the 10-day average discharge of Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days; The District would also order mandatory reductions for all Class A Conditional Permits of 50% for the first 3 months, 75% for the next 3 months, and 100% thereafter, until Barton Springs flow rises above 14 cfs, then the next less severe stage of reduction would be declared until either the 30% use reduction on all permitted wells is reached or the Critical Stage Drought is no longer declared.[2]		X	X

Table 2.3-1. DHCP/PDEIS alternative measures (continued)

Existing or Potential Alternative HCP Measures		Alternative[1]	
	1	2	3
3.0 ADDITIONAL MEASURES EMPLOYED AFTER DECLARING CRITICAL STAGE DROUGHT (CONTINUED)			
3.6 As negotiated in individual conditional-use permits, require mandatory switching to alternative water supplies by groundwater users during an Emergency Response Period, as enabled through prior agreements with current or other water suppliers with excess capacity.		X	X
NET EFFECT OF MEASURES EMPLOYED DURING CRITICAL STAGE DROUGHT (cfs)	2.8	4.2	5.3
4.0 STRUCTURAL MITIGATION INVESTIGATIONS AND MEASURES (To Ameliorate Extreme Conditions That Are Not Able To Be Mitigated By Other Means)			
4.1 Coordinate with the City to investigate feasibility of re-circulating water discharged from Barton Springs to specific habitat protection zones within the spring ecosystem or re-aerating groundwater in the flowpath to Barton Springs during periods of critically low flows.		X	X
4.2 Based on feasibility determined from Measure 4.1 above, a pilot project to re-circulate discharged groundwater to specific habitat protection zones within the spring ecosystem will be planned, designed, and implemented.			X
4.3 A detailed investigation based on results of the HCP Fatal Flaw Study will be performed to determine feasibility of augmenting springflow or elevating dissolved oxygen concentrations using another *groundwater* source.			X
4.4 A detailed investigation based on results of the HCP Fatal Flaw Study will be performed to determine feasibility of augmenting springflow or elevating dissolved oxygen concentrations using *supplemental surface water*.			X
4.5 A project to supplement springflow during severe drought will be planned, designed, and implemented based on 1) feasibility determined from results of investigations obtained by Measures 4.3 and 4.4 above, and 2) other conditions stipulated by the District Board and the City.			X
4.6 The District will seek to enter into an Inter-local Agreement (ILA) between the District and the City to support the Salamander Conservation Program to manage the species during all conditions.		X	X
4.7 Enter into an Inter-local Agreement between the District and the City, under both entities' HCPs, to establish a protocol, including conditions of use, to augment springflow or elevate dissolved oxygen concentrations during periods of severely low springflow or flow cessation.			X
No Quantitative Effect Estimated for Structural Mitigation Measures			

Table 2.3-1. DHCP/PDEIS alternative measures (continued)

Existing or Potential Alternative HCP Measures	Alternative[1] 1	2	3
5.0 ADAPTIVE MANAGEMENT STRATEGIES (To Be Undertaken as Funds, Partners, and Permissions Are Identified – Not Governed by Declared Drought Stage)			
5.1 The District will refine and improve its Groundwater Availability Model (GAM) to serve as a planning and evaluation tool when implementing new groundwater management programs.		X	X
5.2 The District will work with universities, the City, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and toxicity of depressed Dissolved Oxygen and elevated Conductivity levels affecting salamander viability in spring water.		X	X
5.3 Additional studies will be conducted on the potential for the augmentation of water supplies in the brackish water zone (including desalination and aquifer storage & recovery) and from other freshwater (e.g., Trinity aquifer).		X	X
5.4 The District will work with the US Geological Survey, universities, the City, and other qualified parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which will be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events.		X	X
5.5 A survey of aquifer biota will be conducted in sampling wells dispersed throughout the Barton Springs segment of the Edwards Aquifer in order to improve understanding of species richness and diversity.		X	X
5.6 The District will work with universities, the City, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs Ecosystem, and possibly other relevant studies to be determined.		X	X
No Quantitative Effect Estimated for Adaptive Management Strategies			
ESTIMATED CUMULATIVE, MAXIMUM EFFECT OF ALL MEASURES DURING EXTREME DROUGHT (cfs)	4.0	7.0	11.1
(This is the sum of applicable measures in 1.2, 1.3, 1.4, and 3.0; it does not include structural mitigation.)			

[1] See Alternatives definitions* below; [2] Requires authorization from the District Board; [3] Requires authorization from the State Legislature; [4] Requires agreement with another entity.

Alternatives Definitions:

1 - *No HCP; no regional permit; actions by the District and individual pumpers regulated by the District are subject to violation of the Endangered Species Act; represents the No Action Alternative required by NEPA.*

2 - *Regional Permit - Includes HCP with best practicable and attainable measures to protect the species in consideration of cost, regulatory constraints, and political realities; protection for incidental take provided to the District and regulated pumpers under section 10 of the ESA.*

3 - *Regional Permit - Includes HCP with possibly attainable measures that would tend to maximize the protection of the species but with high capital and operating costs and increased uncertainty in obtaining required legislative authorization or approval by other entities for implementation; protection for incidental take provided under the ESA.*

2.3.1 Alternative 1: No Action—Existing Aquifer Management Strategies and Growth of Pumping Demand with No Protection under Incidental Take Permit

Under the No Action Alternative, the aquifer would be managed consistent with the District's existing Groundwater Management Plan (GMP) (BSEACD 2003) and programs as set out in its rules, as mandated by Chapter 36 of the Texas Water Code. This alternative provides a benchmark to which the proposed action as well as the other alternatives can be compared and contrasted. This management scenario would include 1) conformance by 2010 to caps defined by state law and available groundwater determined by the TWDB; 2) phased drought stage reductions in the amount of water that may be used or withdrawn by users of the aquifer during drought periods; and 3) implementation of other water management practices, procedures, or methods consistent with the District's policies and GMP. Aquifer management strategies that would be included under Alternative 1 are listed in Table 2.3-1 and characterized more fully in Appendix B.

2.3.1.1 Measures to Minimize Potential Impacts

Under Alternative 1, No Action, there would be no pumpage limit applied to authorized withdrawals under existing permits. However, future permits issued by the District would be conditional (i.e., an interruptible water supply, as described in Section 1.3.2.4), subject to reductions approved by the District Board. As future unrestricted pumping is neither prudent nor realistically possible, monthly pumpage in Alternative 1 is stipulated to range between 13 and 16 cfs (other, higher levels of pumpage would be possible only if no attention was paid to drought-period water availability, a circumstance considered highly improbable to exist for the current or any future District Board). Moreover, the range stipulated for Alternative 1 is sufficiently different from the ranges likely under other Alternatives to yield a valid alternatives impact analysis and related alternatives comparisons.

The primary strategic measure for managing groundwater withdrawals during drought in Alternative 1 is the definition and use of drought triggers. The current triggers were developed as part of the HCP, replacing an old set of triggers that were problematic in their implementability, reliability, and accuracy. The No Action Alternative includes the new triggers rather than the old ones, since they would be used whether or not an ITP was issued. The new drought triggers are based on aquifer condition as defined by water level in a drought indicator well and/or by flow of Barton Springs. This indicated condition in turn now defines either a No-Drought Stage or one of two drought severity stages that are employed to mandate specified groundwater withdrawal reductions by District permittees:

- ***Alarm Stage*** requires 20 percent mandatory reduction in monthly water use by all permittees when the Lovelady Drought Indicator Well level is more than 180.8 feet below land surface or when the 10-day average discharge of Barton Springs is less than 38 cfs and the District Board declares an Alarm Stage Drought; and

- ***Critical Stage*** requires 30 percent mandatory reduction in monthly water use by all permittees when the Lovelady Drought Indicator Well level is more than 192.1 feet below land surface or when the 10-day average discharge of Barton Springs is below 20 cfs and the District Board declares a Critical Stage Drought.

2.3.1.2 Measures to Mitigate and Monitor Potential Impacts

There would be no structural mitigation investigations and measures or planned adaptive management strategies in Alternative 1.

2.3.1.3 Affected Area

The area affected by the No Action Alternative would apply only to the jurisdictional area of the District, where the District has regulatory authority and responsibility. This would be only a portion of the HCP Planning Area (Figure 1.1-2).

2.3.1.4 Permit Area Boundaries

Since an ITP would not be sought or issued under Alternative 1, the No Action Alternative, there would not be an ITP area. Before actions affecting the Barton Springs segment of the Edwards Aquifer could be implemented, non-federal property owners could seek individual ITPs and federal property managers would initiate consultations with the Service under section 7 of the ESA, if these actions may affect the listed species. Within the affected area many projects could apply for separate ITPs, each with its own permit area. Nothing in this alternative requires or presupposes that project proponents seeking ITPs or consultations would coordinate their activities.

2.3.1.5 Incidental Take

The term *take* in the ESA means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. Incidental take would not be authorized under Alternative 1, since no ITP would be issued. Under the No Action Alternative, aquifer pumpers would have two options for complying individually with the take prohibition of section 9 (Prohibited Acts) of the ESA:

1. Pumpers would be subject to restricted aquifer withdrawals during designated Drought Stages as specified by District Rules. However, individual pumpers could potentially still be considered in violation of the ESA if springflows decline to a level that would result in take of the species.

2. Under section 10(a)(1)(B) of the ESA, individual pumpers could withdraw water under conditions approved by the District, if the Service approved individual HCPs and issued ITPs for the specific withdrawals. To be approved, the individual HCPs must provide assurance that the proposed incidental taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild. In addition, individual HCPs must demonstrate that the aquifer pumper or developer will minimize harm to the species or habitat and will mitigate such harm to the greatest extent practicable.

Because the burden of complying with the ESA shifts to individual aquifer pumpers under the No Action Alternative, the probable result would be that many ITPs might be requested of/by individual entities (e.g., water utilities, municipalities, and businesses).

2.3.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Alternative 2 provides the best practicable and attainable measures for avoidance, minimization, and mitigation of negative impacts on listed and candidate species. Alternative 2 includes a combination of withdrawal demand reduction measures, enhancement and conjunctive use of new water supplies, greater enforcement capabilities, cooperative efforts with other entities, and the development and implementation of adaptive management strategies and emergency measures. On the basis of information obtained during the scoping process (Section 1.4.1), public involvement (Section 1.4.2), discussion from more than eight Citizens Advisory Committee meetings, and meetings with the Service, measures provided by Alternative 2 represent a plan that could be realistically implemented to provide the most protection for the Barton Springs ecosystem. Aquifer management strategies that would be included under Alternative 2 are listed in Table 2.3-1 and characterized more fully in Appendix B.

2.3.2.1 HCP Planning Area

The District's HCP Planning Area depicted in Figure 1.1-2 includes the Barton Springs segment of the Edwards Aquifer Contributing Zone, Recharge Zone, Transition Zone, Artesian Zone, and Saline Water Zone in parts of Bastrop, Blanco, Caldwell, Hays, and Travis Counties in Central Texas. The bulk of the HCP Planning Area is mainly in northern Hays County and southwestern Travis County. Small portions of the HCP Planning Area extend into Blanco, Caldwell, and Bastrop Counties.

2.3.2.2 Permit Area

The ITP area is that part of the HCP Planning Area that includes the subterranean, water-filled pores, joints, crevices, and caverns of the Edwards Aquifer within the District's jurisdictional boundary (Figure 1.1-2), and surface and subsurface components of the individual springs that make up the Barton Springs System. This system includes the Main (Parthenia) Spring and associated Barton Springs Pool, Upper Barton Spring, Eliza Spring, and Sunken Garden Spring (these springs are described and illustrated in Chapter 3 and in Figure 3.3-1). Any incidental take of species covered by this ITP would be expected to occur in this aquifer and these spring locations.

2.3.2.3 Incidental Take

This section complies with the Service interpretation of the requirements of 50 CFR 17.22(b)(1)(ii): "The common and scientific names of the species sought to be covered by the permit, as well as the number, age, and sex of such species if known." The sex, age, and number of individuals cannot be known, because the actual level of incidental take of these species cannot be precisely determined. The key to conserving the species is maintenance of adequate habitat, which can be accomplished, in part, by management of the aquifer to protect and maintain springflows.

The potential incidental take for the Barton Springs salamander and Austin blind salamander within the ITP area that may occur from time to time under Alternative 2 is summarized below.

Federally Listed (Threatened or Endangered) Species

The Barton Springs salamander, federally and state-listed as endangered, is found in the four springs that make up the Barton Springs ecosystem, including the Main Spring (also called Parthenia Spring) in Barton Springs pool, Eliza Spring, Old Mill Spring (also called Sunken Garden Spring), and the Upper Barton Spring (City 1998a). The springs complex is located in Zilker Park, near downtown Austin. The Barton Springs salamander was first collected from Barton Springs Pool and Eliza Spring in 1946 (Brown 1950), from the Old Mill Spring in 1993 (Chippindale 1993), and from Upper Barton Spring in 1997 (City 1998a). Barton Springs salamanders are found in the highest abundance at Eliza Spring, followed by occurrences in Barton Springs Pool. They are rarely in the deep end of Barton Springs Pool, which is often covered in sediment, or in the shallow end. This species is dependent on water quantity and quality flowing from the Barton Springs segment of the Edwards Aquifer.

The salamander was given the taxonomic name *Eurycea sosorum* in honor of the citizens of Austin, who initiated and passed the SOS (Save Our Springs) City Ordinance in 1992 to protect the aquifer that supports Barton Springs. The salamander is neotenic, meaning it does not develop lungs but retains larval, gill-breathing morphology. These salamanders become sexually mature, breed, and live in the water throughout their lives (USFWS 2005b). The recovery plan for the Barton Springs salamander (USFWS 2005b) lists the following principal threats to the species: degradation of water quality and quantity; surface habitat modification; lack of a comprehensive plan to protect the Barton

Springs watershed from increasing threats to water quality and quantity; and restricted range consisting of an entirely aquatic environment.

Observations by City biologists (personal communication, 2006-2007) suggest that when springflow declines to levels that begin to affect the Barton Springs salamander's habitat requirements (e.g., dissolved oxygen [DO}, water temperature, cover and concealment, available food supply, or other presently undefined requisites that would change with declining flows), the numbers of individual salamanders decrease; when the habitat requirements are re-established, the salamanders re-emerge in apparently healthy states and in populations of mixed ages. Such behavior is not inconsistent with movement of individuals to subterranean portions of the springs and aquifer as they seek more optimal habitat conditions, for example, higher velocity groundwater flow paths; Therefore, declining numbers of observed species may not necessarily be directly representative of incidental take. Only after examining longer-term trends, including the outcome of salamander counts during and after extreme drought periods that have not yet been experienced since the commencement of salamander surveys, can the counts be used to estimate the range of actual take. Consequently, the amount of incidental take of the Barton Springs salamander under any of the alternatives cannot be determined accurately from observations of individuals or trends in declining numbers. Rather, incidental take must be evaluated indirectly by looking at the salamander's life requisites and species/habitat relationships with the assumption that when the habitat conditions change, there will be a corresponding change in abundance of the species.

A number of possible factors were evaluated for correlations to incidental take (e.g., DO, flow velocities, wetted perimeters, temperature changes, sedimentation). After consideration of all of these factors, including available information on the effects of these factors on the Barton Springs salamander, spring discharge rates and DO concentrations were selected as the two most salient components to use in establishing incidental take levels. Impact assessment methodology also assumes that any decline in numbers of salamanders resulting from a decline in total discharge of Barton Springs at or below 33 cfs and consequent declines in DO, increased water temperature, or other changes in water quality can be construed to represent incidental take as defined under the ESA (based on data from Poteet and Woods 2007). Because the salamander has demonstrated the ability to move within different water columns of the springs and aquifer and would have some ability to relocate to other surface or subsurface sites within the spring system during declining springflows, estimates of incidental take may be conservative by overestimating actual mortality or stress to the species.

Although Alternative 2 provides an extensive set of measures intended to protect springflow, assurance of water in sufficient quantity and quality to meet the salamander's life requisites during severe drought conditions is uncertain. Under Alternative 2, springflow discharge of 33 cfs or lower (and therefore presumed incidental take) is predicted to occur about 34 percent of the time under aquifer conditions similar to the entire period of record, and 75 to 76 percent of the time under conditions similar to the drought of record, if it should recur in the ITP period.

Candidate Species

The Austin blind salamander, a candidate for listing, is closely related to the Barton Springs salamander. Both are members of the lungless Plethodontidae family of salamanders. However, the Austin blind salamander differs morphologically by eyespots that are covered by skin instead of image-forming lenses, an extended snout, fewer costal grooves, and pale to dark lavender coloration (Hillis et al. 2001). The species was described by Hillis et al. (2001). It is also closely related to the Texas blind salamander (*Eurycea rathbuni*), found in the southern portion of the Edwards Aquifer in San Marcos, Texas. In June 2001, the Austin blind salamander was designated a candidate for listing as endangered (USFWS 2002).

Austin blind salamander specimens have been collected at Barton Springs Pool, Eliza Spring, and Old Mill Spring, but are likely found in highest numbers in the subterranean areas of Barton Springs (Hillis et al. 2001). Since the Austin blind salamander occupies a more subterranean habitat than the Barton Springs salamander, most of the observations of this species have been of more mobile juveniles. Substantially fewer Austin blind salamanders than Barton Springs salamanders have been observed by City biologists during regular surveys. From information documented by Hillis et al. (2001) and observations by City biologists, there have been only 120 documented observations of the Austin blind salamander from January 1998 to February 2002, compared to 2,059 Barton Springs salamanders during the same time frame.

Each of the potential threats to the Barton Springs salamander identified above applies to the Austin blind salamander to some degree. The degradation of water quality that appears to be associated with urbanization, including reduced DO concentration and increased conductivity, affect habitat conditions for this species. Reduced flows exacerbate these conditions and may lead to reduced habitat availability for Austin blind salamanders. In addition, a reduction in habitat suitability for Barton Springs salamander associated with lower flows and reduced water quality conditions may also result in movement of the Barton Springs salamander deeper into the aquifer and result in an overlap in habitat occupation (and increase competitive interaction) between the two species. Competition for food and space along with other unknown biological interactions may negatively affect one or both species.

The amount of incidental take of the Austin blind salamander under Alternative 2 cannot be determined based on numbers of individuals. Observation and collection data suggest that most of the population is subterranean, inhabiting submerged aquifer pools and caverns. Due to the inability of the species or its habitat to to be adequately observed or studied, mortality, stress, habitat modification, or other factors that could be used to establish or estimate incidental take cannot be effectively evaluated. As the habitat requirements and life requisites of the Austin blind salamander are similar to the Barton Springs salamander, protection measures implemented for the Barton Springs salamander under Alternative 2 are presumed to also apply to the Austin blind salamander. Although Alternative 2 provides an extensive set of measures intended to protect springflow, assurance of water in sufficient quantity and quality to meet the Austin blind salamander's life requisites during severe drought conditions is uncertain.

2.3.2.4 Measures to Minimize Potential Impacts

Alternative 2, Best Practicable and Attainable Measures, includes a number of actions to minimize potential impacts to the spring ecosystem. These include continuing measures during non-drought conditions as well as measures that would be implemented during periods of declared drought. For the purposes of impact analysis of Alternative 2, total monthly pumpage from the Edwards Aquifer was evaluated within a range between 10 and 13 cfs. (It should be noted that the currently available regulatory environment, which was very recently developed as part of the HCP process and is described generally by Alternative 2 but has been refined and enhanced in the final proposed HCP in Chapter 6, is estimated by the District to produce total pumpage that ranges around 8.5 cfs during extreme drought, as described in Section 6.5.1.1.) Some measures described below are designed to foster an environment where benefits to springflow can be realized in the long run, even if the measure itself might not produce such benefits directly.

Category 1.0 Measures Undertaken during All Conditions

These measures would include actions to reduce demand for groundwater withdrawals regardless of drought or non-drought conditions. These actions are further divided into establishment and implementation of a permitting program in the District to maintain and improve an extreme drought withdrawal limitation ("Aquifer Cap") (Category 1.1); ongoing/continuing demand reduction measures (Category 1.2); ongoing/continuing water supply enhancement measures (Category 1.3); and ongoing/continuing water supply conversion measures (Category 1.4).

1.1 ESTABLISHMENT AND IMPLEMENTATION OF A PERMITTING PROGRAM IN THE DISTRICT TO MAINTAIN AND IMPROVE AN EXTREME DROUGHT WITHDRAWAL LIMITATION (EDWL, AN "AQUIFER CAP")

Perhaps the most significant measure in this alternative would be the incorporation of new, regulatory-based withdrawal limits during drought at levels established by rule by the District Board. These limits, a type of aquifer cap, would be incorporated in the District's Groundwater Management Plan and approved by the TWDB consistent with Chapters 36 and 356 of the Texas Water

Code. Under current statutory authorities, EDWL for all withdrawals from the Edwards Aquifer will be no more than 8.5 cfs.

1.2 ONGOING AND CONTINUING DEMAND REDUCTION MEASURES

These are measures that are designed to reduce the level of aquifer withdrawals from pumping. Specific measures include:

1.2.1 The registration process for pumpers who withdraw water from the aquifer will be modified to establish a database of exempt wells with supportable estimates of withdrawal rates. This will allow the development of greater accountability in the use of water from the aquifer and proportion of withdrawals accounted for by exempt pumpage.

1.2.2 In order to develop supportable estimates of withdrawal rates from exempt (i.e., unpermitted) wells, as noted above, under this measure a representative number of existing exempt well owners would be solicited to voluntarily participate in a District program, to install meters on currently unmetered wells and report monthly groundwater use. These data would be used to determine and investigate short- and long-term water use and to develop a statistically based, better estimation of pumpage from all exempt wells during all aquifer conditions.

1.2.3 Permitted pumpers would be required to adopt UCPs and UDCPs to identify measures to achieve 10 percent voluntary reductions in pumping during the summertime Conservation Period each year (from May 1 through September 30) and all other groundwater users will be encouraged to implement similar conservation measures.

1.2.4 Pumpers would be required to adopt UDCPs to identify methods and schedules for reducing pumping levels during periods of declared drought.

1.2.5 A water conservation education program would be developed to promulgate information to increase water savings through greater awareness and increased information. The program would target builders, homeowners, homeowner associations and water supply corporations.

1.2.6 The District Board would implement rules that increase the pumping fee cap for non-exempt wells to a level that provides an incentive for shifting to other water supplies.

1.2.7 The District would seek conformance to the maximum extent legally and practicably possible, with the requirements of “Managed Available Groundwater” limits, as established by TWDB, with the limits imposed under this permit.

1.2.8 The District would seek authority to adopt, implement, and enforce rules that limit pumping on all non-exempt pumpers. This would require defining "excessive use" and promulgating rules that would enforce a non-excessive use standard on all users, not just permittees.

1.2.9 The District would work with public water utilities to develop water conservation plans and model ordinances in order to adopt stricter requirements for development that will address water quantity and quality. The District would participate with and extend the conservation program of major water utilities into the District's jurisdictional area. Technical assistance on development of model ordinances would be requested from major water utilities.

1.2.10 The District will adopt a groundwater demand reduction plan that includes both allowable peak monthly pumpage as well as annual pumping limits. Permitted peak monthly pumpage would be defined; permittees would initially be notified of peak monthly volumes and effects on rates and surcharges; and surcharges would be imposed if peak limits are exceeded.

1.3 ONGOING/CONTINUING WATER SUPPLY ENHANCEMENT MEASURES

Under Alternative 2, there are four measures included to improve water supply.

1.3.1 The District would provide support to recharge enhancement projects of all types if they are deemed effective and have minimal negative ecological impacts. (The District would consider any additional water available to well users from this measure as not being available during extreme droughts.)

1.3.2 As guided and approved by the District Board, the District would provide support to clean, maintain, and protect natural recharge features (fractures, fissures, and sink holes) along drainages over the recharge zone. Recharge features would be regularly surveyed and inspected for clogging. If clean-up is undertaken and, as feasible, water quality protection devices would be installed to allow recharge while minimizing clogging.

1.3.3 The District would provide technical assistance and cooperation in the acquisition of undeveloped open space in the recharge zone of the Edwards Aquifer.

1.3.4 The District will initiate policies and programs to prevent waste (including contamination) of ground and surface water including advanced Edwards Aquifer BMPs, described and administered by the Texas Commission on Environmental Quality under 30 TAC[1] Section 213 (the so-called "Edwards Rules"). These measures would serve to implement those actions described in Measure 1.2.8 above.

1.4 ONGOING/CONTINUING WATER SUPPLY CONVERSION MEASURES

Under Alternative 2, there are five ongoing/continuing measures to convert use of groundwater to surface water.

1.4.1 The District would initiate, support, and participate in conjunctive use initiatives to increase use of surface water supplies with existing Edwards groundwater providers in the District's jurisdictional area, including memorandums of agreement (MOAs) with wholesale water suppliers. This would include meeting with water purveyors to exchange information on growth and associated utility expansion; monitoring and interacting with developers who are involved with the planning and construction of utility system extensions; executing MOAs with purveyors of alternative water supplies; and delimiting these conjunctive use policies and measures to selected management zones within the District's jurisdictional area, as described below in measure 1.4.2.

1.4.2 The District would initiate planning and assess feasibility of long-range plans, policies and programs concerning designation of defined water management zones with different hydrogeologic and water availability use situations and incorporate them in a revised Groundwater Management Plan. Initial measures would include completion of a feasibility study in cooperation with wholesalers to identify roles and responsibilities of all parties, projected impacts of alternative measures, and appropriate role of the District. Subsequent measures could include prohibition of new wells, restrictions on new wells, and incentives for conversion to surface water supplies.

1.4.3 The District would initiate, support, and participate in policies and plans to increase use of other alternative water supplies (e.g., units of the Trinity Aquifer, other aquifers, desalinated water, harvested rainwater) with existing Edwards groundwater users in the District. The process would begin with investigating the feasibility of specific projects and roles of cooperating entities including the District. Cooperating parties would execute cooperative agreements to acquire surface water and groundwater from purveyors. The participating parties (including developers) would necessarily share in the cost of construction of conjunctively managed utilities.

1.4.4 The District would seek authority for, and if successful implement, a new regulatory program element that requires existing groundwater users, under certain prescribed conditions, either to convert from Edwards groundwater to alternative water supplies, and/or to encourage such conversion using higher water usage fees and longer term permits as an economic incentive.

1.4.5 The District would encourage and facilitate the construction of excess pumpage and storage capacity within alternative water supply systems by District permittees, to promote the use of alternative water supplies during drought conditions in lieu of groundwater. Some examples of this might be the voluntary curtailment of a larger than mandatory amount of groundwater production during critical or extreme drought and corresponding use of substituted surface water; and the contracted agreement with adjacent surface water suppliers that could enable District permittees to use an emergency interconnect to surface water in lieu of groundwater during an emergency response period declared by the District during extreme drought.

Category 2.0 Additional Measures Employed after Declaring Alarm Stage Drought

Four strategies would be employed to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the first drought trigger stage (Alarm Stage).

2.1 Drought triggers for all permittees will be established to define the drought stages and associated mandatory pumping reduction according to springflow, aquifer levels, and other drought indicators.

2.2 Drought triggers as described in 2.1 above will result in pumping restrictions according to the following: ***Alarm Stage*** requires 20 percent mandatory reduction in monthly water use by all permittees when the Lovelady Drought Indicator Well level is more than 180.8 feet below land surface or when the 10-day average discharge of Barton Springs is less than 38 cfs and the District Board declares an Alarm Stage Drought.

2.3 Additional pumping reductions would be defined that would be required of certain conditional production permittees under certain conditions.

2.4 The District would seek legislation and, if successful, implement authority to apply additional enforcement measures for ensuring/improving drought period compliance with withdrawal restrictions.

Category 3.0 Additional Measures Employed after Declaring Critical Stage Drought

Five measures will be employed to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the second drought trigger stage (Critical Stage).

3.1 Drought triggers described in 2.1 above will result in pumping restrictions, according to the following: ***Critical Stage*** requires 30 percent reduction when the Lovelady Drought Indicator Well level is more than 192.1 feet below land surface <u>or</u> when 10-day average discharge of Barton Springs is below 20 cfs <u>and</u> the District Board declares a Critical Stage Drought.

3.3 Additional reductions would be defined that will be required of certain conditional permittees under certain conditions. Protocol will be developed to allow increasingly more stringent curtailments on Conditional Water Use permittees. Protocol will require demonstration of actual alternative supply arrangement upon high curtailment or cessation order.

3.4 An ***Emergency Response Period,*** which is an extreme drought condition within a Critical Stage Drought, would be defined in which both a) water withdrawals under certain conditional permits may be further curtailed or prohibited, and b) under certain conditions, some historic use permits not directly essential to human health and welfare may be further curtailed. Enhanced demand reduction measures and/or aquifer management measures (currently undefined) will be implemented at the discretion of the District Board as a means of preventing further reduction in springflow. This measure would include investigation of other possible groundwater management measures that would be effective on a temporary basis, but not feasible in the long term (e.g., personal appeals and rewards to large water users to voluntarily curtail use more than required by regulation); and the aquifer conditions that would trigger each measure. Rule changes would also be completed to allow effective use of additional measures.

3.5 An ***Emergency Response Period*** would begin when the 10-day average discharge of Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days. The District would also order mandatory reductions for all Class A Conditional Permits (as described in Section 1.3.2.4) of 50 percent for the first 3 months, 75 percent for the next 3 months, and 100 percent thereafter, until Barton Springs flow rises above 14 cfs, then the next less severe stage of reduction would be declared until either the 30-percent use reduction on all permitted wells is reached or the Critical Stage Drought is no longer declared.

3.6 As negotiated in individual conditional-use permits, the District would require mandatory switching to alternative water supplies by groundwater users during an Emergency Response Period, as enabled through prior agreements with current or other water suppliers with excess capacity.

2.3.2.5 Measures to Mitigate and Monitor Potential Impacts

Several measures would be implemented under Alternative 2 to mitigate and monitor potential impacts to the species. These measures include study of the feasibility, benefit, and risk of structural mitigation measures to ameliorate extreme conditions that cannot be mitigated by other means, and adaptive management strategies that will be undertaken as funds, partners, and permissions are identified. These measures are not governed by declared drought conditions. They also are not being used as a basis for applying for the ITP.

Category 4.0 Structural Mitigation Investigations and Measures

Because springflow cannot be assured during worst-case drought conditions, contingency measures to supplement or augment springflow using water from other sources have been investigated in a preliminary manner. Several structural mitigation strategies have been identified with a fatal flaw evaluation performed to help evaluate some of the constraints, costs, and other issues (Appendix C). Based on this evaluation the following two strategies are included under Alternative 2.

4.1 The District would coordinate with the City of Austin to investigate the feasibility, benefit, and risk of re-circulating or aerating water discharged from Barton Springs to specific habitat protection zones within the spring ecosystem, or re-aerating groundwater in the flowpath to Barton Springs during periods of critically low flows.

4.6 The District would seek to enter into an Inter-local Agreement (ILA) with the City to support the Salamander Conservation Program to manage the species during all conditions.

Category 5.0 Adaptive Management Strategies

Under Alternative 2, six adaptive management strategies have been identified.

5.1 The District would refine and improve its Groundwater Availability Model (GAM) to serve as a planning and evaluation tool when implementing new groundwater management programs.

5.2 The District would work with universities, the City, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and adverse effects of depressed DO and elevated conductivity levels affecting salamander viability in spring water.

5.3 Additional studies would be conducted on the potential for the augmentation of water supplies in the brackish water zone (including desalination and aquifer storage and recovery) and from other freshwater aquifers (e.g., the Middle Trinity Aquifer).

5.4 The District would work with the U.S. Geological Survey, universities, the City, and other qualified parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which will be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events.

5.5 A survey of aquifer biota would be conducted in sampling wells dispersed throughout the Barton Springs segment of the Edwards Aquifer in order to improve understanding of species richness and diversity.

5.6 The District would work with universities, the City, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs ecosystem, and possibly other relevant studies to be determined.

2.3.2.6 Implementing Roles of the District's HCP Plan Participants

The District would apply for a 50-year regional ITP to allow incidental take of listed and candidate species at the Barton Springs ecosystem. ITP conditions that may be required include responsibilities of each entity, conservation and mitigation measures to be implemented, monitoring and research procedures, and any other permit conditions that may be required. Responsibilities of each participant are outlined below.

Barton Springs/Edwards Aquifer Conservation District

- The District would be the primary participant and ITP holder. The ITP would cover all permittees that are issued a groundwater withdrawal permit by the District as well as groundwater users exempt from permitting under Chapter 36.

- As the District issues groundwater withdrawal permits, permit fees would generate funding. The District would provide the administrative framework to distribute this revenue to any other entities that might be involved, at the

District's behest, in implementing certain measures under the HCP so that mitigation measures and adaptive management strategies involving third parties can be effected.

- The District would be responsible for implementing drought stage management as well as comprehensive management of the aquifer.

- The District would report on a regular basis to the Service on the status of aquifer pumping, drought stage management, mitigation measures, and adaptive management.

U.S. Fish and Wildlife Service

- The Service is the federal agency responsible for monitoring compliance with the conditions of the ITP.

Other Entities

Other governmental entities, political subdivisions, universities, or private research groups as yet not selected or specified may be involved cooperatively in conducting studies or other actions identified or included as District HCP measures. Specific responsibilities would be identified in District HCP contracts or implementation agreements with the District and/or the Service.

2.3.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Alternative 3 represents a regional HCP that requires the highest number and level of reasonably conceivable measures to maximize the protection of the listed and candidate species. Alternative 3 includes a combination of withdrawal demand reduction measures, enhancement and conjunctive use of new water supplies, greater enforcement capabilities, cooperative efforts with other entities, and the development and implementation of adaptive management strategies and emergency measures. Alternative 3 also contains the highest number of measures that would require additional legislative authorization, attainment of additional secured funds from new sources, and approval by other entities.

2.3.3.1 HCP Planning Area

The HCP Planning Area for Alternative 3 would be the same as for Alternative 2 and is described in Section 2.3.2.1.

2.3.3.2 Permit Area

The ITP area for Alternative 3 would be the same as for Alternative 2 and is described in Section 2.3.2.2.

2.3.3.3 Incidental Take

This section complies with the Service interpretation of the requirements of 50 CFR 17.22(b)(1)(ii): "The common and scientific names of the species sought to be covered by the permit, as well as the number, age, and sex of such species if known." The sex, age and number of individuals cannot be known because the actual level of incidental take of these species cannot be precisely determined. The key to conserving the species is maintenance of adequate habitat, which can be accomplished, in part, by management of the aquifer to protect and maintain springflows.

The potential incidental take for the Barton Springs salamander and Austin blind salamander within the ITP area that may occur from time to time with the issuance of the ITP under Alternative 3 is summarized below.

Federally Listed (Endangered) Species

Barton Springs salamander (*Eurycea sosorum*). The description of incidental take for the Barton Springs salamander under Alternative 3 is similar to the description for Alternative 2. Under Alternative 3, springflow discharge of 33 cfs or lower (incidental take) is predicted to occur about 29 percent to 30 percent of the time under aquifer conditions similar to the period of record, and 68 percent to 72 percent of the time under conditions similar to the drought of record. Incidental take starts at the same discharge rate as Alternative 2, but the frequency distributions differ between Alternatives 2 and 3 because of different management measures employed. These differences are discussed in Chapter 4.2.3.

Candidate Species

Austin blind salamander (*Eurycea waterlooensis*). A general description of this species can be found in Section 2.3.2.3, while a more detailed description is found in Section 3.2.3.

The actual amount of incidental take that would occur under Alternative 3 cannot be determined precisely from individual counts or declining trend in numbers for the Austin blind salamander. As the habitat requirements and life requisites of the Austin blind salamander are similar to the Barton Springs salamander, protection measures implemented for the Barton Springs salamander under Alternative 3 also apply to the Austin blind salamander. Alternative 3 provides an extensive set of measures intended to support the quantity and quality of springflow. Although Alternative 3 provides an extensive set of measures intended to protect springflow, assurance of water in sufficient quantity and quality to meet the life requisites of the Austin blind salamanders during severe drought conditions is uncertain.

2.3.3.4 Measures to Minimize Potential Impacts

Alternative 3, a regional permit with maximum measures and associated highest costs and increased implementation uncertainty, includes the highest number of actions to minimize potential impacts to the spring ecosystem. These include continuing measures during non-drought conditions as well as measures that would be implemented during periods of declared drought. For the purposes of impact analysis of Alternative 3, total monthly pumpage from the Edwards Aquifer was evaluated within a range between 7 and 10 cfs. (It should be noted that the currently available regulatory environment, which was very recently developed as part of the HCP process and is incorporated within Alternative 3, is estimated by the District to produce total pumpage that ranges between 7 and 8.5 cfs during extreme drought, as described in Section 6.5.1.1.) Some measures are designed to foster an environment where benefits can be realized in the long run, even if the measure itself might not produce such benefits directly.

Many of the measures in Alternative 3 are similar in description to measures described in Section 2.3.2.4 for Alternative 2, differing primarily in the degree of beneficial impact associated with increased authorities, collaborative agreements with third parties, level of funding commitment, and higher legal risks willing to be incurred. Where significant differences exist in the subsets of measures, they are identified in the subsections below.

Category 1.0 Measures Undertaken during All Conditions

These measures would include actions to reduce demand for groundwater withdrawals regardless of drought or non-drought conditions. These actions are further divided into establishment and implementation of a permitting program to maintain and improve an extreme drought withdrawal limitation ("Aquifer Cap") in the District (Category 1.1); ongoing/continuing demand reduction measures (Category 1.2); ongoing/continuing water supply enhancement measures (Category 1.3); and ongoing/continuing water supply conversion measures (Category 1.4).

1.1 Establishment and Implementation of a Permitting Program in the District to Maintain and Improve an Extreme Drought Withdrawal Limitation (“Aquifer Cap”)

This measure is the same as described for Alternative 2. The EDWL was initially only an Alternative 3 measure, but the District has been able to acquire the authority that enables its implementation as part of Alternative 2.

1.2 Ongoing and Continuing Demand Reduction Measures

These are measures that are designed to reduce the level of aquifer withdrawals from pumping under all conditions. Ten specific measures are included under Alternative 3. They are essentially the same as those described for Alternative 2, differing only in degree of imposition.

1.3 Ongoing/Continuing Water Supply Enhancement Measures

Under Alternative 3, there are four strategies that have been identified to improve water supply. They are essentially the same as measures in Alternative 2.

1.4 Ongoing/Continuing Water Supply Conversion Measures

Under Alternative 3, five strategies have been identified to convert use of groundwater to surface water. While similar to water supply conversion measures described in Section 2.3.2.4 for Alternative 2 as “likely” in achieving their benefits, these measures constitute more what may be “possible,” since the District currently lacks the necessary statutory authority or financial capability.

Category 2.0 Additional Measures Employed after Declaring Alarm Stage Drought

Four measures would be employed under Alternative 3 to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the first drought trigger stage (Alarm Stage). These are the same measures as for Alternative 2, only with a more optimistic view about the acquisition of additional legislative authority to curtail both non-exempt and exempt permittees during Alarm Stage Drought and to differentiate among types of users. A new class of conditional permit (Class B), with a more aggressive curtailment schedule, was originally defined as part of HCP Alternative 3, but the District was able to promulgate rules establishing Class B conditional permits during the HCP process and it is now included in both Alternative 2 and Alternative 3.

Category 3.0 Additional Measures Employed After Declaring Critical Stage Drought

Six measures would be employed under Alternative 3 to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the second drought trigger stage (Critical Stage). These are the same measures as for Alternative 2, only with a more optimistic view about the acquisition of additional legislative authority to curtail both non-exempt and exempt permittees during Critical Stage Drought and to differentiate among types of users. A new class of conditional permit (Class B), with a more aggressive curtailment schedule, was originally defined as part of HCP Alternative 3, but the District was able to promulgate rules establishing Class B conditional permits during the HCP process and it is now included in both Alternative 2 and Alternative 3.

2.3.3.5 Measures to Mitigate and Monitor Potential Impacts

A number of measures would be implemented under Alternative 3 in order to mitigate and monitor potential impacts to the species. These measures include structural mitigation investigations and measures to ameliorate extreme conditions that are not able to be mitigated by other means, and adaptive management strategies that will be undertaken as funds, partners, and permissions are identified. These measures are not governed by declared drought conditions. They also are not being used as a basis for applying for the ITP.

Category 4.0 Structural Mitigation Investigations and Measures

Because springflow cannot be assured during worst-case drought conditions, contingency measures to supplement or augment springflow using water from other sources have been investigated in a preliminary manner. Several structural mitigation strategies have been identified with an HCP Fatal Flaw Study performed to help evaluate some of the constraints, costs, and other issues (see Appendix C, Fatal Flaw Evaluation of Alternative Augmentation Strategies at Barton Springs). Based on this evaluation seven structural mitigation strategies have been identified.

4.1 The District would coordinate with the City to investigate the feasibility, benefit, and risk of re-circulating or aerating water discharged from Barton Springs to specific habitat protection zones within the spring ecosystem during periods of critically low flows.

4.2 On the basis of the outcome of the feasibility investigation of Measure 4.1 above, a pilot project to re-circulate or aerate discharged groundwater to specific habitat protection zones within the spring ecosystem would be planned, designed, and implemented. There would be no activity on this measure, unless and until Measure 4.1 affirms the feasibility and benefit.

4.3 A detailed investigation based on results of the HCP Fatal Flaw Study (Appendix C) would be performed to determine feasibility of augmenting springflow or elevating DO concentrations using another *groundwater* source.

4.4 A detailed investigation based on results of the HCP Fatal Flaw Study (Appendix C) would be performed to determine feasibility of augmenting springflow or elevating DO concentrations using *supplemental surface water*.

4.5 A project to supplement or aerate springflow during severe drought would be planned, designed, and implemented based on 1) feasibility determined from results of investigations obtained by Measures 4.3 and 4.4 above, and 2) other conditions stipulated by the District Board and the City.

4.6 The District would seek to enter into an ILA between the District and the City to support the Salamander Conservation Program to manage the species during all conditions.

4.7 The District would seek to enter into an ILA between the District and the City, under both entities' HCPs to establish a protocol including conditions of use, to augment springflow or elevate DO concentrations during periods of severely low springflow or flow cessation.

Category 5.0 Adaptive Management Strategies

Six adaptive management strategies have been identified under Alternative 3. They are similar to adaptive management measures described for Alternative 2.

5.1 The District would refine and improve its GAM to serve as a planning and evaluation tool when implementing new groundwater management programs.

5.2 The District would work with universities, the City, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and toxicity of depressed DO and elevated conductivity levels affecting salamander viability in spring water.

5.3 Additional studies would be conducted on the potential for the augmentation of water supplies in the brackish water zone (including desalination and aquifer storage and recovery) and from other freshwater sources (e.g., the Middle Trinity Aquifer).

5.4 The District would work with the U.S. Geological Survey, universities, the City, and other qualified parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which would be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events.

5.5 A survey of aquifer biota would be conducted in sampling wells dispersed throughout the Barton Springs segment of the Edwards Aquifer in order to improve understanding of species richness and diversity.

5.6 The District would work with universities, the City, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs ecosystem, and possibly other relevant studies to be determined.

2.3.3.6 Implementing Roles of the District's HCP Plan Participants

For Alternative 3, the implementation roles of plan participants would be the same as for Alternative 2 (Section 2.3.2.6), although there would be a higher number and level of involvement and commitment of cooperating third parties.

2.4 Comparison of the Alternatives

A summary-level comparison of the three alternatives is summarized in Table 2.4-1. Alternatives are compared in terms of permit area boundaries, management structures, funding sources, net water gain to the aquifer, biological risk, species incidental take, pumping levels, and frequency of low springflow. Net gain to the aquifer and resulting springflow under each of the alternatives are projected according to specific management measures and expected hydrogeological responses. These comparisons are intended to differentiate and characterize the various alternatives. Impacts to the aquifer, resulting springflow, and listed species are evaluated in detail in Chapter 4.

2.4.1 Permit Area Boundaries

For Alternative 1 (No Action), no ITP would be issued, so there would be no ITP area or boundary. The ITP area for Alternatives 2 and 3 includes subterranean, water-filled caverns within the Barton Springs/Edwards Aquifer Conservation District jurisdictional boundary (Figure 1.1-2), and surface and subsurface components of the individual springs that make up the Barton Springs System. This system includes the Main Springs and associated Barton Springs Pool, Upper Barton Springs, Eliza Springs, and Sunken

Table 2.4-1. Comparison of alternatives summary

Issue	Alternative 1: No Action – Existing Aquifer Management Strategies and Growth of Pumping Demand with No Protection Under an ITP	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty
Permit Boundaries	No Regional ITP would be issued, resulting in no regional ITP boundaries.	Subterranean, water-filled caverns within the Barton Springs/Edwards Aquifer Conservation District jurisdictional boundary (Figure 1.1-2), and surface and subsurface components of the Barton Springs System, including the Main Spring and associated Barton Springs Pool, Upper Barton Springs, Eliza Spring, and Sunken Garden Spring.	Same as Alternative 2.
Management Structure	No regional HCP; the District and individual pumpers would be subject to violation of the ESA; pumpers could seek individual ITPs; includes management of the Barton Springs segment of the Edwards Aquifer consistent with the District's adopted Groundwater Management Plan and programs as set out in its rules; several continuing mitigation measures would be employed by the District during non-drought and drought conditions to improve the likelihood for species survival in the event of reduced or no springflows.	The District would issue individual pumping permits under a regional ITP; Water management strategies would be comprehensive and include a pumpage ceiling, groundwater demand reduction measures, water supply enhancement measures, water supply conversion measures, drought stage pumpage reductions, structural mitigation investigations, and adaptive management strategies.	The District would issue individual pumping permits under a regional ITP; HCP contains similar categories as Alternative 2, but with maximum measures under each category.
Funding	No commitments to fund HCP measures.	Management strategies during first five years would require funding of $550,000, generated from pumping fees assessed by District, increasing in time with inflation.	Potentially as much as $1 million per year for first 5 years, then level funding in subsequent years, increasing in time with inflation.

Table 2.4-1. Comparison of alternatives summary (continued)

Issue	Alternative 1: No Action – Existing Aquifer Management Strategies and Growth of Pumping Demand with No Protection Under an ITP	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty
Net Gain to Aquifer from All Water Management Strategies (Table 4.2-1)	4 cfs.	7 cfs.	11 cfs.
Impacts to Barton Springs Salamander*	Highest risk for adverse impacts.	Risk for adverse impacts less than Alternative 1 but higher than Alternative 3.	Lowest risk for adverse impacts.
Species Incidental Take	Highest predicted frequency and duration of incidental take.	Frequency and duration of predicted Incidental take lower than Alternative 1, but higher than Alternative 3.	Lowest predicted frequency and duration of Incidental take.
Pumping Levels (and Drought Stage Percent Reductions)[1]	No withdrawal limit; pumpage projected to range between 13 and 16 cfs, with 20% pumping reduction during Alarm Stage Drought and 30% reduction during Critical Stage Drought.	Pumpage withdrawal limit of 8.5 to 10 cfs, with 20% pumping reduction during Alarm Stage Drought and 30% reduction during Critical Stage Drought, with additional reductions declared during an Emergency Response Period.	Pumpage withdrawal limit of 7-8.5 cfs, with 20% pumping reduction during Alarm Stage Drought and 30% reduction during Critical Stage Drought, with additional reductions declared during an Emergency Response Period. Additional implementation of conjunctive use programs during critical droughts, or outright conversion to other water supplies.

Garden Springs (these springs are described and illustrated in Chapter 3 and in Figure 3.2-1). Any incidental take of HCP species would be expected to occur in the above-named aquifer and spring locations.

2.4.2 Management Structures

For Alternative 1, the No Action Alternative, the District would retain the power to regulate and manage the aquifer by issuing groundwater withdrawal permits and incorporating other management strategies; however, no ITP would be issued to the District. Under this scenario, individual pumpers could seek ITPs under section 10(a) of the ESA. Individual water supply companies, counties, cities, associations, industries, commercial businesses, farmers and ranchers, and persons could apply for ITPs. The Service would have to determine if the taking associated with individual pumping would appreciably reduce the likelihood of survival and recovery of species in the wild. The difficulty of taking into account the cumulative effects of many individual pumpers and variable weather conditions would complicate this task. The issuance of each ITP may require specific mitigation measures that could lead to a complex management structure involving many entities, including the District, and their respective, differing approaches to the implementation of mitigation measures.

The management structure for Alternatives 2 and 3 would be similar. The District would utilize its authority to regulate aquifer pumping by issuing groundwater withdrawal permits under each alternative, and all pumpers regulated by the District would be covered by the ITP. The District would be the primary permit holder. In addition, the District would enter into cooperative agreements with appropriate entities to implement mitigation measures. The District would also be responsible for reporting to Service on the status of aquifer pumping and mitigation measures.

2.4.3 Funding Sources

For Alternative 1 (No Action), there would be no need for an HCP funding source. For Alternatives 2 and 3, the District and its annual revenues from permittees would serve as the principal source of funding and support for some HCP measures, while cooperating with other entities to advance knowledge and improve habitat conditions for the salamanders. The extent to which some HCP measures could be implemented, especially under Alternative 3, will depend on the current and future financial resources of the District and other cooperating entities.

With respect to funding and other aspects of implementation, the most restrictive regional plan (Alternative 3) would be considerably more difficult and costly relative to Alternative 2 (preferred alternative) or Alternative 1 (no action). The preferred regional plan (Alternative 2) would be intermediate to the other two alternatives in cost, feasibility, and difficulty of implementation.

2.4.4 Incidental Take

The primary threat to the Barton Springs salamander is a decline in the quantity and quality of springflow. The Austin blind salamander is similarly affected, but the extent to which this species is affected in subterranean portions of the aquifer is unknown. Decline in springflow results from the combined effects of low regional rainfall, low aquifer recharge, spring discharge, and aquifer pumping. Based on results of toxicity studies conducted by Poteet and Woods (2007) and data provided by the City correlating DO levels with changes in springflow, stress (take), and, potentially, subsequent mortality of the Barton Springs salamander is predicted to begin occurring at a total combined springflow of 33 cfs or lower. Examination of the historical hydrograph indicates that under baseline conditions (without any pumping), this level of springflow would have occurred 28 percent of the time over the period of record 1917-2004 (see Section 4.2.4). The District has indicated that neither the District nor any other entity can guarantee that aquifer levels will be sufficient to keep Barton Springs flowing during prolonged, severe droughts. Consequently, assurance of water in sufficient quantity and quality to meet the life requisites of the Barton Springs and Austin blind salamanders during severe drought conditions remains uncertain.

With respect to the covered species, no action (Alternative 1) would result in a higher risk to long-term persistence of the species within the Barton Springs system relative to the most restrictive regional plan (Alternative 3). The proposed regional plan (Alternative 2) would be intermediate with respect to the covered species to Alternatives 1 and 3.

Chapter 3
Affected Environment

3.1 Physical Environment

3.1.1 Climate

The prevailing climate of the District HCP Planning Area is within a transitional zone between a subtropical sub-humid region to the west and a subtropical humid region to the east (Larkin and Bomar 1983) (Figure 3.1-1). The subtropical sub-humid climate type is characterized in general by long, hot summers and short, mild winters. Western parts of the region are influenced by a subtropical steppe climate, characterized by semi-arid to arid conditions. Eastern parts of the region, influenced by a subtropical humid climate, have higher humidity and experience slightly milder summers. Regional prevailing winds are generally southerly, except during winter, when they are frequently from the north. Latitude, elevation, and proximity to the Gulf of Mexico influence the climate of the region.

The regional average annual temperature is about 69° Fahrenheit (°F) (National Oceanic and Atmospheric Administration [NOAA] 2005). Winters are generally mild with an average monthly low temperature in January of 42°F. Sub-freezing temperatures occur on average about 25 days each year. North winds with strong cold fronts block any moderating effects from the Gulf of Mexico and occasionally usher in frigid conditions to central Texas. The coldest temperature on record in Austin was -2°F on January 31, 1949. The average occurrence of the last temperature of 32°F in spring is early March and the average first fall occurrence of 32°F is late November. Monthly high temperatures in August average 89°F. Daytime temperatures in summer are hot, with highs over 90°F about 80 percent or more of the time. The highest temperature of record was 112°F on September 5, 2000. Average sunshine varies from about 50 percent in the winter to near 75 percent in the summer (NOAA 2005).

Regional surface water features are subject to evaporation, especially during hot summer months. Average regional monthly gross lake-surface evaporation ranges from

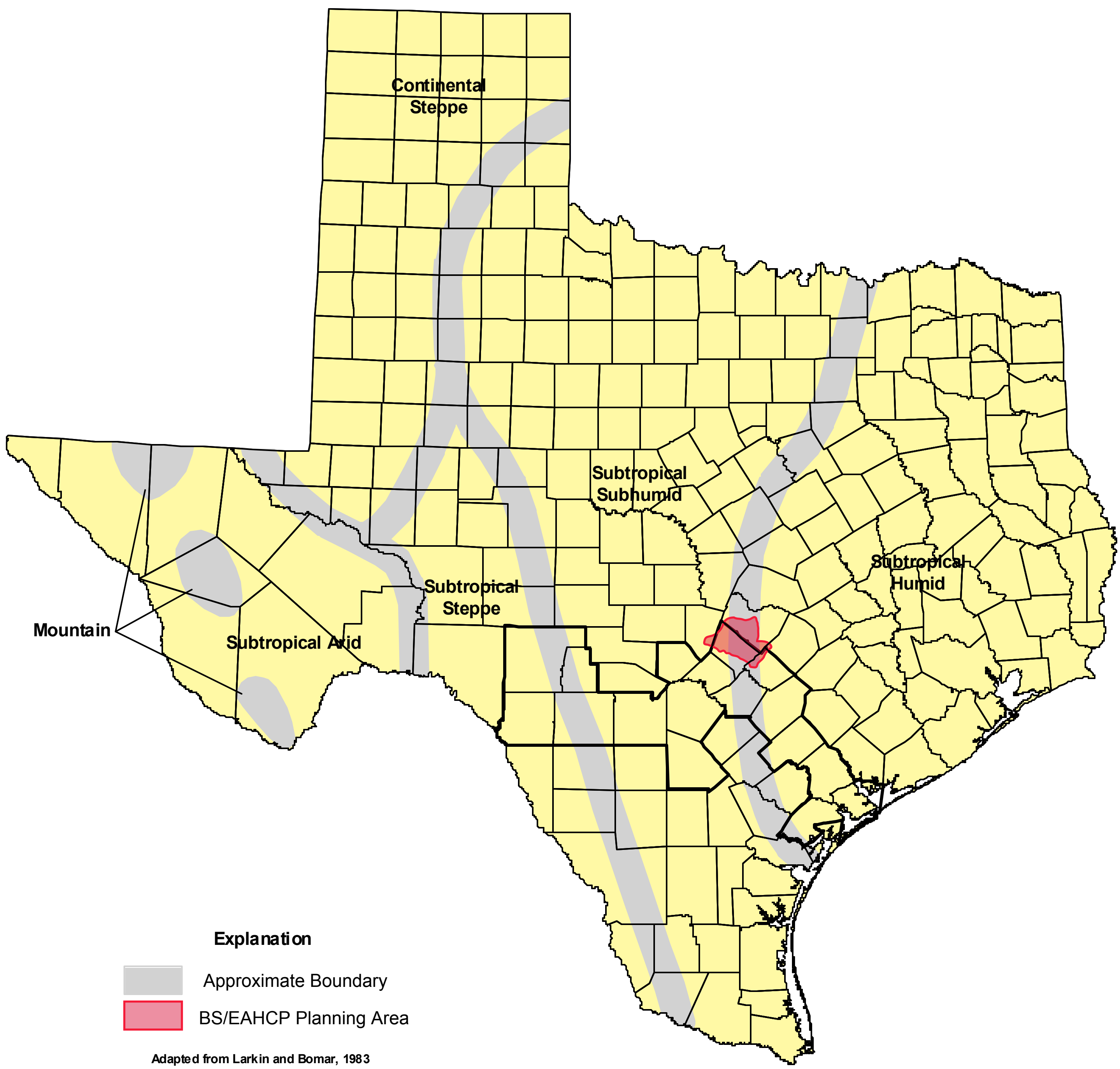


Figure 3.1-1 Climatic Regions of Texas

approximately 2.5 inches in January to about 9 inches in August (Larkin and Bomar 1983).

Average annual precipitation within the region is approximately 32 inches. Extremes vary from 11.5 inches in 1954 to 64.7 inches in 1919 (NOAA 2005). Historically, precipitation is highest during May and September. Stalled cold fronts and summer tropical storms may result in increased precipitation amounts. Information on the frequency of tropical storms and droughts occurring over the Edwards Plateau and Edwards Aquifer Region has been previously documented according to information provided by the Edwards Aquifer Authority (Hicks and Company/RECON 2004) described below.

3.1.1.1 Frequency of Tropical Storms

Tropical storms, including hurricanes, hit the Texas Gulf Coast at a frequency of about 0.67 storm per year (Brown et al. 1974). Occasionally these storms move inland while dissipating, resulting in severe weather over the region. Moisture-laden air masses move inland from the Gulf of Mexico and are forced to rise at the Balcones Escarpment and Edwards Aquifer Recharge Zone, resulting in some of the largest storms ever recorded in the United States. High winds, heavy rainfall, hail, and tornadoes may result from these tropical storms. Flash flooding is common after thunderstorms that produce large amounts of precipitation in a relatively short period of time. One such instance was flooding associated with Hurricane Amelia in August 1978. Between August 1 and 3, 1978, more than 48 inches of rain fell on a ranch in Medina County, the highest three-day precipitation total ever recorded in the United States (Caran and Baker 1986).

Remnant low pressure systems associated with dissipating tropical storms and hurricanes moving northeast into central Texas from western Mexico and the Baja Peninsula in late summer and early fall create weather effects that are generally less severe, but retain the capacity for potentially heavy rainfall.

3.1.1.2 Frequency of Droughts

Serious droughts have been recorded in parts of Texas in every decade since 1900. Droughts usually result from lower than normal precipitation levels; however, years with above average precipitation totals may experience drought conditions especially after dry periods when increased groundwater pumping results in a shortage of water. Therefore, reporting the *annual average amount of rainfall* does not reflect the occurrence of droughts or the impacts that droughts have on the aquifer and the living organisms dependent upon it. Averaging the rainfall data tends to mask the duration and intensity of droughts. In addition, the lack of long-term rainfall data for the area hampers long-term analysis of droughts in the region (Mauldin 2003).

Droughts vary significantly in duration and intensity. At least five droughts of extended duration and extreme intensity have occurred since 1931 in the Edwards Aquifer Region (Riggio et al.1987). Numerous droughts of shorter duration and less intensity have also been recorded. Between 1931 and 1985, the frequency of occurrence of three-month droughts in the Edwards Plateau region varied from 62 to 70 occurrences, depending on location. During the same period, the frequency of occurrence of six-month droughts varied between 32 and 40 occurrences (Riggio et al. 1987). Less than 24 occurrences of the 12-month drought were recorded between 1931 and 1985 (Riggio et al. 1987). Although droughts are cyclic in nature, they are not consistent in frequency.

Each region has its "drought of record," commonly used by water managers and planners to design water supply facilities (American Meteorological Society 1997). Regional water planning guidelines found in the TAC_1 Sections 357.1–357.15 define “drought of record” as the period of time when natural hydrological conditions provided the least amount of water supply. For the purposes of this report, the six-year drought that occurred from 1951 through 1956 will be considered the “drought of record” for the Edwards Aquifer (although some of the analyses incorporated in this document include data not limited to this period). However, the Region K 2005 Water Plan for the Lower Colorado Regional Water Planning Group (LCRWPG 2005) identifies the 1950–1956 drought as the most severe, and it adopted the drought period from 1947-1957 as the drought of record period for the Region K planning area, which includes the District. This six-year drought resulted in the only known cessation of flow of Comal Springs in Comal County in 1956, for 144 days (Longley 1995). During this same period, flow at San Marcos Springs in Hays County declined to a low flow of 47 cfs in comparison to an average flow of 187 cfs during the period 1996 through 2001 (Edwards Aquifer Authority 2005), while Barton Springs in Travis County declined to 10 cfs from an average historical flow of 53 cfs (BSEACD 2004). To better understand the drought of record and how it relates to the long-term climate of the region, a study utilizing dendrochronology was conducted on existing databases to evaluate historic drought patterns in the aquifer region (Mauldin 2003).

Dendrochronlogy is the use of tree-ring analysis to evaluate historic climatic conditions. It is an established, critical element of climate research (Blasing and Fritts 1976; Robinson 1976; Stahle et al. 1985; Stahle and Cleaveland 1988; Cook et al. 1999). An extensive database of tree-ring data for the southwest was used in the analysis (Cook 2000). Data collected from existing databases were correlated with the Palmer Drought Severity Index (PDSI) for a 280-year period (1700–1979). The PDSI is a standard measure of soil moisture conditions used to classify drought frequency, intensity, and duration. It has a range of –4.0 to 4.0, with an average year falling between -0.5 and 0.5. Droughts are defined as –1.0 through –4.0. Over the 280-year period studied, 25.7 percent of the years were drought years (Mauldin 2003).

Although there are insufficient scientific techniques to accurately predict droughts, several conclusions may be drawn from the available data. Droughts are not uncommon to the aquifer region; however, they are usually short in duration and are generally not intense. In the time period 1700 through 1979, the aquifer region experienced forty droughts (using the PDSI definition) of various lengths. The duration of the average drought was 1.8 years, while droughts that lasted only 1 year were more common. Long-term droughts, defined as those exceeding 3 years in duration (Mauldin 2003), occurred only four times, and three of those were in the 1700s. The fourth, long-term drought was the drought of record (1951–1956), which lasted 6 years. The drought of record was the most intense long-term drought (-2.32 average PDSI, peaking about -3.1); however, six other droughts were more intense for shorter durations (PDSI > -3.1; Mauldin 2003). Therrell (2000), also using tree-ring analysis, concluded that the drought of record in the Planning Area was the most prolonged period of sustained drought in the past 347 years. Seager et al. (2007) at Lamont-Doherty Earth Observatory of Columbia University have reported dendrochronological and other investigations that indicate considerably more prolonged droughts of equivalent severity occurred in the Early and Middle Ages, which they term the Medieval mega-droughts.

3.1.1.3 Climate Change

Reports from the Intergovernmental Panel on Climate Change (IPCC 2001) in 1995 and 2001 suggest that the balance of available evidence indicates a discernible human influence on climate change and that most of the warming observed over the last fifty years is attributable to human activities (anthropogenic greenhouse gas emissions). The IPCC concludes that average temperatures over the southern Great Plains of the U.S. might be 2–3 °F warmer over the next fifty years. Recent modeling performed by the Lamont-Doherty Earth Observatory of Columbia University (Seager 2007) suggests that a plausible future for large areas of southwestern North America will be one of perpetual drought by the mid-21st century, although the more severe drought areas are projected to be to the west of the Planning Area.

Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase. However, over the last century, the average annual temperature in San Antonio, for instance, has decreased 0.5°F, and precipitation has decreased by up to 20 percent in some parts of the state.

Over the next century, climate in Texas could experience additional changes. For example, based on projections made by the IPCC and results from the United Kingdom Hadley Centre's climate model, HadCM2, which accounts for both greenhouse gases and aerosols, by the year 2100 temperatures in Texas could increase by about 3°F in spring (with a range of 1–6°F) and about 4°F in other seasons (with a range of 1–9°F). Precipitation is estimated to decrease by 5–30 percent in winter and increase by about 10 percent in the other seasons. Increases in summer could be slightly larger (up to 30%) than in spring and fall. Other climate models may show different results. The amount of precipitation on extreme wet or snowy days in winter is likely to decrease, and the amount of precipitation on extreme wet days in summer is likely to increase. The frequency of extreme hot days in summer would increase because of the general warming trend. It is not clear how severe storms such as hurricanes would change (U.S. Environmental Protection Agency [EPA] 1997).

In response to the growing scientific consensus on climate change, the U.S. Department of Energy in 2006 released the Climate Change Technology Program (CCTP) Strategic Plan (2006), which details measures to accelerate the development and reduce the cost of new and advanced technologies that avoid, reduce, or capture and store greenhouse gas emissions. CCTP is the technology component of a comprehensive U.S. strategy to combat climate change that includes measures to slow the growth of greenhouse gas emissions through voluntary, incentive-based, and mandatory partnerships; advance climate change science; spur clean energy technology development and deployment; and promote international collaboration.

The Strategic Plan sets six complementary goals: (1) reducing emissions from energy use and infrastructure; (2) reducing emissions from energy supply; (3) capturing and sequestering carbon dioxide; (4) reducing emissions of other greenhouse gases; (5) measuring and monitoring emissions; and (6) bolstering the contributions of basic science to climate change. The Strategic Plan outlines approaches toward attaining these goals, articulates underlying technology development strategies, and identifies a series of next steps toward implementation.

3.1.2 Geology

3.1.2.1 Regional Physiography

The District HCP Planning Area lies along a physiographic borderland formed by the Balcones Escarpment. This boundary between two major physiographic regions is evident in the change from the Blackland Prairies on the east to the Edwards Plateau/Hill Country to the west. Across this geographic boundary are changes in almost all the natural attributes of the land—climate, surface water, groundwater, soils, flora, and fauna. Limestone plateaus, predominant oak-juniper woodland and savannah, thin soils, and narrow watercourses in steep canyons characterize the Edwards Plateau region west of the Balcones Escarpment. Terrain in the plateau region is typically steep and rugged, resulting from the numerous streams that dissect the plateau. Groundwater is relatively shallow and occurs in several strata. In contrast, areas east of the escarpment are overlain by deep, fertile soils of the Blackland Prairie. These clay soils are highly productive and support intensive agriculture. The prevailing terrain is generally level to gently rolling and cut by meandering, low-gradient streams. Groundwater may be found at depths much greater than in the Edwards Plateau region, although it is also found at shallow depths in outcrop areas, and is generally fresh to brackish in quality. Elevation within the District HCP Planning Area varies considerably, from about 500 feet above mean sea level (MSL) in Caldwell County to as high as 1,500 feet MSL in Blanco County.

3.1.2.2 Geological History and Structure

The Balcones Escarpment is a geologic fault zone several miles wide consisting of numerous individual faults, most of which both dip and are downthrown to the east. It extends in a line across Texas from Del Rio to the Red River and is visible eastward from Del Rio, where its elevation is about 1,000 feet MSL, and northeastward from San Antonio to Austin, where it is about 300 feet MSL (Handbook of Texas 2005). The escarpment lies within a region that has a rich geological history. During the Paleozoic Era, approximately 300 million years ago, tectonic upheavals associated with the collision of North America with parts of South or Central America formed the Ouachita Mountain belt bisecting Texas from north to south, the remnants of which may be seen in Oklahoma, Arkansas, and the Trans-Pecos region of Texas. In the Planning Area, they are in the deep subsurface. Later, during the Mesozoic Era, the mountains eroded and subsided as rifting occurred and the Gulf of Mexico began to form. Strata of limestone, sandstone, and shale were deposited in the newly formed Gulf of Mexico and buried the roots of this mountain belt.

During the Cretaceous Period, a shallow sea covered much of the region. A large barrier reef, the Stuart City Reef, paralleled the coastline and formed a large interior sea, separated from the Gulf of Mexico. Sediments were slowly deposited in this interior sea, eventually forming the strata of limestones, dolomite, and marls present today. These strata of limestones form the Edwards Group, which makes up the bedrock of the Edwards Aquifer. The Georgetown Formation, overlying the Edwards Group (but also part of the Edwards Aquifer), was deposited in a more openly circulated, shallow-marine environment (Rose 1972).

After the Cretaceous sea retreated, rivers and streams draining the land surface brought sand and mud towards the coast, forming a system of deltas. The prograding deltas began to fill in the coastline until they eventually extended over 250 miles into the Gulf of Mexico. Tertiary-aged clastic (made up of fragments of preexisting rocks) sediments were deposited and formed the Gulf Coastal Plains. Later, during the mid-Cenozoic Era, faulting along the buried Ouachita Mountain belt resulted in the dislocation of overlying strata, forming the Balcones Fault Zone.

The Balcones Fault Zone marks the eastern boundary of the Edwards Plateau. The extensive faulting along the fault zone trends mainly to the northeast, and in aggregate has displaced strata as much as 1,000 feet. Younger units were displaced downward toward the Gulf of Mexico while older units remained higher west of the fault zone, forming the plateau and escarpment present today. Present-day rivers and streams in the plateau are dissecting the plateau area, causing the varied topography evident throughout this region. The faulting has also significantly fractured the limestone bedrock in the region, in particular near the major faults, although jointing occurs throughout the Edwards region. This faulting and jointing affect how groundwater flows through, and is stored in, these strata.

3.1.2.3 Stratigraphy

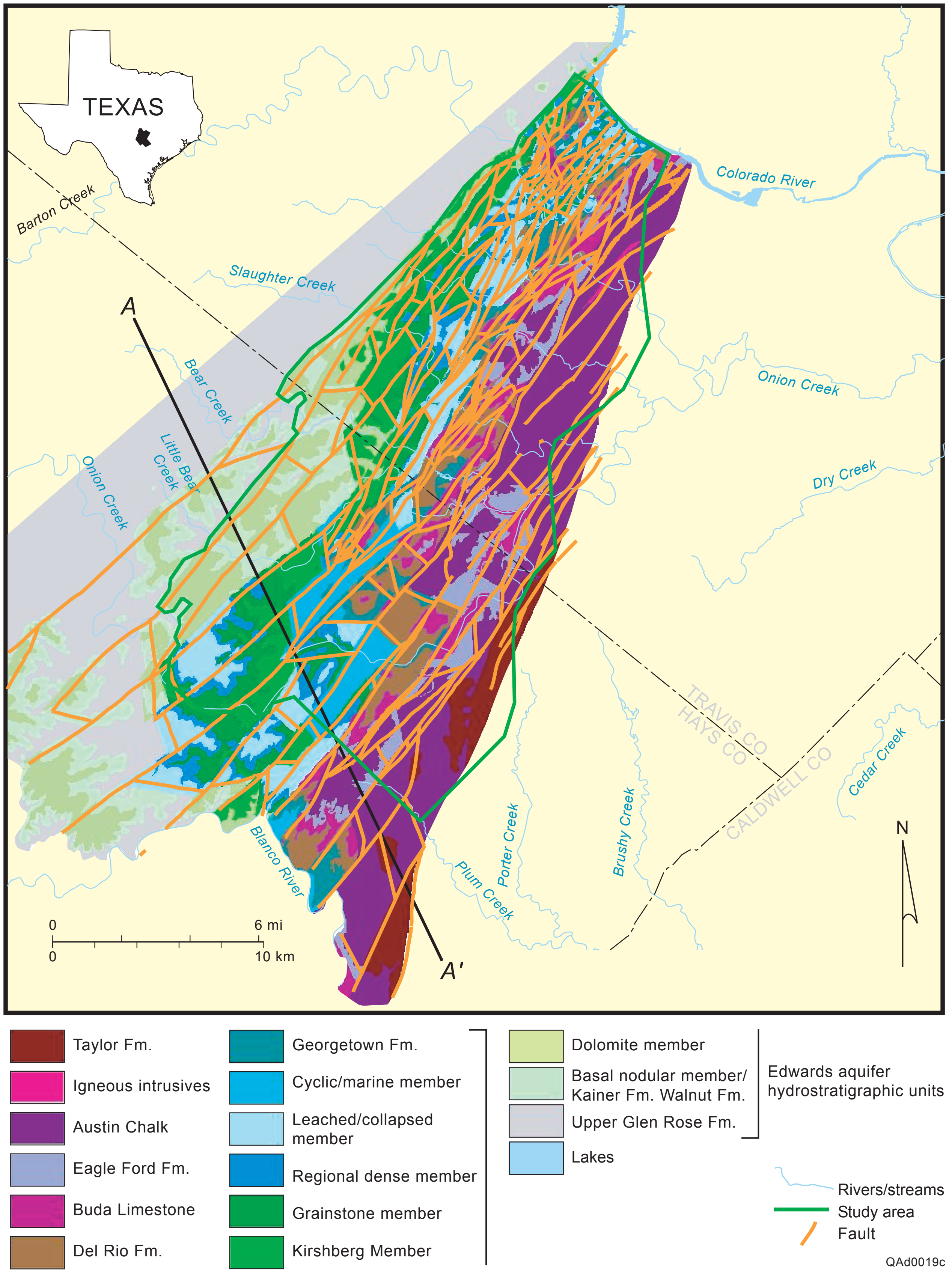
The geologic formations of interest in the District HCP Planning Area include, from oldest to youngest; the Glen Rose Formation, the Walnut Formation, the Edwards Group, the Georgetown Formation, the Del Rio Formation, the Buda Formation, the Eagle Ford Formation, and the Austin Group. These units are all lower to upper Cretaceous strata, which are overlain by Quaternary terrace deposits. The generalized location of these formations is shown in Figures 3.1-2 and 3.1-3.

The Glen Rose Formation—The Glen Rose Formation occurs primarily in the western portions of the District HCP Planning Area, west of the Edwards aquifer recharge area. The Glen Rose consists of alternating layers of limestone, dolomite, and marl, and is between 500 and 1,000 feet thick in the Austin area. Dolomite limestones within the Glen Rose contain water and are part of the Trinity hydrogeologic unit present throughout much of the Texas Hill Country.

The Walnut Formation—The Walnut Formation is also present in the western portion of the District HCP Planning Area, west of the Edwards aquifer recharge area. The Walnut Formation is composed of limestone and marl, and is between 50 and 100 feet thick in the Austin area. The Walnut Formation is not a water-bearing unit.

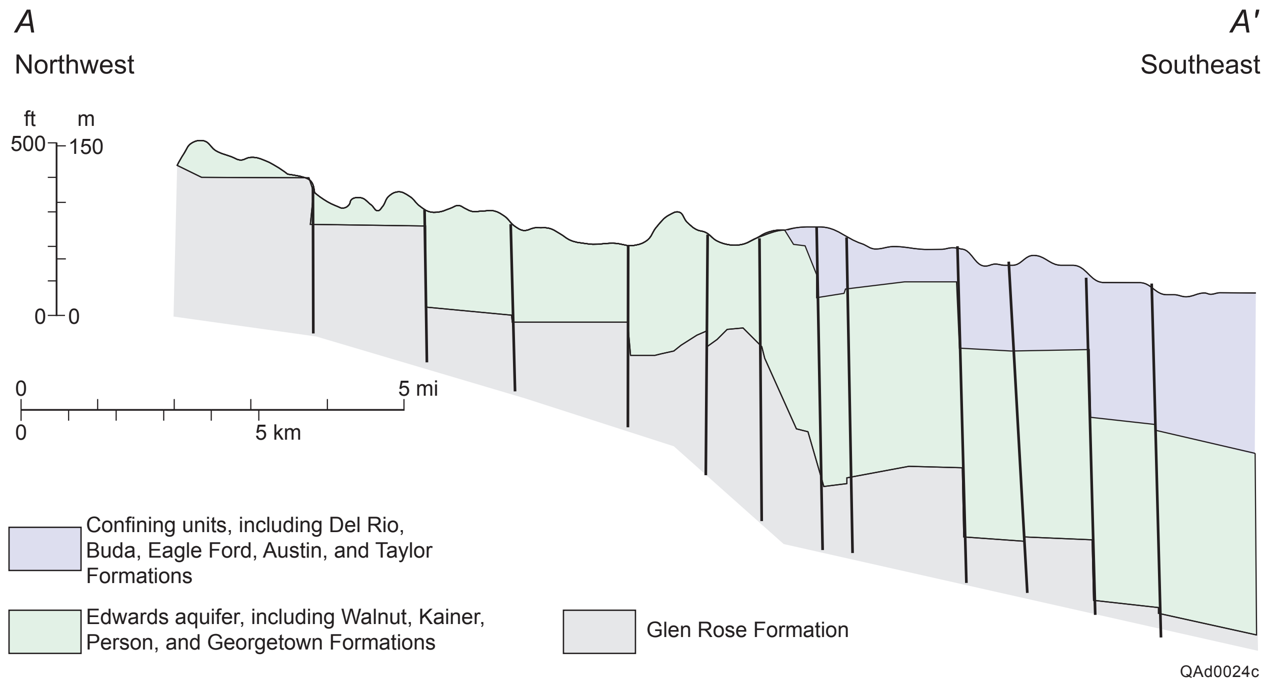
The Edwards Group—The Edwards Group consists of massive to thin-bedded limestone and dolomite. The outcrop of this unit makes up the recharge zone of the Edwards, and is approximately 400 feet thick in the Austin area. The Edwards Group has been subdivided into the Kainer and Person Formations. The Kainer Formation is composed of porous dolomite and dolomitic limestone in the lower part, and fine- to coarse-grained limestone in the upper part. Chert nodules are common in the dolomitic portions of the Kainer. The Kainer is between 240 and 310 feet thick in the Austin area. The Person Formation is located above the Kainer, and consists of marl and soft limestone in the lower part, and variable carbonate units, including limestone, dolomitic limestone, and dolomite in the upper part.

The Georgetown Formation—The Georgetown Formation consists mostly of fossiliferous limestone with some interbedded marls, and unconformably overlies the Person



Source: Scanlon et al. (2001)

Figure 3.1 - 2 Surface Geology in the Barton Springs Segment, Edwards Aquifer



Source: Scanlon et al. (2001)

Figure 3.1 - 3 Geologic Cross-section of the Barton Springs Segment, Edwards Aquifer. Location of the Cross-section is shown in Figure 3.1 - 2

Formation of the Edwards Group. The Georgetown is between 65 and 100 feet thick in the District HCP Planning Area. It is the uppermost formation in what is considered the Edwards Aquifer.

The Del Rio Formation—The Del Rio Formation, commonly referred to as the Del Rio Clay, is a fossiliferous clay and marl that is approximately 65 to 75 feet thick in the Austin area. The Del Rio is the confining unit for the Edwards Aquifer and outcrops in the eastern portion of the Balcones Fault Zone.

Younger Formations—The Buda Formation in the Austin area consists mainly of limestone and is between 3 and 30 feet thick. This unit is overlain by the Eagle Ford Formation, which consists of a lower calcareous shale, a middle silty limestone, and an upper shale, and is between 23 and 65 feet thick in the Austin area. The Austin Group, commonly referred to as the Austin Chalk, consists of thick-bedded chalk, marl, and limestone, and is between 360 and 425 feet thick. The Austin Chalk does contain some amount of groundwater and wells in this formation produce water in some areas. Overlying the Austin Chalk in many areas is the Taylor Clay of the Taylor Group, and Quaternary-age alluvial deposits in stream valleys.

3.1.2.4 Geological Composition of the Edwards Aquifer

The Edwards Aquifer is principally composed of the Georgetown Formation, and the Edwards Group of limestones including the Kainer and Person Formations described above and illustrated in Figures 3.1-4 and 3.1-5. The units crop out in the recharge zone of the aquifer and then are present in the subsurface in the transition and artesian zones, and farther downdip beneath the Gulf Coast plain. A significant amount of the porosity and permeability present in the Edwards Group was developed while the Edwards Group was being eroded prior to the deposition of the Georgetown Formation. Once the Georgetown Formation was deposited, the aquifer system that had developed within the Edwards Group was largely static due to the lack of discharge points to allow groundwater to flow through the system. The formation of the aquifer was then influenced significantly by fracturing and faulting associated with the Balcones Fault Zone, which created significant topographic relief and stream incision in the region. This faulting also produced a large system of faults and fractures, which allowed groundwater to flow through the formations to discharge points at lower elevations, which increased the dissolution of limestone and dolomite units by the infiltrating meteoric water (Senger and Kreitler 1984; Sharp 1990; Barker et al. 1994; Sharp and Banner 1997). Flow through the aquifer was also strongly influenced by bedding. Once established, the groundwater flow system matured, developing a continuously circulating groundwater flow system, which enlarged the fractures and faults into a cavern system that controlled groundwater flow characteristic of karst systems and that is present today in the Edwards Aquifer (Senger and Kreitler 1984).

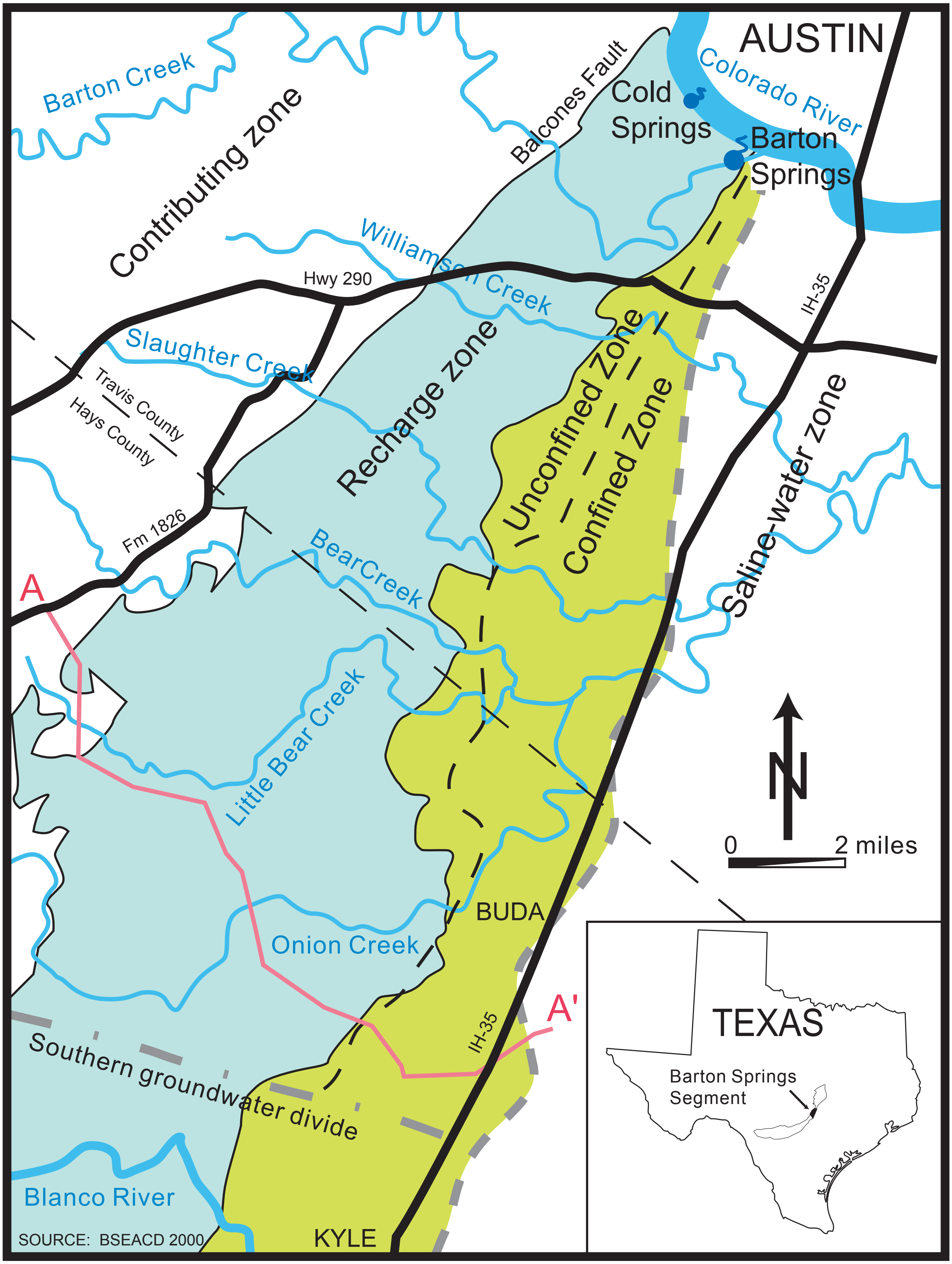
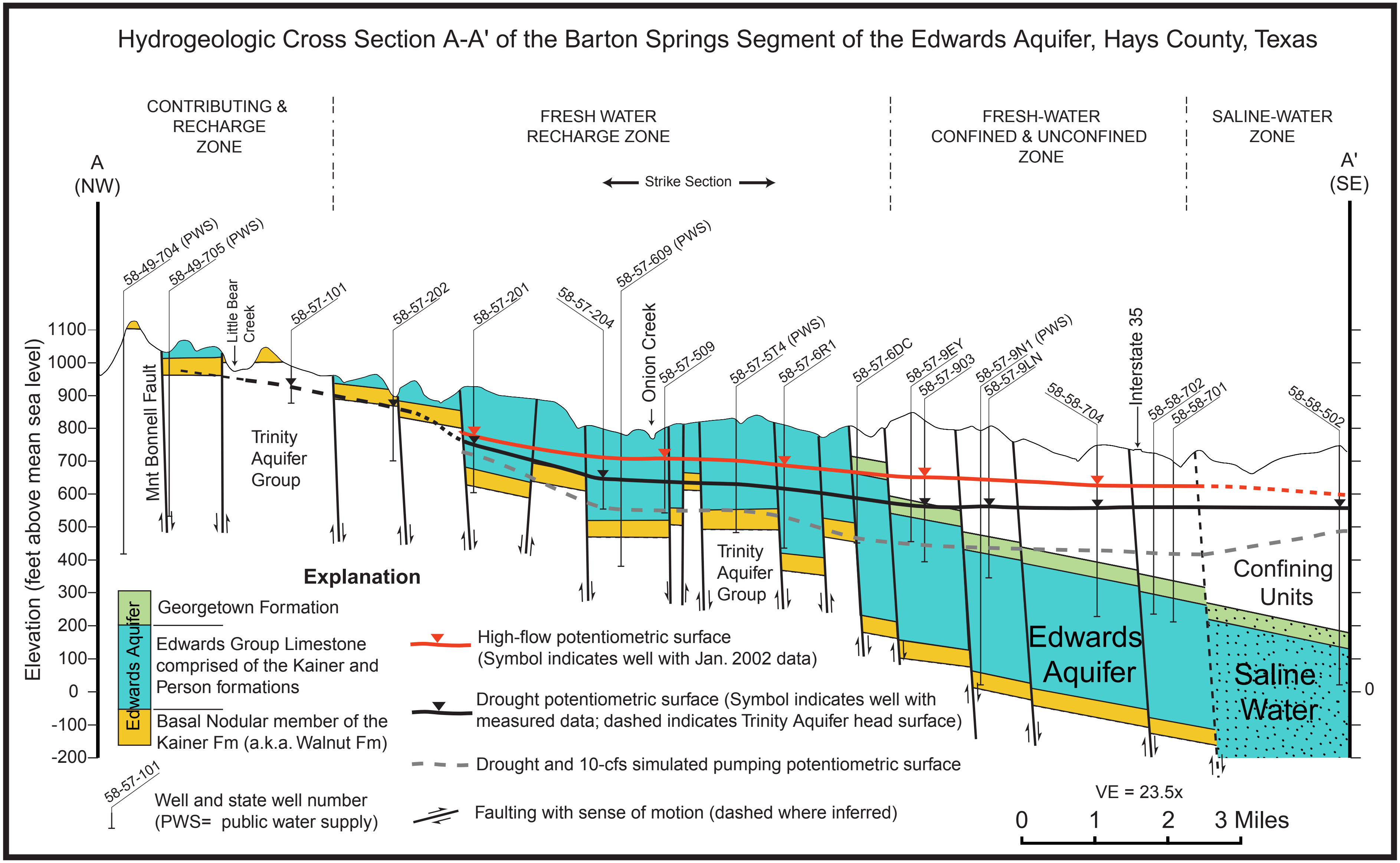


Figure 3.1 - 4 Location of Aquifer Cross Section referenced in Figure 3.1 - 5
Note: shaded area is the Edwards Aquifer.



Source: BSEACD 2000

Figure 3.1 - 5 Cross section of the Barton Springs and Trinity Aquifers in Hays County (see Figure 3.1 - 4).

3.1.3 Soils

3.1.3.1 Regional

Soils within the District HCP Planning Area vary according to the presence of two major physiographic regions, the Edwards Plateau and the Blackland Prairie. Soils on the Edwards Plateau are typically shallow on uplands and include very stony, dark, alkaline clays and clay loams. On steep hillsides and valleys, soils are slightly deeper, lighter, and less stony. Soils in bottomlands are typically deep, dark, alkaline loams and clays. Surface drainage on Edwards Plateau soils is rapid. Land historically was agricultural, used primarily for cattle and sheep ranching, with forage crops grown in the deeper bottomland soils. Soils on the Blackland Prairie are typically deep, dark alkaline clays. These soils are moderately to well drained and have a high shrink-swell potential. This high shrink-swell potential poses an engineering concern, since it can cause damage to roads and foundations. These soils support grasslands, pasture, and crops, including cotton, grains, and hay. A summary of the regional soil associations occurring in the District HCP Planning Area is based on United States Department of Agriculture (USDA) Soil Conservation Service data compiled for Travis County (1974), Comal and Hays Counties (1984), and Caldwell County (1978).

The following Edwards Plateau soil associations occur generally west of the line running from the confluence of Barton Creek and Colorado River to Sunset Valley to Manchaca to the intersection of Farm-to-Market road (FM) 2770 and FM 150 west of Kyle.

- <u>Brackett Association:</u> Shallow, gravelly, calcareous, loamy soils overlying interbedded limestone and marl.

- <u>Speck-Tarrant Association:</u> Shallow, stony, loamy soils and very shallow, stony, clayey soils overlying limestone.

- <u>Brackett–Comfort–Real Association:</u> Shallow, undulating to steep soils over limestone or strongly cemented chalk, on uplands.

- <u>Comfort–Rumple–Eckrant Association</u>: Very shallow to moderately deep, undulating to steep and hill soils over indurated limestone; on uplands.

- <u>Krum–Medlin–Eckrant Association:</u> Deep, very shallow, and shallow, undulating to steep and hill soils over clay, shaley clay, and limestone; on stream terraces, valley fills, and uplands.

Edwards Plateau soils generally have low shrink-swell potential, high foundation strength, low compressibility, high slope stability, low plasticity, and potentially moderate to difficult excavation potential (Kier et al. 1977).

The following Blackland Prairie soil associations occur generally east of the line running from the confluence of Barton Creek and Colorado River to Sunset Valley to Manchaca to the intersection of FM 2770 and FM 150 west of Kyle.

- Houston Black–Heiden Association: Deep, nearly level and gently sloping calcareous, clayey soils overlying marl.
- Austin–Eddy Association: Moderately deep and shallow, calcareous, clayey and loamy soils overlying chalk.
- Burleson–Wilson Association: Deep clayey and loamy soils overlying marl.
- Lewisville–Gruene–Krum Association: Deep, shallow, and very shallow, nearly level to gently sloping soils over loamy, clayey, and gravelly sediments; on stream terraces and valley fills of Blackland Prairie and Edwards Plateau.
- Branyon–Krum Association: Deep, nearly level to gently sloping over clayey sediments; on ancient stream terraces and valley fills.
- Austin–Castephen–Houston Black Association: Shallow to deep, gently sloping to sloping soils over chalk or marly clay; on uplands.

In contrast to the Edwards Plateau soils, the Blackland Prairie soils generally have high shrink-swell potential, low foundation strength, moderate compressibility, low slope stability, high plasticity, and easy excavation potential.

3.1.3.2 Soils in the Vicinity of Barton Creek and Barton Springs

Soil data for Barton Creek and Barton Springs and vicinity were taken from the Soil Survey of Travis County, Texas (USDA 1974). Soils in the vicinity of Barton Springs are primarily silty clays and loams of terraces and floodplains. These soils are generally well drained, allowing for rapid surface water runoff. Detailed descriptions of soil series and associated soils units found in the vicinity of Barton Springs and Barton Creek near Barton Springs are given below.

Altoga Series

Deep, well-drained, silty clay soils occurring high on the landscape, mostly on long, narrow side slopes, but also on ridges paralleling major streams. Altoga soil units in the vicinity of Barton Springs include Altoga soils and urban land, 2 to 8 percent slopes.

Bergstrom Series

Deep, well-drained, nearly level to gently sloping soils that occupy large areas on low terraces above flood plains. Bergstrom soil units in the vicinity of Barton Springs include Bergstrom soils and urban land.

Brackett Series

Shallow, well drained soils that developed under prairie vegetation of grasses and trees. Brackett soils have a mostly gravelly surface layer and are underlain by interbedded limestone and marl, but some are underlain by fractured chalk. Because of outcropping of underlying material, most of these soils are benched. They occupy large areas of gently undulating to steep topography. Brackett soil units in the vicinity of Barton Springs include Brackett soils, rolling; Brackett soils and Rock outcrop, steep; and Brackett soils and urban land, 12 to 30 percent slopes.

Hardeman Series

Deep, well drained, calcareous and friable soils that developed over old alluvium. These soils occupy long and narrow benches above flood plains. Hardeman soil units in the vicinity of Barton Springs include Hardeman soils and urban land, 3 to 12 percent slopes.

Mixed Alluvial Land

A miscellaneous land type that occurs on flood plains of creeks and rivers. It consists of gravelly alluvium, beds of gravel, and exposed limestone beds and boulders randomly interspersed with moderately deep-to-deep calcareous alluvial materials.

San Saba Series

Moderately well drained, moderately deep clay soils overlying limestone. These soils occupy irregular areas on high, broad ridges and in long, narrow valleys. San Saba soil units in the vicinity of Barton Springs include San Saba clays and urban land.

Speck Series

Shallow, well-drained soils overlying limestone. Slopes are smooth and complex and are dissected by widely spaced shallow drainage ways. Speck soil units in the vicinity of Barton Springs include Speck stony clay loam, 1 to 5 percent slopes.

Tarrant Series

Shallow to very shallow, well drained, stony, clayey soils overlying limestone. Large limestone rocks cover 25 to 85 percent of the surface. These soils occupy nearly level to gently sloping ridges, rolling side slopes, and steep, hilly breaks. The soil is calcareous and mildly alkaline throughout. Tarrant soil units in the vicinity of Barton Springs include Tarrant soils, rolling; Tarrant and Speck soils, 0 to 2 percent slopes; Tarrant soils and Rock outcrop, steep; Tarrant soils and urban land, 5 to 18 percent slopes.

Volente Series

Deep, well drained soils that developed in slope alluvium and occupy long and narrow valleys. The soil is calcareous and moderately alkaline. Volente soil units in the vicinity of Barton Springs include Volente complex, 1 to 8 percent slopes.

3.2 Water Resources

The quality and availability of surface and ground water within the District HCP Planning Area are discussed in this section. Competition for water resources has increased along with the region's population. A summary of existing conditions related to these resources is provided below.

3.2.1 Surface Water

3.2.1.1 Colorado River Basin

The Barton Springs segment of the Edwards Aquifer lies within the central portion of the Colorado River Basin. This river basin covers a drainage area of approximately 42,000 square miles in Texas and the eastern portion of New Mexico, 11,400 square miles of which are considered non-contributory to the Colorado River's water supply (LCRWPG 2005). The basin extends from eastern New Mexico and the western portion of Texas in Dawson County southeast approximately 900 miles to the Gulf of Mexico.

The Colorado River Basin includes portions of 55 counties from eastern New Mexico to the Gulf of Mexico. The Colorado River Basin is bordered to the north by the Brazos and Brazos-Colorado River Basins and to the south by the Rio Grande, Nueces, Guadalupe, Lavaca, and Colorado-Lavaca River Basins. The main tributaries to the Colorado River include the North and South Concho River near San Angelo; San Saba River near San Saba; Pecan Bayou near Brownwood; Llano River near Llano; Pedernales River near Johnson City; and Barton Creek and Onion Creek near Austin (Texas Commission on Environmental Quality [TCEQ] 2002a). The base-flow of the Colorado River is affected by stream management as regulated by the TCEQ and the Lower Colorado River Authority (LCRA).

3.2.1.2 Local Watersheds

Watersheds within the District HCP Planning Area are associated with six creek drainages: Barton Creek, Williamson Creek, Slaughter Creek, Bear Creek, Little Bear Creek, and Onion Creek (Figure 3.1-4). The recharge zone stretches across these six watersheds as a band from south of the Colorado River in the City of Austin southwesterly to north of the City of Kyle. The contribution of these watersheds to recharge of the Barton Springs segment of the Edwards Aquifer is described in Section 3.3.2.2, Description of the Edwards Aquifer and the Barton Springs segment.

3.2.1.3 Aquifer-fed Springs

The Barton Springs segment of the Edwards Aquifer naturally discharges principally through the Barton Springs complex, with minor discharge occurring at other ancillary springs (Slade et. al. 1986). Barton Springs, the fourth largest spring in Texas behind Comal Springs (Comal County), San Marcos Springs (Hays County), and San Felipe Springs (Val Verde County) (Brune 2002), is located in and adjacent to Barton Creek in Zilker Park near downtown Austin, about one-quarter mile upstream of the confluence of Barton Creek with the Colorado River (also known as Town Lake). Barton Springs is a complex of four hydrologically connected groups of springs including the Upper Barton Spring (just upstream of Barton Springs Pool), Main (or Parthenia) Spring in the middle of Barton Springs Pool, Eliza Spring on the north side of Barton Springs Pool, and Old Mill (Sunken Garden or Zenobia) Spring just downstream of the Barton Springs Pool dam.

Barton Springs is located in an area of historical, economic, and ecological importance. The springs were an attraction to several tribes of Native Americans before becoming the site of several Spanish missions in the early 1700s. The site was a major stop on the Chisholm Cattle Trail during the late 1800s. During the early 1900s Eliza Spring was modified by placement of a surrounding concrete amphitheater to provide a naturally cooled area for Elk's Club meetings. Although the springs had always been a popular swimming area, acquisition of the springs and surrounding land as a city park in 1917 made the area even more popular. In 1929, the irregular-shaped pool at the main spring was enlarged to about 1,000 feet long by the construction of a concrete lower dam and sidewalks on both sides (City of Austin 2005c). In 1932, an upper dam was added and in 1974-76, a by-pass channel was added to divert moderate floodflows around the pool. Barton Springs, the associated pool, and Zilker Park played a major role in the early development of Austin and are now a major tourist attraction and favorite swimming area for thousands of central Texas residents and non-resident tourists. Barton Springs also supports a productive, diverse aquatic and riparian ecosystem within the lower portion of Barton Creek downstream to its confluence with the Colorado River. The historical, biological and recreational significance of Barton Springs, Barton Springs Pool, and Barton Creek have made these places icons to the Austin community to the extent that they have become surrogate indicators of the overall environmental health of the region. Accordingly, they also are a lightning rod for controversy surrounding human development over and near the contributing and recharge zones of the Barton Springs segment of the Edwards Aquifer and, more generally, growth of the Austin area.

Long-term mean discharge from Barton Springs is about 53 cfs or 34 million gallons per day (BSEACD 2004) (Figure 3.2-1). The temperature of the water discharging from the springs averages about 70°F year round. Hydrostatic pressure of Barton Springs Pool that lies over the Main (Parthenia) Spring appears to affect flow of the other perennial springs. Eliza and Sunken Garden (Old Mill) Springs can cease to flow when the discharge from the Main (Parthenia) Spring drops below 50 cfs and the pool is lowered for routine maintenance and cleaning (City of Austin 1998a). Upper Barton Spring flows only when discharge from the Main Spring exceeds 40 cfs and drops slightly when the pool is lowered (City 1998a). Although the collective flow of Barton Springs has never ceased during recorded history, the lowest instantaneous springflow measurement of 9.6 cfs was made during the drought of record on March 29, 1956 (Brune 2002). The lowest monthly mean springflow of 11 cfs was reported at the end of the drought-of-record (1950's drought) during July and August of 1956 (Slade et al. 1986). Comal Springs in the San Antonio portion of the aquifer ceased flowing for about 4 months in 1956 during the same drought. Recent modeling conducted by the District (BSEACD 2004) indicates that under 1950's drought conditions and 2004 authorized pumping rates of about 10 cfs, flow from Barton Springs would decrease to less than 1 cfs on a monthly basis, and likely cease altogether on some days within that month.

Other minor springs include Cold Springs and Deep Eddy Springs. These springs form a complex of what was originally seven springs, although only two, located on the south bank of Town Lake about 1.5 miles upstream of the mouth of Barton Creek, are now above the normal level of Town Lake (Brune 1975). Measurements of springflow from Cold Springs are limited and imprecise but range from 2.6 to 6.8 cfs (Brune 2002; Hauwert et al. in press). Several other minor springs have been identified within the Barton Springs segment that provide inconsequential flow and may be more influenced by local conditions than directly affected by the aquifer (Brune 1975).

The aqueous chemistry of groundwater discharging from the Barton Springs varies with aquifer conditions, the most substantial decrease in water quality occurring under low flow conditions. Increases in chloride, sodium, sulfate, and strontium concentrations are reported for low flow conditions that result from an influx from the saline-water zone and the underlying Trinity Aquifer (Senger and Kreitler 1984). Additionally, under low flow conditions, nutrients (primarily nitrates) increase in concentration (City 1997). Additional discussion on groundwater quality is provided in Section 3.3.2.4.

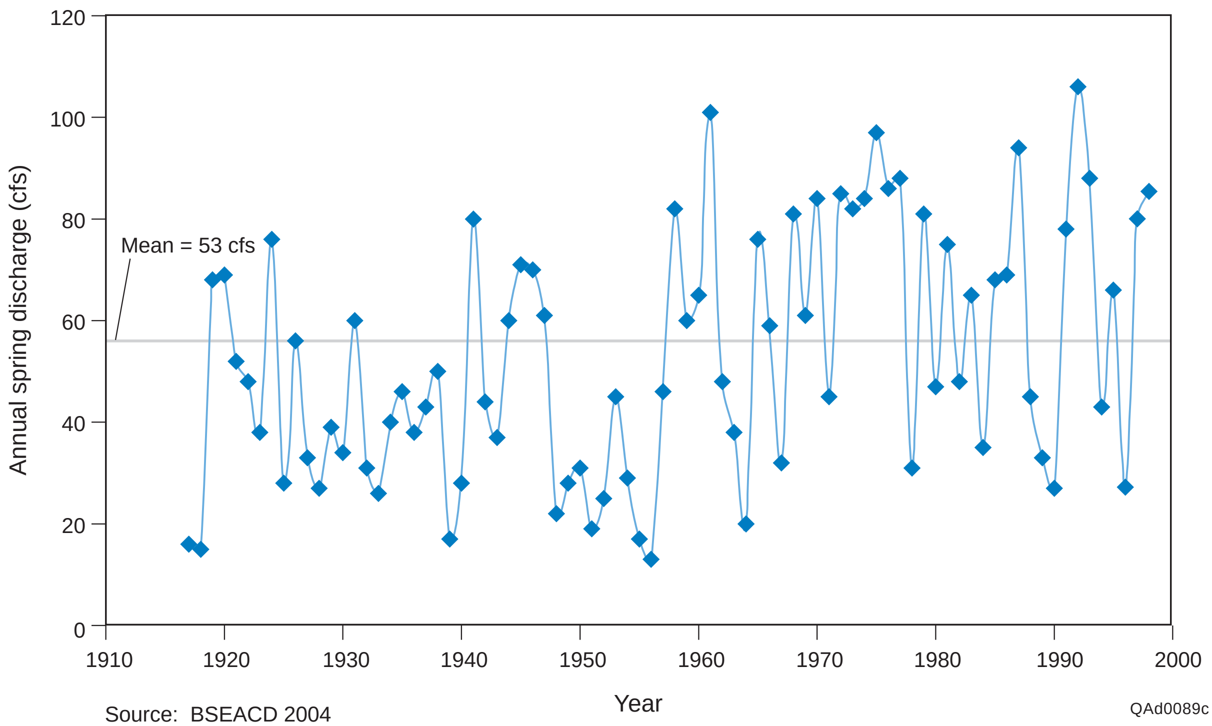


Figure 3.2 - 1 Discharge at Barton Springs

3.2.1.4 Surface Water Quality

Rules and Regulations Governing Surface Water Quality

Surface water quality is regulated and monitored by the TCEQ (Texas Natural Resource Conservation Commission [TNRCC] prior to September 1, 2002) and by the federal EPA. The State of Texas Water Quality Inventory is prepared by the TCEQ and submitted to the EPA as required by Section 305(b) of the federal Clean Water Act. This effort reports on water chemistry information, data on toxic substances in the water, sediments, fish tissue, contaminants, status and trends in water quality statewide and other historical information (TCEQ 2002a). This report assesses water by river or coastal basin where all major bodies of water, creeks, rivers, reservoirs, lakes, bays and estuaries, are divided into monitored segments. The report also includes the degree to which each water body segment supports its designated uses as established by the Texas Surface Water Quality Standards.

The TCEQ defines water body segment classification as follows: Classified surface waters are listed as water quality limited or effluent limited. Water bodies are classified as water quality limited if one or more of the following are applicable: (1) surface water quality monitoring data indicate significant violations of criteria in the Texas State Water Quality Standards (TSWQS) that are protective of aquatic life, contact recreation, public water supply, fish consumption, or oyster waters uses; (2) advanced waste treatment for point source wastewater discharges is required to meet water quality standards; (3) the segment is a public water supply reservoir (requires special wastewater treatment considerations). All other water bodies are classified effluent limited, indicating that water quality standards are being maintained and that conventional wastewater treatment is adequate to protect existing conditions.

Water body segments that did not support designated uses or water quality criteria are listed on the Draft 2004 State of Texas Clean Water Act Section 303(d) List. Stream segments on the TCEQ 303(d) list which lie over the District HCP Planning Area (Table 3.2-1) include Segment #1427-Onion Creek; Segment #1427A–Slaughter Creek, and Segment #1429B–Eanes Creek (TCEQ 2005a).

Section 314 of the federal Clean Water Act of 1987 requires states to rank major lakes and reservoirs according to their “trophic state” or nutrient levels. Data regarding specific water bodies are discussed below.

Table 3.2-1. Stream segments over the District HCP Planning Area listed on the draft 2004 Texas Clean Water Act Section 303(d) List

Segment	Segment Name	Category*	Rank**	Segment Summary
1427	Onion Creek	5c	D	Depressed dissolved oxygen levels from end of segment upstream to US 183.
1427A	Slaughter Creek	5c	D	Impaired macrobenthos community in entire segment.
1429B	Eanes Creek	5c	D	Elevated bacteria levels in entire segment.

*Category 5c: Additional data and information will be collected before a TMDL test is scheduled.
**Rank D: Additional data and information will be collected before a TMDL test is scheduled.
Source: TCEQ (2005a)

Colorado River Basin Water Quality

The Colorado River Basin is characterized in the State of Texas Water Quality Inventory published by the TCEQ as having mixed levels of water quality (TCEQ 2002a). Naturally saline soils and oil-field related activities, coupled with several years of drought, have resulted in high levels of dissolved solids in the upper portion of the basin. The water quality of the San Saba, Llano, and Pedernales Rivers is good. In the middle portion of the basin most water bodies support their designated uses. The water quality of the Highland Lakes is good, with periodic depressed dissolved oxygen concentrations resulting from seasonal mixing. Elevated nutrient levels and fecal coliform (*Escherichia coli*) densities found in many of the tributary streams in the Austin area originate mostly from unidentified non-point source runoff.

TCEQ stream segments that undergo water quality monitoring are summarized in Table 3.2-2, as determined by TCEQ in 2002. The rivers and creeks listed flow through the District HCP Planning Area and indicate typical water quality.

Table 3.2-2. TCEQ surface water quality inventory summary for the stream segments in the Colorado River Basin overlying the District HCP Planning Area

Segment Name	Number	Classification	Designated Water Uses	Water Quality Concerns within Stream Segment
Onion Creek	1427	Water quality limited	Contact recreation, aquatic life, general, fish consumption, public water supply	Depressed dissolved oxygen levels from end of segment upstream to US 183.
Slaughter Creek	1427A	Water quality limited	Contact recreation, aquatic life, fish consumption	Impaired macrobenthos community in entire segment.
Williamson Creek	1427B	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Bear Creek	1427C	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Boggy Creek	1427D	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.

Table 3.2-2. TCEQ surface water quality inventory summary for the stream segments in the Colorado River Basin overlying the District HCP Planning Area (continued)

Segment Name	Number	Classification	Designated Water Uses	Water Quality Concerns within Stream Segment
Marble Creek	1427E	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Rinard Creek	1427F	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Unnamed tributary to Slaughter Creek	1427G	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Eanes Creek	1429B	Water quality limited	Contact recreation, aquatic life, fish consumption	Elevated bacteria levels in entire segment.
East Bouldin Creek	1429D	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
West Bouldin Creek	1429E	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Blunn Creek	1429F	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.
Barton Creek	1430	Effluent limited	Contact recreation, aquatic life, fish consumption, general	While not listed on the 303(d) list, sediment contaminant concerns exist from Barton Springs Pool dam upstream to a point 2 miles upstream of Loop 1.
Barton Springs	1430A	Effluent limited	Contact recreation, aquatic life, fish consumption	While not listed on the 303(d) list, sediment and nutrient contaminant concerns and aquatic life use concern due to depressed dissolved oxygen levels exist for Barton Springs Pool.
Tributaries to Barton Creek	1430B	Effluent limited	Contact recreation, aquatic life, fish consumption	None known.

Source: TCEQ 2002c

3.2.1.5 Unique Ecological Stream Segments

In accordance with the TAC_1 31 §357.8, regional water planning groups such as the LCRWPG:

> "…may include in adopted regional water plans recommendations for all or parts of river and stream segments of unique ecological value located within the regional water planning area by preparing a recommendation package consisting of a physical description giving the location of the stream segment, maps, and photographs of the stream segment, and a site characterization of the stream segment documented by supporting literature and data."

Guidelines for Designating Unique Ecological Stream Segments

The following criteria are to be used when identifying a river or stream segment as being of unique ecological value:

- Biological Function: Segments that display significant overall habitat value including both quantity and quality considering the degree of biodiversity, age, and uniqueness observed and including terrestrial, wetland, aquatic, or estuarine habitats;

- Hydrologic Function: Segments which are fringed by habitats that perform valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization, or groundwater recharge and discharge;

- Riparian Conservation Areas: Segments that are fringed by significant areas in public ownership including state and federal refuges, wildlife management areas, preserves, parks, mitigation areas, or other areas held by governmental organizations for conservation purposes under a governmentally approved conservation plan;

- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: Segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; or

- Threatened or Endangered Species/Unique Communities: Sites along segments where water development projects would have significant detrimental effects on state or federally-listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities.

Unique Ecological Stream Segments within the District HCP Planning Area

Although the Region K Water Supply Plan for the Lower Colorado Regional Water Planning Group (LCRWPG 2005) did not recommend any sites for this designation, the plan did identify ten stream segments in the Lower Colorado Region as meriting further study for future consideration of designation as ecologically unique. Included in these are portions of Barton, Bear, Little Bear, Onion, Slaughter, and Williamson Creeks that flow over the recharge zone of the Barton Springs segment of the Edwards Aquifer located within the District.

Streams within the recharge area of the Barton Springs segment of the Edwards Aquifer are generally influenced by the interaction between groundwater and surface water and the physicochemical conditions of the karst Edwards Aquifer. Water quality is generally good to exceptional, although coliform levels are occasionally elevated after storm events. Nitrate levels can also be high due to the influence of shallow groundwater in the contributing zone. Substrate is typically limestone bedrock with rubble, boulders, and gravel. The upper portions of the streams are generally intermittent, except in spring-fed reaches, which limits aquatic habitat. However, these portions of the stream can be important for aquifer recharge. With the exception of its endemic endangered species, Barton Creek is typical of the streams that recharge the Barton Springs segment, and is characterized below.

Barton Creek is the TCEQ classified stream segment #1430 and extends through the HCP Planning Area from the confluence with Town Lake in Travis County upstream to FM 12 in Hays County. Barton Creek meets the following criteria for designation as ecologically unique:

- Riparian Conservation Area: the lower end of the stream is in the City of Austin's Zilker Park;

- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: the stream was selected as an ecoregion stream based on its physical attributes, water quality, and biological assemblages; the stream exhibits high dissolved oxygen concentrations and a diverse and complex benthic macroinvertebrate community; and,

- Endangered/Threatened Species: the major springs complex in this stream system contains the only known population of the Barton Springs salamander (*Eurycea sosorum*), a federally-listed endangered species.

3.2.1.6 Lower Colorado Regional Water Planning Group (Region K) Water Management Strategies Identified for the District Habitat Conservation Plan Planning Area

The primary emphasis of the regional water planning efforts mandated in state legislation is the development of regional water management strategies sufficient to meet the projected needs of water user groups (WUGs) throughout the state. Water needs were determined by comparing user group water demands to the water supplies available to that user group. The following section presents a brief description of those Region K water management strategies that have been identified or evaluated for WUGs within the District HCP Planning Area (LCRWPG 2000).

City of Austin

Water demand deficits in the Austin metropolitan area include numerous contractual shortages. These contractual shortages will be addressed through the renewal and expansion of existing contracts in order to meet the projected water demands for these WUGs. In addition, the City of Austin, as a major provider of water for municipal and industrial needs has a water supply shortage identified beyond 2030. Other shortages identified in this region of the Planning Area are for the Hays County–other WUGs. Water management strategies to meet these shortages are presented in the following sections.

CITY OF AUSTIN WATER MANAGEMENT STRATEGY ALTERNATIVES

The City of Austin's current water supply is projected to be adequate to meet all of the City's demands, including municipal, industrial, and wholesale demands through 2030. The City has indicated that it will seek to manage its demands for Colorado River water through water conservation and the use of reclaimed water.

Alternative A1—Water Conservation

The municipal, industrial, and wholesale water demands for the City of Austin and the wholesale customers of the City are projected to increase from 180,711 acre-feet per year in the year 2000 to 355,714 acre-feet per year in 2050. (These demand projections are detailed in Chapter 2 of the regional water plan [LCRWPG 2005].) This level of water demand is significantly higher than the historical water demand trend for the City of Austin. The water demand projections were initially based on the TWDB projections that were developed for the 1997 State Water Plan and have been revised for the 2000 plan. The projection for water demand in 2000 is based on water consumption records from 1984, which represent the City's highest historical per capita consumption and is assumed to be representative of dry-year conditions. The projection for 2050 assumes that expected water conservation measures would reduce the per capita water consumption rates by approximately 10 percent. The City's staff has indicated that the LCRWPG's water demand projections do not accurately reflect the additional water conservation that has been achieved in the City since 1984.

The City has implemented and anticipates continuing water conservation programs in the following areas:

- public education;
- rebate and incentive programs; and,
- water-saving ordinances.

Through these programs, the City has made significant advances toward reducing the per-capita consumption of water in its service area. The City of Austin has a long-term commitment to continue its water conservation programs in order to meet the water conservation expectations included in the Region K demand projections.

Alternative A2—City of Austin Reclaimed Water Initiative

In addition to the aggressive water conservation measures the City of Austin has implemented to reduce water demands, the City is pursuing the development of reclaimed water as an additional supply of water to meet non-potable demands in the area. The City has indicated that it will develop and use reclaimed water as the primary strategy to meet the projected needs in 2050, and likely beyond. To meet the total projected water demands, the Water Reclamation Initiative would need to supply up to 30,714 acre-feet per year for non-potable purposes by the year 2050.

The City is currently using reclaimed water from its South Austin Regional Wastewater Treatment Plant to irrigate several golf courses in South Austin. The City estimates this use to be 2,000 acre-feet per year. In order to expand the availability and use of reclaimed water, the City has completed a series of planning activities, which have resulted in the publication of the 1998 Water Reclamation Initiative (WRI) Planning Document. The WRI Planning Document identifies the proposed development of a major distribution system to convey reclaimed water from the Walnut Creek Wastewater Treatment Plant to potential customers in the central and northeast portions of the City. The City has initiated the design and construction of the first phase of this Central–Northeast System. The anticipated, future demands for reclaimed water from the Central–Northeast System are 28.3 million gallons per day (mgd) during peak day and 16.1 mgd during average day conditions. This would equate to approximately 18,000 acre-feet per year.

The City has begun planning efforts for further development of the South Reclaimed Water System. A master plan for this system has been completed. In addition, the City continues to evaluate the feasibility of constructing additional reclaimed water facilities to provide reclaimed water in other areas of the city. The City will continue to pursue the expeditious implementation of its WRI and anticipates that the ability to reuse additional water will be in place well before it is needed to meet the needs identified in 2050.

Currently, the City of Austin plans no increased use of groundwater to meet its future water-supply needs. The Green Water Treatment Plant, which withdraws water from Town Lake downstream of Barton Creek and therefore is in part water derived from groundwater discharges at Barton Springs, is being de-commissioned. However, the City water utility is looking at non–Edwards Aquifer groundwater supplies, especially the Carrizo-Wilcox Aquifer resource, in its long-range planning.

HAYS COUNTY WATER MANAGEMENT STRATEGY

Northern Hays County is within the District HCP Planning Area. It has been experiencing significant population growth due to its proximity to the Austin metropolitan area. Currently, water users in this area rely primarily on groundwater resources to meet their needs. The groundwater supplies in the area are presently showing signs of stress as a result of recent growth. During drought conditions, the area is projected to have a shortage of 990 acre-feet per year beginning in 2010. This shortage steadily increases to 3,525 acre-feet per year in 2030 and ultimately 5,227 acre-feet per year in 2050. It is anticipated that the water supply strategies implemented to meet 2030 demands will also be sufficient to meet 2050 demands. The adopted 2000 Region K recommended plan to meet water supply shortages in the Hays County-Other category includes the following components.

Alternative H1—Obtain Surface Water from LCRA West Travis County Regional System

This alternative would include the construction of booster pump stations, transmission mains, and storage facilities to convey treated surface water from the LCRA West Travis County Regional Water System to users in the vicinity of Dripping Springs. The first phase of this project includes a pipeline, which generally follows U.S. Highway 290 from the Travis County Line almost to Dripping Springs. Construction of this first phase is complete. The first phase of the project is expected to provide a capacity of 2,240 acre-feet per year at a unit cost of $1,259 per acre-foot. A second phase of this project would include an additional water treatment plant, pump stations, and transmission mains. The second phase of the project would increase the available water supply to Hays County by an additional 1,120 acre-feet per year.

Alternative H2—Obtain Surface Water from GBRA/San Marcos Regional System

This alternative would include the construction of a booster pump station at the San Marcos Regional Water Treatment Plant and a transmission line north, generally along Interstate Highway (IH) 35. This system will provide water to several water users between San Marcos and Austin. Only a portion of the water supply from this project would serve WUGs in the Lower Colorado Region. This project is expected to provide a total water supply of 4,480 acre-feet per year; however only 1,680 acre-feet per year of this supply would be for WUGs in the Lower Colorado Region. The anticipated unit cost of providing this water is $647 per acre-foot.

Alternative H3—Obtain Treated Water from City of Austin

This alternative would include the construction of a 16-inch looped transmission system from the City of Austin's existing water distribution system to provide water to the Spillar Ranch and Pfluger Ranch developments in northern Hays County. The system would be able to supply approximately 1,100 acre-feet per year at a unit cost of $818 per acre-foot.

Alternative H4—Dripping Springs Reservoir

Another alternative to provide water to the Hays County–Other WUGs would involve the construction of a dam across Onion Creek approximately five miles south-southeast of Dripping Springs. This project would supply 3,100 acre-feet per year of treated water to the Dripping Springs area. It should be noted that this water-supply reservoir would tend to decrease the flow in Onion Creek downstream, which provides one-third of the recharge to the Barton Springs segment.

Alternative H5—Driftwood Reservoir

This Hays County-Other WUGs alternative would involve the construction of a rock-fill dam about 100 feet in height and approximately 2,500 feet in length. The dam would be constructed across Onion Creek approximately four miles southeast of the town of Driftwood. The dam would impound 55,000 acre-feet of water and would have a surface area of 1,750 acres. This project has been evaluated as a potential recharge enhancement project. That is, water stored in the reservoir would be released at a controlled rate to maximize the amount of recharge to the Barton Springs segment of the Edwards Aquifer downstream along Onion Creek.

This proposed reservoir has been projected to increase recharge to the aquifer by 9,300 acre-feet per year during the recurrence of a seven-year critical drought. The enhanced recharge would be available to groundwater users within the Barton Springs segment of the Edwards Aquifer. The total annual cost for this alternative water management strategy, is estimated to be $3.1 million, which results in a unit cost of water of $333 per acre-foot, or $1.02 per 1000 gallons.

Alternative H6—Onion Creek Recharge Dams

Another Hays County–Other WUGs alternative that has been evaluated to enhance recharge to the Edwards Aquifer is the construction of a series of small channel dams along Onion Creek. These dams would impound water that could later be released at controlled rates to downstream recharge features. A total of four sites have been evaluated in the past. Estimated additional annual recharge for these projects ranges from 768 acre-feet per year to 5,718 acre-feet per year at unit costs ranging from $35 per acre-foot to $111 per acre-foot. These dams are not included in the latest Lower Colorado Regional Water Plan.

3.2.2 Groundwater

Groundwater within the District HCP Planning Area originates from the Trinity and Edwards Aquifers, two major aquifers that are hydrogeologically interrelated. The Edwards Aquifer overlies the Trinity aquifer and the two aquifers are hydraulically connected where no confining unit separates them or where they are juxtaposed by faulting (U.S. Geological Survey [USGS] 2005d). The Trinity Aquifer outcrops on the western portion of the District HCP Planning Area in an area generally corresponding to the contributing zone of the Edwards Aquifer. The stratigraphic relationship of the two aquifers is shown in Figure 3.1-5. A description of the two aquifers is provided below.

3.2.2.1 Description of the Trinity Aquifer

The Trinity Aquifer underlies an area of about 41,000 square miles that extends from south-central Texas to southeastern Oklahoma (USGS 2005d). Groundwater in the Trinity Aquifer has been described as calcium carbonate in western Travis County, changing to a sodium sulfate or chloride type water as the aquifer extends deeper into the subsurface to the southeast (i.e., downdip). The water is very hard and the quality tends to decrease downdip. Low permeability, restricted water circulation, and increase in temperature result in higher mineralization downdip (Brune and Duffin 1983).

Through increased water demand from urban and suburban development, the upper, middle, and lower parts of the Trinity Aquifer are locally experiencing declining water levels (Mace et al. 2000) and degraded water quality. This trend has prompted the need for supplemental surface water supplies in southwestern Travis and Northern Hays Counties as noted in Section 3.2.1.6 above, and largely justified the need for construction of a major distribution pipeline providing surface water supplied by the LCRA (BIO-WEST 2002).

The water-bearing rocks of the Trinity Group Aquifer have been categorized into three principal units according to hydrogeological characteristics. These units are: the lower Trinity Aquifer, consisting of the Sligo and Hosston Members of the Travis Peak Formation; the middle Trinity Aquifer, which includes the lower Glen Rose Formation and the Hensell Sand and Cow Creek Limestone groups of the Travis Peak Formation; and the upper Trinity Aquifer, consisting of the upper portion of the Glen Rose Formation and the Paluxy Formation (Brune and Duffin 1983). Each of these hydrological subunits of the Trinity Aquifer is described separately below.

Upper Trinity Aquifer

The upper Trinity aquifer dips irregularly toward the southeast and has a thickness ranging from about 230 feet in northwestern Travis County to about 600 feet in the southeast. Depths of wells in the Upper Trinity Aquifer within the Dripping Springs area range from 11 to 169 feet with static water levels of 5 to 91 feet (Muller 1990). Artesian conditions exist in the subsurface; however, no flowing wells or springs in the upper Trinity were located within Travis County (Brune and Duffin 1983).

Muller (1990) noted that the quality in the upper Trinity Aquifer was better than the Middle Trinity Aquifer for sulfate, fluoride, and dissolved solids, indicative of shorter flow paths in the upper aquifer. However, elevated nitrate concentrations were present and believed to be primarily caused by septic tank effluent. Samples from wells also documented fecal coliform and fecal streptococcus above Texas Department of State Health Services standards; however, the results were not conclusive (Muller 1990). The Upper Trinity Aquifer is considered to generally be in hydrological communication with the overlying Edwards Aquifer, although the connection is not well-established and poorly known; the differences in hydraulic heads, which control inter-formational flow direction, are not great and are probably variable in much of the District.

Middle Trinity Aquifer

In the middle Trinity Aquifer, groundwater is unconfined in the outcrop area, but it becomes confined downdip. In the downdip portions of the aquifer, groundwater is found under artesian conditions, and wells may flow due to hydrostatic pressure, particularly those drilled in lower areas along Lake Austin and in the City of Austin (Brune and Duffin 1983).

Most of the deep wells in the Dripping Springs area, west of the District's jurisdiction, produce from the Middle Trinity Aquifer. Well depths in the Dripping Springs area range from 99 to 580 feet, with static water levels of 81 to 296 feet (Muller 1990). However, low aquifer permeability has created rapid drawdowns of the wells and slow recharge rates. Bluntzer (1992) documented wells with water levels declining since 1977.

Quality of groundwater from the Middle Trinity Aquifer has been characterized as variable but generally slightly saline and may contain high sulfate that is derived from the gypsum beds of the Cow Creek Limestone (DeCook 1963, Ashworth 1983, Brune and Duffin 1983, Bluntzer 1992). Additional water quality problems involving bad taste and odor have been reported by the LCRA (LCRA 2000). Muller (1990) noted that the groundwater in the Middle Trinity Aquifer could be contaminated at certain locations because of improperly completed wells with open or uncased boreholes.

Lower Trinity Aquifer

The units of the Lower Trinity Aquifer outcrop in extreme western and southwestern Travis County. However, in these areas these units appear to be largely non-water bearing. In the downdip portions of the aquifer, these units appear to be more permeable, and artesian conditions exist, with many flowing wells in lower areas on the Colorado River (Brune and Duffin 1983). The Lower Trinity Aquifer sediments are recharged by vertical leakage from overlying strata (Ashworth 1983). Discharge occurs by wells and cross-formational flow to the Edwards Aquifer, especially along faults (Jones et al. 1997).

The groundwater quality in the lower Trinity Aquifer has been described as slightly saline with dissolved solids content often over 1,000 milligrams per liter (DeCook 1963; Brune and Duffin 1983; PBS&J 1999). A portion of the wells in this aquifer could be expected to exceed drinking water maximum contaminant levels for several constituents including nitrate, fluoride, chloride, sulfate, dissolved solids, and sodium (Bluntzer 1992).

3.2.2.2 Description of the Edwards Aquifer and Barton Springs Segment

The Edwards Aquifer is one of nine major aquifers in Texas and is referred to as the Edwards Balcones Fault Zone Aquifer by the Texas Water Development Board (2002). This aquifer covers approximately 4,350 square miles across parts of 11 Texas counties, from a groundwater divide in Kinney County through the San Antonio area northeast to Bell County (Figure 1.1-1). The aquifer is the sole source of drinking water for approximately 2 million people in central Texas (BSEACD 2005a; Smith et. al 2005), and provides habitat for a number of aquatic cave organisms and species dependent on spring ecosystems, about 75 percent of which are endemic (found only in this region) (Abell et al. 2000; Longley 1986).

Groundwater flow within the Edwards Aquifer is very complex (Maclay 1995). Generally, groundwater is unconfined in the recharge zone and flows with steep hydraulic gradients. As the water flows into the confined portion of the aquifer, the flow direction changes toward the east and northeast. The groundwater is then discharged through a number of springs, the largest being Comal, San Marcos, and Barton Springs. Although the Edwards Aquifer contains vast reserves of groundwater, a large volume of water cannot be extracted without affecting springflow because the springs are at a higher elevation than much of the groundwater in storage in the confined artesian zone.

The Edwards Aquifer is comprised of three segments: the southern (San Antonio) segment which covers 3,600 square miles or 82 percent of the aquifer’s total area (as defined by the TWDB); the Barton Springs (Austin) segment which covers approximately 155 square miles (4 percent of the total aquifer area); and the northern segment which covers about 600 square miles or 14 percent of the total aquifer area (Figure 1.1-1). A groundwater divide running west-northwest from the city of Kyle, in Hays County, hydrologically separates the San Antonio and Barton Springs (Austin) segments. At this location, under most conditions, groundwater from the San Antonio and Barton Springs segments do not mix. Generally, groundwater north of the divide flows north, while groundwater south of the divide flows south. The Colorado River separates the Barton Springs segment from the northern segment of the aquifer. The focus of the groundwater discussion in this report will be on the Barton Springs segment of the Edwards Aquifer.

The Barton Springs segment of the Edwards Aquifer shown in Figures 1.1-1 and 3.1-4 covers approximately 155 square miles (Slade et al. 1985), and extends over Travis and Hays Counties. This aquifer provides municipal, industrial, agricultural, and domestic uses for about 50,000 people (BSEACD 2005a). Approximately 80 percent of the aquifer is unconfined and the remainder is confined (Slade et al. 1985). This segment of the aquifer is bounded on the north by the Colorado River, on the east by the interface between the fresh-water zone and the saline-water or "bad-water" zone of the aquifer, on the west by the western limit of Edwards Aquifer hydrogeologic units and the Balcones Fault Zone (Slagle et al. 1986; Small et al. 1996), and on the south by a groundwater divide that is estimated to occur between Onion Creek and the Blanco River (LBG–Guyton Associates 1994; Hauwert et al. 2004). The Barton Springs segment is divided into several hydrological zones that are described below.

Contributing Zone

The contributing zone of the Barton Springs segment of the Edwards Aquifer is not technically part of the aquifer, consisting mainly of the drainage basins containing streams and creeks that lead to and eventually flow over the aquifer's recharge zone. The contributing zone comprises an area of approximately 264 square miles in Travis, Hays, and Blanco Counties (Scanlon et al. 2001) (Figure 1.1-2). This area is important because it affects the quantity and quality of water received, stored, and eventually discharged by the aquifer.

Recharge Zone

The recharge zone is an approximately 90 square mile area (Slade et al. 1986) where heavily faulted and fractured Edwards limestone crops out at the land surface, allowing water to flow into the aquifer. Recharge occurs when creeks and streams cross the permeable formation and lose a portion of their flow to the geologic units they are crossing, or when precipitation or runoff falls directly on these outcrop areas. Water reservoirs, including small lakes and ponds located in the recharge zone, may also contribute recharge to the aquifer. Based on data from streamflow gages, approximately 85 percent of surface recharge occurs from six creeks that cross the recharge zone (Slade et al. 1986). The remaining portion of recharge comes from surface runoff and possible groundwater leakage from outside the aquifer that may occur under certain hydrological conditions. Streams that contribute recharge to the aquifer include Barton Creek (28% of the percent of total recharge contributed from the respective watersheds); Williamson Creek (6%); Slaughter Creek (12%); Bear Creek (10%); Little Bear Creek, (10%); and Onion Creek (34%) (Figure 3.1-4). East of the recharge zone, the aquifer is overlain by less permeable clay and limestone units, which hydraulically confine the aquifer farther east in the confined, or artesian, zone.

Artesian Zone

The artesian (confined) zone (Figures 1.1-2 and 3.1-4) is located between two relatively impermeable formations, the Glen Rose formation below, and the Del Rio clay above. Approximately 20 percent of the surface extent of the aquifer is under confined conditions, while the remaining part of the aquifer is under water-table conditions (Slade et al. 1986). The water entering the aquifer from the recharge zone creates tremendous pressure on water that is already present in the formation. Flowing artesian wells exist where this pressure is sufficient to force water to the surface in wells, and springs exist where this pressure is sufficient to force the water to the surface through faults, fractures, bedding planes, or other weak points in the overlying formations. Groundwater movement through the aquifer is generally controlled by a number of barrier faults that disrupt the continuity of the permeable Edwards limestone. This movement tends to be from the higher elevations in the west to discharge areas in the east. The displacement of strata ranges from very large, which causes permeable and impermeable layers to be juxtaposed, to very small. Water moves more freely through the aquifer when displacement is minimal.

Freshwater/Saline Water Interface

The freshwater/saline water interface (or saline water line) shown on Figures 1.1-2 and 3.1-4 (above) is not an actual, well-defined boundary but rather a zone of change that generally follows the Interstate 35 corridor through Hays and Travis Counties. The reason why the “bad-water line” exists is not clear; in some places, it is coincident with geologic features such as faults; however, in other places there is no obvious geologic control. The presence of “bad” or more saline water appears to be more associated with relative permeabilities of the aquifer rather than a density boundary between two different water types, which commonly exists in coastal sand aquifers. Wells in the transition zone have shown sections of brackish water that overlie freshwater, which in turn overlie brackish water, indicating that the type of rock and porosity influences the salinity of the water.

For the Barton Springs segment of the Edwards Aquifer, there is evidence that during low aquifer levels, higher salinity water can encroach into the freshwater zone, particularly in the northeastern portion of the aquifer and near Barton Springs (Slade et al 1986).

Measurements from wells on either side of the bad water line (BWL) indicate that during high recharge conditions, water levels within the freshwater zone can exceed levels within the “bad-water zone”, allowing movement of freshwater into the “bad water” zone. During low recharge conditions, the process is reversed, allowing the encroachment of “bad water” into the freshwater zone. While the BWL is often depicted as a line on a map, a substantial component of flows from more saline to less saline strata may be more vertical than horizontal. Measurements of well levels during the drought of record in 1956 also indicate the possibility of water movement from the southern segment of the Edwards Aquifer north into the Barton Springs segment, thus affecting changes in the BWL and resulting increased salinities in Barton Springs (Slade et al 1986, DeCook 1960).

Other Regulatory Zones

In addition to the hydrological zones, the TCEQ has defined a transition zone for implementing aquifer protection rules (Figure 1.1-2). The transition zone is defined by the TCEQ (2001) as geologic features such as faults and fractures that present possible avenues for surface water to reach the water table. This zone is adjacent to the recharge zone and is transitional to the artesian zone. It should also be noted that these same faults and fractures may provide conduits for some amount of saline water intrusion into the freshwater parts of the Edwards Aquifer.

3.2.2.3 Groundwater Storage and Flow

The Edwards Aquifer is extremely dynamic, with rapid fluctuations in springflow, water levels, and storage, reflecting changes in recharge (climatic conditions) and pumpage (demand). Water-level measurements and groundwater dye-tracing studies provide insight into groundwater flowpaths from source areas (recharge locations) to wells and springs. Groundwater generally flows west to east across the recharge zone, converging with preferential groundwater flowpaths subparallel to major faulting, and then flowing north toward Barton Springs. Although regional groundwater flow in the aquifer occurs largely under diffuse conditions, preferential flow paths were traced along troughs in the potentiometric surface, indicating zones of high permeability. Rates of groundwater flow along preferential flow paths, determined from dye tracing, can be as fast as four to seven miles per day under high-flow conditions or about one mile per day under low flow conditions (Hauwert et al. 2004). Heterogeneity of the aquifer is further expressed in terms of well yields, which range from less than 10 gallons per minute (gpm) to greater than 1,000 gpm. Well yields in the confined part of the Edwards Aquifer are often limited more by pump size than by aquifer properties (Schindel et al. 2004).

3.2.2.4 Aquifer Water Budget

Storage Capacity

The volume of water stored in the Barton Springs segment during average springflow conditions has been estimated to be about 306,000 acre-feet, of which about 31,000 acre-feet represents change in storage occurring between high flow and lowest known flow of Barton Springs (Slade et al. 1986). Characteristics of aquifer recharge and discharge have been documented in sustainability studies conducted by the BSEACD (2004). These characteristics are described below.

Surface Recharge

Estimates of recharge based primarily on three years of continuous flow data from five of the six major creeks show that as much as 85 percent of the water that recharges the Barton Springs aquifer occurs within the six major creek channels (Slade et al. 1986). The remaining recharge is attributed to upland runoff areas, which include tributary streams and some leakage from the adjacent Trinity Aquifer. Recent investigations have demonstrated that most recharge infiltrates via discrete features, such as caves, sinkholes, fractures, and solution cavities within stream channels (BSEACD and City of Austin 2001). Additional flow and recharge data are currently being collected by the USGS, the City of Austin, the District, and the University of Texas at Austin to verify and further refine quantification of sources of recharge to the Barton Springs aquifer. Long-term average annual recharge to the aquifer is currently estimated at about 61.5 cfs (Raymond Slade, personal communication).

Subsurface Recharge

The amount of subsurface recharge occurring from adjacent aquifers is unknown, although it is thought to be relatively small on the basis of water-budget analysis for surface recharge and surface discharge (Slade et al. 1985). Leakage from the saline-water zone is probably minimal, although this leakage does influence water quality at Barton Springs during low springflow conditions (Senger and Kreitler 1984; Slade et al. 1986). On the basis of a geochemical evaluation, Hauwert et al. (2004) found that the contribution to springflow from the saline-water zone to Barton Springs under low flow conditions could be about 3.5 percent of the discharge.

Subsurface flow into the Barton Springs aquifer from adjacent aquifers such as the San Antonio portion of the Edwards aquifer and the Trinity Aquifer is limited when compared with surface recharge (Slade et al. 1985). Hauwert et al. (2004) indicated that flow across the south boundary of the aquifer is probably insignificant under the conditions tested. However, the potential exists for such leakage during severe drought conditions, which was not tested in that study. As part of the sustainable-yield evaluation, an analysis of the southern groundwater divide was conducted to evaluate the potential for flow across that boundary (BSEACD 2004).

Flow (or leakage) from the Trinity Aquifer into the Barton Springs aquifer is also thought to be relatively insignificant. In fact, estimates based on water quality at Barton Springs suggest that less than 1 percent of flow to the springs is from the Trinity Aquifer (Hauwert et al. 2004). Although leakage from the Trinity Aquifer may be insignificant compared with total recharge rates, leakage may nevertheless locally impact water quality and influence water levels (Slade et al. 1986). A groundwater model of the Trinity Aquifer includes lateral groundwater leakage into the Edwards Aquifer in the San Antonio area in order for the model to simulate observed hydrogeologic conditions (Mace et al. 2000). However, where the Trinity Aquifer is in contact with the Barton Springs aquifer, the Trinity model indicates little or no lateral flow into the Barton Springs portion of the aquifer. Upward “leakage” from the Trinity Aquifer into the Edwards Aquifer is also thought to be limited and to only occur locally along high-permeability fault zones (Slade et al. 1986). The District investigated the local vertical flow potential between the Edwards and (upper-middle) Trinity Aquifers using a nested well pair in the west part of the recharge zone. Results of that local investigation do not support the idea of limited vertical leakage from the Trinity to the Edwards Aquifer in the District, demonstrating that actual potential for vertical flow is from the Edwards to the Trinity in the vicinity of the nested wells.

Discharge

Discharge from the aquifer is primarily from springflow and pumpage from wells in the study area. The amount of subsurface discharge occurring through adjacent aquifers is unknown, although it is thought to be relatively small on the basis of a water-budget analysis (Slade et al. 1985). Average long-term annual discharge from Barton Springs is estimated to be about 53 cfs or 38,000 acre-feet per year (BSEACD 2004), while Cold Springs and Deep Eddy Springs together contribute about 5.5 cfs or 3,900 acre-feet per year (Raymond Slade, personal communication). Total long-term spring discharge is estimated to be about 58 cfs or 41,900 acre-feet per year. At least some of the discharge from Deep Eddy Springs may be from the northern segment of the Edwards, rather than the Barton Springs segment.

Water supply wells in the Barton Springs aquifer include about 970 active wells that pump water for public, domestic, industrial, commercial, irrigation, and agricultural uses (BSEACD 2004). About 10 percent of these wells have annual pumping permits issued by the District. Most permitted pumpage is for public-supply and industrial purposes, and most of the permitted pumping occurs in the southeast part of the aquifer. Permitted pumpage in 2004 was about 2.3 billion gallons (7,060 acre-feet, or 9.75 cfs). Non-permitted pumpage, such as agricultural and domestic supply, is estimated to have been about 200 million gallons per year. Combined, these authorized pumping volumes are about 2.5 billion gallons per year (7,818 acre-feet per year) and equate to a mean authorized pumping rate of about 10.8 cfs for 2004.

Scanlon et al. (2001) estimated that pumping would increase linearly from 9.3 cfs in 2000 to 19.6 cfs by the year 2050, without regulatory restriction. Future pumping projections are described in Appendix A of that report (Scanlon et al. 2001). These rates are rough estimates that are based on projections from the LCRWPG and the Capital Area Metropolitan Planning Organization (CAMPO). None of these projections, however, could be applied directly to the District's jurisdictional area. Therefore, a multiplier of 2.1 was used to estimate pumpage demand in 2050 from pumpage in 2000, as this multiplier is higher than current estimates for Texas rural areas but lower than for towns.

On the basis of results of hydrogeological modeling studies conducted by the District, the effect of pumping on springflow approximates a 1:1 relationship, for example, for each additional increase in pumping of 1 cfs, springflow at Barton Springs declines by approximately 1 cfs (BSEACD 2004).

3.2.2.5 Groundwater Quality

The highly fractured limestone formations and resulting fissures, cavities, and transport conduits typical of karst aquifers, in conjunction with thin soils make the Barton Springs-Edwards Aquifer susceptible to water quality degradation from chemical pollutants and sedimentation from land surface erosion and runoff. This section describes several studies conducted to assess water quality of the Edwards Aquifer. Recent water quality data is listed in Appendix D, while groundwater quality management and planning efforts are summarized in Appendix E.

Water quality in the Barton Springs segment of the Edwards Aquifer, and at Barton Springs, has been analyzed by several investigators, including Andrews et al. (1984), Slade et al. (1986), and Turner (2000), among others. The most current effort is an on-going water quality project by the USGS entitled *Barton Springs Water Characterization Project* (2007).

USGS 1986 Water Quality Study

The USGS study by Slade et al (1986) examined available water quality data for the period 1979-1983 for each creek that recharges the aquifer, for Barton Springs, and for thirty-eight wells drilled into the Barton Springs segment of the Edwards Aquifer. Analyses for the creeks and Barton Springs included nutrients (ammonia nitrogen, organic nitrogen, nitrite nitrogen, nitrate nitrogen, and phosphorus); physical organics and inorganics (specific conductance, pH, temperature, color, turbidity, dissolved oxygen, suspended and dissolved solids, bio-chemical oxygen demand, and total organic carbon); indicator bacteria (total coliform, fecal coliform, and fecal streptococci);

inorganic chemical constituents (calcium, magnesium sodium, potassium, alkalinity, sulfate, chloride, fluoride, and silica); twelve selected trace elements (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc); twenty-six insecticides and herbicides; and radiochemical analyses for selected dates and sites.

Analyses for the groundwater samples included all the above constituents except color, turbidity, dissolved oxygen, biochemical-oxygen demand, and suspended solids. Water quality of the Barton Springs segment of the Edwards Aquifer was found to be generally very good. Although relatively high concentrations for a few constituents were detected, no regional contamination problems were identified in the 1986 water sampling program.

Water quality from Barton Springs and the wells in the Edwards Aquifer was found to be better than that for the creeks providing surface recharge, which were found to have fecal coliform bacteria levels as high as 100,000 colonies per 100 milliliters. Significant densities of fecal bacteria were occasionally found in Barton Springs. Significant concentrations of nitrate nitrogen, fecal-group bacteria, and fluoride were identified from well samples. The investigators concluded that the fluoride originated in the aquifers (Trinity Group) that underlie the Edwards and that the nitrate nitrogen and fecal-group bacteria originated in residential developments and cattle ranches located in the area.

City of Austin Water Quality Study

An analysis of long-term water quality records (1975-1999) from Barton Springs (Turner 2000) indicated statistically significant changes in water quality potentially related to watershed urbanization. Trends of increasing specific conductance, sulfate, turbidity, and total organic carbon were noted to be significant. A decreasing trend in dissolved oxygen concentrations was also significant in Barton Springs. Significant trends were not noted in other parameters that are commonly considered pollutants, such as nutrients and total suspended solids. However, when older, less verifiable data are included in the analysis, a long-term increase in nitrate nitrogen is statistically significant.

In this study, data from Barton Springs were extracted from the City of Austin's field sampling database. The City of Austin Barton Springs Project data, the USGS Barton Springs data, and the Austin-Travis County Health Department fecal coliform samples were selected. In addition, time series data were collected with a DataSonde every 15 minutes for several years, for one parameter, dissolved oxygen, to aid in interpretation of long-term data. Other available data sets not used in the analyses (TNRCC data, short-term City of Austin sampling projects, citizen monitoring, etc.) are more sporadic in sampling frequency, do not meet quality control standards, or tend to be limited to just a few constituents.

Multiple linear regression analysis was used to determine if parameter levels were changing over time, the direction of change, and the level of significance of the change. Regression analysis was performed for each parameter for three flow classes: base-flow with recharge, base-flow without recharge, and storm-flow. A relationship between spring discharge levels and parameter levels for some parameters has been previously demonstrated at Barton Springs (Senger and Kreitler 1984; City of Austin 1997). Results indicated that parameters with significant changes over time included conductivity, dissolved oxygen, organic carbon, sulfate, and turbidity. The multiple linear regression model using discharge followed by date was significant (at the 0.05 level) in all cases. The model's r-square property is not high in most cases, indicating that many factors, such as antecedent weather conditions, that affect the water quality of the spring discharge are not included in the model. These other factors cannot be adequately characterized over the entire period from 1975 to 1999 and thus cannot be included in the model. Hence, the regression model should not be used to predict future water quality concentrations. In addition, it should be noted that the model is linear. Water-quality changes in response to environmental stresses may be linear over a certain range of stress levels and then change abruptly once a threshold is reached. However, a significant time coefficient in parameters of consequence to drinking water or aquatic life uses would demonstrate a trend for the worse in the water quality of Barton Springs.

In general, the analysis indicates that dissolved oxygen increases with increasing discharge, whereas conductivity and sulfate decrease with increasing discharge. Organic carbon is not significantly related to spring discharge under any flow condition.

CONDUCTIVITY

Conductivity has increased during all flow conditions over the past 20 to 25 years. The largest change over this period is observed during base-flow with recharge and is estimated to be less than a 15 percent change. Storm-flow changes are estimated to be less than 7 percent, and during base-flow without recharge, the change is less than 5 percent. The increase noted in Barton Springs may be an indicator of future change in Barton Springs to more of an urban signature.

DISSOLVED OXYGEN

Dissolved oxygen (DO) has decreased over time during base-flow, when recharge was not occurring. During non-recharge, at low spring discharge levels, the measured DO sometimes drops below 4 milligrams per liter (mg/L). DO is significantly directly related to spring discharge levels, but DO is decreasing both at high discharge levels and at low ones. The median dissolved oxygen concentration has decreased approximately 1.1 mg/L over the last 25 years, from 6.8 to 5.7 mg/L, a decrease of 16 percent. Sampling has been much more frequent recently, leading to a higher probability of observing extreme events.

Therefore it is possible that the change is a sampling artifact. However, DO concentrations in Barton Springs, tracked with a DataSonde (data at 6-hour intervals over month-long periods) have been below 4 mg/L 11 percent of the time during an approximately 4-year period of record. The plots of the DataSonde data, which were not included in the regression or magnitude of change calculations, compared with the discrete DO data show that low DO levels may predominate during periods without much recharge. The DataSonde data have yet to be scrutinized carefully for drift or calibration problems, but it does indicate the potential for the occurrence of low DO in the springs (see Appendix D for recent DO data collected at Barton Springs).

ORGANIC CARBON

Organic carbon has increased during storm-flow only. The size of the increase in median concentration over the last 25 years is 1.9 mg/L, from 1.5 to 3.4 mg/L. This change is an increase of 127 percent. Perhaps increased deposition of degradable organic carbon in the aquifer during storm-flow may lead to decreases in DO during base-flow when no recharge is occurring. However, this mechanism is an untested inference from the two-parameter changes.

SULFATE

Sulfate has increased during base-flow when recharge is occurring. Median sulfate concentrations have increased approximately 10.5 mg/L, from 28.3 to 38.8 mg/L. This is an increase of 37 percent over a 20-year period. Sulfate levels have been found to be fairly consistent indicators of urbanization in much smaller springs in the Jollyville Plateau region. Mean concentrations in rural springs ranged from 12 to 26 mg/L, whereas mean concentrations in newer urban springs ranged from 43 to 59 mg/L (read from graph in City of Austin 1999). The current median concentrations in Barton Springs lie between these two groups. Again, this increase may be an early indicator of the effects of watershed urbanization that are not reflected in more commonly considered pollutants.

TURBIDITY

Turbidity has increased significantly over time during storm-flow. In a study conducted by the City of Austin in 1990, stormwater runoff pollutant loads were found to increase with increasing impervious cover. Stormwater pollution loadings have also been correlated with development intensity in Austin (Soeur et al. 1995). Sampling has been much more frequent recently, leading to a higher probability of observing extreme events. However, the frequency of high turbidities is such that the observed increase is unlikely to be a sampling artifact. The average increase in storm water turbidity is 1.7 nephelometric turbidity units (NTUs), from 5.3 to 7 NTUs. This is an increase of about 32 percent over the past 20 years. It should be noted that the influence of recent data on storm condition results may be significant due to an effort to obtain representation of turbidity over the storm-flow hydrograph. This can be compared to previous sampling strategies whereby only single grab samples were obtained for storm events. Replacement of storm event data with median values causes the regression to be non-significant at the 0.05 level; however, the regression is still significant when these events are replaced with the maximum single grab taken over the storm event.

While the changes in turbidity during base-flow (with and without recharge) are not significant due to the variability of the data and the large number of very low concentrations, some indication exists that change is occurring. Prior to 1990, under base-flow conditions, 82 percent of the turbidity levels during recharge were less than 2 NTUs and all storm-flow turbidities were less than 12 NTUs. In the past 5 years, 74 percent of the base-flow turbidity levels during recharge conditions were between 2 and 12 NTUs, and 34 percent of storm-flow turbidities were between 12 and 50 NTUs (Turner 2000). Although short-term turbidity increases are expected during storm conditions as a watershed is urbanized, base-flow increases in turbidity may also be an early indicator of such watershed changes. Also, the inclusion of data removed due to lack of corresponding coliform and total suspended solids data impacts the turbidity regressions. Including these data as base-flow resulted in a significant increasing trend for non-storm, recharge conditions.

2005 City of austin Update on Barton Springs Water Quality Degradation Analysis

An update of previous studies was recently performed that incorporated approximately 5 years of additional data and additional methods of screening, classifying and evaluating the data from the entire period of record. Most data were collected by either the USGS, the City of Austin, or the Austin Travis County Health Department. The 2005 analysis is the most detailed and thorough for Barton Springs data and represents the best methods and information available for this evaluation to date as indicated in a City of Austin memorandum dated August 19, 2005 (Johns 2005). According to the memorandum, 17 of 18 water quality parameters that were changing over time were contributing to degraded water quality. Among the 18 water quality parameters investigated, the memorandum cited increases in nitrates/nitrites, fecal coliform, and decreasing levels of DO. City staff remained particularly concerned with recent declines in the concentration of DO and the potential impacts on the Barton Springs and Austin blind salamanders.

Additional Analysis on Spring Data

Several additional analyses were completed as checks on the validity of the results on parameters and flow conditions that were shown to have significant changes over time in the results presented above. Most of the data prior to 1995 were gathered by the USGS, whereas in recent years most samples have been collected by other agencies. Time trends identified by analyses on all the data may be due to method or lab differences. To investigate this possibility the analyses were re-run on just the USGS data. Significant results would provide an important confirmation of the original analyses. If the date regression slope were no longer significant, then additional investigation would be needed. In this situation, method or lab differences should be considered. However, the loss of significance may be due simply to the decrease in number of data points. If this were the case, the slope of the time trend would be expected to be similar to that found on the entire data set.

Time trends noted for dissolved oxygen, organic carbon, and sulfate were confirmed by regression on the USGS data, as were time trends for conductivity during base-flow. Time trends for conductivity during storm-flow and turbidity conditions were not significant when only the USGS data were considered. The regression coefficients for date on the USGS data have the same sign and are approximately half the size of the coefficients for the entire data set. This result may imply that the change over time is not as large as indicated by the entire data set, or that with more USGS data the trend will be confirmed, or that the trend does not exist. These parameters under these flow conditions could warrant more investigation.

TREND ANALYSIS ON 1975–1994 DATA

No significant time trends at the 0.05-level were found when the data from the last 5 years of the dataset (1990-1994) were eliminated. This result would explain why previous analyses did not observe such trends. However, for most parameters and flow conditions, the slopes were similar in magnitude and had the same sign. This would imply that the trends were there but that the number of data points was insufficient to confirm the significance of the trend. The parameters and flow conditions where this was not true were conductivity during storm-flow and turbidity conditions. These conditions are also those under which time trends were not confirmed by the analysis on the segregated USGS data.

TREND ANALYSIS ON UNSEPARATED DATA

Since the split of the data into the three flow categories is imprecise, the multiple regression analysis was run on all flow categories lumped together with discharge and date as the independent variables. In addition, regression with date alone for the independent variable was performed. Significant time trends were identified for dissolved oxygen and conductivity with both regressions. When the data are lumped, no trends are observed for organic carbon, sulfate, or turbidity.

SUMMARY OF BARTON SPRINGS DATA ANALYSIS

Analysis of long-term water quality records from Barton Springs using two primary data sources indicated statistically significant changes in water quality that could be related to watershed urbanization. Increasing conductivity, sulfate, turbidity, and total organic carbon trends were noted to be significant. A decreasing trend in dissolved oxygen concentration was also found to be significant. Significant trends were not noted in other parameters that are commonly considered pollutants, such as nutrients and total suspended solids. Significance and presence of trends were variable depending on flow conditions (i.e., base-flow vs. storm-flow, recharge vs. non-recharge).

USGS Barton Springs Water Characterization Project

The USGS on-going study (2007), *Barton Springs Water Characterization Project* has as its goal to better characterize the quality of water discharging from Barton Springs. Variations in geochemical and physical parameters such as temperature, conductivity, pH, and major ion concentrations are being monitored. In addition, analysis of anthropogenic compounds such as pesticides, pharmaceuticals, nutrients, and volatile organic compounds in springwater and in recharging creek water will provide information about the overall quality of water and the susceptibility of the system to contamination by different types of land uses.

BASE-FLOW WATER QUALITY

To characterize the water quality of Barton Springs, water emerging at the springs is sampled every three weeks. Tables summarizing the chemical and physical parameters are presented in Appendix D. In addition, base-flow in Williamson and Onion Creeks are sampled quarterly. Base-flow sampling provides information on seasonal variation in water chemistry and contaminant concentrations. The following are descriptions of the major parameters measured during the water sampling. The sampling data for each group are included in Appendix D.

PESTICIDES

Pesticides are used on a variety of landscapes in the District HCP Planning Area from residential lawns to ranchland to golf courses. Most pesticides applied to these landscapes are water-soluble and can infiltrate into the subsurface via fractures and sinkholes. These pesticides then travel through the aquifer and discharge at the springs. Recent water quality monitoring studies conducted at Barton Springs by the USGS during the years 2003-2005 revealed measurable levels of atrazine, diazinon, prometon, carbaryl, and simazine (USGS 2005a). Atrazine, a widely used weed killer, was the focus of litigation between the Center for Biological Diversity, SOS Alliance, and the EPA in August 2005. This prompted a study by the EPA's Office of Pesticide Programs (2006), which concluded that acute and chronic levels of concern for atrazine were not exceeded and that existing levels of atrazine would have no effect on survival, growth, and reproduction on individuals of the Barton Springs salamander via direct effects.

VOLATILE ORGANIC COMPOUNDS

Volatile organic compounds include constituents of gasoline such as toluene, benzene, and methyl tertiary-butyl ether. Other volatile organic compounds include chloroform, a byproduct from the addition of chlorine to water, and tetrachloroethene, a metal degreaser and dry cleaning solvent. Chloroform and tetrachloroethene have been detected in multiple samples at low levels in Barton Springs in 2003.

NUTRIENTS

Although nutrients occur naturally in the environment of the District HCP Planning Area, there are numerous anthropogenic sources as well. These sources include fertilizer, animal manure, and wastewater. Excess nutrients in streams and lakes can cause eutrophication (excessive growth of algae), resulting in the reduction of dissolved oxygen in water.

TRACE METALS

Groundwater often contains trace concentrations of metals, which naturally leach from rocks and soils. There are numerous anthropogenic sources of metals, however, which can enrich groundwater concentrations above naturally occurring levels. In the urban environment, these sources might include roadway, parking lot, and roof runoff, landfills leachate, wastewater, and fertilizers.

CONDUCTIVITY

Conductivity is a measure of water's capacity to carry an electrical current, which is a direct reflection of the concentration of dissolved solids in the water. The conductivity of rainwater is low compared to that of groundwater, and therefore the dilution of aquifer water by infiltrated surface water can be detected through the measurement of springwater conductivity. After a storm event, a pulse of rainwater moving through the aquifer can be detected at the springs through a sudden drop in conductivity. A subsequent increase in conductivity indicates that the rainwater component of the springwater is diminishing.

REAL-TIME DATA

A real-time data logger installed in the spring orifice at Main (Parthenia) Spring collects temperature, pH, conductivity, dissolved oxygen and turbidity data every 15 minutes and transmits the information to the internet every 1 to 4 hours (USGS 2005a).

Sedimentation

Sediment from soil erosion has been found to be the greatest single source of pollution of surface waters by volume (Menzer and Nelson 1980). The pollution effects of surface water would be directly passed to aquifer groundwater when surface water passes over and through aquifer recharge features. Sedimentation can have adverse impacts to the transport of aquifer groundwater by disrupting recharge (EPA 1986), and contaminating springflow. Mahler and Lynch (1999) found that sediments begin to discharge from the Main Spring located in Barton Springs Pool whenever a rainfall event of 1.5 inches or greater occurs within the Barton Springs watershed. Further, the amount of sediment discharged from Main Spring in a 24-hour period following a 2-inch rainfall event is approximately one metric ton. Although the exact source of the sediment is unknown, a significant amount of the sediment discharging is believed to be contributed from surface runoff (Mahler and Lynch 1999). Suspended sediments can inhibit the respiratory function of fishes and neotenic salamanders (Garton 1977; Werner 1983); decrease the ability to locate food or escape from predators (EPA 1986; Schueler 1987); and become a vector for contaminants toxic to aquatic animals (Ford and Williams 1994; Menzer and Nelson 1980; Landrum and Robbins 1990; Medine and McCutcheon 1989).

Rules and Regulations Governing Groundwater Quality

State, federal and local regulations governing the quality of groundwater in Texas have been developed over the last several decades. In 1974, the federal Safe Drinking Water Act was passed to protect sources of public drinking water. This act, amended in 1996, mandated enforceable drinking water standards established by the EPA. The TCEQ has assumed responsibility for enforcement of drinking water standards in Texas and has established standards as strict as or more strict than the EPA's. As part of this responsibility the TCEQ has established by rule an Edwards Aquifer Protection Program, requiring that those who plan to build on the recharge, transition, or contributing zones of the Edwards Aquifer, must first have an application including construction plans approved by the TCEQ. The Service, the Barton Springs/Edwards Aquifer Conservation District, and several other local jurisdictions have initiated studies, plans, ordinances and programs to address the regulation of groundwater quality in the District HCP Planning Area. These several regulatory efforts are summarized in Appendix E.

3.2.3 Water Demand

3.2.3.1 Water Demand in the District Habitat Conservation Plan Planning Area

In 1997, the District developed groundwater demand projections for three demand centers within the District (BSEACD 1997). These water demand projections cover the period 1996-2016 and were based on the change in the number of system connections within each demand center over the 1991-1995 period. Groundwater use within the District is not limited to the three demand centers described in the report, however, the systems within each demand center account for a majority of groundwater use within the Barton Springs segment of the Edwards Aquifer. Projection methodology is described in Section 2.3.1 of the District report.

Total demand center groundwater use is expected to increase by approximately 47 percent, from 4,195 acre-feet per year in 1996 to 6,157 acre-feet per year in 2016 (compared to approximately 6,900 acre-feet per year total groundwater demand) at an average annual growth rate of 1.94 percent. This projected water use does not take into account consumption by residential domestic wells or permitted wells outside the demand centers. The highest water use expected for 2016 is in Demand Center 1, with a projected use of 2,681 acre-feet per year. The highest projected growth rate is for Demand Center 2, located along the Travis/Hays county line along FM 1626 in the Little Bear Creek watershed. This is a low-density residential area whose subdivisions are primarily supplied by water supply corporations.

District data from 1988 to 2002 for permitted and actual pumpage suggest that actual pumpage has been recently growing at over 5 percent per year (BSEACD 2003). City of Austin population projection growth rates for postal zip codes in the central part of the District range from 1.8 to 5.7 percent per year (Ryan Robinson, City of Austin, personal communication 2007). The near-term completion of State Highway (SH) 45 and SH 130 in the eastern portion of the District could mean that a new water demand center may soon develop east of IH 35. These recent developments, data and growth analyses would suggest a short-term growth rate somewhat higher than that embodied in the District's 1997 projections.

3.2.3.2 Water Demand in the Lower Colorado Regional Planning Area (Region K)

The Lower Colorado Regional Water Planning Group has developed total water demand projections to the year 2050 for the Region K Planning Area, which includes the District HCP Planning Area (LCRWPG 2005). The Region K Planning Area includes portions of Travis and Hays Counties that were included in the 2000 projections for Region K. A small part of the District HCP Planning Area in Caldwell County falls within the South Central Texas Region (Region L).

For Hays County, only the portion of the county that lies in the Colorado River Basin is in the Lower Colorado Region. Population in this portion of Hays County is projected to increase dramatically from approximately 25,090 in the year 2000 to 132,051 in the year 2050, as noted in Table 3.2-3. This increase in population is reflected in water demand projections indicating a projected 399 percent increase in municipal water demand, a growth rate of about 3.3 percent per year. The Region K water demand growth rates are substantially higher (on an annual basis) than the 1.76 percent per year rate projected for the District Demand Centers by the BSEACD in 1997 (above). Municipal water demand accounts for more than 93 percent of the total water demand in 2050 for the portion of Hays County in the Lower Colorado Region.

Table 3.2-3. Region K 2005 population & water demand projections for Hays County and selected political subdivisions

Water User Group	2000	2010	2020	2030	2040	2050	Total Change (%)
Population							
Buda	2,404	8,042	13,971	17,341	20,728	24,797	931
Cimarron Park Water Co.	1,896	2,417	3,013	3,631	4,252	4,998	164
Dripping Springs	1,548	5,325	9,308	11,651	14,005	16,834	988
Dripping Springs WSC	1,481	2,487	3,639	4,832	6,031	7,471	405
Hill Country WSC	1,427	3,117	5,051	7,054	9,067	11,485	705
Mountain City	536	737	737	737	737	737	38
County Other	15,798	24,018	33,658	43,641	53,675	65,729	316
Hays County Total Population	25,090	46,143	69,377	88,887	108,495	132,051	426
Water Demand (acre-feet/year)							
Buda	385	1,252	2,128	2,603	3,088	3,666	852
Cimarron Park Water Co.	327	403	489	582	676	789	141
Dripping Springs	321	1,080	1,856	2,297	2,745	3,300	928
Dripping Springs WSC	217	348	501	660	817	1,013	367
Hill Country WSC	209	440	702	980	1,249	1,582	657
Mountain City	89	118	116	116	115	115	29
County Other	2,407	3,551	4,864	6,208	7,576	9,277	285
Total Municipal Water Demand	3,955	7,192	10,656	13,446	16,266	19,742	399
Type of Use							
Total Municipal	3,955	7,192	10,656	13,446	16,266	19,742	399
Manufacturing	509	691	809	928	1,048	1,156	127
Irrigation	12	11	11	11	11	11	-8
Steam Electric	0	0	0	0	0	0	0
Mining	18	12	6	2	0	0	-100
Livestock	220	220	220	220	220	220	0
Hays County Total Water Demand	4,714	8,126	11,702	14,607	17,545	21,129	348

WSC = Water Supply Corporation

Source: LCRWPG 2005; Only that portion of the county in Region K is included in these data and projections.

For Travis County, population is projected to slightly more than double over the 50-year planning period and is projected to surpass 1.7 million by the year 2050. Travis County is by far the most populated of the 14 counties in the Lower Colorado Region. Because of the associated municipal water demands as well as significant manufacturing, steam electric, and mining water demands, Travis County also has the largest total water demand. This demand is projected to reach approximately 416,432 acre-feet per year in the year 2050 as noted in Table 3.2-4.

Table 3.2-4. Region K 2005 population & water demand projections for Travis County and selected political subdivisions

Water User Group	2000	2010	2020	2030	2040	2050	Total change (%)
Population							
Anderson Mill (p)	0	0	0	0	0	0	0
Aqua WSC	6,300	7,251	8,523	9,698	10,432	11,208	78
Austin (p)	644,752	770,529	946,974	1,111,996	1,258,580	1,409,808	119
Barton Creek West WSC	1,456	1,456	1,456	1,456	1,456	1,456	0
Bee Cave Village	656	948	1,339	1,700	1,926	2,165	230
Creedmoor-Maha WSC*	4,962	5,962	7,301	8,537	9,309	10,126	104
Hill Country WSC	991	1,689	2,623	3,486	4,025	4,595	364
Shady Hollow MUD	4,732	4,732	4,732	4,732	4,732	4,732	0
West Travis County Regional WS (LCRA)	3,260	4,881	7,051	9,055	10,307	11,631	257
Garfield (p)**	1,769	2,295	2,984	3,655	4,091	4,579	159
Jonestown	1,681	1,985	2,391	2,766	3,000	3,248	93
Lago Vista	4,507	6,132	8,307	10,316	11,571	12,898	186
Lakeway	8,002	10,789	14,519	17,965	20,117	22,394	180
Manor	1,204	1,319	1,473	1,615	1,704	1,798	49
Travis County Other	128,008	149,987	175,826	198,259	209,288	222,099	
Total Travis County Population	812,280	969,955	1,185,499	1,385,236	1,550,538	1,722,737	112
Water Demand (acre-feet/year)							
Anderson Mill (p)	0	0	0	0	0	0	0
Aqua WSC	981	1,088	1,251	1,390	1,484	1,582	61
Austin (p)	126,388	150,180	183,509	214,242	241,074	268,462	112
Barton Creek West WSC	403	401	398	395	393	391	-3
Bee Cave Village	343	493	694	880	995	1,118	226
Creedmoor-Maha WSC*	545	628	736	841	907	976	79
Hill Country WSC	145	238	364	484	555	633	337
Shady Hollow MUD	763	747	731	716	700	694	-9
West Travis County Regional WS (LCRA)	537	782	1,114	1,420	1,605	1,811	227
Garfield (p)**	313	373	451	540	596	667	113
Jonestown	245	280	329	372	400	429	75
Lago Vista	1,494	2,006	2,698	3,340	3,733	4,161	179
Lakeway	2,653	3,529	4,716	5,796	6,467	7,199	171
Manor	266	285	312	336	351	369	38
Travis County Other	25,075	28,572	32,625	35,996	37,415	39,348	57
Travis County Total Municipal Water Demand	160,151	189,602	229,928	266,748	296,675	327,840	105

Table 3.2-4. Region K 2005 population & water demand projections for Travis County and selected political subdivisions (continued)

Water User Group	2000	2010	2020	2030	2040	2050	Total change (%)
Type of Use							
Municipal	160,151	189,602	229,928	266,748	296,675	327,840	105
Manufacturing	16,179	23,002	28,294	38,508	50,483	57,703	257
Irrigation	1,224	1,126	1,034	951	875	805	-34
Steam Electric	7,494	17,500	18,500	22,500	23,500	27,500	267
Mining	1,285	1,531	1,649	1,727	1,804	1,880	46
Livestock	704	704	704	704	704	704	0
Total Travis County Water Demand	187,037	233,465	280,109	331,138	374,041	416,432	123

* Includes Colorado and Guadalupe basins.
** Garfield projections from 2001 Plan. Garfield not broken out in 2005 IPP population and water demand projections.
(p) = Portion represented by Travis County
MUD =
WSC = Water Supply Corporation
LCRA = Lower Colorado River Authority
Source: LCRWPG 2005

For Travis County, population is projected to slightly more than double over the 50-year planning period and is projected to surpass 1.7 million by the year 2050. Travis County is by far the most populated of the 14 counties in the Lower Colorado Region. Because of the associated municipal water demands as well as significant manufacturing, steam electric, and mining water demands, Travis County also has the largest total water demand. This demand is projected to reach approximately 416,432 acre-feet per year in the year 2050 as noted in Table 3.2-4.

Although the Travis County population and total water demand projections from the 2005 Region K Plan do not include a specific geographic region exclusively representative of the District HCP Planning Area, several of the water user groups for which projections are presented are included in or close to the District. Population and water demand growth rates for these water user groups over the 50-year period presented are substantial.

In October 2004, the District's Board of Directors accepted, based on groundwater availability modeling, a sustainable yield pumping limit of 10 cfs (7,240 acre-feet per year) for the Barton Springs segment of the Edwards Aquifer for periods of severe drought. The currently prevailing District Management Plan (BSEACD 2003) states that 10 cfs of pumping is the rate at which the District will base its policies.

In 2005, the Texas Legislature passed House Bill 1763 and it was signed into law by the Governor (effective September 1, 2005). The bill strengthens the joint management planning between districts in a groundwater management area (GMA) (the BSEACD is in GMA 10, along with the Edwards Aquifer Authority and four other Groundwater Conservation Districts that regulate the Edwards Aquifer). This new statute requires the districts to base their groundwater management plans on the "Managed Available

Groundwater" that is determined by the Texas Water Development Board to be indicated by the "Desired Future Conditions" in the GMA established through joint planning. The statute requires all districts in a GMA to collaboratively and quantitatively identify the Desired Future Conditions of their groundwater resources. TWDB will use groundwater availability modeling techniques to ascertain the appropriate amount of Managed Available Groundwater, which represents a maximum volume of groundwater that can be permitted by the Districts. GMAs may be subdivided in a number of ways, but the Managed Available Groundwater determinations must be physically and logical consistent, individually and in aggregate.

The "Desired Future Conditions" and "Managed Available Groundwater" that would be applicable for the District have not yet been established by GMA 10 as of 2007. Such determinations may not be formally established for several years, especially since the Desired Future Condition probably will reflect the outcome of the present HCP process. The TWDB has until September 2010 to complete the first round of estimates of Managed Available Groundwater for all GMAs. It presently seems likely, however, that the recent action by the District's Board, setting an Extreme Drought Withdrawal Limitation of 8.5 cfs (7,240 acre-feet per year) for prolonged periods of severe drought, would be a "best case" component of the Managed Available Groundwater for the District. In view of that restriction, along with regional projections of total water demand discussed above, it appears certain that considerable surface water supply development will be needed in the HCP Planning Area to meet future demands, beginning in the near future.

3.2.3.3 Water Conservation in the Region K and L Planning Areas

According to the 2002 State Water Plan (TWDB 2002), current levels of water supply in Texas will fall short of meeting the state's projected annual demand for water in the year 2050, if drought conditions exist, by an estimated 7.5 million acre/feet. The very recently issued 2007 State Water Plan did not change this fundamental situation arising from water shortages that will exist from time to time and place to place. Droughts are a recurring theme in Texas, and a projected shortfall of these dimensions would have devastating effects on the Texas economy. The 2002 State Water Plan recognizes conservation-based water management as one of the most effective strategies to help meet this challenge and ensure that the future water needs of Texans are met. Recommended and required water conservation programs and measures in the 2002 State Water Plan are projected to result in savings of approximately two million acre/feet of water per year by 2050. As a result of the passage of SB 2 in 2001, the second round of regional and state water planning involves assessing additional opportunities for conservation-based water management strategies to meet an even greater share of projected water demands (TWDB 2004a). Conservation strategies identified in the Region K and L plans are summarized below.

Lower Colorado Region (Region K)

The LCRWPG's (Region K) 2001 water demand projections for municipal uses include an "expected" level of municipal water conservation. The TWDB required that this level of assumed water conservation be reflected in all municipal water demand projections statewide. This "expected" level of water conservation includes impacts resulting from the State Water-efficient Plumbing Act of 1991 and the availability of water saving fixtures for new construction and replacement. In most areas of the LCRWPA, the "expected" level of water conservation may be difficult to achieve due to low growth rates and low fixture replacement rates. Additional water savings beyond the "expected" level are not anticipated for most areas and, therefore, were not evaluated as a water management strategy. However, municipal water conservation in the Austin Metropolitan Area is expected to impact the projected demand scenario significantly.

The municipal, industrial, and wholesale water demands for the City of Austin and the wholesale customers of the City of Austin were projected in the 2001 adopted Region K plan to increase from 180,711 acre-feet per year in the year 2000 to 355,714 acre-feet per year in 2050. (These demand projections were being revised as part of the 2006 plan update.) The water demand projections were initially based on the TWDB projections that were developed for the 1997 State Water Plan and have been revised for the 2001 planning effort. The projection for water demand in 2000 was based on water consumption records from 1984, which represent City of Austin's highest historical per capita consumption and is assumed to be representative of dry-year conditions. The projection for 2050 assumes that expected water conservation measures would reduce the per capita water consumption rates by approximately 10 percent.

The City's staff has indicated that the LCRWPG's water demand projections do not accurately reflect the additional water conservation that has been achieved in the City of Austin since 1984. The LCRWPG had estimated the City of Austin's water demand to be 180,711 acre-feet per year in 2000. This level of water demand is significantly higher than the historical water demand trend for the City of Austin. The City of Austin had estimated its year 2000 demand for water to be 165,880 acre-feet per year. The difference between the LCRWPG's projections and the City of Austin's projections is 14,831 acre-feet per year. This difference is presumed to be the result of the accelerated water conservation efforts that the City has pursued. The savings due to conservation are approximately 8 percent. It is important to point out that these projected water savings are based on water demands during a critical drought period.

Over time, the difference between the City of Austin's projections (including the Cities of Round Rock and Pflugerville) and the LCRWPG's projections for the City of Austin gradually decreases until it disappears in 2042. At this point, the water conservation assumptions in the LCRWPG's projections catch up to the City of Austin's accelerated water conservation program. Additional water demand savings, beyond those included in the LCRWPG's estimates for the City of Austin are not anticipated. In 2007, the City of Austin adopted a highly aggressive water conservation plan that is expected to yield considerable additional savings in water use and demand in the coming years.

South Central Texas Region (Region L)

The South Central Texas Regional Water Planning Group (SCTRWPG – Region L) strongly supports water conservation, and for the 2006 SCTR Regional Water Plan has recommended municipal, irrigation, industrial, steam-electric power generation, and mining water conservation water management strategies (TWDB 2005d). Such a small part of Region L is included in the District's jurisdiction that for purposes of characterizing the water management strategies for the HCP Planning Area, no detail for Region L is warranted.

3.2.3.4 Existing and Proposed Water Service Areas and Facilities

Several water utilities in Travis and Hays Counties provided wholesale and/or retail water service to parts of the HCP Planning Area in 2005. These entities have revealed plans to extend their service areas and water infrastructure facilities into portions of the HCP Planning Area in the future. These service areas and proposed extensions are important to the HCP planning process, because they will have an influence on the relative share of ground versus surface water supplies that will be available to meet future water demands projected for the HCP Planning Area. Although surface water supplies currently provided in the HCP Planning Area, or planned for the future, are currently about three to four times more expensive than groundwater from the Barton Springs segment of the Edwards Aquifer, surface supply sources are more reliable than groundwater sources during times of extreme drought as they are based on firm (period and volume reliability near 100 percent during the Drought of Record) water rights in the Colorado and Guadalupe River Basins.

The City of Austin, the LCRA, and the Guadalupe-Blanco River Authority (GBRA) provide or have plans to provide wholesale and/or retail surface water supplies to municipal and industrial users in the HCP Planning Area.

City of Austin

In August 2001, the City of Austin sought water and wastewater certificates of convenience and necessity (CCNs) for those portions of its designated Desired Development Zone that were not already certificated to other utility providers. A CCN is a state permit that allows a utility, under most circumstances, to solely provide water or wastewater services within a specified geographic area. The TCEQ granted the City of Austin its CCN request in 2004 and reaffirmed its decision in 2005. In consideration of the CCN, a utility provider is required to make available water and wastewater services, and any requirements precedent to the provision of service must be reasonable and related to the provision of that service. In 2005, the City of Austin provided water (and limited recycled water) to the northern portion of the HCP Planning Area through its Central, South, Southwest A, Southwest B and Southwest C pressure zones with water from its Ullrich Water Treatment Plant on Lake Austin. The City of Austin's long-range plan, the Austin Water Utility Strategic Water Resource Plan (City of Austin 2003c) indicates that the City of Austin intends to extend its water pressure zones and associated reservoirs and pipes into the northern half of the HCP Planning Area, extending as far south as the northern parts of Hays County. The plan indicates the extension of future water distribution facilities into the southern portions of the South, Southwest A, and Southwest B Pressure Zones, along the Travis-Hays County boundaries. Additional extensions are planned from the Central Pressure Zone into the southeastern part of Travis County south and east of Austin–Bergstrom International Airport in the Saline Water Zone portion of the District.

Lower Colorado River Authority

The LCRA's wholesale water customers include Barton Creek West Water Supply Corporation (WSC), Senna Hills Municipal Utility District, Crystal Mountain WSC, and Dripping Springs WSC. Retail customers include residents of the former Hill Country WSC service area; Bee Cave Seven Oaks, Lake Pointe, Barton Valley, Falcon Head, Spanish Oaks, Uplands, The Preserve, and Sunset Canyon subdivisions; Eanes Independent School District; and the City of Dripping Springs. LCRA water facilities include a treatment plant (9.8 mgd), elevated storage, and transmission and distribution systems. These facilities serve about 8,100 residents in western Travis and northern Hays Counties.

The LCRA has completed a 15-mile water transmission line and pump system that conveys treated water from LCRA's West Travis County Regional Water System at Bee Cave to western Travis County and northern Hays County (LCRA 2002), including western portions of the HCP Planning Area. It is often referred to as the 290-Line, because it was built in easements alongside U.S. Highway 290 (US 290). With improvements to the water treatment plant, the water line has the current capacity to serve about 10,000 households. The LCRA provided these water utility services at the request of rural and suburban communities in its service area, when Hays County residents and officials, citing increasing problems with (Trinity) groundwater supply and quality, asked LCRA to provide drinking water from its nearby regional water system. Because northern Hays County is in the Colorado River basin and in LCRA's water service area, LCRA agreed to work with the county to find a solution to its worsening water supply and water quality problems.

Water service from the 290-Line began in 2002. A little less than half of the 290-Line's capacity was available for developments that existed in May 2000. LCRA also has a contract to provide the Dripping Springs Water Supply Corporation with enough water for 1,100 households and will be providing future service to additional developments (LCRA 2005a).

The LCRA sees the opportunity to expand its provision of water service in Travis and Hays Counties in the future, including portions of the HCP Planning Area (LCRA 2005). The LCRA projects that it will have opportunities to provide water and wastewater utility services to as many as 670,000 new residents in the two counties—about 60 percent of the projected growth over the next 30 years. Many of these services will be through systems already owned and operated by LCRA.

The West Travis County Regional Water and Wastewater system will serve an estimated 91,000 people—83,000 more than are currently served. LCRA also plans to provide water and wastewater services in three new high-growth areas: the Creedmoor/Maha area in northern Hays and eastern Travis counties (in the eastern portion of the District's HCP Planning Area), Williamson County (with the addition of water service), and the Upper Lake Travis/Pedernales River area.

Guadalupe-Blanco River Authority

The GBRA has recently completed its IH-35 Water Supply Project, providing water to the San Marcos area through a pipeline along IH-35 to the San Marcos Water Treatment Plant. The GBRA Strategic Plan (GBRA 2002) indicates that the GBRA is interested in developing new areas for growth in its water operations. Projects and programs in the Strategic Plan that could support the extension of GBRA water service into the HCP Planning Area include: (1) secure and extend existing contracts for service; (2) acquire six retail water systems; (3) groundwater development; (4) file CCNs where necessary; and (5) desalination. GBRA has entered into a contractual partnership with a purveyor of Carrizo-Wilcox Aquifer water, reportedly for some 50,000 acre-feet annually, which will be withdrawn to the east of the HCP Planning Area but anticipated to be imported into the Planning Area and used along the I-35 corridor and farther east.

3.3 Biological Resources

3.3.1 Regional Flora and Fauna

3.3.1.1 Regional Ecology

Vegetation Areas

The vegetation within the District HCP Planning Area encompasses portions of the Edwards Plateau and Blackland Prairies ecological regions, as originally described by Gould (1975) and later refined by the Lyndon B. Johnson (LBJ) School of Public Affairs (1978). Interstate 35 running north-south through Travis and Hays Counties generally corresponds with the boundary separating the Edwards Plateau ecological region to the west from the Blackland Prairies ecological region to the east. Within these ecological regions, the HCP Planning Area encompasses six dominant plant associations among eight major cover types, as defined and mapped by the Texas Parks and Wildlife Department (TPWD) (McMahan et al. 1984). These include mixed native/introduced grasses, Live Oak (*Quercus virginiana* var. *fusiformis*)–Honey Mesquite (*Prosopis glandulosa*)–Ashe Juniper (*Juniperus ashei*) Parks, Live Oak–Ashe Juniper Parks, Live Oak–Ashe Juniper Woods, Post Oak (*Quercus stellata*) Woods, and mixed riparian forests/woods. Other cover types include developed land and cropland. A brief overview of the conditions and representative species found in each of the major ecological regions' areas is provided below.

EDWARDS PLATEAU

This ecological region encompasses approximately 24 million acres, including a large portion of the Hill Country in west-central Texas, as well as the Llano Uplift and Stockton Plateau regions. Average annual precipitation increases from west to east across this region. The surface is rough and well drained, being dissected by several river systems. The shallow, variably textured soils are typically underlain by limestone or caliche, and granitic rock in the Llano Uplift region. Land use in this vegetation area is dominated by cattle, sheep, and goat ranching.

Historically, this region was reportedly once dominated by a grassland or open savannah climax community except in the steep canyons and slopes, where junipers and oaks were dominant. However, with the widespread disturbance associated with livestock grazing and the suppression of fire, brush and tree species have been able to spread widely throughout the grassland and savannah areas.

Grasses that are typical of the Edwards Plateau region include switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), beardgrass (*Bothriochloa* spp.), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Canada wildrye (*Elymus canadensis*), curly mesquite (*Hilaria belangeri*) and buffalograss (*Buchloe dactyloides*). Other plants commonly found within this vegetational area include ashe juniper, plateau live oak (*Quercus fusiformis*), Texas oak (*Q. texana*), Texas persimmon (*Diospyros texana*), elbowbush (*Forestiera pubescens*), Texas mountain laurel (*Sophora secundiflora*), prickly-pear cactus (*Opuntia* spp.), and pencil cactus (*O. leptocaulis*) (Hatch et al. 1990).

BLACKLAND PRAIRIES

The Blackland Prairies ecological region consists of nearly level to gently rolling topography. This area covers approximately 11.5 million acres from Grayson and Red River Counties in northeast Texas to Bexar County in the south-central region of the state, where it merges with the brushland of the South Texas Plains. Annual precipitation averages 30 inches on the west to 45 inches on the east, and elevations range from 300 to 800 feet above sea level. Blackland soils that occur in the region are so named due to the uniform dark-colored calcareous clay component. These soils are interspersed with gray acid sandy loams. This highly fertile region has been widely used for cultivated agriculture, although use of the land for ranching has become increasingly popular (Gould 1975; Schuster and Hatch 1990). It has been estimated that less than one percent of the once extensive Blackland Prairies remains in a near natural condition (Smeins and Diamond 1986).

Studies have shown that the native vegetation of the Blackland Prairies should historically be classified as true prairie, typified by medium tall grasslands with scattered deciduous trees, with little bluestem (*Schizachyrium scoparium* var. *frequens*) being a climax dominant (Gould 1975). Big bluestem (*Andropogon gerardi*), Indiangrass, switchgrass, hairy grama (*Bouteloua hirsuta*), sideoats grama (*B. curtipendula*), tall dropseed (*Sporobolus asper* var. *asper*), silver bluestem (*Bothriochloa saccharoides*), and Texas wintergrass (*Stipa leucotricha*) represent other important grasses in the region. With heavy livestock grazing, invading or increasing species such as buffalograss, Texas grama (*Bouteloua rigidiseta*), and smutgrass (*Sporobolus indicus*), along with other annuals may become prevalent (Gould 1975; Correll and Johnston 1970). Improved pastures with introduced grass species such as dallisgrass (*Paspalum dilatatum*) and bermudagrass (*Cynodon dactylon*) are common in the area. Asters (*Aster* spp.), prairie bluet (*Hedyotis nigricans* var. *nigricans*), prairie clover (*Dalea* spp.), and late coneflower (*Rudbeckia serotina*) are common forbs of these prairies (Hatch et al. 1990). Disturbed areas are also highly susceptible to invasion of honey mesquite and groundsel-tree (*Baccharis* spp.)

Wooded areas along riparian strips in the Blackland Prairies include such species as black willow (*Salix nigra*), oaks (*Quercus* spp.), pecan (*Carya illinoiensis*), osage orange (*Maclura pomifera*), elms (*Ulmus* spp.), and eastern cottonwood (*Populus deltoides*)

(Hatch et al. 1990). Woody invasive species that are commonly found include post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), and cedar elm (*Ulmus crassifolia*) in the north, with honey mesquite being a common invader in the southern portion of the region (Gould 1975).

Wildlife

Because the District HCP Planning Area lies within an ecotone between two major ecological regions and is very near another ecological region (Cross-timbers and Prairies) occurring north of the Colorado River, biological diversity is high with 580 vertebrate species potentially occurring according to county records and other regional checklists. This includes 35 fish species (Linam et al. 1999; unpublished data from BIO-WEST); 10 salamander species, 23 species of frogs and toads, 13 turtle species, 20 lizard species, 38 snake species (TAMU 1998); 418 species of birds (TPWD 2001); and 23 species of mammals (Davis and Schmidly 1997).

3.3.1.2 Rare Species Not Endemic to the Edwards Aquifer, Barton Creek, and Barton Springs

The District HCP Planning Area encompasses a range of terrestrial habitat types, many of which are suitable for rare or otherwise sensitive species. This section discusses rare species occurring within the HCP Planning Area that are not endemic to the Edwards Aquifer, Barton Creek, or Barton Springs. Those rare species that are restricted to the Edwards Aquifer, Barton Creek, and Barton Springs are discussed in Section 3.2.2. Table 3.3-1 lists rare fauna and flora that occur within the HCP Planning Area but are not restricted to the Edwards Aquifer, Barton Creek, Barton Springs, or subterranean habitats. Within the District HCP Planning Area, four species of birds occur or potentially occur that are federally listed as endangered or threatened. Life history information for each of the federally listed species is presented below.

Table 3.3-1. Potential occurrence of rare species in the District HCP Planning Area not endemic to the Edwards Aquifer, Barton Creek, and Barton Springs

Common Name	Scientific Name	County of Potential Occurrence	FWS Status	TPWD Status
Amphibians				
Edwards Plateau springs salamander	*Eurycea* sp. 7	Blanco, Hays, Travis		
Pedernales River springs salamander	*Eurycea* sp. 6	Travis		
Aquatic Invertebrates				
Amphipod	*Stygobromus russelli*	Travis		
Balcones cave amphipod	*Stygobromus balconis*	Travis, Hays		
Bifurcated cave amphipod	*Stygobromus bifurcatus*	Travis		

Table 3.3-1. Potential occurrence of rare species in the District HCP Planning Area not endemic to the Edwards Aquifer, Barton Creek, and Barton Springs (continued)

Common Name	Scientific Name	County of Potential Occurrence	FWS Status	TPWD Status
Arachnids				
Cave spider	*Cicurina cueva*	Travis		
Bandit Cave spider	*Cicurina bandida*	Travis		
Birds				
Arctic peregrine falcon	*Falco peregrinus tundrius*	Bastrop, Blanco, Caldwell, Hays, Travis	DL	T
Bald eagle	*Haliacetus leucocephalus*	Bastrop, Caldwell, Travis	T-PDL	T
Black-capped vireo	*Vireo atricapilla*	Blanco, Hays, Travis	E	E
Golden-cheeked warbler	*Dendroica chrysoparia*	Blanco, Hays, Travis	E	E
Henslow's sparrow	*Ammodramus henslowii*	Bastrop, Blanco, Caldwell, Hays, Travis		
Mountain plover	*Charadrius montanus*	Bastrop, Blanco, Caldwell, Hays, Travis		
Whooping crane	*Grus americana*	Bastrop, Blanco, Caldwell, Hays, Travis	E	E
Wood stork	*Mycteria americana*	Bastrop, Caldwell		T
Zone-tailed hawk	*Buteo albonotatus*	Blanco		T
Fish				
American eel	*Anguilla rostrata*	Bastrop, Travis		
Blue sucker	*Cycleptus elongatus*	Bastrop, Caldwell, Hays		T
Guadalupe bass	*Micropterus treculi*	Bastrop, Blanco, Caldwell, Hays, Travis		
Guadalupe darter	*Percina sciera apristis*	Blanco, Caldwell, Hays		
Insects				
Comal Springs diving beetle	*Comaldessus stygius*	Hays		
Edwards Aquifer diving beetle	*Haideoporus texanus*	Hays		
Flints net-spinning caddisfly	*Cheamatopsche flinter*	Hays		
San Marcos saddle-case caddisfly	*Protoptila arca*	Hays		
Tooth Cave blind rove beetle	*Cylindropsis* sp. 1	Travis		
Mammals				
Cave myotis bat	*Myotis velifer*	Bastop, Blanco, Caldwell, Hays, Travis		
Elliot's short-tailed shrew	*Blarina hylophaga hylophaga*	Bastrop		
Llano pocket gopher	*Geomys texensis texensis*	Blanco		
Plains spotted skunk	*Spilogale putorius interrupta*	Bastrop, Blanco, Caldwell, Hays, Travis		
Mollusks				
Creeper (Squawfoot)	*Strophitus undulatus*	Bastrop, Caldwell, Hays, Travis		
False spike mussel	*Quincuncina mitchelli*	Bastrop, Caldwell, Hays, Travis		
Golden orb	*Quadrula aurea*	Caldwell, Hays		

Table 3.3-1. Potential occurrence of rare species in the District HCP Planning Area not endemic to the Edwards Aquifer, Barton Creek, and Barton Springs (continued)

Common Name	Scientific Name	County of Potential Occurrence	FWS Status	TPWD Status
Mollusks (continued)				
Pistolgrip	*Tritogonia verrucosa*	Bastrop, Caldwell, Hays		
Rock-pocketbook	*Arcidens confragosus*	Bastrop, Caldwell, Hays, Travis		
Smooth pimpleback	*Quadrula houstonensis*	Bastrop, Travis		
Texas fatmucket	*Lampsilis bracteata*	Caldwell, Hays, Travis		
Texas fawnsfoot	*Truncilla macrodon*	Bastrop, Travis		
Texas pimpleback	*Quadrula petrina*	Bastrop, Caldwell, Hays, Travis		
Reptiles				
Keeled earless lizard	*Holbrookia propinqua*	Hays		
Spot-tailed earless lizard	*Holbrookia lacerata*	Bastrop, Blanco, Caldwell, Hays, Travis		
Texas garter snake	*Thamnophis sirtalis annectens*	Bastrop, Blanco, Caldwell, Hays, Travis		
Texas horned lizard	*Phrynosoma cornutum*	Bastrop, Blanco, Caldwell, Hays, Travis		T
Timber/canebrake rattlesnake	*Crotalus horridus*	Bastrop, Caldwell, Hays, Travis		T
Plants				
Basin bellflower	*Campanula reverchonii*	Travis		
Bracted twistflower	*Streptanthus bracteatus*	Travis		
Canyon mock-orange	*Philadelphus ernestii*	Blanco, Hays, Travis		
Correll's false dragon-head	*Physostegia correllii*	Travis		
Granite spiderwort	*Tradescantia pedicellata*	Blanco		
Hill Country wild-mercury	*Argythamnia aphoroides*	Blanco, Hays		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Bastrop, Caldwell		
Texabama croton	*Croton alabamensis* var. *texensis*	Travis		
Warnock's coral root	*Hexalectris warnockii*	Hays		

Sources:
Texas Parks and Wildlife Department, Natural Diversity Database, Annotated County Lists of Rare Species for Bastrop, Blanco, Caldwell, Hays, and Travis Counties (TPWD 2005).
USFWS On-line Endangered Species Lists and Information by County (2005)

USFWS
- E: Endangered (in danger of extinction throughout all or a significant portion of its range)
- T: Threatened (likely to become endangered within the foreseeable future)
- DL: Delisted (no longer protected under the federal Endangered Species Act)
- PDL: Proposed for delisting
- (Blank): Considered rare, but no official protection at present

TPWD
- E: Listed as endangered in the state of Texas
- T: Listed as threatened in the state of Texas
- (Blank): Apparently rare, but no official protection at present

Federally Listed Birds of Potential Occurrence

BALD EAGLE (THREATENED – PROPOSED FOR DELISTING)

The bald eagle (*Haliaeetus leucocephalus*) ranges over much of the U.S. and Canada. This eagle is primarily a fishing species and prefers habitat associated with large bodies of water and could occur near large lakes or along rivers within the District HCP Planning Area. In Texas, wintering and nesting activity occurs mainly near large, freshwater impoundments with standing timber located in or around the water (Mabie 1992) or near streams and rivers. No known active nests occur within the District HCP Planning Area. Any eagles that would occur would be expected to be temporary visitors passing through the area to or from nesting or wintering areas.

BLACK-CAPPED VIREO (ENDANGERED)

The black-capped vireo (*Vireo atricapilla*) is an insectivorous songbird that nests in low, brushy habitat in portions of Mexico, Texas, and Oklahoma and winters on the Pacific slope of Mexico (states of Durango, Sinoloa, Nayarit, Jalisco, Sonora, Guerrero, and Oaxaca) (USFWS 1991a). Each year, individuals of this species arrive in Texas between late March and late April to breed and leave by late September. Typically, adult males arrive before females and first-year males, and stay later in the fall. Black-capped vireos construct small, cup-shaped nests in the densest zones of deciduous vegetation, usually suspended from forks in horizontal branches at a height that ranges between 16 and 47 inches from ground level (USFWS 1991a). Breeding habitat throughout the black-capped vireo's range varies considerably in its vegetation characteristics. Generally, it is described as shrubland thicket that varies in size and distribution and where vegetation cover extends to ground level.

The black-capped vireo has suffered a reduction in range and population size since the time of European settlement. However, the bird nests in shrubland thickets throughout much of the Edwards Plateau and is a spring and summer resident within the District HCP Planning Area. This species no longer nests in Kansas, occurs in only three locales in Oklahoma, and is at risk for extirpation from its former range in north-central Texas and a portion of the southeastern Edwards Plateau. Populations in the Big Bend and Concho Valley are small. The principal reason for small and declining populations appears to be poor reproductive success, largely because of nest parasitism by brown-headed cowbirds (*Molothrus ater*). Secondary threats to the black-capped vireo include direct habitat loss associated with urban or roadway development, overgrazing or over browsing, natural vegetation succession, fire suppression, and brush control. Indirect results of certain types of land uses, such as urbanization-related increases in predation by raccoons, skunks, house cats, and jays also represent a substantial threat to the vireo (USFWS 1991a).

GOLDEN-CHEEKED WARBLER (ENDANGERED)

The golden-cheeked warbler (GCWA) (*Dendroica chrysoparia*) is a small insectivorous neotropical migratory songbird that nests only in the mixed juniper-oak woodlands occurring on rocky limestone soils. This species, which winters in southern Mexico and the Central American countries of Guatemala, Honduras, and Nicaragua, is the only Texas species whose breeding range is entirely confined to the state's boundaries. The known breeding range of the GCWA includes 37 Texas counties on the Lampasas Cut Plain, Edwards Plateau and Llano Uplift regions of the state (USFWS 1991b) and includes areas within the District HCP Planning Area. Golden-cheeked warblers breed in woodlands characterized by a mix of ashe juniper and various deciduous trees including Texas oak, plateau live oak, cedar elm, Texas persimmon, hackberry (*Celtis* spp.), evergreen sumac (*Rhus virens*), Texas ash (*Fraxinus texensis*), redbud (*Cercis canadensis*), and escarpment black cherry (*Prunus serotina*) (USFWS 1991b). Such wooded areas within the District HCP Planning Area that contain a moderate to high density of trees and canopy cover have been identified as suitable habitat for breeding GCWAs. Ashe juniper is often the dominant woody plant and occurs at all sites occupied by the GCWA. Female GCWAs construct nests from ashe juniper bark, which exfoliates in the form of strips, especially in more mature trees (Pulich 1976).

GCWAs return from their winter range to Texas by mid-March of each year. Most GCWAs leave the breeding grounds by the end of July (Pulich 1976). The principal threat to the golden-cheeked warbler (and the reason for the species emergency listing in 1990) is habitat alteration and fragmentation resulting from urbanization and certain range management practices including brush control. The Service (1991b) shows a 35 percent loss of range-wide available habitat since 1962. Other factors that have been implicated in the decline of this species include low oak regeneration rates, oak wilt disease, nest parasitism by the brown-headed cowbird, and increased urbanization, with resulting brush clearing and habitat loss.

WHOOPING CRANE (ENDANGERED)

The whooping crane (*Grus americana*) is North America's tallest bird, with a standing height of 5 ft or more. The bird is a large, white crane with a dagger-like, yellow bill, and with reddish skin on the crown that is darker on the face and lower jaw. The whooping crane's tail plumes form a sort of bustle. In flight, the long extended black legs and neck as well as black-tipped wings are characteristic. The whooping crane ranges from Wood Buffalo National Park in the southern Mackenzie Mountains (Northwest Territories and Alberta, Canada) south to North Dakota, Iowa, and the central coastal prairie in Texas and southwest Louisiana. In Texas, whooping cranes winter at Aransas National Wildlife Refuge and on Matagorda and St. Joseph's Islands in Aransas, Calhoun, and Matagorda Counties (Oberholser 1974). These birds could fly through the District HCP Planning Area during the fall and spring migrating to and from these wintering areas. Whooping cranes are omnivorous, feeding on frogs, minnows, rodents, and berries in the summer and during winter, feeding predominantly on blue crabs and clams. Brackish tidal marshes in the Guadalupe River Estuary provide essential habitat and support the production of clams and crabs for the cranes to eat.

3.3.2 Animal and Plant Species in the Edwards Aquifer, Barton Springs, and Karst Ecosystems

The Edwards Aquifer can be characterized as having a great diversity of aquatic species and high degree of endemism (species found only in a certain locality or region) associated with its springs and karst (dissolved limestone bedrock) features. As many as forty-seven stygobytes (obligate aquatic cave organisms) have been referenced as occurring in the Edwards Aquifer with a majority considered endemic (Hendrickson and Krejca 2000; Abell et al. 2000). As a result of the limited distribution of many of these and other aquifer-dependent species, several have been listed by the Service and the state of Texas as threatened or endangered species. Contributing to the highly localized endemic populations in the aquifer are groundwater divides that hydrologically separate portions of the aquifer. One of these occurs near Kyle in Hays County and separates the Barton Springs (Austin) segment of the Edwards Aquifer from the southern (San Antonio) portion (Ashworth and Hopkins 1995). Most of the species that have been identified as endemic occur south of this divide in the larger portion of the aquifer, but the Barton Springs segment also maintains a diverse biological community, including the Barton Springs salamander (*Eurycea sosorum*) and Austin blind salamander (*Eurycea waterlooensis*). A listing of species documented throughout the Edwards Aquifer including associated springs and karst ecosystems is provided in Appendix F.

3.3.2.1 Edwards Aquifer Ecosystem

The Edwards Aquifer covers approximately 4,350 square miles in parts of 11 Texas counties (Figure 1.1-1). The aquifer lies within the Balcones Fault Zone along the eastern boundary of the Edwards Plateau and extends from its southwestern boundary in Kinney County through the San Antonio area and northward to its northeastern extent in Bell County (Ashworth and Hopkins 1995). The limestone bedrock in which the Edwards Aquifer was formed is readily dissolved, which allowed the development of a porous aquifer with a complex structure of conduits for water and large caverns. The Edwards Aquifer is more fully described in Section 3.3.2.2. The complexity of subterranean features makes the aquifer one of the most unusual in the world and contributes to its diverse assemblage of species (Longley 1981, 1986).

The hydrological division of the aquifer into the Barton Springs and the southern segments results in regions of the same aquifer with differing physical and biological characteristics. The recharge zone in the southern portion of the Edwards Aquifer covers a large region, and although groundwater levels in the southern portion respond relatively rapidly to seasonal and weather-related variability, the smaller recharge area of the Barton Springs segment results in a much quicker response of groundwater levels to changes in weather (Slade et al. 1986). Significant rainfall events typically result in rapid changes to groundwater levels and discharge from spring openings and water levels decrease rapidly during periods of reduced rainfall. Water quality conditions at the spring openings are similar in the two segments with a relatively stenothermal (constant temperature) environment and depressed dissolved oxygen concentrations as a result of water percolating through the aquifer (Groeger et al. 1997; City of Austin, unpublished data).

The different physical characteristics in the two segments of the Edwards Aquifer contribute to variation in the composition of biological communities in subterranean and surface habitats. Subterranean habitats that are isolated or provide unique physical characteristics limit the distribution and movement of organisms (Longley 1981). Examples of subterranean species with limited distributions include blind catfish, blind salamanders, amphipods, and cave spiders (Appendix F). There are also differences in species assemblages found in spring openings in the two segments that may be a result of variation in local conditions and limited connectivity of surface and subsurface habitats. Examples of such species include several fish species, salamanders, and numerous aquatic insects. Several of these species are listed by the Service as endangered, species of concern, or proposed for listing. The endangered species addressed by the HCP are discussed in further detail in Section 3.3.3 while the species of concern are addressed in Section 3.3.4. Appendix F provides a comprehensive status listing of rare species occurring in the Edwards Aquifer region, associated karst formations, and in springs throughout the vicinity of the Southern, Barton Springs, and northern segments of the aquifer. The majority of the listed species within the Edwards Aquifer are found in the southern segment. There has been limited scientific investigation of the biological composition of subterranean species in the Barton Springs section of the aquifer, thus the list of observed species in that segment is less comprehensive.

Ourso and Hornig (1999) conducted a comprehensive review of studies involving aquatic invertebrates, fish, and aquatic plants associated with surface and subterranean waters of central Texas. The streams that are fed by the Edwards Aquifer were described as providing stable substrates, well-vegetated` stream banks, and cool, clear water year-round that contributes to the highest invertebrate species richness in the state. Samples collected within this area have included more than 50 taxa in three square feet of stream bottom (Bayer et al. 1992).

The factors that contribute to the diversity of invertebrates in the Edwards Aquifer and the streams fed by its springs also influence the abundance of fish and aquatic plants. Linam et al. (1999) sampled a total of 27 fish species in the Central Texas Plateau while developing a regional index of biotic integrity. There are several species found in the Barton Springs complex that are not on this list, including Mexican tetra (*Astyanax mexicanus*), Asian grass carp (*Ctenopharyngodon idella*), American eel (*Anguilla rostrata*), flathead catfish (*Pylodictus olivaris*), spotted sunfish (*Lepomis punctatus*), and blackstripe topminnow (*Fundulus notatus*) (City of Austin 1998a).

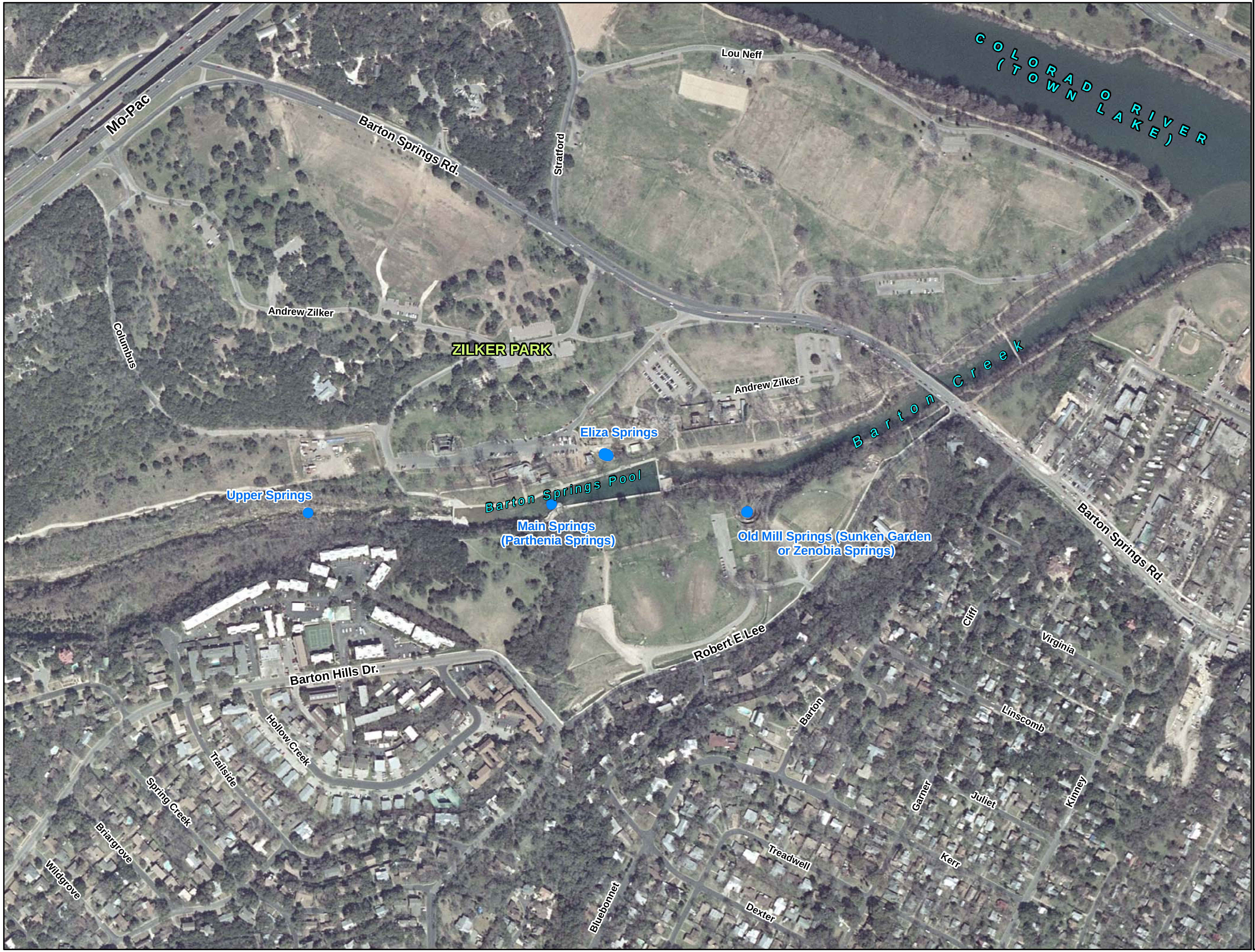
3.3.2.2 Barton Springs Ecosystem

Barton Springs is the main discharge point for the Barton Springs segment of the Edwards Aquifer. Ninety percent of all water that discharges from this segment of the aquifer emerges at Barton Springs, while the remaining 10 percent discharges at ancillary spring sites or is extracted by wells (Slade et. al. 1986). The collective flow of the Barton Springs system is the fourth largest in Texas and is chiefly recharged by surface water flowing through creeks over the recharge zone in the Barton Springs segment of the Edwards Aquifer (Section 3.2.2.4). The spring system has not ceased flowing in recorded history. A description of historical flows is provided in Section 3.2.1.3 and Figure 3.2-1.

The Barton Springs complex is comprised of four springs including the main spring in Barton Springs Pool (Parthenia Spring), Eliza Spring, Old Mill Spring (also called Sunken Garden or Zenobia Spring) and the Upper Barton Spring (Figure 3.3-1). Two dams built in the 1920s maintain the current confines of Barton Springs Pool (City of Austin 1998a). Many additional structural features surrounding the springs were added during the following decades, including a bypass for Barton Creek that flows under the sidewalk on the north side of the pool (constructed in 1974–1976). Eliza Spring was modified during the early 1900s to include a concrete amphitheater. Subsequently, outflow was confined to an underground culvert pipe and a concrete bottom was installed. The concrete substrate has seven 15-centimeter (6-inch) diameter holes and 16 rectangular vents that allow springflow up through the concrete slab to the surface. Old Mill Spring is located downstream and south of Barton Springs Pool. During periods of moderate to high aquifer levels, water in Old Mill Spring can reach a depth of 2.0 meters (6.6 feet) and there is abundant surface flow along a stream that connects Old Mill Spring to lower Barton Creek. Public access is currently restricted at Eliza and Old Mill Springs. Upper Barton Spring is located a short distance upstream of Barton Springs Pool abutting the south bank of Barton Creek. Flow ceases at this spring when total discharge from the Barton Springs complex is approximately 40 cfs (Turner 2004).

Barton Springs provides good to excellent water quality conditions for its biological assemblage. Water temperature remains within a narrow range from approximately 66ºF (19°C) to 75ºF (24°C) (City of Austin, unpublished data) with an annual average varying between approximately 70ºF (21°C) and 72ºF (22°C) (City of Austin 1997). Values for pH range between 6.6 and 7.1 in the main (Parthenia) spring. Dissolved oxygen is typically undersaturated and varies with springflow; lower flows result in lower dissolved oxygen concentrations (Turner 2004). Citing City of Austin (1998c) and Veenhuis and

Figure 3.3-1
Barton Springs Ecosystem
Vicinity Map



Key

Spring Locations

N

0 100 200 400
Feet

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Slade (1990), the Service concludes in its *Barton Springs Salamander Recovery Plan* (USFWS 2005b), that impervious cover, composition and health of the plant community, disturbed surface areas, point source contamination, and operating stormwater treatment facilities can all alter the quality of runoff entering the aquifer. The relationship between dissolved oxygen and discharge in Barton Springs has changed over time such that dissolved oxygen is currently lower at given discharges than in the past (Turner 2004; USFWS 2005b). Dissolved oxygen is a critical component of habitat suitability for the Barton Springs and Austin blind salamanders as well as the rest of the biological community in the springs, and low values appear to have direct and/or indirect effects on abundance of biological fauna (Turner 2004; Wetzl 2001; Lampert and Sommer 1997). Turbidity in the springs has also increased significantly over time during storm-flow (City of Austin 2000). The sediment transported during these high-flow events in Barton Creek is deposited in Parthenia Spring when the creek overflows the upper dam and bypass structure and enters Barton Springs Pool (City of Austin 1998a). Greater sediment loads result in a longer period of time required to clear the springs. Such changes in water quality conditions can have detrimental impacts on the biological communities in these areas.

The aquatic invertebrate community in the Barton Springs complex is diverse. City of Austin biologists have compiled a list of approximately 130 species that have been identified in the four springs and Barton Creek downstream of Barton Springs Pool (City of Austin, unpublished data). This includes several aquatic worms, glossiphoniid leeches, triclad flatworms of the genus Dugesia, at least 12 gastropods (snails and clams), several crustaceans (including 2 species of crayfish, 4 species of amphipods, 3 species of ostracods, and blind isopods) and representatives of 10 orders of aquatic insects. The common species of crayfish found in the pool is *Procambarus clarkii*, which has been reported to be extremely abundant at times with an apparent "crayfish bloom" occurring at Barton Springs in 1995 when thousands of crayfish were found throughout the pool (City of Austin 1998a). Three blind amphipods have been documented at Barton Springs. These include *Stygobromus flagellatus*, *Stygobromus bifurcatus*, and *Stygobromus russelli* (Deeann Chamberlain, City of Austin, personal communication). One apparent endemic species is the Barton cavesnail (*Stygopyrgus bartonensis)* a small, strictly aquatic hydrobiid gastropod (snail), which has only been collected at Barton Springs Pool to date. Common insects include mayfly larvae of the families Baetidae and Heptageniidae, while burrowing nymphs of the genus *Hexagenia* (family Ephemeridae) have been found in the sediments downstream of the main spring discharge. Snail-case caddisflies of the genus *Helicopsyche* have been historically observed in large numbers at Barton Springs Pool, but is not currently common (Deeann Chamberlain, City of Austin, personal communication). At least seven families of aquatic beetles have been collected in Barton Springs Pool.

Stomach analysis of Barton Springs salamanders indicates a number of invertebrate groups are taken as prey species. Amphipods were found in the stomachs of wild salamanders (Chippindale 1993). City of Austin biologists examined the gastro-intestinal tracts of 18 adult and juvenile Barton Springs salamanders and fecal pellets from 11 adult salamanders collected from Eliza Spring, Barton Springs Pool, and Old Mill Spring and observed ostracods, copepods, chironomids, snails, amphipods, mayfly larvae, leeches, and adult riffle beetles. The most common organisms found in these samples were ostracods, amphipods, and chironomids (City of Austin, unpublished data).

In addition to the comprehensive list of aquatic macroinvertebrates found in the Barton Springs complex, the City of Austin has identified 23 species of fish, 3 species of turtles, and 2 species of aquatic salamanders known to occur in Barton Springs Pool (City of Austin 1998a; L. Dries, City of Austin, personal communication). Historically, fish species have ranged from large schools of non-native Mexican tetras (*Astyanax mexicanus*) to single specimens of Asian grass carp (*Ctenopharyngodon idella*) to native species including the American eel (*Anguilla rostrata*). Other large fishes that have been found more frequently in Barton Springs Pool include channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictus olivaris*), Rio Grande cichlid (*Cichlasoma cyanoguttatum*) and gray redhorse sucker (*Moxostoma congestum*). The most common species are centrarchids including green sunfish (*Lepomis cyanellus*), bluegill sunfish (*Lepomis macrochirus*), redbreast sunfish (*Lepomis auritus*), longear sunfish (*Lepomis megalotis*), spotted sunfish (*Lepomis punctatus*), largemouth bass (*Micropterus salmoides*), and Guadalupe bass (*Micropterus treculi*). Smaller-bodied fishes include the central stoneroller (*Campostoma anomalum*), western mosquito fish (*Gambusia affinis*), greenthroat darter (*Etheostoma lepidum*), and the Texas log perch (*Percina carbonaria*). No fish species are listed as threatened or endangered by the Service or the state.

Herpetofauna in and around Barton Springs include three species of turtles, and the Barton Springs and Austin blind salamanders. The Barton Springs salamander is listed as endangered by the Service while the Austin blind salamander is considered a candidate species. These species are the primary focus of this document and will be discussed in greater detail in Section 3.3.3. The turtle species found in the pool are the red ear slider (*Trachemys scripta*), Texas cooter (*Pseudemys texana*), and common snapping turtle (*Chelydra serpentina*). Species of frogs that are common in the area include the Gulf Coast toad (*Bufo valliceps*), Woodhouse's toad (*Bufo woodhousii*), Blanchard's cricket frog (*Acris crepitans*), spotted chorus frog (*Pseudacris clarkii*) and the Rio Grande leopard frog (*Rana berlandieri*).

A list of the plant species known to occur in the Barton Springs complex were generated by Alan Plummer Associates (2000), based on discussions with City of Austin staff. Although the list includes 15 macrophyte species, two bryophytes, and two species of algae, currently there are only four species of macrophytes in any of the Barton Springs.

3.3.2.3 Terrestrial Karst Invertebrates Listed as Endangered or Candidates for Listing

The complex subterranean habitat of caves, sinkholes, fractures, and other features formed by the readily dissolved limestone bedrock creates numerous ecological niches that have been exploited by invertebrate species. There are many terrestrial invertebrates (troglobites) associated with these karst features, many of which are associated with only a single karst feature such as a particular cave or sinkhole. These organisms spend their entire lives in subterranean habitats and have small or absent eyes, elongated appendages, and other adaptations specific to their environment. These organisms require constant, high humidity environments, with nutrient inputs from the surface and are typically found in areas that have nearly constant temperature and humidity (USFWS 1994). The surface community above the karst is an integral part of the habitat, as it buffers the internal environment from fluctuations in temperature and moisture, and supplies the system with energy and nutrients in the form of detritus, leaf litter, animal droppings, and cave visitors. The surface vegetation is important because as surface water permeates the karst features, the vegetation serves as a potential pollution filter and a supplier of nutrients (USFWS 2001).

There are seven terrestrial karst invertebrates found in Travis and Williamson Counties that are listed as endangered species and one species included as a candidate for listing by the Service (Appendix F). Listed species include three insects (one ground beetle and two mold beetles) and four arachnids (Campbell 1995). The three endangered insects include the Tooth Cave ground beetle (*Rhadine persephone*), the Kretschmarr Cave mold beetle (*Texamaurops reddelli*) and the Coffin Cave mold beetle (*Batrisodes texanus*). The four arachnids include the Bee Creek Cave harvestman (*Texella reddelli*), Bone Cave harvestman (*Texella reyesi*), Tooth Cave pseudoscorpion (*Tartarocreagris texana*), and Tooth Cave spider (*Neoleptoneta myopica*). All of these species were listed as endangered on September 16, 1988 (53 *Federal Register* [FR] 36029). Although the Bone Cave harvestman and Coffin Cave mold beetle were not identified initially, a refinement of the taxonomy expanded the original five species into seven distinct species and all are considered listed species under the ESA (58 FR 43818). The Wharton's Cave meshweaver (*Cicurina wartoni*) is a candidate for listing (70 FR 24869). All of these species appear to be predators and are found in relatively small numbers. Each may have a different preferred microhabitat and may depend on specific prey species for survival, but there is little specific information on the life history, habitat requirements, or population estimates of any of these species. Because of their secretive habits, rarity, and inaccessibility, there are no techniques to accurately assess population status.

There are multiple karst faunal regions found within Travis and Williamson Counties and two of these are included within the area considered by this document, the South Travis County karst fauna region and the Rollingwood karst fauna region. The South Travis County region is thought to be bounded to the north by Barton Creek while the southern limit is thought to be near the Travis–Hays County line, however, further investigation is necessary (Veni 1991). To date, no listed species have been found in the caves that have been surveyed in the South Travis County karst faunal region. The Rollingwood region is located to the south and west of the Colorado River along the lower reaches of Barton Creek. Only one of the listed species has been confirmed in the Rollingwood karst fauna region that is within the influence of the Barton Springs segment of the Edwards Aquifer, the Bee Creek Cave harvestman (USFWS 1994). Descriptions of the listed and candidate species follow.

The **Tooth Cave ground beetle** was described by Barr (1974); it is approximately 7–8 mm (0.3 inch) in length and reddish-brown with rudimentary eyes (53 FR 36030). It is believed to feed on cave crickets, which is the food item of other troglobitic species of the genus. This species occurs within ten caves (8 positive, 2 tentative identifications) in the Jollyville Plateau karst fauna region (Travis County) and 17 locations (16 positive identifications) in the Cedar Park karst fauna region (Travis and Williamson Counties). None of these locations are within the area of the Barton Springs segment of the Edwards Aquifer.

The **Kretschmarr Cave mold beetle** was described by Barr and Steeves (1963) and is less than 3 mm (0.12 inch) in length, dark colored, short-winged, and has elongated legs (53 FR 36030). The species is eyeless and occurs in four caves in the Jollyville Plateau karst fauna region in Travis County. It was previously reported from Coffin Cave in Williamson County, but this population was redescribed as the Coffin Cave mold beetle (58 FR 43818). None of these locations are within the area influenced by groundwater levels in the Barton Springs segment of the Edwards Aquifer.

The **Coffin Cave mold beetle** was described by Chandler (1992) and is approximately 2.6 to 2.9 mm (0.1 inch) long, eyeless, and has elongated legs. Very little is known about this species including its food preferences and other basic ecological information. This species occurs exclusively in Williamson County, including two caves in the North Williamson County karst fauna region. These locations are not within the area of the Barton Springs segment of the Edwards Aquifer.

The **Bee Creek Cave harvestman** was described by Goodnight and Goodnight (1967) and has long legs with a body length of less than 2.5 mm. It is an eyeless, orange predator of small insects (USFWS 2001). The Bee Creek Cave harvestman is adapted to the karst environment, completing its life cycle underground. Generally, no more than one or two individuals are seen on a visit to a cave and often none are observed, even in caves where they are considered relatively abundant. This species occurs in three caves (one positive, two tentative identifications) in the Jollyville Plateau karst fauna region and four caves (one positive, three tentative identifications) in the Rollingwood karst fauna region (USFWS 1994). This species is the only one of the endangered terrestrial karst invertebrates that is found within the boundaries of the planning area and within the influence of the Barton Springs segment of the Edwards Aquifer. Because this species is a predator near the top of its food chain, any habitat changes that directly affect its food sources or nutrient inputs may, in turn, affect the Bee Creek Cave harvestman. However, it is not realistic to expect that the groundwater management measures employed by the District under the HCP will have a measurable, much less deterministic effect on the rather stable subterranean habitat conditions (temperature and humidity) for this species; rather, the amount and frequency of local meteoric water infiltrating into the cave system in the unsaturated zone are much more likely to be controlling. Consequently, this terrestrial species is not proposed as a Covered Species in this HCP.

The **Bone Cave harvestman** was described by Ubick and Briggs (1992). It has long legs and is blind, with pale orange coloration and a body length of approximately 1.4 to 2.7 mm (0.06 to 0.1 inch). This species is particularly sensitive to humidities below saturation and are restricted to only the coolest, dampest spots during summer when small caves become warmer and drier (Campbell 1995). This species occurs in 69 caves (60 confirmed, 9 tentative identifications) from northern Travis to northern Williamson Counties, which includes six karst fauna regions, however, none of them are within the planning area. Therefore, the known locations of this species are outside of the Barton Springs segment of the aquifer.

The **Tooth Cave pseudoscorpion** reaches a length of approximately 4 mm (0.16 inch) and resembles a tiny eyeless, tailless scorpion. They have pinchers that are used to catch prey, which is believed to be small insects and other arthropods. It is known only from Tooth and Amber Caves in Travis County (53 FR 36029) and tentatively in two additional caves, all of which are found in the Jollyville Plateau karst fauna region (USFWS 1994) north of the Colorado River. Therefore, the known locations of this species are outside of the Barton Springs segment of the aquifer.

The **Tooth Cave spider** is the smallest of these seven invertebrate species at about 1.6 mm (0.06 inch) in length (Reddell 1963). It is pale colored with relatively long legs and although it is restricted to the subterranean environment, it does possess rudimentary eyes. This species is sedentary and creates webs within the confines of Tooth Cave (53 FR 36029). The species is known to occur in two caves and was tentatively identified in two additional caves, all of which are found in the Jollyville Plateau karst fauna region (USFWS 1994) north of the Colorado River. Therefore, the known locations of this species are outside of the Barton Springs segment of the aquifer.

The **Wharton's Cave meshweaver,** a candidate for listing, is a spider approximately 0.25 inch (6 mm) in length that has been found only in one small cave in northwest Travis County. It was first collected in 1990 and is described by Gertsch (1992) as eyeless, unpigmented, sedentary, and spinning a small web in and under detritus and small rocks. It preys on other small invertebrates. The observed location of this species is outside the Barton Springs segment of the aquifer.

Each of these karst invertebrates requires an environment with stable, mild temperatures and constant, high humidity. To maintain adequate conditions, it is important to maintain an adequate drainage area to supply moisture to the cave and connected karst areas, and to maintain the surface plant communities that insulate the karst system from excess drying and more extreme temperature fluctuations. Water enters the karst ecosystem through the surface and subsurface. Because these karst ecosystems depend on air-filled voids with some water infiltration, a reduction in moisture levels can significantly reduce habitat suitability and potentially the population abundance of each of these species, since they rely on moist air environments. In contrast, extremely high moisture levels can result in flooding and elimination of air-breathing species. Water infiltration also brings nutrients into the subsurface system and, thus, alteration of the quantity of surface water inflow may also change nutrient inflow. Since these species rely on nutrients from the surface for their existence, any alteration of inflow can cause an adverse impact.

3.3.3 Species Addressed by Section 10(a)(1)(B) Permit

There is one salamander within the Barton Springs segment of the Edwards Aquifer listed as endangered by the Service and a second recognized as a candidate for listing that are proposed for incidental take coverage under section 10(a)(1)(B) of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.), and included in this HCP. This includes the Barton Springs salamander (*Eurycea sosorum*) (endangered) and the Austin blind salamander (*Eurycea waterlooensis*) (a candidate for listing). The Barton Springs salamander was federally listed as endangered on April 30, 1997 (62 FR 23377-23392), while the Austin blind salamander was identified as a candidate for listing on June 13, 2002 (67 FR 40657-40679). A brief discussion of the life history and status of each species is provided below.

3.3.3.1 Barton Springs Salamander (*Eurycea sosorum*)

The Barton Springs salamander (Figure 3.3-2) was described by Chippindale et al. (1993), and is a member of the family Plethodontidae (lungless salamanders). Texas species within the genus *Eurycea* inhabit springs, spring runs, and water-bearing karst formations of the Edwards Aquifer.

They are aquatic and neotenic, meaning they do not metamorphose and leave water, but become sexually mature, breed, and live in water throughout their lives while retaining larval, gill-breathing morphology (Petranka 1998).

The species has reduced eyes (indicative of a semi-subterranean lifestyle), elongate, spindly limbs (indicative of an aquatic lifestyle), and a relatively broad head. Newly hatched larvae are about 0.5 inch (12 mm) total length and may lack fully developed limbs or pigment (Chamberlain and O'Donnell 2003). Juveniles closely resemble adults

Barton Springs Salamander
(*Eurycea sosorum***)**

Figure 3.3 - 2

USFWS, W. Meinzer

Austin Blind Salamander
(*Eurycea waterlooensis***)**

Figure 3.3 - 3

Suzanne L. Collins,
The Center for North
American Herpetology

and reach sexual maturity at approximately 2.5 mm snout-vent length; adults reach total lengths of about 2.5 to 3 inches (63–76 mm) (Chippindale et al. 1993). On either side of the base of the head is a set of three, lightly developed, bright-red gills. The upper body coloration varies dramatically and may be light to dark brown, purple, reddish brown, yellowish cream or orange. The presence of melanophores (cells containing brown or black melanin pigments) and silvery white iridiophores in the skin gives individuals a mottled salt-and-pepper color pattern on the upper body surface. The arrangement of these pigment cells is highly variable and can be widely dispersed in some individuals, yielding an overall pale appearance. In other salamanders the melanophores may be so dense that individuals have a dark brown appearance. The ventral side (underside) of the body is cream-colored and often translucent so that some internal organs, and developing eggs in females, are readily visible. The tail is short relative to other aquatic *Eurycea*, with a well-developed dorsal (upper) fin and narrow ventral (lower) fin. The dorsal midline of the tail usually exhibits some degree of orange-yellow pigmentation (Chippindale et al. 1993).

The Barton Springs and Austin blind salamanders are syntopic, found in the same spring sites but inhabit different depths of the aquifer (Hillis et al. 2001). Barton Springs salamanders are predominately in the epigean (surface and sub-surface) areas, while adult Austin blind salamanders are predominately in deeper, subterranean areas (City of Austin unpublished data). Like Barton Springs, nearby San Marcos Springs also has two syntopic species of *Eurycea* salamanders, the subterranean Texas blind salamander (*Eurycea rathbuni)* and the surface-dwelling San Marcos salamander (*Eurycea nana*). Texas blind salamanders inhabit underground caves along the San Marcos Springs Fault, while San Marcos salamanders are restricted to near the headwater streams and spring outlets of the San Marcos River (Petranka 1998). The Barton Springs salamander is more closely related to the San Marcos salamander than either the Austin blind or Texas blind salamanders (Hillis et al. 2001) suggesting that the vertical division of habitat is an ancient characteristic (Hillis et al. 2001).

The Barton Springs salamander has been found in the four springs that make up the Barton Springs complex (Figure 3.3-1), including the largest (Parthenia) spring in Barton Springs Pool, Eliza Spring, Old Mill Spring (also called Sunken Garden or Zenobia Spring) and the Upper Barton Spring (City of Austin 1998a). The spring complex is located within Zilker Park, near downtown Austin. Barton Springs salamanders were first collected from Parthenia and Eliza Springs in 1946 (Brown 1950), Old Mill Spring in 1993 (Chippindale 1993), and Upper Barton Spring in 1997 (City of Austin 1998a). The City of Austin has conducted monthly surveys since 1993 and has found that salamanders within Barton Springs Pool reside primarily near the outlets of Parthenia Spring and the fissures west of the diving board. They have been found sporadically along the north bank of the pool in flowing water just downstream of Parthenia Spring. Currently, these salamanders are found in all four springs (City of Austin 2003a). It is unclear whether this species is distributed throughout the epigean areas of the aquifer within Zilker Park. Sweet (1978) suggested that this species was troglobitic (cave-dwelling) based on several morphological features that are suited for a subterranean existence. He suggested that the salamanders observed at the surface were discharged from the spring outlets; however, observation of Barton Springs salamanders actively swimming into high flow emanating from the spring openings (City of Austin 1998a), and the discovery of a syntopic troglobitic species (*E. waterlooensis*), suggest that the species is not entirely subterranean, nor is its mobility subject to movement with the water currents. Chippindale et al. (1993) evaluated additional characteristics and countered with the argument that the species is primarily surface dwelling and capable of living underground.

In addition to the Barton Springs complex, other springs in the Bartons Springs segment of the Edwards aquifer include Cold Spring, Campbell's Hole, and Backdoor Springs, all located along Barton Creek. Various searches have failed to document either Barton Springs or Austin blind salamanders in these other springs. Searches of springs in the nearby Bear Creek watershed in the early 1990s did not reveal salamanders (Chippindale et al. 1993).

Barton Springs salamanders are currently found in the highest abundance and highest density in Eliza Spring (City of Austin 2006). Anecdotal evidence suggests that Eliza Spring had an abundant population of Barton Springs salamanders in the 1970s (J.R. Reddell 1963, referenced in Chippindale et al. 1993), however, surveys between 1997 and 2003 showed a steady decrease of approximately 81 percent from an average of 23.6 individuals to 4.5 individuals (City of Austin 2003a). Habitat restoration at Eliza Spring in 2003 dramatically altered these numbers with a peak of 738 individuals observed in 2006 (Table 3.3-2). This table also summarizes lowest and highest counts from surveys conducted by the City of Austin at Parthenia Spring, Eliza Spring, Upper Spring and Old Mill Spring during the years 2003 through 2006.

Table 3.3-2. Lowest and highest counts of the Barton Springs salamander within each of the four main springs during the years 2003-2006 (City of Austin 2006)

Year	Parthenia Spring		Eliza Spring		Upper Spring		Old Mill Spring	
2003	11	100	3	148	0	5	1	52
2004	5	127	231	594	1	14	5	67
2005	8	236	146	669	1	9	7	19
2006	1	300	216	738	-*	-*	0	3

*Upper Barton Spring was not flowing; therefore, salamanders were not present

The second highest abundance of Barton Springs salamanders is in the main (Parthenia) Spring, however densities are much lower than Eliza Spring as illustrated by Table 3.3-2 above. These salamanders are primarily found around spring openings and fissures; they are rarely found in areas of little flow and excess sediment accumulation, such as the deep areas of the pool downstream of the spring openings or the shallow end upstream of the fissures.

Barton Springs salamanders are least abundant in Upper Barton Spring with numbers ranging from 0 to 14 individuals during the years 2003 through 2005 (Table 3.3-2). Because this spring stops flowing when the collective flow of the Barton Springs complex is lower than approximately 40 cfs, no aquatic *Eurycea* salamanders are present. However, these salamanders reappear when springflow returns in numbers at or near the maximum of 14. In Old Mill Spring numbers have ranged from 0 to 67 during the years 2003 through 2006.

Barton Springs salamanders appear to feed primarily on small, live invertebrates. Chippindale (1993) found amphipod remains in the stomachs of wild-caught salamanders. The gastro-intestinal tracts of 18 adult and juvenile Barton Springs salamanders and fecal pellets from 11 adult salamanders collected from Eliza Spring, Barton Springs Pool, and Old Mill Spring contained ostracods, copepods, chironomids, snails, amphipods, mayfly larvae, leeches, and adult riffle beetles. The most common organisms found in these samples were ostracods, amphipods, and chironomids (City of Austin, unpublished data).

Gravid females, eggs, and larvae have been found throughout the year in the wild, suggesting year-round reproduction (USFWS 2005b). Also, because salamander larvae are found year-round but very few eggs (which are white and visible to the human eye) have been observed in the wild (Chamberlain and O'Donnell 2003), oviposition is believed to occur in the aquifer. Information gleaned from captive-raised Barton Springs salamanders indicates that females can develop eggs within 11 to 17 months from hatching. One male also exhibited courtship behavior (tail undulation) at one year from hatching; all were about 2 inches (51 mm) total length (Chamberlain and O'Donnell 2003). In the wild, females with eggs are typically at least 1.6 inches (40 mm) total length (Chamberlain and O'Donnell 2003, unpublished data). Hatching in captivity has occurred within 16 to 39 days from the time the egg is laid (Chamberlain and O'Donnell 2003). Barton Springs salamanders in captivity have been maintained in captivity for at least 10 years, but longevity in the wild is unknown (USFWS 2005b).

The Service (62 FR 23377-23392) identified several threats that led to the listing of the Barton Springs salamander. These include: degradation of the quality and quantity of water that feeds Barton Springs as a result of urban expansion, modification of the salamander's surface habitat, lack of a comprehensive plan to protect Barton Springs watershed from increasing threats to water quality and water quantity, and the salamander's extreme vulnerability to environmental degradation because of its restricted range composed of an entirely aquatic environment.

Water quality conditions in the four springs that make up the Barton Springs complex are influenced by both groundwater and surface water. Groundwater recharge occurs through six stream systems (Barton Creek, Williamson Creek, Slaughter Creek, Little Bear Creek, Bear Creek, and Onion Creek). Surface water from Barton Creek periodically enters the surface habitat of Upper Barton Spring. This spring lies directly in the Barton Creek floodplain and is subject to high flow of surface water in Barton Creek itself. Barton Springs Pool, however, receives surface water and sediment from Barton Creek only when floodwater in the creek overtops the pool's upstream dam during floods. The Service identifies the principal threats to water quality in the Aquifer to be changes in land use that degrade the quality of stormwater runoff and the release of contaminants in the recharge areas of these watersheds that potentially can be transported to Barton Springs (USFWS 2005b).

An analysis of spring discharge data by the City of Austin (2000) has indicated that degradation has occurred in a number of water quality parameters at Barton Springs. Dissolved oxygen has decreased while conductivity, sulfates, turbidity, nitrate-nitrogen, and total organic carbon have increased. These changes in water quality at Barton Springs may be related to cumulative impacts of urbanization, but may also be related to seasonal changes in the amount of precipitation (City of Austin 1997). Information concerning how water quality changes have affected the Barton Springs salamander or its habitat is incomplete. Dissolved oxygen appears to be critical for development of eggs, young, and adults; predator avoidance; feeding; reproduction; and basic survival processes in amphibians (Hillman and Withers 1979). There are some indications in the survey data collected by the City of Austin (2003a) that the abundance of Barton Springs salamanders has been influenced by variation in dissolved oxygen.

Conductivity (an approximation of salinity) has also been a water quality parameter of concern for Barton Springs salamanders as high conductivity has been associated with detrimental effects on aquatic salamanders (USFWS 2005b). Conductivity can increase in the springs as a result of increased pollutants in urban runoff and through encroachment of water with higher salinity that is typically maintained deeper in the aquifer but moves upward when the freshwater above it is depleted. Specific conductivity levels have been periodically measured above 1000 µS/cm at Barton Springs (City of Austin 1997). Effects of conductivity on the closely related salamander, *E. nana,* have been investigated by the Edwards Aquifer Research and Data Center (1999). In this study, tests resulted in 100 percent mortality within 24 hours under non-aerated conditions with a conductivity of 1145 µS/cm and a dissolved oxygen level of 6.8 to 7.6 mg/L (Edwards Aquifer Research and Data Center 1999). However, recent findings by Poteet and Woods (2007) found that this species did not show any substantial metabolic response to conductivity levels between 600 and 3000 µS/cm when confined in tanks with DO levels at 6 mg/L.

A recent potential threat to the Barton Springs salamander that may be related to water quality is the development of gas bubbles in some individuals that is consistent with a condition known as gas bubble trauma. In gas bubble trauma, bubbles below the surface of the body and inside the cardiovascular system produce lesions and necrotic tissue that can lead to secondary infections (Fidler and Miller 1994). Death from gas bubble trauma is apparently related to an accumulation of internal bubbles in the cardiovascular system

(Fidler and Miller 1994). However, gas bubbles in Barton Springs salamanders are found predominately under the surface of the skin. This condition is typically caused by water supersaturated with dissolved atmospheric gases (nitrogen, oxygen, carbon dioxide, and trace gases) in concentrations above 100 percent (Bouck 1980; Crunkilton et al. 1980; Finckeisen et al. 1980; Montgomery and Becker 1980; Colt et al. 1984a, 1984b; Krise 1993; Krise and Smith 1993; Fidler and Miller 1994; Mayeaux 1994). Seventeen Barton Springs salamanders were observed with gas bubbles in Upper Barton Spring and two more were observed in Old Mill Spring during the first six months of 2002. Of these, 12 were either found dead or died shortly thereafter (City of Austin 2003a). Symptoms of gas bubble trauma (bulging eyes and lack of buoyancy control) were subsequently observed in several other species trapped within Upper Barton Spring by obstructions at the outflows including Mexican tetras (*Astyanax mexicanus*), mosquito fish (*Gambusia affinis*), Rio Grande leopard frog (*Rana berlandieri*) tadpoles, crayfish (*Procambrus clarki*), and beetle larva (Hydrophilidae) (Chamberlain and O'Donnell 2003). During the time that affected salamanders were found in Upper Barton and Old Mill Springs, supersaturation percentages were high (greater than 110 to 115 percent) at all four of the springs. Upper Barton Spring had the highest supersaturation with up to 125 percent in 2002 and up to 131 percent in 2003 (USFWS 2005b). There had been no evidence of gas bubble trauma in any of the aquatic organisms at this site prior to the incidents in 2002 and 2003. No evidence of a contaminant was found (City of Austin data). Since 2003, there have been only two salamanders found with gas bubble trauma (USFWS 2005b).

The Service (2005b) identifies another potential threat to the Barton Springs salamander and its ecosystem as low flow conditions in the aquifer and at Barton Springs. Lower flows result in changes in physico-chemical conditions such as dissolved oxygen, conductivity, and siltation that may reduce habitat suitability for the species. The long-term average flow at the Barton Springs outlets (including Barton Springs Pool, Eliza Spring, Old Mill Spring, and Upper Barton Spring) is about 53 cfs (BSEACD 2004). The lowest short-term flow measured at Barton Springs was 9.6 cfs on March 29, 1956 (USGS 1957) under drought of record conditions. Although the Barton Springs salamander survived this period, pumpage during the 1950s was estimated at 0.66 cfs (Brune and Duffin 1983). With an estimated 10.3 cfs currently allotted for pumping, discharge from the springs would be much lower during a repeat of similar drought.

3.3.3.2 Austin Blind Salamander (*Eurycea waterlooensis*)

Like the Barton Springs salamander, the Austin blind salamander (*Eurycea waterlooensis*) (Figure 3.3-3), is a member of the Plethodontidae family. The species was described by Hillis et al. (2001) and is more closely related to the Texas blind salamander (*Eurycea rathbuni*), found in the southern portion of the Edwards Aquifer in San Marcos, Texas, than it is to the Barton Springs salamander.

The Austin blind salamander is an aquatic, neotenic, troglobitic species with morphological adaptations to subterranean life. It has eyespots that are covered by skin instead of image-forming lenses, an extended snout, fewer costal grooves than other neotenic Edwards Aquifer *Eurycea*, and pale to dark lavender coloration (Hillis et al. 2001). The tailfin of this species is not well developed; the dorsal portion is weakly developed or absent and the ventral portion only present on the posterior part of the tail. Although the Austin blind salamander is similar to the Texas blind salamander it has shorter limbs, and a head that is narrower at the eyespots than at the gills (the widest point). The largest Austin blind salamander captured at Barton Springs was 66 mm (2.6 inches) in total length, but captive individuals have reached lengths up to 81 mm (3.2 inches) (Hillis et al. 2001). The coloration of the Austin blind salamander is pearl with iridiophores found along the body and tail. Melanophores are uniformly distributed on the dorsal side of Austin blind salamanders resulting in almost no visible mottling on the dorsal part of the body. Like the Barton Springs salamander, the light body color of the Austin blind salamander allows internal organs to be easily seen.

Austin blind salamanders have been found in the highest numbers in Old Mill Spring and sporadically in low numbers in Barton Springs Pool and Eliza Spring. Their morphological characteristics indicate they are likely in greater numbers in the subterranean areas of Barton Springs (Hillis et al. 2001). Since the Austin blind salamander occupies a more subterranean habitat than the Barton Springs salamander, most of the observations of this species have been of the more mobile juveniles. Substantially fewer Austin blind salamanders than Barton Springs salamanders have been observed by City of Austin biologists during regular surveys. From information by Hillis et al. (2001) and observations by City of Austin biologists, there have been only 120 documented observations of the Austin blind salamander from January 1998 to February 2002, compared to 2,059 Barton Springs salamanders during the same time frame.

Due to its recent discovery and the difficulty surveying subterranean populations, very little is known of this salamander’s biology and life history. Hillis et al. (2001) reported that individuals appear to feed on small aquatic invertebrates, specifically amphipods, ostracods, and copepods. As part of its captive breeding program, the City of Austin (2003b) has observed that juveniles collected in the wild “generally grow rapidly for about 8 months (until they reach a total length of about 2.4 inches or 60 mm), after which growth slows to about 1 mm per month.” There is little information currently available on reproduction in Austin blind salamanders. According to Hillis et al. (2001), individuals are likely to reach sexual maturity at about 60mm total length. Two egg laying events have been observed in the City of Austin’s captive breeding program (Chamberlain, City of Austin, personal communication). During these events, white eggs were laid singly. The eggs were covered by sticky sheaths to allow attachment to rocks or other substrate in flowing current.

Each of the potential threats to the Barton Springs salamander identified in Section 3.3.3.1 may be applied to the Austin blind salamander to some degree. The degradation of water quality that appears to be associated with urbanization (Turner 2000), including reduced dissolved oxygen concentration and increased conductivity, also affects habitat conditions for this species. Reduced flows exacerbate these conditions and may lead to reduced habitat availability for Austin blind salamanders. In addition, a reduction in habitat suitability for Barton Springs salamander associated with lower flows and reduced water quality conditions may also result in movement of the latter species deeper into the aquifer and result in an overlap in habitat occupation (and increase competitive interaction) between the two species. Competition for food and space along with other unknown biological interactions may negatively affect one or both species.

Lower flows may also result in a reduced capability for sediments to be forced out of the spring openings and may be a concern for the Austin blind salamander (Hillis et al. 2001). In addition, the modification of Eliza Spring that resulted in no outlet for sediments, including those deposited during storm-flows and naturally discharged sediments from the aquifer, results in an accumulation in the confined area. Sedimentation from surface water flow during flood conditions may also influence habitat suitability for this species temporarily until springflow transports excess sediments from these openings. To date, no Austin blind salamanders have been observed in the wild with gas bubble trauma (Chamberlain and O'Donnell 2003).

3.3.4 Species of Concern

There are several species within or near the District HCP Planning Area that are considered species of concern. Species of concern are those for which there are not enough data to support listing but which have been identified as species considered rare or in decline, that require specialized habitat requirements, or are experiencing widespread habitat alterations. The following sections provide a brief summary of the locations, habitat requirements, and morphological descriptions of these species that might be found in the HCP Planning Area. No direct relationship with the HCP measures is currently known or postulated for these species.

3.3.4.1 Aquatic Invertebrates

The Balcones Cave amphipod (*Stygobromus balconis*) is a fairly large troglobitic species that can be found in caves in Hays and Travis Counties. This amphipod prefers the quiet water of pools containing an abundance of organic debris and silt that serves as an important nutrient source. This amphipod appears to be an isolated remnant of *S. americanus* whose range once extended into Texas but is now found only in Oklahoma, Arkansas, Missouri, and Louisiana. There is morphological evidence to suggest that the Balcones Cave amphipod is still undergoing further speciation (formation of a new biological species) within its current range (Holsinger 1966).

The Edwards Aquifer diving beetle (*Haideoporus texanus*), also known as Texas cave diving beetle, is restricted to the subterranean waters of the Edwards Aquifer in Hays and Comal Counties. Previously, this species was only known from an artesian well on the campus of Texas State University. Recent collections yielded this beetle from Comal Springs and it appears to be more widely distributed in the Edwards Aquifer than previously thought (Bowles and Stanford 1997). The Texas cave diving beetle is the first blind, depigmented, aquifer-adapted water beetle known from North America. They have reduced, nonfunctional eyes and a greater development of sensory setae (hairs) on their wings, legs, and mouth area (Young and Longley 1975).

3.3.4.2 Aquatic Vertebrates

Several neotenic salamanders belonging to the *Eurycea* genera have been found in spring systems in western Travis and Hays Counties that appear to resemble the Texas salamander (*Eurycea neotenes*), however, species taxa have not yet been confirmed (Table 3.3-1). These strictly aquatic species occur in surface springs, caves, and creek headwaters located under rocks, gravel, and leaves. One of the species appears to mature at a very small size (Chippindale et al. 2000).

3.3.4.3 Terrestrial Invertebrates

The Tooth Cave ground beetle (*Rhadine persephone*) is a small, cave-adapted beetle found in Edwards limestone caves in Travis and Williamson Counties (TPWD 2005a). The maculated manfreda skipper (*Stallingsia maculosus*), is a butterfly found throughout the Edwards Aquifer region. It can be found in semi-arid areas in association with its larval food plant *Manfreda maculosa* (Linam 1995).

3.4 Agriculture

3.4.1 Production

Agricultural enterprises in the District HCP Planning Area are extremely diverse with regard to commodities produced, ranging from livestock to row crops to pecans. According to the 2002 Census of Agriculture by the USDA, the top crop items in Travis, Hays, and Caldwell Counties were forage (land used for hay production, grass silage, and greenchop), grain sorghum, corn, wheat, cotton, and pecans. Top livestock items in these counties included cattle and calves, turkeys, goats, horses, sheep and lambs, quail, and chickens including layers (20 weeks old and older) and broilers (including other white-meat chickens). The total market value of agricultural products sold in 2002 was $35,091,000 in Caldwell County—a figure roughly double the value for Travis ($17,116,000) and Hays ($14,614,000) Counties. This valuation illustrates that most agricultural production is in the extreme eastern part of the HCP Planning Area and removed from the Edwards Aquifer groundwater production area.

Agricultural operations throughout the District HCP Planning Area are being influenced by higher equipment costs, higher energy costs for planting, irrigation, and harvest, and low livestock and crop prices. Total farm production expenses increased in the 5 years between 1997 and 2002 by 21 percent, 28 percent, and 55 percent in Caldwell, Hays, and Travis Counties, respectively. This expense increase has resulted in an increase of larger commercialized operations, and a decrease in the size of family-owned farms and ranches.

While the type of crops and livestock is similar in the three counties, the rapid pace of urbanization in Travis County, and portions of Hays County, is evident in the decrease of the amount of land in farms in these counties. Compared to the 1997 Census of Agriculture Data, land in farms in Travis and Hays Counties is down 29 percent and 13 percent, respectively, while land in farms in Caldwell County increased by 9 percent. Average farm size is decreasing in all three counties, although to varying degrees; down 30 percent in Travis, 19 percent in Hays, and 2 percent in Caldwell since 1997.

Table 3.4-1 presents average water requirements for livestock, but these are only general guidelines. Actual requirements are variable and can be influenced by a number of factors.

Table 3.4-1. Average livestock water requirements

Livestock Type	Gallons/Day/Head
Dairy cows	15 to 25
Beef cattle	7 to 12
Swine (market hogs)	1 to 2.5
Sows plus litter	4.5 to 6
Ewes or lambs	1 to 2
100 laying hens	8 to 10
100 turkeys 10 weeks	10
100 turkeys 25 weeks	15

Source: Doane’s Facts and Figures for Farmers.

3.4.2 Irrigation Water Use

Irrigation water demand for the whole of the Lower Colorado Region (Region K) is projected to decrease from 588,635 acre-feet in 2000 to 479,453 acre-feet per year in the year 2050 (LCRWPG 2000). That same Region K planning indicates that this reduction in irrigation water use will be more than offset by rising municipal demand, especially in the growing Austin–San Marcos metropolitan area. Irrigation water demand in the Lower Colorado Region is concentrated in Colorado, Matagorda, and Wharton counties and is largely used to meet irrigation needs for rice farming. Over the next 50 years a decrease in irrigation water demand is projected due to improvements in irrigation efficiency and reductions in irrigated acres due to forecasted unfavorable farming economics. For those counties in the District HCP Planning Area, Table 3.4-2 presents 1996, 2000, and projected irrigation water demands for Travis and Hays (partial) Counties in Region K.

Table 3.4-2 1996, 2000 and projected irrigation water demand (acre-feet per year)

County	1996	2000	2010	2020	2030	2040	2050
Hays (p)	81	23	22	22	22	22	22
Travis	907	736	677	622	572	526	484
TOTAL	988	759	699	644	594	548	506

Source: Lower Colorado Regional Water Planning Group (2000)

Groundwater Pumpage for Irrigation

In 2003, the District had 93 permitted wells/systems totaling an annual permitted amount of 2,182,251,250 gallons or 6,697 acre-feet. Groundwater use is classified as public water supply, commercial, industrial, or irrigation. Permitted irrigation in 2003 amounted to 147,435,550 gallons or 453 acre-feet. Actual irrigation use in 2003 amounted to 112,268,476 gallons or 345 acre-feet (BSEACD 2005b). Irrigation use is defined by the District to include the application of water to plants or land in order to promote growth of plants, turf, or trees. This includes the application of water to plants or land in connection with the production of crops for human food, animal feed, seed, fiber, or cover crops, and the practice of floriculture, viticulture, silviculture, and horticulture. However, virtually all of the irrigation use in the District is for athletic field irrigation (golf courses, soccer fields, football fields, etc.).

For Hays County in 2003, 4,820,550 gallons or 14.7 acre-feet were permitted for irrigation use, but only 3,742,000 gallons or 11.4 acre-feet were actually used in that year. For Travis County in 2003, 142,615,000 gallons or 437 acre-feet were permitted for irrigation use, but only 108,526,476 gallons or 333 acre-feet were actually used.

For 2004, total District permitted (i.e., authorized) and actual irrigation use increased to 179,587,050 gallons or 551 acre-feet and 125,960,765 gallons or 387 acre-feet, respectively. This represents an increase of 22 percent in permitted and 12.2 percent in actual irrigation use.

3.5 Land Use

Land use data from Geographic Information Systems (GIS) mapping sources were compiled for the District HCP Planning Area. The City of Austin maintains land use survey data and maps within its incorporated area, extra-territorial jurisdiction (ETJ), and contributing zone (City of Austin 2005d). The City analyzed appraisal data (2000 and 2003), aerial photo interpretation, and other sources to create a land use GIS data base. Quality control measures included field checks. The southeast portion of the HCP Planning Area is located outside the City's ETJ. Land use in this area was determined by aerial photograph interpretation, using City of Austin-defined land use categories. Land use within the District HCP Planning Area is spatially portrayed in Figure 3.5-1 with total acreages summarized in Table 3.5-1.

Table 3.5-1. Summary of 2003 land uses within the District HCP Planning Area

Land Use Category	Area (Acres)	Area (Sq. Miles)	Percent of Planning Area
Civic	3,058	4.8	0.9
Commercial/Office	4,403	6.9	1.3
Industrial	3,824	6.0	1.1
Multi-family	2,162	3.4	0.6
Open Space	28,168	44.0	8.3
Single Family	150,564	235.3	44.0
Transportation/Utilities	14,468	22.6	4.2
Undeveloped	135,316	211.4	39.6
TOTAL	341,963	534.4	100

[1]Single family housing acreage was estimated by calculating total area within property boundaries categorized as single family housing by the Travis Central Appraisal District, rather than photo-interpretation of actual land cover. This resulted in an over-estimate of acreage of single family housing with a corresponding underestimate of undeveloped land.
Source: City of Austin 2005d.

3.5.1 Residential

As of the year 2003, residential land uses comprised approximately 45 percent of the HCP Planning Area. These uses include the mobile home; high-, medium-, and low-density single-family; and multi-family residential land-use categories (Table 3.5-1). Areas closer to the City of Austin exhibit the highest density single-family residential developments within the HCP Planning Area, while lower density single-family residential developments occur in much of the Hays County portion of the District HCP Planning Area.

The majority of residential growth within the District HCP Planning Area can be characterized as low-density, single-family housing. Research and field visits revealed very little multi-family residential development. Western Travis County in particular has experienced rapid residential growth in recent years. Within Travis County Precinct 3, the southwest quadrant of Travis County, single-family housing starts were near or exceeded 1,000 per year between 1993 and 1997. Data for 1998 show decreasing housing starts to 751; the first and second quarters of 1999 indicate a continuation of this trend. In the first quarter of 1999, Precinct 3 saw 208 single-family housing starts, comprising 35 percent of total single-family housing starts for Travis County. The second quarter of 1999

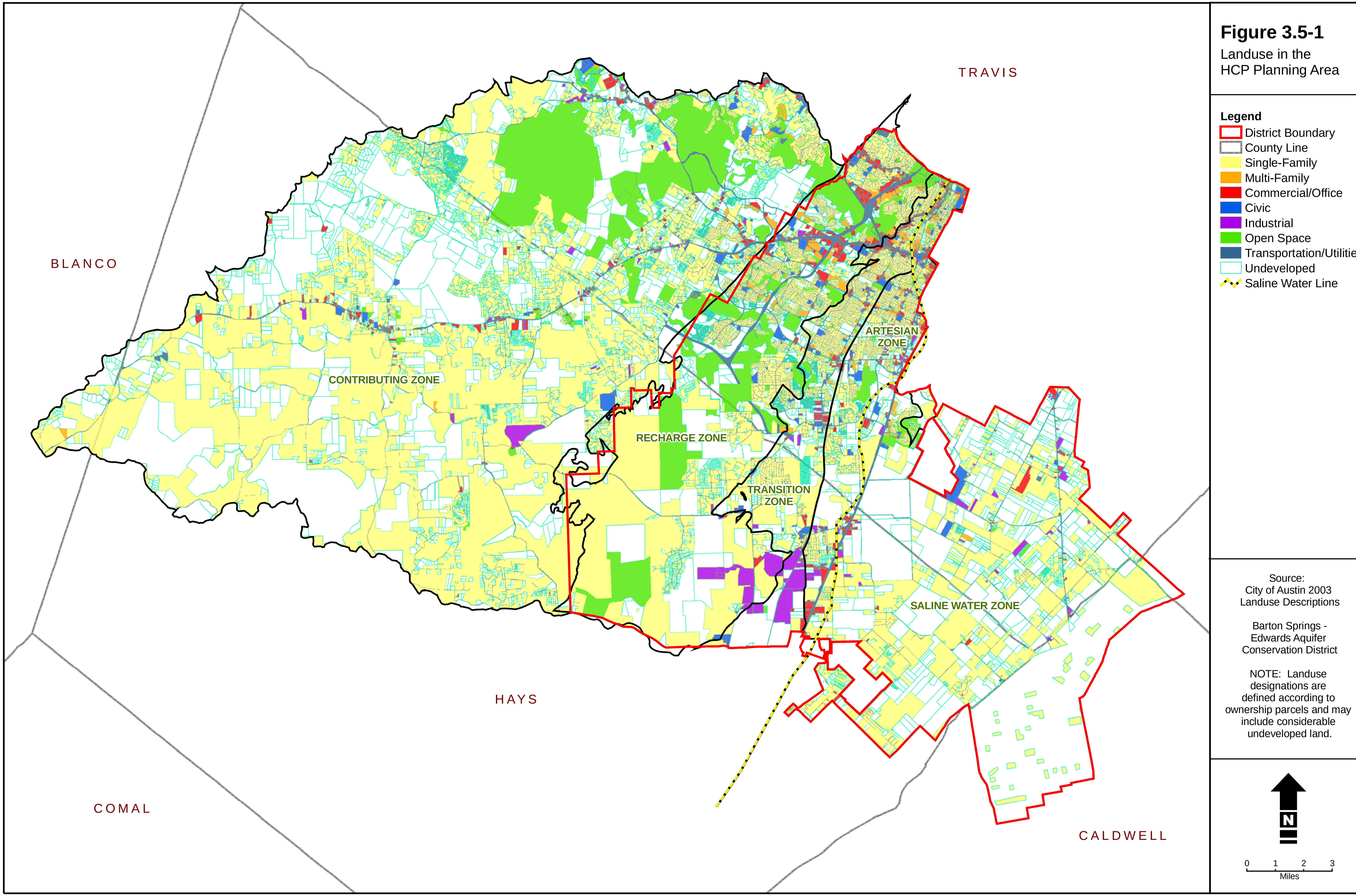
Figure 3.5-1
Landuse in the
HCP Planning Area
Legend
District Boundary
County Line
Single-Family
Multi-Family
Commercial/Office
Civic
Industrial
Open Space
Transportation/Utilities
Undeveloped
Saline Water Line
TRAVIS
BLANCO
HAYS
COMAL
CALDWELL
CONTRIBUTING ZONE
RECHARGE ZONE
TRANSITION ZONE
ARTESIAN ZONE
SALINE WATER ZONE
Source:
City of Austin 2003
Landuse Descriptions
Barton Springs -
Edwards Aquifer
Conservation District
NOTE: Landuse designations are defined according to ownership parcels and may include considerable undeveloped land.
N
0 1 2 3
Miles

showed 203 single-family housing starts, or 30 percent of the county total for the same time period (LCRA 2002).

Much of this westward expansion of single-family housing from the City of Austin is also evident in data from the City of Austin's Smart Growth Zone development activity. The Drinking Water Protection Zone, named for its location over the sensitive Edwards Aquifer, comprises the western third of the City of Austin's area and ETJ. Data for the third quarter of 1998 indicate that the majority of non-residential building permits issued, 48.9 percent, and multi-family units under construction, 68.6 percent, fell within the eastern side of the City's Desired Development Zone Outside Urban Watersheds. The majority of housing starts, 54 percent, and acreage of single-family subdivisions, 66.1 percent, occurred in the Drinking Water Protection Zone on the western side of the city (City of Austin 1998a).

Residential growth has continued westward into Hays County. Within unincorporated areas, housing starts have been increasing since 1991. In 1991 the number of septic permits issued was 266. By 1998 this figure had risen to 1,126. About 2 percent of those permits were issued for commercial uses. While county estimates are not aggregated by precinct, staff indicated that the residential growth had shifted in the past several years. Upscale residential growth in the northern portion of the county had been superseded by less affluent residential growth in the southeastern portion closer to the IH 35 corridor (LCRA 2002).

While the primary transportation corridors between Austin and Dripping Springs (e.g., FM 3238, US 290, and FM 1826) have seen increases in numbers of subdivisions, areas south and west of Dripping Springs continue to maintain a more traditional rural and agricultural pattern. While some commercial development has occurred along these corridors, commercial and industrial land uses have not increased at the same rate as residential land use expansion.

3.5.2 Commercial

Commercial land uses comprise about one percent of the HCP Planning Area. These uses include retail stores, sales shops, shopping centers, service stations, and personal service businesses. Much of the commercial land use within the HCP Planning Area is found within the City of Austin's municipal boundary and ETJ. Commercial land uses tend to concentrate along major transportation corridors and at major transportation interchanges (e.g., the intersection of two or more highways). Outside of Austin, the bulk of the commercial land use is concentrated along US 290 and within the municipal boundaries of the City of Dripping Springs and the Village of Bee Cave.

3.5.3 Office

Office land uses comprise less than one percent of the HCP Planning Area. These land uses include professional/administrative offices (e.g., doctors, dentists, architects, accountants) and office parks. Like commercial land uses, office uses are mostly found within the City of Austin's municipal boundary and ETJ. They tend to concentrate along major transportation corridors and at major transportation interchanges. Outside of Austin, office uses are concentrated along US 290 and within the municipal boundaries of the City of Dripping Springs and the Village of Bee Cave.

3.5.4 Industrial

Industrial land uses comprise about one percent of the HCP Planning Area. These uses include businesses such as resource extraction industries (e.g., rock quarries), manufacturing facilities, and treatment facilities. Though some industrial uses can be found within municipal boundaries and along transportation corridors, several of the larger industrial facilities occur in undeveloped portions of the HCP Planning Area.

3.5.5 Civic

Civic land uses comprise about one percent of the HCP Planning Area. These uses include municipal facilities, schools, churches, cemeteries, and public buildings. Civic uses tend to fall within municipal boundaries and along major transportation corridors. A large component of the HCP Planning Area falls within the Dripping Springs Independent School District (ISD), Austin ISD, and Hays ISD. The Dripping Springs ISD is in the process of building a new intermediate school located on US 290 (LCRA 2002). The southern border of the Lake Travis ISD is the Hays County line. In January 1998 the Lake Travis ISD community passed a $41 million bond issue for new educational facilities. Bee Cave Elementary School opened in fall 1999, and Hudson Bend Middle School opened in fall 2000. Also included in the bond are additional classrooms, a new auditorium, a new softball field (completed in fall 1999), and a new stadium and athletic facility, which opened in spring 2000 (Lake Travis ISD 1999). Within the Hays ISD, three schools have been recently constructed. Within the Austin ISD, nine schools were under construction in 1999.

3.5.6 Open Space

Open space comprises approximately eight percent of the HCP Planning Area. Open space areas include such uses as municipal or county parks, athletic fields, golf courses, preserves and protected areas, water drainage areas, and detention ponds.

A search of the Texas Outdoor Recreation Inventory database revealed a limited number of parks within the Hays County portion of the HCP Planning Area. Common recreational facilities include city parks, athletic fields, and community centers maintained by the City of Dripping Springs and the Dripping Springs ISD. The construction of a 40-acre sports and recreational facility on FM 12 south of Dripping Springs is under way. This project is to be funded by a $400,000 grant from the State of Texas Parks and Wildlife Department with the remainder funded by the Dripping Springs ISD. The city is also in the process of improving Founders Park and building Karhan Park near US 290 (Fischer 1999; LCRA 2002).

In the Travis County portion of the HCP Planning Area, there is a substantial amount of acreage in nature preserves. The Nature Conservancy owns and manages the 4,000-acre Barton Creek Habitat Preserve, which is part of the land set aside for mitigation under the Balcones Canyonlands Conservation Plan (BCCP). Just west of the preserve is another conservation area, the Shield Ranch. Although privately owned, the development rights on this 7,000-acre tract have been purchased by the Nature Conservancy and the City of Austin for the purpose of preserving water quality in Barton Springs (LCRA 2002). Additionally, in May 1998 Austin voters approved a plan that dedicates $65 million to the purchase of 15,000 acres for the purpose of water-quality protection in the Barton Springs Watershed. To date, the City has purchased almost all of the 15,000 acres earmarked for the bond.

3.5.7 Transportation and Utilities

Transportation and utilities uses comprise approximately four percent of the HCP Planning Area. The existing transportation system is a mix of rural county and farm-to-market roads, city streets, and major highways. US 290 connects Austin to Dripping Springs and continues west through the HCP Planning Area (Figure 3.5-1). It is the primary east–west corridor and heavily used by Austin commuters. Farm Road 1826 extends southwest from the eastern portion of the HCP Planning Area. Farm Road 150 connects FM 1826 to the City of Dripping Springs. Farm Road 12 extends both north and south from Dripping Springs. State Highway 71 (SH 71) and FM 3238, Hamilton Pool Road, serve the northern portion of the HCP Planning Area within Travis County.

The CAMPO prepared a comprehensive transportation plan (CAMPO 2000) to guide transportation policy and projects for the next 25 years (to 2025). This plan's primary use is as a regional long-range plan for federally funded transportation projects, and it also serves as a comprehensive, coordinated transportation plan for all of the governmental jurisdictions within the CAMPO area (Travis, Hays, and Williamson Counties).

Within the HCP Planning Area, the following roads are projected to be expanded from four-lane major arterial to six-lane freeway by the year 2025: US 290 from the

Travis/Hays County boundary; SH 45 between MoPac Boulevard to the eastern study boundary, SH 71 from FM 3238 to US 290, Loop 1 (MoPac Boulevard), and Loop 360. Camp Ben McCullough Road (FM 1826) and FM 967 will be expanded to four-lane major arterial roadways within the HCP Planning Area by 2025. Hamilton Pool Road (FM 3238) will be expanded from a two-lane minor arterial to a two-lane major arterial, while FM 2244, also named Bee Cave Road, is projected to be a six-lane major arterial by 2025. In Hays County, a Blue Ribbon Committee was formed to prepare the Hays County Multi Corridor 2025 Transportation Plan (Blue Ribbon Committee 2000), which makes recommendations for road improvements throughout the county.

In Hays County this plan identifies a number of proposed roadway extensions and widenings. Specifically within the HCP Planning Area, the plan calls for the extension of SH 45 both east and west from its current termini, near the Hays and Travis County boundary, as a top priority. The expansion of this highway will connect US 290 on the west with FM 1626 and, ultimately, with IH 35. Construction of safety improvements and widening of the US 290 and FM 12 are also identified as top priorities. Safety improvements, including improved horizontal and vertical curvature, wider shoulders, passing lanes, and additional turning lanes, are high priorities for the FM 1826, FM 150, and FM 1626 roadways within the HCP Planning Area. New road corridors recommended in the plan include a connection between FM 967 on the south to SH 45 on the north, with an additional connection between this corridor on the west and FM 1626 on the east in the City of Hays.

Information provided by Texas Department of Transportation (TxDOT) confirms that there are no roads designated specifically for bicycle use in the HCP Planning Area. However, many of the secondary roads in the Planning Area are heavily used by bicyclists. The City of Austin has amended its Master Plan to include a regional bicycle plan (PBS&J 1999). This plan, while only official within Austin City Limits, recommends path extensions into surrounding counties, including Hays. Several of the roadways in the CAMPO plan are identified as being part of the Metropolitan Bike Route System (CAMPO 2000).

In Hays County, the 2025 plan recommends promoting safe recreational bike routes throughout the county with additional shoulder widening, smooth pavement improvements, and bike route signs (Blue Ribbon Committee 2000).

A review of the San Antonio Sectional Aeronautical Chart (NOAA 1998), the Airport/Facility Directory for the South Central United States (NOAA 1997), and TxDOT’s Airport Directory (TxDOT 1994) indicate one private air strip northwest of Dripping Springs. The HCP Planning Area does not fall within a military operations area.

3.5.8 Undeveloped

Undeveloped lands comprise approximately 40 percent of the HCP Planning Area. This category of land uses includes rural uses, vacant land, and land under construction. Over the past decade urban land use has increased as agricultural land use has decreased. The percentage of urban land use in Travis County increased from 23.5 percent in 1987 to 29.7 percent in 1992. Hays County's urban land use increased from three percent in 1987 to 8.8 percent in 1992. Corresponding decreases have occurred in agricultural percentages. Rangeland comprised 66.7 percent of Hays County and 43.5 percent of Travis County in 1987. By 1992 these figures had decreased to 63.3 percent and 36.5 percent respectively. Within Hays County 7.5 percent of the land is considered cropland and 15 percent pastureland. Within Travis County 13.5 percent of the land is considered cropland and 11 percent pastureland (NRCS 1987, 1992).

The HCP Planning Area falls within the Texas Agricultural Statistics Service South Central District. Data from the 1997 Census of Agriculture indicate that the total amount of land in farms in Hays County decreased by 36 percent between 1992 and 1997 from 463,450 acres to 298,493 acres. While the number of full-time farms, where the majority of income is derived from agricultural sales, increased by 12 percent between 1992 and 1997, the average size of farms decreased by 44 percent, and the market value of agricultural products sold decreased by 25 percent. Although the amount of land in farms in Travis County increased by 19 percent, from 332,826 acres in 1992 to 396,165 acres in 1997, the number of full-time farms decreased by 9 percent and the market value of agricultural products sold decreased by 14 percent (TASS 1997).

3.5.9 Growth Potential in the District Habitat Conservation Plan Planning Area

The City of Austin tracks development trends within its ETJ in terms of building permits, site plans, and subdivision activity in its Growth Watch program (City of Austin 2005f). Although the City's ETJ includes only a part of the District HCP Planning Area, the steady growth in the southern part of the City and its ETJ reflected in the recent data, and in the zip code forecasts noted above, suggests a continued strong potential for future urban growth in the southern part of Travis County and northern Hays County. Of additional importance with respect to growth potential is the continuing development of SH 130 that will, in the next few years, be extended along the existing route of US 183 into the eastern portion of the HCP Planning Area.

Another planned roadway, SH 45 Southeast (SE), will have an impact on growth trends and potential in the area. In April 2005, the TxDOT and the Federal Highway Administration (FHWA) agreed to halt all condemnation and voluntary acquisition of right-of-way for SH 45 SE. Their decision was in response to litigation brought in federal court by Save Our Springs Alliance (SOSA), alleging that TxDOT and FHWA failed to consider the cumulative impacts of different segments of SH 45 SE and SH 45 Southwest (SW), and failed as well to consider alternative routes for SH 45 SE that would not connect with the proposed extension for SH 45 SW, which would cross the Barton Springs Recharge Zone (SOSA 2005). TxDOT has announced that it would do supplemental environmental analyses, and when these studies are completed and accepted, SH 45 SE may be constructed along the existing proposed, or an alternative route, linking IH 35 with SH 130 in the eastern part of the HCP Planning Area.

The completion of these substantial transportation infrastructure projects would provide the roadway support for new residential, commercial, and industrial development in the HCP Planning Area. The additional provision of water and wastewater utilities by various providers would be needed to fully enable the future growth of urban density development in the eastern portion of the HCP Planning Area.

3.6 Demographics

3.6.1 HCP Planning Area

Demographic, economic, and land use data were compiled for the same District HCP Planning Area as outlined in Section 1.1.

There is only one metropolitan statistical area (MSA) located within this region, the Austin-San Marcos MSA. It is primarily dominated by Travis County, but Caldwell and Hays Counties are also included.

3.6.2 Population Growth

According to the Texas State Data Center, the State of Texas' percent change in population was ranked eighth among the 50 states between 1990 and 2000 (22.8 percent). Most of this growth has occurred along the Texas-Mexico border and in the large urban areas of Houston, San Antonio, Austin, and Dallas (Murdock et al. 1996). Approximately 83 percent of the state's population lives in urban areas. According to 2000 U.S. Census Bureau data, between 1990 and 2000, the total population within the District HCP Planning Area grew by an estimated 41 percent—more than a quarter of a million people (286,725) (Table 3.6-1). The largest percent change over the decade was within Bastrop County at 50.9 percent, followed by Hays County at 48.7 percent, followed by Travis County (40.9 percent) and Caldwell County (22.0 percent).

Table 3.6-1. Population in the District HCP Planning Area, by region and county, 1950-2000

County	1950	1960	1970	1980	1990	2000	% Change 1990-2000
Bastrop	19,622	16,925	17,297	24,726	38,263	57,733	50.9
Caldwell	19,350	17,222	21,178	23,637	26,392	32,194	22.0
Hays	14,272	15,947	22,114	32,475	52,491	78,071	48.7
Travis	160,980	212,136	295,516	419,573	576,407	812,280	40.9
TOTAL	214,224	262,230	356,105	500,411	693,553	980,278	41.3

Source: U.S. Census Bureau 2000a.

3.6.3 Population Projections

3.6.3.1 Texas Water Development Board Population Projections

The total population within the four counties encompassing the District HCP Planning Area is projected to increase by approximately 96 percent—or by nearly one million people (899,555)—between the years 2000 and 2040, according to updated population projections developed by the TWDB (2004b). This projected increase is presented in Table 3.6-2.

Table 3.6-2. Population projections for counties in the District HCP Planning Area, 2000–2040

County	2000	2010	2020	2030	2040	% Change 2000-2040
Bastrop	57,733	75,386	97,601	123,734	153,392	165.7
Caldwell	32,194	45,958	59,722	71,459	83,250	158.6
Hays	78,071	166,342	242,051	302,795	363,678	272.7
Travis	812,280	969,955	1,185,499	1,385,236	1,550,538	90.9
TOTAL	980,278	1,257,679	1,584,873	1,883,224	2,150,858	115.1
State of Texas	20,851,790	24,909,072	29,108,012	33,040,032	36,877,046	76.9

Source: Texas Water Development Board 2004b.

3.6.3.2 Other Existing Population Projections

The Texas State Data Center (TSDC 2004) publishes several scenarios of population projections by race/ethnicity for the State and individual counties based on different assumptions about future migration rates. Presidential Executive Order 12898 on Environmental Justice requires an analysis to determine whether proposed federal actions may result in disproportionately high and adverse human health or environmental effects on minority or low-income populations. The data in Tables 3.6-3 and 3.6-4 serve as a baseline for environmental justice analyses to take place during the alternatives evaluation phase.

Table 3.6-3. Zero migration (Scenario 0.0)* projections of population by race in District HCP Planning Area counties, 2000–2040

County	Race	2000	2010	2020	2030	2040	% Change 2000-2040
Bastrop	Total	57,733	62,149	66,099	68,721	69,864	21.0
	Anglo	38,169	39,553	40,617	40,653	39,789	4.2
	Black	5,110	5,275	5,459	5,491	5,424	6.1
	Hispanic	13,845	16,646	19,294	21,798	23,873	72.4
	Other	609	675	729	779	778	27.8
Caldwell	Total	32,194	34,871	37,406	39,323	40,764	26.6
	Anglo	16,149	16,338	16,599	16,616	16,559	2.5
	Black	2,761	2,945	3,117	3,189	3,191	15.6
	Hispanic	13,018	15,281	17,345	19,144	20,629	58.5
	Other	266	307	345	374	385	44.7
Hays	Total	97,589	114,651	123,247	128,087	131,114	34.3
	Anglo	63,684	72,385	75,067	74,905	73,645	15.6
	Black	3,653	4,588	4,928	5,076	5,022	37.5
	Hispanic	28,859	35,848	41,231	45,962	50,231	74.1
	Other	1,393	1,830	2,021	2,144	2,216	59.1
Travis	Total	812,280	890,747	939,844	972,082	977,363	20.3
	Anglo	465,317	480,044	479,369	466,876	438,164	5.8
	Black	76,192	83,104	87,599	89,229	87,731	15.1
	Hispanic	229,048	280,455	322,007	362,742	396,198	73.0
	Other	41,723	47,144	50,869	53,235	55,270	32.5
TOTAL	Total	999,796	1,102,418	1,166,596	1,208,213	1,219,105	21.9
	Anglo	583,319	608,320	611,652	599,050	568,157	2.6
	Black	87,716	95,912	101,103	102,985	101,368	15.6
	Hispanic	284,770	348,230	399,877	449,646	490,931	72.4
	Other	43,991	49,956	53,964	56,532	58,649	33.3
State of Texas	Total	20,851,820	22,802,959	24,330,707	25,449,093	26,085,101	25.1
	Anglo	11,074,716	11,331,893	11,381,151	11,171,425	10,733,074	-3.1
	Black	2,421,653	2,627,284	2,771,391	2,823,276	2,796,626	15.5
	Hispanic	6,669,666	8,060,578	9,336,524	10,576,281	11,662,262	74.9
	Other	685,785	783,204	841,641	878,111	893,139	30.2

*Using Zero Migration Scenario (0.0) (suggests slower but steadier growth than occurred during 1990-2000). The zero scenario is a scenario that assumes that immigration and outmigration are equal (i.e., net migration is zero) resulting in growth only through natural increase (the excess or deficit of births relative to deaths). This scenario is commonly used as a base in population projections and is useful in indicating what an area's indigenous growth (growth due only to natural increase) will be over time. Growth through net inmigration and the highest population projection for counties with historical patterns of population decline through net outmigration. In general, this scenario produces the lowest population projection for counties with historical patterns of population growth.

Source: Texas State Data Center 2004.

Table 3.6-4. Migration (Scenario 0.5)* projections of population by race in District HCP Planning Area counties, 2000–2040

County	Race	2000	2010	2020	2030	2040	% Change 2000-2040
Bastrop	Total	57,733	76,195	99,453	127,344	160,017	177
	Anglo	38,169	47,183	56,805	65,702	72,865	91
	Black	5,110	6,065	7,237	8,533	9,860	93
	Hispanic	13,845	22,270	34,667	52,306	76,492	453
	Other	609	677	744	803	800	31
Caldwell	Total	32,194	40,312	50,041	60,192	70,698	120
	Anglo	16,149	18,579	21,249	23,558	25,445	57
	Black	2,761	3,413	4,294	5,220	6,125	122
	Hispanic	13,018	18,010	24,147	31,035	38,732	197
	Other	266	310	351	379	396	49
Hays	Total	97,589	140,173	183,847	230,859	280,076	187
	Anglo	63,684	88,541	111,872	134,519	154,870	143
	Black	3,653	5,120	6,350	7,508	8,372	129
	Hispanic	28,859	44,549	63,279	86,056	113,595	294
	Other	1,393	1,963	2,346	2,776	3,239	132
Travis	Total	812,280	963,894	1,108,849	1,253,626	1,390,858	71
	Anglo	465,317	489,006	495,391	485,142	454,805	-2
	Black	76,192	87,435	97,044	103,514	106,474	40
	Hispanic	229,048	330,195	440,507	567,240	706,120	208
	Other	41,723	57,258	75,907	97,730	123,459	196
TOTAL	Total	999,796	1,220,574	1,442,190	1,672,021	1,901,649	90
	Anglo	583,319	643,309	685,317	708,921	707,985	21
	Black	87,716	102,033	114,925	124,775	130,831	49
	Hispanic	284,770	415,024	562,600	736,637	934,939	228
	Other	43,991	60,208	79,348	101,688	127,894	191
State of Texas	Total	20,851,820	24,330,643	28,005,792	31,830,579	35,761,159	72
	Anglo	11,074,716	11,533,980	11,796,479	11,789,292	11,525,083	4
	Black	2,421,653	2,754,737	3,052,412	3,268,611	3,403,176	41
	Hispanic	6,669,666	9,080,466	11,882,993	15,140,088	18,804,297	182
	Other	685,785	961,460	1,273,908	1,632,588	2,028,603	196

* The One-Half 1990-2000 Migration (0.5) Scenario has been prepared as an approximate average of the zero (0.0) and 1990-2000 (1.0) scenarios. It assumes rates of net migration one-half of those of the 1990s. The reason for including this scenario is that many counties in the State are unlikely to continue to experience the overall levels of relative extensive growth of the 1990s. A scenario which projects rates of population growth that are approximately an average of the zero and the 1990-2000 scenarios is one that suggests slower than 1990-2000 but steady growth. Source: Texas State Data Center 2004.

Two of the TSDC migration scenarios have been presented in Tables 3.6-3 and 3.6-4 for the counties of the HCP Planning Area. According to the TSDC's 0.0 Migration Scenario, Texas' population will continue to become more ethnically diverse between 2000 and 2040. Whereas the Anglo population (composed of White, non-Hispanic origin persons) is projected to decrease by 3.1 percent from 2000 to 2040, the Black or African American population (consisting of Black, non-Hispanic origin persons) is expected to increase by 15.5 percent, the Hispanic population (Hispanics of all races) by 74.9 percent, and the "other" population (composed of other non-Hispanic racial groups) by 30.2 percent. The 0.5 Migration Scenario projects rates of population growth that are approximately an average of the zero and the observed growth between 1990 and 2000 and suggests slower than 1990–2000 growth, but steady growth. This scenario also shows that the HCP Planning Area population will continue to become more ethnically diverse between 2000 and 2040, but population growth rates are much higher, producing a 2040 total population for the HCP Planning Area of 1,901,649.

Projected demographic changes from 2000 to 2040 for the 0.0 Migration Scenario within the counties encompassing the District HCP Planning Area include an increase of 21.9 percent for the total population. Within the four counties, Hays had the highest percent change within the Hispanic population. TSDC has projected an increase of 74.1 percent for the Hispanic population in Hays County. For the 0.5 Migration Scenario, total population changes within the counties encompassing the District HCP Planning Area include an increase of 90 percent. This scenario also shows Hays County as the fastest growing county in the HCP Planning Area, with a total 2000–2040 population growth of 187 percent, or about 2.7 percent per year.

In addition to the TSDC projections noted above, several other local or regional agencies have developed population projections for the Hays, Travis, and Williamson Counties area, including the CAMPO (2004). The CAMPO is the federally designated metropolitan transportation planning organization for Williamson, Travis and Hays counties in Central Texas. CAMPO has been analyzing and forecasting population and employment growth and preparing long-range (+20-year) regional transportation plans since 1973.

The CAMPO Board in their April 2003 meeting approved a 2030 three-county population forecast of 2,750,000 people. The annual growth rate of CAMPO's 2030 forecast **(**2.9%) is lower than both the TSDC's 1.0 scenario growth rates (3.3% and 3.4%) for 2030 and far below the historical rates in the past three decades, which range between 3.9 percent and 4.0 percent. CAMPO and other agency staffs allocated the county level forecasts to 1,074 traffic serial zones (TSZs) for the three forecast years (2007, 2017 and 2030). Various development constraints, growth policies, and growth potentials were considered in the population and employment allocations from the county totals to TSZs. For Travis County, the CAMPO projections indicate a 2030 population of 1,514,000 and for Hays County of 359,000. Although, as noted above, CAMPO has developed projections for smaller geographic units (1,074 traffic serial or assignment zones) they are not included here.

Envision Central Texas (ECT), a regional planning program, used citizen input in developing four possible future patterns of land use. Each pattern is a distinct type that represents clear and consistent choices. Four regional transportation alternatives were developed to accompany the 4 ECT land use alternatives. Using state of the art transportation and land use modeling, the program developed a considerable amount of information about what these four alternative land use futures could mean. The culmination of this process has been the synthesis of all the public input by the ECT Board of Directors into a regional "vision" which is described largely in qualitative terms, but includes the need to accommodate 1.25 million new people in the next 20 to 40 years. This vision, which has been derived from the informed expressions of the desires of the citizens of the region, is intended as a guide, as ECT moves forward in assisting residents, regional planners, and policy makers with voluntary implementation guidelines for working towards this common vision.

The Preferred Option of ECT, which was selected by an unofficial poll of citizens throughout the region with 12,000 responding, favored a concentrated growth pattern within existing built-up areas. Correspondingly, the Preferred Option favored a dramatic reduction in development intensity over sensitive areas such as the Barton Springs watersheds and the Aquifer Recharge Zone in particular.

The City of Austin has recently completed a short-range population forecast within selected postal ZIP Codes (City of Austin 2005e). The purpose of this effort was to establish mid-decade (2005) population and household estimates for the City of Austin by ZIP Code and to generate a short-term population and household forecast for 2010 by ZIP Code. This study concluded that the City grew at an annualized rate of 1.3 percent from 2000 to 2004, well below the City’s average growth rate experienced in the 1990s of 3.5 percent. The pace of population growth is expected to accelerate over the last half of the decade, according to the study, and approach an annualized rate of 2.0 percent.

The study further concluded that overall population growth, from 2000 to 2010, is projected to be greatest in ZIP Code 78748 in south central Austin, with a net gain of more than 10,000 new residents. Over two thousand single-family structures were built within ZIP Code 78748 from 2000 to 2004. The large contributing subdivisions in the area are far from built-out and there is still an abundance of available, developable acreage remaining. The study notes that housing developers within this ZIP Code have been meeting a demand for medium-priced housing. The City's upper-end single-family market continues to be rather soft in most parts of Austin, while the demand for starter homes and medium-priced products has continued to be quite strong. Projected growth rates to 2010 for the zip codes in the District HCP Planning Area range from 1.8 percent per year to 5.7 percent per year (R. Robinson, City of Austin, personal communication 2006).

3.6.4 Population Density

Population density is measured by dividing population by area and is summarized for the HCP Planning Area in Table 3.6-5. Travis County is the densest, with approximately 795 persons per square mile, compared to approximately 144 persons per square mile in Hays County, approximately 64 persons per square mile in Bastrop County, and 59 persons per square mile in the Caldwell County. The average density of the HCP Planning Area counties (225 persons) is higher than the average of the State of Texas (79.6 persons per square mile). Within the four counties encompassing the District HCP Planning Area, 70.9 percent of the population resides in the largest cities in each county.

Another measure of population density is persons per household. These data are available for 1990 and 2000. Analyzing the change in persons per household along with the change in population between 1990 and 2000 provides an indication of whether population density in the District HCP Planning Area is increasing or decreasing In general, population appears to be increasing in the HCP Planning Area, while population density in terms of persons per household appears to remain constant (Table 3.6-6).

Table 3.6-5. Population density in District HCP Planning Area counties, 2000

County	Total Area (sq. mi.)	Population	Density	Largest City in County	City Population	% of County
Bastrop	896	57,733	64.4	Elgin	5,700	9.9
Caldwell	548	32,194	59.0	Lockhart	11,615	36.1
Hays	680	97,589	143.9	San Marcos	34,733	35.6
Travis	1,022	812,280	794.8	Austin	656,562	80.8
State of Texas	262,017	20,851,820	79.6	Houston	1,953,631	9.4*

Sources: U.S. Census Bureau 2000a; Texas Workforce Commission 2005a.
*Percent of Texas.

Table 3.6-6. Population change and persons per household by county in the District HCP Planning Area, 1990-2000

County	1990 Population	1990 Persons per Household	2000 Population	2000 Persons per Household	Population Percent Change 1990-2000
Bastrop	38,263	2.8	57,733	2.8	50.9%
Caldwell	26,392	3.0	32,194	3.0	22.0%
Hays	65,614	3.0	97,589	2.9	48.7%
Travis	576,407	2.4	812,280	2.5	40.9%
State of Texas	16,986,510	2.8	20,851,820	2.8	22.8%

Source: U.S. Census Bureau 2000b.

Within Bastrop and Caldwell counties, persons per household remained constant at 2.8 and 3.0, from 1990 to 2000. Hays County had a slight decrease of 0.1 percent in persons per household between 1990 and 2000 while Travis County had a slight increase of 0.1 percent in persons per household within the same time. All four counties encompassing the HCP Planning Area have experienced population growth with percentages ranging from 22.0 percent in Caldwell County to 50.9 percent in Bastrop County. The District HCP Planning Area has been rapidly urbanizing due to the proximity of Austin, its largest city. In the State of Texas, persons per household remained the same from 1990 to 2000, although the population grew by 22.8 percent during this time period.

3.7 Economy

The District HCP Planning Area maintains a diversified economy that is supported by strong manufacturing, government, trade and service sectors (including a strong tourism industry). The rapid growth of the region's high-technology sector, as well institutions of higher education have boosted the area's economy in the last several decades. Table 3.7-1 summarizes employment by major sectors of the economy for the counties encompassing the District HCP Planning Area. As of January 2005, covered employment and wage data are reported based on the North American Industrial Classification System (NAICS), which has replaced the Standard Industrial Classification System (SIC). Notable changes include increased segmentation of the service sector, the addition of an information sector, and the combination of agriculture, forestry, fishing, hunting, and mining into the Natural Resources and Mining sector.

The counties encompassing the District HCP Planning Area as a whole contained approximately six percent (6.1 percent) of state employment in the first quarter of 2004. A brief summary of the HCP Planning Area's economic resources is included below. Table 3.7-1 presents employment data for each sector by county. These data do not represent the number of employees in each county but the number of jobs in each county. These data differ from the labor force estimates contained in Table 3.7-2, which track the number of people in each county considered eligible to participate in the labor force and whether or not they are employed or unemployed.

The Agriculture Industry segment includes jobs in agricultural production, forestry, commercial fishing, hunting and trapping, and related services including all reported farm and ranch workers, according to the Texas Workforce Commission (TWC). However, TWC estimates that their records include only 47 percent of all agricultural jobs since only reported farm and ranch workers are included (TWC, personal communication 2002).

Table 3.7-3 contains the most recent income and poverty estimates for the counties encompassing the District HCP Planning Area. As of January 2005, Caldwell County contained the largest percentage of persons living below the poverty rate. As noted in Table 3.7-2, Caldwell County had the highest unemployment rate (6.2 percent) among the HCP Planning Area counties.

Generally, those counties in the more populous areas fared better, in terms of poverty estimates, with Travis County containing the smallest percentage of persons living below the poverty rate in the HCP Planning Area in 2000 (12.5 percent). Travis County also contained one of the lowest unemployment rates (4.1 percent) in the HCP Planning Area in 2000 (Table 3.7-2).

Table 3.7-1. Employment by sector for the District HCP Planning Area – 1st quarter, 2004

	Bastrop County		Caldwell County		Hays County		Travis County		Counties in the District HCP Planning Area		State of Texas	
Sector*	Total Emp.	% of Total	Total Emp.	% of Total	Total Emp.	% of Total	Total Emp.	% of Total	Total Emp.	% of Total	Total Emp.	% of Total
Natural Resources & Mining	131	1.2	278	4.1	155	0.4	982	0.2	1,546	0.3	206,940	2.3
Construction	559	4.9	218	3.3	2,488	6.7	24,439	4.8	27,704	4.9	537,342	5.8
Manufacturing	988	8.7	201	3.0	3,300	8.8	45,954	9.1	50,443	9.0	884,571	9.6
Trade, Transportation, & Utilities	2,130	18.8	1,276	19.0	7,563	20.2	78,205	15.5	89,174	15.9	1,901,404	20.7
Information	85	0.7	49	0.7	789	2.1	18,547	3.7	19,470	3.5	227,277	2.5
Financial Activities	477	4.2	217	3.2	1,131	3.0	32,225	6.4	34,050	6.1	409,117	4.4
Prof. & Business Services	393	3.5	327	4.9	2,328	6.2	75,731	15.0	78,779	14.1	1,224,987	13.3
Education & Health Services	1,146	10.1	1,707	25.5	3,527	9.4	47,837	9.5	54,217	9.7	1,031,779	11.2
Leisure & Hospitality	1,207	10.6	543	8.1	4,415	11.8	49,915	9.9	56,080	10.0	853,499	9.3
Other Services	357	3.1	206	3.1	938	2.5	17,463	3.5	18,964	3.4	269,325	2.9
Unclassified	23	0.2	3	0.0	37	0.1	747	0.1	810	0.1	11,188	0.1
Federal Government	384	3.4	57	0.9	171	0.5	9,611	1.9	10,223	1.8	179,552	2.0
State Government	205	1.8	72	1.1	5,332	14.3	58,380	11.6	63,989	11.4	329,196	3.6
Local Government	3,249	28.7	1,547	23.1	5,229	14.0	44,585	8.8	54,610	9.8	1,128,032	12.3
Total Employment	11,334	100.0	6,701	100.0	37,403	100.0	504,621	100.0	560,059	100.0	9,194,249	100.0

Source: Texas Workforce Commission 2005a; Labor Market Information - Covered Employment and Wages.
*As of November 2001, the Texas Workforce Commission reports Covered Employment and Wages according to the North American Industrial Classification System. Notable changes from the previous Standard Industrial Classification (SIC) system include more detailed segmentation of the Services category and the addition of an Information category including establishments that create, disseminate, or provide the means to distribute information (such as technology-based companies). Agriculture, Forestry, Fishing, and Hunting as well as Mining are reported in the Natural Resources and Mining category.

Table 3.7-2. Labor force and unemployment in the counties of the District HCP Planning Area—2000 and 2005*

County	Labor Force		Employed		Unemployed		Unemployment Rate	
	2000	2005	2000	2005	2000	2005	2000	2005
Bastrop	27,642	33,224	26,554	31,361	1,088	1,863	3.9	5.6
Caldwell	14,206	16,057	13,430	15,067	776	990	5.5	6.2
Hays	53,942	63,220	50,563	60,104	3,379	3,116	6.3	4.9
Travis	460,525	499,614	441,691	473,685	18,834	25,929	4.1	5.2
Planning Area Total	556,315	612,115	532,238	580,217	24,077	31,898	4.3	5.2
State of Texas	9,937,150	11,103,726	9,340,963	10,413,977	596,187	689,749	6.9	6.2

* January 2005

Source: Texas Workforce Commission 2005b

Table 3.7-3. Income and poverty estimates in the counties of the District HCP Planning Area

County/Region	Percentage of Persons Living Below Poverty	Estimated Median Household Income
Bastrop	11.6	$43,578
Caldwell	26.1	$36,573
Hays	14.3	$45,006
Travis	12.5	$46,761
State of Texas	15.4	$39,927

Source: U.S. Census Bureau 2000e.

3.7.1 Government

As noted in Table 3.7-1, federal, state, and local governments together employ approximately 23 percent (128,822) of the workforce in the HCP Planning Area. State government employs the largest percentage of workers with 49.7 percent.

3.7.2 Services

Service industries include professional and business services, education and health services, leisure and hospitality, and other services. Service industries provided approximately 37.1 percent of the HCP Planning Area's employment (208,040 jobs) in the first quarter of 2004. The HCP Planning Area and surrounding region are also home to several popular tourist destinations, which contribute to service employment. These include but are not limited to Texas' State Capitol, which was ranked 7th top attraction in Texas in 2004 (Office of the Governor 2004b); the Hill Country; Barton Springs and Zilker Park; Aquarena Springs; and the Tanger and Prime Outlet Malls in San Marcos (ranked fourth top attraction in Texas in 2004).

3.7.3 Trade, Transportation, and Utilities

The trade, transportation and utilities sector made up the largest single percentage of employment with 15.9 percent of the total. Travis County employment in this sector dominated the HCP Planning Area with 78,205 workers, or almost 88 percent of this sector's employment in the HCP Planning Area.

3.7.4 Manufacturing

Manufacturing employment accounted for about nine percent of the jobs in the HCP Planning Area, approximately 50,000 jobs. Major manufacturing facilities in the region are presented in Table 3.7-4. The largest employers are located in Travis County.

Table 3.7-4. Top manufacturing employers in the counties of the District HCP Planning Area, 2005

Company	Type of Business
Dell Computer	Computers
Freescale Semiconductor, Inc.	Semiconductor devices
Advanced Micro Devices Inc.	Semiconductors and other related devices
Motorola	Electronic components
Applied Materials Inc.	Semiconductors and other related devices
IBM Corp.	Computers and software
Hospira	Physician and surgeon's equipment and supplies
3 M Co	Photographic equipment and supplies
National Instruments	Instruments
Solectron Corporation	Printed circuit boards
VRC Industries	Plastics and plastic products
Abbott Laboratories	Pharmaceuticals
BAE Systems	Search, detection, navigation, guidance
Commemorative Brands Inc.	Jewelry, precious metal

Source: Texas Workforce Commission. 2005c: City of Austin 2005f.

3.7.5 Natural Resources and Mining

Natural resources and mining include agriculture, forestry, fishing, hunting, and mining. This sector is a relatively small one in the HCP Planning Area's economy, supplying only 0.3 percent of the area's employment in the first quarter of 2004. Of the counties that comprise the HCP Planning Area, Caldwell County has the largest number of natural resources and mining jobs (4.1 percent) relative to the rest of the counties.

3.7.6 Recreation and Tourism

Tourism is an important, multibillion-dollar industry in the Austin–San Marcos Metropolitan region (Table 3.7-5), and, to a lesser extent, in the District HCP Planning Area. Millions of tourists who visit the area annually are drawn in by the area's rich southwestern cultural heritage and numerous attractions.

Table 3.7-5. Travel and tourism impact for Travis and Hays counties, 2003

County	Total Direct Spending ($000)	Visitor Spending ($000)	Earnings ($000)	Employment (Jobs)	Tax Receipts	
					Local ($000)	State ($000)
Hays	129,300	128,390	34,870	1,650	2,130	8,750
Travis	2,605,940	2,285,450	705,050	31,140	50,540	137,700
Total	2,735,240	2,413,840	739,920	32,790	52,670	146,450

Source: Office of the Governor (2004)

Austin is one of the top tourist destinations in Texas. Located at the center of the State, it is the gateway to the Texas Hill Country and the Highland Lakes. As the state capital—the State Capitol building, an imposing pink granite structure and the largest domed statehouse in the country, commands a stately presence in downtown—and home to the University of Texas, the city supports a politically charged and culturally rich environment. A large and culturally diverse creative population—including musicians, writers and graphic artists—enhances its eclectic nature.

Contribution of Aquifer Springflow at Barton Springs to Eco-tourism and Water-based Recreation

Blessed with a temperate year-round climate and 300 days of sunshine a year, recreation and tourism in Austin is oriented to the outdoors. Barton Springs; Zilker and other parks; Lakes Travis, Austin, Walter Long, and Town Lake; nature and hike-and-bike trails; and wilderness preserves create a strong eco-tourism attraction for the city.

Although difficult to capture in any single employment sector, the recreation and tourism industry in Travis and Hays Counties has an influence on both the trade and service employment sectors of the District HCP Planning Area's economy.

Water-based recreation, primarily swimming and canoeing, associated with the Edwards Aquifer, affects the local trade and service sectors. The Barton Springs Pool, located in Zilker Park, is fed by water naturally discharging from the Barton Springs segment of the Edwards Aquifer (Barton Springs is more fully described in Section 3.3.1.3). Three acres in size, the pool's springwater is on average 70°F year round. Over the years, Barton

Springs Pool has attracted a large and diverse following of people, especially during the hot summer months. Table 3.7-6 presents annual visitor data for the period 2001 through 2004. Annual gross receipts for 2004 were $495,470 (Pedro Patlan Jr., City of Austin, personal communication 2007).

Table 3.7-6. Annual Barton Springs Pool visitors 2001–2004

Year	Visitors
2001	325,592
2002	318,323
2003	338,302
2004	291,686

Source: City of Austin, Parks and Recreation Department, Aquatics Division (2005c)

Several golf courses, either through direct pumping or the purchase of municipal utility or water supply corporation water, are dependent upon the Edwards Aquifer for irrigation water. A large convention industry has developed in the District HCP Planning Area, partly as a result of its water-based recreation opportunities, as well as the diversity of other attractions and activities available in the area.

3.8 Cultural Resources

This section is an assessment of the potential for cultural resources within the vicinity of Barton Springs and Barton Creek, located in Travis County, Texas. Research focused on previously recorded archeological sites, State Archeological Landmarks (SALs), properties listed on the National Register of Historic Places (NRHP), Texas Historical Markers, archeological surveys and other historic properties within 500 feet of the waterways within the District boundary (Texas Archeological Sites Atlas 2005). Background and site study has focused on Barton Springs and the lower portion of Barton Creek as this area is the focus of the HCP. The Area of Potential Effect (APE) for the archeological and historic properties aspect of the HCP begins at the confluence of Barton Creek and Short Spring Branch and extends to the Creek's confluence with the Colorado River. Properties, sites or districts that lie within 500 feet of the waterway are discussed. Water management strategies that will require infrastructure development such as aquifer recharge enhancement projects, pipelines, or pump stations may also impact other cultural resource sites outside the vicinity of the springs. Research was conducted through the Texas Historical Commission's (THC) online Texas Archeological Sites Atlas (2005) and the THC library. Field reports consulted included (1) *An Archeological Survey with Shovel Testing Along Existing and Proposed segments of Zilker Loop Trail, Travis County, Texas* in *Texas Archeological Research Laboratory Technical Series 46*, Austin. (Collins 1996); and (2) *Archeological and Geomorphological Testing along the Proposed South Austin Outfall Relief Main, Phase II Tunnel Alignment: The Vara Daniel Site (41TV1364), Zilker Park, Austin, Texas* (Takac et al. 1992).

3.8.1 Regulatory Compliance

Under 36 CFR 800.1 of the Advisory Council on Historic Preservation (ACHP) regulations pertaining to the protection of historic properties, Section 106 of the National Historic Preservation Act (1992, as amended) requires a Federal Agency Head with jurisdiction over a federal undertaking or one that is federally assisted or federally licensed to take into account the effect that the undertaking will have on properties included in or eligible for listing on the NRHP. The Section 106 process, as defined in 36 CFR 800.4, requires the federal agency to identify and evaluate the significance of historic properties that may be affected by the proposed undertaking, in consultation with the State Historic Preservation Officer (SHPO) and consistent with the Secretary of the Interior's Guidelines and Standards for NRHP evaluation. If the Agency Head and the SHPO agree that a property potentially affected by the undertaking is NRHP eligible, then they shall apply the Criteria of Adverse Effect found in 36 CFR 800.5 to such a property. If an adverse effect is determined, then the federal agency and the SHPO shall seek ways to either avoid the property or minimize the impacts to it, to the fullest possible extent. However, approval of Regional HCPs under section 10(a) of the ESA had been determined by the Service to not represent a federal undertaking with respect to Section 106, to the extent that the plan does not authorize any action that would result in impacts to cultural resources without subsequent project level review.

In pursuit of the above regulatory requirements, an effort will be made to identify and evaluate the significance of historic properties located within the APE for the proposed Barton Springs Edwards Aquifer Conservation District Habitat Conservation Planning Area. At this point in the Section 106 process, archeological sites and historic structures located within the APE have been identified through archival information and available state records. They will next be evaluated with respect to the National Register Criteria of Evaluation in 36 CFR 60.4. Further efforts, and advancement of the Section 106 process, will be conducted in conjunction with the selection and evaluation of alternatives and the information will be presented in the final EIS.

This project also falls under the purview of the Texas Antiquities Code (TAC_2), because it involves archeological sites located "on land owned or controlled by the State of Texas or any city, county, or local municipality thereof." Therefore, the THC Archeology Division, under jurisdiction of the TAC_2, will closely monitor any impacts to these sites as a result of the proposed action. The TAC_2 allows all such properties to be considered as potential SALs and requires that each be examined for their potential significance. Chapter 26 of the THC's Rules of Practice and Procedure for the TAC_2 outlines the standards for determining significance.

3.8.2 Cultural History of Barton Creek and Barton Springs

Archeological investigations indicate that human occupation in the vicinity of Barton Springs and Barton Creek dates to the Paleoindian period and continue to the modern era. The prehistoric background of Barton Creek and Barton Springs parallels that of the overall Central Texas region as a whole. Paleoindian (10,000–8,800 BP) cultures in Central Texas are related to the Great Plains big game hunting traditions in the early phases followed by smaller game during later Paleoindian periods. Artifacts are most often large lanceolate projectile points with minimal plant processing features. Sites attributed to this phase of occupation are relatively rare across the continent but particularly so in this region. One of the earliest sites along Barton Creek and Barton Springs is the Vara Daniel Site, in Zilker Park along the left (north) bank of Barton Creek. This massive, deeply buried archeological site contains occupational deposits that date to this rare Paleoindian period (10,000 BP) with an additional, substantial Archaic period occupation. Archaic period (8,800 BP–AD 600, subdivided into Early, Middle and Late I and II Phases) sites in Central Texas are dramatically more numerous. During this period, subsistence shifted toward an increased reliance on plants and plant processing. Burned rock hearths and middens (stone ovens used for plant processing) are typical of this period. Hunters still relied on large projectile points as the bow and arrow was not in use up to this point. Several of the sites are attributed to the Archaic period. Beyond the Archaic period, the Late Prehistoric (600–1600 AD) period is marked by the replacement of the dart and atlatl with the bow and arrow, reflected in a shift from large dart points to smaller, lighter arrow points. Later technology includes pottery. A number of sites along portions of Barton Creek are attributed to this phase of occupation.

During the Historic Era, the Barton Creek and Springs area underwent dramatic changes. First the Tonkawa and Comanche, who camped along the banks through the 18th century, were replaced by Spanish settlers, who commented on the site's beauty. Shortly thereafter, Anglo-Americans moved into the area and established home sites, mills and ranches. The creek itself was named for one of these settlers, a William Barton, who moved to the area in 1837. Some of the earliest Anglo occupations of the Barton Creek/Springs area are the Gail Rabb House Site and the Andrew Cox Ranch. The Barton Springs gained local and regional prominence beginning around the turn of the century, being called "Austin's Eden" in the 1880s. The famed swimming hole was built into a more modern pool in the 1930s and continues to be a top recreational attraction to this day.

A detailed discussion of existing archeological surveys, and recorded archeological sites in the vicinity of Barton Springs and the lower portion of Barton Creek including sites that are listed or are candidates for listing on the NRHP or as SALs is provided in Appendix G, Cultural Resources.

3.9 Air Quality

To adequately depict the baseline air quality characteristics of the District HCP Planning Area, several distinct data sets must be collected and evaluated. The ability of the atmosphere to cleanse itself from the accumulation of pollutants must be determined by evaluating the region's dispersal characteristics. Those data, which quantify the levels of pollutants in the HCP Planning Area's atmosphere, must be examined and the region's regulatory compliance status established. The following subsections provide the data and analyses necessary to adequately characterize the HCP Planning Area's air quality.

3.9.1 Pollutant Dispersion Characteristics

The topography of the District HCP Planning Area is predominately composed of rolling terrain located in the central Texas Edwards Plateau region, which is primarily devoted to ranching operations. There are no significant canyons or severe topographic features which would tend to limit the dispersal or channel the flow of airborne pollutants.

Thermal and mechanical turbulence in the atmosphere affect the dispersal of air pollutants. The mixing layer is the layer of air next to the earth's surface through which relatively vigorous mixing occurs. The mixing height and mean wind speed of this layer determine the volume into which pollutants will eventually be mixed. Low night time mixing heights and light wind speeds decrease dilution of regional pollutant emissions and can trap pollutant plumes near the surface. Higher mixing heights typically occurring during the day and stronger transport wind speeds will generally increase dilution and dispersal of emissions and result in lesser impacts of pollutants on air quality. Throughout the year, Central Texas experiences better than average mixing height conditions. The HCP Planning Area typically experiences good to excellent dispersion characteristics.

3.9.2 Regional Compliance Standards

The Clean Air Act (CAA), which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. There are two types of standards, primary and secondary. Primary standards protect against adverse health effects; secondary standards protect against welfare effects, such as damage to crops and vegetation and damage to buildings. The six principal pollutants or "criteria" pollutants addressed in the NAAQS are carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), particulate matter (PM_{10}, $PM_{2.5}$), and sulfur dioxide (SO_2). The criteria pollutants and their respective averaging periods, standard values, and standard type(s) are listed in Table 3.9-1.

Table 3.9-1. National ambient air quality standards

Pollutant	Standard Value	Standard Type
Carbon Monoxide (CO)		
8-hour Average	9.5 ppm	Primary & Secondary
1-hour Average	35.5 ppm	Primary & Secondary
Nitrogen Dioxide (NO_2)		
Annual Arithmetic Mean	54 ppb	Primary & Secondary
Ozone (O_3)		
8-hour Average	85 ppb	Primary & Secondary
Lead (Pb)		
Quarterly Average	1.55 µg/m^3	Primary & Secondary
Particulate (PM_{10}) Particles with diameters of 10 micrometers or less		
24-hour Average	155 µg/m^3	Primary & Secondary
Particulate ($PM_{2.5}$) Particles with diameters of 2.5 micrometers or less		
Annual Arithmetic Mean	15.1 µg/m^3	Primary & Secondary
24-hour Average	35 µg/m^3	Primary & Secondary
Sulfur Dioxide (SO_2)		
Annual Arithmetic Mean	35 ppb	Primary
24-hour Average	145 ppb	Primary
3-hour Average	550 ppb	Secondary

ppm = parts per million
ppb = parts per billion
µg/m^3 = micrograms per cubic meter
Source: TCEQ 2005b.

If measured levels of the pollutants listed in Table 3.9-1 are higher than what is considered acceptable by EPA (the standards listed in Table 3.9-1), then the area and adjacent contributing areas are designated "non-attainment areas." Non-attainment areas must meet certain CAA requirements, such as:

- **Transportation Conformity** - Requires a demonstration that regional long-range transportation plans will not negatively impact air quality, or federal transportation funds can be withheld;
- **New Source Review** - Requires a review of new or expanded industrial operations to minimize air pollution;
- **Rate of Progress Requirements** - A certain percentage of pollutants must be reduced each year;
- **Specific Attainment Date -** Consequences of failure to reach attainment by the specified date include stricter control measures and the potential for stiff penalties; and,
- **10-year Maintenance Plan -** Includes additional or continuing mandatory programs for 10 years following attainment.

Another requirement obligates the state to develop and implement a prescriptive comprehensive clean air plan that mandates how the area will come into compliance with the standard. This plan and any revisions to it are known as the State Implementation Plan (SIP).

If the criteria pollutant levels meet the national primary or secondary ambient air quality standards, then the region is classified as "attainment." An area can also have an "unclassifiable" designation which is defined as an area that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standard for the pollutant. An unclassifiable designation implies attainment and therefore no restrictions are applied.

Air quality within the HCP Planning Area and surrounding region is generally good to excellent. The HCP Planning Area is located within the TCEQ Office of Air Quality Region 11 (Austin Region). This region is considered to be in attainment or unclassifiable with respect to each of the National Ambient Air Quality Standards.

On July 16, 1997, EPA issued revised air quality standards for particulate matter ($PM_{2.5}$) and ozone (8-hour), which are more restrictive than the former NAAQS standards for the respective pollutants. On June 15, 2005, the 1-hour ozone standard was revoked for all areas except the 8-hour ozone non-attainment Early Action Compact (EAC) areas (those that do not yet have an effective date for their 8-hour designations). Within Texas, the 1-hour ozone standard applies only to the San Antonio MSA EAC area which does not include the District HCP Planning Area.

Within the District HCP Planning Area, the EPA 8-hour ozone standard applies. Ozone monitored levels are considered by the EPA to be "unhealthful" and exceed the NAAQS when they are measured at 85 ppb or higher under the eight-hour standard. To attain the standard and remain in compliance, the three-year average of the fourth-highest daily maximum 8-hour average ozone concentration measured at each monitored area over each year must not exceed 85 ppb. Based on data collected through 2006, Travis County and the Austin Area MSA recorded exceedances of the new 8-hour ozone standard on several occasions. All other counties within the District HCP Planning Area continued to be designated in attainment of all NAAQS standards.

The EPA designated 8-hour ozone nonattainment areas in April 2004. Some of these areas, including the Austin Area MSA, are participating in EACs. EACs are formal agreements among counties, EPA, and the TCEQ whereby counties agree to develop comprehensive, enforceable air quality plans to attain and maintain compliance with the 8-hour ozone standard earlier than would otherwise be required. In exchange for their effort, the effective date of the 8-hour ozone nonattainment designation will be deferred as long as the counties meet agreed upon milestones. Specifically for the Austin MSA and Travis County, including parts of the HCP Planning Area, the EAC commits the region to developing and implementing a local Clean Air Action Plan (CAAP) in accordance with the following milestones:

- June 16, 2003 - Potential local emission reduction strategies identified and described;
- December 31, 2003 - Local emission reduction strategies selected;

- January 31, 2004 - Submission of preliminary CAAP to TCEQ and EPA;
- March 31, 2004 - Submission of final CAAP to TCEQ and EPA;
- December 31, 2004 - CAAP incorporated into the SIP; SIP adopted by TCEQ;
- December 31, 2005 - EAC emission reduction strategies must be implemented;
- December 31, 2007 - Attainment of the 8-hour standard; and,
- 2008 - EPA re-designates area as attainment, with no further requirements.

Should the Austin Area MSA miss an EAC milestone at any time during the agreement, including attaining the 8-hour standard by 2007, it will forfeit its participation and rejoin the 8-hour nonattainment implementation process in progress, and will be subject to the same requirements and deadlines which would have been effective had it not participated in this program, with no delays or exemptions from EPA rules.

3.9.3 Relevant Pollutant Data

TCEQ has monitored airborne pollutants in the Edwards Aquifer region using both continuous and non-continuous methods for over 20 years. This long-term monitoring of the area's ambient air provides a basis for quantifying the level of pollutants, which have been introduced into the atmosphere by stationary sources (i.e., industrial activity), mobile sources (i.e., cars, trucks, buses), area sources (i.e., lawn maintenance, home furnaces, water heaters), and natural phenomenon (i.e., dust storms). The pollutants monitored in the HCP Planning Area include O_3, inhalable particulate matter (PM 2.5), and CO. Tables 3.9-2 through 3.9-4, show these HCP Planning Area baseline data including highest values and second highest values for $PM_{2.5}$ and fourth highest for O_3 for the collection sites for the 2004 through 2006 time period. The data show that there have been no violations of regulatory standards within the HCP Planning Area during the monitored period.

Table 3.9-2. Ambient ozone monitoring summary for the nearest TCEQ sites, 2004-2006

Site	Year	High 8-hr (ppb)	Exceedance Days	Fourth Highest 8-hr (ppb)	Exceedance Days
Austin/San Marcos MSA	2004	92	4	82	0
	2005	88	3	82	0
	2006	91	6	83	0

Source: TCEQ 2005c
ppb = parts per billion
Non-attainment occurs only if the 3-year average of 4^{th} highest value exceeds the standard

Table 3.9-3. Ambient PM 2.5 summary for the nearest TCEQ sites, 2004-2006

Site	Site No.	Year	24-hr Max. (µg/m^3)	2nd Highest 24-hr (µg/m^3)	Exceedance Days
Austin Northwest	484530014	2004	50.64	50.49	0
CAMS 3		2005	39.73	37.08	0
		2006	46.43	45.39	0

Source: TCEQ 2005d
µg/m^3 = micrograms per cubic meter

Table 3.9-4. Ambient carbon monoxide summary for the nearest TCEQ sites, 2004-2006

Site	Year	High 1-hr (ppm)	Exceedance Days	High 8-hr (ppm)	Exceedance Days
Austin Northwest	2004	1.2	0	0.7	0
CAMS 3	2005	1.0	0	0.6	0
Site No. 484530014	2006	0.8	0	0.5	0

Source: TCEQ 2005d
ppm = parts per million

3.9.4 Prescribed Burning

The primary instance in which water management operations would be expected to influence air quality is with regard to prescribed burning for rangeland management. As the state regulatory agency charged with safeguarding air quality, the TCEQ regulates virtually all outdoor burning activities, including prescribed burning under 30 TAC Section 111.211(1). Prescribed burns are defined as burning operations used for the management of forests, rangeland, wildland and wildlife, and coastal salt-marsh areas. These operations are subject to the general requirements for allowed burning which were designed to reduce the likelihood that burning activities will create a nuisance, cause a hazard, or harm the environment. The general requirements are contained in the TCEQ's Local Government Guide to the TCEQ—Chapter 22, Outdoor Burning. The TCEQ delegates primary responsibility for administering outdoor burning activities to the local regional offices. The TCEQ regional office responsible for outdoor burning activities including prescribed burning within the District HCP Planning Area is the Austin Region (Bastrop, Caldwell, Hays, and Travis Counties). The designated TCEQ regional office must be contacted prior to any prescribed brush burning activities associated with water management operations. It should be noted that prescribed burning is not a proposed measure in the District HCP.

Chapter 4
Environmental Consequences

This chapter describes the environmental effects of each of the three PDEIS alternatives on specific components of the natural and human environment within the District HCP Planning Area. A detailed description of each alternative is provided in Section 2.3. Each alternative comprises a number of specific measures grouped into five broad categories that correspond with the numerically designated categories listed in Table 2.3-1:

1.0 Measures Undertaken During All Conditions;
2.0 Additional Measures Employed after Declaring Alarm Stage Drought;
3.0 Additional Measures Employed after Declaring Critical Stage Drought;
4.0 Structural Mitigation Investigations and Measures; and
5.0 Adaptive Management Strategies.

Specific measures listed for each of the three alternatives also correspond with numerical designations shown in Table 2.3-1. This chapter describes environmental effects of the measures included in each alternative. Discussion of environmental effects of each alternative may be limited to a specific alternative measure or group of measures; if so, the specific measure is identified herein.

A brief synopsis of each alternative is provided below which can be used to assist comparisons of the environmental consequences between the alternatives on major components of the environment.[1]

Alternative 1: No Action

Alternative 1 (No Action) includes management of the Barton Springs segment of the Edwards Aquifer consistent with the District's adopted Groundwater Management Plan

[1]The Proposed Action (the DHCP) is contained in Chapter 6 of the PDEIS documentation. After the three alternatives were developed and evaluated as described in the PDEIS documentation, the proposed DHCP measures were then refined and developed in greater detail over the course of several more months, culminating in the completion of the DHCP (see Chapter 6).

(BSEACD 2003) and programs as set out in its rules as mandated by Chapter 36 of the Texas Water Code, but without a section 10(a) ITP and associated HCP. Under Alternative 1, springflow would not be assured during periods of high pumping and low aquifer recharge.

Because there would be no ITP, no HCP would be implemented resulting in no mitigation measures to lessen overall impacts to affected endangered species.

Alternative 1 includes implementation of six ongoing/continuing demand reduction measures (Measures 1.2.1 through 1.2.5 and Measure 1.2.7), two measures to address ongoing/continuing water supply enhancement measures (Measures 1.3.1 and 1.3.2), one measure for ongoing/continuing water supply conversion (Measure 1.4.2), three measures to address an Alarm Stage Drought declaration (Measures 2.1 through 2.3), and one measure (Measure 3.1) to address Critical Stage Drought. Under Alternative 1, an Emergency Response Period will be declared at the discretion of the District Board. Alternative 1 does not include any measures to ameliorate extreme drought conditions (Measures under 4.0) nor does it include any adaptive management strategies (Measures under 5.0).

Although Alternative 1 does not include regulatory-based withdrawal limits on Edwards Aquifer "Pumpage under Permit" in the District, the combined effect of future issuance of conditional permits and the inability of the aquifer to sustain unlimited pumping would result in projected permitted pumpage ranging from 13 to 16 cfs.

Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Alternative 2 includes a regional ITP and HCP that includes the best practicable and attainable measures to protect the Barton Springs and Austin blind salamanders in consideration of cost, regulatory constraints, and political realities. Alternative 2 includes implementation of regulatory-based withdrawal limits on Edwards Aquifer "Pumpage under Permit" in the District that would limit permitted pumpage to within a range of 10 to 13 cfs (Measure 1.1), ten ongoing/continuing demand reduction measures (Measures 1.2.1 through 1.2.10), four ongoing/continuing measures to enhance water supply (Measures 1.3.1 through 1.3.4), five measures to encourage water supply conversion (Measures 1.4.1 through 1.4.5), four measures to be employed during declared Alarm Stage Drought (Measures 2.1 through 2.4), five measures to be implemented during Critical Stage Drought (Measures 3.1, 3.3, 3.4, 3.5 and 3.6), two structural mitigation feasibility investigations (Measures 4.1 and 4.6), and six adaptive management strategies (Measures 5.1 through 5.6).

Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Alternative 3 provides measures that would maximize the protection of the species but with the highest capital and operating costs and increased uncertainty in obtaining required legislative authorization or approval by other entities for implementation. Under this alternative, permitted pumpage would be subject to regulatory-based withdrawals within a range of 7 to 10 cfs (Measure 1.1) and implementation of ten continuing demand reduction measures (Measures 1.2.1 through 1.2.10). Additionally, four water supply enhancement measures are included (Measures 1.3.1 through 1.3.4), five measures to encourage conversion from groundwater use to surface water (Measures 1.4.1 through 1.4.5), four measures to be employed during Alarm Stage Drought (Measures 2.1 through 2.4), and six measures to be implemented during Critical Stage Drought (Measures 3.1 through 3.6). Additionally, seven structural mitigation measures have been identified as contingency measures during emergencies (Measures 4.1 through 4.7), and six adaptive management strategies would be pursued (Measures 5.1 through 5.6).

4.1 Physical Environment

This section describes direct impacts of each of the three PDEIS alternatives on the climate, geology, and soils within the HCP Planning Area.

4.1.1 Climate

None of the PDEIS alternatives are expected to produce any appreciable effects to the climate of the HCP Planning Area. Precipitation enhancement (i.e., cloud-seeding) has been identified as a possible source of additional water in the Region L Regional Water Plan (HDR 2000) and is being investigated and evaluated for the southern portion of the Edwards Aquifer. This measure is not being considered for the Barton Springs Segment and is not included in the District HCP, as the geographic size of the District is too small to consider using this option. Effects to climate resulting from the employment of weather enhancement and/or modification over the southern segment of the Edwards Aquifer are anticipated to be localized and of short duration, and would not affect climate within the HCP Planning Area. Although regional temperatures are expected to increase by several degrees over the next fifty years (see Section 3.1.1 in Chapter 3) as a result of global warming, none of the measures in the three PDEIS alternatives are expected to have any influence on the expected warming over the southern Great Plains, including the HCP Planning Area.

4.1.2 Geology

Long-term processes formed the geologic structure of the Edwards and Trinity Aquifers. There should be no effects to the geology of either of the aquifers from any of the alternatives. Potential effects to groundwater are discussed in Section 4.2.3 Groundwater.

4.1.3 Soils

4.1.3.1 Alternative 1: No Action

Erosion Potential near Barton Springs

Erosion effects from Alternative 1 on soils near Barton Springs are expected to be minimal. Existing soils exhibit only a slight to moderate potential for water erosion (USDA 1974, 1978, 1984).

Changes in Regional Soil Conditions

Regional effects to soils resulting from the measures incorporated under Alternative 1 are expected to be minimal. Pumping from the aquifer to sustain irrigation for crop production is not extensively practiced in the HCP Planning Area. Both agricultural irrigation and lawn watering are expected to decline in response to measures under all of the alternatives. A reduction in irrigation could result in a decrease in soil moisture, increasing the potential for wind erosion. However, soil residues from crops and or mowed yard clippings not removed as waste material help to regulate soil moisture, which decreases the potential for wind erosion. Increases in irrigation using wastewater effluent are expected with suburban development. This will increase soil moisture within the localized areas being irrigated. Flows of creeks and streams in the HCP Planning Area are not expected to change substantially by measures implemented under Alternative 1. Although erosion and sediment runoff into creeks is occurring in all of the watersheds within the HCP Planning Area, causes of this erosion and sedimentation are attributed to increased stormwater runoff from urban and suburban development (Naismith Engineering 2005; City of Austin 1990). Effects of Alternative 1 measures are not expected to substantially change the rate of erosion within the watersheds.

4.1.3.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Erosion Potential near Barton Springs

Although slightly higher springflows are expected under Alternative 2 than Alternative 1, particularly in dryer years, flow conditions that would create soil erosion near Barton Springs would not be substantially changed. Therefore, erosion effects from measures under Alternative 2 on soils near Barton Springs are expected to be minimal, similar to Alternative 1.

Changes in Regional Soil Conditions

Effects of measures under Alternative 2 on agricultural irrigation would be similar to Alternative 1. Erosion processes would be most heavily influenced during heavy rainfall events that would not be greatly affected by measures under Alternative 2. Consequently, effects of Alternative 2 on regional soils would be minimal, similar to Alternative 1.

4.1.3.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Erosion Potential near Barton Springs

Although measures under Alternative 3 would result in higher flows discharged from Barton Springs during dryer conditions than Alternatives 1 and 2, the volume of flow would not be substantial enough to change erosional processes. Consequently, effects of measures under Alternative 3 on soils near Barton Springs are expected to be minimal, similar to Alternatives 1 and 2.

Changes in Regional Soil Conditions

Effects to soils resulting from measures under Alternative 3 are similar to the effects described in Alternatives 1 and 2.

4.2 Water Resources

4.2.1 Surface Water

Environmental consequences to surface water resources occurring within the HCP Planning Area identified in Chapter 3, Affected Environment, are described in this section for each of the three PDEIS alternatives.

4.2.1.1 Alternative 1: No Action

The Alternative 1, No Action, measures would not substantially affect surface water resources within the HCP Planning Area except for Barton Springs Pool and lower Barton Creek which are directly affected by the discharge of Barton Springs. Impacts of Alternative 1 on springflow are discussed in Section 4.2.4. The demand reduction measures are expected to increase springflow and would contribute to slightly higher surface water flows in Barton Creek below the springs and in the Colorado River below the confluence with Barton Creek. Ongoing/continuing water supply enhancement

Measure 1.3.1 (development of recharge enhancement impoundments) could adversely affect flows of creeks below the impoundment structures, particularly during periods of low rainfall. Although these structures would only impound water for a few days or weeks following storm events allowing water to flow down into the recharge zone through sinkholes, cracks, and fissures, the water diverted for aquifer recharge would no longer be available for downstream flows. Construction of recharge enhancement structures may be restricted by prior water rights claims and associated water rights permitting. No structural mitigation investigations or measures (Measures 4.0) or adaptive management strategies (Measures 5.0) are identified under Alternative 1. Effects of Alternative 1 to creeks and streams within the HCP Planning Area not affected by surface water recharge enhancement or other water detention structures would be minimal to low.

4.2.1.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

The effects of all the measures described under Alternative 1 on surface water would be similar for the same measures included under Alternative 2. If proven feasible and supported by statutory authorization, implementation of additional measures under Alternative 2 would result in more water available to the aquifer with correspondingly more water available for springflow than Alternative 1, with corresponding higher surface flow available to Barton Springs Pool, lower Barton Creek, and the Colorado River below its confluence with Barton Creek.

Recharge enhancement structures (Measure 1.3.1) could adversely reduce flows in those stream segments directly downstream of the recharge impoundment structures. This adverse effect could be compounded by development of surface water supplies (Measure 1.4), if on-channel or off-channel surface water impoundments are built in watersheds within the HCP Planning Area that would hold back additional water within stream drainages, further reducing instream flows. However, positive effects of Measure 1.4 are also possible, if water management strategies are implemented that are designed to discharge surface water from sources outside the HCP Planning Area into creeks to augment use of groundwater by users downstream or to provide additional recharge to the aquifer.

In summary, environmental consequences of Alternative 2 to surface water throughout the six watersheds in the HCP Planning Area would be similar to Alternative 1, except for Barton Springs Pool, lower Barton Creek, and the Colorado River, where flows would be potentially higher.

4.2.1.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

The effects of all the measures described for Alternatives 1 and 2 on surface water would be similar for the same measures under Alternative 3. All of the additional measures in Alternative 3 not included in Alternative 2, if proven feasible and supported by statutory authorization, would have the effect of making more groundwater available to the aquifer and to springflow than Alternative 2. This would result in potentially more stream flow through Barton Springs Pool, lower Barton Creek, and the Colorado River than either Alternatives 1 or 2.

In summary, environmental consequences of Alternative 3 to surface water flows throughout the six creek watersheds in the HCP Planning Area would be similar to Alternative 2, except for Barton Springs Pool, lower Barton Creek, and the Colorado River, where flows would be potentially higher.

4.2.2 Surface Water Quality

This section describes effects of the three PDEIS alternatives on surface water quality within the District’s HCP Planning Area. Surface water quality is the capacity of surface water to meet standards of use according to established criteria involving levels of suspended or dissolved solids, oxygen demanding substances, nutrients (principally nitrogen and phosphorus), pathogens, petroleum hydrocarbons, synthetic organic compounds, metals, and physical parameters including dissolved oxygen, water temperature, conductivity (a measure of salinity), and pH.

4.2.2.1 Alternative 1: No Action

Lower Barton Creek

Water quality in lower Barton Creek is directly influenced by the amount of flow resulting from runoff contributions in the Barton Creek watershed in combination with aquifer discharge through Barton Springs.

In years of average to above average rainfall, effects of measures under Alternative 1 on the quality of water in lower Barton Creek would be determined by the combination of groundwater discharged by Barton Springs in addition to water contributed by Barton Creek and its associated watershed. Resulting water quality would be highly variable depending on the frequency of rainfall events. It is likely that water quality will continue to be degraded by non-point-source contaminants and sedimentation immediately after rainfall events. Influences of the higher quality groundwater discharged by Barton Springs would be diminished by the additional flows (including flood flows) contributed by upper Barton Creek. In years of below average rainfall, the quality of water in lower

Barton Creek would be directly affected by springflow as influenced by aquifer management strategies under Alternative 1. During low flow conditions water quality would decline with resulting higher water temperature and lower dissolved oxygen levels. Demand reduction and recharge enhancement measures in Alternative 1 (Measures 1.2 and 1.3) would increase the springflow contribution to lower Barton Creek, providing for dilution of lower quality flows from the upper reaches of the creek and improving water quality below the springs.

Other Creeks

The placement of aquifer recharge enhancement structures or detention ponds on creeks over the recharge zone (Measure 1.3.1) would have positive effects on water quality downstream by trapping point-source and non-point-source contamination, but this benefit could be offset by potential contamination of recharge at or above the structures, by lower stream flows occurring immediately below the recharge structures, or by failure of the structures to perform because of construction deficiencies or lack of maintenance.

No impacts would occur to the quality of surface water from structural mitigation strategies (Measures 4.0) or adaptive management strategies (Measures 5), because none are identified under Alternative 1.

In summary, effects of measures of Alternative 1 on water quality in other creeks within the HCP Planning Area are expected to be minimal.

4.2.2.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Lower Barton Creek

In years of average to above average rainfall, effects of measures under Alternative 2 on surface water quality in lower Barton Creek would be similar to Alternative 1, as effects of Barton Springs discharge would be diminished by the additional flows (including flood flows) contributed by upper Barton Creek. In years of below average rainfall, the quality of water in lower Barton Creek would be directly affected by springflow as influenced by aquifer management strategies that would increase springflows (Measures 1.1, 1.2, 1.3 and 1.4) under Alternative 2. As Alternative 2 would result in potentially higher springflow, the quality of water in lower Barton Creek is expected to be higher than Alternative 1 under similar rainfall conditions.

Other Creeks

Effects of Alternative 2 Measure 1.2.9 (development of water conservation plans and model ordinances to address water quantity and quality), Measure 1.3.1 (construction of recharge enhancement features, e.g., detention ponds over the recharge zone), Measure 1.3.3 (acquisition of undeveloped open space), and Measure 1.4.1 (development of surface water supplies) would positively benefit surface water quality in creeks and streams in the HCP Planning Area. On-channel reservoirs or impoundments would filter sediment and pollutants, thus increasing water quality downstream of the structures. However, these positive benefits could be lessened by reduced flows resulting from the on-channel impoundments. Acquisition and preservation of undeveloped open space would moderate the increase in impervious cover that has been shown to contribute to water quality degradation, while also providing a protection buffer between developed areas and sensitive stream corridors.

With implementation of on-channel recharge structures (Measure 1.3.1), model ordinances to protect water quality from development (Measure 1.2.9), and acquisition of open space under Measure 1.3.3 (the latter two measures are not included under Alternative 1), the beneficial effects of Alternative 2 on surface water quality in other creeks in the HCP Planning Area would be somewhat higher than Alternative 1.

4.2.2.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Lower Barton Creek

Measures under Alternative 3 providing a lower pumpage under permit relative to Alternatives 1 or 2 (Measure 1.1), water supply enhancement (Measures 1.3), and water supply conversion (Measures 1.4) would provide potentially more springflow and therefore higher water quality under similar rainfall conditions than either Alternative 1 or 2. In years of average to above average rainfall, effects of measures under Alternative 3 on water quality would be minimal, similar to Alternatives 1 and 2, as effects of Barton Springs discharge would be diminished by the additional flows (including flood flows) contributed by upper Barton Creek. In years of below average rainfall, the quality of water in lower Barton Creek would be directly affected by springflow as influenced by aquifer management strategies under Alternative 3, which would support higher springflows than either Alternative 1 or 2.

Other Creeks

Alternative 3 contains similar measures as Alternative 2 that would enhance the quality of surface water within the HCP Planning Area. As with Alternative 2, these measures could positively benefit surface water quality in creeks and streams in the HCP Planning Area. Construction of on-channel reservoirs or impoundments would filter sediment and pollutants, thus increasing water quality downstream of the structures. These positive benefits could be lessened by reduced stream flows below the on-channel impoundments. Acquisition and preservation of undeveloped open space would moderate the increase in impervious cover that has been shown to contribute to water quality degradation, while also providing a protection buffer between developed areas and stream zones.

If proven feasible and supported by statutory authorization, measures providing for a higher level of development restrictions, implementation of on-channel recharge structures, and acquisition of open space under Alternative 3 would have more positive effects on surface water quality in other creeks in the HCP Planning Area than Alternatives 1 and 2.

4.2.3 Groundwater

4.2.3.1 Aquifer Water Balance and Net Gains in Water Availability to Springflow from Aquifer Management Strategies

This section describes effects of aquifer management strategies under each of the three alternatives on projected pumpage and resulting gains in water availability to the aquifer and resulting springflow. The fundamental purpose of the alternative groundwater management strategies is to beneficially affect groundwater quantity (flow) and quality by restricting "permitted pumpage" (i.e., groundwater withdrawals authorized by the District under an issued permit) to the extent required to preserve existing uses. Gains in water available to the aquifer and the resulting increase in springflow from measures under each of the three alternatives (Table 2.3-1) were estimated by the District using aquifer water balance calculations (BSEACD 2006, Appendix H). These gains, reflected as changes in flow during extreme drought, are summarized in Table 4.2-1. These data were used to estimate and compare daily springflow values over the period of record for each alternative (Section 4.2.4, Aquifer-fed Springs). Effects of changes in springflow to biological resources are described in Section 4.4.

Table 4.2-1. Estimated gains in groundwater available to the Barton Springs segment of the Edwards Aquifer and resulting springflow from water management strategies identified in each of the three PDEIS alternatives

Aquifer Management Strategies	Gain in Water and Resulting Springflow (cfs)		
	Alternative 1	Alternative 2	Alternative 3
Non-drought Measures 1.0			
Non-drought Demand Reduction Measures 1.1, 1.2.1 – 1.2.10	0.5	1.2	1.7
Non-drought Supply Enhancement Measures 1.3.1-1.3.6	0.4	0.8	1.8
Non-drought Source Conversion Measures 1.4.1-1.4.5	0.3	0.8	1.3
Subtotal Water Gain Available from Non-drought Measures	1.2	2.8	5.8
Alarm Drought Measures 2.0 or	2.0	2.8	3.8
Critical Drought Measures 3.0	2.8	4.2	5.3
Subtotal Water Gain Available from Drought Measures	2.8	4.2	5.3

Table 4.2-1. Estimated gains in groundwater available to the Barton Springs segment of the Edwards Aquifer and resulting springflow from water management strategies identified in each of the three PDEIS alternatives (continued)

Aquifer Management Strategies	Gain in Water and Resulting Springflow (cfs)		
	Alternative 1	Alternative 2	Alternative 3
Subtotal Water Gain Available from Drought Measures	2.8	4.2	5.3
Net Gain from All Water Management Strategies Under Each Alternative	4.0	7.0	11.1

NOTE: Gains were estimated by District staff based on professional judgment, experience, and factors that led to noncompliance by permittees. Values represent the averages of the inputs from three, two -person teams of professional groundwater specialists independently judging the likely minimum effective change in water withdrawals during average aquifer conditions caused by the set of activities included under each alternative. The evaluation also assumes all of the Alternative 3 measures are feasible and will be supported by statutory authorization. These changes were independently peer reviewed for reasonableness by professional staff from another groundwater management organization.

Alternative 1: No Action

Implementation of measures identified under Alternative 1 would result in an estimated gain in available water volume to the aquifer that would correspond to an increase in flow from Barton Springs of approximately 1.2 cfs during non-drought conditions with an additional 2.8 cfs gained during critical drought. The total gain in water to the aquifer that would be anticipated under Alternative 1 corresponds to an increase in Barton Springs flow of approximately 4 cfs, assuming that permitted pumpage is within a range from 13 to 16 cfs with an annual growth rate of 3.5 percent (see Appendix H).

Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Implementation of measures identified under Alternative 2 would result in an estimated gain to the aquifer that would correspond to an increase in flow from Barton Springs of approximately 2.8 cfs during non-drought conditions with an additional 4.2 cfs gained during critical drought. The total gain in water available to the aquifer that would be anticipated under Alternative 2 corresponds to an increase in Barton Springs flow of approximately 7 cfs, assuming that permitted pumpage is within a range from 10 to 13 cfs (see Appendix H).

Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Implementation of measures identified under Alternative 3 would result in an estimated gain to the aquifer that would correspond to an increase in flow from Barton Springs of approximately 5.8 cfs during non-drought conditions with an additional 5.3 cfs gained during critical drought. The total gain in water available to the aquifer that would be anticipated under Alternative 3 corresponds to an increase in Barton Springs flow of approximately 11.1 cfs, assuming that permitted pumpage is within a range from 7 to 10 cfs (see Appendix H).

4.2.3.2 Groundwater Quality

Impacts of the three PDEIS alternatives on important groundwater quality parameters are discussed in this section. The quality of water discharged at Barton Springs is generally higher than the quality of water in the creeks that recharge the aquifer (Slade et al. 1986). While the quality of water discharged has historically been good, ongoing water sampling studies by the City of Austin (2005h) indicate a long-term gradual decline in water quality involving decreased DO with increases in turbidity, sedimentation, salinity (total dissolved solids), alkalinity, nutrients involving nitrates and nitrites, and fecal coliform. Additionally, pesticides involving polycyclic aromatic hydrocarbons have been detected in the aquifer and at Barton Springs (USFWS 2005b). The overall decline in water quality is generally attributed to the following anthropogenic influences regarded as continuing future threats (Naismith Engineering 2005): urbanization; long-term groundwater withdrawal exceeding recharge; point-source discharges, including domestic wastewater collection, treatment, and discharge; stormwater/non-point-source pollution; lack of water quality protection measures on existing development; failure to implement/enforce existing regulations of various political subdivisions other than the District; use, storage, and disposal of harmful materials; improper vegetative management; and improper agricultural practices. Additionally, groundwater at Barton Springs may also be affected by inflows from a portion of the aquifer that contains naturally occurring higher levels of total dissolved solids that do not meet national drinking water quality standards.

The freshwater/saline water interface, also known as the “Bad Water Line” (BWL), is described in Section 3.3.2.2. Wells to the south and southeast of this line typically have total dissolved solids (TDS) concentrations greater than 1,000 mg/L. Wells on the northwest side of this line typically have TDS concentrations less than 1,000 mg/L.

Historically, some water quality changes have been observed in wells in the transition zone as water levels in the aquifer change. As discussed in Section 3.3.2.2, elevated TDS levels appear to encroach from the saline zone as aquifer levels decrease, with reversal of the process as aquifer levels increase (Slade et al. 1986).

None of the three PDEIS alternatives discussed below would eliminate continuing water quality threats. As more population growth and attendant development occur over the aquifer, there will likely be greater risk in the HCP Planning Area for point- and non-point-source pollution.

Because the anticipated impacts of each individual measure under each alternative on water quality cannot be precisely measured or projected, each alternative will be collectively evaluated for the relative “net effect” that the alternative would have on the quality of groundwater.

Alternative 1: No Action

A total of 13 ongoing and future aquifer management and spring protection measures would be implemented under the No Action Alternative if proven feasible and supported by appropriate authorization. While most of these measures focus on increasing the quantity of water in the aquifer, groundwater quality would be positively benefited. Reduced withdrawals would allow a higher volume of confined water, thus reducing the concentration and rate of transmission of physical and chemical components that contribute to degraded water quality. Under Alternative 1, there are two measures that would directly benefit water quality: Measure 1.3.1, development of recharge enhancement projects including detention ponds over the streams and creeks flowing over the recharge zone, and Measure 1.3.2, support of cleaning, maintaining, and protecting natural recharge features over the recharge zone. Some wells may exhibit variable salinity in the transition zone or on the saline side of the BWL; consequently Barton Springs could exhibit higher salinities during drought conditions under Alternative 1.

Alternative 2: Regional Permit, Best Practicable and Attainable Measures

A total of 37 ongoing and future aquifer management and spring protection measures would be implemented under Alternative 2 if proven feasible and supported by appropriate authorization, with five measures directly affecting water quality. These include: Measure 1.2.9, cooperative efforts with public water utilities to develop water conservation measures and model ordinances to adopt stricter requirements for development to protect water quantity and quality; Measure 1.3.1, development of recharge enhancement projects including detention ponds over the streams and creeks flowing over the recharge zone; Measure 1.3.2, support of cleaning, maintaining, and protecting natural recharge features over the recharge zone; Measure 1.3.3, District participation in the acquisition and protection of undeveloped land; and Measure 1.3.4, implementation of policies and programs to prevent waste and contamination of ground and surface water using Edwards Aquifer Best Management Practices (BMPs). Groundwater quality could be benefited eventually by the results of Measure 5.3, implementation of engineering studies to investigate potential for augmentation of water supplies in the brackish water zone including desalination and aquifer storage and recovery.

With increased restrictions on pumpage under permit, similar impacts on salinities would be expected as with Alternative 1. However, the changes should be less frequent and less severe, because with lower pumpage the decrease in water levels and resulting effects on water quality should be less frequent and less severe. Measures under Alternative 2 would collectively ameliorate future water quality degradation but would not eliminate it completely. Effectiveness of water quality protection measures would depend on policies and rules approved by the District's Board of Directors, enforcement powers provided by the District's Enabling Act and Chapter 36 of the Texas Water Code, and the implementation of water quality measures by other political subdivisions whose actions would also affect the Barton Springs segment of the Edwards Aquifer.

Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

A total of 43 ongoing and future aquifer management and spring protection measures would be implemented under Alternative 3 if proven feasible and supported by appropriate authorization, with six measures directly affecting water quality. These include: Measure 1.2.9, cooperative efforts with public water utilities to develop water conservation measures and model ordinances to adopt stricter requirements for development to protect water quantity and quality; Measure 1.3.1, development of recharge enhancement projects including detention ponds over the streams and creeks flowing over the recharge zone; Measure 1.3.2, support of cleaning, maintaining, and protecting natural recharge features over the recharge zone; Measure 1.3.3, District participation in the acquisition and protection of undeveloped land; Measure 1.3.4, implementation of policies and programs to prevent waste and contamination of ground and surface water using Edwards Aquifer BMPs; and Measure 5.4, development of a sediment transport model to examine influence of sediment inputs and ability of spring openings to flush sediments deposited during flood events. Groundwater quality could be benefited eventually by the results of Measure 5.3, implementation of studies to investigate potential for augmentation of water supplies in the brackish water zone including desalination and aquifer storage and recovery, and recovery of freshwater from other sources (e.g., Trinity Aquifer). However, withdrawals of saline Edwards Aquifer water in the District for large-scale desalination also could alter freshwater flow paths in currently indeterminate ways and affect both the quantity and quality of fresh water in the aquifer and at Barton Springs.

Despite increased restrictions on pumpage under permit, similar impacts on salinities would be expected as with Alternatives 1 and 2. However, the changes should be less frequent and less severe because with lower pumpage the decrease in water levels and resulting effects on water quality should be less frequent and less severe. Measures under Alternative 3 would collectively ameliorate future water quality degradation, but as with Alternatives 1 and 2, they would not eliminate it. Protection of the quality of groundwater in the Barton Springs Segment of the Edwards Aquifer would be assured only through collective efforts by the District and other state, county, and local political subdivisions with statutory responsibility for water quality protection.

4.2.4 Aquifer-fed Springs

This section describes impacts of each of the three PDEIS alternatives on the discharge of Barton Springs. Consequent impacts to the biological resources supported by the Barton Springs ecosystems from each of the three PDEIS alternatives are discussed in Section 4.4. Numerical designations of alternative measures correspond with previous designations listed in Table 2.3-1, and accompanying descriptions in Chapter 2, Alternatives including Proposed Action.

Evaluation of the impacts of the three PDEIS alternatives on the volume and frequency of springflow is focused on total springflow at Barton Springs (incorporating the four individual springs). Total springflow for each PDEIS alternative is compared with a “baseline” flow condition that represents an estimate of total springflow that would have occurred historically absent *any* groundwater withdrawals. The baseline condition was calculated for the period of record (1917–2004), for all of the days when flows were less than or equal to 40 cfs (when total spring complex flows fall below 40 cfs, flow at the Upper Barton Spring ceases). Daily values before 1978 are estimates based on irregular instantaneous discharge measurements and interpolation using the recession curve of diminishing spring discharge, as well as other hydrologic factors, for any day where total Barton Springs discharge was less than or equal to 40 cfs. Estimation and compilation of the dataset using this methodology were performed in 2005 by Raymond Slade (retired USGS hydrologist under contract with the District). After the USGS gage was installed in 1978, a continuous record of daily discharge values became available. To reduce the potential error associated with daily discharge values, a 7-day running average was used for describing baseline conditions (and subsequently, each PDEIS alternative).

The baseline flow condition was also used to predict the anticipated daily spring discharge for each PDEIS alternative, assuming the measures under each alternative were in place throughout the period of record. Changes in daily springflow values associated with the anticipated groundwater withdrawal amounts for each PDEIS alternative were applied to the baseline springflow to arrive at the projected springflow conditions for each alternative. In addition, a range of groundwater withdrawal limitations are evaluated for each PDEIS alternative. Under Alternative 1, the range of withdrawals as a result of having Alternative 1 management measures in place was estimated to be between 13 and 16 cfs of groundwater withdrawal. Under Alternative 2, the estimated range of withdrawals was between 10 and 13 cfs; and under Alternative 3 it was estimated to be between 7 and 10 cfs.

Appendix I describes the modeling efforts to predict springflow conditions for this evaluation. As with the outcome of any model, predicted springflow values from these efforts are approximate, not absolute; they are predicted estimates that are affected by the limitations and accuracy of the model, quality of input data, and major assumptions.

Therefore, analyses of predicted springflows are limited in this assessment to the evaluation and comparison of PDEIS alternatives. Use of the predicted springflow values beyond the described analyses should be exercised with caution.

Discharge conditions among alternatives were compared using several methods. The anticipated frequency of occurrence (percent of time during the period of record) that total Barton Springs discharge would be between 0 and 40 cfs is displayed for the upper and lower limits of the pumping range expected for each PDEIS alternative and baseline conditions in Figure 4.2-1. The seven-day running average daily discharge was computed for each day to produce these results. These data are also summarized in a series of tables that focus on specific discharge conditions that are useful for comparison among alternatives. The tables include percent of time (Table 4.2-2), number of days (Table 4.2-3), and maximum number of consecutive days (Table 4.2-4) that each alternative would be at or below the individual threshold discharge level. Threshold discharge levels selected for comparison include 33, 18, 10, 6, and 4 cfs total discharge from Barton Springs (see Section 4.4.1 and Appendix I for more details).

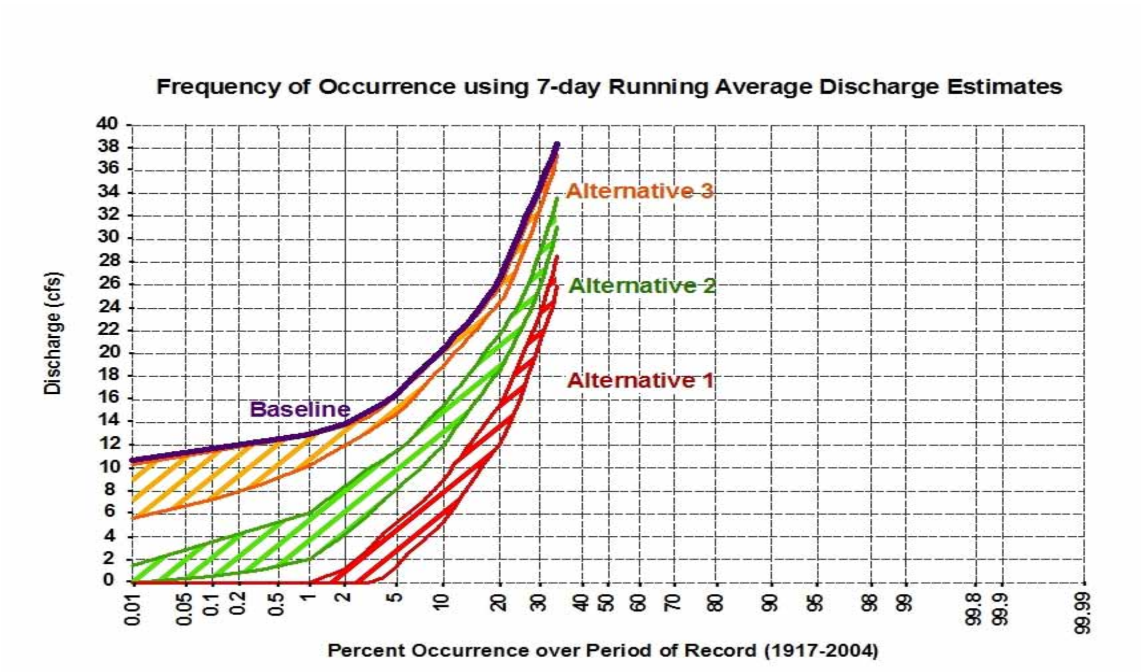

Figure 4.2-1. Frequency of occurrence using 7-day running average discharge estimates. Curves representing the upper and lower limits of the pumping range of each PDEIS alternative are colored orange (Alternative 3), green (Alternative 2), and red (Alternative 1) with the area between the lines hatched in the same color to represent the range of possible discharge conditions within each alternative.

Table 4.2-2. Percent of time that Barton Springs discharge would have been at or below specified (threshold) discharge values at the upper and lower pumpage limits of each PDEIS alternative during the period of record.

Total Barton Springs Discharge (cfs)	Baseline	Alternative 1		Alternative 2		Alternative 3	
		16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	28%	37%[a]	37%[a]	34%	34%	30%	29%
18	7%	27%	23%	19%	14%	9%	7%
10	0.2%	17%	12%	8%	3%	1%	0.1%
6	0%	11%	6%	3%	1%	0.2%	0%
4	0%	8%	4%	2%	0.3%	0%	0%

[a] All 11,650 days in the evaluated subset of the period of record where baseline discharge was less than or equal to 40 cfs (37 percent of the period of record) are predicted to fall within this category. It should be noted that the frequency of occurrence of discharge conditions within this category could be higher under certain aquifer conditions, but were not calculated because the evaluation was intended to focus only on baseflow less than or equal to 40 cfs rather than evaluate higher, less critical flows occurring throughout the entire period of record.

Table 4.2-3. Number of days (out of 32,050 days, between 1917 and 2004) that Barton Springs discharge would have been at or below specified (threshold) discharge values at the upper and lower pumpage limits of each PDEIS alternative during the period of record.

Total Barton Springs Discharge (cfs)	Baseline	Alternative 1		Alternative 2		Alternative 3	
		16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	8,974	11,650[a]	11,650[a]	11,027	10,789	9,700	8,573
18	2,083	8,654	7,500	6,122	4,519	2,564	1,186
10	0	5,384	3,686	2,404	994	288	32
6	0	3,590	2,019	994	321	64	0
4	0	2,660	1,250	577	96	0	0

[a] All 11,650 days in the evaluated subset of the period of record where baseline discharge was less than or equal to 40 cfs (37 percent of the period of record) are predicted to fall within this category. It should be noted that the frequency of occurrence of discharge conditions within this category could be higher under certain aquifer conditions, but were not calculated because the evaluation was intended to focus only on baseflow less than or equal to 40 cfs rather than evaluate higher, less critical flows occurring throughout the entire period of record.

Table 4.2-4. Maximum number of consecutive days that Barton Springs discharge would have been at or below specified (threshold) discharge values at the upper and lower pumpage limits of each PDEIS alternative during the period of record.

Total Barton Springs Discharge (cfs)	Baseline	Alternative 1		Alternative 2		Alternative 3	
		16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	1,055	1,137	1,137	1,137	1,126	1,061	1,053
18	463	1,055	1,022	813	668	233	167
10	24	745	614	229	158	83	19
6	0	332	226	153	83	53	0
4	0	229	159	120	62	0	0

In addition to summarizing the frequency of occurrence of each of the selected discharge thresholds over the period of record, the three PDEIS alternatives were compared to baseline conditions over a period of time corresponding to the drought of record (1950–1957; 2,922 total days) (Tables 4.2-5 and 4.2-6). This comparison used the same discharge conditions and metrics of comparison as the evaluation over the entire period of record.

Table 4.2-5. Percent of time that Barton Springs discharge would be at or below specified (threshold) discharge values at the upper and lower pumpage limits of each PDEIS alternative during a repeat of the drought of record (1950-1957).

Total Barton Springs Discharge (cfs)	Baseline	Alternative 1		Alternative 2		Alternative 3	
		16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	70%	76%	76%	76%	75%	72%	68%
18	36%	69%	65%	61%	54%	38%	21%
10	2%	57%	49%	33%	17%	5%	1%
6	0%	45%	28%	16%	5%	2%	0%
4	0%	34%	19%	11%	2%	0%	0%

Table 4.2-6. Number of days (out of 2,922 days during a repeat of the drought of record, 1950-57) that Barton Springs discharge would be at or below specified (threshold) discharge values at the upper and lower pumpage limits of each PDEIS alternative.

Total Barton Springs Discharge (cfs)	Baseline	Alternative 1		Alternative 2		Alternative 3	
		16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	2,031	2,226	2,207	2,207	2,181	2,098	1,999
18	1,063	2,029	1,885	1,769	1,574	1,097	600
10	46	1,670	1,428	977	493	147	19
6	0	1,301	826	472	147	53	0
4	0	1,005	548	312	62	0	0

4.2.4.1 Alternative 1: No Action

The anticipated range of springflow conditions under Alternative 1 would provide the farthest deviation from baseline (absence of all groundwater withdrawals) and lowest springflow among the alternatives. Alternative 1 would allow the highest rate of pumpage (13-16 cfs as an average discharge) and drought and non-drought measures would provide the least demand reductions/supply enhancements among the three PDEIS alternatives. The resulting spring discharge conditions under this alternative would include flows of 4 cfs or lower, between 4 and 8 percent of the time (Table 4.2-2), and such flows would persist for a maximum of 159 to 229 consecutive days over a repeat of the 87-year period of record (Table 4.2-4). This alternative would also result in discharge conditions below the historical low flow (approximately 10 cfs) between 12 and 17 percent of the time over a repeat of the period of record (Table 4.2-2) and between 614 and 745 maximum consecutive days below this threshold over that period (Table 4.2-4). In the event of a repeat of the drought of record from 1950 to 1957, this alternative would result in a range of 19 to 34 percent frequency of springflow at or below 4 cfs (Table 4.2-5). The biological impacts of these dramatic flow alterations compared to baseline conditions are discussed in Section 4.3.4.

4.2.4.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

The anticipated range of springflow conditions under Alternative 2 would provide higher springflow than Alternative 1, but flows would still remain lower than the zero-pumpage baseline. The range of possible restrictions on maximum annual groundwater withdrawals associated with Alternative 2 includes permitting up to an average discharge of 10 to 13 cfs. This range includes the current (March 2007) permitted pumpage amount of slightly over 11 cfs. Although permitted groundwater withdrawals limit the amount to an average discharge amount, the short-term pumpage (actual daily pumpage) may differ substantially from these monthly or annual averages. This potential short-term variation was incorporated into estimates of actual daily withdrawal amounts based on historical variation (see Appendix I). The frequency of reduced discharge conditions associated with this alternative is intermediate between Alternatives 1 and 3, as are reductions in withdrawal volumes resulting from demand reductions and supply enhancements (mitigation). Non-drought management measures would reduce demand and/or enhance supply by approximately 2.8 cfs and drought-stage measures (including mandatory reduction in water use) would reduce withdrawals by another 2.8 to 4.2 cfs, such that up to 7.0 cfs that would otherwise be available for withdrawal would remain in the aquifer for discharge from Barton Springs (according to water balance calculations discussed in Section 4.2.3.1 above and in Appendix H).

The range of discharge conditions anticipated for Alternative 2 includes the possibility that springflow at or below 4 cfs would occur up to 2 percent of the time (Table 4.2-2) and up to 120 consecutive days during a repeat of the 87-year period of record (Table 4.2-4). With the more restrictive groundwater withdrawal limits within the range for this alternative (10 cfs maximum permitted), these surface flow conditions would occur only 0.3 percent of the time (Table 4.2-2) and up to 62 consecutive days (Table 4.2-4) during a repeat of the period of record conditions. The historical low-flow condition (approximately 10 cfs) would occur between 3 and 8 percent of the time (Table 4.2-2) and up to 229 consecutive days (Table 4.2-4). In the event of a repeat of the 7-year drought of record, there would be a range of 2 to 11 percent frequency of springflow conditions at or below 4 cfs; and a 17 to 33 percent frequency of discharge at or below the historical low discharge of 10 cfs (Table 4.2-5). The deviation from baseline conditions for Alternative 2 is an appreciable improvement over the No Action Alternative, but there would be biological impacts associated with the deviation from baseline conditions, as discussed in Section 4.3.4.

4.2.4.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

The anticipated range of springflow under Alternative 3 would provide springflow conditions that would be most similar to baseline conditions (i.e., absence of all groundwater withdrawals) among the three PDEIS alternatives. At the lowest maximum withdrawal for this alternative (7 cfs), the discharge conditions over a repeat of the period of record would be very similar to baseline conditions (Figure 4.2-1), but higher withdrawal limits of 10 cfs would result in reduced discharge conditions relative to baseline. Non-drought demand reduction/supply enhancements for this alternative would include numerous measures that would result in a reduction of approximately 5.8 cfs, and drought measures (including mandatory reduction in water use) would reduce withdrawals by another 3.8 to 5.3 cfs, such that up to 11.1 cfs that would otherwise be available for withdrawal would remain in the aquifer for discharge from Barton Springs (see water balance calculations discussed in Section 4.2.3.1 above and in Appendix H). The anticipated flow conditions resulting from Alternative 3 would remain above zero cfs springflow at all times. The historical low flow would occur approximately 0.1 to one percent of the time (Table 4.2-2), and persist for a maximum of 19 to 83 consecutive days (Table 4.2-4) during a repeat of the period of record. A repeat of the drought of record would result in a range of 1 to 5 percent frequency of discharge at or below the historical low discharge of 10 cfs (Table 4.2-5). The resulting flow conditions in Alternative 3 would yield the lowest deviation from the baseline hydrology and lowest level of adverse biological impacts among the three PDEIS alternatives (Section 4.3.4).

4.3 Biological Resources

This section discusses impacts of each of the three PDEIS alternatives on regionally occurring flora and fauna within the HCP Planning Area. Section 4.3.1 addresses regional effects of the three alternatives on aquatic communities. Section 4.3.2 describes regional effects on terrestrial resources. Section 4.3.3 summarizes expected effects on regional threatened and endangered species, and Section 4.3.4 describes effects on the endangered species covered by the District HCP.

The Barton Springs ecosystem, including the Upper Springs, Main Springs and associated Barton Springs Pool, Eliza Springs, and Old Mill Spring, geographically represents an extremely small portion of the HCP Planning Area. The riparian corridor containing Barton Creek and the spring complex is also very small in comparison to other riparian corridors in the region. However, vegetation within riparian corridors associated with the river and stream floodplains can be very sensitive to changes in the water table and the frequency, intensity, and duration of both high and low flow events, as well as Barton Springs Pool operations and maintenance. Predictive models of how riparian vegetation would change in response to alterations of the flow regime are needed to quantify riparian effects.

The primary threat to biological resources in the region is the modification and loss of plant and animal habitat from anthropogenic influences as a consequence of ongoing urbanization in the District. This includes changes in native plant and animal communities through land clearing, introduction of non-native species in urban landscapes, little or no applied management to increase habitat value in undeveloped lands, and degradation of water quantity and quality in urban/suburban watersheds by both point-source and non-point-source pollutants and their impacts.

4.3.1 Aquatic Resources

This section describes impacts of each of the three PDEIS alternatives on regional aquatic resources in creeks, streams, and wetlands throughout major watersheds within the HCP Planning Area; discussion of the impacts to the Barton Springs ecosystem is the focus of Section 4.3.4. Impacts from changes in the contribution of aquifer springflow to aquatic resources associated with streams and drainages within the HCP Planning Area are discussed below.

4.3.1.1 Alternative 1: No Action

Aquatic flora and fauna occurring in streams, creeks, and wetlands within the HCP Planning Area have developed and evolved in response to a variable flow regime. This regime is characterized by “normal” or average flows over time as well as above normal flows from seasonal flooding events and below normal flows from seasonal droughts. Long-term deviations from historical flows to either wetter or drier conditions would likely result in gradual as well as episodic changes to the aquatic communities, including the abundance and distribution of species.

Lower Barton Creek

The flow within the lower reach of Barton Creek, extending a distance of approximately 0.5 mile between Barton Springs Pool and the confluence with the Colorado River, is heavily influenced by springflow discharged by the Barton Springs complex. In years of average to above average rainfall, effects of measures under Alternative 1 to fish and aquatic invertebrate communities in the stream channel and to the high quality riparian corridor would be minimal, as springflow effects would be diminished by the additional flows (including flood flows) contributed by upper Barton Creek. In years of below average rainfall, most if not all of the flow of lower Barton Creek would be directly affected by springflow as influenced by measures under Alternative 1. Preservation of springflow would also allow preservation of flows within lower Barton Creek, providing positive benefits to aquatic vertebrate and invertebrate communities that are dependent on these flows.

Other Creeks

During years of high to normal rainfall, effects of Alternative 1 would be minimal on aquatic resources in creeks and streams and associated riparian corridors throughout the HCP Planning Area, as flows would be mostly influenced by the combined effects of regional and localized runoff. However, during years of low rainfall, detention ponds to divert stream flow into the aquifer in the recharge zone (Measure 1.3.1) could affect downstream aquatic communities by reducing flows directly downstream of the structures. This reduced flow would adversely affect aquatic stream communities by reducing the availability of pool, riffle, and stream habitat. Conversely, the prolonged release of detained waters in such ponds could mitigate the adverse effects of droughts in downstream segments, as long as discharge from such ponds continues. Effects of Alternative 1 to aquatic resources in other creeks and streams not affected by surface detention structures in the HCP Planning Area would be minimal to low.

4.3.1.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Lower Barton Creek

In years of average to above average rainfall, effects of measures under Alternative 2 to fish and aquatic invertebrate communities and to the riparian corridor associated with lower Barton Creek would be minimal, similar to Alternative 1. In years of below average rainfall, most if not all of the flow of lower Barton Creek would be directly affected by springflow as influenced by measures under Alternative 2 and water levels of Town Lake near the confluence. The enhanced preservation of springflow under this alternative would also allow preservation of flows within lower Barton Creek, providing positive benefits to aquatic vertebrate and invertebrate communities that are dependent on these flows.

Other Creeks

During years of high to normal rainfall, effects of Alternative 2 on other creeks in the HCP Planning Area, similarly to Alternative 1, would be minimal on aquatic resources. However, during years of low rainfall, detention ponds to divert stream flow into the aquifer in the recharge zone (Measure 1.3.1) could have either adverse or positive net impacts on aquatic communities, either by reducing or by prolonging the duration and magnitude of flows in those stream segments directly downstream of the structures.

These effects could be compounded if, through Measure 1.4, on-channel or off-channel surface water impoundments are built in watersheds within the HCP Planning Area that would hold back additional water within stream drainages, further reducing downstream flows. However, positive effects of Measure 1.3.1 are also possible, if water management strategies are implemented that are designed to divert surface water from sources outside the HCP Planning Area into creeks to augment the use of groundwater by users downstream or to provide additional recharge to the aquifer.

Effects of Alternative 2 on aquatic resources in other creeks and streams not affected by surface detention structures in the HCP Planning Area would be minimal to low, similar to Alternative 1.

4.3.1.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Lower Barton Creek

In years of average to above average rainfall, effects of Alternative 3 on fish and aquatic invertebrate communities would be minimal, similar to Alternatives 1 and 2. In years of below average rainfall, most if not all of the flow of lower Barton Creek would be sustained by springflow enhanced by measures under Alternative 3. Preservation of springflow would also allow preservation of flows within lower Barton Creek, providing positive benefits to aquatic vertebrate and invertebrate communities and to the riparian corridor dependent on these flows.

Other Creeks

During years of high to normal rainfall, effects of Alternative 3, similar to Alternatives 1 and 2, would be minimal on aquatic resources in creeks and streams throughout the HCP Planning Area. However, during years of low rainfall, detention ponds to divert stream flow into the aquifer in the recharge zone (Measure 1.3.1) could adversely or positively affect aquatic stream communities by reducing flows in those stream segments directly downstream of the structures, depending on the patterns of water release from such structures. These effects could be compounded by Measure 1.4, if on-channel or off-channel surface water impoundments are built in watersheds within the HCP Planning Area that would hold back additional water within stream drainages, further reducing downstream flows. However, positive effects of Measure 1.3.1 are also possible, if water management strategies are implemented that are designed to discharge surface water from sources outside the HCP Planning Area into creeks to augment use of groundwater by users downstream or to provide additional recharge to the aquifer.

Effects of Alternative 3 to aquatic resources in other creeks and streams not affected by surface detention structures in the HCP Planning Area would be minimal to low, similar to Alternatives 1 and 2.

4.3.2 Terrestrial Resources

This section describes impacts of each of the three PDEIS alternatives on regional terrestrial resources including vegetation and wildlife habitat throughout the HCP Planning Area.

4.3.2.1 Alternative 1: No Action

Vegetation

Under Alternative 1 (No Action), population growth and corresponding development within the HCP Planning Area are expected to increase. More land will be converted from undeveloped, unmanaged landscapes to urban, suburban, and industrial uses. The composition and density of vegetation cover will change, heavily influenced by land clearing for residential housing and commercial businesses. Mixed oak–juniper–mesquite woodlands that consist of mature or old age native trees and shrubs will decline in favor of trees, shrubs, and grasses planted according to either approved development plans or to individual preferences of private landowners. Tracts of mixed grasslands and mesquite–juniper parklands will also become more fragmented as development and attendant disturbance continue. Future residential landscapes will include a mixture of both native and exotic species. Due to increased emphasis on water conservation measures under Alternative 1 and growing popularity for low maintenance, low water demand lawns, there will be greater emphasis on the establishment of native trees, shrubs, flowers, and grasses that will be more tolerant of local climate conditions and require less water to maintain.

Wildlife

The existing trend of conversion of established mature woodland and grassland vegetation communities in the HCP Planning Area to urban and suburban landscapes will result in a conversion of wildlife habitat, and corresponding change in wildlife communities. This conversion will result in the decline of less fragmented, wooded tracts preferred by many wildlife species, for example, neotropical bird migrants whose populations are diminishing. These habitats will be replaced by suburban landscapes preferred by many other species (grackles, raccoon, opossum, white-tailed deer, and coyote) that are highly adaptable to human disturbance. These animal populations can quickly increase to levels where interactions with humans become more frequent.

Some positive benefits to terrestrial resources might be gained by Measure 1.3.1 through creation of detention impoundments over the recharge zone. These features would add ecological diversity to the landscape, increase the quality of habitat near the impoundments and attract many species of wetland-dependent wildlife. As the HCP Planning Area develops, moderate adverse regional impacts would be expected to native terrestrial wildlife resources not adapted to human development and related disturbance, with concurrent positive benefits occurring to species that are adapted to human development and disturbance. Due to the increasing populations of some wildlife species coupled with a greater number of suburban developments, greater conflicts between animals and humans are expected. Adverse impacts would be ameliorated by gradual changes in the landscape from water demand reduction measures (1.2) that would collectively result in the conversion of non-native, high water demand trees, shrubs, and grasses to low water demand, low maintenance native or regionally-adapted plants that would provide higher habitat value for wildlife in terms of available food and cover.

4.3.2.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Under Alternative 2, impacts to terrestrial resources including native vegetation and associated wildlife habitat would be similar to Alternative 1, although some impacts will be ameliorated by acquisition and preservation of open space land under Measure 1.3.3 that would also preserve and protect wildlife habitat. Under Alternative 2 there would be greater incentives for establishment of low maintenance, low water demand landscapes resulting from the water demand reduction measures (1.2). These indirect effects would result in higher wildlife habitat benefits than Alternative 1 due to the increased conversion of high water demand, non-native plants to native or regionally-adapted plants that generally provide higher value for wildlife in terms of available food and cover. The construction of water conveyance infrastructure needed to implement water recirculation and augmentation measures (4.0) or water source conversion measures (1.4) could create additional site-specific impacts to terrestrial wildlife resources along potential pipeline routes.

4.3.2.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Impacts from Alternative 3 would be similar to those described for Alternative 2. The construction of water conveyance infrastructure needed to implement water recirculation and augmentation measures (4.0) or water source conversion measures (1.4) could create additional site-specific impacts to terrestrial wildlife resources along potential pipeline routes.

4.3.3 Regional Threatened and Endangered Species

As previously described in Section 4.3.2, impacts to wildlife habitat under Alternatives 1, 2, and 3 will be similar as conversion of established mature woodland and grassland vegetation communities to urban, suburban, and industrial uses would continue under each of these alternatives.

Minimal impacts under each of the three alternatives would be expected to the federal and state-listed bald eagle and whooping crane; and state-listed wood stork, and zone-tailed hawk. These species are highly mobile, and are considered uncommon or rare visitors to the area and would not be directly dependent on any habitat within the HCP Planning Area.

The federal and state-listed black-capped vireo and golden-cheeked warbler are spring and summer residents that nest in the HCP Planning Area. Urban and suburban development supported by increased groundwater and/or surface water under Alternatives 1, 2, and 3 could have potential adverse effects to these species through loss of habitat. Similar impacts would likely occur with or without the HCP, and among the three alternatives. These impacts would be ameliorated by the preservation and management of habitat under the existing Balcones Canyonlands Preserve system and other open space preserves supported by Measure 1.3.3 under Alternatives 2 and 3.

Of the seven federally-listed karst invertebrates in Travis and Williamson Counties, only the Bee Creek Cave harvestman occurs within the HCP Planning Area. Reduction in groundwater levels under each of the three alternatives (with less reduction in groundwater levels under Alternatives 2 and 3) could indirectly influence habitat conditions (temperature and humidity) for this species. The extent to which each alternative could impact this species is not known because the relationships of aquifer levels upon the life requisites of this species are unknown. Development of recharge enhancement structures (Measure 1.3.1) and maintenance of recharge features (Measure 1.3.2) under each of the three alternatives could also affect the habitat of this species to the extent that karst habitat occupied by this species is disturbed or altered by construction and operation of the recharge enhancement features or maintenance of recharge features. Such disturbances are considered highly unlikely.

The state-listed Texas horned lizard and timber/canebrake rattlesnake could occur in the HCP Planning Area. Urban and suburban development supported by increased groundwater and surface water under Alternatives 1, 2, and 3 could have potential adverse effects on these species through loss of habitat. Similar impacts would likely occur with or without the HCP, and among the three alternatives.

Impacts to the state-listed blue sucker (occurring principally in the Colorado River and possibly lower Barton Creek) and Arctic peregrine falcon are expected to be minimal under each of the three alternatives.

4.3.4 Covered Species

This section describes impacts of each of the three PDEIS alternatives on the federally endangered Barton Springs salamander. Because of limited information on habitat suitability and distribution of the Austin blind salamander (a candidate species for federal listing) no direct estimate of impacts are made for that species. The impact assessment for the Barton Springs salamander is assumed to approximate the impacts to the Austin blind salamander.

As described in Section 3.2, the Barton Springs salamander occurs in each of the four springs that make up the Barton Springs complex, as well as within subsurface areas to an unknown extent. The evaluation of impacts to the species focuses on the cumulative discharge anticipated from the four springs for each alternative (Section 4.2.4). Reduced discharge decreases surface habitat availability for the Barton Springs salamander (little is known about how much subsurface habitat is occupied by and suitable for the species). In addition, the remaining habitat is likely reduced in suitability for the species because of decreased DO concentration, possibly increased salinity, reduced dilution of other dissolved constituents that may be detrimental to the species, and the potential for increased predation, competition and reduced forage. Reduced flows may also change the physical characteristics of the spring openings by increasing sedimentation (which also reduces biological suitability). Springflows carry sediment loads from inputs contributed in the recharge and contributing zones, as well as particles that are dislodged as a result of erosion of the karstic limestone rock within the aquifer.

In order to determine the anticipated response of the Barton Springs salamander population to reduced discharge, and compare the relative impacts of the HCP Alternatives, it is necessary to describe the impact of each of these changes in habitat conditions on the species. However, for many parameters that may change with reduced discharge and impact Barton Springs salamander habitat suitability, little information is available to describe the relationship between the parameter and its potential impact. The primary parameters used for this analysis are DO concentration and spring discharge in Barton Springs, which are two components of Barton Springs salamander habitat that appear to be very important and likely capture a significant proportion of the influence of habitat changes on the species. These parameters also are supported by sufficient available data to develop a model to describe their relationship to other aspects of Barton Springs as a habitat for the Covered Species (City of Austin 2004, 2007). In addition to the model that describes DO concentration relative to discharge in Barton Springs (City of Austin 2007), a response curve of the Barton Springs salamander mortality to the range of DO concentrations that may occur in Barton Springs was needed. This information was collected using a surrogate species (due to the endangered species status of the target organism) by Poteet and Woods (2007) in a laboratory setting (Figure 4.3-1). Initially, salinity was intended be included as an additional factor for evaluation, but Poteet and Woods (2007) found that even very high salinity concentrations had little influence on the test organisms. Although there is uncertainty regarding the response of the Barton Springs salamander population to reduced DO in the wild compared with the response observed in a surrogate species in a laboratory setting, the estimates of Barton Springs salamander mortality from the latter provides a means of comparing alternatives with a common metric. This model for relating decreasing springflow with a response in the Barton Springs salamander population is based on the best available information, but much is still unknown; and the potential impacts described with this analysis have increasing uncertainty with decreasing discharge.

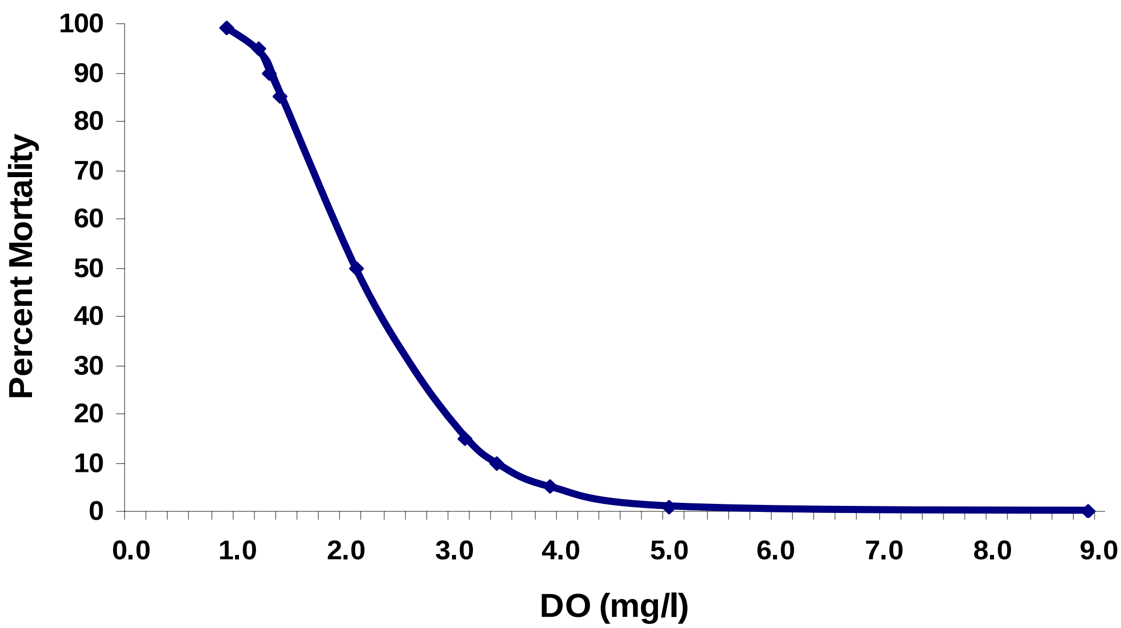

Figure 4.3-1. Curve of predicted mortality over a range of DO concentrations (modified from Poteet and Woods 2007).

As discussed in Section 4.2.4 and in Appendix I, five discharge thresholds were selected for the comparison of HCP alternatives; these are referred to as Impact Categories I-V (Figure 4.3-2; Table 4.3-1). These thresholds provide multiple opportunities for comparison over a range of conditions that yield potential impacts to Barton Springs salamander from minimal to substantial reductions in habitat suitability and high mortality risk. The discharge values for the thresholds were selected largely to correspond with a distributed series of mortality risk levels (as estimated by Poteet and Woods [2007]) that facilitate a detailed comparison among alternatives. The percent mortality risk (as expressed by a lethal concentration) associated with these impact categories

Figure 4.3 - 2 Barton Springs Discharge Thresholds and Levels of Impact

Total Springflow (cfs)	Historical Frequency of Occurrence Over the Period of Record	Drought Stage	Predicted Flow Among Individual Springs (cfs)[1]			Predicted Dissolved Oxygen Concentration at Main Spring (mg/l)[2]	Predicted Mortality From Laboratory DO Toxicity Study[3]		
			Main Spring	Eliza Spring	Old Mill Spring		Main Spring	Eliza Spring	Old Mill Spring
53[4]	50%	No Drought	44	4	5	5.8	Minimal or No Impacts	Minimal or No Impacts	Minimal or No Impacts
38	36%	38 cfs	31	4	3				
33	31%	Alarm Stage	27	4	2	5.0	<5% Mortality	<5% Mortality	<5 - 100% Mortality[5]
20	17%	20 cfs	17	3	0	4.1			
18	11%	Critical Stage	15	≤3	0	4.0	5 - 15% Mortality	5 - 15% Mortality	100% Mortality
16	5%		13	≤3	0	3.8 Lowest Historical Flow w/ Available Water Quality Data; Water Quality Results Below 16 cfs are Extrapolated			
		14 cfs							
10[6]	0.2%	Emergency Response Period	9	≤1	0	≤3.8[7]	>15% Mortality	>15% Mortality	100% Mortality
6	0%		5	≤1	0	≤3.8[7]	>15% Mortality	>15% Mortality	100% Mortality
4	0%		4	<1	0	≤3.8[7]	>15% Mortality	>15% Mortality	100% Mortality

Impact Categories (Lowest to Highest)

Note: Colors are used only for clarity to highlight categories and associated effects at designated springflow discharge levels.

Category I	Category II	Category III	Category IV	Category V Highest Risk

1 Flow estimates derived from interpolating values in Table 2-3, Appendix C.
2 Estimates derived from data provided by City of Austin (2007).
3 Mortality estimates for the Barton Springs salamander (*Eurycea sosorum*) were determined from dissolved oxygen toxicity studies using surrogate salamanders (*Eurycea nana*) (Poteet and Woods, 2007). The mortality estimates assume that the *E. sosorum* remain in place and are subjected to low DO and reduced flow. In the wild, the salamanders may avoid stressful conditions by moving to locations within the ecosystem that have higher quality habitat conditions.
4 Average historical flow over the period of record 1917 - 2004.
5 Estimates of 100% mortality in Old Mill Spring are based on loss of surface flow. Salamanders may avoid lethal conditions by moving deeper into the aquifer or laterally to higher quality habitat conditions.
6 Historical low flow (9.6 cfs) occurred on March 29, 1956.
7 Predicted DO values below 3.8mg/l (16 cfs) (Categories III, IV, and V) and resulting *E. sosorum* mortality have not been verified by field observation. However, Poteet and Woods (2007) were able to estimate mortality rates of *E. nana* in the laboratory at dissolved oxygen levels lower than 3.8mg/l. These mortality rates and associated Impact Categories III, IV, and V are discussed in Section 4.3.4

are approximately 1, 5, 15, 50, and 90 percent mortality of the Barton Springs salamander population (an adjustment of the model describing the DO-to-discharge relationship with recent data adjusted these values slightly). The DO concentration that results in each of these mortality risk levels correspond to approximately 5.0, 3.9, 3.1, 2.1, and 1.3 mg/L, respectively (Table 4.3-2).

Table 4.3-1. Impact categories and the approximate percent of time that discharge would be at or below each impact level at the upper and lower pumpage limits of each PDEIS alternative during the period of record.

Total Barton Springs Discharge (cfs)	Impact Level	Predicted DO (mg/L)	Esti-mated Mortality[a]	Recurrence Percentage - Baseline Discharge	Alternative 1		Alternative 2		Alternative 3	
					16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	I	4.8	>1%	28%	37%[b]	37%[b]	34%	34%	30%	29%
18	II	3.8	>5%	7%	27%	23%	19%	14%	9%	7%
10	III	2.9	>15%	0.2%	17%	12%	8%	3%	1%	0.1%
6	IV	2.0	>50%	0%	11%	6%	3%	1%	0.2%	0%
4	V	1.3	90%	0%	8%	4%	2%	0.3%	0%	0%

[a] Predictions from Poteet and Woods (2007) using surrogate salamanders (*Eurycea nana*) under laboratory conditions; these mortality estimates may differ from actual mortality of *E. sosorum* in the wild. (Mortality estimates for Impact Categories I-IV are slightly higher than originally predicted by Woods and Poteet [Table 4.3-2] due to a shift in the model describing DO-to-discharge relationship in Barton Springs.)

[b] These values are based on a dataset of 11,650 days, during which baseline discharge was less than or equal to 40 cfs (37 percent of the period of record). The evaluation was intended to focus only on baseflow less than or equal to 40 cfs rather than evaluate higher, less critical flows occurring throughout the entire period of record.

Table 4.3-2. Estimated in-vitro mortality of Barton Springs salamanders at various DO concentrations (adapted from Poteet and Woods [2007])

Estimated Percent Mortality	Lethal DO Concentration (mg/L)
1	5.0
5	3.9
10	3.4
15	3.1
50	2.1
85	1.5
90	1.3
95	1.2
99	0.9

The Barton Springs discharge conditions that are predicted to result in DO concentrations in Impact Categories I and II can be estimated from actual collected data, using a logistic regression model that describes the relationship between total Barton Springs discharge and DO in the main spring (City of Austin 2007). For Impact Categories III-V, the DO-to-discharge model for Barton Springs must be extrapolated beyond the existing data (the lowest Barton Springs discharge for which there is currently water quality data is 16 cfs) (City of Austin 2007). Using the logistic regression model that best fits the continuous water quality monitoring dataset collected by the City of Austin (City of Austin 2007), DO is predicted to decline to approximately 2.9 mg/L at a discharge of 10 cfs. At this DO concentration, mortality of the Barton Springs salamander population would be slightly higher than 15 percent; this corresponds with Category III impacts. Category IV impacts occur when mortality is slightly higher than 50 percent, which corresponds to a DO concentration of approximately 2.0 mg/L in a laboratory setting; this DO concentrations predicted by the logistic regression equation to occur around 6 cfs, but there is significant uncertainty in extrapolating to this value. Category V impacts occur when mortality reaches 90 percent at a DO concentration of approximately 1.3 mg/L in the laboratory.

It is unclear how low the DO concentration may decline in Barton Springs, given the uncertainties about various physical characteristics within the aquifer and the DO concentrations in the source of the water issuing from the springs. It is possible that a lower threshold limit of DO concentration occurs at some point as the contribution of spring flow varies among different water sources within the aquifer, but no data are available to evaluate this possibility. It is also possible that DO concentration approaches 0 mg/L as spring discharge approaches zero flow. So, a critical aspect to the use of the regression model that describes the relationship between DO and Barton Springs discharge is that there is great uncertainty in the DO predictions that are extrapolated beyond the existing dataset. The relationship between DO concentration and discharge when discharge is lower than 16 cfs could result in any number of possibilities, ranging from a sharp decline in DO to immediately reaching an inflection point and remaining nearly constant as discharge continues to decline, or any point in between. The regression model predictions of DO concentrations at lower discharge values are used only to provide a means for comparison among alternatives. More information is needed on the response of the ecosystem at such low flow conditions to more accurately characterize or predict the actual impact of such flows.

To conduct the comparison of relative impacts among HCP alternatives, the frequency and duration of each of the threshold discharge values (Impact Categories I-V) were calculated for each alternative over a repeat of the period of record (Table 4.3-1). This assessment permits comparison of long-term impacts of each alternative—over a period that is longer than the life of the requested permit (50 years). In addition to this focus on long-term trends in impacts, the State of Texas and the District bylaws mandate evaluating a repeat of the drought of record as the benchmark for groundwater planning purposes. Therefore, a second calculation was conducted to estimate the frequency and duration of each of the threshold discharge values (Impact Categories I-V) for each alternative in the event of a repeat of the drought of record (Table 4.3-3). Although there is a great deal of uncertainty in relating the actual impact of very low flow conditions in Barton Springs on the Barton Springs salamander population, decreasing discharge will have progressively increasing negative impacts on habitat condition of the species. Therefore, the focus of the comparison among alternatives is on the frequency and duration of the higher Impact Categories.

Table 4.3-3. Approximate percent of time that discharge would be within each impact category, by alternative, during a repeat of the drought of record (1950-1957). The values for the upper and lower limits of the pumping range of each PDEIS alternative were determined to evaluate the range of possible conditions.

Total Barton Springs Discharge (cfs)	Impact Cate-gory	Predicted DO (mg/L)	Estimated Mortality [a]	Recurrence Percentage – Baseline Discharge	Alternative 1		Alternative 2		Alternative 3	
					16cfs Limit	13cfs Limit	13cfs Limit	10cfs Limit	10cfs Limit	7cfs Limit
33	I	4.8	>1%	70%	76%	76%	76%	75%	72%	68%
18	II	3.8	>5%	36%	69%	65%	61%	54%	38%	21%
10	III	2.9	>15%	2%	57%	49%	33%	17%	5%	1%
6	IV	2.0	>50%	0%	45%	28%	16%	5%	2%	0%
4	V	1.3	90%	0%	34%	19%	11%	2%	0%	0%

4.3.4.1 Alternative 1: No Action

Alternative 1 would result in the most frequent occurrence of low discharge conditions among the PDEIS alternatives. Category V impacts would occur between approximately 4 to 8 percent of the time during a repeat of the period of record (Table 4.3-1) with a maximum of over 220 consecutive days anticipated at or below this threshold discharge value (Table 4.2-4). During a repeat of the drought of record, Category V impacts would occur 19 to 34 percent of the time (Table 4.2-5). Category IV impacts would occur between 6 to 11 percent of the time during a repeat of the period of record (Table 4.3-1) with a maximum of over 330 consecutive days anticipated at or below this threshold discharge value (Table 4.2-4). During a repeat of the drought of record, Category IV impacts would occur 28 to 45 percent of the time (Table 4.2-5). Such frequent and extended periods of severely reduced habitat suitability would likely cause severe adverse affects to the Barton Springs salamander. Under Alternative 1, there are no structural mitigation measures (4.0) to address contingencies associated with low or no springflow, and no adaptive management measures (5.0) to identify and implement changes in aquifer management in response to changes in future conditions.

4.3.4.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Alternative 2 would result in Category V impacts approximately 0.3 to 2 percent of the time during a repeat of the period of record (Table 4.3-1) and a maximum duration of 62–120 days (Table 4.2-4). During a repeat of the drought of record, Category V impacts would occur 2 to 11 percent of the time (Table 4.2-5). Category IV impacts would occur approximately 1 to 3 percent of the time during a repeat of the period of record (Table 4.3-1) with a maximum duration of 83–153 days at or below this threshold discharge value (Table 4.2-4). During a repeat of the drought of record, Category IV impacts would occur 5 to 16 percent of the time (Table 4.2-5). This alternative provides an improvement in anticipated flow conditions and thus reduced biological impacts to the Barton Springs salamander compared with the No Action Alternative, but may result in severely reduced habitat availability for the species during periods of critically low rainfall. Measure 1.2.10 may serve to reduce potential low flow conditions beyond the measures already incorporated into the evaluation. This measure would incorporate a monthly peak allowable pumpage amount in addition to the current annual limits. Currently, daily and monthly pumpage values may vary widely without violating the annual permitted pumpage limit. This large variation was incorporated into the estimated maximum short-term pumpage (water balance calculations in Section 4.2.3.1 and Appendix H) by allowing for variation from the daily average permitted value. Reducing the amount of daily fluctuation with monthly pumpage limits in addition to the annual limits would decrease the frequency and duration of low flow conditions.

Under Alternative 2 the feasibility of re-circulating or re-aerating water discharged during low flows from Barton Springs to specific natural or enhanced habitat protection zones would be investigated (Measure 4.1). This could provide positive impacts to the spring ecosystem by assuring water flow when it would not otherwise occur, thereby assuring continued survival of the species in the wild. An inter-local agreement with the City of Austin to support the Salamander Conservation Program (Measure 4.6) would have positive impacts to the Barton Springs salamander and associated habitat.

4.3.4.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Alternative 3 would result in springflow conditions that would be most similar to baseline conditions among the three PDEIS alternatives. Category III impacts would occur at a frequency of 0.1 to 1.0 percent of the time during a repeat of the period of record, as compared to the 0.2 percent that would be anticipated under hypothetical baseline flows (Table 4.3-1). The maximum consecutive number of days that these Category III impacts would be expected is 19–83 days compared to 24 under baseline flows (Table 4.3-4). During a repeat of the drought of record, Category III impacts would occur 1 to 5 percent of the time compared to 2 percent under baseline flows (Table 4.3-3). Unlike the other two HCP Alternatives, discharge under this alternative would not be anticipated to decline to less than 4 cfs surface flow (Category V biological impacts) during either a repeat of the period of record (Table 4.3-1) or the drought of record (Table 4.3-3). The additional gains in water available to the aquifer would result from greater demand reduction and water supply enhancement efforts than Alternative 1. This alternative would provide the most biological benefits among the three HCP alternatives.

4.4 Agriculture

Consequences to the agricultural resources of the HCP Planning Area identified in Chapter 3, Affected Environment, are presented in this section for each of the three PDEIS alternatives.

Agricultural production has been largely dependent on the character of the soils found throughout the HCP Planning Area. As noted in Section 3.1.3.1, soils on the Edwards Plateau are typically shallow on uplands and include very stony, dark, alkaline clays and clay loams. Land use in the Edwards Plateau portion of the HCP Planning Area has historically been agricultural, primarily cattle, sheep, and goat ranching, with forage crops grown in the deeper bottomland soils. Soils on the Blackland Prairie portion of the HCP Planning Area are typically deep, dark alkaline clays. These more productive soils have supported more intensive cultivation, including improved pasture and crops, such as cotton, grains, and hay. Groundwater withdrawals for irrigation have been quite limited in the HCP Planning Area. In 2003, a total of 345 acre-feet of Barton Springs Edwards groundwater was used for irrigation, mostly in Travis County, rising to 387 acre-feet in 2004 (BSEACD 2005b). Virtually all of this irrigation was for sports fields rather than agriculture. This amount of irrigation groundwater withdrawals is very small compared with irrigation withdrawals in the southern portion of the Edwards Aquifer in Bexar, Medina, and Uvalde Counties, where irrigation use of groundwater is dominantly agricultural and amounts to about 250,000 acre-feet per year (EAA 2004).

4.4.1 Alternative 1: No Action

Under Alternative 1, an Emergency Response Period will be declared at the discretion of the District Board. Alternative 1 does not include any specific measures to ameliorate extreme drought conditions (Measures 4.0), nor does it include any adaptive management strategies (Measures 5.0).

None of the measures identified for Alternative 1 explicitly address aquifer withdrawals for crop irrigation or livestock watering. Measures 2.2 and 3.1 would require pumping restrictions of 20 percent and 30 percent respectively, when drought triggers are reached. Implementation of Measure 3.1 by the District Board could result in additional pumping restrictions. Irrigators relying on groundwater withdrawals could face withdrawal limitations of 30 percent or more during severe drought conditions. Water enhancement measures (1.3.1 and 1.3.2) would be implemented under Alternative 1 and would tend to reduce the frequency and duration of impact of drought conditions on irrigation operations. Impacts to agricultural production from the Alternative 1 measures are minimal to low except during the most severe drought conditions. Withdrawal limitations associated with the District’s drought management measures could, under extreme drought conditions, impose moderate negative impacts to any irrigation operations associated with crop production or maintenance of turf or trees in public or private landscape operations.

But because agricultural water use in the District is incidental to other uses provided by a permit, or is very small scale and supported by non-permitted use (i.e., exempt well users), impacts to agriculture in Alternative 1 are expected to be minimal.

4.4.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Impacts to agricultural production from the Alternative 2 measures could be, in general, more severe than those from Alternative 1, with the level of adverse effects being related to the dependency of agricultural production on irrigation. Measure 1.1, establishment of regulatory-based withdrawal limits, could restrict the future expansion of irrigated crops in the HCP Planning Area. Measure 1.2.6, increased pumping fees, could negatively affect irrigated crops by increasing the cost of production. Measures 1.2.8 and 1.2.10, including limits on actual pumping, could also negatively affect future irrigation. Measure 1.3.3, acquisition of open space, could reduce the availability of farmland and could reduce future agricultural production.

Measures 2.2 and 3.1 would require pumping restrictions of 20 percent and 30 percent, respectively, when drought triggers are reached. Implementation of Measures 3.4 and 3.5 by the District Board could result in additional pumping restrictions. Irrigators and ranchers relying on groundwater withdrawals for crop irrigation and livestock watering could face withdrawal limitations of 30 percent or more during severe drought conditions.

Additional pumping reductions under Measure 3.3 could reduce the water available for crop irrigation. Emergency reduction Measures 3.4, 3.5, and 3.6 could also reduce water available for irrigation in the HCP Planning Area during drought conditions. Measure 5.3, water supply augmentation studies, could potentially lead to an increase in the supply of groundwater available for irrigated agriculture production or landscape maintenance.

But because agricultural water use in the District is incidental to other uses provided by a permit, or is very small scale and supported by non-permitted use (i.e., exempt well users), impacts to agriculture in Alternative 2 are expected to be minimal.

4.4.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Alternative 3 impacts to agricultural production would be similar to those identified for Alternative 2, with one exception. Implementation of Measure 3.2 would extend additional pumping reductions to some Historic Exempt Users that could further restrict irrigation.

Measures 1.4.4 and 1.4.5, and 3.6, conversion or switching of groundwater to surface water, could negatively impact irrigation operations by increasing the cost of irrigation water.

But because agricultural water use in the District is incidental to other uses provided by a permit, or is very small scale and supported by non-permitted use (i.e., exempt well users), impacts to agriculture in Alternative 3 are expected to be minimal.

4.5 Land Use

Urban land uses are growing rapidly in the HCP Planning Area in response to a strong demand for suburban housing in the Austin area, and the provision of municipal and industrial water supplies is playing an important role in the character and timing of this growth.

As noted in Section 3.5.3, various governmental and planning entities have produced population projections for the Central Texas region and the HCP Planning Area that suggest continued moderate to high population growth rates. Underlying these population projections is the assumption that water for municipal and industrial uses will be provided to support this growth, either from the Edwards Aquifer or from alternative ground or surface sources.

Although the quantity and spatial distribution of future urban land use development in the HCP Planning Area is expected to be mainly influenced by the same historically important factors that have shaped the growth of the Austin area in the past, substantial effects to urban land use resources in the HCP Planning Area are possible under Alternatives 2 and 3 primarily because of Measure 1.3.3, acquisition of open space, although the District's role will be limited in the implementation of this measure. Other measures in these alternatives could affect the character and timing of urban land use growth in the HCP Planning Area.

Urban land use development in the HCP Planning Area is regulated by ordinances at the municipal and county levels of government. Larger municipalities impose zoning and subdivision regulations while counties regulate development primarily through subdivision, road and other public facility provisions, and on-site wastewater disposal requirements. Although these ordinances and regulations could be amended in the future, they have traditionally been designed and enforced to address growth and development issues related to water quality protection in the Barton Springs portion of the Edwards Aquifer.

In recent years, cities and counties in the District area have been requiring, as a condition of subdivision plat approval, assurances of an adequate municipal water supply for future land use and development. The District in 2006 instituted a policy whereby all future groundwater permits would be conditional, or subject to pumping curtailment or even cessation in the event of an extreme drought, as well as a requirement that an alternative water supply be available to shift from Edwards Aquifer water. This provision is likely to have very significant impacts on the extent of future urban development in the District that is dependent on the Edwards Aquifer.

Notwithstanding the trends and issues noted in this section, future development and redevelopment in the HCP Planning Area are likely to be predominantly influenced by existing growth management polices and regulatory provisions, resulting in a future urban land use pattern that would be a logical continuation of existing development trends and regulations.

4.5.1 Alternative 1: No Action

Measures 1.2.7 and 1.4.2 would limit groundwater production, and could force future development in the HCP Planning Area to rely more heavily on surface water supplies—supplies with higher costs and longer infrastructure development lead times. These measures could, therefore, affect the timing and character of future growth in the HCP Planning Area. Higher municipal water costs could mandate higher cost (and denser) housing and longer infrastructure development schedules and could delay future development beyond the market-based development regime currently in place.

In response to higher water costs associated with conversion to other water supply sources, municipal water providers in the HCP Planning Area would pass these costs (possibly associated with Measures 1.2.7 and 1.4.2) on to their customers through higher retail prices. This would likely stimulate the introduction or expansion of voluntary and mandatory programs to reduce landscape irrigation. These programs, if persistently applied, could eventually lead to a transition in the character of the existing urban landscape if water intensive landscaping were to be reduced or replaced by more drought-tolerant plant species.

New development at the suburban periphery of the Austin–San Marcos metropolitan area could reflect the need for more water efficient landscaping by reducing the total amount of new project acreage devoted to landscaping, by installing more efficient irrigation systems, or by utilizing more drought-tolerant landscape plants. These responses could have the effect of reinforcing or increasing the demand for higher density urban development, especially for infill or redevelopment projects in existing developed portions of the HCP Planning Area. Existing market forces, responding to economic factors unrelated to water availability and price, have been driving increased densities in the Austin area for several years. It would be difficult, therefore, to differentiate the possible changes to the urban landscape resulting from the Alternative 1 measures from the changes that have been occurring and will continue to occur for unrelated reasons. Consequently, no substantial effects to the character of the urban landscape arising specifically from any of the Alternative 1 measures considered here are expected.

Measures 2 and 3 would reduce permitted pumping by at least 20 percent when Alarm Stage or Critical Stage reductions are required and would require additional reductions for some conditional production permittees. These measures could periodically limit groundwater production substantially and have similar effects on urban land use as noted for the measures in 1.2 Ongoing/Continuing Demand Reduction Measures.

4.5.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Impacts to urban development under Alternative 2 would, in general, be more severe than those under Alternative 1 because of additional measures. Measures 1.1, 1.2.8, and 1.2.10, that would place withdrawal limits on permitted pumpage or otherwise limit groundwater production in the District, would have the effect of forcing more future development in the HCP Planning Area to acquire surface water supplies or groundwater from another aquifer or from sources outside the HCP Planning Area rather than lower the cost of Edwards groundwater procured locally. This could have the effect of driving up the cost of development as higher cost alternative water supplies and treatment and delivery infrastructure would be needed. As noted above under Alternative 1, such measures could affect the timing and character of future growth in the HCP Planning Area, leading to higher cost and denser housing development. As with Alternative 1 above, the market for commercial and industrial development in the HCP Planning Area would likely be less affected by these measures.

Measure 1.3.3, acquisition of open space, could substantially affect the quantity, character, location and timing of new development in the HCP Planning Area. Although the District’s role in the implementation of this measure would be limited, land acquired for open space, whether through fee simple or conservation easements, would reduce the available supply of developable land in the HCP Planning Area in the face of continuing strong demand, leading to an increase in land development costs. The possible result of this measure, depending on the scale of land acquisition, could reduce the total quantity of urban development or affect the density, cost, location, and timing of development in the HCP Planning Area.

Measures 1.2.6, 1.4.1 and 1.4.3 that encourage the development of higher cost surface water supplies in the HCP Planning Area, could have the effect of increasing the cost of municipal water supplies and subsequently the cost of urban development.

As with Alternative 1, municipal water providers could respond to higher water costs associated with conversion to other water supplies by passing higher water costs on to their customers. This would likely stimulate the introduction or expansion of voluntary and mandatory programs to reduce landscape irrigation. These programs, if persistently applied, could eventually lead to a transition in the character of the existing urban landscape if water intensive landscaping were to be reduced or replaced by more drought-tolerant plant species.

Measures 2.1 through 2.3 could limit groundwater production and would, in general, have the same effects under Alternative 2 as noted for Alternative 1, above. Greater enforcement of regulations would occur under Alternative 2 by implementation of Measure 2.4. Measure 3.3 would impose pumping reductions to certain conditional pumping permits and have the effect of increasing the cost of municipal water supplies and subsequently the cost of urban development. Measure 3.4 would further curtail certain conditional permits and, with additional legislation, reduce pumping under certain historic use permits. Measures 3.5 and 3.6 would impose additional enhanced demand reduction measures and could increase the level of uncertainty with respect to the costs and reliability of groundwater supplies for future urban development and would entail increased costs for future developments required to manage the increased level of risk.

Like Alternative 1, no substantial effects to the character of the urban landscape arising specifically from any of the Alternative 2 measures considered here are expected, other than the effects noted in this section.

Measure 5.3, studies of augmentation of water supplies in the brackish water zone, could potentially lead to an increase in available groundwater supplies and foster the provision of new water supplies to urban developments, offsetting to some extent the negative impacts to urban land uses from the Alternative 2 measures noted above. However, the costs of desalination may be even higher than surface water development.

4.5.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

The effects of the measures under Alternative 3 on urban land uses would be very similar to those identified under Alternative 2.

Measures 1.4.4 and 1.4.5 would encourage the conversion of urban land uses from local groundwater use to either surface water or groundwater either from a deeper aquifer or imported from outside the HCP Planning Area. As noted above, conversion from lower cost local groundwater use to higher cost alternative water sources would increase land development costs in the HCP Planning Area. Resulting increased development costs could affect the quantity, density, location and timing of future development and the character of the urban landscape as noted for Alternative 2. Impacts to urban land uses noted for Alternative 2 could be greater under Alternative 3 as a result of more emphasis on the reduction of local groundwater use. Such impacts could be substantial for future planned developments, but may not affect overall urban land use throughout the HCP Planning Area, as a substantial and increasing proportion of the HCP Planning Area is currently served by surface water purveyors.

4.6 Social Resources

Consequences to the social resources of the HCP Planning Area, identified in Chapter 3, Affected Environment (Section 3.5), are presented in this section for each of the three PDEIS alternatives evaluated. Effects to social resources are discussed below under Population Effects (Section 4.6.1), Minority Populations (Section 4.6.2), Low-Income Populations (Section 4.6.3) and Community and Public Resources, including: governmental facilities, police and fire protection, medical services, schools, museums, zoos, botanical gardens, libraries, and recreational facilities such as pools, parks, and open space (Section 4.6.4).

Effects on the existing population, future population dynamics, and the economic welfare of minority and low-income populations in the HCP Planning Area described here are largely indirect and induced effects based on the direct economic effects arising from the alternative pumpage withdrawal limits, conservation, drought stage and other measures, as evaluated in Section 4.7, Economics.

4.6.1 Population Effects

Consequences to the population of the HCP Planning Area are presented in this section for each of the three PDEIS alternatives. As stated in Section 3.6.2, municipal water demand accounts for more than 93 percent of the total water demand projected for the year 2050 for the portion of Hays County in the Lower Colorado Region. Most of the impacts to the population in the HCP Planning Area are expected to arise from the increased costs of water use associated with limitations and reductions to aquifer withdrawals. Positive impacts are expected as a result of potentially increased open space and as a result of relatively higher flows at Barton Springs supporting its function as an important community recreation area. Psychological or perceptual effects are difficult to evaluate, but it is likely that measures which enhance or protect the quantity and quality of springflow at Barton Springs, and hence its value as a recreational resource would contribute positively to the subjective sense of quality of life values of the HCP Planning Area's population. Similarly, the enhanced reliability of the Edwards Aquifer as the sole drinking water source for approximately 50,000 individuals in communities and households in the District would contribute significantly to those individuals' quality of life and economic investment in their households.

4.6.1.1 Alternative 1: No Action

A projected permitted pumpage under Alternative 1 ranging from 13 to 16 cfs would imply an eventual limit on the potential population growth of the HCP Planning Area if alternative sources of water were not available. Numerous water providers are, however, poised to extend treated water supplies to the HCP Planning Area in the foreseeable future, albeit at a somewhat higher cost than existing groundwater supplies from the Edwards Aquifer.

Measures 1.2.1 through 1.2.5 and 1.2.7 would potentially reduce groundwater use in the HCP Planning Area through more efficient record keeping, education, conservation, drought management, and legislative regulatory requirements. These measures, in the absence of reliable alternative water supplies, would have the effect of reducing the period and volume reliability of municipal and industrial supplies to commercial and industrial users in the HCP Planning Area (see Section 4.7, Economics). This could potentially discourage industries such as high technology microelectronic plants, which require a highly reliable water supply, from locating in the HCP Planning Area, having a subsequent negative effect on employment in the high paying microelectronics sector. These measures, as well as Measure 1.4.2, would also require future growth in the HCP Planning Area to develop surface water supplies, increasing the cost of water. Consequently, new development in the HCP Planning Area would be slightly more expensive relative to historical development.

Measure 1.2.5 would establish a water conservation education program, which could have a minor positive social effect to the HCP Planning Area population of decreasing the amount and cost of water usage.

Several measures included in Alternative 1, especially the need for User Conservation Plans and User Drought Contingency Plans, would require water users to decrease their water use by 20 percent during Alarm Stage Droughts (Measure 2.2) and 30 percent in Critical Stage Droughts (Measure 3.1). Water use reduction measures may include covering pools, reducing watering of landscape plants, and not washing cars. These measures are not expected to have a measurable social impact on the overall population, although individual households or individuals might be adversely affected. If the aquifer were to fall to extremely low levels, the required restrictions may be such that water suppliers would not be able to guarantee sufficient supplies and water pressure for health and safety requirements. Such an outcome could have very negative effects on the groundwater–dependent population of the HCP Planning Area. It is assumed here, however, that the need to assure the public health and safety of HCP Planning Area citizens would necessitate the provision of more reliable alternative water supplies, thereby avoiding, albeit at increased cost, these potential negative impacts.

4.6.1.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Measure 1.1, leading to a withdrawal of 10-13 cfs on pumpage under permit, would have social consequences on the HCP Planning Area population similar to those noted above for Alternative 1, but would require additional quantities of alternative water supplies at higher costs, implying additional incremental costs for new development in the HCP Planning Area. These additional costs, other things equal, are not expected to impact the existing population or deter overall population growth in the HCP Planning Area. The likelihood that Barton Springs as a recreational resource would be sustained over a greater time span each year and in times of drought under this alternative would have a positive impact on the social quality of life of residents and visitors to Austin and to nearly communities in the HCP Planning Area. Ongoing/Continuing Demand Reduction Measures 1.2.1 through 1.2.10 would substantially increase efforts to reduce groundwater production in the HCP Planning Area. Measure 1.2.9 would strengthen plans and regulations that protect the quality and quantity of groundwater but would have greater restrictions, which would have the effect of increasing the cost of new development in the HCP Planning Area relative to developments in areas not subject to the same requirements. But as noted above for Alternative 1, the availability of alternative water supplies to the HCP Planning Area would likely prevent these measures from limiting population growth.

Measure 1.3.3 would reduce the available supply of developable land in the HCP Planning Area through a combination of land acquisition efforts and increasing the cost of land remaining for development. Measures 1.4.1 and 1.4.3, which would encourage the increased development of surface water supplies in the HCP Planning Area, would have a similar effect on development costs. Higher land and water costs would be passed on in the form of higher housing costs, making the HCP Planning Area somewhat less affordable compared to areas not subject to the same requirements and with already established surface water supply infrastructure. But these measures should not affect the population growth of the HCP Planning Area.

Increased open space and parkland and potentially improved water quality and quantity in the aquifer and springs would be a positive impact to the quality of life for the population living in the HCP Planning Area as well as visitors and tourists, and increase the value of adjacent residential property.

Measure 3.3, additional pumping reductions, and Measures 3.4, 3.5, and 3.6, emergency reduction measures, would likely have the same sort of effect as the measures described above that would periodically reduce available groundwater withdrawals. These additional pumping reduction measures could cause periodic inconvenience to the population of the HCP Planning Area that is solely dependent on groundwater, encouraging conversion to more dependable surface water supplies as they become available. Measure 4.1, investigating the re-circulation of groundwater, and Measures 5.1 through 5.6, adaptive management strategies, are not expected to have any social impacts to the population in the HCP Planning Area.

4.6.1.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

The withdrawal limit on pumpage under permit for Alternative 3 (7-10 cfs) would affect the population in the HCP Planning Area much the same as the limits Alternative 2. Population growth would continue in the HCP Planning Area supported by the development of alternative water supplies.

Measure 1.4.4 would encourage the conversion of existing groundwater use to surface or alternative uses through the adoption of District rules or through increased water rates associated with increased groundwater pumping as an incentive to conversion. The costs of conversion to surface water would be passed on to end users, making new development in the HCP Planning Area less affordable. Population growth in the HCP Planning Area under Alternative 3 is expected to continue.

Measure 1.4.5, cost participation in the construction of excess capacity in alternative water supplies, could offset some of the negative cost impacts of other water supply conversion measures, depending on the extent of participation by the District. Overall population growth in the HCP Planning Area should not be affected by Measure 1.4.5.

Measure 2.4, increased enforcement, is not expected to have a substantial social impact to the population. Measure 3.6, requiring mandatory switching to alternative supplies during Critical Stage conditions, would in general result in the same negative cost impacts to affordability in the HCP Planning Area as noted for other water supply conversion measures, but would be much more limited in duration. Measures 4.5 and 4.7, which would augment springflow during periods of severe drought, would result in a positive impact on the population in the HCP Planning Area. Increased flow would allow the popular Barton Springs Pool to remain open longer than it otherwise could in periods of drought, allowing water contact recreation and support of related businesses for area residents, visitors, and tourists.

None of the measures in 5.0 (adaptive management strategies) would have any direct social impacts in the population of the HCP Planning Area.

4.6.2 Minority Populations

During the last few decades, federal agencies have been mandated to include environmental justice in project planning. Executive Order 12898, issued February 11, 1994, requires that federal agencies make achieving environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of programs, policies, and activities on minority populations and low-income populations in the United States (59 FR 7629, 1994 WL 43891 [Pres], Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations) (EPA 1997).

In analyzing mitigation measures in its environmental assessments, environmental impact statements, and records of decision under NEPA, federal agencies, whenever feasible, should address significant and adverse environmental effects of their proposed actions on minority communities and low-income communities. The Presidential Memorandum identifies four important ways to consider environmental justice under NEPA, which are summarized in the Council on Environmental Quality's environmental justice guidance as follows:

> Each Federal agency should analyze the environmental effects, including human health, economic, and social effects of Federal actions, including effects on minority populations, low-income populations, and Indian tribes, when such analysis is required by NEPA. Mitigation measures identified as part of an environmental assessment (EA), a finding of no significant impact (FONSI), an environmental impact statement (EIS), or a record of decision (ROD), should, whenever feasible, address significant and adverse environmental effects of proposed Federal actions on minority populations, low-income populations, and Indian tribes.

According to population projections by the Texas State Data Center, presented in Section 3.5.3, Hispanic persons are expected to have by far the highest rates of population increase in all of the counties in the HCP Planning Area by 2040, while the Anglo population is expected to have the lowest rates of growth. In addition, according to 2000 Census data, Hispanic and Black/African American populations in Travis and Hays counties (the majority of the HCP Planning Area) had lower median household incomes and a higher percentage of persons living below the poverty level than white populations. Therefore, any increase in the cost of water to all water users would have disproportional consequences on these populations.

All three of the PDEIS alternatives considered imply the need for supplemental water supplies to meet projected demands as a result of the aquifer withdrawal limitations and reductions on the use of Edwards Aquifer water. The conversion to surface water supplies encouraged by several of the proposed measures would require that the cost of new infrastructure would be passed on to consumers. These higher water rates represent a loss of net economic benefits or real income to municipal consumers, as they must forego expenditures on other goods and services to pay these higher water bills.

A potential impact to minority populations arising from the higher water rates needed to meet the costs associated with the supplemental water required under the PDEIS alternatives could be a loss of net economic benefits to minority populations moving into the HCP Planning Area. The water rates in the HCP Planning Area currently may be lower than those of other similar residential areas, owing to the cheaper groundwater component, so the degree to which higher water rates may be an obstacle to in-migration by minority populations and increased diversity in the Planning Area is not certain.

Of the three alternatives, Alternative 1, which includes the fewest restrictions, would have the lowest potential for adverse impacts to minority populations, while Alternative 3, which includes the implementation of the most restrictive measures, would have the highest potential of negative economic impacts to these populations. The positive impacts arising from enhancement of the recreational qualities of the springs and adjoining recreation areas as a result of higher springflows at Barton Springs would not be different for minority populations. The anticipated impacts of each alternative to minority populations are addressed below.

4.6.2.1 Alternative 1: No Action

Alternative 1 includes the fewest measures to restrict water use from the Edwards Aquifer in the HCP Planning Area. The expected increase in costs for residential developments in the HCP Planning Area due to demand reduction and water supply conversion measures would disproportionately affect those persons moving into the HCP Planning Area in the future, who would need to purchase surface water, compared to existing users who have groundwater supplies from permitted withdrawals from the aquifer. Other things equal, a higher percentage of these new users would presumably be Hispanic, according to the population projections. Uncertainty with regard to the actual race/ethnicity of future migrants to the HCP Planning Area, however, makes it difficult to draw a definite conclusion with regard to the impacts of the Alternative 1 measures on minority populations.

4.6.2.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

In addition to the measures proposed in Alternative 1, Alternative 2 includes measures that would decrease withdrawal limits on pumpage under permit to 10-13 cfs, facilitate the acquisition of open space, increase surface water supplies, and require additional pumping reductions. As noted for Alternative 1, conclusions with respect to the impacts of Alternative 2 measures on minority populations in the HCP Planning Area are difficult to draw.

4.6.2.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Under Alternative 3, the impacts to new users would be greater than those estimated for Alternatives 1 and 2, but may not disproportionately affect new users, since more existing groundwater users would be required to convert to alternative supplies as well. As noted for Alternatives 1 and 2, however, it is difficult to draw conclusions with respect to the potential impacts of Alternative 3 measures on minority populations in the HCP Planning Area.

4.6.3 Low-Income Populations

As noted in Section 4.6.1 above, the water supply conversion measures that are present in varying degrees in all three alternatives would generally make the HCP Planning Area less affordable for new residents due primarily to the cost of providing new infrastructure. Any additional housing costs represent a disproportionate cost for low-income persons, who must allocate a higher proportion of their budget to housing and water, and who may be priced out of the residential housing market in the HCP Planning Area.

All three of the PDEIS alternatives imply the need for supplemental water supplies to meet projected demands in the HCP Planning Area as a result of measures requiring aquifer withdrawal limitations on the Edwards Aquifer. The required conversion to surface water supplies in Alternatives 2 and 3 (Measures 1.4.1, 1.4.3 and 1.4.4) would mean that the cost of new infrastructure would be passed on to HCP Planning Area consumers. These higher water rates would represent a loss of net economic benefits or real income to water-supply consumers, as they must forego expenditures on other goods and services to pay these higher water bills. The water rates in the HCP Planning Area currently may be lower than those of other similar residential areas, owing to the cheaper groundwater component, so the degree to which higher water rates may be an obstacle to low-income persons in the Planning Area is not certain.

4.6.3.1 Alternative 1: No Action

Alternative 1 includes the fewest measures to restrict water use from the Edwards Aquifer in the HCP Planning Area. Any potential adverse effects to low-income populations which might arise as a result of the measures would, therefore, be least under this alternative.

4.6.3.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

In addition to the measures proposed in Alternative 1, Alternative 2 includes measures that would decrease pumpage under permit to 10-13 cfs, facilitate the acquisition of open space, increase surface water supplies, and require additional pumping reductions. Any potential impacts to low-income populations would be higher for Alternative 2 than for Alternative 1.

4.6.3.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Under the additional Alternative 3 measures, the impacts to new users would be higher than for Alternatives 1 and 2, but may not disproportionately affect new users, since more existing users would be required to convert to alternative supplies as well.

In summary, Alternative 1 is least likely to negatively impact low-income populations in the HCP Planning Area, while Alternative 3 is most likely to negatively impact these low-income populations. The positive impacts of enhancing the recreational qualities of the springs and adjoining recreation areas which would be greatest for Alternative 3 are not likely to be substantially different for low-income populations.

4.6.4 Community and Public Resources

The three PDEIS alternatives evaluated would have varying direct and indirect effects on community and public resources in the HCP Planning Area. Such resources would include governmental facilities and services including police and fire protection, medical services, schools, botanical gardens, libraries, as well as recreational facilities such as Zilker Park and Barton Springs Pool.

Direct effects of the alternatives on community and public resources would depend on the severity of pumping limits and reductions, type of resource involved, and location within the region. Within the overall types of community and public resources, little or no impact would occur to the functioning of governmental facilities, schools, libraries, medical services, museums, zoos, and botanical gardens. Limitations in the use of Edwards Aquifer water that might result in reduced functioning of essential services could adversely affect human health or safety, or result in loss or degradation of a public resource and would require the acquisition of supplemental alternative water supplies. Recreational facilities such as swimming pools, golf courses, coliseums, and parks may be moderately or substantially affected depending on pumping limits and water use restrictions during drought periods. Landscapes associated with community and public resource infrastructure that include water fountains and hydrophytic (high water demand) grasses, trees, and shrubs could also be moderately to severely affected by measures to reduce aquifer water use.

While constructed recreational facilities may be adversely impacted, natural water-based recreation, primarily swimming in Barton Springs and canoeing on lower Barton Creek, associated with the Edwards Aquifer would be positively impacted by all measures to restrict aquifer withdrawals. Recreation in Zilker Park, especially Barton Springs, affects local trade and service sectors, and contributes heavily to the community's perception of a high quality of life.

All three of the PDEIS alternatives considered include pumpage levels and reductions that would require the development of supplemental water supplies to meet projected needs. The construction of these water supply projects would necessarily require the commitment of community and public resources. Financing the construction of needed water supply infrastructure would likely require the long-term commitment of community financial resources in addition to end user cost recovery by private sector suppliers. The dedication of these public revenues for the duration of the required financing term would represent a substantial long-term commitment of community financial resources, amounting to a net loss of economic benefits as community income would be diverted from other expenditures to pay higher water rates needed to meet debt service, as well as operation and maintenance requirements for the new capital facilities.

4.6.4.1 Alternative 1: No Action

Alternative 1 would have the least adverse effects on community and public resources within the HCP Planning Area. Community and public resource facilities would face restrictions imposed by conditional permits. The extent of these restrictions would depend on the specific measures in the required User Conservation Plans (Measure 1.2.3) and User Drought Contingency Plans (Measure 1.2.4). In addition, during drought periods (Measures 2.0 and 3.0), these restrictions would increase. However, under the Alternative 1 pumping limits and drought period restrictions, community and public resource facilities providing services essential for the public welfare would experience no serious impacts. If necessary to support essential services needed to maintain public health and safety, it is assumed that alternative sources of water would be developed.

It is likely that the indirect impacts to community and public resources of Alternative 1 would also be minimal. In the short-term, it is possible that the construction of new public recreation facilities could be postponed, or existing schools and libraries could have less money available for maintenance and improvements if alternate and higher cost water sources were developed to meet local demand. In the event of prolonged drought periods, uncertainty could affect local employment and population growth, creating additional restrictions for the financing of community resources. Overall, however, Alternative 1 measures would not be expected to substantially reduce the local economy or tax base needed to fund the maintenance and operation of public facilities.

4.6.4.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

In addition to the measures proposed in Alternative 1, Alternative 2 would establish withdrawal limits on pumpage under permit from 10 to 13 cfs (Measure 1.1), facilitate the acquisition of open space, increase surface water supplies, and require additional pumping reductions. Community facilities would be faced with meeting higher water conservation needs, potentially having less available water to operate and maintain their facilities, particularly landscaping. In addition, community facilities would be forced to reconcile increasing water rates needed to support new alternative water projects with other operational budget increases, thus detracting from their ability to continue their activities at current levels.

Measure 1.3.3, Acquisition of Undeveloped Land, would potentially increase the amount of public open space available for community recreation in the HCP Planning Area.

As a result of the reduced pumpage under permit limit mandated in Alternative 2, community facilities such as public swimming pools and sports fields that require irrigation for summertime use and are dependent on groundwater could experience reduced hours of operation. Cities, water supply corporations and water districts in the HCP Planning Area could impose watering schedules. Demand for water from alternative water sources would increase. Without alternative sources of water, community facilities could face substantial water conservation measures under Alternative 2. Under the Alternative 2 limits and drought period restrictions (Measure 3.3), essential community services including police, fire, medical, and other emergency services would experience no serious impacts, as it is assumed that alternative sources of water would be developed to protect public health and safety.

Under worst-case drought conditions, communities may have to adjust operational budgets to purchase more expensive alternate water sources, a substantial cost that would detract from their ability to fund other community facilities and services. There could be reductions in available resources for non-essential public facilities. For instance, the construction of new public recreation facilities could be postponed, and existing schools and libraries could have less money available for maintenance and operation. Overall, Alternative 2 would limit the amount of Edwards Aquifer water available for future community and public resources and could restrict the growth of the local economy and the tax base needed to support the maintenance, operation, and expansion of public facilities. Such impacts would be moderated because the amount of water supplied from groundwater sources would be a very small fraction of the total future water demand.

4.6.4.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

The direct and indirect effects of Alternative 3 measures on community and public resources would be similar to those experienced under Alternatives 1 and 2, but would be experienced to a greater extent.

4.6.5 Summary of Impacts to Social Resources

The three PDEIS alternatives evaluated would have similar social resources impacts but would differ in terms of degree. As the need for the development of surface water and alternative supplies increases with additional limits and restrictions on aquifer use, new users could be more likely to be impacted by somewhat higher costs for housing and water service. Other factors equal, a substantial proportion of people expected to move into the HCP Planning Area could be of Hispanic ethnicity. As with any increase in costs, low-income and minority populations are likely to feel the burden more acutely and some may be priced out of the HCP Planning Area residential market. Community resources and facilities may face reduced budgets if an increased proportion of public budgets are diverted to the development of alternative water supplies. However, in the long term, shifts to alternative water supplies and the associated cost adjustments for new development are probably inevitable and also more reliable, regardless of the District's actions under these alternatives, given the regional trends of urban land use and development. All three alternatives would tend to promote a more water-wise consciousness among consumers, an overall beneficial change in the social fabric of an area that has finite supplies of water from all sources.

Measures in all three alternatives that would support the persistence of adequate springflow at Barton Springs would sustain and protect one of the key recreational and quality of life resources in the HCP Planning Area.

4.7 Economics

Consequences to the economic resources of the District's HCP Planning Area identified in Chapter 3 Affected Environment (Section 3.7 Economy) are presented in this section for each of the three PDEIS alternatives. The HCP Planning Area comprises a relatively small part of the regional economy as described in Section 3.7. The HCP Planning Area includes urban areas in south central Travis County, including portions of the City of Austin, but is largely comprised of rural and suburban parts of southwestern Travis and northern Hays counties. Consequently, the HCP Planning Area does not, with some exceptions, include the major economic facilities and entities that have driven the rapid expansion of the Austin regional economy. Potential economic impacts of the three alternatives will depend, to a substantial degree, on the regional economic context within which the alternative water management measures would be implemented.

Several major road construction projects, especially S.H. 130 and S.H. 45 Southwest and Southeast, will soon be completed in the HCP Planning Area and are likely to support the introduction of important new residential, commercial and manufacturing facilities in the central and eastern part of the HCP Planning Area. The planned intersection of S.H. 130 and S.H. 45 Southeast in the eastern portion of the HCP Planning Area would represent a particularly high potential for the location of large-scale economic developments, including regional retail malls, multi-family residential and high-tech industrial plants similar to existing plants located elsewhere in the Austin area. The availability, quality, reliability and cost of municipal and industrial water supplies to this potential growth area could have substantial repercussions for the future economic development of the HCP Planning Area. Recent studies of the expected economic impacts associated with the construction of S.H. 130 have confirmed the potential for substantial future growth in this new highway corridor (TxDOT, 2006). Economic growth related to S.H. 130 and S.H. 45 is just beginning and will likely continue over the next thirty years or more. The construction of S.H. 130 in combination with the provision of other required utilities and subordinate roadways (especially major arterials connecting to the IH 35 corridor), including water and wastewater facilities, and the renewed growth of the existing regional high tech complex in the Austin area could form the basis for a nascent advanced technology growth pole or corridor along S.H. 130.

The concept of the growth pole—a group or cluster of industries that are centered on and linked with one or more propulsive industries in a close set of market relationships and that form a center of growth and dynamism in an economy—has been widely applied in regional economics both as an explanation for the geographical clustering of particular industries and as a policy model for understanding economic growth in rural regions. Propulsive industries are groups of key industries whose interaction and expansion can provide a stimulus to growth. They are conceived as having certain characteristics, principally technological sophistication, strong forward and backward links with the other industries forming the group, and expanding demand for their products (Pearce, 1986).

The development of propulsive industries is held to affect the rest of the economy both by generating demand for the products of other industries as inputs, and through imitation, by stimulating innovation and technical progress. Both the Samsung Electronics and Dell Computer complex components fit into these regional economic development paradigms. A reasonable conclusion, in terms of the potential economic context of the HCP Planning Area, could be that these types of facilities represent potential propulsive industries that could, given the development of S.H. 130 and support infrastructure in the Saline Water Zone portion of the HCP Planning Area, rapidly drive the development of a high tech growth corridor focused around the computer and microelectronics industries, as well as suburban residential development in the District that is directly or indirectly supported by such industries located either inside or outside of the District.

4.7.1 Alternative 1: No Action

Measures 1.2.1 through 1.2.5 and 1.2.7 would potentially reduce groundwater use in the HCP Planning Area through more efficient recordkeeping, education, conservation, drought management, and legislative regulatory requirements. All of these measures would have the effect of reducing the period and volume reliability of municipal and industrial groundwater supplies to commercial and industrial users in the HCP Planning Area. Reliability of municipal and industrial water supplies is an important factor in the determination of industrial location decisions by major economic entities, especially high technology microelectronic plants, some of whom require a highly reliable water supply of as much as 3 mgd or 5.6 cfs. Many such industries who might want to locate facilities in the HCP Planning Area along S.H. 45 or S.H. 130 would likely respond to the lower reliability of Edwards supplies by developing alternative surface water supplies which would, of course, involve additional site development costs. These higher costs could put potential industrial locations in the HCP Planning Area at a competitive disadvantage, at least relative to similar locations with reliable surface water supplies already in place. The lower cost of Edwards Aquifer groundwater supplies would, on the other hand, be a factor that would contribute to the competitive advantage of locations in the HCP Planning Area, especially for industries that do not have a strong need for highly reliable water supplies. The net effect of these opposing impacts is hard to predict, but for specific industries, such as high technology microelectronics manufacturers, the measures would probably represent a minor deterrent to locating in the HCP Planning Area, potentially reducing the area's future economic growth potential.

Several of the measures included in Alternative 1, especially the need for User Conservation Plans and User Drought Contingency Plans, would increase the reporting and monitoring requirements on businesses in the HCP Planning Area, imposing additional administrative and accounting costs. These types of costs are not unexpected for any area and therefore should not have a major negative impact on the economic resources of the area.

Measures 2.1 through 2.3 include additional measures employed after the declaration of Alarm Stage Drought. Measure 2.2 would require 20 percent reductions in permitted pumping when Alarm Stage Drought Triggers are reached. As noted above, measures that would have the effect of reducing the period and volume reliability of municipal and industrial groundwater supplies to commercial and industrial users in the HCP Planning Area, such as the Alarm Stage Drought Reductions, might require the development of alternative surface water supplies to supplement needed supplies during Drought Stage

Reductions. This would involve additional site development and ongoing costs, and could put potential commercial and industrial locations in the HCP Planning Area at a competitive disadvantage relative to similar locations with reliable surface water supplies already in place. Such conditions could foster development of alternative supplies by third parties.

Measure 3.1 would impose additional reductions in permitted pumpage during drought declarations by requiring a 30 percent reduction in permitted pumpage during Critical Stage Drought. This measure could substantially increase uncertainty and affect costs for developments located within the HCP Planning Area. As noted above for the measures in 2.0, these measures would have negative economic effects on existing and prospective development in the HCP Planning Area, as long as alternative supplies were not available. Those same cost drivers would encourage the recycling and beneficial reuse of wastewater associated with various developments, which offsets both economic and environmental negative impacts.

4.7.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Measure 1.1 would establish a regulatory-based withdrawal limit on pumpage under permit that would range from 10 to 13 cfs, would have economic consequences very similar to those noted for Measures 1.2, Ongoing/Continuing Demand Reduction Measures. These measures would establish an absolute upper range of permitted pumping limits on Edwards groundwater withdrawals, and would provide a relative economic advantage to those users who have already acquired permitted firm-yield withdrawals from the District compared to those economic entities that would be required to develop higher cost surface water or alternative groundwater supplies. These differential effects would persist through time and provide market advantages to users with historic-use permits and market constraints to those without such permits. These market advantages would endow Edwards Aquifer historic-use permits granted by the District with considerable value should legislation be passed allowing the transfer of water use rights between users.

Measures 1.2.8 through 1.2.10 would substantially increase efforts to limit groundwater production in the HCP Planning Area. Measure 1.2.9 would impose stricter development requirements in the HCP Planning Area and potentially have the effect of increasing the cost of new residential, commercial, and industrial development. These efforts could put real estate developments in the HCP Planning Area at a distinct disadvantage relative to developments in areas not subject to the stricter development requirements, reducing sales, property values, and local income in the real estate development sector of the economy.

These measures could largely offset the relative cost advantage offered by the availability of high quality and low cost Edwards Aquifer groundwater to developers in the HCP Planning Area. As such, the Alternative 2 measures could represent a moderate negative impact to the HCP Planning Area economy relative to Alternative 1.

Measure 1.3.3 would reduce the available supply of developable land in the HCP Planning Area through a combination of land acquisition efforts. A reduction in the supply of developable land in an area that is experiencing substantial demand for new development could result in an increase in the cost of land remaining for development. A potentially higher cost of land would result in higher residential, commercial and industrial development costs. Residential housing could be the most severely affected as these higher costs would be passed on, increasing the price of new residential homes in a highly competitive local real estate market. Higher housing costs would imply the need to market properties to higher income buyers, typically a smaller segment of the housing market than moderate-income buyers. This could result in changes to housing development patterns and resulting economic values.

Measure 1.4.1, the increased development of surface water supplies in the HCP Planning Area, would also have a similar effect on development costs, reducing the relative price advantage provided by low-cost Edwards Aquifer groundwater supplies. This measure would differentially favor property owners and developers who have already secured withdrawal permits, especially historic-use permits, to serve existing and proposed developments relative to those who will have to rely upon surface water supplies for future development needs.

Measure 1.4.3, 1.4.4, and 1.4.5 would encourage the development of conjunctive use of Edwards Aquifer groundwater with surface water or other alternative sources. This measure would entail the development of a parallel or dual water supply system infrastructure along with the current Edwards Aquifer groundwater supply system. As with the measures above, the additional capital and operating costs associated with the provision of a new surface (or alternative groundwater) supply system would contribute to higher development costs throughout the HCP Planning Area. These higher costs could eliminate the comparative advantage enjoyed by developments using low-cost Edwards Aquifer groundwater relative to developments requiring higher cost surface supplies, or in some circumstances, possibly result in relatively higher infrastructure costs associated with a dual supply system. Higher development infrastructure costs in the HCP Planning Area associated with dual supply systems would necessarily be passed on in the development process, resulting in higher priced or higher density end products on the local real estate market, perhaps impacting sales and related economic values as a result of price competition with nearby developments not required to have a dual supply system in place.

As in the No Action Alternative, Alternative 2 includes additional measures employed after the declaration of Alarm Stage Drought. Measure 2.2 would require 20 percent reductions in permitted pumping when Alarm Stage Drought Triggers are reached. Measures that would have the effect of reducing the period and volume reliability of municipal and industrial groundwater supplies to commercial and industrial users in the HCP Planning Area, such as Alarm Stage Drought Reductions, would require the development of alternative, typically surface water supplies to supplement needed supplies during Drought Stage Reductions. This would, in turn, involve additional site development costs, and could put potential commercial and industrial locations in the HCP Planning Area at a competitive disadvantage relative to similar locations with reliable surface water supplies already in place.

Measures 3.1 and 3.3 through 3.6 would impose additional reductions in permitted pumpage during Critical Stage Drought declarations. Measure 3.1 would require a 30 percent reduction in permitted pumpage during Critical Stage Drought.

Measure 3.3, additional pumping reductions on Historic Non-exempt Users and Conditional permittees, would have the same effect as the measures described above that reduce available groundwater withdrawals. In general, these impacts would have a negative economic impact in the HCP Planning Area based upon the same reasoning as noted above.

Measures 3.4 and 3.5, emergency response reduction measures, would also have the same negative economic impacts as described above. These measures, however, would likely be invoked very rarely and as a result would have moderate, but largely transitory negative economic impacts. Some negative economic costs would need to be incurred, however, on an ongoing basis, for users to prepare conservation and alternative supply measures needed to meet these emergency demand reductions without serious economic dislocations.

Measure 3.6, requiring mandatory switching to alternative supplies during Critical Stage reductions, would, in general, result in the same negative impacts to the local economy as noted for Measure 1.4.4, but would be much more limited in duration than the above measure. Mandatory switching would temporarily increase water supply operating costs during the relative brief Critical Stage periods. Capital costs associated with the infrastructure needed to make alternative supplies available for switching would need to be met by users in all aquifer conditions.

None of the structural mitigation investigations (Measure 4.0) or adaptive management strategies (Measure 5.0) should affect the HCP Planning Area economy in any way.

4.7.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Measure 1.4.4 would encourage the conversion of existing groundwater use to surface or alternative uses through the adoption of District rules or through increased water rates associated with increased groundwater pumping as an incentive to conversion. This measure could impose considerable infrastructure development and increases in operating costs on existing groundwater users in the HCP Planning Area. For most economic entities, these increased costs for conversion to surface water use would be passed on to end users (residents and businesses) and manifest in the form of higher capital costs and increased water rates to pay for the needed infrastructure and the higher cost of surface water treatment and distribution. These higher costs would tend to eliminate or neutralize the comparative cost advantage that current Edwards Aquifer permit-holders hold over surface water users. This effect could lead to a reduction in the rate of economic growth in the HCP Planning Area as real estate developments in the HCP Planning Area that are based on groundwater lose competitive price advantages.

Measure 1.4.5, cost participation in the construction of excess capacity of alternative water supplies, would represent a positive economic impact to groundwater users in the HCP Planning Area and tend to offset the negative impacts of Measure 1.4.4 noted above. The magnitude of cost participation by the District would determine the net impacts of these two measures. The required funding for the proposed cost participation would necessarily need to come from higher fees from permittees and would, to some extent, offset the positive economic impacts of this measure.

As in Alternatives 1 and 2, Alternative 3 proposing maximum measures includes additional measures employed after the declaration of Alarm Stage Drought. Measure 2.2 would require 20 percent reductions in permitted pumping when Alarm Stage Drought Triggers are reached. As noted above, measures that would have the effect of reducing the period and volume reliability of municipal and industrial groundwater supplies to commercial and industrial users in the HCP Planning Area, such as Alarm Stage Drought Reductions, would require the development of alternative surface water supplies. This would have the same effects as previously described for Alternatives 1 and 2.

Measures 3.1 through 3.6 would impose additional reductions in permitted pumpage during Critical Stage Drought declarations. Measure 3.1 would require a 30 percent reduction in permitted pumpage during Critical Stage Drought.

Measures 3.2 and 3.3, additional pumping reductions on conditional permittees, and, with legislation, on certain Historic Non-exempt Users would have the same effect as the measures described above that reduce available groundwater withdrawals. In general, these impacts would have a negative economic impact in the HCP Planning Area based upon the same reasoning as noted above.

Measures 3.4 and 3.5, emergency reduction measures would also have the same negative economic impacts as described above. These measures, however, would likely be invoked very rarely and as a result would have moderate, but largely transitory negative economic impacts. Some negative economic costs would need to be incurred, however, on an ongoing basis, for users to prepare conservation and alternative supply measures needed to meet these emergency demand reductions without serious economic dislocations.

Measure 3.6, requiring mandatory switching to alternative supplies during Critical Stage reductions, would, in general, result in the same negative impacts to the local economy as noted for Measure 1.4.4, but would be much more limited in duration than the above measure. Mandatory switching would temporarily increase water supply operating costs during the relative brief Critical Stage periods. Capital costs associated with the infrastructure needed to make alternative supplies available for switching would need to be met by users in all aquifer conditions.

None of the structural mitigation investigations (Measure 4.0) or adaptive management strategies (Measure 5.0) would directly affect the economy of the HCP Planning Area.

4.8 Cultural Resources

4.8.1 Types and Extent of Effects

This section summarizes the expected impacts of each of the alternatives on cultural resources in the HCP Planning Area. Cultural resources include pre-historic as well as historic artifacts and archeological sites. More detailed descriptions of the types of impacts that could occur are provided in Appendix G.

The overwhelming majority of possible direct impacts (whichever the Alternative), would be located along lower Barton Creek from Barton Springs to Town Lake (Colorado River). Under normal or above normal rainfall conditions, maximum and minimum water level elevations of lower Barton Creek (below Barton Springs Pool) are not anticipated to change appreciably as a result of implementing any of the alternatives. Under low flow conditions the frequency and duration of inundation is expected to vary under each of the three alternatives. As such, sites that currently are subject to varied water flows at Barton Creek and Barton Springs (sites immediately adjacent to the waterway channels) will continue to be impacted in much the same way as they are now while those that are not (sites on higher creek terraces) will most likely continue to be unaffected. Any affects from new pumping regulations or construction-related action will need to be assessed on a case-by-case basis once those locations are determined.

Alternatives Considered and Associated Effects

Natural and human impacts will result in varying degrees from implementation of any of the PDEIS alternatives. Generally, water levels are expected to be the same for this portion of the Barton Creek Watershed. Areas adjacent to Barton Springs will be the most affected by the alternatives, but even those effects will be relatively minor. Cultural resource sites potentially impacted by each of the three alternatives are listed in Table 4.8-1. More detailed descriptions of potential impacts are provided in Appendix G.

Table 4.8-1. Summary of impacts to cultural resource sites from water flow variations for each of the three PDEIS alternatives

Site Trinomial	NRHP/SAL	Barton Springs/ Barton Creek	Potential Impact of Alternatives		
			1	2	3
41TV1364	SAL	Barton Springs	Some potential impact	Some potential impact	Some potential impact
41TV2	SAL	Barton Springs	Some potential impact	Some potential impact	Some potential impact
41TV689	NRHP/SAL	Barton Springs	Will not be impacted	Will not be impacted	Will not be impacted
41TV690	NRHP/SAL	Barton Springs	Some potential impact	Some potential impact	Some potential impact
41TV197	N/A	Barton Springs	Some potential impact	Some potential impact	Some potential impact
41TV324	NRHP	Barton Creek	Will not be impacted	Will not be impacted	Will not be impacted
41TV1762	SAL	Barton Creek	Will not be impacted	Will not be impacted	Will not be impacted

Documented sites along Barton Creek that will not be impacted by any of the alternatives are listed in Table 4.8-2. Sites described as “Will not be impacted” are located sufficiently above the current water levels that any alteration in surface water flow would not affect any portions of the sites. Sites described as “Some Potential Impact” are close enough to the current watercourse that any alteration in surface water flow will most likely carry some impact to some portion of the site, however the extent of this impact is currently now known. As noted in 4.1.3, generally, all three alternatives carry minimal erosional potential, with Alternatives 2 and 3 containing the highest potential due to consecutively increased spring flow in the vicinity of Barton Springs. With all alternatives, there will be periods of time in which seasonally inundated archeological sites may be exposed and susceptible to human impacts (looting and modification). These human impacts are potentially more hazardous to buried archeological sites in the Barton Springs area than fluctuating water levels. Although all three alternatives are expected to have impacts on the identified archeological sites, Alternative 1 will likely carry the most impacts in relation to water level fluctuation while Alternatives 2 and 3 will have incrementally less impacts. Given the overall minimal adjustment in water flow and surface water levels with any of the plans, any impacts noted with one alternative will likely be seen in the others, but potentially in varying degrees.

Table 4.8-2. Documented archeological sites along Barton Creek that will not be impacted by any of the alternatives

41TV1379	41TV391	41TV384	41TV580
41TV357	41TV398	41TV377	41TV579
41TV338	41TV993	41TV386	41TV345
41TV588	41TV992	41TV387	
41TV389	41TV385	41TV704	

4.8.1.1 Alternative 1: No Action

Primary impacts would result from the frequency and duration of inundation of archeological sites. Greater fluctuation of flow would increase mechanical impacts from wet-dry cycling and erosion. Prehistoric ceramic artifacts, and typically preserved organic materials such as bone, pollen and shell would be the most adversely impacted during these cycles. The result would be the dissolution of these artifacts and loss of accompanying data. Biochemical impacts could result when water covers the sites. Primary results would be changes in soil composition and accompanying loss of information concerning the sites. The most susceptible organic materials to biochemical change would be wood, bone, pollen, and seeds. Generally, artifacts such as stone tools and other lithics would be least affected. With more frequent wet-dry cycles, effects of inundation would be exacerbated. Human impacts (primarily looting) may occur when previously remote sites become more accessible. This is considered to be the most important possible impact to archeological sites. A greater probability of impacts exists for sites adjacent to Barton Springs because the variability of flow would be greater than along Barton Creek. The flow fluctuations that lead to such cyclical inundations are already occurring, as a result of storm runoff in the Barton Creek watershed, and they will continue to occur to a similar extent with or without any of the alternatives evaluated here.

4.8.1.2 Alternative 2: Regional Permit, Best Practicable and Attainable Measures

Types of impacts described for frequency and duration of inundation of sites would be the same as those described for Alternative 1. Due to increased flows associated with the more restrictive Alternative 2 pumping limit, periods of exposure for normally inundated sites would be minimized during dry periods. This could reduce the potential of looting at these sites. Water level fluctuation will continue and human impacts remain a threat. But again, the flow fluctuations that lead to such cyclical inundations are already occurring, as a result of storm runoff in the Barton Creek watershed, and they will continue to occur to a similar extent with or without any of the alternatives evaluated here.

4.8.1.3 Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty

Types of impacts to archeological sites would be similar to Alternative 1. With maximum restrictions on pumping, this will result in the least decline in water levels below Barton Springs during dry periods. This will result in the least exposure of inundated sites and the shortest duration of this exposure, reducing the potential for human impact. But as with Alternatives 1 and 2, the flow fluctuations that lead to such cyclical inundations are already occurring, as a result of storm runoff in the Barton Creek watershed, and they will continue to occur to a similar extent with or without any of the alternatives evaluated here. Overall water level fluctuation will continue and human impacts will remain a primary threat to sites, even if not created by any alternatives for the HCP. The construction of water conveyance infrastructure needed to implement water recirculation and augmentation measures (4.0) could impact archeological and historical sites near the Barton Springs complex (See Section 3.9).

Potential for site impact on cultural resources as a result of water flow in the Barton Springs area is summarized in Table 4.8-1. More detailed descriptions of potential impacts are provided in Appendix G.

4.8.2 Summary of Potential Impacts by Alternative

Each of the three alternatives could have direct impacts on those sites that are situated immediately adjacent to Barton Creek and Barton Springs. Alternative 1 (No Action) would have the greatest effect on known archeological sites along the study corridor. Water levels would generally remain the same as they are now or would decrease over time. Impacts from erosion would be minimized as sites currently exposed would remain so. Reduction in water flow could expose additional, previously unknown elements of known sites to looting and inundation/exposure cycles. While consistent inundation or exposure maintains a general stasis of intact organic materials in a site (inundation still producing some negative effects) alternation between the two states causes notable and rapid degradation of the primarily organic materials' viability for further research, leaving generally only non-organic artifacts (burned rocks, flakes, stone tools, etc.) within the site boundaries. Looting can result in the destruction of all once-intact research elements, both organic and inorganic, as site integrity is rarely a concern of site looters.

Alternatives 2 and 3 would have similar impacts to those encountered in Alternative 1, with declining water levels. Under low flows there would be some small risk for exposure of artifacts to looting or human disturbance. Higher flows supported by Alternatives 2 and 3 would minimize such risk. Alternative 3 includes measures (4.0) that would require the construction of water conveyance infrastructure needed to implement water recirculation and augmentation measures. These construction activities could impact archeological sites near the Barton Springs complex.

Variations in the level of Barton Creek will probably not adversely affect any nearby historic buildings, but this may not be true for all types of cultural resources. It is important to note that the distributional patterning and density of archeological sites around Barton Creek and Barton Springs indicate that there is some possibility that any alternative will have an impact on cultural resources especially in undisturbed river bank deposits. Before any alternative measures are implemented a reassessment of any sites that would be impacted may be required. The type and amount of work required to effectively mitigate these effects would be coordinated between the District, City of Austin, and the SHPO in compliance with Section 106 of the National Historic Preservation Act (1966, as amended) and the Texas Antiquities Code. The scope of work should conform to the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation and Chapter 26 of the Texas Historical Commission's Rules of Practice and Procedure for the Antiquities Code of Texas.

4.9 Air Quality

No direct effects on local or regional air quality are expected to occur under any of the proposed alternatives. Air quality within a specific area is determined from a number of source activities including local and regional pollutant emissions combined with large-scale meteorological patterns and dispersal characteristics. Air quality within the HCP Planning Area is primarily influenced by human activity resulting from increased population growth in urban areas. Increased automobile usage and industrial emissions in urban and rural areas contribute to the degradation of air quality, which is subject to regulation by state and federal agencies. Air quality impacts associated with ongoing development will occur within the HCP Planning Area based on prevailing market conditions. Air quality impacts associated with such development are not a direct or indirect effect of any of the proposed alternatives.

4.10 Comparison of Direct Impacts by Alternatives

Direct impacts of the three alternatives with respect to the affected resources, as presented in Sections 4.1 through 4.9, are summarized for comparison in Table 4.10-1.

Table 4.10-1. Comparison of environmental consequences of the PDEIS alternatives

Affected Environment	Alternative 1: No Action	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Implementation Uncertainty
Physical Environment (Section 4.1)			
Climate (4.1.1)	Minimal or no impact.	Same as Alternative 1.	Same as Alternatives 1.
Geology (4.1.2)	Minimal or no impact.	Same as Alternative 1.	Same as Alternative 1.
Soils (4.1.3)	Minimal or no impact.	Same as Alternative 1.	Same as Alternatives 1.
Water Resources (Section 4.2)			
Surface Water (4.2.1)	Some effect to streamflow below recharge enhancement structures (Measure 1.3.1), otherwise minimal or no effects to creeks other than lower Barton Creek, where flows would be potentially higher.	Same as Alternative 1	Same as Alternatives 1 and 2.
Surface Water Quality (4.2.2)	*Lower Barton Creek:* Highly variable depending on contributions of localized runoff from rainfall events and mixing with groundwater discharge. *Other Creeks:* Minimal or no impacts.	*Lower Barton Creek:* Higher gains in water quality than Alternative 1. *Other Creeks*: Would provide more benefits than Alternative 1, but less benefits than Alternative 3.	*Lower Barton Creek:* Highest gains in water quality compared to Alternative 1 or 2. *Other Creeks*: Would provide higher benefits compared to Alternatives 1 or 2.
Groundwater (4.2.3)			
Projected Net Gain in Groundwater Availability from Water Management Measures (4.2.3.1)	4.0	7.0	11.1
Groundwater Quality (4.2.3.2)	Minimal or no impacts to existing water quality or future water quality degradation.	Will ameliorate future water quality degradation, but would not eliminate it completely.	Will ameliorate future water quality degradation to a greater extent than either Alternative 1 or 2, but would not eliminate it completely.

Table 4.10-1. Comparison of environmental consequences of the PDEIS alternatives (continued)

Affected Environment	Alternative 1: No Action	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Implementation Uncertainty
Aquifer-fed Springs (4.2.4)			
Barton Springs	Greatest adverse impacts to spring discharge; spring discharge below historical low (10 cfs) predicted to occur between 12 and 17% of the time.	Adverse impacts to spring discharge less than Alternative 1 but greater than Alternative 3; spring discharge below historical low (10 cfs) predicted to occur between 3 and 8% of the time.	Lowest adverse impacts to spring discharge; discharge below historical low (10 cfs) predicted to occur between 0.1 and 1% of the time.
Biological Resources – Regional (Section 4.3)			
Aquatic Resources (4.3.1)	*Lower Barton Creek:* Minimal to low negative impact in average years, with moderate to high negative impacts in driest years. *Other Creeks:* Minimal or no impacts.	*Lower Barton Creek*: Minimal to low positive impact in average years; increasing to moderate positive impact in drier or driest years. *Other Creeks:* Minimal or no impacts except for effects of on-channel detention structures that could have both positive or negative effects on aquatic organisms depending on location of structures and detention period.	*Lower Barton Creek:* Minimal to low positive impact in average years; increasing to high positive impact in drier or driest years. *Other Creeks:* Minimal or no impacts except for effects of on-channel detention structures that could have both positive or negative effects on aquatic organisms depending on location of structures and detention period.
Terrestrial Resources (4.3.2)	Low to moderate adverse impacts from on-channel detention structures and infrastructure associated with water development projects.	Similar impacts as Alternative 1; increasing supplies of surface water will result in a higher rates of development and corresponding higher rates of habitat conversion and loss, with some amelioration of adverse impacts through preservation of open space and development of xeriscapes that provide wildlife habitat value.	Same as Alternatives 1 and 2. Possible adverse impacts associated with development of water conveyance infrastructure needed to implement water recirculation and augmentation measures.

Table 4.10-1. Comparison of environmental consequences of the PDEIS alternatives (continued)

Affected Environment	Alternative 1: No Action	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Implementation Uncertainty
Biological Resources – Barton Springs (Section 4.4)			
Barton Springs Salamander	Highest risk of adverse impacts; Category V impacts occurring at a discharge of 4 cfs or lower predicted to occur between 4-8% of the time with longest duration of over 220 consecutive days.	Risk of adverse impacts lower than Alternative 1 but higher than Alternative 3; Category V impacts predicted to occur at a discharge of 4 cfs or lower between 0.3 and 2 percent of the time with longest duration between 62-120 days.	Lowest risk of adverse impacts; highest impacts would be Category IV predicted to occur at a discharge of 6 cfs between 0 and 0.2 percent of the time with longest duration of about 53 days.
Austin Blind Salamander	Impacts under Alternative 1 assumed to be the same as for the Barton Springs Salamander.	Impacts under Alternative 2 assumed to be the same as for the Barton Springs Salamander.	Impacts under Alternative 3 assumed to be the same as for the Barton Springs Salamander.
Agriculture and Urban Land Use (Section 4.5)			
Agriculture Production (4.5.1)	Minimal to low adverse impacts except during the most severe drought conditions when impacts could be moderate for crop irrigation and livestock watering.	Low to moderate adverse impacts.	Moderate adverse impacts.
Urban Land Use (4.5.2)	Minimal to no impact.	Low negative impact to the total quantity of urban development; potential negative impacts to the density, cost, location, and timing of new development.	Low to moderate negative impact to the total quantity of urban development; potential negative impacts to the density, cost, location, and timing of new development.
Social Resources (Section 4.6)			
Population Effects (4.6.1)	Low negative impact.	Moderate negative impact.	Slightly more negative impact than Alternative 2.
Minority Populations (4.6.2)	Low negative impact.	Low negative impact.	Low negative impact.
Low-Income Populations (4.6.3)	Low negative impact.	Moderate negative impact.	Slightly more negative impact than Alternative 2.
Community & Public Res. (4.6.4)	Minimal to low negative impact.	Moderate negative impact.	Slightly higher than Alternative 2.

Table 4.10-1. Comparison of environmental consequences of the PDEIS alternatives (continued)

Affected Environment	Alternative 1: No Action	Alternative 2: Regional Permit, Best Practicable and Attainable Measures	Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Implementation Uncertainty
Economics (Section 4.7)			
Local economic development	Low negative impacts.	Moderate negative impacts.	Moderate to high negative impacts.
Cultural Resources (Section 4.8)			
Barton Springs/ Barton Creek	Some potential impact to 4 archeological sites; minimal or no impacts to 21 archeological sites.	Some potential impact to 4 archeological sites; minimal or no impacts to 21 archeological sites.	Some potential impact to 4 archeological sites; minimal or no impacts to 21 archeological sites. Possible adverse impacts associated with development of water conveyance infrastructure needed to implement water recirculation and augmentation measures.
Air Quality (Section 4.9)			
Local/Regional Air Quality	Minimal or no impact.	Minimal or no impact.	Minimal or no impact.

Impacts are described in relative terms, from minimal or no impact to high or severe. In those cases where potential impacts could vary or are relatively less predictable, a range is presented.

It is clear from the table that the most substantial impacts to the region's resources are driven by measures that affect aquifer pumping. The greatest positive impacts to the Barton Springs ecosystem are associated with Alternative 3: Regional Permit, Maximum Measures with Highest Costs and Increased Implementation Uncertainty. This alternative provides the greatest level of protection to the Barton Springs ecosystem and the Barton Springs salamander and Austin blind salamander by sustaining a higher level of water flow through the spring ecosystems and assures springflow during aquifer conditions that would most closely duplicate the drought of record. At the same time, this alternative provides the greatest uncertainty in the establishment of future water management policy, principally because it requires new state legislative action. It would provide the highest level of negative impacts on economic resources as it would require greater reliance on higher cost alternative water supplies reflected in higher development costs that could affect many economic sectors, primarily real estate development.

Under Alternative 1: No Action, there would be no HCP and no coverage provided by an ITP. The alternative would result in aquifer pumpage that would be higher than currently exists (future pumpage estimated at 13–16 cfs), with the least number of measures to encourage demand reduction or water supply enhancement. There would be lower economic impacts than for Alternatives 2 and 3, but Alternative 1 does not assure springflow if aquifer conditions occur that would be similar to the drought of record. Consequently, there would be no protection for the District or regulated pumpers from violation of the ESA in the event of species take during low or no springflow. Similarly, under Alternative 1 there would be little protection from failure of exempt as well as nonexempt well production due to declining water tables in the unconfined zone of the aquifer during critical drought periods.

Under Alternative 2, Regional Permit, Best Practicable and Attainable Measures, a pumpage withdrawal limit would be implemented by the District along with an array of measures to reduce groundwater demand, enhance supply of alternative water sources, and adapt management strategies to future changing conditions. These HCP measures and associated ITP would provide the District and its regulated pumpers with compliance under the ESA. Under conditions similar to the drought of record, some springflow is predicted at the low end of the pumpage range of 10 to 13 cfs, but not under the high end of the range.

Alternative 3, Regional Permit, Maximum Measures with Highest Costs and Implementation Uncertainty provides the highest number of HCP measures including the most restrictive pumpage withdrawal limits (7–10 cfs), maximum number of contingency measures in the event of low springflow, and maximum number of adaptive measures to address future changes in conditions. This alternative would assure springflow during aquifer conditions that would most closely mimic the drought of record, but would result in the highest negative economic impacts in the HCP Planning Area. This alternative would require the greatest number of regulatory and policy actions from the District Board and other involved governmental agencies including the Texas Legislature.

A comparison of direct impacts indicates Alternative 2 to be the most balanced alternative in consideration of biological, economic, and political realities.

Funding

A comparison of HCP funding levels is provided in Table 4.10-2. As there would be no HCP and no ITP under Alternative 1, no incremental funding would be required. Funding for Alternative 2, the proposed HCP, would require over the 50-year life of the ITP. As Alternative 3 incorporates the highest number of protection measures, required funding would total over the 50-year life of the ITP.

Table 4.10-2. Comparison of District HCP funding levels for the PDEIS alternatives

Alternative	District HCP Estimated Funding Level*
Alternative 1: No Action	No funding commitment for District HCP needed.
Alternative 2: Regional Permit, Best Practicable and Attainable Measures	$ 550,000/yr distributed over the 50-year life of the ITP; (See Table 6.8-1 for distribution of estimated costs)
Alternative 3: Regional Permit, Maximum Measures with Highest Cost and Increased Implementation Uncertainty	$ 550,000/yr distributed over the 50-year life of the ITP; (See Table 6.8-1 for distribution of estimated costs)

*Funding based on estimates of District HCP measures in 2007 dollars.

4.11 Indirect and Cumulative Impacts

4.11.1 Indirect Impacts

The Council on Environmental Quality (CEQ) defines indirect (or secondary) impacts as those "…caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect impacts may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR § 1508.8). These induced actions are those that would not or could not occur except for the implementation of the proposed project. Recent agency guidance documents (CEQ 2005; FHWA 2003) on preparation of cumulative and indirect effects assessments emphasize that these assessments should focus on individual resources such as surface water, land, or wildlife habitat, as well as on the overall effects on the human and natural resources of the project area.

Indirect impacts on the HCP Planning Area environment are the indirect or induced impacts arising from the direct impacts of the three alternatives. These direct impacts will be determined primarily by those measures that impose limits and reductions on the permitted production of groundwater in the HCP Planning Area and that, in turn, encourage the development of alternative water supplies. As Alternative 3 includes the most aggressive reductions and limitations, it is expected to generate the most induced and indirect effects in the HCP Planning Area.

The most substantial direct impacts associated with the measures for the three alternatives include (1) the reduction in available groundwater supplies in the HCP Planning Area (Measures in 1.0, 2.0 and 3.0; (2) the encouragement of the development of alternative water supplies to the HCP Planning Area (Measures 1.4.1–1.4.5); and (3) the development of water supplies and infrastructure needed to implement recirculation and augmentation measures identified in Measure 4.0 Structural Mitigation Investigations and Measures. To a lesser extent, direct impacts would also result from the contribution of Measure 1.3.3 to the reduction of land available for development through the preservation of undeveloped open space. Indirect impacts arising from these direct impacts would primarily have implications for the character and pace of future urban and economic development of the HCP Planning Area. These indirect impacts have been discussed for each of the three alternatives in Sections 4.5, 4.6, and 4.7.

In summary, indirect impacts to agricultural production and landscape development and maintenance from the Alternative 2 measures could be, in general, more substantial than those for Alternative 1 because of additional limitations and reductions on aquifer water use and open space acquisition, but less substantial than Alternative 3, with the level of adverse effects being related to the dependency of agricultural production and landscape maintenance on irrigation. Indirect impacts to urban development under Alternative 2 would, in general, be more substantial than those under Alternative 1 because of open space acquisition and stricter development requirements. Indirect impacts of Alternative 2 to social resources would, overall, reduce the amount of Edwards Aquifer water available for community and public resources and could restrict the growth of the local economy and the tax base needed to support the maintenance, operation and expansion of public facilities.

An additional indirect effect of Structural Mitigation Investigations and Measures (Measures 4.0) in Alternatives 2 and 3 could be the perception by some stakeholders that structural measures to recirculate and augment water to the springs could potentially have the effect of reducing the perceived need for shifting to alternative water supplies for future growth, and/or for compliance with land use and development regulations (such as limits on impervious cover) in the recharge and contributing zones, to the detriment of water quality and spring-dependent species.

4.11.2 Cumulative Impacts

The CEQ defines cumulative impacts as "…the impact on the environment which results from the incremental impact of the proposed action when added to other past, present and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR §1508.7).

4.11.2.1 Resources Included in Cumulative Impact Analysis

Recent agency guidance documents (CEQ 2005; FHWA 2003) on preparation of cumulative and indirect effects assessments emphasize that these assessments should focus on individual resources such as surface water, land, or wildlife habitat, as well as on the overall effects on the human and natural resources of the project area. The resources addressed in the cumulative impacts assessment include surface water, ground water, biological resources, land, and social and economic resources. The goal is to determine whether the proposed action's direct and indirect impacts, considered with other past, present and reasonably foreseeable actions, would result in substantial degradation of a resource that would not result from the proposed action considered alone. The analysis will give particular attention to resources that are currently in poor or declining health or at risk, even if project impacts are relatively small. In some cases, the geographic limits of the study area for a particular resource may be different from those of the HCP Planning Area, owing to the way in which data for that resource are collected and reported.

4.11.2.2 Current Condition/Health of the Resource

This section briefly summarizes the historical context, existing condition, and trends of the five resource categories to be analyzed for cumulative impact. This summary includes past and present actions as defined by CEQ guidelines. Another element in characterizing current resource conditions is the collection of plans, programs, and policies implemented by other agencies or organizations that are intended to protect the human and natural resources of the region. These plans, programs, and policies are addressed in Section 4.11.2.3. For more information on existing conditions, see Chapter 3.

Surface Water

The Barton Springs segment of the Edwards Aquifer lies within the central portion of the Colorado River Basin. Discharge from the springs flows into Barton Creek, then into

Town Lake, an impoundment of the Colorado River. The base-flow of the Colorado River is affected by stream management as regulated by the TCEQ and the LCRA. The Colorado River Basin is characterized in the State of Texas Water Quality Inventory published by the TCEQ as having mixed levels of water quality (TCEQ 2002a). The water quality of the Highland Lakes is good, with periodic depressed DO concentrations resulting from seasonal mixing. Elevated nutrient levels and fecal coliform densities found in many of the Colorado's tributary streams in the Austin area originate mostly from unidentified non-point-source runoff.

The most significant recent trend in the provision of surface water supplies and wastewater services in the HCP Planning Area is the increasing availability of these services to new residential, commercial and industrial development from large, centralized providers, including cities, municipal utility districts, river authorities and private water supply corporations. This trend has been driven by the accelerated increase in demand for urban and suburban land uses from rapidly growing cities, particularly in and adjacent to Austin, into formerly rural and agricultural areas. Municipal and industrial water supplies, mostly from the Highland Lakes, and wastewater services are currently provided to a large part of the HCP Planning Area by a number of river authorities, municipalities, water supply corporations and special utility districts.

Groundwater and Aquifer-fed Springs

The Barton Springs segment of the Edwards Aquifer provides municipal, industrial, agricultural, and domestic uses for about 50,000 people (BSEACD 2005A). Long-term average annual recharge to the aquifer is currently estimated at about 61.5 cfs (Raymond Slade, personal communication 2006).

Discharge from the aquifer is primarily from springflow and pumpage from wells in the HCP Planning Area. Average long-term annual discharge from Barton Springs is estimated to be about 53 cfs or 38,000 acre-feet per year (BS/EACD 2004), while Cold Springs and Deep Eddy Springs together contribute about 5.5 cfs or 3,900 acre-feet per year (Raymond Slade, personal communication). High water marks occurred in 1935, 1991, and 1995. Barton Springs pool has been closed to the public a number of times since the 1980s due to unsafe levels of fecal coliform bacteria in its waters arising from surface runoff of impaired quality that overtops the upper dam and enters the pool directly from Barton Creek. Studies by the City of Austin (2005h) also indicate a long-term gradual decline in water quality in the discharges of Barton Springs itself (Section 4.2.3.2).

Most permitted pumpage is for municipal and industrial purposes, and most of the permitted pumpage occurs in the southeast part of the aquifer. Permitted pumpage in 2004 is estimated to have been 2.3 billion gallons (7,060 acre-feet or 9.75 cfs). Non-permitted pumpage, such as agricultural and domestic supply, is estimated to be about

200 million gallons per year. Combined, these pumping rates are about 2.5 billion gallons per year (7,818 acre-feet per year) and equate to a mean pumping rate of about 10.8 cfs for 2004. See Section 1.1.2.2 and Appendix E for more complete descriptions on the management and use of groundwater in and near the vicinity of the HCP Planning Area.

Biological Resources

The HCP Planning Area is rich in biodiversity. It encompasses a range of terrestrial habitat types, many of which are suitable to many common wildlife species in addition to several rare or otherwise sensitive species endemic to the area. Due to rapid urbanization, the area within and near the HCP Planning Area exhibits continuing threats of habitat loss for terrestrial wildlife, including the endangered black-capped vireo and golden-cheeked warbler, as well as one endangered aquatic salamander, and seven endangered karst invertebrates.

The Barton Springs salamander was federally-listed as endangered on April 30, 1997, while the Austin blind salamander was identified as a candidate for listing on June 13, 2002. Monthly surveys conducted from 1993 to 2003 resulted in Barton Springs salamander observations ranging from 1 to low hundreds (City of Austin 1998a; USFWS 2004). Habitat restoration in Eliza Spring in 2003 dramatically altered these observations with a peak of 738 individuals occurring at this spring in the fall of 2006, in spite of a prolonged summer drought and resulting low flows. (City of Austin 2006).

Since the Austin blind salamander occupies a more subterranean habitat than the Barton Springs salamander, most of the observations of this species have apparently been of more mobile juveniles that were accidentally flushed out of their underground habitat. Substantially fewer Austin blind salamanders than Barton Springs salamanders have been observed by City of Austin biologists during regular surveys. From January 1998 to February 2002, there were only 120 documented observations of the Austin blind salamander compared to 2,059 Barton Springs salamander observations during the same time frame (Hillis 2001). See Chapter 3, Section 3.2.2 for biological resources most affected by changes in aquifer levels and springflow.

Land Use

As more fully described in Section 3.2.1.1, land within the HCP Planning Area straddles the Edwards Plateau and the Blackland Prairies ecological regions, representing a major geological, physiographic, and ecological transition zone in Texas that results in a diverse landscape. The Edwards Plateau ecological region encompasses approximately 24 million acres, including a large portion of the Hill Country in west-central Texas, as well as the Llano Uplift and Stockton Plateau regions. The Blackland Prairies ecological region consists of nearly level to gently rolling topography. It has been estimated that less than one percent of the once extensive Blackland Prairies landscape remains in a near natural condition (Smeins and Diamond 1986). The key pattern of historic development in recent years has been the rapid urbanization of the HCP Planning Area, involving a transition from rural/agricultural land uses to low-moderate density urban land uses, particularly in the north-central portion of the HCP Planning Area.

Social and Economic Resources

The HCP Planning Area is part of the rapidly growing Austin area economy (See Section 3.0). The prospect for accelerated high technology industrial development in the HCP Planning Area appears to be substantial, driven by a number of factors. These include the renewed growth of the existing regional high technology complex in the Austin metropolitan area, exemplified by the substantial expansion of the Samsung Electronics semiconductor manufacturing plant in 2006 and 2007; improvements to the regional transportation network within the HCP Planning Area, including SH 130 and SH 45 as well as major arterials connecting to the IH 35 corridor; and an expanding water and wastewater infrastructure provided by cities, river authorities, special districts and water supply corporations. A reasonable conclusion, in terms of potential cumulative socioeconomic effects, could be that the development of SH 45, SH 130 and support infrastructure will also influence growth in the HCP Planning Area, particularly the development of a growth corridor along these major facilities focused on high technology industries. Social and Economic Resource Conditions are more fully described in Sections 3.5 through 3.7. Projected growth in the HCP Planning Area is discussed in Section 3.5.3.

4.11.2.3 Policies, Plans, and Programs in the HCP Planning Area

Recognition of the need to protect water, land, and biological resources in the Austin metropolitan region and the HCP Planning Area has given rise to a variety of regulations, plans and programs to protect these natural resources. Table 4.11-1 describes the primary plans, ordinances, and programs initiated by a variety of agencies, with a summary of general effects on surface and groundwater resources, land, biological, resources, and social and economic resources in the region.

4.11.2.4 Reasonably Foreseeable Actions in the HCP Planning Area

Table 4.11-2 identifies reasonably foreseeable future actions that may contribute to the cumulative impacts to resources in the HCP Planning Area. These actions are likely to occur (and in some cases are well underway) in the foreseeable future, regardless of which HCP alternative is selected as the Proposed Action. The future actions considered in the analysis include transportation projects, public and private utilities, and private real estate developments. Table 4.11-2 describes each action and provides a general profile of its potential affects on surface and groundwater, land, biological resources, and social and economic resources of the HCP Planning Area.

Table 4.11-1. Public plans, policies, and programs considered in the cumulative effects analysis

Public Plans, Policies, & Programs	Description	Potential Effects on Resources
District Drought Contingency and Conservation Plans	The District requires User Conservation Plans (UCPs) and User Drought Contingency Plans (UDCPs) for five categories of users, including: agricultural, commercial, industrial, public water suppliers and general. The UDCP is guided by the Drought Contingency Plan of the District and must comply with the Drought Contingency Rules of the District, sections 3-7.6 and 3-7.7. Its intent is to maintain an adequate supply of water during the various stages of periodic drought.	Management of withdrawals from the aquifer by existing and future developments during drought and non-drought conditions is likely to result in higher index well levels; higher springflows; beneficial impact to biological resources; and more reliable groundwater production for wells in the unconfined zone.
District Groundwater Management Plan	The District's groundwater management plan, adopted in 2003, was required to meet the requirements of 31 TAC §356.5. It governs the overall management of groundwater in the District and will be revised to comply with the managed available groundwater determinations of HB 1763, 79th Legislature, in 2010.	Management of withdrawals from the aquifer by existing and future developments during drought and non-drought conditions to comply with managed available groundwater is expected to result in higher index well levels; higher springflows; and beneficial impacts to biological resources; and more reliable groundwater production for wells in the unconfined zone.
Groundwater Management Under H.B. 1763, 79th Legislature	The bill strengthens the joint management planning between groundwater conservation districts in a groundwater management area (GMA). This new statute requires districts to base their groundwater management plans on the "Managed Available Groundwater" that is determined by the Texas Water Development Board (TWDB) to be indicated by the "Desired Future Conditions" in the GMA established through joint regional planning.	Management of withdrawals from the aquifer during drought and non-drought conditions would lead to higher index well levels; higher springflows; beneficial impacts to biological resources; and more reliable groundwater production for wells in the unconfined zone.
USFWS Barton Springs Salamander Recovery Plan	The Recovery Plan includes planning and scientific research activities intended to generate information that will assist with management of the species and assessment of the success of the Recovery program for the Barton Springs salamander. Monitoring the implementation of those management actions is intended to ensure that management tools are appropriately and effectively addressing impacts on the species. Implementation of the Recovery Plan is strictly voluntary and dependent on the cooperation and commitment of numerous partners.	Beneficial impacts to endangered species; Increased knowledge of species requirements; development of management tools to monitor and manage species; and potential economic and social impacts from limitations on aquifer use.

Table 4.11-1. Public plans, policies, and programs considered in the cumulative effects analysis (continued)

Public Plans, Policies, & Programs	Description	Potential Effects on Resources
City of Austin and Other Municipality Water Quality Ordinances and Plans	The City of Austin has imposed watershed ordinances to require development standards for erosion and sedimentation control, impervious cover limits, stream or creek setback requirements and water quality control. Provisions of the various ordinances include impervious cover, development density, transfer of impervious cover or development rights, stormwater treatment and detention requirements, construction site management and stream setbacks or buffer zones. The City of Austin, and other adjoining municipalities including Dripping Springs, Sunset Valley, and Buda protect water quality through the Land Development Regulations that govern zoning, subdivision and the site plan process.	Beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quantity of surface water recharging to aquifer; higher quality aquifer water; beneficial impact to biological resources in springs ecosystem; change in character of new development in Contributing and Recharge Zones; and reduced land use development and density in Contributing and Recharge Zones with negative impacts to jobs, earnings, and output.
LCRA Water Quality Protection	LCRA's ordinances apply to portions of Travis County. LCRA regulates septic systems and construction that could lead to runoff within approx. 2,200 feet of the Highland Lakes. LCRA's Nonpoint Source Program consists of two ordinances that do not limit impervious cover; instead, the program is performance-based.	Beneficial impacts to surface water quality from stormwater control facilities and performance standards; higher quality water recharging to aquifer; higher quality aquifer water; beneficial impact to biological resources in springs ecosystem; and minor increase in development costs.
City of Austin Water Conservation Program	Program components include rebates for efficient appliances; water audits; waste reporting; and educational programs related to landscaping and irrigation.	Beneficial impacts to surface water quantity through demand reduction; change in character of landscape features in Contributing and Recharge Zones; decreased need for alternative water supplies; lower cost of water supplies.
City of Austin's HCP for Barton Springs Pool Management	Authorizes the incidental take of the federally protected endangered Barton Springs salamander that would result from the operation and maintenance of Barton Springs Pool and the adjacent springs.	Beneficial impacts to species habitat in Barton Springs Pool from more careful management procedures; and increased protection provided by Incidental Take Permit for City of Austin from an enforcement action under the ESA; beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quality aquifer water.

Table 4.11-1. Public plans, policies, and programs considered in the cumulative effects analysis (continued)

Public Plans, Policies, & Programs	Description	Potential Effects on Resources
Water Quality Measures by Local Cooperating Entities	The Regional Water Quality Protection Plan for the Barton Springs Segment of the Edwards Aquifer and Contributing Zone is an ongoing initiative to implement local groundwater protection measures not yet fully implemented by cooperating sponsors including the Cities of Dripping Springs, Austin, Buda, Kyle, Rollingwood, Sunset Valley, Bee Cave, the counties of Blanco, Hays, and Travis, and the BS/EACD , Hays-Trinity Groundwater Conservation District, and Blanco-Pedernales Groundwater Conservation District.	Beneficial impacts to surface and groundwater resources; higher quality aquifer water; beneficial impact to biological resources in springs ecosystems; change in character and cost of new development in Contributing and Recharge Zones; and increased implementation of stormwater quality BMPs in Contributing and Recharge Zones with negative impacts to cost of new development and related impacts to jobs, earnings, and output.
Region K Lower Colorado Regional Water Plan	The 2006 plan covers the 2000-2060-time period. It identifies the difference between available supplies and demand for each water user group as either a surplus or a need. Needs are estimated for each decade and a listing of potential alternative strategies to meet those needs is provided.	Alternative water supplies identified in Plan would reduce aquifer demand and increase springflow at Barton Springs; and beneficial impact on biological resources at Barton Springs Pool.
Hays Trinity Groundwater Conservation District	Included in Regional Water Quality Protection Plan for the Barton Springs Segment of the Edwards Aquifer and Its Contributing Zone	Beneficial impact to groundwater quantity and quality in the Trinity Aquifer providing an alternative water supply to District; and reduced demand for Edwards water; beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quality aquifer water.
TCEQ's Edwards Aquifer Protection Program	TCEQ promulgated rules regulating development activity in the Edwards Aquifer recharge, transition, and contributing zones. Certain facilities are also prohibited in the recharge or transition zones, such as Type 1 municipal solid waste landfills and waste disposal wells.	Beneficial impact to biological resources in springs ecosystem; change in character and cost of new development in Contributing and Recharge Zones; and increased implementation of stormwater quality BMPs in Contributing and Recharge Zones with negative impacts to cost of new development and related impacts to jobs, earnings, and output.

Table 4.11-1. Public plans, policies, and programs considered in the cumulative effects analysis (continued)

Public Plans, Policies, & Programs	Description	Potential Effects on Resources
TCEQ TPDES Regulations	(Described in detail in regulations section of water resources Section 3.3.1.4)	Beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quality aquifer water; beneficial impact to biological resources in springs ecosystem; change in character and cost of new development in Contributing and Recharge Zones; and increased implementation of stormwater quality BMPs in Contributing and Recharge Zones with negative impacts to cost of new development and related impacts to jobs, earnings, and output.
Clean Water Act, Sections 401 and 404, implemented by USACE	(Described in detail in regulations section of water resources Section 3.3.1.4)	Beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quality aquifer water; beneficial impact to biological resources in springs ecosystem; change in character and cost of new development in Contributing and Recharge Zones; and increased implementation of stormwater quality BMPs in Contributing and Recharge Zones with negative impacts to cost of new development and related impacts to jobs, earnings, and output.
Balcones Canyonlands Conservation Program	The BCCP is a 30-year regional permit that allows for incidental take of eight endangered species outside of proposed preserve lands, and provides mitigation for new public schools, roads and infrastructure projects of the participating agencies (Travis County, the City of Austin, and the LCRA). A minimum of 30,428 acres of endangered species habitat in western Travis County make up the Balcones Canyonlands Preserve, including karst (cave) features and rare plants.	Beneficial impacts to surface water quality; higher quality water recharging to aquifer; higher quality aquifer water; beneficial impact to biological resources in springs ecosystem; change in character and cost of new development in Contributing and Recharge Zones; and increased implementation of stormwater quality BMPs in Contributing and Recharge Zones with negative impacts to cost of new development and related impacts to jobs, earnings, and output.

Table 4.11-1. Public plans, policies, and programs considered in the cumulative effects analysis (continued)

Public Plans, Policies, & Programs	Description	Potential Effects on Resources
Other plans, programs, and regulations by other entities	The Cities of Buda, Sunset Valley, Dripping Springs and the Village of Bee Caves have water quality protection ordinances (see Appendix E).	Same as above.

Table 4.11-2. Summaries of reasonably foreseeable actions and impacts to resources considered in the cumulative effects analysis

Reasonably Foreseeable Actions	Description	Type of Impact
Transportation		
S.H. 130	15-mile (in District HCP Planning Area) 4-lane controlled access toll way. Now under construction.	Induced land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution.
S.H. 45 SE	7-mile, 6-lane controlled access toll way. Expected completion date 2009.	Induced land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution.
S.H. 45 SW	3-mile, 4-lane toll parkway/freeway with non-tolled frontage roads. Included in CAMPO Mobility 2030 Plan.	Induced land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.
Trans-Texas Corridor 35	Multi-use route with vehicle and truck lanes; commuter railways; utility infrastructure; and transmission lines. TTC 35 would extend north-south across Texas; parts of two ten-mile wide study corridors overlap S.H. 130.	Induced land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution.

Table 4.11-2. Summaries of reasonably foreseeable actions and impacts to resources considered in the cumulative effects analysis (continued)

Reasonably Foreseeable Actions	Description	Type of Impact
Public and Private Utilities		
Austin-San Antonio Inter-municipal Commuter Rail	Planned rail district following the UP rail line west of IH 35 between Austin and San Antonio. Should this project be developed, and should rail be developed in conjunction with S.H. 130, these facilities together would enhance regional capabilities of rail transportation in central Texas.	Induced land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.
Planned Water Supply Projects	Various proposals under Region K & L Regional Water Plans to be implemented by: municipalities; river authorities; water supply corporations; and private developers. Several entities have announced plans to provide new surface and groundwater supplies to the HCP Planning Area. These supplies will represent alternatives to the use of Edwards groundwater for existing and new developments.	New infrastructure would facilitate land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater. Benefits would be derived by providing alternative water supplies to entities that otherwise would rely on the Edwards Aquifer, allowing conversion to surface water supplies either entirely or through conjunctive use thus reducing demand on the aquifer and improving springflow.
Municipal Utility Districts (MUDs)	The provision of additional water and wastewater facilities and services by various municipal utility districts in the HCP Planning Area.	New water and wastewater infrastructure would facilitate land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.
Water Control & Improvement Districts	The provision of additional water facilities and services by various water control and improvement districts in the HCP Planning Area.	New water supply infrastructure would facilitate land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.

Table 4.11-2. Summaries of reasonably foreseeable actions and impacts to resources considered in the cumulative effects analysis (continued)

Reasonably Foreseeable Actions	Description	Type of Impact
Private Real Estate Developments		
Water Supply Corporations	The provision of additional retail water facilities and services by various private supply corporations in the HCP Planning Area.	New water supply infrastructure would facilitate land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.
River Authorities	The provision of additional water supplies, treatment, transmission, distribution and wastewater facilities and services by the LCRA, and GBRA in the HCP Planning Area.	New infrastructure would facilitate land use growth including increased residential, commercial and industrial development creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.
Various small to large scale private real estate development projects	The development of residential, commercial and industrial projects within the HCP Planning Area. Low-density single family and commercial projects are likely to occur in the western portion of the HCP Planning Area. Low and medium density residential, large scale commercial and industrial projects will likely occur in the eastern portion of the HCP Planning Area, especially along IH 35 and around the intersection of S.H. 45 SE and S.H. 130.	New private developments on undeveloped tracts, including increased residential, commercial and industrial land uses creating jobs, earnings and output; increased impervious cover; increased stormwater runoff and pollution; increased recharge of polluted water to aquifer; increased threat to biological resources from polluted groundwater.

Although climate warming is now considered a reasonably foreseeable event (IPCC 2001), with average temperatures over the southern Great Plains of the U.S. expected to increase 2–3 degrees Fahrenheit over the next fifty years, the impacts of this warming to regional precipitation, recharge and the Barton Springs ecosystem remain uncertain. As the State of Texas mandates use of the “drought of record” in both surface and groundwater planning, climate change effects, therefore, are not explicitly included in the estimation of cumulative effects on the HCP Planning Area’s resources.

4.11.2.5 Cumulative Impacts

For each resource, cumulative impacts were evaluated qualitatively in light of the following factors: the historical context and current condition and trend of each resource; the reasonably foreseeable actions that may adversely impact these resources; the pertinent regulations, programs, and policies designed to protect each resource from development pressures; and the proposed action. These factors address the influences that are likely to determine the current and future condition of each resource.

Because some of the policies and plans, including the proposed action, are designed to address the adverse trends and impacts from foreseeable actions to natural resources in the HCP Planning Area, this cumulative impacts analysis focuses on the “net” cumulative effects on each resource that remain after full compliance with the regulatory requirements at all levels.

Table 4.11-3 summarizes the cumulative impacts to identified resources of the past, present and reasonably foreseeable actions when added to the direct and indirect impacts estimated for each of the three PDEIS alternatives. A narrative discussion of the cumulative effects of the HCP alternatives on the various resources follows.

Surface Water

Past, present and reasonably foreseeable actions in the HCP Planning Area indicate that rapid urbanization will continue to occur with negative impacts to surface water quality as a result of increased impervious cover, polluted stormwater runoff and the discharge of treated wastewater into surface streams. Implementation of the policies and plans outlined in Table 4.11-1 would substantially mitigate these trends, but surface water quality would continue to decline. Alternative 1 does not include specific measures to sustain or improve surface water quality and would therefore not create direct or indirect effects that would influence the cumulative impacts on surface water quality in the HCP Planning Area.

Table 4.11-3. Cumulative impacts on resource categories of the PDEIS alternatives

Current Condition/Trend	Impacts From Past, Present, and Reasonably Foreseeable Actions	Effects of Policies, Plans, and Programs	Alternative 1	Alternative 2	Alternative 3
Surface Water (In-stream flows)					
Generally good, but deteriorating trend (quality)	Increased impervious cover, runoff, erosion and sedimentation in waterways (reduced quality).	Improved quality from stormwater quality protection measures; reduced demand from conservation programs.	Increases to Barton Creek flows below springs and inflows to Town Lake; continued declining quality of instream flows.	Increases to Barton Creek flows below springs and inflows to Town Lake; continued declining quality of instream flows.	Greatest increases to Barton Creek flows below springs and inflows to Town Lake; continued declining quality of instream flows.
Surface Water (M&I supplies)					
Provision of surface water supplies to HCP Planning Area	Increased provision of alternative surface water supplies to the HCP Planning Area; increased private development; increased provision of transportation facilities.	Increased use from utility developments and conversion from groundwater to surface water supplies.	Gradually increased conversion to surface water supplies.	Greater conversion to surface water supplies; greater rate of provision of surface water supplies.	Greatest rate of conversion to surface water supplies; maximum rate of provision of surface water supplies.
Groundwater and Aquifer-fed Springs (quality and quantity)					
Generally good, but deteriorating trend	Increased availability of surface water supplies; increased polluted runoff and sediments to aquifer; increased withdrawals due to growth in HCP Planning Area.	Limited withdrawals, demand reduction measures.	Demand reduction, conversion to surface and other supplies. Highest adverse cumulative impacts; continued declining quality and quantity.	Greater demand reduction and conversion to surface and other supplies; enforcement of additional demand reduction measures, open space acquisition. Medium adverse cumulative impacts; continued declining quality and slightly increased quantity.	Greatest demand reduction and conversion to surface and other supplies; enforcement of additional demand reduction measures, recirculation and augmentation of springflow. Lowest adverse cumulative impacts; stable quality and quantity.
Biological Resources					
Barton Springs salamander designated endangered	Reduced quality and quantity of groundwater could eventually lead to greater mortality and habitat modification resulting in "take".	Efforts to improve quality and reduce withdrawal of groundwater would benefit species.	Minimum demand reduction measures. Highest adverse cumulative impacts; rapidly increasing probability of take.	Moderate demand reduction measures; open space acquisition. Medium adverse cumulative impacts; moderately increasing probability of take.	Moderate demand reduction measures; open space acquisition; recirculation and augmentation measures. Lowest adverse cumulative impacts; minimal probability of take.

Table 4.11-3. Cumulative impacts on resource categories of the PDEIS alternatives (continued)

Current Condition/Trend	Impacts From Past, Present, and Reasonably Foreseeable Actions	Effects of Policies, Plans, and Programs	Alternative 1	Alternative 2	Alternative 3
Land					
Conversion from rural to urban land uses	Increased conversion from undeveloped rural land to infrastructure, residential, commercial, and industrial uses.	Open space acquisition and regulations to reduce impervious cover and control stormwater runoff would preserve some existing undeveloped land.	Minimal measures to encourage conversion to surface water supplies; no land acquisition for open space; possible higher density and quantity of residential development in association with availability of surface water supplies. Lowest positive cumulative impacts; rapid loss of rural land.	Moderate measures to encourage conversion to surface water; open space acquisition; possible higher density and quantity of residential development in association with availability of surface water supplies. Medium positive cumulative impacts; less rapid loss of rural land.	Maximum measures to encourage conversion to surface water; open space acquisition; possible higher density and quantity of residential development in association with availability of surface water supplies. Medium positive cumulative impacts; less rapid loss of rural land
Socioeconomics					
Rapidly growing regional economy; Highly used and socially valued recreational resources in Zilker Park and Barton Springs.	Increased jobs, earnings, and output; Increased stress on recreational areas due to demand and use.	Increased regulation of development and reduced availability of developable land would increase land and development costs; recreational areas and open space would benefit.	Conversion to surface water would make the HCP Planning Area slightly less affordable; increased springflow would benefit water-based recreation at the springs in Barton Creek and Town Lake. Lowest adverse economic impacts and lowest positive quality of life impacts.	Reduced developable land and conversion to surface water would lead to increased land and development costs and make the HCP Planning Area less affordable; increased springflow would benefit water-based recreation at springs, Barton Creek and Town Lake. Medium adverse economic impacts and medium positive quality of life impacts.	Reduced developable land and conversion to surface water would lead to increased land and development costs and make the HCP Planning Area less affordable; highest springflow would benefit water-based recreation at the springs, Barton Creek and Town Lake. Highest adverse economic impacts and highest positive quality of life impacts.

Alternative 2 includes a measure (1.3.3) that would tend to indirectly have a positive impact on surface water quality through the acquisition of undeveloped open space. This measure would help ameliorate future increase of impervious cover and polluted stormwater runoff into the HCP Planning Area's surface waters and would contribute to reducing the adverse cumulative impacts associated with rapid urbanization of the contributing watersheds.

Alternative 2 and 3 include Measure 1.3.3 and Measure 5.4, the development of a sediment transport model for the Barton Springs contributing watersheds that would increase scientific knowledge of the effects of sediment in stormwater runoff on the spring ecosystem. Both of these measures would tend to reduce the adverse cumulative impacts associated with rapid urbanization of the contributing watersheds.

Groundwater and Aquifer-fed Springs

As noted above for surface water resources, past, present and reasonably foreseeable actions in the HCP Planning Area indicate that rapid urbanization will continue to occur with negative impacts to groundwater quality as a result of increased impervious cover, polluted stormwater runoff and the discharge of treated wastewater into surface streams. Recharge to the aquifer of polluted stormwater would have a negative impact on groundwater water quality and the quality of water issuing from the springs. Implementation of the policies and plans outlined in Table 4.11-1 would mitigate these trends, but groundwater and spring water quality would continue to decline. In addition, more intense development in the contributing zone of the Barton Springs segment will increase the potential for direct discharge of domestic wastewater from publicly owned treatment works, of which there currently are none.

Alternative 1 does not include specific measures to sustain or improve surface or groundwater quality and would therefore not directly or indirectly influence the cumulative impacts on surface water quality in the HCP Planning Area.

Alternative 2 includes a measure (1.3.3) that would indirectly have a positive impact on surface, groundwater and spring water quality through the acquisition of undeveloped open space. This measure would help ameliorate future increase of impervious cover and polluted stormwater runoff into the HCP Planning Area's surface waters and subsequent recharge to the aquifer and would contribute to reducing the adverse cumulative impacts associated with rapid urbanization of the contributing watersheds on groundwater quality. Measures 1.2.7 and all of 1.4 address environmental impacts in an aggregate cumulative way, which would have the effect of sustaining springflow and groundwater availability, and of increasing the reliability of wells in the unconfined zone during critical droughts.

Alternatives 2 and 3 includes Measure 1.3.3 and Measure 5.4, the development of a sediment transport model for the Barton Springs contributing watersheds that would increase scientific knowledge of the effects of sediment in stormwater runoff on the aquifer and spring ecosystem.

Both of these measures would reduce the adverse cumulative impacts to groundwater quality associated with rapid urbanization of the contributing watersheds.

Biological Resources

As noted above for surface and groundwater resources, past, present and reasonably foreseeable actions in the HCP Planning Area indicate that rapid urbanization will continue to occur with negative impacts to terrestrial habitat of wildlife species not tolerant to human disturbance. Negative impacts would also occur to surface and groundwater quality as a result of increased impervious cover, polluted stormwater runoff and the discharge of treated wastewater into surface streams. Decreased water quality would have substantial adverse impacts to the biological resources in the spring ecosystem. Implementation of the policies and plans outlined in Table 4.11-1 would substantially mitigate these trends, but surface and groundwater quality would continue to decline, continuing the threat to the endangered biological resources in the springs. Alternative 1 does not include specific measures to sustain or improve surface or groundwater quality. It does, however, include several measures designed to increase springflow by reducing withdrawals from the aquifer. These measures would have positive effects on groundwater quality and the ecosystems biological resources by sustaining a higher level of dilution of pollutants and would therefore create indirect effects that would help offset the adverse cumulative impacts of rapid urbanization on the biological resources in the HCP Planning Area.

Alternative 2 includes additional water reduction measures as well as a measure (Measure 1.3.3) that would indirectly have a positive impact on surface, groundwater, spring water quality and biological resources through the acquisition of undeveloped open space. This measure would help ameliorate future increase of impervious cover and polluted stormwater runoff into the HCP Planning Area's surface waters and subsequent recharge to the aquifer and would reduce the adverse cumulative impacts to the spring's biological resources associated with rapid urbanization of the contributing watersheds on groundwater quality. Measure 1.2.7 and all of 1.4 address environmental impacts in an aggregate cumulative way, which would have the effect of sustaining springflow and groundwater availability, and of increasing the reliability of wells in the unconfined zone during critical periods.

Alternatives 2 and 3 include Measure 1.3.3, assistance and cooperation in acquisition of open space over the recharge zone of the Edwards Aquifer, and Measure 5.4, the development of a sediment transport model for the Barton Springs contributing watersheds that would increase scientific knowledge of the effects of sediment in stormwater runoff on the aquifer and spring ecosystem. Both of these measures would reduce the adverse cumulative impacts to biological resources associated with rapid urbanization of the contributing watersheds.

The City of Austin's Habitat Conservation Plan for Barton Springs Pool Operation and Maintenance (COA 1998) will have direct cumulative impacts on the endangered species population in the Barton Springs complex during low flow conditions for all alternatives in the District HCP. Cleaning the pool is stressful to these species; the City's HCP acknowledges the harm and harassment and contains measures to minimize and mitigate the take associated with those activities. Any activities under the City HCP that take place at Barton Springs discharges less than 33 cfs will have cumulative impacts on the endangered species. The District's HCP includes several measures that are to be specified/authorized in a MOU between the District and City, and the District will seek to include in the MOU specific constraints on operation and maintenance that represent discretionary actions in order to minimize or avoid such cumulative impacts.

Land Use

As described in Section 4.5, undeveloped land within the HCP Planning Area is undergoing rapid conversion from rural/agricultural uses to urban and suburban uses. Implementation of the policies and plans outlined in Table 4.11-3 would address these trends primarily through growth management regulations oriented toward water quality protection, but the conversion of rural land to urban land would continue. Alternative 1 does not include specific measures to sustain undeveloped land in the HCP Planning Area and would therefore not create direct or indirect effects that would influence the cumulative impacts on land conversion in the HCP Planning Area.

Alternative 2 includes a measure (1.3.3) that would directly have a positive impact on rural, agricultural and undeveloped land through the acquisition of undeveloped properties for open space. This measure would tend to help ameliorate future increases of impervious cover and the rate of future urbanization in the HCP Planning Area and offset, to some degree, the adverse cumulative impacts of rapid urbanization on rural and agricultural land in the HCP Planning Area. This measure would also, however, have the indirect effect of increasing the aesthetic or quality of life appeal of adjacent developable land. Measure 1.2.7 and all of 1.4 address environmental impacts in an aggregate cumulative way, which would have the effect of sustaining springflow and groundwater availability and of increasing the reliability of wells in the unconfined zone during critical periods.

Alternative 3 includes Measure 1.3.3 as well and would also offset, to some degree, the adverse cumulative impacts of rapid urbanization on rural and agricultural land in the HCP Planning Area.

Socioeconomics

Past, present and reasonably foreseeable actions in the HCP Planning Area indicate that rapid economic development will continue to occur with positive impacts to the regional economy of the HCP Planning Area. Implementation of the policies and plans outlined in Table 4.11-1 would tend to manage future economic growth in the HCP Planning Area, primarily by increasing the cost of future water supplies needed for development by encouraging the conversion from groundwater use to higher cost surface water.

Alternative 1 does not include specific measures that would sustain or inhibit growth of the regional economy, but the groundwater reduction measures would create indirect effects (through higher water costs) that would offset, to some extent, the positive socioeconomic cumulative impacts to employment, earnings and business sales of ongoing private and public development in the HCP Planning Area.

Alternative 2 includes additional measures to reduce groundwater use, and a measure (1.3.3) that would have direct and indirect negative impacts on land available for development (and subsequently on land costs) through the acquisition of undeveloped properties for open space. This measure would tend to increase the cost of future real estate development (the magnitude of the increase depending on the amount of land acquired for open space) in the HCP Planning Area and offset, to some degree, the positive cumulative impacts of regional economic development on employment, earnings and business sales in the economy of the HCP Planning Area. Measure 1.2.7 and all of 1.4 address environmental impacts in an aggregate cumulative way, which would have the effect of sustaining springflow and groundwater availability and of increasing the reliability of wells in the unconfined zone during critical periods

Alternative 3 includes additional measures to reduce groundwater use in favor of higher cost surface water supplies, and Measure 1.3.3 that would have direct and indirect negative impacts on land available for development (and subsequently on land costs) through the acquisition of undeveloped properties for open space. Measure 1.4.4 would increase groundwater rates to encourage conversion to surface water supplies. Measure 1.4.5 would involve costs for construction of excess pumpage and storage capacity within alternative water supply systems to offset water demand during drought conditions. These measures would tend to increase the cost of future real estate development (the magnitude of the increase depending on the amount of land acquired for open space and the extent of water rate increases) in the HCP Planning Area and offset, to a greater degree than Alternatives 1 and 2, the positive cumulative impacts of regional economic development on employment, earnings and business sales in the economy of the HCP Planning Area.

In summary, direct and indirect effects associated with all three PDEIS alternatives would generally tend to offset the adverse cumulative impacts of urbanization on the groundwater resources, aquifer-fed springs, biological resources, and land resources in the HCP Planning Area, but would also offset, to some degree, through higher water and land costs, the positive socioeconomic effects of the growing regional HCP Planning Area economy. Alternative 1 would contribute the most to the positive cumulative effects of past, present and reasonably foreseeable actions on the economy of the HCP Planning Area, allowing for maximum use of lower cost groundwater to support real estate development. Alternative 3 would contribute the most to offsetting the negative cumulative effects of rapid urbanization in the HCP Planning

Area by minimizing the use of groundwater resources and reserving undeveloped open space. Alternative 2 would represent an intermediate alternative with respect to cumulative effects on the resources of the HCP Planning Area.

4.12 Irreversible and Irretrievable Commitment of Resources

The primary threat to the listed species is the modification or loss of habitat from reduced springflows. As noted in Section 4.2.4, the alternatives include measures that result in varying levels of biological risk to the Barton Springs ecosystem. Irreversible and irretrievable commitment of resources could occur for each of the alternatives depending on specific circumstances and the measures employed. Alternative 2: Regional Permit, Best Practicable and Attainable Measures would reduce adverse indirect and induced impacts to the species relative to the No Action alternative. It should be noted that although the No Action alternative would not include an ITP and associated HCP, it nevertheless includes several measures or actions designed to reduce aquifer water use and protect the spring ecosystem, which will be implemented by the District even if an ITP is not obtained.

For Alternative 1 (No Action), lower flows associated with less restrictive pumping limits would generally result in continuation of current conditions of biological risk to the ecosystem during critical drought periods. Since the No Action alternative would not include extraordinary measures to mitigate the impact of low flows on the listed species, prolonged periods of low flows could result in irreversible and irretrievable impacts. However, Alternative 1 does include measures that would encourage use of alternative water supplies, enhance aquifer recharge, and move toward conjunctive use of groundwater and surface water. All of these actions would require increased economic investments in additional water supply infrastructure and management. Funding of measures identified under Alternative 1 would require additional funding on the part of the District, which could at least partially be reflected in increased pumpage and groundwater user fees. As discussed in Section 4.7 irretrievable resources such as expended funding and staff time would be lowest under Alternative 1 as there would be no requirement to implement HCP measures. Increased supplies of surface water concurrent with stricter regulations for groundwater use would result in higher land costs that would influence the local economy. Commitments of irretrievable resources to promote less reliance on groundwater and higher use of surface water through the development of physical infrastructure to collect and transport surface water supplies would be lowest under Alternative 1. Similarly, irretrievable commitments of resources to protect endangered species would be lowest under Alternative 1.

Alternative 3 represents the highest commitment of regulatory resources and funding to limit pumpage, and encourage use of alternative water supplies. However, as springflow would be assured, irretrievable commitments of funding and other resources to protect the spring ecosystem during emergency situations would be partially avoided. Alternative 2 represents best practicable and reasonably attainable measures that would represent an irretrievable commitment of funding and management resources that would best balance economic impacts with biological impacts.

Issuance of the ITP by the Service for the Alternative 2 would result in aquifer management that would assure a minor amount of springflow only at the lower end of the pumpage range (10 cfs). Adverse changes would be expected to occur during periods of prolonged low rainfall (severe drought) and resulting low aquifer recharge in combination with high levels of aquifer discharge from pumping withdrawals. Adverse changes would be considered irretrievable only if aquifer levels were never allowed to recover to historic levels and resulting habitat conditions never recovered because of permanently reduced flows or permanent alterations to the pools and outlets and associated infrastructure at the springs.

Even during the lowest recorded flow at Barton Springs during the drought of record in 1951 to 1956, there was no irreversible or irretrievable loss of biological resources. The spring ecosystem recovered naturally, even with continued anthropogenic influences associated with continued high use and maintenance of Barton Springs Pool. With the higher water withdrawals of the present day, irreversible changes could occur, however, without captive propagation and artificial refugia afforded by the City's HCP to protect the species during periods of reduced flows and to allow reintroduction of the species into the ecosystem. A factor of consideration that is noteworthy, but not easily able to be documented, is the reasonable likelihood that over the course of the thousands of years spanning the life history of the Barton Springs salamander, the springs stopped flowing in dry periods that were considerably more extreme than any recorded during the period of record.

Several of the measures identified in the alternatives intended to minimize or mitigate potential impacts would involve commitments of resources that would be difficult or expensive to reverse. These include development of recharge enhancement structures, studies to determine feasibility of springflow augmentation, and preservation of open space.

Chapter 5
Relationship between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

Among the three alternatives evaluated, Alternative 2, Best Practicable and Attainable Measures, attempts to balance the short-term water demands and endangered species concerns in the HCP Planning Area with the relatively long-term (50 years) water supply, species conservation issues, and regional water planning mandated by the State of Texas. Under this alternative, the District could allow pumping from the Barton Springs segment of the Edwards Aquifer with the District and pumpers protected under the ITP in the event that harm or incidental take would occur to federally listed species. In addition, the District DHCP would provide measures to conserve the Barton Springs salamander, the Austin blind salamander, and the Barton Springs ecosystem. Under the No Action Alternative, the District and regulated pumpers would not be protected from harm or take of the species under the ESA, and any adverse effects of pumping on the Barton Springs and Austin blind salamanders would not be mitigated.

Under an approved HCP and ITP, the District will implement actions and measures necessary to maintain springflows and natural habitats in spring-fed ecosystems for the direct benefit of the Barton Springs and Austin blind salamanders. A number of mitigation measures and adaptive strategies would be implemented during normal aquifer conditions as well as periods of drought to protect species inhabiting the Barton Springs ecosystem. Measures under Alternative 2 would serve both short-term and long-term needs. Actions include conservation and adaptive management measures. Once these measures are implemented, the success of the DHCP measures and resulting health of the Barton Springs ecosystem would be subject to continuing biological analysis and management intended to enhance long-term species viability and conservation.

Implementation of the District DHCP sets in motion several processes that potentially enhance conservation over the long-term. With the DHCP in place, the issuance of an ITP would allow the District and pumpers to continue using the water resources of the aquifer while conservation measures are implemented. This orderly and systematic approach to implementing the measures is intended to streamline compliance and conservation efforts in the region. In the long term, this balanced approach to water use and conservation would provide funding for mitigation and management, as well as public benefit and other long-term positive effects.

The imposition of long-term regulatory limits on pumping from the aquifer will require implementation of future water management strategies, both to supplement available water supplies to satisfy current water demands and to provide additional water supplies to meet the growing water demands of the region. Estimated aquifer pumping of 13-16 cfs for Alternative 1, and regulated withdrawals of 10-13 cfs for Alternative 2 and 7-10 cfs for Alternative 3, with additional gains to the aquifer from a number of non-drought demand reduction strategies, alternative water supply enhancement measures, and drought stage reductions were used for evaluating water availability from the Barton Springs segment of the Edwards Aquifer. The area covered by the District's DHCP includes portions of five Texas counties and encompasses all of the District's jurisdictional area. Pursuant to rules of the TWDB, the regional water plans were required to include an assessment of current and projected water demands and current water supply availability, the identification of water supply needs, and an evaluation of strategies for meeting the identified water needs. Specific strategies have been recommended for individual "water user groups" with current or projected needs through 2030. Long-term strategies or alternative scenarios could also be included in the adopted regional water plans for the period from 2030 to 2050. Development and operation of each water management strategy could affect short-term use of man's environment and maintenance/enhancement of long-term productivity.

The District adopted a management plan for the Barton Springs segment of the Edwards Aquifer on October 30, 2003. The District Management Plan is a groundwater management plan that is in partial fulfillment of the requirements of SB1, SB2, and TWDB rules, specifically Texas Administrative Code, Chapter 356 (31TAC[1] §356). The District Management Plan includes components addressing coordination with surface water management entities, consistency with the Region K Plan, existing and projected water supplies and demands, conservation and drought programs, groundwater recharge, conjunctive water management and goals, management objectives and performance standards. Early in the plan development process it was determined that the District's groundwater management planning would be coordinated with the development of the Region K Water Plan to avoid unnecessary and costly duplication of effort, to comply with 31TAC §356.6 (a)(5), and to ensure consistency.

As noted in Section 4.11.1, indirect or growth inducing impacts arising from the direct impacts associated with the DHCP would primarily have implications for the character and pace of future urban and economic development of the HCP Planning Area. These indirect impacts have been discussed for each of the three alternatives in Sections 4.5, 4.6, and 4.7. Indirect impacts of Alternative 2 for agriculture, land use, social, and economic resources are summarized in Table 4.11-1.

Chapter 6
Barton Springs/Edwards Aquifer Habitat Conservation Plan

6.1 Introduction

The Barton Springs/Edwards Aquifer Conservation District (District) has prepared a Draft Edwards Aquifer Regional Habitat Conservation Plan (District DHCP) and Preliminary Draft Environmental Impact Study (PDEIS) in support of an application for an Incidental Take Permit (ITP) for the Barton Springs salamander, listed as endangered, and for the Austin blind salamander, a candidate for listing as threatened or endangered by the U.S. Fish and Wildlife Service (Service). This section presents an organized plan consisting of a number of regulatory and management measures proposed by the District for protecting these species.

6.1.1 Goals

The broad, guiding principles for development and implementation of the District DHCP can be summarized as follows:

> To develop a long-term regional HCP that will provide for the conservation, preservation, and protection of groundwater resources and springflow in the Barton Springs segment of the Edwards Aquifer while:

1) Minimizing and mitigating negative impacts upon federally listed species dependent upon springflow from Barton Springs through aquifer demand management, springflow protection, and other management strategies; and

2) Minimizing the negative impact of the plan on the regional economy and economic interests of all of the stakeholders.

Section 6.7.1.4 of this DHCP contains a set of more specific biological goals and objectives for the conservation and protection of the Barton Springs salamander and its habitat.

6.1.2 Covered Species

The ITP will cover the Barton Springs salamander (*Eurycea sosorum*), federally listed as endangered, and the Austin blind salamander (*Eurycea waterlooensis*), a candidate for listing as endangered or threatened.

6.1.3 Covered Activities

The District's primary statutory obligation is to preserve, conserve, and protect the groundwater resources of the District. A major dimension in meeting this charge is managing the withdrawal of groundwater from the Barton Springs segment of the Edwards Aquifer. The District seeks coverage in this DHCP for the District's programs that implement this aspect of its statutory function. It is important to note that these are required, not discretionary activities of the ITP applicant; in fact, the DHCP measures and the groundwater management measures are identical in practice. The District may carry out its statutory powers and responsibilities to amend rules from time to time, and substitute alternative practices and procedures and methods for reduction in pumping if the effect of the amendment maintains the protection of springflows at equivalent or enhanced levels as estimated in this DHCP. The activities for which the District seeks coverage are as follows:

- District Permitting Program in General (see Section 1.1.2 for more detail)
- Exempt Wells and Users
- Non-exempt Domestic Use Wells and Users
- Non-exempt Wells and Users
- Well Construction Standards
- Pump Test Guidelines
- Conservation Planning and Education
- Drought Contingency Planning
- Permit, Water Use, and Well Construction Fees
- Enforcement Protocols
- Other Aquifer Management Strategies

Virtually all of these activities relate to and affect the regulated groundwater-user community in the District. This community is the focus of the DHCP management measures and is described in remainder of this subsection.

More than one thousand water wells exist in the jurisdictional area of the District, and hundreds more exist in the HCP Planning Area outside the District boundaries. The large majority of wells in the District only draw water from the Edwards Aquifer. Moreover, usage of other aquifers in the District is currently very small. Nearly all of the known wells in the District are registered with the District, and most are small-volume users, typically individual households.

The District classifies the registered wells into several categories of users, and the category classification determines whether and how the District regulates its groundwater use.

Exempt Wells and Users

An exempt well is exempt from the District's permitting program and therefore has no authorized pumpage level set by the District. Exempt wells generally use only small volumes of groundwater, but they are subject to District Rules concerning avoidance of waste, pollution, and excessive use. By definition, an exempt well has the following restrictions on its usage:

A. Domestic supply - 1) may only be used to supply the domestic use needs of 5 or fewer households (where a person who is a member of each such household is either the owner of the well, a person related to the owner, a member of the owner's household within the second degree by consanguinity, or an employee of the owner); 2) must be either drilled, completed or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day; and 3) must be located on a tract larger than 10 acres; or

B. Livestock or poultry supply - 1) may only be used for providing water for livestock or poultry; 2) must be drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day; and 3) must be located on a tract of land larger than 10 acres.

Exempt wells are mostly used as water supplies for livestock (including windmill-powered wells) and/or for residences on ranch or farm lands. Most current exempt wells existed at the time the District was formed in 1987. Exempt wells are generally equipped with pumps of less than 1 horsepower, which produce no more than about 6 to 7 gallons per minute. These wells usually are not metered, are not required to report water use, and are not charged for their water at any time. Most new wells will not meet the criteria to be exempt.

Non-exempt Domestic Use Wells and Users

A NDU well is a well used by, and connected to, a household for personal needs or for household purposes such as drinking, bathing, heating, cooking, sanitation or cleaning, and landscape irrigation. NDUs operate under a "general permit by rule" and apply to wells that were drilled and completed on or after August 14, 2003.

These wells must be on a single-ownership plot smaller than 10 acres in size that contains a household. NDUs must have meters, and the owners must report water usage monthly. No water use fee is charged to NDUs for water withdrawals, but the District does charge their users a permit fee. NDUs have UCPs and UDCPs as well. The District has about 30 NDUs.

Non-exempt Wells and Users

All other wells are classified as non-exempt wells. These wells are required to have permits from the District, are metered, and report water use monthly. In 2006, users of non-exempt wells paid a water use fee of $0.17 per 1,000 gallons of water used. The District had about 90 non-exempt permittees, not including NDUs. It is estimated that in 2006, almost 90 percent of all the groundwater withdrawn in the District was by non-exempt wells.

Non-exempt wells are categorized by usage: agricultural, commercial, industrial, irrigation, and public water suppliers. The permittees include churches, office parks, quarry operations, schools, community athletic fields, municipalities, water supply companies, etc. By far, the largest use is for public water supplies. The type of use is one determinant of the provisions that the District Board considers when it examines the permittees' UCPs and UDCPs.

More information on UCPs and UDCPs, which are mandatory parts of permits, is included in Appendix K.

Another important classification of non-exempt wells includes existing wells that were registered with the District and that had authorized groundwater production permits approved by the District as of September 9, 2004. These wells are classified as historic-use wells. Wells that received permits after September 9, 2004, are classified as conditional-use wells. The distinction is important, because conditional-use wells are authorized only on an interruptible supply basis. They have UDCPs that provide for pumpage curtailments of 50, 75, or 100 percent of their authorized monthly usage during declared droughts. The District further subdivides conditional-use permits as to whether they existed or were in processing on April 27, 2007 (Class A conditional permits) or after that date (Class B conditional permits); Class B permits have an accelerated curtailment schedule during drought. Historic-use wells are required to curtail their authorized monthly pumpage by 20 and 30 percent during Alarm and Critical Stage droughts, respectively. Permits amended after September 9, 2004, authorizing an increase in the historic-use volume of groundwater are subject to conditional-use rules for the increase, and the date of the amendment determines whether that volume is Class A or Class B conditional water.

The relationship between production permit types and curtailment conditions is summarized in Table 6.1-1.

Table 6.1-1. Curtailment of water withdrawals for different permit types and drought conditions.

	Trigger		**Drought Curtailment Schedule (percent reduction required)**		
Drought Stage	Barton Springs (flow)	Lovelady Well (depth to water)	Historical	Class A Conditional	Class B* Conditional
No Drought	> 38 cfs	< 180.8’	--	--	--
Alarm Stage Drought	≤ 38 cfs	≥ 180.8’	20%	20%	50%*
Critical Stage Drought	≤ 20 cfs	≥ 192.1’	30%	30%	75%*
Emergency Response Period*	≤ 14 cfs*	N/A	30%*	50%, then 75% after 90 days, then 100% after 90 days*	100%*

NOTES ON TYPES OF PERMITS

Historical:

- Permits issued prior to 9/9/2004
- Production Fee: $0.17/1000 gallons
- 30% maximum curtailment during extreme drought

Conditional Class A:

- Permits issued after 9/9/2004
- Production Fee: $0.17 - $0.38*/1000 gallons (*effective date 9/1/07)
- 100% maximum curtailment during extreme drought
- Includes all non-exempt Middle and Lower Trinity wells
- Certain existing un-permitted non-exempt Edwards wells *(upon rule revision)*

Conditional Class B:

- Permits applied for or issued after 4/12/2007
- Production Fee: $0.17 - $0.38*/1000 gallons (*effective date 9/1/07)
- 100% maximum curtailment during extreme drought
- Only applies to fresh Edwards/Upper Trinity
- Accelerated curtailment schedule
- Require conjunctive use/alternate water supplies

6.1.4 Pre-existing Conditions Applicable to the Habitat Conservation Plan

There are pre-existing conditions and extant environmental impacts for which the District may not reasonably, and perhaps legally, be able to take responsibility under this DHCP.

The pumpage history at various pertinent milestones illustrates these conditions. They are depicted graphically in Figure 6.1-1 below and summarized in this subsection.

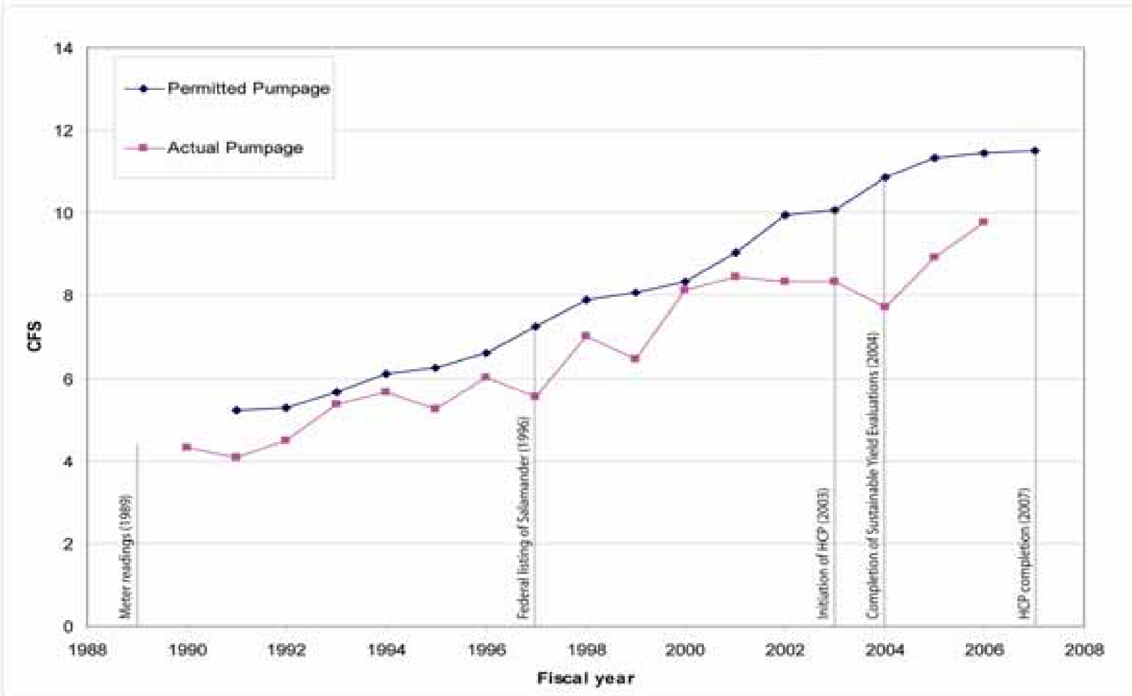

Figure 6.1-1 Pumpage History, Showing District and DHCP Milestones.

Before the establishment of the District in 1987, there was no authority or ability to manage groundwater production from the Edwards Aquifer. Not until 1989, when a groundwater management plan and rules were adopted by the District and meters were first set on permitted wells, was there any operational permit program by which the District could manage groundwater production. In 1989, the estimated pumpage in the District was about 5 cfs.

Before the federal listing of the Barton Springs salamander in 1997, there were no compliance measures under the ESA to be addressed by the District—no basis of reference to measure how much groundwater production or what limitation of production would be needed for protection of the salamander population at Barton Springs. In 1997, actual pumpage under approved permits or exemptions to permits is estimated to have totaled about 6 cfs.

Before the award of a federal grant in 2003 and execution of a contract for a DHCP and PDEIS in 2004, the District did not assume responsibility for compliance with the ESA in the implementation of its groundwater management programs. Even now, the authority and responsibilities for the District in complying with the ESA are not specifically established. Rather, the DHCP and PDEIS are entirely voluntary and are proposed in a proactive manner, pursuant to excellence in groundwater management and stewardship. In 2003, the actual permitted pumpage from all wells in the District was slightly more than 8 cfs; in 2004 it was somewhat less than 8 cfs.

The conditions of groundwater production and permitting as of these earlier dates, from 1988 to 2004, should be considered in the development of the DHCP and EIS. Accordingly, the Service and other interested parties should evaluate the enhancements under this DHCP in the context of conditions pre-existing at those times.

One other aspect of historical groundwater production deserves mention. It should be apparent that there has not been a time during the history of the District, which began in 1987, in which pumpage has been zero. The use of the term “zero-pumpage baseline” in this document does not refer to a practical condition that could now exist, nor is it an appropriate target for groundwater management; rather, it references an artificially constructed baseline used for impact evaluation purposes, as illustrated in Appendix H. Essentially, the zero-pumpage baseline was calculated by adding back in the actual pumpage withdrawn from the aquifer by all wells on a given day to the amount of aquifer water discharged at that time via springflow, to arrive at a synthetic springflow that might have existed on that day if there had been no pumpage from the aquifer. This derivation relies on the modeled results of aquifer hydrodynamics achieved in the Sustainable Yield study (Appendix L), in which it is shown that during extreme drought conditions, each gallon of water withdrawn from wells in the aquifer is one less gallon of water that will be discharged from the springs complex during the same time period. Use of this synthetic baseline for all alternatives facilitated the assessment of the effects of various mitigation measures and comparison of alternatives on an “apples to apples” basis.

6.2 Plan Area

The District’s HCP Planning Area (Figure 1.1-2) includes the Barton Springs segment of the Edwards Aquifer Contributing Zone, Recharge Zone, Transition Zone, Artesian Zone, and Saline Water Zone in parts of Bastrop, Blanco, Caldwell, Hays, and Travis Counties in Central Texas. The bulk of the HCP Planning Area is mainly in northern Hays County and southern Travis County. Small portions of the HCP Planning Area extend into Blanco, Caldwell, and Bastrop Counties.

6.3 Incidental Take Permit Area

The ITP area includes: subsurface, water-bearing strata of the Edwards and Georgetown geologic formations within the Barton Springs/Edwards Aquifer Conservation District jurisdictional boundary (Figure 1.1-2), and surface and subsurface components of the individual springs that make up the Barton Springs System. This includes the Main

(Parthenia) Spring and associated Barton Springs Pool, Upper Spring, Eliza Spring, and Sunken Garden (Old Mill) Spring (Figure 3.2-1). Any incidental take for DHCP species would be expected to occur in the above-named aquifer and spring locations.

6.4 Incidental Take

This section complies with the Service interpretation of the requirements of 50 CFR 17.22(b)(1)(ii): "The common and scientific names of the species sought to be covered by the permit, as well as the number, age, and sex of such species if known." The sex, age, and number of individuals is not precisely known because the population is very small and is not reliably surveyable at any one time. Only long-term trends can be inferred from transect surveys of observable individuals, in association with recorded variations in climate, spring flow and other relevant factors influencing habitat (COA 2007b). Consequently, the actual level of take of these species cannot be precisely determined. The key to conserving the Barton Springs and Austin blind salamanders is maintenance of adequate habitat to provide the necessary life requisites for these species. This can be accomplished, in large part, by management of the aquifer to protect and maintain springflows.

Take of these species (as defined by *Federal Regulation* 50 CFR 17.3, to include harm from "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering") must be estimated indirectly by examining changes in habitat conditions rather than demonstrable loss of individual animals. This is because the spring complex is not a closed system and both salamanders have the capability of migrating between spring runs where they can be counted, to areas inside the spring orifices and subterranean aquifer caverns and fissures where physical counts of individuals are not possible. Because of this limitation, estimates of take for the Barton Springs salamander are based on the interrelationship of two, measurable life requisites of the species: rate of springflow discharge and associated dissolved oxygen concentration of discharged spring water. The probability of mortality (take) of the species, in the event of adverse drought and associated reduced spring flow conditions, has been predicted using estimates determined from experimental toxicity studies showing the effects of changes in dissolved oxygen on the metabolism of salamanders (Poteet and Woods 2007), and the correlation of lower dissolved oxygen with decreased springflow (COA 2007a). Based on results of the experimental, *in situ* laboratory toxicity studies using the San Marcos salamander *(Eurycea nana*) as a surrogate for the Barton Springs salamander, mortality rates were correlated with declining levels of dissolved oxygen concentrations. As dissolved oxygen concentrations were shown to be statistically correlated with the rate of springflow discharge (COA 2007a), and because springflow discharge rates could be approximately related to specific aquifer management strategies, these relationships provided a reasonable approach for estimating and comparing levels of take, especially in the event of an extreme drought.

This methodology has the distinct benefit of relating activities covered by the prospective ITP with the amount of take. At springflow discharge rates higher than 33 cfs, there appears to be minimal or no impacts to salamanders at the Main Spring, Eliza Spring, and Old Mill Spring. At combined springflow discharge rates of 33 cfs or lower, dissolved oxygen concentration declines to about 4.8 mg/L and impacts become apparent as fewer salamanders are observed in the spring system and mortality begins to occur according to observations from laboratory studies of Poteet and Woods (2007). Based on these observations, take as defined by 50 CFR 17.3 above, therefore, begins to occur at a combined springflow discharge rate of 33 cfs or lower (Figure I-1, Appendix I).

A detailed discussion of the potential take for the Barton Springs salamander and Austin blind salamander within the ITP area that may occur with the issuance of the ITP under the District DHCP is discussed below.

6.4.1 Federally Listed (Threatened or Endangered) Species

The Barton Springs salamander (*Eurycea sosorum*), federally and state-listed as endangered, is found in the four springs that make up the Barton Springs ecosystem (Figure 3.2-1), including the Main (Parthenia) Spring in Barton Springs Pool, Eliza Spring, Old Mill Spring (also called Sunken Garden), and the Upper Barton Spring (COA 1998a). The springs complex is located in Zilker Park, near downtown Austin. The Barton Springs salamander was first collected from Parthenia and Eliza Springs in 1946 (Brown 1950), Old Mill Spring in 1993 (Chippindale 1993) and in Upper Barton Spring in 1997 (COA 1998a). Barton Springs salamanders are found in the highest abundance and density at Eliza Spring (COA 2006) with second highest abundance in Parthenia Spring. They occur near spring openings and fissures and rarely found in areas of little flow such as the deeper parts of Barton Springs Pool, which is often covered in sediment, or in the shallow end upstream of the spring openings. This species is dependent on the quantity and quality of water flowing from the Barton Springs Segment of the Edwards Aquifer.

The salamander was given the taxonomic name *Eurycea sosorum* in honor of the citizens of Austin, who initiated and passed the SOS (Save Our Springs) City of Austin Ordinance in 1992 to protect the aquifer that supports Barton Springs. The salamander is aquatic and neotenic, meaning it does not develop lungs and retains larval, gill-breathing morphology. These salamanders become sexually mature, breed, and live in the water throughout their lives (Petranka 1998). The recovery plan for the Barton Springs salamander (USFWS 2005b) lists the following principal threats to the species: degradation of water quality and quantity, surface habitat modification, lack of a comprehensive plan to protect the Barton Springs watershed from increasing threats to water quality and quantity, and restricted range in an entirely aquatic environment.

Additional biological and natural history information for the species proposed for coverage in this ITP are presented in Section 3.3 and Appendix F.

There are a number of characteristics of Barton Springs salamander habitat that vary with changes in Barton Springs discharge. As discharge declines, surface habitat availability for the Barton Springs salamander decreases (little is known about how much subsurface habitat is occupied by and suitable for the species). In addition, the remaining habitat is likely reduced in suitability for the species because of decreased DO concentration, increased salinity, reduced dilution of other dissolved constituents that may be detrimental to the species, and the potential for increased predation, competition, and reduced forage. Reduced discharge may also change the physical characteristics of the spring openings by increasing sedimentation (which also reduces biological suitability). Springflows carry sediment loads from inputs contributed in the recharge and contributing zones, as well as particles that are dislodged as a result of erosion of the karstic limestone rock within the aquifer.

Of the potential components of suitable Barton Springs salamander habitat that are affected by changes in discharge, many are difficult to directly relate to a response on the species due to limited information and access to the aquatic habitat. However, DO and conductivity (a measure of salinity) were identified as potentially important variables that might also be readily evaluated to develop a response curve of toxicity for the Barton Springs salamander to each. This response curve was then used to develop models describing the relationship of each variable to Barton Springs discharge. To determine the response of the Barton Springs salamander to changes of these variables, a laboratory study evaluated the "toxicity" of reduced DO and high conductivity on the species (Poteet and Woods 2007) (Appendix J). A closely related, surrogate salamander species (San Marcos salamander; *Eurycea nana*) found in springs at the headwater of the San Marcos River was used for mortality experiments due to the success of raising that species in captivity and the availability of these organisms to be collected from the wild. Based on metabolic tests run on both species to evaluate response to changes in DO and conductivity, this species appeared to respond similarly to the Barton Springs salamander in test conditions.

The Poteet and Woods (2007) testing procedure generated 28-day mortality estimates for adult San Marcos salamanders as a surrogate for the Barton Springs salamander as well as describing sub-lethal effects such as growth and behavioral response to various treatment levels. As discussed above, the estimated response of the Barton Springs salamander population to changes in DO and conductivity do not represent the complete range of possible factors that influence the population during reduced discharge. However, models developed from these data provide the most robust method currently available for evaluating potential impacts of reduced discharge conditions on the Barton Springs salamander population in the wild. There are additional areas of uncertainty to this method of describing potential take of Barton Springs salamanders in the wild that should be acknowledged. As in all laboratory studies, the response of the test organisms under controlled conditions may not be the same as in the wild. There is also variation in response among individuals that affect the precision of mortality estimates; this variation is accounted for by presenting 95 percent confidence intervals around the mean value of each estimate. As described above, the surrogate species appeared to react similarly among treatments when metabolism was monitored, but the mortality estimates determined for San Marcos salamander may not exactly equate to what may be expected in the Barton Springs salamander population. Mortality estimates are for adult salamanders and other life stages may have different sensitivity to reduced DO or elevated conductivity. DO and conductivity concentrations are likely heterogeneous in the springs inhabited by these salamanders, and microhabitats may be higher or lower than data measured by the City of Austin data collection methods. In addition, test organisms were not able to move to higher quality habitat conditions (e.g., areas with higher flow velocities so as to increase oxygen exchange across the gills) as they are able to in the wild. Sub-lethal effects observed in the laboratory (such as reduced activity) may not have contributed directly to mortality estimates in the tests, but in the wild such behavioral changes may increase predation risk, reduce foraging, or have other effects that increase the chances of mortality in the wild. Finally, there is a possibility that reduced DO has synergistic effects with variation in other parameters during reduced discharge that are not accounted for in these tests.

Despite the areas of uncertainty that affect the use of laboratory-derived estimates of mortality to describe the risk of mortality to the population in the wild, the data collected by Poteet and Woods (2007) provide the best available information to describe anticipated impact of low discharge conditions to the Barton Springs salamander population. The results of that study were used in conjunction with continuous water quality data and monthly Barton Springs salamander survey data collected by the City of Austin to determine incidental take to the Barton Springs salamander under the District DHCP. With an estimated response of the Barton Springs salamander to changes in DO and conductivity (Poteet and Woods 2007) and known relationships between total discharge in Barton Springs and changes in DO and conductivity (COA 2004, 2007) it is possible to estimate the response of the Barton Springs salamander to reduced discharge in Barton Springs.

One of the primary findings of Poteet and Woods (2007) was that salinity did not result in mortality of the test organisms even at very high concentration. This finding is the result of what appears to be the most controlled, systematic, and replicable laboratory study available. Therefore, this variable was not considered to be an important habitat feature and thus was not used in the take evaluation.

The response curve of test organisms to various concentrations of DO (Figure 6.4-1) indicates that the "no observed effect concentration" (NOEC) is approximately 5.5 mg/L. This concentration of DO occurs at approximately 50 cfs total discharge from Barton

Springs as determined from the City of Austin data noted above. At just 3 cfs lower than the historical average, this discharge volume has occurred frequently over the period of record. The initiation of impacts to the Barton Springs salamander from reduced discharge conditions ("take") appears to occur when the combined total discharge of the individual springs declines to approximately 33 cfs. At this flow, existing data collected during regular survey efforts by the City of Austin have indicated that the habitat of the Barton Springs salamander is reduced such that fewer salamanders have been observed in Old Mill Spring. The potential impacts associated with this 33 cfs discharge rate include reduced numbers of salamanders observed in surface habitat (primarily Old Mill Spring) and reduction in DO concentration (predicted to be 4.8 mg/L) in the springs that may result in some very low rate of mortality (1–5% as predicted by Poteet and Woods 2007). The reduction in number of salamanders in surface habitat suggests that some individuals may move in response to these discharge conditions and/or some mortality may be occurring. However, 33 cfs is predicted to occur over the period of record approximately 28 percent of the time even under zero-pumpage baseline (i.e., no groundwater withdrawal) conditions so the species is accustomed to a relatively frequent occurrence of this condition. Because of the difficulty in sampling the subsurface component of this population, there is little information to indicate whether these conditions are affecting the actual population abundance or whether the salamanders are just changing movement patterns to seek refuge from less suitable habitat conditions. It is not unreasonable to assume that both, not one or the other, of these circumstances exist.

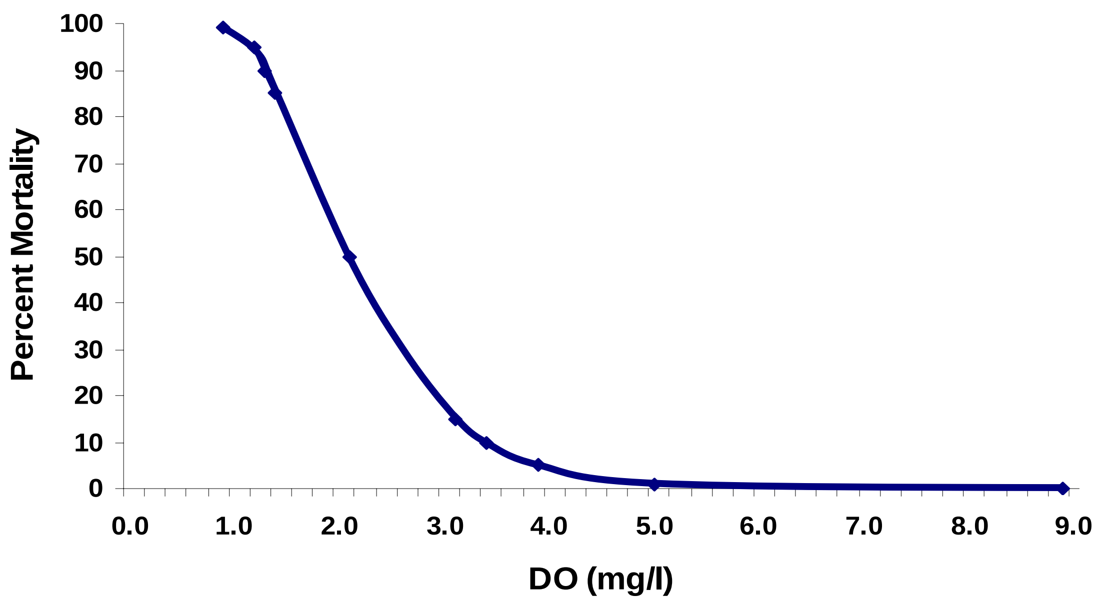

Figure 6.4-1. Curve of predicted mortality over a range of DO concentrations (modified from Poteet and Woods 2007).

Although take may be initiated around 33 cfs, more distinct biological impacts presumably occur at lower discharge levels. A more useful means of investigating the impact associated with the District DHCP is to identify a condition that has not occurred frequently over the historical record, but could potentially result in a measurable impact to the population. Table 6.4-1 provides the estimated percent mortality of Barton Springs salamanders that would occur during a 28-day period over a range of DO concentrations as well as the 95-percent confidence intervals around each of these values based on the laboratory study by Poteet and Woods (2007). The lethal concentration at which 50 percent of the test animals died (LC50) was 2.1 mg/L, which, based on extrapolation of the best available model (COA 2007), would occur at approximately 6 cfs total Barton Springs discharge. This condition results in a potentially high impact to the Barton Springs salamander population. The LC5 (lethal concentration at which 5 percent of the test animals died) value is another concentration that results in much lower potential impact to the population. The LC5 value of approximately 3.9 mg/L DO was observed in the laboratory at approximately 18 cfs total Barton Springs discharge (this discharge value is also extrapolated beyond the existing water quality dataset). The LC50 and LC5 each provide useful benchmarks for estimating the quantity of take that will occur under the anticipated discharge conditions of the District DHCP.

Table 6.4-1. Estimated mortality of Barton Springs salamanders at various DO concentrations. Adapted from Poteet and Woods (2007).

Estimated Percent Mortality	Lethal DO Concentration (mg/L)	95% Confidence Limits*	
		Upper	Lower
1	5.0	67	3
5	3.9	29	3
10	3.4	18	2
15	3.1	13	2
50	2.1	4	2
85	1.5	2	1
90	1.3	2	0.5
95	1.2	2	0.3
99	0.9	1	0.1

* Refer to Poteet and Woods (2007) (Appendix J) for explanation of confidence intervals on the lower mortality estimates.

The District is required by State statute to consider the “drought of record” as the basis for its drought management plans and strategies. The drought of record for the Barton Springs segment is the 1950-1956 period, which has been estimated by tree-ring studies to have been the worst prolonged drought in this region in about 350 years (Therrell 2000). (More information on climate changes is found in Section 3.1.1.2.) Statistically, the return period of the drought of record is likely to be considerably longer than the term of this DHCP, and therefore impacts based on the drought of record are not likely to be suffered during the DHCP period. During a repeat of the drought of record, the LC50 would occur approximately 1–3 percent and the LC5 would occur approximately 14–19 percent of the time under the District DHCP. The occurrence of discharge values at or below 33 cfs would occur approximately 34 percent of the time in the District DHCP compared with approximately 28 percent of the time under zero-pumpage baseline discharge (no groundwater withdrawal) conditions. During a repeat of the drought of record, the LC50 would occur approximately 5–16 percent of the time and the LC5 would occur approximately 54–61 percent of the time (compared with 36% of the time under the zero-pumpage baseline discharge).

The frequency of occurrence of LC5 conditions under various alternative pumping limitations is shown in Figure 6.4-2. The data, which are summed by day of the year over the 88-year period of record, indicate that critical conditions under the District DHCP would occur more frequently in August and September than in other periods. As an example of the information illustrated in Figure 6.4-2, there are 88 years for which there is a discharge estimate for September 1, and of those, the discharge would have been less than or equal to 18 cfs on 22–29 occasions (25–33% of the time) under a synthesized range of discharge conditions in the proposed District DHCP. The frequency of occurrence of LC5 conditions under the No Action Alternative is also provided for comparison. A similar trend is observed in the frequency of occurrence of LC50 conditions under the District DHCP and baseline (Figure 6.4-3).

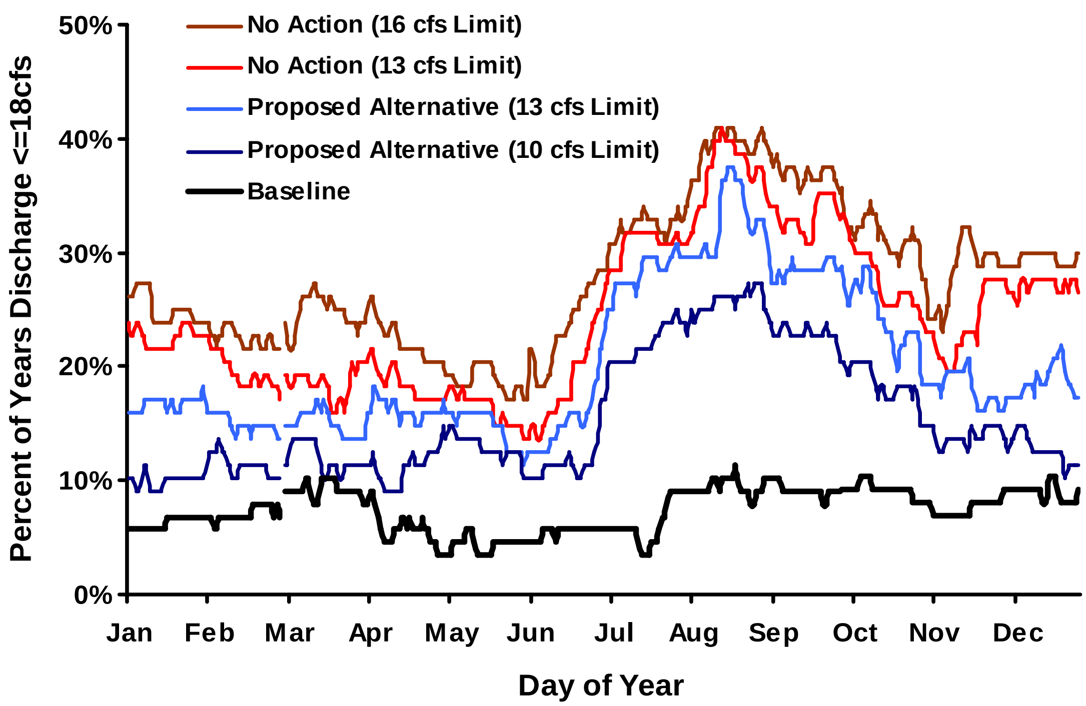

Figure 6.4-2. The frequency of occurrence of LC5 (18 cfs) conditions at the upper and lower pumpage limits of the District DHCP alternatives and the zero-pumpage synthetic baseline, summed by day of the year, over the period of record (1917-2004).

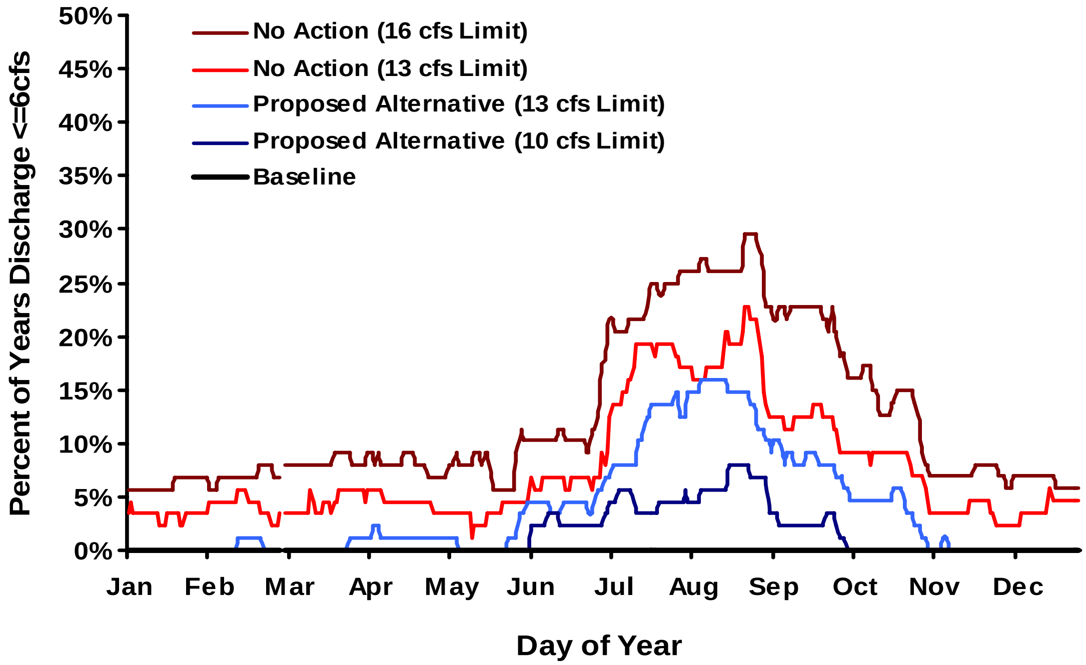

Figure 6.4-3. The frequency of occurrence of LC50 (6 cfs) conditions at the upper and lower pumpage limits of the District DHCP alternatives and the zero-pumpage synthetic baseline, summed by day of the year, over the period of record (1917-2004).

A summary of the frequency of time that predicted dissolved oxygen and associated predicted mortality would occur at various Barton Springs discharge levels under the DHCP 13, 10 cfs, and 7 cfs pumpage limits (Alternatives I, II, and III, respectively) during conditions similar to the period of record and to the drought of record is given in Tables 6.4-2 and 6.4-3, respectively. The proposed DHCP measures, which are described in detail in Section 6.5, are predicted to result in discharge rates, DO levels and mortality probabilities at a level mid-way between Alternatives 2 and 3.

Table 6.4-2. Approximate percent of time spring discharge would be at or below specified levels and associated predicted mortality of the Barton Springs salamander at the upper and lower pumpage limits of the proposed DHCP during conditions similar to the period of record.

Total Barton Springs Discharge (cfs)	Pre-dicted DO (mg/L)	Esti-mated Mortality	Recurrence Percentage - Baseline Discharge[a]	DHCP Measures		
				Alternative 1 13cfs Limit	Alternative 2 10cfs Limit	Alternative 3 7 cfs Limit
33	4.8	>1%	28%	34%	34%	27%
18	3.8	>5%	7%	19%	14%	4%
10	2.9	>15%	0.2%	8%	3%	0%
6	2.0	>50%	0%	3%	1%	0%
4	1.3	90%	0%	2%	0.3%	0%

[a] Percent of time springflow would be at various discharge and impact levels without any pumping over the period of record.

Table 6.4-3. Approximate percent of time that spring discharge would be at or below specified levels and associated predicted mortality at the upper and lower pumpage limits of the proposed DHCP during conditions similar to a repeat of the drought of record (1950-1957).

Total Barton Springs Discharge (cfs)	Pre-dicted DO (mg/L)	Estimated Mortality	Recurrence Percentage – Baseline Discharge	DHCP Measures		
				Alternative 1 13 cfs Limit	Alternative 2 10 cfs Limit	Alternative 3 7 cfs Limit
33	4.8	>1%	70%	76%	75%	68%
18	3.8	>5%	36%	61%	54%	21%
10	2.9	>15%	2%	33%	17%	1%
6	2.0	>50%	0%	16%	5%	0%
4	1.3	90%	0%	11%	2%	0%

6.4.2 Candidate Species for Listing

The Austin blind salamander (*Eurycea waterlooensis*), a candidate for listing, occurs in the Barton Springs ecosystem and is syntopic, found in the same spring sites as the Barton Springs salamander, but inhabits predominantly deeper, subterranean parts of the aquifer (City of Austin unpublished data). Both are members of the lungless Plethodontidae family of salamanders. However, the Austin blind salamander differs morphologically by eyespots that are covered by skin instead of image-forming lenses, an extended snout, fewer costal grooves, and pale to dark lavender coloration (Hillis et al. 2001). The species was described by Hillis et al. (2001) as closely related to the Texas blind salamander (*Eurycea rathbuni*), found in the southern portion of the Edwards Aquifer in San Marcos, Texas. In June 2001, the Austin blind salamander was designated a candidate for listing as endangered or threatened (USFWS 2002).

Austin blind salamander specimens have been collected at Barton Springs Pool, (Main Spring), Eliza Spring, and Old Mill Spring, but most are likely inhabiting the subterranean areas of Barton Springs in the Edwards Aquifer (Hillis et al. 2001). Since the Austin blind salamander occupies a more subterranean habitat than the Barton Springs salamander, most of the observations of this species have been of juveniles that apparently were accidentally flushed out of their underground habitat. Substantially fewer Austin blind salamanders than Barton Springs salamanders have been observed by City of Austin biologists during regular surveys. From January 1998 to February 2002, there were only 120 documented observations of the Austin blind salamander compared to 2,059 Barton Springs salamanders during the same time frame (Hillis et al. 2001). Additional information for this species is presented in Section 3.3.

Each of the potential threats to the Barton Springs salamander identified above applies to the Austin blind salamander to some degree. The degradation of water quality that appears to be associated with urbanization, including reduced dissolved oxygen concentration and increased conductivity, affect habitat conditions for this species. Reduced flows exacerbate these conditions and may lead to reduced habitat suitability for Austin blind salamanders. In addition, a reduction in habitat suitability for Barton Springs salamander associated with lower flows and reduced water quality conditions may also result in movement of the Barton Springs salamander deeper into the aquifer with possible overlap in habitat occupation (and increased competitive interaction) between the two species. Competition for food and space along with other unknown biological interactions may negatively affect one or both species. The amount of incidental take of the Austin blind salamander under the District DHCP cannot be determined at this time. As the habitat requirements and life requisites of the Austin blind salamander are similar to the Barton Springs salamander, protection measures implemented for the Barton Springs salamander under the District DHCP also apply to the Austin blind salamander. Although the District DHCP provides an extensive set of measures intended to protect springflow, assurance of water in sufficient quantity and quality to meet the salamander's life requisites during severe drought conditions is uncertain.

6.5 Measures to Minimize Potential Impacts

The District DHCP includes a number of actions to minimize potential impacts to the spring ecosystem. These include continuing measures during non-drought conditions as well as measures that would be implemented during periods of declared drought. The measures are explained in further detail in Table 6.5-1 and Appendix B, and are enumerated according to the Category number in Table 2.3-1 (Category numbers in parentheses). Collectively, they represent a series of implementable and accountable measures that comply with the statutory objectives of the ESA and HCP guidelines as promulgated by the Service. They will maintain and accomplish the biological goals and objectives for the Barton Springs salamander that are presented in Section 6.7.1.4 of this chapter.

These proposed measures for the DHCP are generally similar to those of Alternative 2 of the PDEIS, but the actual, recent implementation of the Extreme Drought Withdrawal Limitation (Measure 2.1 of Alternative 2) has produced a total pumpage estimate, including exempt and non-exempt Edwards Aquifer use, of 8.5 cfs, rather than the 10 cfs estimates for aquifer pumpage used in the impact evaluation of Alternative 2; this is discussed in more detail in Section 6.5.1.1. Accordingly, groundwater flow impacts for the proposed DHCP measures are more similar to those evaluated for Alternative 3 in the PDEIS, or 7 cfs. The proposed DHCP's management goals, phasing, new statutory or regulatory authority, predicted outcome, and performance metrics for each of the proposed measures are presented in Table 6.5-1 and discussed in the remainder of this section. The means of enforcing the various management measures are explained in Section 6.7.1.9.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
I. MEASURES UNDERTAKEN DURING ALL CONDITIONS			
A. Establish and implement a permitting program in the District to maintain and improve an Extreme Drought Withdrawal Limitation (“Aquifer cap”) [1.1]			
1. Adopt rules and implement a “soft cap” on allowable pumpage, applicable to all withdrawals of Edwards groundwater during times when a drought is declared by the District. [1.1]	**Goal:** Implement a regulatory program that ensures withdrawals from all wells of all types are at statutory and legal minimums during extreme drought, as defined by Rules. **Before ITP Issuance:** District Board will establish a program of EDWL on pumping Edwards groundwater; Board will establish more rigorous measures for the conditional permitting program; Board will incorporate EDWL in Groundwater Management Plan, which will be submitted to TWDB for approval. **After ITP Issuance:** Evaluate and compile data and information pertinent to the formulation of the EDWL; and produce a report at least once every five years, to determine and document whether the measures are at the “best feasible and practical” ”level of management. This would include a review of specific studies such as salamander movement studies in the Barton	**Proposed Rule:** Section 3-1.23. The Extreme Drought Withdrawal Limitation for the Barton Springs segment of the Edwards Aquifer. **Proposed Rule:** Section 3-1.6. District Action on Permits. A. Permits. (9). The approved User Drought Contingency Plan for the well yields a maximum volume of authorized groundwater production that does not exceed the Extreme Drought Withdrawal Limitation specified in Section 3-1.23 of District Rules.	EDWL is implemented by District Rules before ITP issuance. Groundwater Management Plan containing EDWL is approved by TWDB within one year of ITP issuance, and every five years thereafter.

[1] Number in brackets […] following the Preferred Alternative Measure denotes the equivalent measure in the Alternative DHCP Measures tables presented elsewhere (in Chapters 2 and 4).

[2] “Exempt” means wells exempt from permitting; “exempt” and “non-permitted” are synonymous here. “Non-exempt” means wells that require permits; “non-exempt” and “permitted” are synonymous here. For both terms, the statutorily correct usage is that the owner/operator of the well is exempt or non-exempt, but common use is to refer to the wells themselves as exempt or non-exempt.

[3] More detail on rules identified here may be found by referring to the appropriate section of the Rules & Bylaws contained in its entirety in Appendix M.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	Springs complex, as well as regional studies such as projections of climate change. As statutory or regulatory authorities change or every five years, whichever is earlier, review and revise the specified EDWL as needed, to maintain or improve effectiveness of pumpage reductions during droughts. **By 2010:** The adoption of "Desired Future Conditions," as required by the Texas Water Development Board, are set for the state-designated "Groundwater Management Area," so that "Managed Available Groundwater" incorporates the EDWL. **Note:** The EDWL program is to be implemented by rules and regulations applicable to various drought and non-drought stages and other conditions, as noted throughout this table.		
B. Establish Ongoing Demand Reduction Measures			
1. Implement a new database of Registered wells that contains estimates of groundwater withdrawal for a subset of exempt (i.e., non-permitted) wells to better gauge location and amount of pumpage from all exempt wells. [1.2.1].	**Goal:** Provide a more accurate estimation of actual exempt pumpage **Before ITP Issuance:** Relate census tract data and/or City of Austin estimates of population, "Living Unit Equivalents," and number/location of exempt wells; District Board will authorize a new database of registered wells that includes geographically representative subsets of exempt well owners who voluntarily characterize current uses of groundwater, and number of customers or persons using groundwater, and rates of withdrawal for each well. **Within First Year of ITP Permit**: Confirm or modify estimated withdrawals by aggregating results of well-by-well assessments.	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management."	At least 50 exempt wells and their data will be entered into the new database within 2 years of date of ITP issuance. At least 150 exempt wells and their data will be entered into the new database within 5 years of date of ITP issuance.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
2. Institute a new, voluntary metering and water use monitoring program for non-permitted (exempt) wells [1.2.2]	**Goal:** Assess more accurately the typical water-use profiles of exempt users and end-users that are not direct permittees, and assess variations of water use in time and space **Before ITP Issuance:** Purchase inventory of meters to lend to exempt non-metered well users; Educate all registered well owners about the program and the benefits to them; Provide small cash incentives to exempt users for temporary metering with District-owned meters on representative sample of exempt wells. **Within First Year of ITP Permit:** Develop a reporting method, for use by water supply providers, to report the water use of their end-use customers anonymously; Establish use profiles for all groundwater users in the District.	**Note**: This is a voluntary Program, whereby District will seek cooperation from a reasonable number of well owners who are not currently metered. **Note:** All non-exempt (permitted) users and their customers, as relevant, are already metered and report monthly.	A budget commitment of at least $20,000 will be made in the first year, and $10,000 in each of the succeeding two years, not including in-kind District labor, to cover the costs of equipment and small cash incentives to obtain cooperation of exempt, currently un-metered users to participate in the assessment program. At the end of five years from ITP issuance, the District will produce a report on exempt and non-exempt domestic and public water supply use in the District, including estimates of total withdrawals, monthly/seasonal variations, and geographic area variations.
3. Require non-exempt users (permittees) to identify and encourage them to employ measures in their adopted UCPs and UDCPs so that they may voluntarily achieve at least a 10% reduction during the summertime Water Conservation Period, and encourage and all	**Goal:** Better awareness of water use and accomplishment of conservation needs and practices by all groundwater users at all times **Before ITP Issuance:** Develop water-conservation templates for various use types to include in permittees' UCPs/UDCPs for the summertime WCP, applicable during No-Drought status; Align the water conservation plans of the Texas Commission on Environmental Quality's CCN with the District's UCPs/UDCPs; Require adoption of new UCPs/UDCPs on the next annual permit renewal	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and Texas Water Development Board Rules, TAC Sec. 356.5, "Groundwater Management."	All permits of nonexempt wells will incorporate appropriate new UCPs/UDCPs template measures or their negotiated equivalents. Actual monthly water use during summertime Water Conser-vation Period (measured as a percentage of authorized monthly usage) is at least 10% lower than the authorized usage experienced in other months, averaged over the WCP.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
other groundwater users to implement similar conservation measures. [1.2.3]			
4. Require permittees to identify and commit to mandatory measures in UDCPs to achieve specified levels of curtailment during District-declared drought [1.2.4]	**Goal:** Reduced demand by end users that is commensurate with the severity of drought. **Before ITP Issuance:** Develop new drought-management templates for various water use categories, to be included in permittees' UDCPs for drought stages and periods; Align the TCEQ's mandated CCN drought contingency plans and the District's UDCPs; Require adoption of new UDCPs on the next annual permit renewal cycle.	**New Rule:** Section 3-7.5 User DCPs D. Consistency with CCN DCPs. Any permittee that is also a holder of a CCN issued by TCEQ shall assure that all drought-management provisions in the TCEQ DCP and in the District permit's UDCP are aligned and internally consistent. The CCN holder shall modify its TCEQ DCP to conform to requirements of the District UDCP, if necessary, upon the earlier of twelve (12) months from the effective date of this provision or when the DCP is next amended.	All District well permits shall incorporate appropriate new UDCP template measures or their negotiated equivalents by end of FY 2008. Overall, the cumulative compliance with specified levels of curtailment will not exceed 5% of the targeted volume during declared drought.
5. Conduct a continuing water conservation and demand reduction education program with a specified minimum budget directed at all groundwater users in the District [1.2.5]	**Goal:** Increase awareness of water use, water conservation, and practical conservation measures by all groundwater users. **Before ITP Issuance:** Become sponsoring member of the regional Water IQ program; Perform survey and audit of current state of knowledge, reach, and District program awareness; Contract with a communications consultant to help design, budget, and execute a continuing educational campaign, and develop new program materials targeted at individual groups (builders, homeowners, homeowners associations) for drought-time practices; Offer educational assistance to noncompliant permittees during droughts.	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management."	A budget commitment of at least $40,000 per year for salary, overhead and expenses for implementing this program will be made and expended in each of the next three years, increasing thereafter (a) with inflationary indexes or (b) in proportion to the District's annual budget increase, whichever is less. The number of referrals to the District from other organizations and other parties seeking water conservation information will increase on an annual basis for the first five years of the DHCP, as the District becomes more

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	Within 3 Years of ITP Issuance: Develop demonstration-scale water conservation projects, including drought-tolerant, water-wise landscaping plots and functional rainwater-harvesting system associated with the District's new office.		well known as an information resource.
6. Seek authority for, and if successful implement, higher water use fees for non-exempt groundwater users as necessary to promote conservation and substitution of alternative water supplies for Edwards Aquifer water [1.2.6]	**Goal:** Develop neutrality in the relative costs of groundwater versus surface water, so as to reduce groundwater demand by permittees and their customers, especially for discretionary water use. **Before ITP Issuance**: This legislative initiative or an equivalent incentive-based measure will be sought in at least one out of every two legislative sessions until enacted or for the duration of the ITP; Conduct a study to determine range and conditions for raw water costs for other supplies; Develop a strategy of charging higher water costs and permitting terms to promote shifting to other supplies; Seek higher water use fees initially on conditional permittees. **Within 3 Years of ITP Issuance:** Refine strategy for water use fee increases; Seek higher water use fees on historic non-exempt permittees on certain, then-defined conditions.	**Pending State Legislation:** SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature: Increase water use fees on new conditional permits to a level comparable to the raw water rate of surface water. **Note:** This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. government ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.	Average conditional water use fees, on a dollars per thousand gallons basis, will be comparable to the prevailing raw (untreated, undelivered) wholesale water rates for surface water by end of FY 2008, or within 18 months of the time that authorization is granted to implement this measure.
7. Seek conformance, to the maximum extent legally possible, of the requirements of "Managed Available Groundwater"	**Goal:** Equivalence of Managed Available Groundwater limits and EDWL, if they are supportive of the District's strategies to maintain minimum spring flow. **Before ITP Issuance:** Participate in Groundwater Management Area planning in order to including appropriate Desired Future	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management."	The District will obtain approval by TWDB of District's Groundwater Management Plan that includes applicable Desired Future Conditions and Managed Available Groundwater.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
limits, as established by TWDB, with the limits imposed under this ITP. [1.2.7]	Conditions in joint planning; Advocate for Desired Future Conditions that are protective of spring flows and endangered species; assist TWDB in providing boundary conditions for modeling that are consistent with best available, most representative groundwater modeling. **No later than 2010:** Adjust EDWL in Measure I.A [1.1] above, as required and to the extent legally possible, to be consistent with MAG, and incorporate into revised and submitted Groundwater Management Plan		
8. Seek authority for, and if successful implement, programs to limit groundwater production by all permittees under certain prescribed conditions [1.2.8]	**Goal:** Eliminate waste of Edwards groundwater by all end-users, including permittees and their customers. **Before/After ITP Issuance:** This legislative initiative or an equivalent incentive-based measure will be sought in at least one out of every two legislative sessions until enacted or for the duration of the ITP.	**Pending State Legislation:** SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature: Allow different restrictions among uses during (severe) drought. **Pending State Legislation:** HB 1699, 80th Legislature (Hilderbran). Among other provisions, allows Groundwater Conservation Districts to apply definitions of "waste" more broadly. **Note:** This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.	Less than 2% of the total volume of Edwards groundwater actually pumped in the District each year will be classifiable as "undesirable use for the prevailing aquifer conditions"
9. Work with public water utilities and other governmental entities to enhance	**Goal:** To eliminate sources of significant, continuing pollution from non-point and point sources in the Edwards Aquifer Contributing and Recharge Zones. The District will serve	**See**: Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management."	Within five years of ITP issuance, the District will seek to cooperate with and provide technical assistance to at least

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	**Management Goals, Explanation, and Phasing Plan**[2]	**New Statutory or Regulatory Authority**[3]	**Outcomes or Performance Measures**
plans and regulations that protect both the quantity and quality of Edwards groundwater [1.2.9]	as a resource and catalyst to conserve groundwater supplies and to protect surface water quality that affects recharge quality, **Before/After ITP Issuance:** Attempt to enter into Memoranda of Understanding with various major public water utilities to participate in and extend the water conservation programs into the District; Provide requested technical assistance whenever requested within the District or upstream from the District, on model guidelines and ordinances from other water utilities; Actively participate in municipal processes for developing and adopting development ordinances; Actively participate in reviewing pollution abatement plans and permit applications for both point-source and non-point source sources of potential pollution in the Contributing and Recharge Zones. As deemed necessary by the Board, oppose those facilities at those locations that are inconsistent with protection of recharge quality. **After ITP Issuance:** Work with individual permittees that are public water utilities to showcase and demonstrate the effective-ness of conservation plans and ordinances; Promote stronger state-wide minimum planning and infrastructure design criteria.		10 public or private water utilities and/or public agencies to implement the measures described herein.
10. Adopt authorized production limits on a monthly as well as annual basis for	**Goal:** Track and manage the amount of authorized groundwater withdrawals closely at all times, so that the authorized amounts are more reflective of total water demand on a seasonal basis and provide for a more	**See**: Texas Water Code, Chp. 36, “Groundwater Conservation Districts,” and Texas Water Development Board Rules, TAC Sec. 356.5, “Groundwater Management.”	The District will promulgate Rules implementing this new program no later than the end of FY 2008.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
all District permittees under all aquifer conditions [1.2.10]	effective management program. **Within 1 Year of ITP Issuance:** Define peak monthly pumpage volumes for each annual permitted withdrawal; Clarify any variances to account for unusual circumstances in defining ‘peak’ pumpage volumes (in context of new land development and construction activity, leaks, emergencies, etc.); Develop and publicize new plan; Modify the District’s Groundwater Management Plan to accommodate the new monthly limits regulatory program.		
C. Establish Ongoing Water-Supply Enhancement Measures			
1. Provide support to recharge enhancement projects of all types, if they are deemed effecttive and have minimal negative ecological impacts [1.3.1]	**Goal:** Increase the amount of high-quality water that enters the aquifer as recharge, either naturally or from man-made alterations **Before/After ITP Issuance:** Commit in-kind services, e.g., for hydrogeological assessment and project/task management, to facilitate those projects that are determined to be feasible and beneficial; Retain an engineering consultant, when necessary, to assist staff in evaluating efficacy of significantly increased recharge or amount of significantly reduced recharge through new small-scale structural features; Attempt to enter into MOUs with large-tract landowners, including COA, Travis County, Hays County, and Hill Country Conservancy, for providing such support; seek other grant funds to defray capital/operating costs of worthwhile projects.		The Board will authorize the District’s staff to participate in each specific recharge enhancement project that is judged to be cost-effective with respect to improving aquifer conditions during drought.

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
2. Provide support to clean, maintain and protect recharge features in natural drainage-ways in the District [1.3.2]	**Goal:** Preserve and maintain the existing recharge from natural recharge features **Before/After ITP Issuance:** Attempt to enter into MOUs with large-tract landowners, including COA, Travis County, Hays County, and Hill Country Conservancy, for access to and participation in cleaning debris and sediment from major recharge features; Seek other grant and contract funds to protect and maintain those features.		A budget and personnel commitment to assist in such projects will take place on a continuing basis, providing the equivalent of at least $5,000 per year of in-kind support of debris removal and other recharge feature maintenance.
3. Provide technical assistance and cooperation in the acquisition of open space in the recharge zone of the Edwards Aquifer [1.3.3]	**Goal:** Maintain natural quantity, quality, and flow characteristics of runoff from large, undeveloped areas contributing recharge to the Edwards Aquifer. **Before ITP Issuance:** Commit in-kind services, e.g., for hydrogeological assessment and related projects/tasks, to determine the feasibility and benefit of proposed acquisitions of land; Explore opportunities to enter into MOUs and to partner with other entities, including those named in B.1 and B.2 above, that are involved in acquiring land for conservation easements and that will also preserve recharge quality. **After ITP Issuance:** Respond to specific opportunities and needs, as feasible.	**See:** Texas Water Code, Chp. 36, “Groundwater Conservation Districts,” and Texas Water Development Board Rules, TAC Sec. 356.5, “Groundwater Management.”	The District will seek to execute and implement at least three MOUs with partnering entities involved in land acquisition, by the end of FY 2009, to provide in-kind technical assistance and cash contributions to MOU partners, as appropriate. The District will participate in at least one cooperative program each year, in support of open space acquisition for contribution of recharge to the aquifer, for the next five years.
4. Promulgate programs to prevent waste, including contamination and excessive use, of groundwater [1.3.4] (**Note**: These measures serve to	**Goal:** Minimize excessive use of Edwards groundwater by all end-users, including permittees and permittees’ customers; prevent contamination of recharge sources. **Before ITP Issuance:** Actively promote inter-jurisdictional cooperation in implementing recommendations of the Regional Water Quality Protection Plan for the Barton Springs segment;	**New Rule:** Section 3-3.7 Proscribed Water Use During Declared Droughts. C. Domestic use that meets the following criteria is presumed to be excessive use that harms the groundwater reservoir and aquifer resources and is therefore proscribed use.	Less than 1% of the total volume of Edwards groundwater actually pumped in District each year will be classifiable as “excessive use.” No direct discharges of treated wastewater will be allowed into contributing or recharge zones of the Barton Springs Edwards Aquifer.

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
implement those actions described in Measure 1.2.8 above)	Establish and promulgate by rule, enforceable criteria for wasteful "excessive water use" by end-users (on a per connection basis), e.g. limiting residential water connections to a maximum production of 20,000 gallons per month during extreme drought conditions; Develop procedures, including reporting and penalties, for enforcement against individual users' excessive use through production permit of permittee; Seek authority for establishing, and if successful implement, new definitions of groundwater waste that include proscribed uses during certain, declared drought stages by end users as well as permittees, e.g., limitations on selected outdoor water uses; Establish or adopt a set of desired BMPs for land use and development in the Edwards Aquifer contributing and recharge zone; Review and comment on subdivision and site development plans in the Edwards contributing and recharge zones, in relation to Edwards Aquifer recharge; Seek authority by statute or rules for establishing, and implement as needed, rules for prohibiting point source discharges in the contributing and recharge zone of the Aquifer **After ITP Issuance:** Promulgate rules, applicable at all times, that apply excessive water use standards to end-users of permittees as well as permittees; Review and revise, as necessary, the criteria and variances for the excessive water use standard.	**Pending State Legislation:** HB 1699, 80th Legislature (Hilderbran): Among other provisions, allows groundwater conservation districts to define waste more broadly. **Pending State Legislation:** HB 3039, 80th Legislature (Rose): Prohibits direct discharge of treated effluent in contributing and recharge zones of the Barton Springs segment. **Note**: This commitment to enhanced management is contingent on gaining and maintaining the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law. **Note**: The District cannot commit to adopting policies and programs directly regulating and protecting water quality from urban storm runoff pollution without significant additional legal authority.	

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
D. Establish Ongoing Water-Supply Conversion Measures			
1. Initiate, support, and participate in conjunctive use policies and plans to increase use of surface water supplies with existing Edwards groundwater providers in the District [1.4.1 and 1.4.2]	**Goal:** Maximize the substitution of surface water for Edwards groundwater use during severe drought through conjunctive water use programs, as feasible **Before ITP Issuance:** Convene and/or actively participate in meetings with surface water purveyors and providers to exchange information about future plans for utility construction and growth generally; Monitor and facilitate actions of developers who catalyze utility system extensions; Prohibit new Edwards withdrawals without conjunctive use plans in place; Develop a policy framework concerning designation of "groundwater management zones" with different hydrogeologic and water availability/use situations, and incorporate them in a revised Groundwater Management Plan submitted to TWDB. **After ITP Issuance:** MOAs or modified permits with purveyors of alternative water supplies as feasible, to enable and enforce conversion to surface water during drought; Consider delimiting this policy to apply to selected management zones, whereby supply substitutions are promoted in some areas and not in others (i.e., address the unanticipated consequences of providing new water supplies in sensitive aquifer zones).	**See**: Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and Texas Water Development Board Rules, TAC Sec. 356.5, "Groundwater Management." **Note**: This commitment to accomplish conjunctive use management is contingent on obtaining and maintaining the statutory and common law authority to carry them out, as well as negotiating mutual agreements with permittees to commit to conjunctive use management. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement and enforce these measures, they will necessarily be adjusted to comply with applicable law.	Within five years from the date of ITP issuance, the District will reduce the authorized peak demand for Edwards groundwater during severe drought by at least 10% from the amount previously authorized five years earlier in the same season, by substitution with surface water supplies. Within 10 years from the date of ITP issuance, the District will reduce the authorized peak demand for Edwards groundwater during severe drought by at least 20% from the amount previously authorized 10 years earlier in the same season, by substitution with surface water supplies.
2. Initiate, support, and participate in policies and plans to increase use of	**Goal:** Maximize the substitution of other alternative water for Edwards groundwater use during severe drought through conjunctive water use programs, as feasible.	**Proposed Rule:** Section 3-7.5 User Drought Contingency Plans. A. Contents of UDCP 8. UDCP special provisions for Conditional Production	

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
other alternative water supplies (e.g., units of the Trinity Aquifer, other aquifers, desalinated water, harvested rainwater) with existing Edwards groundwater providers in the District [1.4.3]	**Before ITP Issuance:** Convene and/or actively participate in meetings with water purveyors and providers to exchange information about future plans for utility construction and growth generally; Assist providers in making feasibility studies of alternative water supply availability; Monitor and facilitate actions of developers who catalyze utility system extensions; Prohibit new permits for Edwards withdrawals without enforceable conjunctive use plans; Promote rainwater harvesting through education programs, demonstration units at District facilities, and referral of users to grants and low-cost loan programs available for such systems. **After ITP Issuance:** Execute MOAs or modified permits with water supply providers to enable conversion to alternative water supplies during drought; Consider delimiting the application of this policy to selected management zones (as described in Measure C.1. above).	Permits shall include… **Proposed Rule:** Section 3-1.11. Permit Conditions and Requirements. N. Permittees holding Class B conditional permits under Rule 3-1.24(B)(2) must maintain at all times the certain ability and binding commitment to switch from the to-be-permitted volume of groundwater to some alternate water supply source(s) on a 100% basis, including a) all necessary physical infrastructure and supporting agreements, rates, and tariffs required for such substitution, and b) the commitment to use the alternative supply as warranted by District-declared drought conditions. **Note**: This commitment to accomplish conjunctive use management is contingent on obtaining and maintaining the statutory and common law authority to carry them out, as well as negotiating mutual agreements with permittees to commit to conjunctive use management. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement and enforce these measures, they will necessarily be adjusted to comply with applicable law.	
3. Seek authority for, and if successful implement, a new regulatory program	**Goal:** Preserve aquifer use during extreme drought for use essential to human health and welfare by those without recourse to alternative supplies. **Before/After ITP Issuance:** This legislative	**Proposed Rule:** Section 3-1.24. Conditional Production Permits. E. Term of Conditional Production Permit (2). All Class B conditional production permits are effective for the fiscal year	New permit applicants will be issued Class B Conditional Permits, or a comparable type that achieves the same goal, requiring curtailment or

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
element that requires existing groundwater users, under certain prescribed conditions, either to convert from Edwards groundwater to alternative water supplies, and/or to encourage such conversion using higher water usage fees and longer term permits as an economic incentive [1.4.4]	initiative will be sought in at least one out of every two legislative sessions until enacted or for the duration of the ITP; Establish rules that require permittees for water uses that are not essential to human health and welfare to be curtailed during extreme drought; Establish rules that accomplish more rapid curtailment of withdrawals by new conditional permit holders during declared extreme drought; Require the demonstration of availability and commitment to using alternative water supplies by holders of new conditional permits.	of issuance and, unless otherwise stated on the permit, are automatically renewable annually for an aggregate term up to 40 years, provided… **Pending State Legislation:** SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature: Increase water use fees on new conditional permits to a level comparable to raw water rate of surface water; Allow different restrictions among uses during drought. **Note**: This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.	cessation of Edwards groundwater withdrawals during extreme drought.
4. Encourage and facilitate the construction of excess pumpage and storage capacity within alternative water supply systems by District permittees, to promote the use of alternative water supplies during drought conditions in lieu of groundwater [1.4.5]	**Goal:** Build-in and use excess alternative supply capacity available to certain historic use permittees to reduce Edwards groundwater use during extreme drought. **Before ITP Issuance:** Adoption of a policy in support of providing additional surface water or alternative water utility capacity to high pumpage zones; Develop program to implement the policy and amend the Groundwater Management Plan to incorporate and authorize its use; Educate historic use permittees of prospective incentives available to them if they participate.		The amount of Edwards groundwater able to be effectively "retired" from any use by historic-water users during extreme drought will increase through time.

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	Within Three Years After ITP Issuance: Implement rules that provide incentives in the District's permitting and rate provisions to encourage switching to surface or alternative water sources during droughts for any one historic use permittee or among permittees, provided that Edwards Aquifer levels and spring discharge are expected to benefit at all times; Consider delimiting the application of this policy to selected management zones (as described in Measure C.1. above).		
II. ADDITIONAL MEASURES EMPLOYED AFTER DECLARING ALARM STAGE DROUGHT			
1. Develop a drought trigger methodology that can be effectively used to signal timely curtailment of groundwater withdrawals [2.1]	**Goal:** Develop a rational, science-based framework for early detection and public communication of drought-stage conditions in the aquifer. **Before ITP Issuance:** Promulgate and use new, science-based drought triggers for declaring drought stages and actions. **After ITP Issuance:** Consider and, if needed, develop drought triggers for Trinity Aquifer.	**New Rule:** Section 3-7.3. Drought Stages and Triggers.	The new drought trigger methodology was developed, peer-reviewed, adopted, and put into operation during 2006.
2. Define trigger conditions that require a mandatory 20% reduction in monthly groundwater withdrawals by permittees [2.2]	**Goal:** Require water use reductions before aquifer levels and spring flows are at critical stage, to minimize likelihood of becoming a severe groundwater drought. **Before ITP Issuance:** Evaluate and then promulgate by Rule pumping restrictions requiring 20% reduction in monthly pumpage allocation when Lovelady Well level is equal to or greater than 180.8' below the land surface, or when the 10-day average discharge of Barton Springs is equal to or	**New Rule:** Section 3-7.3. Drought Stages and Triggers.	The total volume of water actually withdrawn by permittees, in the aggregate, will comply with the 20% target of demand reduction, as authorized in the UDCPs.

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Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	less than 38 cfs; enforce compliance with permittees' UDCPs.		
3. Define additional reductions that will be required of certain conditional production permittees under certain conditions [2.3]	**Goal:** Ensure that if a permit applicant seeks to use Edwards water during non-drought, it is able to curtail or completely cease such use during drought to protect other users and uses. **Before ITP Issuance**: Establish more rigorous conditional permit application requirements for new (Class B) conditional permittees; Promulgate by Rule more aggressive curtailment targets for Class B conditional permittees in an Alarm Stage drought, including the demonstration of an effective alternative supply arrangement if a higher-percentage curtailment or cessation is ordered by the District.	**Proposed Rule:** Section 3-1.24 Conditional Production Permits. F. Compliance with Drought Stages…(2) Alarm Stage Drought…(ii) Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and shall curtail monthly groundwater production by a mandatory 50% drought reduction requirement.	Renewal of all such permits with these provisions in place
4. Seek legislation, and if successful implement, authorities to apply additional enforcement measures for ensuring/improving drought period compliance with withdrawal restrictions [2.4]	**Goal:** Penalties, fines, and fees are set sufficiently high so that egregiously non-compliant permittees cannot treat them as "just a cost of doing business." **Before/After ITP Issuance**: This legislative initiative or an incentive-based measure will be sought, if required by court actions in the application of the defined regulatory program, in at least one out of every two legislative sessions until enacted or for the duration of the ITP; If authorized, implement an administrative fines program; Implement a regulatory compliance fee for non-compliant permittees; Use tiered penalty matrix to multiply fines and penalties based on amount of water used in excess of authorized amount,	**New Rule: Section** 3-7.9. Imposition of Regulatory Fees. **New Rule:** Section 3-7.11. Enforcement/Penalties During Drought.	

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	providing an elastic response to higher demands; Develop additional enforcement strategies for non compliance, as necessary.		
III. ADDITIONAL MEASURES EMPLOYED AFTER DECLARING CRITICAL STAGE DROUGHT			
1. Define trigger conditions that require a mandatory 30% reduction in monthly groundwater withdrawals by permittees [3.1]	**Goal:** Require water use reductions before aquifer levels and spring flows enter an extreme drought period that requires extreme management actions to attempt to minimize severe impacts. **Before ITP Issuance**: Evaluate and then promulgate by Rule pumping restrictions requiring 30% reduction when Lovelady Well level is equal to or greater than 192.1 ft. below land surface, or when a 10-day average discharge of Barton Springs is equal to or less than 20 cfs. **After ITP Issuance**: Evaluate on the basis of new data or management experience attained from prior implementation, and then modify, as warranted, these measures to achieve groundwater demand reductions equal to or greater than what is anticipated by using the measures specified here.	**New Rule:** Section 3-7.3. Drought Stages and Triggers.	The total volume of water actually withdrawn by permittees, in the aggregate, will comply with the 30% target of demand reduction, as authorized in the UDCPs.
2. Define additional reductions that will be required of certain conditional permittees under certain conditions [3.3]	**Goal**: Ensure that if a user of "new" Edwards groundwater seeks to use Edwards water during non-drought, it is able and willing to curtail completely such use during drought to protect other users and uses. **Before ITP Issuance:** Establish and promulgate in the District Rules more rigorous conditional permit application requirements for new (Class B) conditional permittees;	**Proposed Rule**: Section 3-1.24 Conditional Production Permits. F. Compliance with Drought Stages…(3) Critical Stage Drought…(ii) Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and shall curtail monthly groundwater production by a mandatory 75%	Renewal of all such permits with these provisions in place Compliance with achieving mandated curtailments by all Class B conditional permittees.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
	Promulgate more aggressive curtailment targets for Class B conditional permittees in Critical Stage drought, including the demonstration of an effective alternative supply arrangement upon a high percentage curtailment or cessation order by the District.	drought reduction requirement.	
3. Define an Emergency Response Period, deep within the Critical Stage drought period, in which both a) water withdrawals under certain conditional permits may be further curtailed or prohibited, and b) if legislative authority is granted, certain historic use permits not directly essential to human health and welfare may be curtailed [3.4 and 3.5]	**Goal:** Implement short-term, emergency management measures that are designed to prevent or minimize harm from further reduction in spring flows. **Before ITP Issuance**: Establish a new Emergency Response Period that will be declared at the discretion of the District Board and generally when the 10-day average flow at Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days; If legislative authority is given, develop and communicate a regulatory program to curtail certain non-essential uses, as described in I.C.3 above; Initiate conversion program for historic-use permittees described in I.C.4 above; If and as available from adaptive management measures, implement programmed structural or other non-structural measures as last-resort initiatives to avoid irrecoverable damage to the aquifer and its uses.	**New and Proposed Rules:** Section 3-1.24 Conditional Production Permits. F. Compliance with Drought Stages. (4) Emergency Response Period. **New Rule:** (i) Upon declaration of an Emergency Response Period (ERP) under Rule 3-7.3(F), the Board shall order mandatory curtailments for all Class A conditional permits of 50% for the first three full months, 75% for the next three full months, and 100% (cessation of use) thereafter. If Barton Springs flow rises above 14 cfs for a continuous 90-day period, the next less severe stage of curtailment will be declared following that increment, until either the 30% use curtailment on all permitted wells is reached or the Critical Stage Drought is no longer declared. **Proposed Rule:** Section 3-1.24 (ii) Upon declaring an ERP, the Board shall order all Class B conditional permits to cease all pumping of groundwater, which order shall remain in effect until the ERP is declared by the Board to no longer exist. Once the ERP no longer exists, the curtailment schedule will then follow the Class A conditional permit restrictions for the balance of that Critical Stage drought period.	Renewal of all permits with these provisions in place.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
		Pending State Legislation: SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature: Allow different restrictions among uses during (severe) drought. **Note**: This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.	
4. As negotiated in individual conditional-use permits, require mandatory switching to alternative water supplies by groundwater users during an Emergency Response Period, as enabled through prior agreements with current or other water suppliers with excess capacity [3.6]**.**	**Before/After ITP Issuance:** Hold work sessions with utilities and water supply providers that are most likely to construct surface or alternative water systems, to discuss feasibility and options, and possible nonstructural incentives by the District that might promote availability of such excess capacity; contract with engineering specialist to evaluate economic and engineering studies by permittees, to determine the efficacy of the multi-source systems.		An increased amount of "excess capacity" potentially available to or in District permittees' systems.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
IV. OTHER MITIGATION INVESTIGATIONS, MEASURES, AND ADAPTIVE MANAGEMENT STRATEGIES (To Be Further Defined and Undertaken as Funds, Partners, and Agreements Are Available)			
1. The District will seek to enter into an Inter-local Agreement (ILA) between the District and the City of Austin to support the Salamander Conservation Program to manage the species during all conditions. [4.1, 4.6]	**Goal:** Maintain close coordination with the City of Austin on all stages of drought or other risk situation, to manage groundwater production and springflow and to protect the species of concern under highly adverse conditions. **Before ITP Issuance**: This Inter-local Agreement may be a master MOU that describes roles and responsibilities of the City and the District on this and several additional areas of collaboration, including those described elsewhere in this table and also those that are eventually authorized as part of the City's Barton Springs Pool Master Plan, possibly including extension of spring runs, re-aeration, more accurate spring flow measurements, and others to be identified.		If the ILA/MOU is authorized, a cash contribution of some amount to be determined and commensurate with the scope of the programs included in the MOU will be made to the Barton Springs Salamander Conservation Fund.
2. The District will refine and improve its groundwater modeling capabilities (such as the enhanced GAM or the emerging dual conductivity model) to serve as a planning and evaluation tool when implementing new groundwater management programs [5.1].	After ITP Issuance: Use and apply appropriate model revisions in the development and modification of specific management techniques, such as the effect of new conditional permit requirements and the aquifer's transient response to various short-term drought scenarios. Evaluate new models for future use as GAMs.		The model to be currently used for Managed Available Groundwater determinations was completed, and submitted to extensive peer review in 2005 and 2006. The District's model is used by Texas Water Development Board to define the amount of Managed Available Groundwater once the Groundwater Management Area 10 submits its agreed Desired Future Conditions to the TWDB.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
3. The District will work with universities, the COA, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and toxicity of depressed DO and elevated conductivity levels affecting salamander viability in spring water [5.2].	**Before ITP Issuance:** Incorporate final peer-reviewed results of the salamander toxicity studies into DHCP biological impact assessments.		DHCP Studies were completed in 2006 and reported in 2007.
4. Additional studies will be conducted on the potential for augmentation of water supplies in the brackish water zone (including desalination and aquifer storage & recovery) and from other freshwater (e.g. Trinity) aquifers [5.3].	**Before/After ITP Issuance:** Consider participation with the City of Austin and/or other entities in feasibility studies of various water augmentation approaches. If feasibility study is positive, plan and execute programs to evaluate desalination, aquifer storage and recharge, rainwater harvesting, Trinity Aquifer production, etc.; Install a multi-port monitoring well system in Edwards and Trinity Aquifers to evaluate potentiometric relationships; Continue evaluation of geophysical tools for assessing saline zone properties.		Complete feasibility study on one or more of the more viable alternatives within one year of ITP issuance.
5. The District will work with the US Geological Survey, universities, the City of Austin, and other qualified	**Before/After ITP Issuance:** Commit in-kind or matching cash support in the amount of at least $30,000 over a two-year period to USGS or other District-approved studies.		Commitment of in-kind and cash support of $30,000 annually for two years in support of these studies.

Table 6.5-1. Proposed groundwater management measures under the Habitat Conservation Plan and Incidental Take Permit.

Management Measures[1]	Management Goals, Explanation, and Phasing Plan[2]	New Statutory or Regulatory Authority[3]	Outcomes or Performance Measures
parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which will be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events [5.4].			
6. The District will work with universities, the COA, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs Ecosystem, and possibly other relevant studies to be determined. [5.5 and 5.6].	**Before/After ITP Issuance:** Commit in-kind or matching cash support in the amount of at least $20,000 over a two-year period. This would entail a MOU with the City of Austin and/or TPWD, and would likely involve seeking a Sec. 6 grant from the Service.		Commitment of in-kind and cash support of $20,000 over two years in support of these studies.

These measures would include actions to reduce demand for groundwater withdrawals regardless of the occurrence of drought or non-drought conditions. These actions are further divided into establishment of regulatory-based withdrawal limits on Edwards Aquifer "pumpage under permit" (Category 1.1); ongoing/continuing demand reduction measures (Category 1.2); on-going/continuing water supply enhancement measures (Category 1.3); and ongoing/continuing water supply conversion measures (Category 1.4). The District's regulatory programs, based on several different types of production permits, are central to implementing most of these measures. These permits and their applicable groundwater withdrawal curtailment schedules are described in more detail in Section 6.1.3.

6.5.1 Management Strategies Undertaken during All Conditions (Category 1.0)

6.5.1.1 Establish and Implement a Permitting Program in the District to Maintain and Improve an Extreme Drought Withdrawal Limitation ("Aquifer Cap") (1.1)

This measure, now implemented by Rule, established a "pumpage under permit"–driven ceiling at levels established by rule by the District Board. While it must be established as a regulatory vehicle during all aquifer conditions, it is designed to be at maximum effectiveness during a defined Extreme Drought; the ceiling, termed the Extreme Drought Withdrawal Limitation, or EDWL, is a type of cap on the Edwards Aquifer and will be incorporated in the upcoming revision of the District's Groundwater Management Plan and approved by the TWDB consistent with Chapters 36 and 356 of the Texas Water Code.

Currently, the EDWL has been established at 8.5 cfs of pumpage from all sources, including an allowance for exempt wells. This is the smallest amount of pumpage that the District can currently manage to achieve under existing authorities in a reasonably reliable fashion during Extreme Drought. The operation of the EDWL is depicted in Figure 6.5-1, on the following page, using four pumpage scenarios: the existing condition (2007), during non-drought; some hypothetical future condition, where conditional permits are stipulated at 5 cfs, during non-drought; that same future condition during Critical Stage drought; that same future condition during a defined Extreme Drought/Emergency Response Period. Pumpage under conditional permits decreases to zero during extreme, prolonged drought; pumpage under historical permits decreases according to the maximum curtailments provided by the User Drought Contingency Plans, currently at 70 percent of the authorized monthly usage for all historical permits.

6.5.1.2 Ongoing and Continuing Demand Reduction Measures (1.2)

These are measures that are designed to reduce aquifer withdrawals from pumping. Specific measures include:

(1.2.1) Implement a new database of registered wells that contains estimates of groundwater withdrawal for a subset of exempt (i.e., non-permitted) wells to better gauge location and amount of pumpage from all exempt wells.

(1.2.2) Institute a new, voluntary metering and water use monitoring program for non-permitted (exempt) wells.

(1.2.3) Require nonexempt users (permittees) to identify and encourage them to employ measures in their adopted UCPs and UDCPs so that they may voluntarily achieve at least a 10% reduction during the summertime Water Conservation Period, and encourage all other groundwater users to implement similar conservation measures. (Implemented)

(1.2.4) Require permittees to identify and implement the mandatory measures stipulated in UDCPs to achieve specified levels of curtailment during District-declared drought. (Implemented)

(1.2.5) Conduct a continuing water conservation and demand reduction education program with a specified minimum budget directed at all groundwater users in the District. (Implemented)

(1.2.6) Seek authority for, and if successful implement, higher water use fees for non-exempt groundwater users as necessary to promote conservation and substitution of alternative water supplies for Edwards Aquifer water. (Implemented, in part)

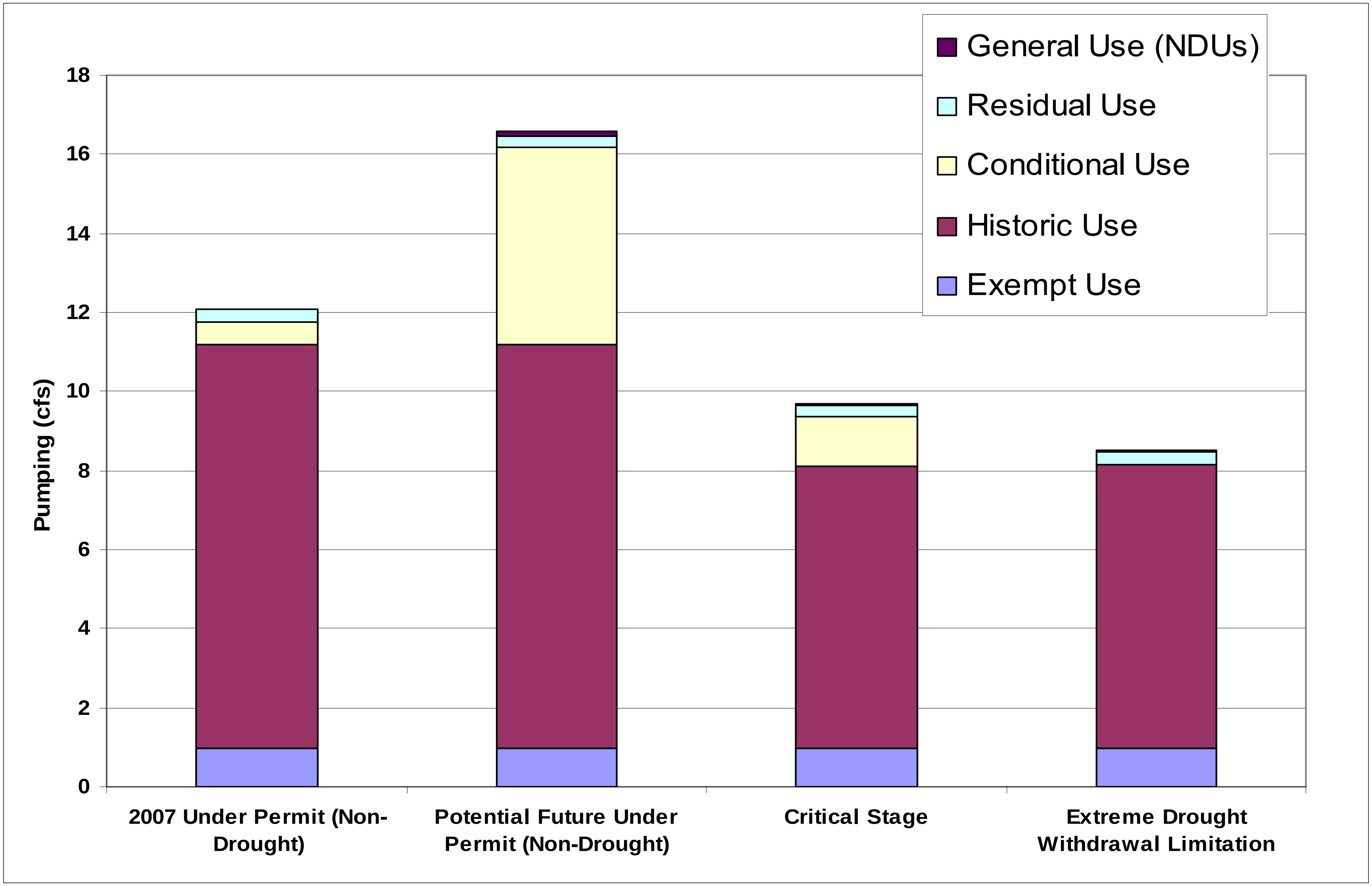
(1.2.7) Seek conformance, to the maximum extent legally possible, of the requirements of “Managed Available Groundwater” limits, as established by TWDB, with the limits imposed under this ITP.

(1.2.8) Seek authority for, and if successful implement, programs to limit groundwater production by all permittees under certain prescribed conditions. (Implemented, in part)

(1.2.9) The District will work with public water utilities and other governmental entities to enhance plans and regulations that protect both the quantity and quality of Edwards groundwater.

(1.2.10) The District will adopt authorized production limits on a monthly as well as annual basis for all District permittees under all aquifer conditions.

Figure 6.5-1 Pumping Limits Under the EDWL for Four Different Aquifer Scenarios



6.5.1.3 Ongoing/Continuing Water Supply Enhancement Measures (1.3)

There are four measures included to improve water supply:

(1.3.1) Support will be provided to recharge enhancement projects of all types, if they are deemed effective and have minimal negative ecological impacts. (Implemented, in part)

(1.3.2) Support will be provided to clean, maintain and protect recharge features in natural drainage-ways in the District. (Implemented)

(1.3.3) Provide technical assistance and cooperation in the acquisition of open space in the recharge zone of the Edwards Aquifer.

(1.3.4) Promulgate programs to prevent waste, including contamination and excessive use, of groundwater. ***(Note:*** These measures serve to implement those actions described in Measure 1.2.8 above.) (Implemented, in part)

6.5.1.4 Ongoing/Continuing Water Supply Conversion Measures (1.4)

There are five ongoing/continuing measures to convert use of groundwater to surface water:

(1.4.1) The District will initiate, support, and participate in conjunctive use initiatives to increase use of surface water supplies with existing Edwards groundwater providers in the District. (Implemented, in part)

(1.4.2) The District will initiate planning and assess feasibility of long-range plans, policies and programs concerning designation of defined water management zones with different hydrogeologic and water availability/use situations and incorporate them in a revised Groundwater Management Plan.

(1.4.3) The District will initiate, support, and participate in policies and plans to increase use of other alternative water supplies (e.g., units of the Trinity Aquifer, other aquifers, desalinated water, harvested rainwater) with existing Edwards groundwater providers in the District.

(1.4.4) Seek authority for, and if successful implement, a new regulatory program element that requires existing groundwater users, under certain prescribed conditions, either to convert from Edwards groundwater to alternative water supplies, and/or to encourage such conversion using higher water usage fees and longer term permits as an economic incentive. (Implemented, in part)

(1.4.5) Encourage and facilitate the construction of excess pumpage and storage capacity within alternative water supply systems by District permittees, to promote the use of alternative water supplies during drought conditions in lieu of groundwater.

6.5.2 Additional Measures Employed after Declaring Alarm Stage Drought (Category 2.0)

Under the permitting program and curtailment schedules described in Section 6.1.3, four strategies will be employed to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the first drought trigger stage:

(2.1) A drought trigger methodology has been developed pursuant to this DHCP that will effectively signal timely curtailment of groundwater withdrawals. (Implemented)

(2.2) Trigger conditions have been defined, pursuant to this DHCP, that require a mandatory 20% reduction in monthly groundwater withdrawals reported by permittees.[2] ***Alarm Stage*** = 20% reduction when Lovelady Well level is equal to or greater than 180.8’ from the Land Surface Datum (LSD) or when a 10-day average discharge of Barton Springs is equal to or less than 38 cfs. (Implemented)

(2.3) Additional reductions that will be required of certain conditional production permittees under certain conditions have been defined and included in permittees’ User Drought Contingency Plans. (Implemented, in part)

(2.4) The District will seek legislation, and if successful implement, authority to apply additional enforcement measures for ensuring/improving drought period compliance with withdrawal restrictions.

6.5.3 Additional Measures Employed after Declaring Critical Stage Drought (Category 3.0)

Under the permitting program and curtailment schedules described in Section 6.1.3, five measures will be employed to mandate specific aquifer withdrawal reductions after the aquifer level or flow of Barton Springs reaches the second and most severe drought trigger stage, called the “Critical Stage.”

(3.1) Trigger conditions have been defined, pursuant to this DHCP, that require a mandatory 30% reduction in monthly groundwater withdrawals by permittees.[2] ***Critical Stage*** = 30% reduction when Lovelady Well level is equal to or greater than 192.1 feet from Land Surface Datum (LSD) or when a 10-day average discharge of Barton Springs is equal to or less than 20 cfs. (Implemented)

(3.3) Additional reductions have been defined, pursuant to this DHCP, that are required of certain conditional permittees (under Class B conditional permits) under certain conditions. (Implemented)

(3.4) An Emergency Response Period has been defined, pursuant to this DHCP, deep within the Critical Stage drought period, in which both a) water withdrawals under certain conditional permits may be further curtailed or prohibited, and b) if legislative authority is granted, certain historic use permits not directly essential to human health and welfare may be curtailed. (Implemented)

(3.5) An ***Emergency Response Period*** will begin when the 10-day average discharge of Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days; The District would also order mandatory reductions for all Class A Conditional Permits of 50% for the first 3 months, 75% for the next 3 months, and 100% thereafter, until Barton Springs flow rises above 14 cfs, then the next less severe stage of reduction would be declared until either the 30% use reduction on all permitted wells is reached or the Critical Stage Drought is no longer declared. (See Section 6.1.3, Covered Activities, for a discussion of the various types of groundwater users and the various permits authorizing groundwater production.) (Implemented)

(3.6) As negotiated in individual Class B conditional-use permits and subsequently stipulated by their UDCPs, require mandatory switching to alternative water supplies by groundwater users during an Emergency Response Period, as enabled through prior agreements with current or other water suppliers with excess capacity.

6.5.4 Expected Rulemaking Associated with Additional Authority Arising from New Legislation

In the Texas Legislative Session that ended in May 2007, the District requested some additional authority in legislation that it sponsored (identified in Table 6.5-1 as SB 747). The provisions of this legislation in large part were identified through the DHCP process. The bill was signed into law by the Governor and has an effective date of September 1, 2007. Shortly thereafter, the District will be proposing some new Rules to implement those new authorities.

These rules will generally be designed to improve the District's drought management program, by promoting conjunctive water use and substitution of alternative water for Edwards groundwater during severe, prolonged drought. The new rules will increase the water usage fee on most new, conditional-use permitted Edwards Aquifer withdrawals from $0.17 to $0.38 per thousand gallons, putting the cost of newly requested, conditional Edwards groundwater on a par with raw (untreated, undelivered) surface water resource costs. Another prospective rule change will increase the curtailment of historic industrial, commercial, and non-agricultural irrigation users of Edwards water during extreme drought from the current 30 percent up to 40 percent, provided an alternative water supply for the additionally curtailed water is available. This will ultimately have the direct effect of further reducing the pumpage cap represented by the EDWL and increasing springflow at Barton Springs.

More generally, the new statutory authority provided by this legislation reinforces and codifies the District's ability to curtail differentially groundwater use for purposes of drought-period management, rather than rely upon the implied authorities that previously existed.

6.6 Measures to Mitigate and Monitor Potential Impacts

Several measures would be implemented under the District DHCP to attempt to mitigate and monitor potential impacts to the species. These measures include structural mitigation investigations and measures to ameliorate extreme conditions that are not able to be mitigated by other means, and adaptive management strategies that will be undertaken as funds, partners, and permissions are identified. These measures are not governed by declared drought conditions.

6.6.1 Structural Mitigation Investigations and Measures (Category 4.0)

Because springflow may not be assured during worst drought conditions, contingency measures to supplement or augment springflow using water from other sources have been investigated. Several structural mitigation strategies have been identified with a fatal flaw evaluation performed to help evaluate constraints, costs and other issues (Appendix C). Based on this evaluation a strategy to investigate structural methods for supplementing springflow is included under the DHCP.

(4.1) Coordinate with the City of Austin to investigate feasibility of re-circulating water discharged from Barton Springs to specific habitat protection zones within the spring ecosystem or re-aerating groundwater in the flow path to Barton Springs during periods of critically low flows.

(4.6) The District will seek to enter into an ILA between the District and the City of Austin to support the Salamander Conservation Program to monitor and manage the species during all conditions.

6.6.2 Adaptive Management Strategies (Category 5.0)

Six adaptive management strategies have been identified for the DHCP:

(5.1) The District will refine and improve its GAM to serve as a planning and evaluation tool when implementing new groundwater management programs. (The description and discussion of the current GAM, its core assumptions concerning the effects of pumpage on springflow, and its results, findings, and conclusions are presented in the Sustainable Yield Report, included as Appendix L.)

(5.2) The District will work with universities, the City of Austin, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and toxicity of depressed Dissolved Oxygen and elevated Conductivity levels affecting salamander viability in spring water.

(5.3) Additional studies will be conducted on the potential for the augmentation of water supplies in the brackish water zone (including desalination and aquifer storage and recovery) and from other freshwater (e.g., Trinity Aquifer).

(5.4) The District will work with the U.S. Geological Survey, universities, the City of Austin, and other qualified parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which will be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events.

(5.5) A survey of aquifer biota will be conducted in sampling wells dispersed throughout the Barton Springs segment of the Edwards Aquifer in order to improve understanding of species richness and diversity.

(5.6) The District will work with universities, the City of Austin, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs ecosystem, and possibly other relevant studies to be determined.

The Adaptive Management Program, including roles and responsibilities of various entities and a general protocol for guiding its development and incorporation into the active DHCP, as warranted and agreed, is described in more detail in Sections 6.7.1.3 and 6.9.6.

6.7 Implementation Roles of the District Habitat Conservation Plan Participants

The District will apply for a 50-year regional ITP to allow incidental take of listed species at the Barton Springs ecosystem. Water resources planning in Texas is mandated to use a 50-year time horizon, and the groundwater management plans, strategies, and tactical measures used by water resource management agencies like the District are continuing functions. Responsibilities of the participant and cooperating entities are outlined below. The ITP may specify responsibilities of each entity, conservation and mitigation measures to be implemented, monitoring and research procedures, and any other permit conditions that may be required of these parties.

6.7.1 Barton Springs/Edwards Aquifer Conservation District

The Barton Springs/Edwards Aquifer Conservation District is the only Participant, as the term is defined by the Service, in this DHCP.

- The District will be the primary ITP holder. The ITP will cover all groundwater users that are issued a groundwater withdrawal permit by the District.

- As the District issues and renews groundwater withdrawal permits, permit fees will generate funding for the DHCP. The District will provide the administrative framework to distribute part of this revenue to any other entities with implementation responsibilities under the DHCP so that mitigation measures and adaptive management strategies, as are specified under the ITP, can be implemented.

- The District will be responsible for implementing drought stage management as well as comprehensive management of the aquifer, using its rules and statutory authorities.

- The District will report on an annual basis to the Service on the status of aquifer pumping, drought stage management, mitigation measures, and adaptive management.

6.7.1.1 Administration and Reporting

The District will provide an annual report of the progress of implementation of the District DHCP to the Service. The annual report will provide information on District DHCP measures implemented during the previous year, funding expended on District DHCP measures, and expected implementation during the next year. The annual report will also provide an assessment of anticipated versus implemented measures during the previous year and a discussion of unexpected events or conditions. More detail on the contents of the annual report to the Service is provided in Section 6.11.

6.7.1.2 District Habitat Conservation Plan Management Advisory Committee

The District will establish an HCP Management Advisory Committee (Committee) to advise and assist in the coordination of conservation activities affecting Covered Species at Barton Springs. The Committee will:

- Provide a forum for exchange of information relative to covered species;
- Provide advice on covered species management activities;
- Advise the District on budgetary issues relating to management of covered species;
- Advise the District on priorities for conservation actions; and
- Guide the development and implementation of the adaptive management program.

The Committee will be appointed by the District Board and will include volunteer representatives with biological or natural resource management roles from the District, Service, TPWD, the City of Austin, and other participating management entities. The composition of the Committee will focus on active management of the Covered Species at Barton Springs.

6.7.1.3 Development and Implementation of Adaptive Management Process

The District DHCP Adaptive Management Process would be targeted at:

- Guiding long-term aquifer management monitoring and research planning;
- Further defining critical attributes and linkages within and between physical components of the spring ecosystem;

- Promoting an improved understanding of key factors that drive changes in the spring ecosystem;

- Making qualitative and quantitative assessments of resource changes resulting from various flow regimes and impacts to the Barton Springs salamander and Austin blind salamander; and

- Providing information to stakeholders regarding the potential impacts/benefits of various flow regimes in the Barton Springs ecosystem.

Specific Adaptive Management Measures 5.1 through 5.6 as discussed in Section 6.6.2 would become a part of the Adaptive Management Process.

6.7.1.4 Biological Goals and Objectives for Salamanders in the Habitat Conservation Plan Adaptive Management Process

Barton Springs Salamander

The biological goal of the District DHCP for the Barton Springs salamander is to maintain adequate springflow from the Barton Springs complex to meet the minimum ecological requirements of the species population. The following objectives underpin the Plan in pursuit of this over-arching goal:

- Adopt and implement groundwater management measures to minimize the extent of range and time that dissolved oxygen concentration is less than 3.0 mg/L under all aquifer conditions;

- Adopt and implement groundwater management measures to produce dissolved oxygen concentrations with a ten-day average of at least 3.9 mg/L during all but extreme drought conditions;

- Adopt and implement groundwater management measures to preserve the available surface habitat of the Barton Springs salamander; and

- Adopt and implement groundwater management measures that do not cause other water chemistry and quality parameters to exceed their historical ranges.

The specific measures identified in Table 6.5-1, both individually and in aggregate, substantially improve the probabilities that all of these objectives are achieved during the life of the ITP. However, both natural system variations and anthropogenic variations over which the District has no control prevent a guarantee that the overarching goal will be reached.

Austin Blind Salamander

The biological goal and objectives for the Austin blind salamander are the same as those for the Barton Springs salamander.

6.7.1.5 General Management Actions

- Aquifer management will focus on an array of measures affecting the production of water from wells in the Edwards Aquifer, so as to maintain springflows in Barton Springs, as outlined in Sections 6.5 and 6.6.

- A monitoring strategy will be developed and implemented to measure future success of aquifer management activities, and modify management actions based on the availability of new information:

    - Conduct annual review of Barton Springs salamander survey data collected monthly and continuous water quality data by the City of Austin and other entities to re-evaluate biological risk during low flow conditions; and

    - Conduct annual review of total discharge in Barton Springs and production from wells to ensure accuracy of water balance model predictions (see Appendix H for more detailed information on estimating water balances under the various management alternatives).

6.7.1.6 General Performance Metrics

A process will be developed to evaluate performance of the District DHCP measures and management strategies. These measures and strategies will include:

- Frequency or necessity of Alarm and Critical Stage Drought Measures;

- Level of the aquifer as measured by springflow and indicator wells;

- Total daily discharge from Barton Springs;

- Through coordination with the City of Austin staff, current/recent biological data to evaluate responses to groundwater management actions during any low flow conditions, including:

    - Availability of suitable habitat during various low flow conditions; and

    - Relative abundance and population characteristics (based on observations) of Barton Springs salamander during low flow and other conditions.

    - Characteristics of flow through the spring orifices during normal and low flow conditions.

- Educational outreach program measures:

    - Quantity, quality, and timeliness of information disseminated to the general public and stakeholder interests about water use, demand management, and aquifer conditions; and

    - Awareness and attitude of general public and cooperating stakeholders to critical issues concerning water use, demand management, and aquifer conditions.

6.7.1.7 Implementation Monitoring

The District will ensure that all management objectives are implemented to meet requirements specified in the Performance Metrics through implementation of the Groundwater Management Plan and the reporting procedure outlined in Section 6.7.1.1.

6.7.1.8 Effectiveness Monitoring

The District receives monthly water use reports from all of its non-exempt users; such reporting is by rule. These water use reports are used to determine actual water use on a monthly basis (and at the Board's discretion, more frequently during severe drought) and to elucidate trends in water use overall and by permittee. These meter readings are the fundamental tool used to monitor effectiveness of the DHCP and Management Plan with respect to water withdrawals from the aquifer.

In addition, the District will coordinate with the City of Austin to obtain and analyze biological survey data currently being obtained by the City. The District believes that the City of Austin efforts are sufficient and there would be no benefit in duplicating efforts nor is there any need to augment the frequency or extent of the current data collection efforts conducted by the City, for the purposes and needs of this DHCP. As specific data needs and gaps are identified that may require a focused research effort, and commensurate with adaptive management measures as specified in Section 6.6.2, the District will commit resources to the extent that additional funds are available (see Section 6.8 for detail on funding).

6.7.1.9 Enforcement Program

The District has established an aggressive enforcement program under District Rule 3-8, Enforcement (within Appendix M). The District enforces all of its Rules, whether for permit violations (e.g., overpumpage), well construction violations, wasteful water use, or failure to make timely use reports and fee payments. Enforcement measures include warning letters, show cause hearings, assessment of fines and penalties, revocation of permits, “red-tagging” of wells that limit or prohibit production from permitted wells, and finally litigation in District court (which is rarely needed).

Of particular note with respect to the DHCP are the enforcement measures and penalties that have been established during declared droughts. Each day that a violation occurs is a separate violation, and the penalties are cumulative. Every District permit contains both a UCP and a UDCP as an agreed part of the permit, specifying voluntary and mandatory actions that the permittee and end users, as warranted, will take under various drought stages. The UDCPs define the allowed pumpage each month during drought stages and emergency response periods of various durations. Penalties related to pumpage violations during Critical Stage Drought carry twice the dollar fines as those during Alarm Stage Drought. For example, the daily penalties for violations related to failure to reduce pumpage during District-declared drought are shown in the daily penalty matrices below:

Permitted Pumpage	Daily Penalties During Alarm Stage Drought Rule 3-7.7.B(1)		
	Overpumpage Level		
	Level A	Level B	Level C
Tier 1	\$50-\$100	\$100-\$200	\$200-\$400
Tier 2	\$200-\$400	\$400-\$800	\$800-\$1,600
Tier 3	\$800-\$1,600	\$1,600-\$3,200	\$3,200-\$5,000

Permitted Pumpage	Daily Penalties During Critical Stage Drought Rule 3-7.7.B(2)		
	Overpumpage Levels		
	Level A	Level B	Level C
Tier 1	\$100-\$200	\$200-\$400	\$400-\$800
Tier 2	\$400-\$800	\$800-\$1,600	\$1,600-\$3,200
Tier 3	\$1,600-\$3,200	\$3,200-\$6,400	\$6,400-\$10,000

Where:

Permitted Pumpage (gallons/year):		% Pumpage over Monthly Target:	
Tier 1:	< 12,000,000	Level A:	< 25%
Tier 2:	≥ 12,000,000 and < 120,000,000	Level B:	> 25% and < 100%
Tier 3:	≥ 120,000,000	Level C:	> 100%

6.7.2 U.S. Fish and Wildlife Service

The Service would be the federal agency responsible for monitoring compliance with the conditions of the ITP.

6.7.3 Texas Parks and Wildlife Department

Involvement by the Texas Parks and Wildlife Department, other state governmental agencies, and political subdivisions in the development of regional Habitat Conservation Plans is guided by provisions of Subchapter B, § 83.011 through §83.020 of the Parks and Wildlife Code. These subsections lay out definitions of habitat conservation plans, regional habitat conservation plans, land development standards, and plan participants and provide guidance in the acquisition of habitat preserves. Structure and function of the Biological Advisory Team and Citizens Advisory Committee in the development of the DHCP are guided by the above noted subsections of the code. Other activities of the Department including biological consultation, coordination, or participation in future adaptive management strategies beyond current activities of the BAT and CAC remain unspecified.

6.7.4 City of Austin

The City of Austin is not an applicant in this DHCP. However, the City traditionally has been a collaborative partner with the District in many of its programs, and the City currently is providing a substantial amount of additional funding for various District activities. In addition the City has a complementary HCP for operation and maintenance of the Barton Springs Pool, and there are likely opportunities for synergies between the two related HCPs. Under the District DHCP, the District and the City may collaborate, perhaps through a Memorandum of Understanding, in the following areas:

- Provision of data and evaluative reports, in preliminary and final formats to the District so that mutual interest on salamander viability and aquifer/spring dynamics are always being met.

- Collaboration and participation with the District, in long-range planning to provide City of Austin water supplies and possibly other alternative sources, to new and existing communities and businesses in the HCP planning area.

- Possible collaboration and participation in a variety of adaptive management measures as specified in the Section 6.6.2.

6.7.5 Others

Other governmental entities, political subdivisions, universities, or private research groups may be involved cooperatively in conducting studies or other actions identified or included as District DHCP measures. If they become an essential condition in maintaining compliance with the ITP, specific responsibilities of the parties would be identified in District DHCP contracts or implementation agreements with the District and/or the Service. Currently there are some entities whose statutory roles could either directly or indirectly affect DHCP implementation.

- U.S. Geological Survey – This agency will continue to have future programs that will involve monitoring of springflows and aquifer levels.
- Texas Commission on Environmental Quality – This agency has, as a primary responsibility, protection of water quality in the Edwards Aquifer.
- The Texas Water Development Board will review and approve the District's Groundwater Management Plans, and provide additional support to the District in regard to compliance with state laws pertaining to groundwater management.

6.8 District HCP Funding

Essentially all of the measures to be implemented by the District for the HCP program, including the prospective minimization, mitigation, and monitoring measures and their administration, are now or soon will be specified in (and authorized by) the District's revised, approved Management Plan, which is the driver for the ITP. As such, the funding for these measures over the 50-year life of the District DHCP will represent a significant share of the District's annual operating budget. This budget is derived from water use and other related fees that are statutorily authorized; in certain years, these revenues are supplemented by 1) funds from term agreements with other entities, and 2) from time to time, other external funds for special initiatives, such as grants, that are not under District control. Accordingly, inasmuch as the entire continuing-operations budget of the District is by law established to execute the District's Management Plan (and nothing else), a substantial share of the normal operating budget of the District provided by continuing water use fees will in effect be committed to implementing the DHCP incorporated as the Management Plan. The DHCP is a significantly enhanced commitment to what the District is already undertaking; it is what the District will be doing as a natural resource management agency pursuing its statutorily defined mission.

The District has therefore committed to funding the DHCP and its Management Plan at a minimum of $550,000 per year (in 2007 dollars); these funds comprise all of the anticipated revenue from groundwater usage and related fees. Absent significant changes in the statutory or legal landscape, it anticipates continued annual funding at that rate. However, the District by State law cannot commit funds in advance to any purpose except those budgeted each fiscal year, and it is allowed to budget only for one year at a time. These restrictions notwithstanding, it is the District's stated intent to continue to fund all of its activities that support all of the DHCP measures at this rate throughout the life of the HCP.

As part of the aggregated DHCP program to be prosecuted by the District, a specific contribution in the form of specialized District labor and/or cash over certain time periods has been committed to a number of the individual measures in the DHCP. A schedule of the estimated minimum annual costs to be committed for these specific measures is included and broken out in Table 6.8-1, to highlight the District's intent with respect to their time-phasing.

6.9 Changed Circumstances, Unforeseen Circumstances, No Surprises, and Other Federal Commitments

Section 10 regulations [50 CFR 17.22(b)(2)(iii)] require that an HCP specify the procedures to be used for dealing with changed and unforeseen circumstances that may arise during the implementation of the DHCP. In addition, the Habitat Conservation Plan Assurances ("No Surprises") Rule [50 CFR 17.2, 17.22(b)(5) and (6); 63 FR 8859] defines "unforeseen circumstances" and "changed circumstances" and describes the obligation of the permittees and the Service.

6.9.1 General

The District has made every effort to anticipate the minimization, monitoring, and mitigation measures (conservation measures) necessary to conserve the Covered Species and the habitats that support those species and, to that end, have relied upon the best scientific and commercial information available. In addition, the adaptive management strategies and the flexible provisions regarding the expenditure of mitigation funds provided by the District are intended to meet and address future exigencies and emergency situations. Thus, the District DHCP is intended to minimize the potential for adverse, changed, or unforeseen circumstances on the Covered Species and their habitats. However, notwithstanding the provisions of the District DHCP, should adverse, changed, or unforeseen circumstances result in, or threaten, a substantial change in the population of any Covered Species or the overall quality of any habitat of that species, as determined pursuant to the procedure outlined hereinafter, the District and the Service shall cooperate to resolve the adverse impacts in accordance with this section.

The terms *changed circumstances* and *unforeseen circumstances* as defined in this District DHCP are intended to have the same meanings as defined in the Habitat Conservation Plan Assurances ("No Surprises") Rule:

Table 6.8-1. Projected Funding of All District DHCP Measures and Certain Specific Measures.

	Funding ($ in thousands, presuming 2% annual growth/inflation)										
Measure	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 - Year 50 (40 Years)
All Measures of All Types (including those enumerated below)	550	561	577	583	596	607	619	631	645	657	40,478
Specific Measures:											
1.2.2 Institute metering and water use monitoring program	20	10	10	-	-	-	-	-	-	-	-
1.2.5 Water conservation/reduction education program	40	41	42	42	43	44	45	46	47	48	2,945
1.3.2 Provide support to maintain and protect recharge enhancement features	5	5	5	5	5	6	6	6	6	6	368
1.3.3 Provide technical assistance and support to acquisition of open space	5	5	5	5	5	6	6	6	6	6	368
4.6 Inter-local agreement with City of Austin to support the Salamander Conservation Program	-	10	10	10	11	11	11	11	12	12	722
5.4 Develop/refine sediment transport model	-	-	-	30	30	-	-	-	-	-	-
5.6 Study of movement of Barton Springs salamander and associate biota	-	20	20	-	-	-	-	-	-	-	-

Changed Circumstances: If additional conservation and mitigation measures are deemed necessary to respond to changes in circumstances that were provided for in the DHCP, the permittee(s) will be expected to implement the measures specified in the DHCP, but only those measures and no others; and

Unforeseen Circumstances: The Service will not require the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water or other natural resources, even upon a finding of unforeseen circumstances, unless the permittee consents. Upon a finding of unforeseen circumstances, the Service will be limited in its ability to require additional measures, to modifications within the conserved habitat areas and consistent with the District's approved Management Plan that authorizes its groundwater management program. Additional required conservation and mitigation measures will not involve the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water or other natural resources.

6.9.2 Methodology for Developing Criteria for Changed *Versus* Unforeseen Circumstances

The District has determined that several specific changed circumstances are not unlikely to occur during the course of the DHCP. These are discussed in more detail in Section 6.9.5. There are also possibilities for truly unforeseen events to affect the DHCP, as provided for under FWS Habitat Conservation Plan rules and guidelines; types of events that could be addressed as unforeseen are identified in Section 6.9.4. In addition, there are several dimensions of the ecosystem that are not known or only poorly known, as discussed in Section 6.9.3, and the likelihood of those factors affecting the efficacy of the DHCP is indeterminate; these could be either changed or unforeseen circumstances. The Service, after coordinating with the District, will determine if a particular event, circumstance, or factor constitutes an unforeseen circumstance, on the basis of the likelihood of the change or event occurring during an average 50-year period (the proposed term of the District DHCP). This process is described in more detail in Section 6.9.7. The responses of the District, and the Service, to determinations of changed and unforeseen circumstances are discussed in Sections 6.9.6 and 6.9.8/6.9.9, respectively.

As part of the DHCP, the District will collect, appropriately analyze, and make available to the Service available data and findings on the frequency and magnitude of such events, as applicable to the ecosystems covered by the District DHCP or to appropriate, scientifically comparable surrogate areas, in order to assist the Service in determination of unforeseen circumstances.

6.9.3 Unresolved Issues and Uncertainties

A number of issues and uncertainties, including the uncertain existence and magnitudes of various factors, that could affect the efficacy of the DHCP remain unresolved, unquantified, or not otherwise taken into account in the plan. This subsection identifies the more important of these and their possible effects and impacts, without attempting to characterize or evaluate them in detail.

6.9.3.1 Climate Change

A growing consensus among climatologists suggests that the next 50 years will be warmer and drier in the Planning Area than the previous 50 years, especially if anthropogenic climate changes continue to accelerate (Seager, 2007), but also even if atmospheric carbon dioxide concentrations stay where they are presently (Martin Hoerling, NOAA, at Conference on Managing Drought and Water Scarcity in Vulnerable Environments, Longmont, CO, September 2006). The State of Texas mandates use of the drought of record for water planning purposes, but such droughts of record may not present the worst-case condition that actually could be experienced in the DHCP permit period; put another way, it is possible that the drought of record could occur with higher frequency than history otherwise indicates. Under such circumstances, the sustainable yield of the Edwards Aquifer could be somewhat less than that modeled, and the flow at Barton Springs reduced concomitantly, other factors equal. On the other hand, the drought of record has already been estimated to have a recurrence period several times longer than the duration of the DHCP, as described in Section 6.4.1; that suggests the probability of the sustainable yield of the aquifer being limiting during the course of the DHCP period is quite small now, and would increase under such influences to some indeterminate, but still probably small degree.

A more detailed discussion of climate trends and possible changes within the HCP Planning Area is found in Section 3.1.1, Climate.

6.9.3.2 Ecological Significance of Paleo-climatic Indications

Tree-ring studies and stable isotopic evidence suggest that the part of the North American continent containing the study area has experienced much more severe (especially longer) droughts than the drought of record during medieval times (e.g., Seager, Herweijer, and Cook, 2007) and even in pre-recorded history (e.g., Texas River Systems Institute, 2006; and Canadian Climate Center, 2006). It is not known whether or how many times Barton Springs has stopped flowing over the course of several millennia. Yet the salamanders at Barton Springs have somehow survived. The DHCP is based on a premise that extremely low flows or no flow at the Barton Springs outlets could jeopardize the continued existence of the species, but there is no certainty that is the case.

6.9.3.3 Lack of Water Chemistry/Quality and Flow Data during Extreme Low Springflows and Limitations of Predictive Modeling

Appendix I describes the modeling efforts to predict springflow conditions. As with the outcome of any model, predicted springflow values from these efforts are not absolute; rather they are theoretical, predicted estimates that are affected by the limitations and accuracy of the model, quality of input data, and major assumptions. Therefore, analyses of predicted springflows are limited in this document to the evaluation and comparison of EIS alternatives. Use of the predicted springflow values beyond the described analyses should be exercised with caution.

Because the recorded lowest flow at Barton Springs is just under 10 cfs and during a time when little groundwater was being withdrawn from the aquifer, there are no data available to corroborate predicted or modeled flow and water chemistry relationships below 10 cfs. In fact, most of this type of information comes from flows that are no lower than about 16 cfs. Accordingly, extrapolation of trends in flow, chemical components, and their relationships to flows less than 15 cfs is problematic. It is not known, for example, whether DO continues to decline with flow, or “plateaus” at some small, sub-saturated concentration. A cursory statistical analysis of correlations between DO and springflow between 1993 and 2006 by the City of Austin may indicate a minimum concentration under ambient conditions that could be as high as 3 to 3.5 mg/L or as low as 0 mg/L DO. There is no currently available basis for reliably determining the DO concentration at extremely low flow.

6.9.3.4 Cumulative Negative Effect of Pollutants in Groundwater Discharges on Salamanders

In the development of the DHCP, the studies funded by the District have focused on the relationship of DO and conductivity with toxicity and other adverse effects on the salamander. These parameters, now especially DO and springflow, are believed to be controlling. Springflow is presumably correlated with water flow velocity in the habitat zones near the spring outlets, which in turn may be correlated with oxygen exchange potential across salamander gills (having potential significance in times of depressed DO concentration). Little information exists in the biological literature on impacts of other chemical constituents and physical conditions. But non-point-source pollution in the Contributing and Recharge Zones of the Edwards is already increasing the amount of anthropogenic pollutants like pesticides, fertilizers, suspended sediment, and some heavy metals in spring discharges, and concentrations of those pollutants are likely to increase with time. Development in these areas is foreseen to increase, and in addition it is foreseeable there will be increasing pressure to directly discharge treated domestic wastewater (sewage) and its oxygen-demanding waste loads to streams that recharge the aquifer. There has been no attempt to assess the impacts of varying concentrations of these water quality pollutants or their possible adverse impacts on the salamander. Since management and control of land uses and associated development activities that generate these pollutant loads are beyond the authority and scope of the District's programs, they have not been fully researched or documented and are not proposed for management or research under the DHCP.

6.9.3.5 Response of Salamanders to Variation in Habitat Conditions

By necessity, the status of the salamander populations has been based on counts of individuals at the spring outlets and in spring runs. Lower counts have been interpreted as an indicator of stress-related impacts, including population decline. However, the salamanders do appear to be able to migrate locally to areas of less stress (more flow, higher velocities, higher DO, more prey, fewer predators) in the aquifer during certain times of even moderate drought. For example, the population of salamanders at Upper Spring "disappears" when that outlet stops flowing and reappears, in a healthy state, months later when it starts flowing again. Similar observations have been made recently at the Old Mill Spring outlet, with a population of mixed ages reappearing after extremely low flow at the outlet. But the areal extent and proportional amount of such migration, while apparently present, are largely unknown. These factors confound the interpretation of salamander reactions to stress and suggest decreased counts may not be equivalent to mortality. It is not clear that a reliable, deterministic measure of take and especially jeopardy exist.

Perhaps related to this migration is another, more hydrological uncertainty. The majority of water naturally discharging from the aquifer discharges at Cold Springs and Barton Springs. However, smaller springs have been noted that discharge directly into Barton Creek upstream of Upper Barton Springs and into the Colorado River. The springs upstream of Upper Barton Springs only discharge under moderate to high flow conditions. Some small springs are visible on the south shore of Town Lake at the level of the water in the lake. Other discharges into the river bed, but below the lake level, are likely, but are difficult to see either by direct observation or by monitoring temperature differences in the lake. Although the presence of small springs below the lake level is unproven, the conceptual model of the aquifer suggests that there are numerous small pathways for flow along faults, fractures, and bedding planes. Geologic mapping in the vicinity of Barton Springs shows that there are about six major faults that extend to the Colorado River between the downstream end of Barton Creek and Cold Springs. Fractures are commonly seen at outcrops of the various Edwards Aquifer units. It is very likely that small discharges occur where these faults, fractures, and bedding planes intersect the river bed. Such discharges into the Colorado River may be foreseen to occur even at no flow at the major spring outlets and offer alternative groundwater flow paths, and therefore possible flow environments with sufficiently high water velocities to support the salamander ecosystem.

6.9.4 Procedure for Determining Occurrence of Unforeseen Circumstances

Prior to making a determination regarding the occurrence of any unforeseen circumstance, the Service shall comply with the following procedure:

6.9.4.1 Notice to Applicants and Participants

The Service shall provide written notice to the District together with a detailed statement of the facts regarding the unforeseen circumstance involved, the anticipated impact thereof on the Covered Species and its habitat, and all information and data that supports the allegation. In addition, the notice shall include any proposed conservation measure(s) that is believed would address the unforeseen circumstance, an estimate of the cost of implementing such conservation measure, and the likely effects upon (a) the District and its permittees and (b) the existing plans and policies of any involved federal or state agencies.

6.9.4.2 Response through the Adaptive Management Plan

The District, in consultation with the Service, may choose to perform an expedited Adaptive Management Plan (AMP) analysis of the Covered Species or its habitat affected by the alleged unforeseen circumstance and to modify or redirect existing conservation measures to mitigate the effects of the unforeseen circumstance, within the scope of existing funded conservation actions. To the extent that these modified or redirected conservation measures do not affect conservation of other species or habitats, this may be deemed an adequate response to the unforeseen circumstance. If the proposed modifications or redirected conservation actions could affect the conservation of other Covered Species or its habitat, the procedure outlined below will be followed.

6.9.4.3 Submission of Information by Others

The District shall have a meaningful opportunity to submit information to the Service and shall submit such information to the Service within 60 days of the written notice as provided above. Upon the written request of the District or any other participant in the DHCP, the time for submission of said information may be extended by the Service, which request will not be unreasonably denied.

6.9.4.4 District Review

Within 90 days after the close of the period for submission of additional information, the District shall assess (a) the alleged unforeseen circumstances, (b) the proposed additional conservation measure(s), (c) its effects upon the Covered Species and its habitat and the economy and lifestyles of the District and permittees, and (d) possible alternatives to the proposed additional conservation measures which would result in the least adverse impacts upon the economy and lifestyles of the District and permittees while at the same time leading to the survival and recovery of the Covered Species.

6.9.4.5 Findings

The Service shall have the burden of demonstrating that an unforeseen circumstance has occurred and that such unforeseen circumstance is having or is likely to have a significant adverse impact on the Covered Species or its habitat. The findings of the Service must be clearly documented and be based upon the best scientific and commercial data available regarding the status and habitat requirements of the species. In addition, based on the results of an expedited AMP analysis of the changed or unforeseen circumstance and the information provided by District or other participants in the DHCP, the Service shall provide the justification and approval for any reallocation of funds or resources necessary to respond to the unforeseen circumstance within the existing commitments of the District under the District DHCP.

6.9.5 Changed Circumstances

Events likely to occur or could be reasonably anticipated during an average 50-year period would be considered changed circumstances. Events expected to occur less frequently than once during an average 50-year period (such as a drought worse than the drought of record, and perhaps the drought of record itself) would be unforeseen circumstances. For the purposes of this District DHCP, “changed circumstances” include:

- Listing of a new species not covered by this DHCP;
- Vandalism, acts of terrorism, or other intentional, destructive illegal human activities;
- Chemical spills;
- Floods, water erosion and sedimentation, droughts of varying intensity to include severe droughts that would degrade the health of the Covered Species or change the quality of their habitats throughout a substantial portion of their distribution;
- Anthropogenic influences or other circumstances that would degrade the health of the Covered Species or change the quality of their habitats throughout a substantial portion of their distribution; and
- Major curtailments or other related changes in the annual revenues available to the District to implement the DHCP.

6.9.6 Response to Occurrence of Changed Circumstances—Adaptive Management

While the District believes that the initial measures to be funded by the District DHCP will be effective in conserving both habitats and the Covered Species, it is anticipated that conditions within the 1, the status of habitats, and the overall conditions of individual species over time will change (changed circumstances). In addition, it is likely that additional and different conservation measures, not contained within the District DHCP, will be suggested and be proven to be effective during the term of the District DHCP. Finally, it may be found that measures currently funded by the District DHCP may prove to be ineffective to conserve either species or the habitats in which they dwell. Therefore, the District, with the cooperation of the Service and TPWD, are proposing an AMP to gauge the effectiveness of existing conservation measures and to propose additional or alternative conservation measures that could be implemented or supported by the District within its regulatory limits as the need arises and to deal with changed circumstances.

In order to mitigate the impact of changed circumstances defined above requiring immediate response, the District and the appropriate state and federal agencies will conduct an expedited analysis for the purposes of development of appropriate management responses for the species, their habitats, or key areas impacted by any changed circumstance. This expedited analysis will be a function of the AMP.

The analysis will be commenced as soon as the requisite personnel from the District and the federal and state agencies can be made available. If specific AMP management analysis has been performed previously for such species, habitat, or key areas, then the management for these affected species, habitats, or key areas will be reviewed in light of the changed circumstances. If management protocols for the species, habitats, or key areas have not been previously developed as part of the AMP established by this plan, then the affected species, habitats, or key areas will be made a priority for analysis and development of appropriate management protocols.

If multiple changed circumstances occur sufficiently close to each other in time such that the response will be significantly delayed due to lack of available personnel, the District will meet and confer with the applicable agencies in order to prioritize the analyses that need to be done. The purpose of the prioritizing will be to consider first those species, habitats, or key areas that are most at risk of further impacts.

The outcome of the analysis will be the development of appropriate measures to minimize to the extent practicable the occurrence of adverse effects resulting from the changed circumstances on species, habitats, or key areas. The measures developed will be implemented. Ongoing management activities may continue until new measures resulting from the analyses are developed. However, as the agencies deem necessary, in consultation with the District, measures will be promptly implemented to minimize adverse effects prior to completion of the analysis to the extent feasible.

The new listing of a species not covered by this District DHCP may constitute a changed circumstance. The Service will notify the District or publish notice in the *Federal Register*, upon becoming aware that a species which is associated with the habitats found in Barton Springs and which is not a Covered Species (but an “Uncovered Species”) may or has been proposed for listing.

Upon receipt of notice of the potential listing of an Uncovered Species, the District may enter into a consultative process with the Service regarding necessary modifications, if any, to the District DHCP required to amend the applicable federal permit to cover the Uncovered Species. If the District elects to pursue amendment of the applicable permit, the Service will provide technical assistance to the District in identifying any modifications to the District DHCP that may be necessary to amend the applicable federal permit.

In determining whether any further conservation or mitigation measures are required in order to amend the affected permit to authorize incidental take of such Uncovered Species, the Service shall take into account the conservation and mitigation measures already provided in the District DHCP and cooperate with the District to minimize the adverse effects of the listing of such Uncovered Species on the covered activities consistent with section 10 of ESA, as required by the Implementation Agreement.

Once a species is proposed or a petition is determined warranted, the Service shall use its best efforts to identify any necessary measures to avoid the likelihood of jeopardy to or take of the Uncovered Species (“no take/no jeopardy” measures).

A substantial reduction in the level of annual revenues available to the District for implementation of this DHCP may constitute a changed circumstance. The District is dependent on annual revenues from usage fees derived from well production permits, based on statutory authority granted by the Texas Legislature, and also from prescribed contributions by the City of Austin under a long-term agreement. While these revenues may vary somewhat each year, as explained in Section 6.8, they are not anticipated to be curtailed or terminated during the course of the ITP. Additionally, the District maintains reserves as a routine policy of fiscal management to provide protection from emergency conditions affecting its revenues or expenses.

If a portion of the District’s annual revenues were to be curtailed on an ongoing basis (more than two years continuously) to a level that the District would not be able to maintain the funding levels specified in the DHCP, the District will notify the Service and enter into consultations with the Service to develop mechanisms to address and resolve the changed circumstances.

6.9.7 Unforeseen Circumstances

For the purposes of this District DHCP, "unforeseen circumstances" are any events not identified as a changed circumstance and specifically includes:

- Natural catastrophic events, such as fire, droughts worse than the drought of record (or equivalent to the drought of record but occurring more than once during the 50-year term of permit), severe wind or water erosion, floods, landslides, faulting, or other such alteration of the springs or aquifer, of a magnitude exceeding that expected to occur during the term of the permit.

- Invasion by exotic species and/or habitat-specific or species-specific disease that threaten Covered Species or their habitats which cannot be effectively controlled by currently available methods or technologies or which cannot be effectively controlled without resulting in greater harm to other Covered Species than to the affected Covered Species.

In making the determination that such an event constitutes an unforeseen circumstance, the Service will consider, but not be limited to, the level of knowledge about the affected species and the degree of specificity of the species' conservation program under the District DHCP and whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

6.9.8 Response to Occurrence of Unforeseen Circumstances—No Surprises

If, after the conclusion of the process outlined above, the Service determines that an unforeseen circumstance has occurred and that additional conservation measures are required to address such circumstance which are not contemplated or capable of implementation by the AMP and procedures of the District DHCP, and provided that the District has fully complied with the terms of the District DHCP, any proposed additional conservation measures shall fit, to the maximum extent possible, within the terms of the District DHCP and its AMP. Additional conservation measures shall not require the payment of additional compensation by the District or permittees. If additional expenditures are required, the Service or any other federal agency shall take additional actions that might lead to the conservation or enhancement of a species that is being adversely affected by an unforeseen circumstance. The costs of these additional actions shall be borne by the Service or any other federal agency. However, the Service agrees that, prior to undertaking or attempting to impose any action or conservation measure, it shall consider all practicable alternatives to the proposed conservation measures, and adopt only that action or conservation measure which would have the least effect upon the economy and lifestyle of the District and permittees while at the same time addressing the unforeseen circumstance and the survival and recovery of the affected species and its habitat. The purpose of this provision is to recognize that Congress intended, even in the event of unforeseen, extraordinary, or changed circumstances, that additional mitigation requirements not be imposed upon a section 10 permittee who has fully implemented the requirements undertaken by it pursuant to an approved HCP.

6.9.9 Response to Occurrence of Unforeseen Circumstances—Adaptive Management

The District believes that the initial measures to be funded by the District DHCP will be effective in conserving both habitats and the Covered Species for that period. However, over time, unforeseen circumstances may affect the status of habitats and the condition of individual species within the Barton Springs ecosystems. Therefore, the District, with the cooperation of the Service and TPWD, are proposing an Adaptive Management Process to gauge the effectiveness of existing conservation measures and to propose alternative conservation measures as the need arises, to deal with unforeseen circumstances, within the budget and scope of the AMP. If existing or additional conservation measures within the budget and scope of the approved District DHCP AMP do not adequately respond to unforeseen circumstances, the District will assist and coordinate with any additional conservation efforts undertaken by the Service.

6.9.10 Additional Federal Commitments

The U.S. Department of the Interior, as a Participant in the District DHCP process, agrees that it shall annually include in its agency budget requests dedicated and earmarked funding adequate to allow the agency to fully operate, manage, maintain, and monitor its responsibilities pursuant to the terms of this District DHCP and to fulfill its obligations to protect the species and ecosystems consistent with statutory obligations imposed by Congress and to actively cooperate with and provide technical assistance to the District.

6.10 Clarifications, Minor Administrative Amendments, and Amendments

Circumstances may arise which necessitate amendments to the ITP. This section complies with the Service interpretation of the requirements of 50 CFR 17.22(b)(1)(iii): “the procedures to be used to deal with unforeseen circumstances.”

Amendments may include those actions or decisions that would affect the scope of mitigation or method of implementation of the District DHCP or ITP and would require the consent of the Service. Generic examples of amendments include the following (although none are currently planned or imminently envisioned):

- Addition or withdrawal of parties to the ITP;
- Changes in the ITP boundaries;
- Additions to or deletions from the list of species protected under the HCP;
- Changes in state or local legislation that diminish the authority of parties to the ITP to carry out the terms and conditions of the ITP;
- Changes in the conservation, monitoring, compliance, or enforcement programs which are likely to increase the level of incidental take of species; and
- Renewal of the ITP beyond the initial term.

6.10.1 Clarifications and Minor Administrative Amendments

From time to time it may be necessary for the Service and the District, as Administrator of the District DHCP, to clarify provisions of the District DHCP or the ITP to deal with issues that arise with respect to the administration of the process or to be more specific regarding the precise meaning and intent of the language contained within those documents. Clarifications do not change the provisions of any of the documents in any way but merely clarify and make more precise the provisions as they exist.

In addition, it is contemplated that from time to time it may be necessary to make Minor Administrative Amendments to the documents that do not make substantive changes to any of the provisions of the documents but which may be necessary or convenient, over time, to more fully represent the overall intent of the District and the Service. Clarifications and Minor Administrative Amendments to the documents may be approved by the Field Supervisor of the Austin Ecological Field Office, US Fish and Wildlife Service, and the General Manager of the District after review and approval by the District and shall be memorialized by letter agreement or by substituted Plan Documents which are modified to contain only the Clarification or Minor Administrative Amendment.

The District DHCP may, under certain circumstances and at the discretion of the Service, be amended without amending its associated ITP, provided such amendments are of a minor or technical nature and that the effect on the species involved and the levels of take resulting from the amendment are not significantly different from those described in the original District DHCP.

6.10.2 Adaptive Management Changes and Subsequent Listing of Covered Species

It is also anticipated that, over time, the AMP will recommend modifications and changes to conservation measures undertaken and/or financed by the District DHCP. Such future conservation measures may or may not be proposed in this first phase of the District DHCP but may be developed by the District HCP Management Advisory Committee, the participating federal and state agencies, and the Service over time. The discretionary authority to include such modifications resulting from the AMP into the DHCP resides solely with the District Board, but would require review and concurrence by the Service. Conservation measures undertaken pursuant to the AMP shall not require formal amendment of any of the plan documents but shall be processed and approved by the Service and the District in connection with the periodic review and approval, as described below.

6.10.3 Amendments

Except as provided for Clarifications and Minor Administrative Amendments, neither the District DHCP, the ITP, nor any Implementation Agreement may be amended or modified in any way without the written approval of the District, as Administrator of the District DHCP; all signatories; and the Service. All proposed material changes or amendments shall be reviewed by the District. Material changes shall be processed as an amendment to the permit in accordance with the provisions of the ESA and regulations at 50 CFR Parts 13 and 17 and shall be subject to appropriate environmental review under the provisions of NEPA.

Amendments of the District DHCP section 10(a) permit would be required for any change in the following: (a) the listing under the ESA of a new species not currently addressed in the HCP that may be taken by project actions; (b) the modification of any project action or mitigation component under the HCP, including funding, that may significantly affect authorized take levels, effects of the project, or the nature or scope of the mitigation program with the exception of those plan modifications specifically addressed in the original District DHCP and ITP application; and (c) any other modification of the project likely to result in significant adverse effects to the Covered Species not addressed in the original District DHCP and ITP application.

Amendment of a section 10(a) permit must be treated in the same manner as an original ITP application. ITP applications typically require a revised HCP, a permit application form, an Implementing Agreement if another Plan Applicant is added, a NEPA document, and a 30-day public comment period. However, the specific documentation needed in support of a permit amendment may vary depending on the nature of the amendment.

Proposed amendments to the HCP or ITP can be initiated by the District, Service, or other participating entities in the Implementing Agreement, if any. A proposed amendment would be submitted as a formal proposal to the District and Service for possible action. The proposal should state the reason the amendment is being requested, description of the proposed change, and an analysis of the potential effects of the proposed amendment on the species and the terms and conditions of the ITP. Additional information may be requested. The approval process is as follows:

- Action on a proposed amendment under the District's jurisdiction must first be taken by the District. In a timely manner, the District must approve or deny the request;

- The plan amendment would be referred to other section 10(a)(1)(B) permit holders (if any) for review and action; and

- A plan amendment which has been approved by ITP holders would then be forwarded to the Service for final action.

The same procedure would be followed when plan amendments are initiated by the Service, such as listing of a new species that could result in a change to the HCP terms and conditions.

6.11 Reporting

An annual report of covered activities as well as management activities undertaken under the terms of this HCP will be prepared by the District and submitted to the Service. The report will summarize information on the management of the aquifer including:

- Permitted withdrawals;
- Reference well levels;
- Springflows at Barton Springs;
- Estimations of annual aquifer recharge;
- Aquifer discharge from wells and springflow;
- Drought Stage management reductions;
- Adaptive management activities undertaken during the year;
- Expenditures by the District on implementation activities; and
- Proposed activities for the next year.

In addition, the report will summarize species-specific research and management actions undertaken with specific reference to the biological objectives identified for each species.

Chapter 7
Coordination and Consultation

This chapter is divided into three sections. Section 7.1 summarizes the public involvement in determining the scope of issues addressed in this PDEIS, and Section 7.2 lists the federal, state, and local agencies and the other interested parties who participated in the process and to whom copies of the DEIS have been sent. Section 7.3 lists agencies, organizations, and persons with whom the Service consulted during the preparation of the DEIS.

7.1 Public Involvement

Public involvement involving initial scoping is described in detail in Section 1.4.2. Public involvement has been a continuing element of the HCP development and preparation, beginning May 23, 2005, with the first meeting of a CAC followed by an initial meeting of a BAT on September 7, 2005. More information about these groups is provided in Section 1.4.2 and Appendix A, Participating Individuals and Organizations. Members of the CAC have a wide range of affiliations including government agencies, landowners, permit applicants, and municipal, county, regional, and state organizations. Their membership in the CAC reflects a concerted effort to achieve consensus among representatives of affected interests. Meetings held with the CAC and BAT are summarized in Table 7.1-1 below. Agendas and minutes of meetings describing the work of the CAC were regularly distributed and also posted on the Barton Springs/Edwards Aquifer Conservation District website at http://www.bseacd.org/. In addition, District staff and consultants held numerous meetings with individual members of the CAC and BAT, and also various technical specialists and governmental representatives during the course of the investigations.

On August 23, 2005 the NEPA public scoping process began with a scoping meeting held in Austin to identify issues for the District's Draft HCP and DEIS. From this meeting, a number of issues were identified (Section 1.4) After analyzing legal and legislative issues, biological resource impacts, landowner concerns, and economic impacts, the District prepared a first preliminary draft of the BS/EAHCP and DEIS in March 2007. Based on comments provided by the CAC, BAT, and guidance provided by the District's

Board of Directors and staff, additional revisions that reflect a completed draft HCP/EIS are contained in this document.

Table 7.1-1. Stakeholder involvement

Stakeholder	Date	Description
City of Austin	March 9, 2005	Discuss Toxicity Testing Study and Literature Review Meeting and also hydrogeological modeling meeting.
Citizens Advisory Committee	May 23, 2005	Introductions, role of CAC, Discussion of HCP Scope of Work, Landowner Rep Caucus to designate BAT rep.
Miscellaneous Stakeholders Attending NEPA EIS Scoping Meeting	August 23, 2005	Identification of EIS scoping issues & concerns.
Biological Advisory Team	September 7, 2005	Discussion on function of BAT, briefing on low flow toxicity study contract and scope of work
Biological Advisory Team	September 12, 2005	Discussed Status of HCP work, preparation of EIS, drought trigger methodology development and biological studies.
City of Austin	September 15, 2005	Discussed status of project, biological studies, alternatives development, and related work.
LCRA	October 13, 2005	Investigate feasibility of structural alternatives (Fatal Flaw Analysis)
Combined Biological Advisory Team/ Citizens Advisory Committee	October 24, 2005	Project status, discussion of alternatives development and feedback, discussion of UT low flow toxicity study
City of Austin	November 4, 2005	Discussion of feasibility of structure alternatives and associated opportunities/liabilities with COA
Combined Biological Advisory Team/ Citizens Advisory Committee	December 5, 2005	Initial discussion on development of Alternative Concepts and Measures
Combined Biological Advisory Team/ Citizens Advisory Committee	January 23, 2006	Discuss HCP status, COA salamander activities, FWS Recovery Plan for Barton Springs Salamander
Citizens Advisory Committee	February 27, 2006	Discuss HCP Alternative Measures
Combined Biological Advisor Team/ Citizens Advisory Committee	April 17, 2006	Discuss UT Study and Biological Impact Methodology

Table 7.1-1. Stakeholder involvement (continued)

Stakeholder	Date	Description
U.S. Fish and Wildlife Service	June 21, 2006	Brief FWS on Alternative Measures and Biological Impact Analyses
Citizens Advisory Committee	June 26, 2006	Discuss status of HCP/EIS development and methodology
Combined Biological Advisory Team/ Citizens Advisory Committee	August 15, 2006	Discussed Project Status and Alternatives/Process for further interaction of BAT & CAC
City of Austin	November 30, 2006	Discuss preliminary findings of the UT Toxicity study, status of the HCP/EIS development, and impact assessment methodology
U.S. Fish and Wildlife Service	February 8. 2007	Status report, description of Impact Analysis & Related Issues
Biological Advisory Team	February 12, 2007	Discuss results of UT Toxicity Study and status of HCP and ongoing tasks
Citizens Advisory Committee	March 5, 2007	Discuss status of HCP/EIS work and obtain feedback on work performed
Combined Citizens Advisory Committee and Biological Advisory Team	July 9, 2007	Review and receive comments on Preliminary Draft DHCP and PDEIS

7.2 Distribution List

Copies of the DEIS have been placed in the following locations for public review:

City of Austin
One Texas Center
100 Barton Springs Rd.
Austin, TX 78704

City of Buda
P.O. Box 1218
121 North Main Street
Buda, Texas 78610

City of Dripping Springs
P.O. Box 384
Dripping Springs, Texas 78620

City of Kyle
100 W. Center St
P.O. Box 40
Kyle, Texas 78640

City of Sunset Valley
City Hall
3205 Jones Road
Sunset Valley, Texas 78705

City of Rollingwood
403 Nixon Drive
Rollingwood, Texas 78746

Village of Bee Cave
13333-A Highway 71 West
Bee Cave, Texas 78738

Judge Bill Guthrie
Blanco County Judge
P.O. Box 387
Johnson City, Texas 78636

Judge Liz Sumter
Hays County
111 East San Antonio St. #300
San Marcos, Texas 78666

Judge Samuel T. Biscoe
Travis County Judge
314 W. 11th St. #520
Austin, Texas 78701

Barton Springs/Edwards Aquifer Conservation District
1124 Regal Row
Austin, TX 78748

Hays Trinity Groundwater Conservation District
PO Box 1648
Dripping Springs, Texas 78620

Blanco-Pedernales Groundwater Conservation District
P.O. Box 1516
Johnson City, Texas 78636-1516

Edwards Aquifer Authority
Environmental Studies
1615 N. St. Mary's Street
San Antonio, Texas 78215

Edwards Aquifer Research and Data Center
Texas State University
Freeman Aquatic Science Building
Texas State University
San Marcos, Texas 78666

Lower Colorado River Authority
P.O. Box 220
Austin, Texas 78703

Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Texas Department of Agriculture
1700 N. Congress Ave.
Austin, Texas 78701

Texas Department of Transportation
118 E. Riverside Drive
Austin, Texas 78704

Texas General Land Office
P.O. Box 12873
Austin, Texas 78711

Texas Parks and Wildlife Department
4200 Smith School Rd.
Austin, Texas 78744

Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

U.S. Army Corps of Engineers
P.O. Box 17300
Fort Worth, Texas 76102-0300

U.S. Bureau of Reclamation
5316 Hwy. 290 West, Suite 510
Austin, Texas 78735

National Resource Conservation Service
101 S. Main Street
Temple, Texas 76501-7682

Rural Utilities Service
Stop 1571
1400 Independence Avenue
Washington, D.C. 20250-1571

U.S. Farmers Home Administration, Temple, Texas

U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue
Suite 1200
Dallas, Texas 75202

U.S. Geological Survey
8027 Exchange Drive
Austin, Texas 78754

Senator Kirk Watson
P.O. Box 12068 - Capitol Station
Austin, Texas 78711

Senator Jeff Wentworth
P.O. Box 12068 - Capitol Station
Austin, Texas 78711

Congressman Lamar Smith
2409 Rayburn House Office Bldg.
Washington, D.C. 20515

Rep. Elliott Naishtat
Texas House of Representatives
P.O. Box 2910
Austin, Texas 78768

Save Our Springs Alliance
P.O. Box 684881
Austin, Texas 78768

Sierra Club
P.O. Box 1931
Austin, Texas 78767

Sportsmen Conservationists of Texas

Texas Nature Conservancy
P.O. Box 1440
San Antonio, Texas 78295

Texas Farm Bureau
1005 Congress Ave. Suite 555
Austin, Texas 78701

Copies of the DEIS have been distributed to the following federal, state, and local agencies:

Edwards Aquifer Authority, Environmental Studies
Edwards Aquifer Research and Data Center, Texas State University
Lower Colorado River Authority
Texas Commission on Environmental Quality
Texas Department of Agriculture
Texas Department of Transportation
Texas General Land Office
Texas Parks and Wildlife Department
Texas Water Development Board
U.S. Army Corps of Engineers, Fort Worth, TX
U.S. Bureau of Reclamation, Austin, TX
U.S. Department of Agriculture
  Natural Resources Conservation Service, Temple, TX
  Rural Utilities Service (RUS), Washington, D.C.
U.S. Environmental Protection Agency, Region 6, Dallas, TX
U.S. Farmers Home Administration, Temple, TX
U.S. Geological Survey, Austin, TX

Copies of the DEIS have been provided to the members of BS/EAHCP Development Team:

Barton Springs/Edwards Aquifer Conservation District
U.S. Fish and Wildlife Service
BIO-WEST, INC.
Hicks & Company
RECON
LBG-Guyton Associates
Kent Butler and Associates
Greg Ellis

Copies of the DEIS have been sent to the following state and federal congressional offices:

State Senators

State Representatives

U.S. Representatives

Copies of the DEIS have been sent to the following organizations:

Save Our Springs Alliance
Sierra Club
Sportsmen Conservationists of Texas
Texas Nature Conservancy
Texas Farm Bureau

The PDEIS is available in PDF format on the home page of the Barton Springs/Edwards Aquifer Conservation District Web site at http://www.bseacd.org.

7.3 Consultation with Others

The following agencies, organizations, and individuals contributed information that was incorporated into the preparation of the DEIS:

Chapter 8
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Chapter 9
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Chapter 10
Glossary of Terms and Acronyms

10.1 Acronyms

°F – degrees Fahrenheit

ACHP – Advisory Council on Historic Preservation

AMP – Adaptive Management Plan

APA– Administrative Procedures Act

APE – Area of Potential Effect

ASR – Aquifer Storage and Recovery

BAT – Biological Advisory Team

BCWO – Barton Creek Watershed Ordinance

BMP – Best Management Practices

BOD – Biochemical Oxygen Demand

BS/EACD – Barton Springs/Edwards Aquifer Conservation District (the District)

BWL – Bad Water Line

CAC – Citizens Advisory Committee

CAMPO – Capital Area Metropolitan Planning Organization

CCN – Certificate of Convenience and Necessity

CCTP – Climate Change Technology Program

CEQ – Council on Environmental Quality

CFR – Code of Federal Regulations

cfs – cubic feet per second

CO – Carbon monoxide

CZ – Contributing Zone

CWO – Comprehensive Watersheds Ordinance

DCP – Drought Contingency Plan

DEIS – Draft Environmental Impact Study

DO – Dissolved Oxygen

EAA – Edwards Aquifer Authority (the Authority)

EDWL – Extreme Drought Withdrawal Limitation

EIS – Environmental Impact Study

EPA – Environmental Protection Agency

ERP – Emergency Response Period

ESA – Endangered Species Act

ETJ – extra-territorial jurisdiction

FM – Farm-to-Market road

FR – *Federal Register*

FY – Fiscal Year

GAM – Groundwater Availability Model

GBRA – Guadalupe-Blanco River Authority

GCP – Groundwater Conservation Plan

GCWA – golden-cheeked warbler

GIS – Geographic Information Systems

GMA – groundwater management area

GMP – Groundwater Management Plan

gpm – gallons per minute

GSA – gross site area

HB – House Bill

HCP – Habitat Conservation Plan

IA – Implementing Agreement

IFBs – Invitation for Bids

IH – Interstate Highway

ILA – Interlocal Agreement

IPCC – Intergovernmental Panel on Climate Change

ISD – Independent School District

ITP – Incidental Take Permit

JFA – Joint Funding Agreement

LAWO – Lake Austin Watershed Ordinance

LCRA – Lower Colorado River Authority

LCRWPG – Lower Colorado Regional Water Planning Group

LDC – Land Development Code

LWO – Lower Watersheds Ordinance

µg/l – micrograms per liter.

mg/l – milligrams per liter

MAG - Managed Available Groundwater

mgd – million gallons per day

MOA – Memorandum of Agreement

MOU – Memorandum of Understanding

MSA – Metropolitan Statistical Area

MSL (or msl) – Mean Sea Level

NAAQS – National Ambient Air Quality Standards

NAFTA – North American Free Trade Agreement

NAICS – North American Industrial Classification System

NDU – non-exempt domestic use

NEPA – National Environmental Policy Act

NGWA – National Groundwater Association

NHPA – National Historic Preservation Act

NRHP – National Register of Historic Places

NOAA – National Oceanic and Atmospheric Administration

NOI – Notice of Intent

NO_x – Nitrogen Oxides

NPS – non-point source

NRCS – Natural Resource Conservation Service

NRI – National Resource Institute

NSA – net site area

NTU – nephelometric turbidity unit

O_3 – Ozone

PDSI – Palmer Drought Severity Index

Pb – Lead

PM_{10} – Particulate matter (10 micrograms)

$PM_{2.5}$ – Particulate matter (2.5 micrograms)

R&D – Research and development

RFPs – Request for Proposals

SAL – State Archeological Landmark

SB – Senate Bill

SC – Specific Conductance

SCTRWP – South Central Texas Regional Water Plan

SCTRWPA – South Central Texas Regional Water Planning Area

SCTRWPG – South Central Texas Regional Water Planning Group

SH – State Highway

SHPO – State Historic Preservation Officer

SIC – Standard Industrial Classification

SO_2 – Sulfur Dioxide

SOS – Save Our Springs Alliance

SWT – Southwest Texas State University (now designated Texas State University at San Marcos)

SWTJC – Southwest Texas Junior College

TAC_1 – Texas Administrative Code

TAC_2 – Texas Antiquities Code

TAG – Technical Advisory Group

TARL – Texas Archeological Research Laboratory

TC&B – Turner, Collie and Braden

TCEQ – Texas Commission on Environmental Quality

TDA – Texas Department of Agriculture

TDS – Total Dissolved Solids

TGWA – Texas Groundwater Association

THC – Texas Historical Commission

TNRCC – Texas Natural Resource Conservation Commission (now TCEQ)

TPWD – Texas Parks and Wildlife Department

TSDC – Texas State Data Center

TSWQS – Texas State Water Quality Standards

TWC – Texas Workforce Commission

TWDB – Texas Water Development Board

TxDOT – Texas Department of Transportation

UCP – User Conservation Plans required by the BS/EACD

UDCP – User Drought Contingency Plans required by the BS/EACD

USACE – United States Army Corps of Engineers

USDA – United States Department of Agriculture

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WCWO – Williamson Creek Watershed Ordinance

WORD – Water-oriented Recreation District

WRI – Water Reclamation Initiative

WSC – Water Supply Corporation

WUG – water user groups

10.2 Glossary of Terms

This glossary was prepared to provide terms commonly used in describing underground and surface hydrological processes. It also provides additional terminology to assist in understanding information provided in this Environmental Impact Study document. Definitions were derived in part by referencing the BS/EACD (2006); the EAA (1998); the Edwards Underground Water District; the Edwards Aquifer Research and Data Center (1981); and Eckhardt (2007). Complete references to these citations are found in Chapter 9, References Cited.

abandoned well. A well which is no longer used. In many places, abandoned wells must be filled with cement or concrete grout to prevent pollution of groundwater.

accretion. A gradual increase in land area adjacent to a river.

acid rain. The acidic rainfall which results when rain combines with sulfur or nitrogen oxide emissions from combustion of fossil fuels.

acre-foot (ac-ft). The quantity of water required to cover one acre to a depth of one foot, equivalent to 43,560 ft^3 (cubic feet), about 325,851 gal (gallons), or 1,233 m^3 (cubic meters).

adjudication. A court proceeding to determine all rights to the use of water on a particular stream system or groundwater basin.

adsorption. The adhesion of a substance to the surface of a solid or liquid. Adsorption is often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to clean up oil spills from waterways.

algal bloom. A phenomenon whereby excessive nutrients within a river, stream or lake cause an explosion of plant life which results in the depletion of the oxygen in the water needed by fish and other aquatic life. Algal blooms can be caused by urban runoff (of lawn fertilizers, etc.) or pollution. The potential tragedy is that of a "fish kill," where the stream life dies in one mass extinction.

alkalinity. The measurement of constituents in a water supply which determine alkaline conditions. The alkalinity of water is a measure of its capacity to neutralize acids. See pH.

alluvium. Sediments deposited by erosional processes, usually by streams.

alvusion. A sudden or perceptible change in a river's margin, such as a change in course or loss of banks due to flooding.

aquatic. Growing in, living in, or frequenting water.

aquaculture. The raising or fattening of fish in enclosed ponds.

aquiclude. A formation which, although porous and capable of absorbing water slowly, will not transmit water fast enough to furnish an appreciable supply for a well or a spring.

aquifer. A water-bearing stratum of permeable rock, sand or gravel.

artesian aquifer. One type of aquifer in which two impermeable layers surround one permeable water-bearing layer. The water is confined and stored under pressure and will rise above the top of the aquifer when penetrated by a well.

artesian well. A well tapping confined groundwater. Water in the well rises above the level of the confined water-bearing strata under artesian pressure but does not necessarily reach the land surface.

artesian zone. An area where the water level from a confined aquifer stands above the top of the strata in which the aquifer is located.

average annual recharge. Amount of water entering the aquifer on an average annual basis. Averages mean very little for the Edwards because the climate of the region and structure of the aquifer produce a situation in which the area is usually water rich or water poor.

bacteria. Microscopic unicellular organisms, typically spherical, rod-like, or spiral and threadlike in shape, often clumped in colonies. Some bacteria are pathogenic (causing disease), while others perform an essential role in nature in the recycling of materials (measured in colonies/100 milliliters).

bad water. Characterized by having more than 1,000 milligrams/liter (mg/l) of dissolved solids. It may be low in dissolved oxygen, high in sulfates and have a higher temperature. The bad water line is the eastern boundary of fresh water in the Edwards Aquifer in the Barton Springs segment.

Balcones escarpment. A steep series of fault-formed hills which divide the higher plateau from lower coastal prairies. Escarpments can be formed by erosion, or as with the Balcones, by faulting.

Balcones fault zone. The area bounding the Edwards Plateau having extensive cracks and faults caused by the force of crustal movement.

barrage. Any artificial obstruction placed in water to increase water level or divert it. Usually the purpose is to control peak flow for later release.

base flow. A theoretical minimum flow of water within a river or stream. .

beneficial use. The amount of water necessary when reasonable intelligence and diligence are used for a stated purpose; Texas law recognizes the following uses as beneficial: (1) domestic and municipal uses, (2) industrial uses, (3) irrigation, (4) mining, (5) hydroelectric power, (6) navigation, (7) recreation, (8) stock raising, (9) public parks, and (10) game preserves.

bio-accumulation. Uptake and retention of substances by an organism from its surrounding medium (usually water) and from food.

bio-monitoring. A test used to evaluate the relative potency of a chemical by comparing its effect on a group of living organisms (treatment group) with the effect of an untreated group (control group) of the same organisms.

best management practices. Professionally accepted, state-of-the-art management techniques.

Biochemical Oxygen Demand (BOD). A measure of the amount of oxygen required to neutralize organic wastes.

bog. A type of wetland that accumulates appreciable peat deposits. They depend primarily on precipitation for their water source, and are usually acidic and rich in plant matter with a conspicuous mat of living green moss.

brine. Highly salty and heavily mineralized water containing heavy metal and organic contaminants.

calcium carbonate. $CaCO_3$ – the common mineral causing the hard water of the Edwards Aquifer. It is the main component of limestone.

carbonates. The collective term for the natural inorganic chemical compounds related to carbon dioxide that exist in natural waterways.

carbonic acid (H_2CO_3). The acid formed by the combination of water, supplied by rainfall, and carbon dioxide produced in the atmosphere. This weak acid dissolves the Edwards limestone.

casing. A tubular structure intended to be watertight installed in the excavated or drilled hole to maintain the well opening and, along with cementing, to confine the groundwaters to their zones of origin and prevent the entrance of surface pollutants.

cavern. A large underground opening in rock (usually limestone) that occurs when some of the rock is dissolved by slightly acidic water.

Comprehensive Environment Response, Compensation and Liability Act. Also known as SUPERFUND. The Act gave EPA the authority to clean up abandoned, leaky hazardous waste sites.

certificate of water right. An official document which serves as court evidence of a perfected water right.

check dam. A small dam constructed in a gully or other small water course to decrease the stream flow velocity, minimize channel erosion, promote deposition of sediment and to divert water from a channel.

chemical weathering. Attack and dissolving of parent rock by exposure to rainwater, surface water, oxygen, and other gases in the atmosphere, and compounds secreted by organisms. Contrast physical weathering.

chlorination. The adding of chlorine to water or sewage for the purpose of disinfection or other biological or chemical results.

chlorine demand. The difference between the amount of chlorine added to water, sewage, or industrial wastes and the amount of residual chlorine remaining at the end of a specific contact period.

chute spillway. The overall structure which allows water to drop rapidly through an open channel without causing erosion. Usually constructed near the edge of dams.

circulate. To move in a circle, circuit or orbit; to flow without obstruction; to follow a course that returns to the starting point.

cistern. A tank used to collect rainwater runoff from the roof of a house or building.

climate. Average condition of weather at a given place on Earth over a period of years as exhibited by temperature, precipitation, wind velocity, and humidity.

climatic cycle. The periodic changes climate displays, such as a series of dry years following a series of years with heavy rainfall.

climatic year. A period used in meteorological measurements. The climatic year in the U.S. begins on October 1.

coliform bacteria. Non-pathogenic microorganisms used in testing water to indicate the presence of pathogenic bacteria.

collector well. A well located near a surface water supply used to lower the water table and thereby induce infiltration of surface water through the bed of the water body to the well.

colloids. Finely divided solids which will not settle but which may be removed by coagulation or biochemical action.

completion. Sealing off access of undesirable water to the well bore by proper casing and/or cementing procedures.

composite sample, weighted. A sample composed of two or more portions collected at specific times and added together in volumes related to the flow at time of collection. Compare to grab sample.

concentration. Amount of a chemical or pollutant in a particular volume or weight of air, water, soil, or other medium.

condensation. The transformation of the gaseous water vapor into liquid water.

conditional permit (permittee). A permit issued by the BSEACD after September 9, 2004, for new or increased water use that is subject to additional restrictions on use during drought, including complete curtailment. This is an interruptible supply permit. Compare to historic permit.

conductivity. A measure of the ease with which an electrical current can be caused to flow through an aqueous solution under the influence of an applied electric field. Expressed as the algebraic reciprocal of electrical resistance (measured in microSiemens per centimeter (µS/cm) at ambient temperature). Generally, in water the greater the total dissolved solids content, the greater the value of conductivity. See also specific conductance.

conduit. A natural or artificial channel through which fluids may be conveyed.

cone of depression. Natural depression in the water table around a well during pumping.

confined aquifer. An artesian aquifer or an aquifer bound above and below by impermeable strata, or by strata with substantially lower permeability than the aquifer itself.

confining bed or unit. A body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

conjunctive management. Integrated management and use of two or more water resources, such as an aquifer and a surface water body.

connate growth. Water trapped in the pore spaces of a sedimentary rock at the time it was deposited. It is usually highly mineralized.

conservation. To protect from loss and waste. Conservation of water may mean to save or store water for later use.

conservation period. For the BS/EACD, the period from May 1 to September 30 each year during which User Conservation Plans must identify measures to achieve a 10 percent voluntary reduction in aquifer pumping.

consolidated formation. Naturally occurring geologic formations that have been lithified (turned to stone). The term is sometimes used interchangeably with the term "bedrock." Commonly, these formations will stand at the edges of a bore hole without caving.

consumptive use. The quantity of water not available for reuse. Evapotranspiration, evaporation, incorporation into plant tissue, and infiltration into groundwater are some of the reasons water may not be available for reuse. Compare to non-consumptive use.

contact recreation. Activities involving a significant risk of ingestion of water, such as wading by children, swimming, water skiing, diving and surfing. Compare to non-contact recreation.

contaminate. To make unfit for use by the introduction of undesirable substances.

correlative rights. Rights that are coequal or that relate to one another, so that any one owner cannot take more than his share.

creek. A small stream of water which serves as the natural drainage course for a drainage basin. The term is relative according to size. Some creeks in a humid region would be called rivers if they occurred in an arid area.

crest. The top of a dam, dike, or spillway, which water must reach before passing over the structure; the summit or highest point of a wave; the highest elevation reached by flood waters flowing in a channel.

critical low flow. Low flow conditions below which some standards do not apply. The impacts of permitted discharges are analyzed at critical low-flow.

cubic foot per second (cfs). The rate of discharge representing a volume of one cubic foot passing a given point during 1 second. This rate is equivalent to approximately 7.48 gallons per second, or 1.98 acre-feet per day.

current. The portion of a stream or body of water which is moving with a velocity much greater than the average of the rest of the water. The progress of the water is principally concentrated in the current. See thalweg.

dam. A structure of earth, rock, or concrete designed to form a basin and hold water back to make a pond, lake, or reservoir.

delta. An alluvial deposit made of rock particles (sediment, and debris) dropped by a stream as it enters a body of water.

demand. The number of units of something that will be purchased at various prices at a point in time. Compare to supply.

deposit. Something dropped or left behind by moving water, as sand or mud.

desalination. The process of salt removal from sea or brackish water.

desired future conditions. Aquifer conditions jointly determined as "desired" by defined groups of groundwater conservation districts (members of a Groundwater Management Area) as required by HB 1763, 79th Legislature.

detection limit. The lowest level that can be determined by a specific analytical procedure or test method.

diatomaceous. Consisting of or abounding in diatoms, a class of unicellular or colonial algae having a silicified cell wall that persists as a skeleton after death.

diluting water. Distilled water that has been stabilized, buffered, and aerated. Used in the BOD test.

discharge. Water which leaves the aquifer by way of springs, flowing artesian wells, or pumping. The volume of water that passes a given point within a given period of time.

discharge area. An area where groundwater is lost from the aquifer to surface water.

discharge permit. A permit issued by a state or the federal government to discharge effluent into waters of the state or the United States. In many states both State and federal permits are required.

dispersion. The movement and spreading of contaminants out and down in an aquifer.

displacement. Distance by which portions of the same geological layer are offset from each other by a fault.

dissolution. The process of dissolving.

dissolved oxygen. Amount of oxygen gas dissolved in a given quantity of water at a given temperature and atmospheric pressure. It is usually expressed as a concentration in parts per million or as a percentage of saturation.

dissolved solids. Inorganic material contained in water or wastes. Excessive dissolved solids make water unsuitable for drinking or industrial uses. See TDS.

district management plan. A groundwater district management plan that meets the requirements of 31TAC §356.5 as required by Texas Water Code, §36.1071 and §36.1072.

diversion. To remove water from a water body. Diversions may be used to protect bottomland from hillside runoff, divert water away from active gullies, or protect buildings from runoff.

drainage area. At a specified location, that area of a stream measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the stream above the specified location.

drainage basin. An area bounded by a divide and occupied by a drainage system. It consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

drought stages. For the BS/EACD: Alarm Stage and Critical Stage -- two aquifer stages declared by the BS/EACD during low aquifer conditions. In 2006, Alarm Stage required a 20 percent reduction in pumping, and Critical stage required a 30 percent reduction.

Drought triggers. For the BS/EACD: In 2006, Alarm Stage Drought Trigger – when a 10-day running average rate of discharge from Barton Springs is equal to or less than 38.0 cfs, or the depth to water in the Lovelady Drought Indicator Well is equal to or greater than 180.8 ft from land surface datum (LSD), and the District's Board of Directors determines that conditions warrant the declaration of this stage; Critical Stage Drought Trigger – when a 10-day running average rate of discharge from Barton Springs is equal to or less than 20.0 cfs, or the depth to water in the Lovelady Drought Indicator Well is equal to or greater than 192.1 ft from land surface datum (LSD), and the District's Board of Directors determines that conditions warrant the declaration of this stage.

driller's well log. A log kept at the time of drilling showing the depth, thickness, character of the different strata penetrated, location of water-bearing strata, depth, size, and character of casing installed.

drought. A long period of time without sufficient rain.

ecosphere. Total of all the ecosystems on the planet, along with their interactions; the sphere of air, water, and land in which all life is found.

Edwards and Associated Limestone (Edwards Formation). Layers of sediment, deposited during the Cretaceous period that later became limestone rock.

Edwards Aquifer. Water bearing zone comprising Edwards and Associated Limestones.

Edwards Aquifer Region. A region of Texas that obtains its water from the Edwards Aquifer. This area consists of the contributing zone, recharge zone, and the artesian zone of the Edwards Aquifer.

Edwards outcrop. Where the Edwards and associated limestone formations are found at the surface. This area is also referred to as the Recharge Zone.

Edwards Plateau. Area west and northwest of the Balcones Fault Zone where the Edwards Formation is essentially flat-lying and is the principal aquifer of the region.

Edwards Underground Water District. The regional governmental entity that preceded the Edwards Aquifer Authority.

effective porosity. The portion of pore space in saturated permeable material where the movement of water takes place.

effective precipitation. The part of precipitation which produces runoff; a weighted average of current and antecedent precipitation "effective" in correlating with runoff. It is also that part of the precipitation falling on an irrigated area which is effective in meeting the requirements of consumptive use.

effluent. Any substance, particularly a liquid, that enters the environment from a point source. Generally refers to wastewater from a sewage treatment or industrial plant.

emergency response period (ERP). For the BS/EACD, an emergency response period may be declared when the 10-day average flow at Barton Springs is equal to or less than 14 cfs; at the discretion of the Board and in accordance with District Rules, additional aquifer demand reduction measures may be required of conditional permittees.

environment. Aggregate of external conditions that influence the life of an individual organism or population.

erosion. The wearing away of the land surface by wind, water, ice or other geologic agents. Erosion occurs naturally from weather or runoff but is often intensified by human land use practices.

escarpment. The topographic expression of a fault.

estuarine waters. Deepwater tidal habitats and tidal wetlands that are usually enclosed by land but have access to the ocean and are at least occasionally diluted by freshwater runoff from the land (such as bays, mouths of rivers, salt marshes, lagoons).

estuarine zone. Area near the coastline that consists of estuaries and coastal saltwater wetlands.

estuary. An area where freshwater from rivers mixes with salt water from the sea and is characterized by reduced salinity. Estuaries are important nurseries for many marine species.

eutrophic. Having a large or excessive supply of plant nutrients (nitrates and phosphates). Compare to oligotrophic.

eutrophication (natural). An excess of plant nutrients from natural erosion and runoff from the land in an aquatic ecosystem supporting a large amount of aquatic life that can deplete the oxygen supply.

evaporation. The process by which liquid water is transformed into gaseous water vapor due to the heat of the sun.

evapotranspiration. Combination of evaporation and transpiration of water into the atmosphere from living plants and soil. Distinguish from transpiration.

external cost. Cost of production or consumption that must be borne by society; not by the producer.

extinction. Complete disappearance of a species because of failure to adapt to environmental change.

fatal flaw study. A study designed to identify potential fatal flaws in a proposed project prior to commitment of additional resources.

fault zone. A region containing several breaks in the Earth's crust along which slippage has taken place.

fault zone aquifer. An aquifer developed in association with a zone of faulting, i.e. Balcones fault zone and the resulting Balcones Escarpment with the associated Edwards fault zone aquifer.

faults. Fracture of the Earth's crust accompanied by movement.

fecal coliform. The portion of the coliform bacteria group which is present in the intestinal tracts and feces of warm-blooded animals. A common pollutant in water.

filtration. The mechanical process which removes particulate matter by separating water from solid material, usually by passing it through sand.

"first in time, first in right," Phrase indicating that older water rights have priority over more recent rights if there is not enough water to satisfy all rights.

fixed groundwater. Water held in saturated material that it is not available as a source of water for pumping.

flood. An overflow or inundation that comes from a river or other body of water and causes or threatens damage. It can be any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream. It is also a relatively high flow as measured by either gage height or discharge quantity.

floodplain. Land next to a river that becomes covered by water when the river overflows its banks.

flora. Plant population of a region.

flow. The rate of water discharged from a source expressed in volume with respect to time.

flow augmentation. The addition of water to meet flow needs.

food chain. Series of organisms usually starting with green plants in which each organism serves as a source of energy for the next one in the series.

fracture. Breaks in rocks due to intense folding and faulting; a simple break in which no movement is involved.

free groundwater. Water in interconnected pore spaces in the zone of saturation down to the first impervious barrier, moving under the control of the potentiometric pressure.

freshwater. Water containing less than 1,000 parts per million (ppm) of dissolved solids of any type. Compare to saline water.

freshwater/saline water interface. The interface or area that separates total dissolved solids (TDS) values less than 1,000 mg/L (freshwater) from TDS values greater than 1,000 mg/L (saline water). Commonly referred to as the "bad water line."

gallon. A unit of volume. A U.S. gallon contains 231 cubic inches, 0.133 cubic feet, or 3.785 liters. One U.S. gallon of water weighs 8.3 lbs.

gauging station. A particular site that systematically collects hydrologic data such as stream flow, spring flow or precipitation.

geohydrology. A term which denotes the branch of hydrology relating to subsurface or subterranean waters; that is, to all waters below the land surface.

geologic erosion. Normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc.

groundwater. Water that is stored under the earth's surface.

groundwater availability model. A mathematical model of aquifer dynamics used to estimate the availability of groundwater under specific assumptions.

groundwater divide. A ridge, or mound in the water table or other potentiometric surface from which the groundwater moves away in both directions.

groundwater hydrology. The branch of hydrology that deals with groundwater; its occurrence and movements, its replenishment and depletion, the properties of rocks that control groundwater movement and storage, and the methods of investigation and utilization of groundwater.

groundwater law. The common law doctrine of riparian rights and the doctrine of prior appropriation as applied to groundwater.

groundwater recharge. The inflow to a groundwater reservoir.

groundwater reservoir. An aquifer or aquifer system in which groundwater is stored. The water may be placed in the aquifer by artificial or natural means.

groundwater runoff. The portion of runoff that has passed into the ground, has become groundwater, and has been discharged into a stream channel as spring or seepage water.

groundwater storage. The storage of water in groundwater reservoirs.

gully. A deeply eroded channel caused by the concentrated flow of water.

hardpan. A shallow layer of earth material that has become relatively hard and impermeable, usually through the deposition of minerals. In the Edwards region hardpans of clay are common.

hard water. Water containing a high level of calcium, magnesium, and other minerals. Hard water reduces the cleansing power of soap and produces scale in hot water lines and appliances.

hardness (water). Condition caused by dissolved salts of calcium, magnesium, and iron, such as bicarbonates, carbonates, sulfates, chlorides, and nitrates.

head. The pressure of a fluid owing to its elevation, usually expressed in feet of head or in pounds per square inch, since a measure of fluid pressure is the height of a fluid column above a given or known point.

historic permit (permittee). A permit issued by the BSEACD on or before September 9, 2004. Compare to conditional permit

hydroelectric plant. Electric power plant in which the energy of falling water is used to spin a turbine generator to produce electricity.

hydrogeology. A term which denotes the branch of geology relating to subsurface or subterranean waters; that is, to all waters below the land surface.

hydrograph. A chart that measures the amount of water flowing past a point as a function of time.

hydrologic cycle. Natural pathway water follows as it changes between liquid, solid, and gaseous states; biogeochemical cycle that moves and recycles water in various forms through the ecosphere. Also called the water cycle.

hydrologic unit. A geographic area representing part or all of a surface drainage basin or distinct hydrologic feature.

hydrology. A science dealing with the properties, distribution and circulation of water on the surface of the land, in the soil and underlying rocks and in the atmosphere.

hydropower. Electrical energy produced by falling water.

hydrostatic head. A measure of pressure at a given point in a liquid in terms of the vertical height of a column of the same liquid which would produce the same pressure.

hydrostatic pressure. Pressure exerted by or existing within a liquid at rest with respect to adjacent bodies.

impermeable. Material (such as dense rock) that will not permit liquid or water to flow through it.

impervious. The quality or state of being impermeable; resisting penetration by water or plant roots. Impervious ground cover like concrete and asphalt affects quantity and quality of runoff.

impoundment. A body of water such as a pond, confined by a dam, dike, floodgate or other barrier. It is used to collect and store water for future use.

infiltration. The process of water entering the ground through cracks, soil or porous rock.

inland freshwater wetlands. Swamps, marshes, and bogs found inland beyond the coastal saltwater wetlands.

instream use. Use of water that does not require withdrawal or diversion from its natural watercourse; for example, the use of water for navigation, recreation, and support of fish and wildlife.

interbasin transfer. The physical transfer of water from one watershed to another; regulated by the Texas Water Code.

intermittent stream. One that flows periodically. Compare to perennial stream.

interstices. The void or empty portions of rock or soil occupied by air or water.

irrigation. Supplying water by artificial means to crops.

irrigation efficiency. The percentage of water applied, and which can be accounted for, in the soil moisture increase for consumptive use.

irrigation return flow. Water that is not consumptively used by plants and returns to a surface or groundwater supply. Under conditions of water right litigation, the definition may be restricted to measurable water returning to the stream from which it was diverted.

irrigation water. Water that is applied to assist crops in areas or during times where rainfall is inadequate.

lake. An inland body of water, usually freshwater, formed by glaciers, river drainage etc. Usually larger than a pool or pond.

limestone. Rock that consists mainly of calcium carbonate and is chiefly formed by accumulation of organic remains.

limiting factor. Factor such as temperature, light, water, or a chemical that limits the existence, growth, abundance, or distribution of an organism.

littoral zone. Area on or near the shore of a body of water.

lotic system. A flowing body of freshwater, such as a river or stream. Compare to lentic system.

managed available groundwater. An amount of groundwater determined to be available by the TWDB modeling of specific aquifers based on “desired future conditions” identified by groups of groundwater conservation districts under the requirements of HB 1763, 79th Legislature.

marsh. An area periodically inundated and treeless and often characterized by grasses, cattails, and other monocotyledons.

MCL - Maximum Contaminant Level. The maximum level of a contaminant allowed in water by federal law. Based on health effects and currently available treatment methods.

median stream flow. The rate of discharge of a stream for which there are equal numbers of greater and lesser flow occurrences during a specified period.

migration. The movement of oil, gas, contaminants, water, or other liquids through porous and permeable rock.

milligrams per liter (mg/l). A measure of chemical concentration; this measure is numerically equivalent to parts per million (ppm) in dilute aqueous solutions.

minimum stream flow. The specific amount of water reserved to support aquatic life, to minimize pollution, or for recreation. It is subject to the priority system and does not affect water rights established prior to its institution.

municipal sewage. Sewage from a community which may be composed of domestic sewage, industrial wastes or both.

municipalities. Self-governing urban political units having corporate status.

natural flow. The rate of water movement past a specified point on a natural stream. The flow comes from a drainage area in which there has been no stream diversion caused by storage, import, export, return flow, or change in consumptive use caused by man-controlled modifications to land use. Natural flow rarely occurs in a developed country.

natural resource. Any form of matter or energy obtained from the environment that meets human needs.

nitrogen. A plant nutrient that can cause an overabundance of bacteria and algae when high amounts are present, leading to a depletion of oxygen and fish kills. Several forms occur in water, including ammonia, nitrate, nitrite or elemental nitrogen. High levels of nitrogen in water are usually caused by agricultural runoff or improperly operating septic tanks and wastewater treatment plants. Also see phosphorus.

non-consumptive use. Using water in a way that does not reduce the supply. Examples include hunting, fishing, boating, water-skiing, swimming, and some power production. Compare to consumptive use.

non-contact recreation. Recreational pursuits not involving a significant risk of water ingestion, including fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity. Compare to contact recreation.

nonpoint source. Source of pollution in which wastes are not released at one specific, identifiable point but from a number of points that are spread out and difficult to identify and control. Compare to point source.

nonporous. Something that does not allow water to pass through it. Compare to porous.

nonpotable. Not suitable for drinking. Compare to potable.

nutrient. As a pollutant, any element or compound, such as phosphorus or nitrogen, that fuels abnormally high organic growth in aquatic ecosystems. Also see eutrophic.

oligotrophic. Having a low supply of plant nutrients. Compare to eutrophic.

outcrop. Exposed at the surface. The Edwards limestone outcrops in its recharge zone.

outfall. The place where a wastewater treatment plant discharges treated water into the environment.

perched water table. Groundwater standing unprotected over a confined zone.

percolating waters. Waters passing through the ground beneath the Earth's surface without a definite channel.

percolation. The movement of water through the subsurface soil layers, usually continuing downward to the groundwater or water table reservoirs.

perfected water right. A water right which indicates that the uses anticipated by an applicant, and made under permit, were made for beneficial use. Usually it is irrevocable unless voluntarily canceled or forfeited due to several consecutive years of nonuse.

perennial stream. One that flows all year round. Compare to intermittent stream.

permeability. The ability of a water bearing material to transmit water. It is measured by the quantity of water passing through a unit cross section, in a unit time, under 100 percent hydraulic gradient.

permeable. Having a texture that permits liquid to move through the pores.

pH. Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases). Technically speaking, pH is the logarithm of the reciprocal (negative log) of the hydrogen ion concentration (hydrogen ion activity) in moles per liter.

phosphorus. A plant nutrient that can cause an overabundance of bacteria and algae when high amounts are present, leading to a depletion of oxygen and fish kills. High levels of phosphorus in water are usually caused by agricultural runoff or improperly operating wastewater treatment plants. Also see nitrogen.

phreatophytes. Plants that send their roots into or below the capillary zone to use groundwater.

physical weathering. Breaking down of parent rock into bits and pieces by exposure to temperature, wind and water and the physical action of moving ice and water, growing roots, and human activities such as farming and construction. Compare to chemical weathering.

phytoplankton. Free-floating, mostly microscopic aquatic plants.

piezometric surface. The imaginary surface to which water will rise from a confined aquifer.

plankton. Microscopic floating plant and animal organisms of lakes, rivers, and oceans.

point source. Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant. Compare to nonpoint source.

pollutant. Any substance which restricts or eliminates the use of a natural resource.

pollution. Undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that can harmfully affect the health, survival, or activities of human or other living organisms.

porosity. Any property of geologic formations that have the ability to hold and yield water, arising from the spaces between particles.

porous. Having openings that may or may not be connected.

potable. Suitable, safe, or prepared for drinking. Compare to non-potable.

potentiometric surface. An imaginary surface representing the total head of groundwater and defined by the level that water will rise in a well.

ppb - parts per billion. Number of parts of a chemical found in one billion parts of a solid, liquid, or gaseous mixture. Numerically equivalent to micrograms per liter (µg/l).

ppm - parts per million. Number of parts of a chemical found in one million parts of a solid, liquid, or gaseous mixture. Numerically equivalent to milligrams per liter (mg/l).

precipitation. Discharge of water from the air in the form of rain, ice or snow.

priority date. The date of establishment of a water right. It is determined by adjudication of rights established before the passage of the Water Code. The rights established by application have the application date as the date of priority.

pump. A device that moves, compresses, or alters the pressure of a fluid, such as water or air, being conveyed through a natural or artificial channel.

pumpage under permit. The amount of aquifer withdrawals that have been permitted by the BS/EACD.

recharge. Process involved in absorption and addition of water to the zone of saturation.

recharge zone. The area in which water infiltrates into the ground and eventually reaches the zone of saturation in one or more aquifers. For the Barton Springs portion of the Edwards Aquifer, an area in southern Travis and northern Hays Counties defined by the BS/EACD in which recharge to the Edwards Aquifer occurs.

reclaimed water. Domestic wastewater that is under the direct control of a treatment plant owner/operator and that has been treated to a quality suitable for a beneficial use.

recurrence interval. Average amount of time between events of a given magnitude. For example, there is a one percent chance that a 100-year drought will occur in any given year.

refugium. A suitable artificial environment into which endangered plants and animals are temporarily removed during a period of extreme ecosystem stress.

reserves. Amount of a particular resource in known locations that can be extracted at a profit with present technology and prices.

reservoir. A man-made body of water contained behind a dam.

right of (free) capture. The legal concept that the water under a person's land belongs to that person and they are free to capture and use as much as they want. Also called the "law of the biggest pump".

riparian water right. The legal right held by an owner of land contiguous to or bordering on a natural stream or lake, to take water from the source for use on the contiguous land.

riparian zone. A stream and all the vegetation on its banks.

river basin. The area drained by a river and its tributaries.

runoff. Surface water entering rivers, freshwater lakes, or reservoirs.

saline water. Water containing more than 1,000 parts per million (ppm) of dissolved solids of any type.

salinity. Amount of dissolved salts in a given volume of water.

sediment. Solid material (mineral and organic) which has been transported from its site of origin by air, water or ice and has been deposited on the land's surface, river or stream beds, or on the sea floor.

sedimentary cycle. Biogeochemical cycle in which materials primarily are moved from land to sea and back again.

sedimentation. A large scale water treatment process where heavy solids settle out to the bottom of the treatment tank after flocculation.

seep. A spot where water contained in the ground oozes slowly to the surface and often forms a pool; a small spring.

septic tank. Underground receptacle for wastewater from a home. The bacteria in the sewage decompose the organic wastes, and the sludge settles to the bottom of the tank. The effluent flows out of the tank into the ground through drains.

siltation. The deposition of finely divided soil and rock particles upon the bottom of stream and river beds and reservoirs.

soil erosion. The processes by which soil is removed from one place by forces such as wind, water, waves, glaciers, and construction activity and eventually deposited at some new place.

spray irrigation. Application of finely divided water droplets to crops using artificial means.

specific conductance. Specific conductance is a measure of how well water can conduct an electrical current. Conductivity increases with increasing amount and mobility of ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, specific conductance is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of salinity.

spring. A place where water flows from rock or soil upon the land or into a body of surface water.

storm water discharge. Precipitation that does not infiltrate into the ground or evaporate due to impervious land surfaces but instead flows onto adjacent land or water areas and is routed into drain/sewer systems.

stream. A general term for a body of flowing water.

streamflow. The discharge that occurs in a natural channel.

stream segment. Refers to the surface waters of an approved planning area exhibiting common biological, chemical, hydrological, natural, and physical characteristics and processes. Segments will normally exhibit common reactions to external stress such as discharge or pollutants.

subsidence. Sinking down of part of the Earth's crust due to underground excavation, such as removal of groundwater.

subterranean. Being or lying under the surface of the Earth.

supply. Various quantities of things offered for sale at various prices at a point in time.

surface impoundment. An indented area in the land's surface, such a pit, pond, or lagoon.

surface irrigation. Application of water by means other than spraying such that contact between the edible portion of any food crop and the irrigation water is prevented.

surface water. Water on the land’s surface including lakes, streams, rivers and glaciers.

sustainable management. Method of exploiting a resource that can be carried on indefinitely. Removal of water from an aquifer in excess of recharge is, in the long term, not a sustainable management method.

sustained overdraft. Long-term withdrawal from the aquifer of more water than is being recharged.

technology-based treatment requirements. National Pollutant Discharge Elimination System (NPDES) permit requirements based on the application of pollution treatment or control technologies including best practicable technology (BPT), best conventional technology (BCT), best available technology economically achievable (BAT), and new source performance standards (NSPS).

total dissolved solids. The concentration of dissolved minerals in water, expressed in units of milligrams per liter (mg/l).

transect wells. A group of water quality monitoring wells positioned in a site to monitor water quality changes, such as across the freshwater/saline water interface.

transmissivity. Refers to the rate at which limestone allows the transmission of water. Limestone can be highly porous, but not very transmissive if the pores are not connected to each other. Technically speaking, it is the rate at which water is transmitted through a unit width of aquifer under unit hydraulic gradient. Transmissivity is directly proportional to aquifer thickness, thus it is high where the Edwards is thick and low where it is thin, given the same hydraulic conductivity.

transpiration. Loss of water vapor to the air from plants.

tributary. A stream that contributes its water to another stream or body of water.

turbid. Thick or opaque with matter in suspension. Rivers and lakes may become turbid after a rainfall.

unconfined aquifer. Aquifer, or portion of an aquifer, with a water table and containing groundwater that is not under pressure beneath relatively impermeable rocks.

unconsolidated formations. Naturally occurring earth formations that have not been lithified. Alluvium, soil, gravel, clay, and overburden are some of the terms used to describe this type of formation.

undercurrent. Movement of water flowing beneath the land surface within the bed or alluvial plain of a surface stream.

underflow. Movement of water through subsurface material.

unsaturated zone. Layer of soil and rock above the water table but below the top layer of earth. This area is also known as the zone of aeration because the spaces between the rock particles are at least partially filled with air.

vested water right. The right granted by a state water agency to use either surface or groundwater.

void. The pore space or other openings in rock. The openings can range from very small to cave size and are filled with water below the water table.

wastewater. Water containing waste including gray water, black water, or water contaminated by waste contact, including process-generated and contaminated rainfall runoff.

water cycle. Natural pathway water follows as it changes between liquid, solid, and gaseous states; biogeochemical cycle that moves and recycles water in various forms through the ecosphere. Also called the hydrologic cycle.

water level observation (index) well. A water well used to measure the water level or potentiometric surface of water-bearing strata such as the Edwards Aquifer and Trinity Aquifer.

water pollution. Degradation of a body of water by a substance or condition to such a degree that the water fails to meet specified standards or cannot be used for a specific purpose.

water quality criteria. Scientifically derived ambient limits developed and updated by EPA, under section 304(a)(1) of the Clean Water Act, for specific pollutants of concern. Criteria are recommended concentrations, levels, or narrative statements that should not be exceeded in a water body in order to protect aquatic life or human health.

water quality standards. Laws or regulations, promulgated under Section 303 of the Clean Water Act, that consist of the designated use or uses of a water body or a segment of a water body and the water quality criteria that are necessary to protect the use or uses of that particular water body. Water quality standards also contain an antidegradation statement. Every State is required to develop water quality criteria standards applicable to the various waterbodies within the State and revise them every 3 years.

water table. The interface between the zone of saturation and the zone of aeration, where the surface pressure of unconfined groundwater is equal to the atmospheric pressure.

water well. Any artificial excavation constructed for the purpose of exploring for or producing groundwater.

watershed. Land area from which water drains toward a common watercourse in a natural basin.

wetland. Area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year, such as a bog, pond, fen, estuary, or marsh.

xeriscape. Creative landscaping for water and energy efficiency and lower maintenance. The seven xeriscape principles are: good planning and design; practical lawn areas; efficient irrigation; soil improvement; use of mulches; low water demand plants; good maintenance.

yield. The quantity of water expressed either as a continuous rate of flow (cubic feet per second, etc.) or as a volume per unit of time. It can be collected for a given use, or uses, from surface or groundwater sources on a watershed.

zone of aeration. The subsurface zone where the voids and pore spaces are filled with water under less pressure than that of the atmosphere and air.

zone of saturation. The subsurface zone in which all voids and pore spaces are filled with water under pressure greater than that of the atmosphere.

zooplankton. Tiny aquatic animals eaten by fish.

Chapter 11
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To be completed after USFWS Revisions.

ATTACHMENT

Comments and Preliminary Responses on an Earlier Version of the DHCP/PDEIS

DRAFT HCP REVIEW MEETING WITH CITY OF AUSTIN, JULY 12, 2007

Attending:
City: Ed Peacock, Laurie Dries, Deeann Chamberlain, Martha Turner, David Johns
District: Kent Butler

Comments and edit suggestions:

In Ch. 6, compare the HCP proposed measures in Ch. 6 (namely, the Extreme Drought Withdrawal Limitation formulation) to Alternatives 2 and 3, from which they are derived.
Preliminary comment by District:
Will address this with further text discussion in Sec. 6.4-1.

In the HCP, address what percentage of time will certain low discharge rates or low DO levels endure (e.g., number of consecutive days) under the proposed measures. In other words, what beneficial effects will the proposed measures achieve in this regard, in comparison to other alternatives or no alternative at all.
Preliminary comment by District:
Will consider whether to add this to Sec. 6.4-1

It is not clear or directly evident, how to interpolate where the proposed alternative falls in terms of impacts on springflow and DO and percent mortality. A direct estimate, as was done for Alternatives 1, 2 and 3, would be helpful. In trying to interpolate, does the proposed alternative fall between the 7- and 10-cfs range limits as shown in Alt. 3, or would it fall between the 10-cfs in Alt. 2 and 7-cfs in Alt. 3.? The two are not the same. See in particular, Table 4.2-4.
Can these impacts be brought forward into the HCP and shown in Tables 6.4-2 and 6.4-3, ie., can these tables display also the Alt. 3 values?
Preliminary comment by District:
Will address this by additions to Tables 6.4-2 and 6.4-3

Can there be a table in the HCP that shows the number of consecutive days of low springflow or low DO, under each of the Alternatives and under the proposed alternative? (See, for ex., Table 4.2-4.)
Preliminary comment by District:
Will consider whether or how to integrate Table 4.2-4 and the subsequent tables into a new Table in Ch. 6.

Staff suggested that it might be preferable to go ahead and insert some very general, qualified range estimations of numerical take, so as to avoid other parties making very disparate presumptions based on their own interpretations of the information presented.
Preliminary comment by District:
Will further evaluate written comments and suggestions provided by Martha Turner, City of Austin.

If some of the above additions are made in the HCP (Ch. 6), they might also be made in the tables in Ch. 4 from which some of these values would be taken.
Preliminary comment by District:
Will consider whether to add these in Ch. 4.

In the paragraph immediately following Table 4.3-2, it should refer to the model and the equation as being ‘logarithmic,’ not ‘logistic.’
Preliminary comment by District:
The City of Austin produced the regression analysis and curve that are being referenced here, and they identified it as “logarithmic”; so after it is verified, the District will revise its reference accordingly.

It would be helpful to explain better that the District is not proposing to implement any of the fatal flaw measures without further feasibility analysis, including in particular, an assessment of the biological impacts and risks associated with such structural measures. Suggestions were either to put a cover sheet in that appendix explaining this, or some comparable means of clarification in a footnote wherever the fatal flaw study or the structural measures are mentioned (could do a ‘search’ for the ‘fatal flaw’ reference, and add a footnote in those locations). If the District can affirmatively address these now, it will save the District and the City and others from having to address these again at each juncture in the NEPA review process.
Preliminary comment by District:
*Will consider inserting **footnotes** in various places in the text to explain that the fatal-flaw study was mentioned, explaining that it is not being implemented, per se, without thorough biological impact analysis and evaluation of environmental risks.*

RE: the Salamander Recovery Program: The District will produce annual reports under this HCP; and in these reports, the District could also comment on its success in advancing the Salamander Recovery Program.
Preliminary comment by District:
This recommendation will be considered later on.

RE: Adaptive management process: Add a front section to the Adaptive Management measures: explain that we need to adapt as we learn more, and yet we need to commit to some certainty as to what the District will do in future circumstances. There is a need to implement and further the FWS Recovery Plan. And there’s a need to coordinate with, and further the City’s HCP, as well as make sure that all District initiatives involving the springs complex are fully supported by and administered with or by the City. Accordingly, the District’s adaptive measures will be tied to the following commitments; it will participate in the development and implementation of an emergency drought response plan, in which the City and District and perhaps other parties participate and synchronize their respective programs. And specifically, the District’s HCP funding commitments will follow this plan; and will be reevaluated each year in its reporting process to FWS.
Preliminary comment by District:
This recommendation will be considered later on.

FYI on Take analysis: Martha Turner has been formulating a series of incidental take scenarios based on the duration of low DO conditions and associated LCs for each Alternative, based on the UT in vivo laboratory study results.
Preliminary comment by District:
There has already been some public and peer-level discussion about the relative merits of this approach, given 1) the uncertainties associated with estimating take at flow rates for which no biological data exist, 2) the level of dependence on controlled laboratory conditions to estimate numerical take probabilities, 3) the influence of adaptive response of individual organisms to stressed conditions associated with potential take, and 4) the appropriateness of associating take with climate-influenced springflow rates not directly under the District's control, and other factors. More analysis of these uncertainties and examination of appropriate ways to present current knowledge are forthcoming.

It was suggested that the District use the City's salamander survey count data, plus the data from previous modeling efforts, to predict and then evaluate future population data.
Preliminary comment by District:
No comment at this time.

It was suggested that the District could develop and produce a 'life table' analysis that could address the following**:** is the population likely to be stable over time, or decrease over time?
Preliminary comment by District:
No comment at this time.

Suggestion: The District should state that it will commit to continue the assessment and consideration of salamander population-related study findings, and stay responsive to what knowledge is gained about the species' life history and population dynamics that helps population recovery.
Preliminary comment by District:
These comments were offered as suggestions on ways to restate wording already included in Sec. 6.9, generally.

JOINT WORK SESSION OF THE CITIZENS ADVISORY COMMITTEE AND THE BIOLOGICAL ADVISORY TEAM, JULY 9, 2007

Attending:

CAC and BAT Members:
Helen Besse, representing Sunset Valley
Joe Vickers, well driller
Sarah Baker, SOS Alliance
Jennifer Walker, Sierra Club
Nancy McClintock, City of Austin
Will Amy, US Fish and Wildlife Service
Nora Mullarkey, LCRA
Matt Wagner, Texas Parks and Wildlife Dept.
Laurie Dries, City of Austin (member of BAT)

Citizens Attending:
Kelly Davis, SOS intern/citizen
Phil Savoy, Murfee Engineering/citizen

Others Attending:
Martha Turner, City of Austin
Ed Peacock, City of Austin
David Johns, City of Austin
Carolyn Meredith, City of Sunset Valley

Consultants and District Representatives:
Kirk Holland, Barton Springs/Edwards Aquifer Conservation District
Robert Larson, Barton Springs/Edwards Aquifer Conservation District
Craig Smith, Barton Springs/Edwards Aquifer Conservation District
Gary Franklin, Barton Springs/Edwards Aquifer Conservation District
Roy Frye, Hicks and Co.
Paul Fromer, RECON Environmental Consultants
Kent Butler, Kent Butler and Associates

Comments and edit suggestions:

Changes made to the Draft HCP, Ch. 6 by the District between mid-June and mid-July, were presented and discussed. They included the following:

- Ch. 6, representing the Draft HCP, is being expanded by incorporating sections from other chapters so as to produce a stand-alone document, still annotated with appendices but not dependent on the content of other chapters in the preliminary draft EIS.

Preliminary comment by District:
This work was still in progress at the time of the July 11 meeting.

- Addition of more detail on the biological goals of the HCP, including several objectives.

Preliminary comment by District:
Insertions have been made in Sec. 6.7.1.4.

- Addition of more detail on the pumpage history of the District, in relation to milestone events.

Preliminary comment by District:
Insertions have been made in Sec. 6.1.1, including a new figure.

- Clarification of the "baseline" levels of pumpage, including the use of a "zero pumpage baseline" for comparing alternative measures, as well as reference to other historical baselines.

Preliminary comment by District:
Insertions have been made in Sec. 6.1.1.

- Expanded presentation of the *in-vivo* biological study results including confidence intervals.

Preliminary comment by District:
Insertions have been made in Sec. 6.1.4 and Sec. 6.4.1.

Expected changes as a result of the new legislative authority were also described and discussed. They included:

- Promotion of conjunctive surface- and groundwater use and conversion to surface water supplies
- Increase in water usage fees for conditional-use permittees, up to $0.38/1,000 gals.
- Increase in the percentage curtailment of water use during extreme drought stages for certain historical water users that are connected to alternative water supplies.
- Stronger, more clear authority and mechanisms to enforce drought-period water use for different groundwater users.

Preliminary comment by District:
These new authorities have been discussed and summarized in public meetings. Several specific management measures in the Draft HCP are likely to be revised in the fall-winter of 2007 as a result of District rulemaking under these new authorities. Those measures in the text of the Draft HCP (Ch. 6) that are likely to be revised will be place-marked in the coming weeks, until new rules and management measures are actually adopted and incorporated into the HCP.

Comments from CAC and BAT Review of Documentation

The Dissolved Oxygen objectives in Sec. 6.7.1.4 could be more specific in terms of the time duration of minimum DO levels such as 3.0 mg/l.

Preliminary comment by District:
These numerical values are already presented in the PDEIS, in Sec. 4.2.4 (see Tables 4.2.4 and 4.2.5). They could be incorporated into later versions of the HCP in Ch. 6 as well.

More specific discussion of the impacts of low DO concentrations could be provided, including discussion of the expected mortality associated with low levels, and how often (and for what duration) it is likely to occur, based on the period of record. A related suggestion was to include more quantification of the range of possible take of salamanders as a result of low DO concentrations at critical drought stages.
Preliminary comment by District:
See comments above. No additional comments on this suggestion at this time.

Specific measures to enhance the low DO levels in the springs complex during extreme droughts, such as structural reaeration methods and supplemental pumped flow from nearby wells, should be included in the HCP. Discussion followed, concerning the criterion of ensuring survival of the species "in the wild."
Preliminary comment by District:
A feasibility study of such structural measures is already part of the HCP measures. The reference to structural measures in the Barton Springs pool and springs area will be refined in the coming months based on the development of the City's Barton Springs Master Plan and associated drought recovery planning. It is anticipated that the District's and the City's commitment to feasibility studies and actual use of such measures will be specified in a future MOU between the two entities.

Could we estimate the number of individuals of the species of concern that is likely to be taken?
Preliminary comment by District:
See comments above concerning quantification of take. No additional comments on this suggestion at this time.

Could we address the cumulative impacts of this HCP, in combination with the City of Austin's HCP? How will this HCP perform in combination with the City's HCP, as compared to this one standing alone, or the City's standing alone?
Preliminary comment by District:
Revisions have been made in the text of Sec. 4.11.2.5 to address these comments.

Can we quantify the net increases in spring discharge that are attributable to the proposed new legislation? Specifically, the new legislation that will likely be incorporated as rules and management measures in the near future, and then the proposed adaptive measures that are included in the HCP as measures that will be adopted if and as the legislative authority (not currently available) is granted?
Preliminary comment by District:
It was pointed out that this has already been done for each measure, qualitatively, in Appendix B. The quantification of pumpage reduction and associated increases in springflow has intrinsic limitations in terms of empirical data and precision.

Accordingly, the District is hesitant to attempt to insert additional, more refined estimations of the springflow augmentations associated with specific legislative actions. In each case, however, the District will assert the degree to which it is able and committed to implement each such measure to the maximum feasible and practical limits, under its legal authority to do so.

A related question to the one above was asked—how much benefit, in additional spring discharge, was attained in Alternative 3 as compared to Alternative 2?
<u>Preliminary comment by District:</u>
This is already included in considerable detail in the comparative analysis of the alternatives, in Sec. 4.2.4.

There were some criticisms of the text in the Biological Impact Assessment Methodology, Appendix I. It was expected to be more clear, and there is a need to include more citations to the technical sources being relied upon.
<u>Preliminary comment by District:</u>
The District encouraged and solicited written comments and edit suggestions. As of this time, no specific written suggestions have been received. The District is proposing to leave Appendices I and J as-is, as stand-alone work product. Any changes would be reflected in Ch. 4 and/or 6.

There was extensive discussion concerning the duration of the Incidental Take Permit. How did we arrive at the proposed duration of 50 years? What are the pros and cons of a shorter vs. longer period? What do other HCPs typically specify?
<u>Preliminary comment by District:</u>
The reasons for the 50 year period were explained, in terms of wanting a long time for administrative consistency, legislative surety (avoiding changes by future legislatures that would relax or even jeopardize the species), consistency with the time scale of planning that is appropriate for the species and the permittee (developers seek shorter, 15-20 year permits, forestry agencies seek 75-100 year permits, water agencies seek 50-year or longer permits). The issue of climate change and drought periodicity was also discussed, and it was indicated that 50 years seemed reasonable given the low likelihood of encountering the 1950s drought of record in any 50 year period.

There was concern raised about the date and clarity of findings referenced in the text in Section 3.1.1.3, concerning long-term climate change. A study that was more current and clear about the likelihood of warmer conditions in Texas was noted. It was also noted that a much more current and more clear indication of climate change, consistent with the findings being introduced during the work session, were already incorporated in the HCP itself, in Section 6.9.3.1.
<u>Preliminary comment by District:</u>
It was noted that a more current and more clear indication of climate change, consistent with the findings being introduced during the July 9 HCP work session, was already incorporated in the HCP itself, in Section 6.9.3.1. The additional study has since been incorporated and referenced in Sections 6.9.3.1 and 6.9.3.2.

There was considerable discussion concerning the adaptive management measures involving participation in future scientific studies in the springs complex, involving salamander migration, etc. It was suggested that the HCP might address these future studies in a more flexible manner, given that some of them may be completed before the date of issuance of the ITP.

Preliminary comment by District:

The District noted that everyone should plan on further revisions by the time of the final HCP (to be completed many months from now), whereby the specified studies would be revised and finalized and the needs for further studies and specific adaptive management mechanisms would be made more clear, and maintain a level of specificity and accountability that is acceptable to USFWS. See comment above concerning coordination with the City's Barton Springs Master Plan.

There was discussion about existing as well as expanded memoranda of agreement between the District and the City of Austin. It was pointed out that, while the HCP in its revised form doesn't include a provision for Interagency Agreements as in the case of a multi-party HCP, it is intended that the City and District will expand their prior agreements and collaborate on various specific tasks, such as drought-stage springs management as well as water utility extension policies.

Preliminary comment by District:

It was pointed out that, while the HCP in its revised form doesn't include a provision for Interagency Agreements as in the case of a multi-party HCP, it is intended that the City and District will expand their prior MOU and collaborate on various specific tasks, such as drought-stage springs management under the Barton Springs Master Plan, as well as water utility extension/interconnection policies. It is anticipated that the District's and the City's commitment to feasibility studies, funding of certain joint measures, and other collaboration and use of such measures will also be specified in the future MOU between the two entities.

It was pointed out that a term on page 4-29 should read, "logarithmic," not "logistic."

Preliminary comment by District:

This requested edit will be made, pending final verification of the terms of use and their applicability.

There were general concerns raised about Appendix I (Biological Impact Assessment Methodology).

Preliminary comment by District:

Already addressed in the comments of the meeting with City staff, above. The District encouraged and solicited written comments and edit suggestions. As of this time, no specific written suggestions have been received.

It was suggested that the Save Barton Creek Association, which holds a monthly meeting, would be a good forum for a group meeting and presentation on the draft plan. It was pointed out that a representative of SBCA serves on the CAC, and that a presentation to the SBCA would perhaps be most appropriate once the many ongoing revisions and clarifications are completed.

Preliminary comment by District:
There was agreement with this recommendation. The suggestion was made to hold a presentation to this organization once a set of revisions is completed and able to be circulated for general reading and use.

JOINT WORK SESSION OF THE CITIZENS ADVISORY COMMITTEE AND THE BIOLOGICAL ADVISORY TEAM, JULY 11, 2007

Attending:

Citizens Advisory Committee (CAC) Members:
Valarie Bristol, CAC Chair, Texas Nature Conservancy
John Mickels, hydrogeologist
Jeff Goldman, landowner and realtor
Todd Voteller, Guadalupe Blanco River Authority
Bob Russell, Texas Cave Management Association
Jennifer Walker, Sierra Club
Sarah Baker, SOS Alliance
Carolyn Meredith (for Cat Quintanilla), City of Sunset Valley

Biological Advisory Team Members (BAT):
Andrew Price, Ph.D., BAT Chair, Texas Parks and Wildlife Dept.
Bryan Brooks, Ph.D., Baylor University
Laurie Dries, Ph.D., City of Austin

Visitors and Guests
Gary Franklin, BSEACD Board
Ed Peacock, City of Austin
David Johns, City of Austin
Martha Turner, City of Austin
Kelly Davis, Save Our Springs Alliance

District Representatives and Consultants
Kirk Holland, Barton Springs/Edwards Aquifer Conservation District
Kent Butler, HCP Project Coordinator

Comments and edit suggestions:

The discussion and comments presented at this work session included considerable overlap with, and review of comments made at, the preceding July 9 meeting. New or modified comments received at this meeting are detailed and discussed below.

Can we/should we differentiate who is responsible for take, as between the City of Austin, other parties, and the District?
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

It's difficult to sort out flow rates and take, but biologically, in terms of importance, the issues of flow supersede the impacts of cleaning; and yet the water levels could be good for the cleaning activity.

__Preliminary comment by District:__
This was a comment and an opinion expressed from one BAT member to another BAT member who was the maker of the comment, immediately above.

Need to have a critical emergency drought management plan, comparable to the captive breeding program of the City, in a condition that would wipe out the species.
__Preliminary comment by District:__
This comment has not yet been addressed, or incorporated in any revisions.

The refugium issue is being brought up now (unlike in the past), because City officials would like the District to address how it will respond to take, at the most extreme drought conditions, such as levels of funding support for the City's salamander recovery program.
__Preliminary comment by District:__
This was a comment and an opinion expressed from one City official about another City official who was the maker of the comment, immediately above.

There are insufficient citations to the very extensive literature on the species of concern. There are a number of statements in the PDEIS where opinions are apparently being made, without a citation to a reference or clarification that it is the maker's own opinion.
__Preliminary comment by District:__
This comment has not yet been addressed, or incorporated in any revisions. It was pointed out, though, that the PDEIS has over 20 pages of references, all of which are specifically cited in the document.

As regards the priority given to pool area management/enhancement activities vs. pumpage control measures, which one comes first? They seem to have two different orders of magnitude, in terms of time response.
__Preliminary comment by District:__
This comment has not yet been addressed, or incorporated in any revisions. . However, it may not be appropriate for this matter to be addressed until after both HCPs are established.

What is the better way to evaluate the issue of quantification of take: by counting individuals in the spring habitat, or monitoring flow and pumpage and associated DO concentration?
__Preliminary comment by District:__
Representatives of the District responded by saying we need to discuss these factors more fully in the text, and cite more references where appropriate as to what we know and don't know, and then let USFWS and the public decide. District representatives also stated that all parties, of necessity, will have to depend on each other to do their best with the measures that they are each responsible for implementing.

Comments and discussion were exchanged on the general topic of translating *in vivo* findings to *in situ* conditions. The District should discuss the lab and field transfer issues more thoroughly in the HCP, and also clarify what it can and cannot predict in the field conditions.

<u>Preliminary comment by District:</u>
These comments have not yet been addressed, or incorporated in any revisions.

The duration of the salamander toxicity study is also relevant. Why were the 60-day metabolic study period picked, and why the 28-day toxicity study? It was suggested that significant variations are likely over 28- vs. 60-day studies, as the length has a big influence. Longer duration studies yield higher mortalities (LCs); and shorter durations yield less significant impacts. The raw data used in these studies could be very useful if made available to other investigators, from a management standpoint, to think about shorter-term, more episodic events. In a shorter-term study, a lower DO level would be required to cause the same mortality as a higher DO level in a longer-term study. But there may be greater statistical uncertainties associated shorter-term laboratory studies.
<u>Preliminary comment by District:</u>
These comments have not yet been addressed, or incorporated in any revisions. The District expects to receive further text drafts from a BAT member to address issues pertaining to 'uncertainty' in experimental studies versus field studies.

And the DO-flow curve is another area of uncertainty, especially in the low flow conditions.
<u>Preliminary comment by District:</u>
This comment has not yet been addressed, or incorporated in any revisions. However, it may not be appropriate for this matter to be addressed until after both HCPs are established. The current document recognizes this uncertainty and notes that the confidence limits associated with that relation are cited as an obstacle to making precise statements about the salamander.

We might want to look at episodic phenomena, by examining raw data, as being helpful to responding to emergencies of short-term problems.
<u>Preliminary comment by District:</u>
It was pointed out that very short-term periods (a few days) are not as crucial to understanding risk of take, as the rate of decline in springflow rate, in response to drought conditions is generally longer in nature.

The metabolic rate should have been used, as it's a better indicator of the usefulness of the surrogate (nana) for these activities.
<u>Preliminary comment by District:</u>
This comment has not yet been addressed, or incorporated in any revisions.

Need to look at how the organism actually responded to various flow velocities.
<u>Preliminary comment by District:</u>
This comment has not yet been addressed, or incorporated in any revisions.

Field is 'in-situ', and lab is 'in-vivo.'
<u>Preliminary comment by District:</u>
Edit changes are being made to the text.

Take analysis needs more treatment. This is not to advocate so much for the particular number of individuals predicted to be taken in an estimated flow condition, as we've already addressed percent mortality in association with flow rates and DO levels. But the duration issue needs to be addressed. We could calculate percent mortality and number of salamanders, and estimate how many days it would it take to go extinct.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

There is reason to wonder whether the outcome of a 28-day in vivo analysis, vs. other numbers of days, will really affect the outcome for the species or the decision on the ITP by USFWS. By the time we figure out that DO is declining to severe levels, presumably the District is doing virtually all that it can already. So, can we learn anything further from the data in studying the system under these conditions, with precision?
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

The Edwards Aquifer Authority, in the review of its HCP, had to deal with the following issue: what are the triggers leading to aggressive groundwater management, and when do you initiate a critical drought period plan? Is there a biological relation to the drought triggers?
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. District representatives pointed out that the District did learn things from having lived through a critical drought in 2006--during the HCP formulation period. The District's main concern is its ability to maintain curtailment levels for a long time period. New legislative authority granted in the last session will go a long way in this regard. Moreover, the District's drought triggers were specifically selected to provide time for responses to regulatory actions to be effective before what it viewed at that time as biologically significant thresholds were reached. The results of the HCP support those triggers at 38 cfs, 20 cfs, and 14 cfs..

What about discharge levels from wastewater treatment plants, and their effect on DO levels? (One wastewater plant surface discharge permit was just issued, in the Edwards Aquifer Contributing Zone.) This should figure in to the discussion of cumulative impacts, as well.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

Could we have one table that shows the alternatives and the discharge, along with the mortality?
Preliminary comment by District:
It was pointed out that Table 4.2 shows those relationships.

One landowner representative stated that the document seems complete and well written, and seems acceptable, but the criticisms raised by others also make sense. There was

concern about the claim that assertions made without attribution in the report might be considered by some to be intellectual dishonesty.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

There was considerable discussion to clarify the statements made in this meeting that there may be some intellectual dishonesty. One person pointed out that there are assertions in the document that the reader cannot determine where it came from, and yet the reader really wants to know.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. Reviewers were encouraged to identify specific passages were the provenance of the assertion is questionable.

Need to discuss the opinion of the District Board of Directors, at some point, as to what this HCP does—to what extent it serves the District's desire to conserve and protect the species and habitat. The Board should develop its opinion as to how far the HCP goes—how far does it go towards being the maximum feasibility and practical combination of mitigative and proactive measures that can be taken.
Preliminary comment by District:
It was suggested that after the measures are finalized, it would be appropriate for the Board President to write a letter of transmittal, representing the entire board, stating the Board's opinion and position on this issue.

JENNIFER WALKER, SIERRA CLUB LONE STAR CHAPTER,AND SARAH BAKER, SAVE OUR SPRINGS ALLIANCE, JULY 13, 2007

1. Comments on CAC Process:

a. Appendix A states that the role of the Citizen Advisory Committee was to "advise the District in development of the HCP, assist in determination of the scope of the HCP, recommend mitigation measures and other HCP conditions, provide a forum for public discourse and conflict reconciliation, help meet public disclosure requirements, oversee HCP progress and development, and most importantly, build consensus among diverse organizations and interests." Some of these undertakings, however, were not encouraged by the BSEACD in this process and in correspondence these specific activities were denied CAC participants. In a September 8, 2006 letter the District stated to CAC participants Dan Gildor (SOS Alliance) and Jennifer Walker (Sierra Club)15, 2007: "There seems to be misconception of the role of the CAC that permeates your comments. The CAC isn't expected or asked to independently 'recommend measures, goals, implementation tasks, metrics of success, HCP credit, and rationale.' Rather, the CAC's role is to reflect a sense of what is important to the community at large…in response to what we in the District might propose, and then in response to what we actually recommend." These conflicting representations by the District of the role of the CAC call into question the validity with which CAC comments were received and incorporated. In addition, the CAC was never instructed to or given the proper venue to work towards consensus on items presented to them. The CAC spent many meetings going over slightly changed versions of the Alternatives Table as presented by the EIS/HCP team. CAC members voiced concerns but never worked together on solutions or consensus. We have repeatedly requested updated schedules or GANTT charts in order to better understand the process and not received them.

<u>Preliminary comment by District:</u>

There is a need to restate some of this text to more accurately reflect the purpose and functions of the CAC. Also, there is a need to explain the processes used to seek and obtain input from CAC members, as not meeting in an effort to strive for consensus in the ideal situation, but sometimes a caucus of stakeholder interests to ensure that diverse positions and interests were able to be effectively presented and addressed. The quote from the District letter to Dan Gildor was in direct response to his written statement that the CAC needed to develop its own independent recommendations, which is clearly not accurate. But more generally, the District went out of its way to accommodate many different parties and interests in the CAC, and just because one party had certain expectations that were unmet does not invalidate the overall process.

b. The description of CAC members in Appendix A does not include representatives of environmental public interest groups: "Participants include private landowners, irrigators, water purveyors, private consultants, representatives from major cities, federal, state, and local governmental agencies, and universities." There are however, several of individuals representing their organizations interests on the CAC, including: Sarah Baker (Save Our Springs Alliance), Jon Beall (Save Barton Creek Association), Dick Kallerman (Sierra Club, Save Our Springs Alliance), and Jennifer

Walker (Sierra Club).
Preliminary comment by District:
This has been addressed in the Appendix A.

2. Comments on Methodology:
a. The expected flow conditions under the various alternatives are dependent on the "savings" produced from the various measures within each Alternative. On page 4-10 the note to table 4.2-1 explains the process for estimating gains and resulting springflow. This process undertaken by District staff should be independently verified. The basis of any water savings needs to be capable of explanation and objective review. The assertion that "changes were independently peer reviewed for reasonableness by professional staff from another groundwater management organization" does not make it clear that the entire process was peer reviewed, how and by whom. While the District staff has significant professional judgment and experience it may be difficult for such staff to objectively estimate the various factors affecting water savings from the various measures. This is a critical element of the entire HCP, the selection of an alternative, and the validity of the ITP to be asserted without background data or external verification.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. In further discussions with Baker and Walker, suggestions were received, calling for more explanation of the variability of estimated pumpage reductions—the range of results in the peer group process. The District does not agree that the validity of the HCP/ITP or the selection of the preferred alternative hinges on this.

b. Discharge Levels and Thresholds and Levels of Impact. Levels of springflow are analyzed at very broad intervals. Total springflow in relation to DO and mortality jump from 33 to 20 cfs, then 18cfs, then 16 cfs, then 10 cfs, then 6 cfs and 4 cfs. Smaller intervals should be used in order to better estimate impacts to the habitat. It would be helpful if the intervals included the District's drought stages under its current rules. Likewise, impacts to salamander (take) do not provide specificity to evaluate levels of take. The only levels of mortality provided jump from 5-15% mortality and then greater than 15% mortality. "Greater than 15% mortality" does not allow any evaluation of when incidental take levels are exceeded. These percents are not related to actual population numbers and minimum population levels needed to evaluate whether the granting of the permit will significantly reduce the likelihood of the species persisting in the wild. There is data available with population counts in relation to cfs flow, but nowhere in the document are the estimated effects on population related to observed population counts at various flow levels. These suggestions could be applied to an expanded table 4.3-1. This expanded table should be included in Chapter 6.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. In further discussions with Baker and Walker, suggestions were received, calling for more explanation of the basis for referencing 14 cfs, as it is not a biologically relevant figure. The District understands that 14 cfs actually may have some biological relevancy

with respect to wetted habitat availability, but more importantly the 14 cfs value corresponds to the Emergency Response Period determination, which is designed from a groundwater management perspective to provide some lead time for regulators and the regulated community to react to an extreme drought that has the potential for equaling the lowest spring flow historically recorded. Also, there was criticism that the "impact ranges" I through V were not used in the HCP, raising questions about the purpose of the ranges. The impact ranges were used in the impact assessment of the PDEIS, not the DHCP.

c. Some of the measures do not include enough specificity to justify equating an exact amount of cfs gain, for example measure 1.3.3 includes providing technical assistance and cooperation in acquisition of open space in the recharge zone of the Edwards Aquifer." How can this be evaluated in terms of cfs gains with no indication of how much acreage would be acquired for open space? Surely there is a difference in cfs gains if it is 20 acres or 200. Given that most of these measures are broad in scope, determining the effects to the tenth of cfs is unlikely to be accurate. The district should round down to the nearest whole number to determine savings estimates.
Some of the measures are similar in sections 1.0, 2.0, and 3.0 of the Alternatives. Without more details and assigning the projected savings to each measure, it is impossible to determine whether or not double-counting has taken place.
Several measures rely on conversion to alternative water supplies/conjunctive use. However, there are no plans, methods, or goals to facilitate a change to an alternative source. Currently, one of the largest surface water providers in the area has a policy that is in direct conflict with this measure. The City of Austin's policy is to only provide water in their service area and they have recently turned down requests from users in the BSEACD area for surface water.
The structural mitigation measures described in section 4.0 of the Alternatives do not appear to take into account water quality. The only water quality parameter addressed is DO. All water is not the same and cannot be interchanged into specialized habitats without potentially catastrophic results.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. In further discussions with Baker and Walker, suggestions were received, calling for clarification about the fact that the same management measure can have different levels of pumpage reduction effectiveness, under the different alternatives. This will be addressed in future versions. Also, the District should explain whether some measures actually don't have any estimated pumpage reduction benefit at all. The District is not proposing at this time to use any structural mitigation measures, only a feasibility study, which will examine all aspects of feasibility, including water quality. The benefits to springflow may arise from both supply increase/conversion as well as pumpage reductions.

d. Peak Pumpage Estimates: The peak pumpage estimates are not explained and are frankly unclear. Under Alternative 1: No Action, the peak pumpage estimate is 13-16cfs (page 2-11). There is no timeframe or step model describing how peak pumpage grows over time or how the total was reached. The District's Sustainable

Yield Study, however, projects total pumpage in 2050 at 19.6 cfs. The ITP is proposed as a 50 year permit (page 2-26), therefore it is critical that all projected pumping be taken into consideration through 2057. Aquifer pumpage for Alternative 2, the preferred Alternative, is "evaluated within a range between 10 and 13 cfs; however, more recent projections estimate pumpage to range between 8.5 and 10 cfs" (page 2-20). There is no citation for these more recent projections, which estimate pumpage will decrease from current permitted pumpage. It is also not clear why under Alternative 1 "peak pumpage" was estimated but for Alternative 2 only "aquifer pumpage" is provided.

Preliminary comment by District:

These comments have been addressed in the current version. More clarification is also provided on the meaning of the Extreme Drought Withdrawal Limitation, and the estimated maximum pumpage limit of approximately 8.5 cfs, in comparison to the estimated pumpage reductions of 7, 10, and 13 cfs under the three management alternatives presented in the PDEIS.

e. Incidental Take: Section 2.3.2.3 describes the evaluation of incidental take under Alternative 2. "Evidence" (*without citation*) suggest that when springflow declines to levels that begin to affect salamander habitat requirements, species may move to subterranean portions of springs and aquifer…therefore declining numbers of observed species may not be directly representative of incidental take…consequently, amount of take of salamander under any alternatives cannot be determined accurately from observations of individuals or trends in declining numbers. Rather incidental take must be evaluated indirectly by looking at salamander's life requisites and species/habitat relationships with the assumption that when the habitat conditions change, there will be a corresponding change in abundance of species."

The incidental take levels are based on the assumption that habitat alteration and species mortality can be directly compared. There are many factors affecting species mortality and it is too great of an assumption that the mortality conclusions can be directly related to habitat changes. There are many other pollutants and water constituents affecting salamander habitat, the synergistic effects of low flow on all water characteristics should be incorporated into the assumptions. Furthermore reduced habitat may result in negative effects to the species due to greater competition from within the species and with competitor species.

Preliminary comment by District:

These comments have not yet been fully addressed, but some clarifying and amplifying text has been incorporated in the current revisions. Further discussion in the text of the HCP is needed to describe more completely, to the extent known, the uncertainties and complexities associated with these and related factors of the life history of the salamander.

f. The EIS/HCP measures only take into account the effects of reduced springflow on species persistence, rather than also taking into account the effects of sufficient and high springflow. The City of Austin has data correlating increases in juvenile populations with higher level flows. These high flows may be critical to reproduction, yet the EIS/HCP only takes into account effects of lower flows on individual mortality. Many of the measures take focus on reducing pumping when the Aquifer is in drought phase and assume pumping when the Aquifer is at higher levels does not affect species persistence. Higher level flows may also be critical to the natural cleaning and reduction of sediment in the salamander habitat. There is no analysis of the effects of the habitat being covered in sediment as a result of persistently reduced springflow due to permitted pumping that is restricted only during drought.

Preliminary comment by District:

The District's plan does not propose, nor is it physically possible to produce, some sort of control on the amount of water discharging from the natural outlet of the aquifer during all aquifer conditions. Further, there is no evidence that suggests the habitat is covered in sediment as a result of persistently reduced springflow due to permitted pumping that is restricted only during drought.

g. Water Demand Projections. Water Demand projections specifically for groundwater are described in section 3.2.3.1. This uses estimated total growth of 47% between 1996 and 2016. This was based on an average annual growth rate of 1.94% per year. District data from 1998 to 2002, however, suggest that actual pumpage has been growing at over 5% per year. The projections should be updated to reflect the actual increase in groundwater demand that has been observed since the 1997 demand projection report. Groundwater demand should be projected as much as possible through 2057, which is the duration of the permit. It is not possible to tell how effective the measures will be without an indication what the actual pumping demand will be in the future.

These values should be reported in cfs rather than acre-feet since that is the unit that is used in the rest of the report.

Preliminary comment by District:

These comments have not yet been addressed, or incorporated in any revisions. It is noted however that demand for groundwater will be greatly affected by the regulatory policies of the District, and simply extrapolating past growth in demand indexed to population growth will not result in an accurate "forecast". This aspect needs and deserves more explanation in the text.

h. Population growth/land use projections. The residential growth projections are based on data from 1998 City of Austin reports and 2002 LCRA reports. This information should be updated with more recent data. The projections should also be based on regional data that considers the District Planning Area, such as CAMPO, Envision Central Texas, and others, not just COA, which has a very specific jurisdiction.

Preliminary comment by District:

These comments have not yet been addressed, or incorporated in any revisions.

i. Water Quality Impacts to Barton Springs Salamander. The Biological Risk Assessment Methodology only takes into account Dissolved Oxygen in relation to cfs flow at Barton Springs. Previous studies, however, have identified conductivity as affecting *E. nana* (the surrogate species), such as the Edwards Aquifer Research and Data Center (1999). Conductivity effects are not taken into consideration because the Poteet and Woods (2007) study did not show "substantial metabolic response to conductivity." Intrusion of water from the saline zone of the aquifer is estimated to increase during low-recharge conditions, and at higher pumping levels or drought conditions conductivity may be greater and affecting the salamander. There is no explanation how these different outcomes were resolved or why one study outcome was used in creating the HCP rather than the other; the only justification provided is that one study is "more recent." (page 3-79). "One of the primary findings of Poteet and Woods (2007) was that salinity did not result in mortality of the test organisms even at very high concentration [sic]. Therefore, this variable was not considered to be an important habitat feature and thus was not used in the take evaluation" (page 6-6).

Preliminary comment by District:
These comments have been addressed by adding explanatory information. The District believes that D.O. is the primary parameter that will be central to determining take.

j. Laboratory v. Wild Habitat. Issuance of the incidental take permit requires a finding that the "taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild." 50 C.F.R. section 17.22(b)(2)(i)(D). The HCP relies on the laboratory study and states that, "sub-lethal effects observed in the laboratory (such as reduced activity) may not have contributed directly to mortality estimates in the tests, but in the wild such behavioral changes may increase predation risk, reduce foraging, or have other effects that increase the chances of mortality in the wild" (page 6-6). It is not explained how these increased risks in the wild were taken into account and whether any extra measures were put in place to account for the discrepancies in mortality that may occur in the wild versus those from the laboratory study.

Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. However, the District points out that it is difficult to take such factors into account when their existence is only speculative and the direction and degree of those effects on mortality are uncertain.

k. Daily Water Balance Table. The table in Appendix H does not have any explanation and is not usable in its current form.

Preliminary comment by District:
Appendix H has been reformatted and expanded to provide the needed explanation.

3. Comments on Outcomes

a. The permit. The permit term should be decreased from fifty years to a shorter term. If the additional authorities sought are never acquired, the District is insulated from prosecution of take for fifty years and the mitigation measures will not have been achieved.

Preliminary comment by District:
The comment about insulation from prosecution is not relevant and also unwarranted. The reasons for the 50 year period were explained, in terms of wanting a long time for administrative consistency, legislative surety (avoiding changes by future legislatures that would relax or even jeopardize the species), consistency with the time scale of

planning that is appropriate for the species and the permittee (developers seek shorter, 15-20 year permits, forestry agencies seek 75-100 year permits, water agencies seek 50-year or longer permits). The issue of climate change and drought periodicity was also discussed, and it was indicated that 50 years seemed reasonable given the low likelihood of encountering the 1950s drought of record in any 50-year period. This rationale will be included in the next revision at a place still to be determined..

b. Greater detail should be provided as to the long term effects of exposure to severely impaired habitat on the probability that the species will persist. The expected periods of impaired habitat under the preferred alternative could significantly affect the species in ways not observed in the 28 day toxicity study. There is no calculation of how the mortality rate applies to the species population every day and after the salamanders are exposed to impaired habitat from low flow conditions. The mortality estimates are for adult salamanders only and other life stages may have different sensitivity to reduced DO or elevated conductivity (6-6) although there is no description of how this was taken into account.

<u>Preliminary comment by District:</u>

These comments have not yet been addressed, or incorporated in any revisions. The District notes, however, that these factors principally affect the impact assessment and, further, most of these factors are indeterminate or very poorly known at this point. Accordingly, they are more related to the uncertainties involved in the HCP, rather than to deficiencies.

c. Even with all measures performing as expected springflow is too low to sustain the species during a repeat of the drought of record. A determination that this program will not appreciably reduce the likelihood of the survival of the species in the wild cannot be made where the survival of the species is projected to decline to extinction under a repeat of the drought of record.

<u>Preliminary comment by District:</u>

These comments have not yet been fully addressed. Additions have been made that acknowledge this situation. At the same time, these measures per se, limited by the extent of management responsibility and authority of the District, will not be responsible for reducing the likelihood of survival of the species in the wild.

d. Mitigation measures are speculative and require cooperation from others and authority the District asserts it does not currently have. Many of the measures in Alternative 2, the Preferred Alternative, rely on cooperation from well owners with activities that are not required by their permits, or from well owners that are not current permittees. Other measures rely on approval from the Texas Water Development Board. Other measures rely on acquiring enhanced authority from the Texas Legislature. While some additional authority was granted this session by the Legislature others were not and the prospect of acquiring additional authority in the future is highly speculative. The measures should be updated to reflect the outcomes of the last session, i.e. SB 747 passed into law and HB 1699 was strictly limited. Only those measures available under existing authority should be considered. The adequacy of the mitigation program cannot be evaluated if there is uncertainty as to

whether many of the measures can actually be undertaken.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. However, no measure is proposed that cannot be undertaken before the application for the ITP permit.

e. The Draft HCP does not include binding cooperation agreements with entities needed for carrying out the measures. Many of the measures will require participation of the City of Austin and will impact the City's implementation of their own HCP. Without a specific commitment by the City of Austin to comply and cooperate with the measures those measures cannot be considered under the District's existing authority.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. However, the HCP is a commitment of the District to seek cooperative agreements with other parties, and in fact such agreements are currently being discussed. No measure that is a non-adaptive management measure depends on such agreements.

f. None of the Alternatives proposes an upper pumping limit. The Extreme Drought Withdrawal Limit (EDWL) goal/limit is 8.5 cfs. This is below the currently permitted amount in the District. The District is continuing to issue permits (conditional Class A & B) and this only increases the total amount of non-drought pumping and makes it more challenging for the district to meet its EDWL goal of 8.5 cfs. Furthermore, the goal of 8.5 cfs pumping is too high to ensure species persistence during times of drought.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. The District disagrees with the conclusion of this comment with respect to continuing Class A permitting, as it is required by state law to do, and also notes that it is not known with absolute certainty the amount of protection the EDWL of 8.5 cfs does or does not provide.

g. None of the Alternatives propose methods for retiring historic permits and not repermitting historic water that is retired. Under the current measures any water savings could be re-permitted as conditional use water, which requires compliance with drought reduction measures in order to be available to increase springflow during drought. These permits would not be curtailed completely unless the district is in extreme drought.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions. However, the District notes that the salamander is most at risk and take is highest during extreme drought.

h. The district should determine whether any of the proposed actions conflict with the City of Austin's ITP/HCP or Salamander Recovery Program.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

i. (New comment made in a followup meeting with Baker and Walker on July 15) It was suggested that, if the District or another entity is successful in acquiring the rights associated with a historic use pumpage permit, then the rights should be placed in a trust or water bank so that the conservation objectives of the HCP are advanced.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

j. (New comment made in a followup meeting with Baker and Walker on July 15) The District should try to avoid any cases in which it might have preemptively declared, legally, that the District does not have a certain authority, when in reality the District has not made that legal determination. To claim no authority at one stage could have limiting consequences if such authority is interpreted as already enabled, at a later stage.
Preliminary comment by District:
These comments have not yet been addressed, or incorporated in any revisions.

k. (New comment made in a followup meeting with Baker and Walker on July 15) The District should seek legislative action to ban all surface discharges of sanitary effluent from wastewater treatment plants in the Edwards Aquifer Recharge and Contributing Zones, as a part of this HCP.
Preliminary comment by District:
This comment has not yet been addressed, or incorporated in any revisions.

4. Conclusion
The measures presented in the current draft EIS/HCP do not avoid jeopardizing the species and do not demonstrate that impacts to the species are minimized to the maximum extent practicable.
Preliminary comment by District:
There is not an adequate basis for drawing such conclusions by the commentors, only a fear. They represent only an opinion of someone not charged with making such judgments in any accountable fashion, and therefore will not be specifically addressed. Obviously, the District disagrees with the conclusion.

ATTACHMENT TO COMMENTS BY JENNIFER WALKER AND SARAH BAKER: CLIMATE CHANGE AND DENDROCHRONOLOGY STUDIES

Climate Change and Recurrence of Drought: Section 3.1.1.3 cites a 1997 EPA report stating that climate change may result in a 5-30% reduction in precipitation during the winter and a 10% increase in other seasons. The lack of baseline precipitation amounts coupled with the wide range of projected reduction (5-30%) in winter make it difficult to determine how much precipitation in inches we could expect, whether it would amount to a net increase or decrease in precipitation, and how quickly such changes will occur. Moreover, the HCP does not address the effect of climate change on evaporation levels. Although section 6.9.3.1 acknowledges that the next 50 years will be warmer and direr, it does not discuss the severity or implications of this prediction. And while accepting that the "drought of record may not present the worst-case scenario," the HCP does not incorporate planning efforts should a worse drought occur. Rather, it classifies this possibility as an "unforeseen circumstance" for which the U.S. FWS will have the burden of demonstrating-- although it cannot require the commitment of additional land, water, or money.

There are numerous reports that are more recent, integrate several studies, and give more definitive projections. A recent Columbia University analysis of global-warming patterns predicts that Texas will enter a period of permanent drought within the next 15 years. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America. SCIENCE, vol. 316, May 25, 2007, at 1181- 1184. Of 19 projection models of projected drought recurrence in the southwest, only one model shows a trend toward a wetter climate. The other 18 models demonstrate that the trend towards a drier climate has already begun and could become very noticeable by 2021. The drought conditions would be comparable to those in the drought of record, but will be permanent. Of 49 projections of future rainfall, all but three concluded the region would face drought conditions by 2021. The rest showed that all of Texas would receive much less rain, with drier conditions in west and southwest Texas.

A U.S. Global Change Research Program (GCRP) study employs HAD & CCC models to predict climatic change. Effects of Climatic Change on a Water Dependent Regional Economy: A Study of the Texas Edwards Aquifer. CLIMATIC CHANGE, vol. 49, number 4, June 2001, at 397-409. The HCP states that by 2100, temperatures could increase by 3° in spring (with a range of 1-6°) and about 4° in other seasons (with a range of 1-9°).

The GCRP report predicts temperature increases in the uppermost range of the HCP's projections. Using the HAD Model, by 2030 temperature is expected to rise by 3.2° and precipitation to decrease by 4.10 inches. By 2090, the temperature will rise by 9.01° and the precipitation will decrease by .78 inches. Using the CCC Model, by 2030 temp will rise 5.41 and precipitation will decrease by 14.36 inches. By 2090, temp will rise 14.61° & precipitation will decrease by 4.56 inches.

Online Links to Sources:

The Columbia University Study:
http://www.sciencemag.org/cgi/rapidpdf/316/5828/1181.pdf?ijkey=CAlzmuA008O0.&keytype=ref&siteid=sci

More reader-friendly summary: http://www.ldeo.columbia.edu/res/div/ocp/drought/science.shtml

USGCRP Study: http://www.usgcrp.gov/usgcrp/nacc/agriculture/chen1.pdf

Dendrochronology and Recurrence of Drought: The HCP uses an extensive database of tree-ring data for the *southwest* to conclude that long-term droughts occurred only 4 times, and 3 of those were in the 1700's. However, the American Meteorological Society conducted a study specific to Texas in which it analyzed five tree ring chronologies from south-central Texas. Stahle, David W. and Malcolm K. Cleaveland. Texas Drought History Reconstructed & Analyzed from 1698 to 1980. JOURNAL OF CLIMATE, vol. 1, issue 1, January 1988, at 59-74. The study reported that, although there has been an increase in precipitation since the 1700's, the driest decade experienced in Texas since 1698 occurred from 1855-1864. Furthermore, in the last 283 years, it is estimated that five out of the seven most severe droughts occurring in south Texas have occurred since 1917, with the most severe occurring in the 1920's. The HCP claims that forty droughts occurred from 1700 to 1979. However, this study concludes that sixty-six moderate or worse drought (PDSI equivalent < – 1.58) have occurred in Texas from 1698-1980. There is better than a 50% occurrence of an extreme drought every ten years in south Texas (PDSI < – 4.0).

Land-Use and Population Growth Projections: The residential growth projections are based on data from 1998 City of Austin reports and 2002 LCRA reports. This information should be updated with more recent data. For example, Austin Growth Watch predicts that Austin's population will grow by 19,000 people annually, to reach 800,000 by 2010. While the highest percentage of population growth is within the desired development zone (5.29%), there is nevertheless a higher combined growth rate (5.72%) in the Protection Zone and Urban Watershed Zone.

Current Number of People per Developable Acre in Austin

Protection Zone	2.3	4.8%	Annual population growth rate 2000-2005
Urban Watershed Zone	8.9	.92% “”	
Desired Dev. Zone	2.2	5.29% “”	

Overall Population Growth Rate = 3.54%

Source: http://www.ci.austin.tx.us/growth/default.htm

The projections should also be based on regional data that considers the District Planning Area, such as CAMPO, Envision Central Texas, and others, not just COA, which has a very specific jurisdiction.

Hays Co. Projected Pop. Growth

2005	129,220
2010	168,807
2020	248,737
2030	304,161

Source: Envision Central Texas, Hays Countywide Presentation, 2/23/07.

The Sunset Valley Area in 1990 had 63% undeveloped land. In 2000, this percentage had shrunk to 24%. During this same period, single-family units increased from 23 to 31% of land use and commercial uses went from 1 to 4%.

Source: Texas Center for Policy Studies Time to Act: the Future of the Texas Hill Country, Hill Country Roundtable, 12/07/06, www.texascenter.org/publications/act.pdf.

Preliminary comment by District:
These comments have not yet been fully addressed or incorporated in any revisions. However, some additional text and citations for some of this information have been incorporated in the most recent version.