PROPOSED

Draft Habitat Conservation Plan For Managed Groundwater Withdrawals from the Barton Springs Segment of the Edwards Aquifer

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Barton Springs/Edwards Aquifer
Conservation District

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For:
U.S. Fish & Wildlife Service

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DRAFT HABITAT CONSERVATION PLAN FOR MANAGED GROUNDWATER WITHDRAWALS FROM THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

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List of Acronyms, Abbreviations, and Terms Used in This Document

Act, the	The federal Endangered Species Act
AF	acre-feet
AMP	Adaptive Management Plan
BAT	Biological Advisory Team
BSEACD	Barton Springs/Edwards Aquifer Conservation District
C	Celsius, temperature scale
CAC	Citizens Advisory Committee
CCSP	U.S. Climate Change Science Program
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO2	carbon dioxide
COA	City of Austin
COMM	Commercial water use type
DFC	Desired Future Condition
DISTRICT	Barton Springs/Edwards Aquifer Conservation District
DO	Dissolved Oxygen
DOR	Drought of Record
EAA	Edwards Aquifer Authority
EIS	Environmental Impact Statement
ERP	Emergency Response Period (drought stage)
ESA	Endangered Species Act (the Act)
GBRA	Guadalupe-Blanco River Authority
GCD	Groundwater Conservation District
GCM	Global Circulation Model
GMA	Groundwater Management Area
GWSIM- IV	USGS groundwater flow model
HCP	Habitat Conservation Plan
IND	Industrial, water use type
IPCC	Intergovernmental Panel on Climate Change
IRG	Irrigation, water use type
ITP	Incidental Take Permit
LC_x	Lethal Concentration [x is percent of total]
MAC	Management Advisory Committee; also Committee
MAG	Modeled Available Groundwater (derived from DFC)
MG	million gallons
mg/L	milligrams per liter (chemical concentration)
mm	millimeter
MP	[District] Management Plan
msl	mean sea level, datum for elevation measurement
NDU	Nonexempt Domestic Use

NEPA	National Environmental Policy Act
NOAEL	No Observed Adverse Effect Level
PEHA	Probabilistic Ecological Hazard Assessment
pH	Concentration of hydronium ion (acid-base measure)
Production	(Amount of) groundwater withdrawn by pumping a water well
PWS	Public Water Supply, water use type
Pumpage	Amount of groundwater pumped from water well(s)
r	Correlation Coefficient
R^2	Coefficient of Determination
SAP	Synthesis and Assessment Product
Service	U.S. Fish and Wildlife Service, Department of the Interior
SYS	Sustainable Yield Study
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks & Wildlife Department
TWC	Texas Water Code
TWDB	Texas Water Development Board
UCP	User Conservation Plans
UDCP	User Drought Contingency Plans
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Withdrawal	Groundwater withdrawn from aquifer by pumping water well(s)

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The Barton Springs/Edwards Aquifer Conservation District is the entity that prepared and is submitting the Habitat Conservation Plan as the sole Plan Participant, and it alone is responsible for its contents. However, it was assisted in the preparation of various drafts of the HCP and in the conduct of supporting investigations by a set of contractors that provided important contributions to the overall effort. They include:

- Hicks & Company, for environmental impact assessment and NEPA-related documentation;
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Moreover, the District has assembled a multi-lateral stakeholder group to serve as a continuing HCP Management Advisory Committee (MAC, or Committee) to advise the District Board of Directors and assist the District staff in implementing the HCP, as described in Section 6.5.1.2 of this HCP. The inaugural members of the Committee also participated in a comprehensive, facilitated review process on earlier versions of this HCP, and their comments substantially improved the final draft document. These members and their interest groups include:

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Todd Votteler	Guadalupe Blanco River Authority (River Authority)
Jon White	Travis County (County Government)
Clif Ladd	Interested Private Citizen (Public At-Large)
Karen Huber	Interested Private Citizen (Public At-Large)

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Draft Habitat Conservation Plan for Managed Groundwater Withdrawals from the Barton Springs Segment of the Edwards Aquifer

1.0 Introduction and Background

This habitat conservation plan (HCP) is proposed by the Barton Springs/Edwards Aquifer Conservation District (BSEACD, or the District) in support of an application for an incidental take permit (ITP, or Permit) from the U.S. Fish and Wildlife Service (Service) for the Barton Springs salamander, *Eurycea sosorum* , and for the Austin blind salamander, *E. waterlooensis*, both protected species listed as endangered by the Service (together, the Covered Species). The District is a political subdivision of the State of Texas, a local agency of the State that was formed and authorized by the Texas Legislature specifically to manage the groundwater resources within its jurisdiction under applicable state laws and statutes, particularly Texas Water Code Chapter 36 and Special District Local Laws Code Chapter 8802. This document comprises the HCP for the regulated withdrawal of groundwater of the Barton Springs segment of the Edwards Aquifer as a water supply by permitted well owners/operators under the conservation program and auspices of the District (hereinafter, District HCP); it proposes a substantial number of regulatory and groundwater management measures that will be implemented by the District as HCP conservation measures upon issuance of an ITP under Section 10 of the Endangered Species Act (Act).

Issuance of an ITP is a federal action subject to a review by the Service in compliance with the National Environmental Policy Act (NEPA), which may involve preparation and further documentation of overall environmental consequences in an Environmental Assessment or Environmental Impact Statement. The District HCP focuses exclusively on the biological and ecological effects and consequences of certain District actions as they relate specifically to the Covered Species. A separate NEPA document presents the Service's analysis of the direct, indirect, and cumulative impacts of issuing the requested ITP on all of the natural and the man-made environments.

The District HCP is a public document under the Texas Public Information Act. It is the District's intent that this document provides such additional context and information, beyond that required by the Service, to be comprehensible and useful to the District's stakeholders, including District permittees and the state, regional, and local entities affecting and affected by the HCP. However, an HCP is essentially a proposal to the Service that informs a Service-internal consultation process specifically designed to form a Biological Opinion on the likely effects and consequential impacts on the Covered Species, which then becomes the basis for decision-making on issuance of an ITP. As such, its format, content, and level of detail are largely prescribed by Service regulations, policy, and guidance.

The District's statutory mandate is to provide for the conservation, preservation, and protection of groundwater resources of all aquifers in its jurisdictional area, including portions of northwestern Caldwell, northeastern Hays, and southeastern Travis Counties. This area encompasses all locations of groundwater withdrawal from the Barton Springs segment of the Edwards Aquifer, sometimes called the Barton Springs aquifer (hereinafter, the Aquifer, unless the narrative's context requires additional specificity). This mandate is entirely consistent with the HCP, and the same measures that benefit the Aquifer's human users, by extending the water supply during drought, also benefit the Covered Species that depend on the Aquifer as habitat. The purpose of the District HCP is to meet the requirements of applying for and receiving an ITP to be compliant with the Act. Not only are the Covered Species conserved, but also the District and its regulated community are benefited by having such a permit, to comply with Federal statute, regulation, and policy in carrying out otherwise lawful activities as authorized by the State of Texas and that may result in incidental take of the Covered Species.

The District's activities described by this HCP are consistent with current statutory authorities of the District and are based on sound science and effective groundwater management practices. They have been formulated and framed in collaboration with other conservation efforts affecting the Covered Species and/or their habitat. In particular this includes the City of Austin's July 2013 "Major Amendment and Extension of the Habitat Conservation Plan for the Barton Springs Salamander (*Eurycea sosorum*) and the Austin Blind Salamander (*Eurycea waterlooensis*) to Allow for the Operation and Maintenance of Barton Springs and Adjacent Springs" (hereinafter, the Barton Springs Pool HCP). Certain aspects of the Edwards Aquifer Recovery Implementation Plan/HCP for the use and management of the neighboring San Antonio segment of the Edwards Aquifer (EARIP, 2012) were relevant to and useful in developing the District's HCP.

The biological goals and objectives of the District's conservation program are presented in Section 6.1 of this HCP document. Other District goals and objectives are characterized in the current Texas Water Development Board-approved District Management Plan (BSEACD, 2013) and are complementary to and consistent with the goals and objectives described in this HCP.

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2.0 Purpose and Need for ITP/HCP

2.1 Purpose

As described above, the District's statutory mandate is to provide for the conservation, preservation, and protection of groundwater resources of all aquifer systems in its jurisdictional area, including the Aquifer. Certain activities associated with that mission may produce both beneficial and adverse effects on the rate and water chemistry of spring flows at Barton Springs that in turn impact the habitats of the Covered Species. In particular, the District's drought management program both allows and restricts the amount of groundwater withdrawn from the Aquifer by certain well owners. Nevertheless, the federal Endangered Species Act (Act) prohibits take of its listed species except as prescribed in the Act. The purpose of the District Habitat Conservation Plan (HCP) is to meet the requirements of applying for and receiving an Incidental Take Permit (ITP) under the Act (see Section 2.2.2 below) so the District, on a federally authorized exception basis, may continue to carry out its otherwise lawful activities as authorized by the State of Texas that may unavoidably result from time to time in incidental take of the Covered Species.[1]

2.2 Need for the HCP

2.2.1 Programmatic Basis of Need

The District's activities that create the need for an ITP relate to the following groundwater management functions that are explicated in the District Management Plan (District, 2013):

- Adopt, implement, and enforce regulations and management programs that protect existing groundwater supplies, improve aquifer demand management, provide Aquifer and springflow protection during droughts, promote and improve aquifer recharge, and carry out other beneficial management strategies; and

- Avoid, or minimize, and mitigate negative impacts upon federally listed species dependent upon springflow from Barton Springs through adoption and implementation of regulations, management programs, scientific research programs, conservation education programs, and collaborative efforts with other governmental entities.

These activities directly and indirectly affect the amount of pumping of the Aquifer (the withdrawal of groundwater by operating pumps set in wells installed within the Aquifer for providing the water supply of well owners/operators). In turn, as a result of the hydrology of the groundwater system, such pumping lowers the elevation (altitude referenced to

[1] The Covered Species may also be stressed by the introduction of pollutants that also affect the quality of the water recharging the Aquifer. Unlike the natural water chemistry changes, these water quality impacts are generally caused by human activities on the land surface that result in pollution from point sources and especially non-point sources. In this document, these are referred to as "water quality" impacts, to distinguish them from the "water chemistry" impacts. The water quality impacts of these actions, over which the District has no control and therefore are not Covered Activities, are cumulative with the natural changes in water chemistry associated with lower springflows, and both are generally antagonistic to aquatic life requirements.

mean sea level) of its groundwater levels, and consequently reduces the amount of discharge at Barton Springs. There is a well-established relationship, within the observed data range available, between the amount of water issuing from the outlets of Barton Springs and the chemistry of that water. As flow decreases, the dissolved oxygen concentration of the water, which is required by the Covered Species for survival, decreases, and the concentration of dissolved solids increases. This natural variation in water chemistry derives from the physical system of the Aquifer, and it occurs regardless of whether spring flow decreases are due to drought, or to water withdrawals by wells in the Aquifer, or both (BSEACD, 2013; BSEACD, 2004).

During normal and high flow conditions in the Aquifer, the combined discharges at its natural outlets at Barton Springs are many multiples of the aggregated amount of water that is being withdrawn by wells in the Aquifer. Under these conditions, the District's program elements principally address the long-term sustainability of the Aquifer as a water supply. During these times the amount of water withdrawn from the Aquifer by wells and the provisions of the District's regulatory program are believed to have essentially no effect on the chemistry of the spring flow, as both the physical and chemical characteristics of those spring flows are mostly attributable to meteorologically–induced storm flows and seasonal factors, and from time to time, other exogenous factors (Mahler and Bourgeais, 2013; Mahler et al., 2011). Accordingly there is essentially no incidental take ascribable to the Covered Activities when the water levels in the Aquifer are above a certain elevation, which determines the amount of discharge of the groundwater at the Aquifer's major outlet, Barton Springs. This threshold elevation and spring flow are characterized in Section 3.2.2.1 below.

But during drought, and especially prolonged severe drought (including "Exceptional Drought" and "Extreme Drought" as defined by the District[2]), the amount of water naturally discharging from the springs complex is much smaller, similar in magnitude to the amount of water withdrawn from wells. During these drought conditions, the District's groundwater drought management program is key to preserving groundwater levels in the Aquifer and spring flows. The joint and regional water planning conducted by the State, with which the District's groundwater management plan is integrated, utilizes a recurrence of the drought of record in the 1950s (DOR) as the planning objective, and that is also the framework for the District's drought management program. The District's integrated regulatory program is designed to protect the water supply of those Aquifer's users who are most vulnerable to supply interruption during those Extreme Drought times and to conserve the flows at Barton Springs for both ecological and recreational purposes. It is during certain of these drought periods that the groundwater levels and springflows unavoidably decline sufficiently to create incidental take of the Covered Species, which

[2] "Exceptional Drought" is a term used herein to refer specifically to droughts that are more severe than Stage III-Critical Drought, and are declared by the District Board when springflow at Barton Springs is less than 14 cfs, or water level in the Lovelady monitor well is below 457.1 feet (msl) elevation. "Extreme Drought" refers to an even more severe drought condition, deep within an Exceptional Drought, that is declared by the District Board when springflow at Barton Springs is less than10 cfs on a sustained basis. The more general term "severe drought" is used herein to refer qualitatively to conditions that represent those groundwater drought conditions in the District that range from prolonged Stage II-Alarm through Stage IV-Exceptional droughts, as declared by the District. See Appendices E, F, and G for more information on drought stage definition and drought management implementation.

creates the programmatic need for the HCP and the ITP. The circumstances that give rise to such incidental take are discussed in more detail in Sections 5.2.2 and 5.2.3.

Demand for and pumping of groundwater for beneficial public water supply and other uses has increased substantially in recent decades (see Figure 3-4), exacerbating the need for programmatic action. For many users, the Aquifer continues to be the only feasible water supply available. The cumulative rate of pumpage of all operating wells in the Aquifer can now have significant impacts on spring flow during drought flow conditions, even increase the likelihood of low flow conditions, and during severe drought may produce habitat-significant water chemistry changes, as will be characterized in the following sections of this HCP. The production from permitted operating wells reached an all-time monthly peak of approximately 13.4 cfs (equivalent to 3.21 billion gallons per year) in the month of June 2008 (BSEACD, unpublished data, 2014).

Since that time, despite increased demand for water supplies in the District, pumpage rates of the Aquifer have generally been smaller as a result of groundwater management policies and regulations of the District and of responses by its permittees to projected shortfalls during severe droughts. As the demand for groundwater has increased, the District has gradually changed its drought management and regulatory program to improve the effectiveness of Aquifer and springflow protection, supported in no small part by the studies and planning for the ongoing HCP development. The average monthly pumpage for the three years 2007-2009 was 8.2 cfs, which also included a regulated drought period in 2008-09 with mandatory pumpage reductions of 20 and 30% during District-declared Stage II-Alarm and Stage III-Critical drought, respectively (BSEACD, 2010). The pumping rates were once predicted to increase steadily with urban development over the Aquifer and reach as high as 19.6 cfs by the year 2050 (Scanlon et al., 2001). However, owing to the implementation of conservation plans, demand-management programs, and imposition of severe drought withdrawal limitations by the District, as described in detail in Section 6.2 of this HCP, the estimated pumpage maxima over the long-term are now considerably lower, no more than 25% of that previously projected amount of pumping.

The HCP specifies the District commitments to a set of conservation (avoidance, minimization, and mitigation) measures that are consistent with statutory authorities of the District and that are based on sound science and effective groundwater management practices. The District HCP has been formulated and framed in collaboration with other conservation efforts affecting the Covered Species and their respective habitats, viz., the habitat conservation plan of the City of Austin for operation and maintenance at Barton Springs Pool and environs, including particularly the individual spring outlets. The well owners and users, especially the District's permittees, who are described in Section 4.1.1, and all those citizens who consider Barton Springs as an ecological, recreational, and aesthetic resource, are the key additional stakeholders for this HCP.
Every approved HCP is based on achieving a set of biological goals and objectives as the ITP holder pursues its programmatic activities. The biological goals and specific objectives of the District HCP are presented in Chapter 6, along with specific protective conservation measures.

2.2.2 Statutory Basis of Need: the Endangered Species Act

The Act, at 50 CFR § 17.3, is the relevant federal statute that protects and promotes the recovery of endangered and threatened species. Section 9 of the Act (16 USC 1538(a)) prohibits "take" of any federally endangered wildlife. Take is defined as an action that may annoy, harm, harass, pursue, shoot, wound, hunt, kill, trap, capture, or collect members of any threatened or endangered species. Section 10(a)(1)(B) of the Act of 1973 (16 USC 1539(a)(1)(B)) authorizes the U.S. Fish & Wildlife Service (Service) to issue a permit (or ITP) allowing on a conditional and exception basis the take of protected species that is incidental to, and not the purpose of, the carrying out of otherwise lawfully conducted activities (Covered Activities). The District is an applicant for an ITP. For the issuance of an ITP, the applicant must submit a conservation plan that satisfies the requirements of Section 10(a)(2)(A) of the Act. The required elements of an HCP and ITP under the Act are identified in Section 2.3 below.

Section 10(a)(2)(B)(ii) of the Act allows non-federal entities to conduct otherwise lawful activities likely to cause take of endangered species, as long as the detrimental effects of the activities are not purposeful and are minimized and mitigated to the maximum extent practicable, and further provided that the Service determines that jeopardy of the Covered Species' populations related to the Covered Activities is avoided. HCPs are the vehicles by which such take can be authorized by the Service on an exception basis, provided that it will be minimized and mitigated by the ITP applicant to the maximum extent practicable. This HCP is expressly designed to fulfill those obligations of the District for the regulated groundwater withdrawal from the Aquifer (its Covered Activities).

2.3 Correspondence between HCP Sections and Information Required by the Service

The location of the information required or pertinent for an HCP to comply with Service regulations and guidance is tabulated in the following subsections. These correspondence tables are provided to assist not only the Service but also and especially the District's stakeholders and the public in finding and reviewing information that relates the descriptions of the District's groundwater management programs to the required conservation plan elements.

2.3.1 Information Requirements of an HCP in Support of an ITP

Service Requirement (16 USC § 1539(a)(2)(A)(i)-(iv)	HCP Report Section(s)
1. The impact that will likely result from the taking;	5.2; 5.3
2a. Steps the applicant will take to monitor, minimize, and mitigate such impacts,	6.0; 6.1; 6.2; 6.3; 6.4; 6.5.1; 7.1; 7.2.2
2b. The funding available to implement the steps, and	8.0
2c. The procedures to be used to deal with unforeseen circumstances;	7.3
3. Alternative actions to the proposed taking considered by the applicant and the reasons why such alternatives are not proposed to be used; and	9.0; 9.1; 9.2
4. Other measures that may be required or appropriate for the purposes of the plan.	None yet identified, but see 6.4; 6.5.1.3; 7.1

2.3.2 Findings for the Service to Issue an ITP

Service Requirement (16 USC § 10(a)(2)(B)	HCP Report Section(s)
1. The taking will be incidental;	1.0; 2.1; 4.1
2. The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;	6.0-6.4; 7.0-73; 9.2
3a. The applicant will ensure that adequate funding of the conservation plan [will be provided], and	8.0
3b. [The applicant will ensure that] procedures to deal with unforeseen circumstances will be provided;	7.2, 7.3
4. The taking will not appreciably reduce the likelihood of survival and recovery of the species in the wild; and	5.1.3;.5.1.4; 5.2.3.4; 5.3
5. The applicant will ensure that other measures as may be required by Service as necessary or appropriate for purposes of the HCP will be implemented.	1.0; 4.1.2.1; 4.1.3; 6.1; 6.3; 6.4; 6.5.1; 7.0-7.3; 8.0

2.3.3 Additional Guidance and Recommendations for Developing HCPs (the “Five Point Policy”)

HCP Handbook Addendum (65 FR 32,250-32,256)	HCP Report Section(s)
1. Defined conservation goals and objectives;	1.0; 6.1; 6.2
2. An adaptive management strategy;	6.4; 6.5.1.2; 6.5.1.3; 7.2; 7.3
3. Compliance and effectiveness monitoring;	6.3; 6.3.1- 6.3.4
4. An established permit duration; and	4.2
5. Opportunities for public participation.	4.1.3; 4.1.4

3.0 Description of Areas to Be Analyzed

The geographic area of this Habitat Conservation Plan (HCP) is in central Texas, straddling the Balcones Escarpment at the margin of the Edwards Plateau, with the Blackland Prairie physiographic province on the east and the Texas Hill Country of the Edwards Plateau province on the west. It is an area that is rich in the amount and variety of its natural and human resources but it is undergoing rapid suburbanization associated with burgeoning growth of the Austin-San Marcos metropolitan area, with both land use and cultural aspects converting from dominantly rural to dominantly suburban/commercial character (BSEACD, 2013).

Two areas are described in more detail in this part of the HCP. The first is the larger “Planning Area,” which includes the entire area that either affects or is affected by the HCP and in which mitigation measures could take place. The second area is the smaller “Incidental Take Permit Area,” or ITP Area, which is coincident with the District’s jurisdictional area, and is where the Covered Activities of the District are located and where any resulting incidental take of Covered Species occurs.

3.1 Planning Area

The HCP “Planning Area” is depicted in Figure 3-1. It encompasses not only the jurisdictional area of the District, which includes the Barton Springs complex as well as the geographic area where all wells in the Aquifer are located, but also those areas outside the District that affect the Aquifer’s resources, including areas that contribute recharge to the Aquifer and areas that utilize the Aquifer as a water supply. This area is characterized in more detail in the subsections below.

3.1.1 General Environmental Setting of Planning Area

The environmental setting of much of the Planning Area has been described in considerable detail in the recent Barton Springs Pool HCP that addresses the same Covered Species, and those descriptions are incorporated herein by reference (City of Austin, 2013); it may be accessed online at: http://www.austintexas.gov/watershed_protection/publications/document.cfm?id=203078. This section of the HCP is largely based on those descriptions, and highlights those aspects of the environmental setting that are salient with respect to the District’s Covered Activities, the Covered Species, and this HCP.

3.1.1.1 Physical Environment

The Planning Area is in the southern extension of the North American Great Plains, at the eastern edge of the large Edwards Plateau region in central Texas. The Balcones Fault Zone is the boundary between the Edwards Plateau to the north and west and the Gulf Coastal Plain to the east and south. A number of large karstic springs, including Barton Springs, are located at the land surface along the fault zone, where more permeable, older limestone strata are juxtaposed against less permeable younger strata. Barton Springs, located along and in a major tributary (Barton Creek) just upstream of the Colorado River, is the lowest in elevation of these springs, and it and the Colorado River form the regional discharge boundary location for deep, fresh groundwater that is not discharged at other, higher-elevation springs.

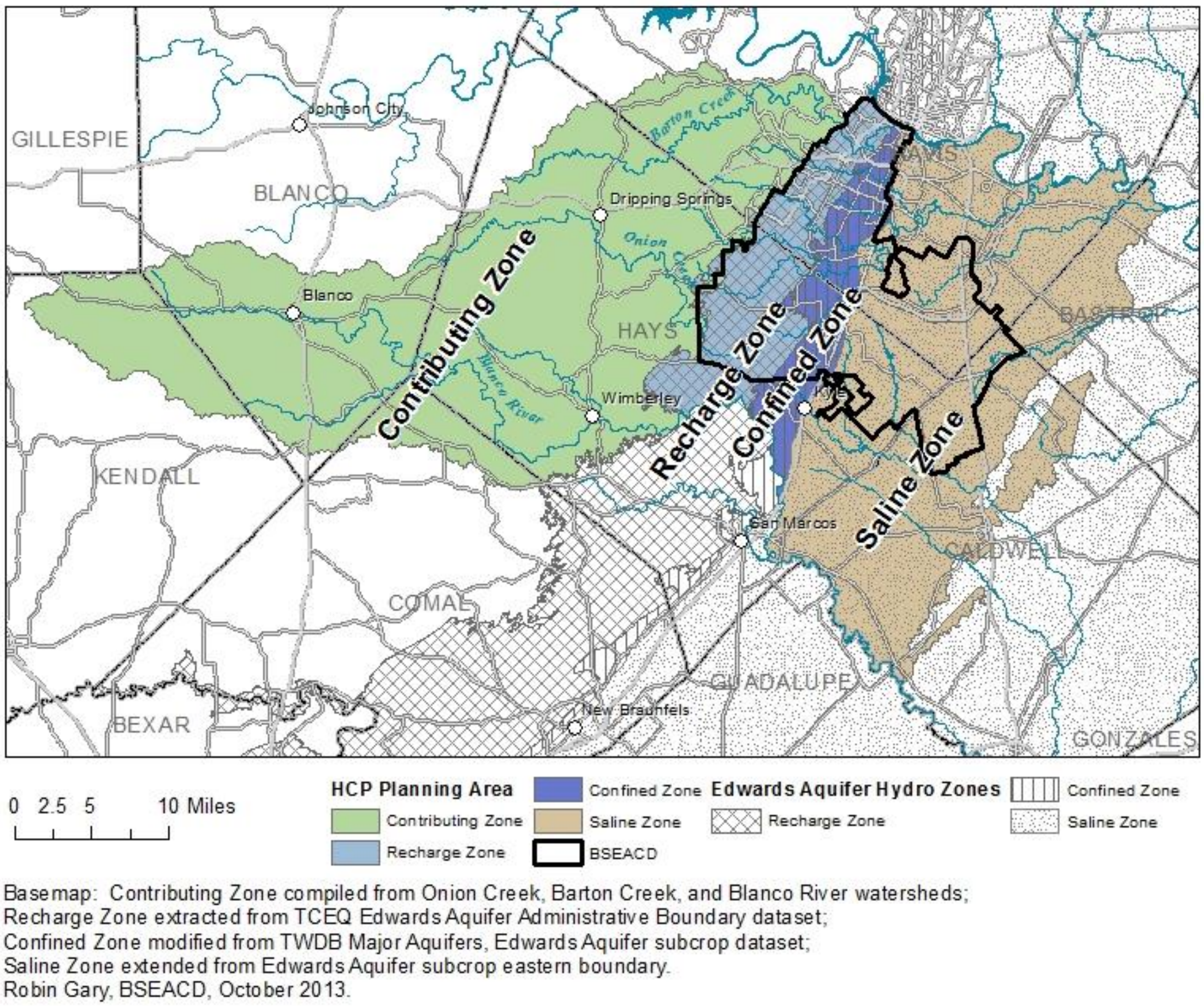

Figure 3-1: The Planning Area of the District HCP.
The District's jurisdictional area, outlined in black, is a small part of the Planning Area, shown in color, but it forms the entirety of the ITP Area.

The climate of the Planning Area is classified as subtropical humid, with mild winters and hot summers, although during multi-year periods it may be more accurately considered semi-arid, especially in the western portions in the Hill Country. Heavy rainfall can occur in any month, but generally the winter months are drier and, at least statistically, the early and late summer months are wetter than average. But rainfall and runoff are highly variable in time and space. The concept of "average rainfall" is rather misleading when considered in a predictive sense at any one location, but there is a significant gradient from northeast to southwest across the Planning Area toward smaller rainfall amounts and higher evapotranspiration. Generally, annual evaporation rates exceed annual rainfall rates considerably, often by a factor of two or more; the long-term average factor is about 1.6. Antecedent soil-moisture conditions are deterministic of whether and how much rainfall of a given duration is required to produce runoff to the local streams.

The entire area is prone to drought, which may be severe and persist for months to many years. Virtually every decade has had one or more significant drought periods that has lasted for a substantial part of a year or more. The most severe drought in recorded history in this area was the drought from 1950-1957, which is designated for water planning purposes as the DOR; during that drought, Barton Springs had its lowest recorded daily flow, 9.6 cfs, and its lowest monthly flow, 11 cfs. (Variations in springflows at Barton Springs are characterized more completely in Section 3.2.2.1.2 below.) Conversely, the area's small streams from time to time are also subject to short-term, sometimes extreme flooding associated with tropical moisture systems moving inland and meeting the Balcones Escarpment and/or cold air masses, producing flooding rainfall intensities in the Planning Area. Floods may actually occur in the midst of a drought period and the rainfalls that created the floods may or may not relieve the droughts, depending on their location and persistence. During the decade that is designated by the Texas Water Development Board (TWDB) as the DOR for this region, there were significant periods of time when stream flows and spring flows were near average, at least for a while.

It has been widely recognized that these variations play an integral role in the natural resilience and ecological health of creeks, rivers, and streams and their resident flora and fauna (Service, 2013b; Poff and Ward, 1989; Resh et al., 1988).

The Planning Area is drained by two major Texas river systems, with the Colorado River system tributaries in the northern part and the Guadalupe-Blanco River system tributaries (including the upper part of the main stem of the Blanco) in the southern part of the area. All of the surface streams except the main river stems are non-perennial, although most have base flows that are supported by shallow groundwater contributions during non-drought and non-severe drought periods. Only the primary river systems have large enough catchment areas to support reservoirs for water supply and/or downstream areas that justify flood-control impoundments. Areas distant from the rivers' main stems are typically dependent on wells and groundwater for reliable and economic water supplies; these include the more rural parts of the Planning Area.

The near-surface hydrogeology of the Planning Area is dominated by the karst aquifers associated with the Balcones Fault Zone. The aquifer systems of this zone are central to the need for and development of the HCP, so they are described in much more detail in Section 3.1.2 below.

3.1.1.2 Biological Environment

The Planning Area includes portions of two terrestrial biogeographically-defined ecoregions, with the dissected margin of the Edwards Plateau ecoregion to the west and the southern portion of the Texas Blackland Prairie ecoregion on the east (Texas Parks and

Wildlife Department (TPWD), 2012). The rolling topography has level to more gently rolling plains in the east and more steeply sloping and dissected uplands in the west. In combination with the climate gradients from east to west and the different geological substrates on either side of the Balcones Fault Zone, soil types with different depths and textures have been produced, which in turn support diverse vegetation and wildlife.

The Blackland Prairie is a native prairie grassland community which is dominated by a diverse assortment of perennial and annual grasses. Its dark soil is considered some of the richest soil in the world and supports an active agricultural community, especially to the north of the Planning Area. This ecoregion is predominately comprised of live oak and Ashe juniper, with increasing amounts of post oak, blackjack oak, American elm, winged elm, cedar elm, sugarberry, green ash, osage-orange, honey mesquite, and eastern red cedar in the more northeastern parts of the Planning Area. Pecan, black walnut, black willow, American sycamore, honey locust and bur oak are commonly found in bottomland woodlands throughout this region (Texas Forest Service, 2008).

Common vegetation in the Planning Area includes (TPWD, 2013):

Switchgrass	Bald cypress
Bluestem grass	Pecan
Grama grass	Possumhaw
Indiangrass	Smartweed
Wild rye	Sugarberry
Curly mesquite	Boxelder
Buffalograss	Buttonbush
Live oak	Black willow
Shinnery oak	Marsh purslane
Ashe juniper	Water pennywort
Mesquite	Cattail

Common wildlife in the Planning Area includes (TPWD, 2013):

Muskrat	Northern mockingbird
White-tailed deer	Guadalupe bass
Rio Grande turkey	Salamanders
Raccoon	Cricket frog
Javelina	Gulf Coast toads
Brazilian freetail bat	Grebes
Ringtail	Blue herons
Nine-banded armadillo	Green-backed heron
Tarantula	Kingfishers

Both of the ecoregions are undergoing change as the area is increasingly populated by humans. In some areas closer to the urban areas, suburbanization is replacing native vegetation with turf grasses, non-native plants, and impervious cover, and displacing native wildlife. But perhaps the most pervasive and ecologically significant long-term change for the non-suburbanizing portion of the Planning Area is the purposeful suppression of wildfire. As noted in the City of Austin's HCP (City of Austin, 2013):

> The natural vegetation of the Edwards Plateau uplands is characterized by oak savannas and grassy terrains, bisected by canyons and riparian areas with thick forest vegetation and a great diversity of trees and shrubs. The Blackland Prairie was dominated by tall-grass prairie and deciduous bottomland forest. The savanna and prairie ecosystems were maintained by fires and grazing bison. With the suppression of fire [as the area has developed], the openness once characterizing portions of these regions has been severely reduced. This allowed the encroachment and increase in abundance of species once controlled by fire, such as Ashe Juniper (*Juniperus ashei*). Natural savanna and tall-grass prairie are absent in much of both ecoregions today.

The karst springs along the margins of the Edwards Plateau have their own ecological character. The smaller, headwater seeps and springs tend to have shallow water, high canopy cover, fast current, and low nutrient content (City of Austin, 2013; Mabe, 2007); these, factors likely result in the naturally low abundance and diversity of aquatic macrophytes and macroalgae. The City of Austin notes that larger springs located within wider, higher order streams, such as the stretch of Barton Creek that contains outlets of Barton Springs, likely had a greater abundance of aquatic macrophytes than headwater springs because the canopy cover is less, current is slower, and nutrient load is greater (City of Austin, 2013).

The fauna within the Planning Area are mostly transitional, with substantially more diversity north of the Colorado River as the river is the southern boundary for many species (Abell et al., 1999). While this ecoregion is home to over 100 fish species, few of them are endemic (found only in a specific location); in contrast, many endemic karst aquatic fauna are found in spring-fed streams of the Edwards Plateau.

More information on the vegetation and fauna that are specifically associated with the Barton Springs complex itself is included in Section 3.2.2.2 below.

A summary listing of those plant and animal species that the TPWD considers to be in greatest need of conservation is found in Appendix A, with separate tables for the Edwards Plateau and Texas Blackland Prairie ecoregions. Federally protected species of potential interest specifically to this HCP are also identified and discussed as to their relationship to the proposed Covered Activities in Section 3.2.4 below.

3.1.1.3 Man-made Environment

As previously noted, the Planning Area is on the suburban fringes of the Austin-San Marcos Metropolitan Statistical Area, including the City of Austin, the City of Buda, the City of Kyle, and the City of San Marcos, all of which are undergoing rapid growth that extends into the Planning Area. The current population of this area has been estimated by the District, on the basis of geospatial analysis of the latest census data, to be about 583,000, and it is expected to increase to more than 800,000 during the proposed 20-year term of the ITP, using rather conservative growth-rate projections in the ongoing regional water resource planning by the TWDB:

Planning Horizon	Population in HCP Planning Area
2010 Census	525,000
2015 (Start of ITP)	583,000
2035 (End of ITP)	803,000
2040	855,000

The City of Austin has indicated that much of the population increase in the Colorado River basin portion of the Planning Area will occur in the Barton and Williamson Creek watersheds (City of Austin, 2013). Growth associated with the Cities of Kyle and San Marcos in the Planning Area will largely be in the Plum Creek and Blanco River watersheds of the Guadalupe-Blanco River basin. The more western and eastern portions of the Planning Area will continue to be mostly rural, although some areas near transportation corridors and exurban communities will increasingly become rural residential and commercial.

Much of the firm-yield water supply (water that will be physically available and that is authorized for use during all hydrologic conditions, including Extreme Drought) throughout the Planning Area is fully subscribed, including supplies of fresh groundwater from the Aquifer. For this reason, the accuracy and precision of these future population estimates are not particularly germane to future demand for existing water supplies in the Planning Area. Public water supply (PWS) systems are now actively pursuing alternative surface-water and groundwater supplies from outside the Planning Area to serve their projected growth. Consequently, the number of people who are now provided groundwater from the Aquifer is not expected to increase significantly from the current 70,000 estimate; in fact it may decrease as smaller PWS systems using the Aquifer are subsumed by and become part of larger PWS systems on alternative supplies.

The population growth that takes place in the areas that are outside of the various municipal limits will create wastewater treatment and disposal challenges that may have an adverse effect on water quality. Increasing use of centralized wastewater treatment systems that directly discharge even highly treated wastewater into the small streams that are upstream of the recharge zone is not unlikely, along with continued proliferation elsewhere of land application systems and septic tanks. These facilities have a potential for surface- and groundwater quality degradation if they are not adequately sited, designed, and/or maintained.

3.1.2 Hydrogeologic Framework of Planning Area

An understanding of the hydrogeologic and hydrologic framework underpins the District HCP. The detail provided in this subsection of the HCP is required to establish and monitor effectiveness of suitable conservation measures for the Covered Species. Even more detailed information is provided in the City of Austin's HCP (2013).

The only recognized known habitats for the Covered Species are the four spring outlets[3] (the multiple sub-outlets of Main Springs [Parthenia Spring] in Barton Springs Pool, Eliza (Concession) Spring, Old Mill [Sunken Garden, or Zenobia] Spring, and Upper Barton Spring); their associated surface spring runs; and the subterranean areas of the Barton Springs complex (see Figure 3-4 in Section 3.2.2.1, below). These outlets are the primary points of freshwater discharge from the Aquifer. So water passing into and through Barton Springs comes primarily from the Aquifer, although also occasionally and transiently from a flooding Barton Creek.

The Aquifer is a karst aquifer, characterized by features such as caves, sinkholes, sinking streams (streams that lose water to an aquifer), springs, and other karst conduits that have been enlarged by dissolution of the host carbonate rock (Woodruff and Abbott, 1979). This Aquifer also is located in an area with extensive, complex faulting and fracturing, which provide the potential for additional hydrologic interconnections.

3.1.2.1 Aquifers and Hydrozone Boundaries

At the regional level, the Edwards Aquifer has three segments, commonly referred to as the Southern (or San Antonio) segment, the Barton Springs segment, and the Northern segment, which are separated by hydrologic and geologic divides (as shown in Figure 3-2 in Section 3.1.2.2 below). The freshwater portion of the Barton Springs segment that contributes solely to the habitat for the Covered Species covers about 170 square miles (440 square km) (Slade et al., 1986). The hydrologic region that influences the Aquifer and therefore the District HCP, as shown in Figure 3-1, includes the Aquifer's Contributing Zone (green shaded area), Recharge Zone (light blue shaded area), Confined Zone (dark blue shaded area), and Saline Water Zone (tan shaded area) in Central Texas. Most of the HCP Planning Area is located in northern Hays and southern Travis Counties. Smaller portions of the Planning Area extend into Bastrop, Blanco, Caldwell, Comal, and Kendall Counties.

The freshwater portion of the Barton Springs segment consists of two major zones: (1) the Recharge Zone, where the Edwards Group crops out (is present at the land surface) and which is a hydrologically unconfined area (light blue shaded area in Figure 3-1); and (2) the Confined Zone, where the Edwards subcrops (is present only below other rock units) and which is generally a hydrologically confined area (the darker blue shaded area in Figure 3-1). Each of these are characterized below.

The Recharge Zone as defined herein covers about 107 square miles (277 square km) of the Planning Area. Recharge is the process by which water enters and replenishes an aquifer. The majority of recharge to the Aquifer is derived from streams originating on the contributing zone, located up gradient and generally west of the recharge zone. Water flowing onto the recharge zone sinks into numerous caves, sinkholes, and fractures along numerous (ephemeral to intermittent) losing streams. For the Barton Springs segment,

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[3] Throughout this HCP, the District designates the specific outlets of the Barton Springs complex by the following names: Main Springs (which in this HCP actually refers to closely associated multiple sub-outlets within Barton Springs Pool), Eliza Spring, Old Mill Spring, and Upper Barton Spring. All of these have alternative names, shown here in parentheses, which are variably used by various other entities. There is no standard usage.

Slade et al. (1986) estimated that as much as 85% of recharge to the aquifer is from water flowing in these streams. The remaining recharge (15%) occurs as infiltration through soils or direct flow into discrete recharge features in the upland areas of the recharge zone (Slade et al., 1986). However, a more recent study by Hauwert (2009) indicates that upland recharge may constitute a larger fraction of recharge than stated in the Slade et al. (1986) study. Both studies recognize that a significant amount of recharge to the Edwards Aquifer is from flow in the creeks that cross the recharge zone. (Also see discussion in Section 3.1.2 below for other potential recharge sources during certain hydrologic conditions.)

Mean surface recharge to the Barton Springs segment of the Edwards Aquifer should be approximately equivalent to the more directly measured mean discharge, or about 53 cubic feet per second (cfs) (1.5 m^3/s); however, maximum recharge rates during flooding may approach 400 cfs (11 m^3/s) (Slade et al., 1986). Studies have shown that recharge is highly variable in space and time and focused within discrete features (Smith et al., 2001). For example, Onion Creek is the largest contributor of recharge to the Barton Springs segment (34% of total creek recharge) with maximum recharge rates up to 160 cfs (4.5 m^3/s) (Slade et al., 1986). Antioch Cave, which is located within the Onion Creek channel, is the largest-capacity discrete recharge feature known in the Barton Springs segment, with an average recharge of 46 cfs (1.3 m^3/s) and a maximum of 95 cfs (2.7 m^3/s) during a 100-day study (Fieseler, 1998). A more recent study (Smith et al., 2011) estimates that Antioch Cave is capable of recharging up to 100 cfs (2.8 m^3/s) and that the recharge portion of Onion Creek upstream of Antioch Cave is capable of recharging about 100 cfs (2.8 m^3/s). The District has constructed and currently operates under an Environmental Protection Agency grant program, a recharge enhancement facility at Antioch Cave to preserve and increase the amount of recharge to the Aquifer derived from this discrete feature.

Protection from deleterious effects of storm runoff and conservation of streamflow in the watersheds of these creeks are important to maintaining the water quality and chemistry of the habitat at Barton Springs (Service 2005). The recharge zone has numerous wells, many of them low-capacity individual household supply (domestic use) wells and also a few large-capacity wells, especially where the saturated thickness of the Aquifer is larger and is able to supply larger amounts of water without being overly susceptible to drought impacts.

The Confined Zone (down gradient from the recharge zone in the eastern portion of the Aquifer but up gradient from the saline zone of the Edwards) generally has a full or nearly full saturated thickness; this 63-square mile (163-square km) area is where most of the groundwater production from the Aquifer's wells occurs. It includes both an artesian zone, which is an area farther from the recharge zone that is always confined and under artesian pressure, and an intermediate transitional area closer to the recharge zone that varies between being hydrologically unconfined and confined, depending on the water levels in the Aquifer. Some areas immediately east of the recharge zone are unsaturated to variable depths below the overlying low-permeability units. In the Confined Zone, dipping and faulted impermeable layers of clay and other less permeable rocks overlie the Aquifer; as its groundwater moves deeper, away from the recharge areas, the Aquifer eventually becomes fully saturated and hydraulically confined and then subject to higher than atmospheric pressure, i.e., artesian conditions. Because much of the water moving through the Aquifer is pressurized in dissolution cavities and conduits that transport water from higher elevations, the transitional and recharge zones of the Aquifer near springs exhibit both water-table and artesian characteristics, depending on water levels in the Aquifer (Wong et al., 2012). Accordingly the Barton Springs complex could be considered a hybrid (gravity and artesian) spring complex.

Upstream from the Aquifer is the Contributing Zone, which contributes surface runoff and base flow of streams to the Aquifer but is not considered a part of the Aquifer itself (see green shaded area in Figure 3-1). What has been historically designated as the Contributing Zone of the Aquifer during all hydrologic conditions encompasses the upper watersheds of the six major creeks that cross the recharge zone. However, this definition excludes the upper Blanco River watershed that recent studies (Smith, et al., 2012) have shown to be a contributor of recharge to the Aquifer during drought conditions. Although the six creeks in this area are the source for most of the water that will enter the aquifer as recharge (see discussion in Section 3.1.2 below), the Blanco River is an important contributor during severe drought conditions. The extended contributing zone spans about 665 square miles (1722 square km) of the Planning Area and includes portions of Travis, Hays, Blanco, Kendall, and Comal Counties. The recharge and contributing zones together make up the total area that provides meteoric water (water that is derived from relatively recent precipitation on the land surface) to the Aquifer, and is about 772 square miles (1999 square km) in areal extent (Robin Gary, BSEACD, personal communication in September 2013).

The eastern boundary of the Aquifer is the interface between the fresh-water zone and the saline-water (or "bad-water") zone of the aquifer, characterized by a sharp increase in dissolved constituents (more than 1,000 mg/L total dissolved solids, or TDS) and a decrease in permeability (Flores, 1990). The Edwards saline zone, shown in the light tan color in Figure 3-1, has groundwater that ranges from brackish (greater than 1,000 mg/L TDS) to saline (greater than 10,000 mg/L TDS). Smith (2011) provides the following description of the hydrogeology of the saline zone:

> Lithologies of Edwards units east of the saline/freshwater interface are similar to the lithologies to the west. All of these sediments were deposited on a broad, shallow, carbonate shelf. The main difference between Edwards units on either side of the saline/freshwater interface is the degree of dissolution of the rocks and the amount of void space created by dissolution. Flux of fresh water has been high in the portion of the aquifer between the recharge zone and Barton Springs. This flow of slightly acidic water has dissolved a considerable amount of limestone and dolomite along faults, fractures, bedding planes, and even within the matrix. Significant conduits have developed along some of these zones that facilitate flow of even greater quantities of water. To the east of this zone of high flux, the amount of water flowing through the rock is less and therefore less dissolution takes place. However, there is some dissolution, but the minerals that are dissolved from the rock are not carried away from the zone of dissolution as quickly as the area to the west, and therefore

concentrations of dissolved minerals increase and the water is then considered to be saline or brackish.

Another factor that has contributed to the isolation of the saline zone from the freshwater zone is faulting that has offset similar units by tens to hundreds of feet, with the units on the eastern side of the faults mostly being down-dropped relative to the western side. The combination of horizontal separation from the main flow paths and vertical faulting has limited flow in the saline zone such that salinities increase to the east of the saline/freshwater interface.

The recharge zone and the confined freshwater and saline zones of the Aquifer overlie the Trinity Group, which includes clays, marls, and evaporites interbedded with the dominant limestone and dolostone. The Trinity is also a karst aquifer but with much more variable yield (limiting rate at which a groundwater volume is capable of entering a well bore) and water chemistry than the Edwards Aquifer, owing to its lithology. The Trinity Aquifer crops out across the entire contributing zone and provides base flow to the larger streams there that eventually recharge the Edwards. In addition, the uppermost part of the Trinity Aquifer and the Edwards Aquifer are in hydrologic communication (Wong et al., 2013), and in some places the Trinity probably contributes interformational flows to the Edwards and vice versa, depending on their respective water-level elevations. Recent studies (Wong et al., 2013; Smith and Hunt, 2011) have shown that the Edwards Aquifer is not in hydrologic communication with the deeper units of the Trinity Aquifer.

3.1.2.2 Groundwater Flow Conditions

In the recharge zone, meteoric water moves vertically from the land surface into the Aquifer through faults, fractures, and dissolution features in streambeds and less dominantly via soil infiltration in the karstic uplands. After reaching the water table, it then moves more laterally through the Aquifer via groundwater flow paths inside caverns, conduits, and other dissolution features that differ in size. Groundwater movement in the western part of the Aquifer is generally to the east and then north (Figure 3-2). Groundwater levels throughout the Aquifer are highly interrelated and, in many areas, correlate well with springflow rates at Barton Springs (BSEACD, 2004). Runoff flowing across the recharge zone and entering the Aquifer reaches the water table quickly. Groundwater flow velocities in the Aquifer are also very rapid (Hauwert, 2009; Hauwert et al., 2004; BSEACD, 2003). Groundwater-tracing studies have delineated several major groundwater flow routes and have been used to measure their groundwater velocities. The major flow routes transmit water derived from different contributing sources, including relatively new recharge, water moving into and out of storage, older recharge from areas distant to Barton Springs, and inter-formational flows of differing characteristics, including the saline part of the Edwards (Mahler and Bourgeais, 2013;Johns, 2006). The flow rates of groundwater along the dominant flow paths ranges from about 1 mile (1.6 km) per day under low groundwater flow conditions to about 5 miles (8 km) per day under moderate to high groundwater flow conditions (BSEACD 2003). The rapid hydrologic response of the Aquifer to precipitation and surface runoff emphasizes the importance of protecting the quality and quantity of water in each of the six major creeks in conserving the habitats of the Covered Species (Johns, 2006; Service, 2005; Hauwert et al., 2004).

The rate at which groundwater discharges at Barton Springs[4] is directly dependent on the water level in the Aquifer. Under drought conditions, surface flow in the contributing-zone creeks ceases, and the Aquifer water levels fall as water is discharged from the Aquifer at pumping wells and spring outlets. Many of the "over-flow" spring outlets, such as those in Upper Barton Springs, become dry for extended periods, and even the discharges from the main outlets of the Aquifer decrease. At lower water levels in the Aquifer, less groundwater flows solely (albeit rapidly) through large conduits.

In the immediate vicinity of the Aquifer's major resurgence at Barton Springs, periods of high and low water flow have been a natural characteristic of the Barton Springs/Barton Creek ecosystem (City of Austin 2013, 2007a, 2007b, 2006, 1997). In the present day, the dam and other constructed infrastructure creating Barton Springs Pool inhibit the beneficial flushing of sediment and debris provided by shallower, free-flowing water from both the spring outlets and the creek. For a given flow, shallower streams and creeks have greater flow velocities and consequently, stronger natural cleansing power. In addition, disturbance by episodic flooding is an important feature of streams and rivers (Gordon et al., 2004 and references therein; Poff and Ward, 1989; Resh et al., 1988) and was a natural characteristic of the Barton Springs complex prior to alteration by humans beginning in the late 1800s. The District has no authority or control over the hydrographic conditions and maintenance of the surface water systems that could affect the creeks and spring outlets.

Dye-tracing studies (BSEACD, 2003; Hauwert et al., 2004), direct flow measurements of the individual outlets that are statistically correlated with combined discharge (City of Austin, 2013), and outcomes of human-controlled pool-drawdown events have shown that the spring sites within Barton Springs are hydrologically related, particularly Main and Eliza Springs. These analyses indicate that any factor that causes a change in water quantity at one spring site also has the ability to affect water quantity at the other spring sites at Barton Springs (Service, 2005).

[4]Rates of stream flow and springflow discharges are conventionally expressed as cubic feet per second, or "cfs." Rates of groundwater use and overall production from an aquifer are usually expressed in acre-feet (AF) per time unit, typically per year. Groundwater production from individual wells is usually expressed in gallons per minute or thousand gallons per day. The District's permits are issued in terms of gallons per year. To facilitate comparisons of discharges from both wells and springs, the District uses "cfs" for both in this HCP. 1.00 cfs = 723 AF per year. 1000.0 AF per year = 325.9 million gallons per year = 892,700 gallons per day.

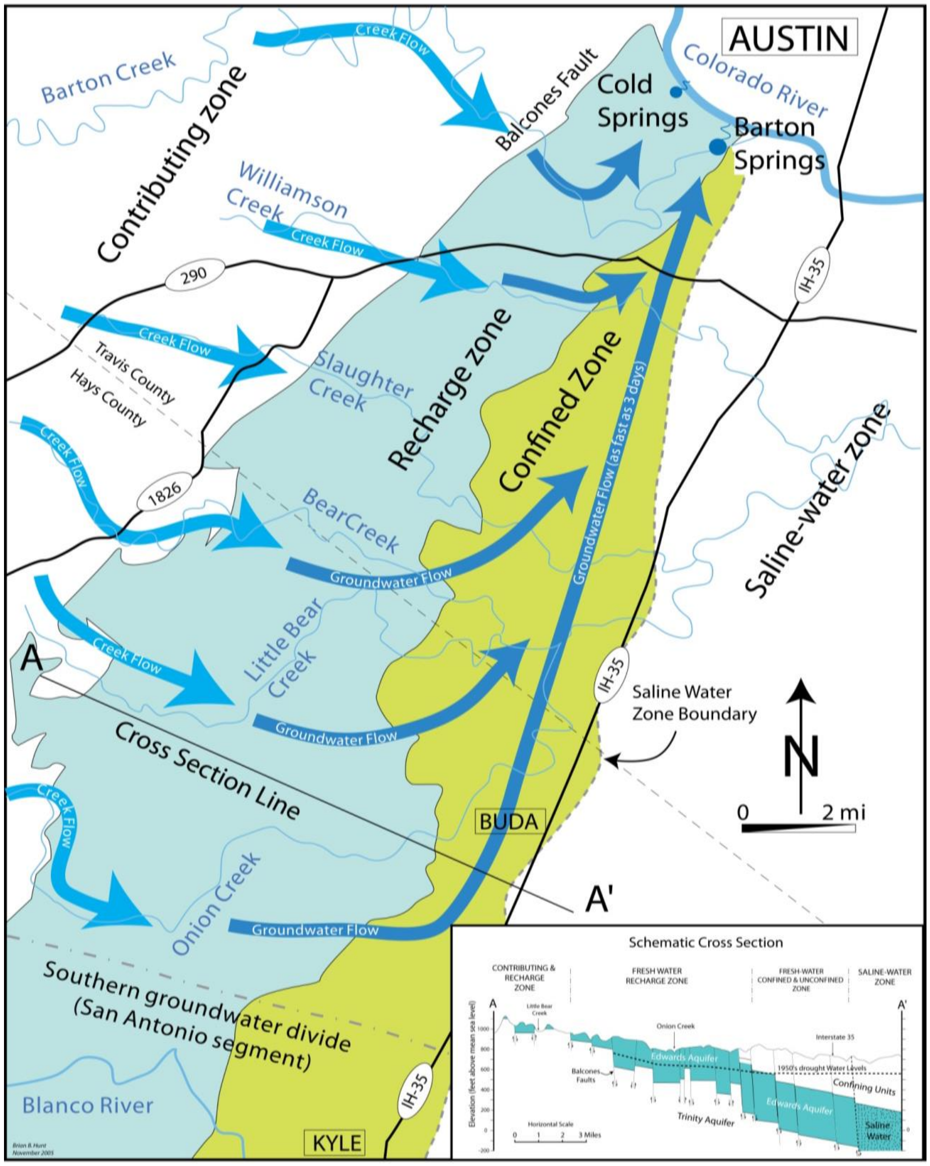

Figure 3-2: Conceptual Hydrology of the Aquifer
Map showing groundwater flow paths and approximate location of the hydrologic divide with the San Antonio segment of the Edwards. (Source: Adapted by BSEACD from figure in Smith and Hunt, 2004).

3.1.3 BSEACD Jurisdictional Area

The District's jurisdictional area, bounded by the black lines in Figure 3-1 above, is shown in more detail on the map in Figure 3-3. This territory, which comprises about 255 square miles in northwestern Caldwell, northeastern Hays, and southeastern Travis Counties, is statutorily established and delineates the area where the District's rules and regulations are enforceable. The boundaries of this territory approximate the hydrogeologic boundaries of the Aquifer, as described above, along with certain boundaries of the service areas of several public water supply utilities when the District was formed in 1987.

Under its enabling legislation, the District's jurisdiction is defined by metes and bounds to approximate a combination of natural and man-made boundaries. On the west the boundary was drawn to approximate the location of the western edge of the Edwards Aquifer outcrop, and on the north by the Colorado River. The eastern boundary is generally formed by what were the easternmost service area limits, at the time the District was formed in 1987, of what are now the Creedmoor-Maha Water Supply Corporation, Monarch Utilities/Southwest Water Company, and Goforth Special Utility District; changes made in those other entities' boundaries since then have not changed the District's boundaries. (In 2009 the District legislatively de-annexed the small portion of one of these utility's service area in Bastrop County, which is now outside the District.) The District's southwestern and southern boundary is generally established in alignment with the approximate average position of the groundwater divide or "hydrologic divide" between the Barton Springs and the San Antonio segments of the Edwards Aquifer (as shown in preceding Figure 3-2). To the southeast the boundary is along the southernmost service area boundaries of several water supply utilities, including Goforth (the District permittee with the largest authorized use, at 351 million gallons annually) and Monarch Utilities, another large Aquifer user. So, by original design, the District's jurisdictional boundaries have been aligned with the area where the Aquifer is used as a water supply.

Some of the Aquifer water produced within the District is physically transported by pipeline to other parts of the District and to nearby areas outside the District. The native groundwater (water that occurs naturally within an aquifer without influence from pumping or other anthropogenic activities) in the eastern part of the District's jurisdiction is brackish to saline, and therefore it is generally unsuitable as a potable water supply without expensive treatment. Freshwater supplies to this area are provided by Edwards wells west of Interstate Highway 35 and transported to those water utilities' customers by various water suppliers that are District permittees. (Other water sources also supply this area.) Also, a single well in the extreme southern part of the District's jurisdiction is the most prolific well in the District, providing a large amount of water that is exported from the District to the City of Kyle, just outside the District's jurisdictional boundary. However, its well is within the District, and Kyle is one the District's largest permittees (350 million gallons per year).

The District regulates groundwater from all aquifers underlying its jurisdictional area. An increasing amount of groundwater from other aquifers, especially the underlying Middle and Lower Trinity Aquifers, is now being used in this area as an alternative supply to the Edwards and is also managed by the District.

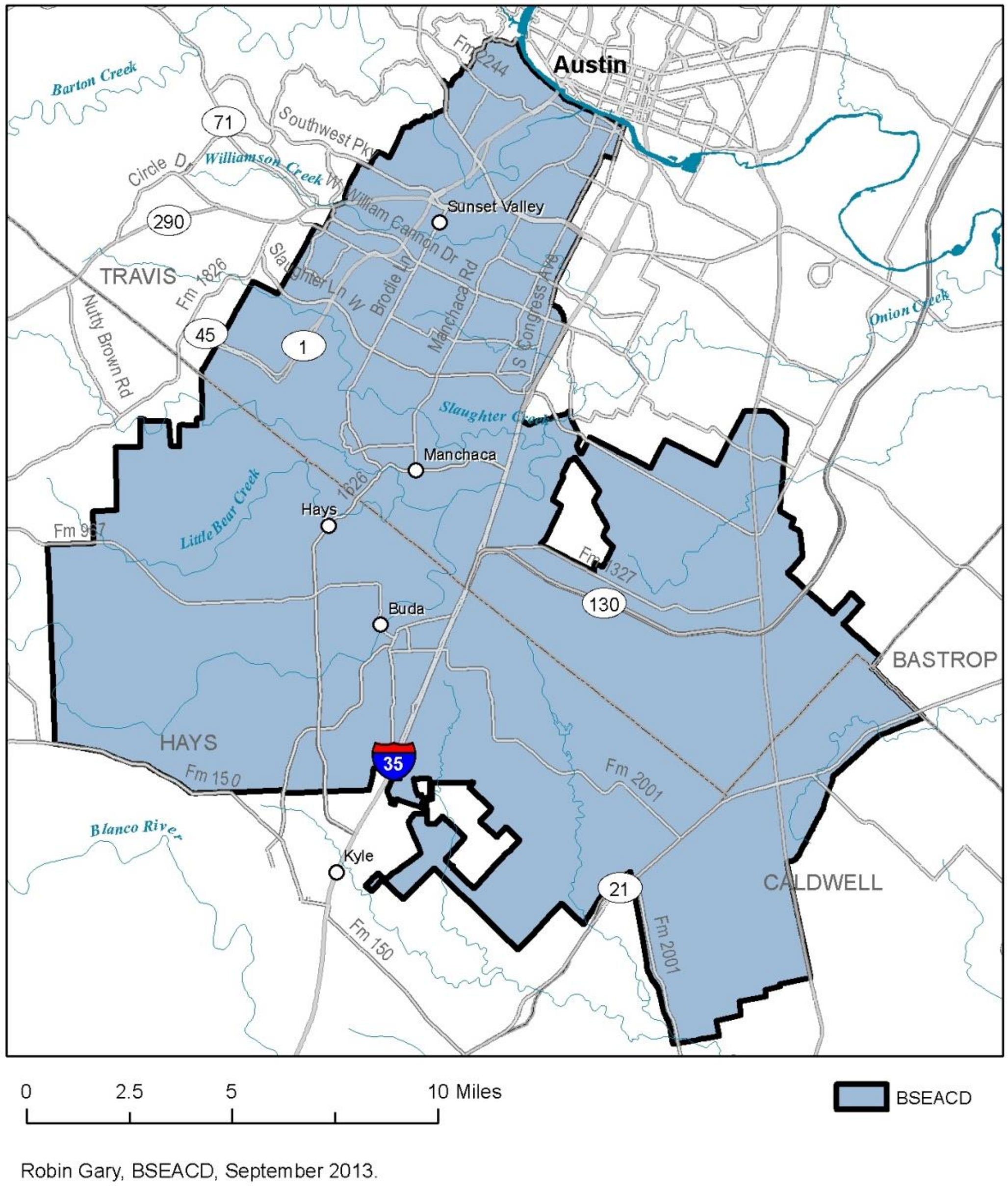

Figure 3-3: Barton Springs/Edwards Aquifer Conservation District Jurisdictional Area. The subsurface fresh-water environment in this area is the most extensive part of the ITP Area. Source: BSEACD (2013).

3.2 Incidental Take Permit Area for the District HCP

The ITP Area includes both (a) subsurface areas within and throughout the District's jurisdictional area, and (b) the surface/subsurface areas in the immediate vicinity of the natural outlets of the Aquifer at Barton Springs. Each of these is characterized in the following subsections. The ITP Area defines where the Covered Activities are authorized under the ITP and where conservation measures are to be implemented.

3.2.1 Subsurface Portion of the District’s Jurisdictional Area

The subsurface, fresh water-bearing strata of the Edwards and Georgetown geologic formations that are within the District’s jurisdictional boundary (outlined in black in Figure 3-1 and in Figure 3-3, above) are hydrogeologically and geographically the ITP Area. As described in Section 3.1 above, the area covers the hydrologically unconfined (recharge) zone, the hydrologically confined (transition and artesian in subcrop) zone, and the presumably hydrologically connected saline zone of the Aquifer. The Aquifer’s contributing zone is not included. It also includes portions of the Upper Trinity Aquifer (Upper Glen Rose formation) immediately underlying the Edwards Aquifer in this area, inasmuch as recent studies have shown the upper 100 feet of the Upper Glen Rose formation is hydrologically connected with the Edwards Group in the ITP Area. The lower portion of the Upper Glen Rose behaves as an aquitard (a barrier to hydrologic flow) between the Edwards and the Middle Trinity Aquifer (Wong et al., 2013).

The ITP Area includes the locations of all wells in the Aquifer and also the hydrogeologic systems that provide water to the natural outlets of the Aquifer at Barton Springs and several other smaller springs along the Colorado River. It is within this area, and only this area, that the District’s rules and regulations for groundwater management apply.

As shown in Figure 3-2 above, that part of the Edwards Aquifer in the southernmost part of the Planning Area, outside the District’s jurisdictional area, is governed by the Edwards Aquifer Authority (EAA) in San Antonio. The subsurface portion of the aquifer in this area is not included in the District’s ITP Area, rather in EAA’s own HCP (Edwards Aquifer Recovery Implementation Plan) and ITP Area (EARIP, 2012).

3.2.2 Spring Outlets Area

3.2.2.1 Physical Setting

3.2.2.1.1 Physical Characteristics of Barton Springs

In addition to the subsurface hydrogeologic components of the Aquifer throughout the District described in the subsection above, the ITP Area also includes the submerged surface substrates and shallow subsurface rock below those substrates in the immediate vicinity of the individual springs that comprise the Barton Springs complex. The complex itself includes the Main (Parthenia) Springs, which is impounded to form Barton Springs Pool; Upper Barton Spring; Eliza (Concession) Spring; and Old Mill (also Zenobia, or Sunken Garden) Spring (Figure 3-4). Any incidental take of Covered Species would be expected to occur in the submerged areas in, below, or just beyond the individual spring outlets, which are the primary natural discharge points of the Aquifer and the only known habitats of the Covered Species. The black line in Figure 3-4 circumscribing the outlets illustrates the inferred area of potential surface and subterranean habitat and subterranean migration zones for the Barton Springs salamander, and is the ITP Area for the City of Austin’s HCP. The larger area enclosed by the red line is the Service’s designated Critical Habitat for the Austin blind salamander (Service, 2013a). The yellow lines represent the perimeters of protected salamander habitat in each spring site. Currently, the surface outflow stream from Eliza Spring is contained within a buried pipe, which has until now carried water from Eliza in the subsurface directly into the bypass culvert , but it is to be restored ("daylighted") by the City of Austin in 2015.

This more localized portion of the District ITP Area encompassing the spring outlets is also included in the ITP area for the City of Austin's Barton Springs Pool HCP and ITP (City of Austin, 2013), to cover the impacts on the same Covered Species from the recreational use (swimming, diving, wading) and the maintenance operations (cleaning, caretaking) of the Pool and work in the spring outlet areas, including their surface flow regimes. A detailed description of the habitats at the spring outlets is excerpted from the City of Austin's HCP and provided as Appendix C. The City of Austin owns the land where the individual spring outlets are located and under its HCP maintains and operates all man-made structural elements around the spring outlets, including the Barton Springs Pool dam, impoundment, and bypass. The District does not control access to or operate and maintain any part of the infrastructure at Barton Springs. Its groundwater management activities only affect, within limits, the amount of water issuing from the spring outlets and the chemistry of that water as related to and determined by its rate of discharge.

3.2.2.1.2 Sources of Variation in Springflows at Barton Springs

The primary threat to the Covered Species and their ecosystems, which is habitat changes accompanying low spring flows, is affected by the District's Covered Activities during drought conditions in the Aquifer and at Barton Springs (Service, 2013b). Variable spring flow conditions are the norm, for which the Covered Species appear to be well suited. Cleaveland (2006) concludes on the basis of regional dendrochronological studies that droughts substantially more severe and prolonged than the drought of the 1950s have been a part of the pre-historical record. But increasing frequency of severe droughts and flash flooding also appear to be the "new normal" (IPCC, 2013), which will continue to challenge and stress the salamander populations.

The long-term (1917-1986) mean springflows at the Barton Springs outlets, based on U.S. Geological Survey data for combined springflows from the Barton Springs complex (Main Springs within the Pool, Eliza Spring, and Old Mill Spring; Upper Barton Springs is not included in these flows) was 53 cfs (BSEACD, 2009). In the more recent period of 1978 to 2009, the mean springflow was 63 cfs (U.S. Geological Survey, 2009). However, springflow has varied by as much as 15-fold from extreme low to extreme high flow conditions. The lowest daily flow recorded at Barton Springs was about 10 cfs during the record drought in the 1950s (Smith and Hunt 2004), and the highest-recorded flow was 166 cfs (Slade et al., 1986). The lowest daily value of the recent severe drought of 2008-09 (on July 21, 2009) was about 13 cfs (US Geological Survey, 2010); the more recent 2011 and 2013 severe droughts caused minimum daily flows of about 16 to 17 cfs. There is considerable uncertainty (as much as ±3 to 4 cfs) in measuring flows at these very low discharge levels, owing to the measurement approaches and tools available (Hunt et al., 2012a).

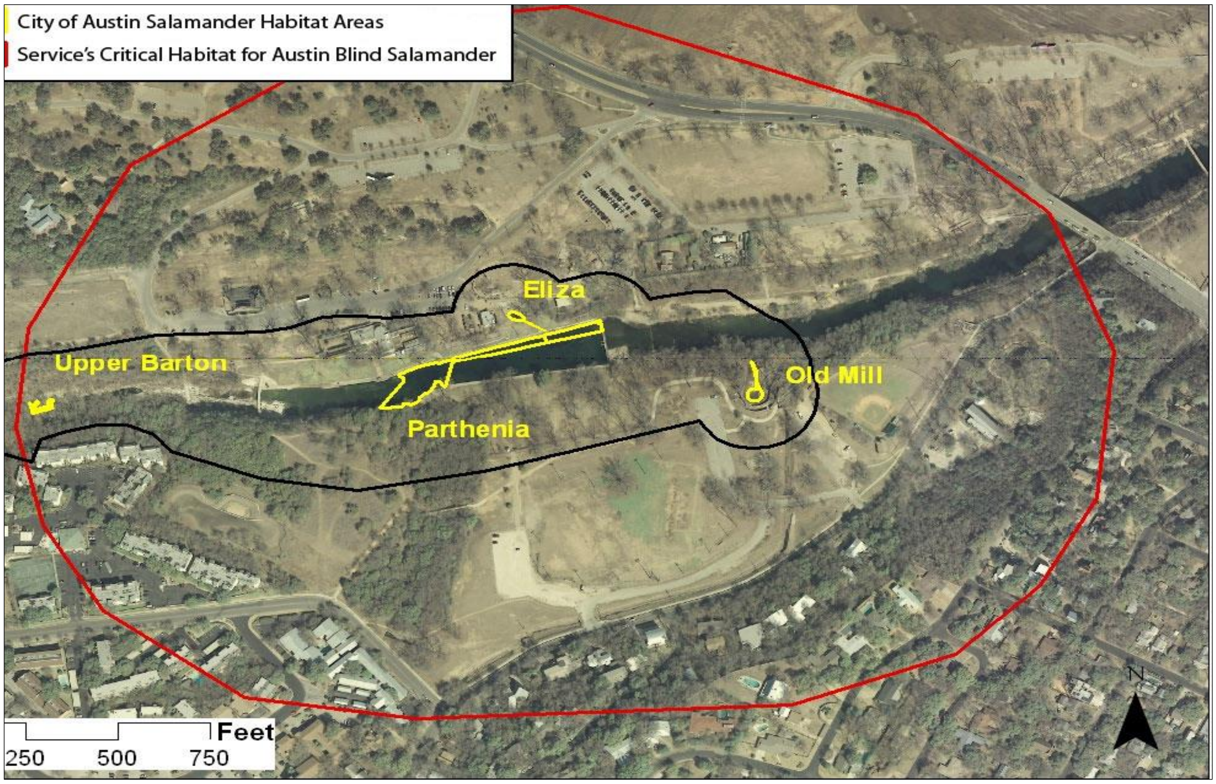

Figure 3-4: ITP Area Map - Barton Springs Ecosystem Vicinity.
See text for explanation of features shown. Source: City of Austin (2013)

It should be recognized; however, that pumping from the Aquifer does not *cause* the wide variation in springflows, rather exacerbates it to a variable degree, depending on overall aquifer condition. This is illustrated by Figure 3-5, which is a synthetic hydrograph of springflows at Barton Springs that would have existed "naturally," i.e., without any pumping of the Aquifer, for the period of historical record, 1917-2013. This naturalized hydrograph was constructed using measured (for later portions of the period) and inferred (for certain earlier portions of the period) monthly data for both spring discharges and total pumpage. Statistical analysis of the hydrograph, upon its conversion to an exceedence frequency distribution (showing the percent of time that a designated springflow is or isn't exceeded) yields the relationships shown in Table 3-2, showing natural (i.e., without any pumping occurring) frequencies for several springflows of importance to drought management (discussed further in Section 4.1.2):

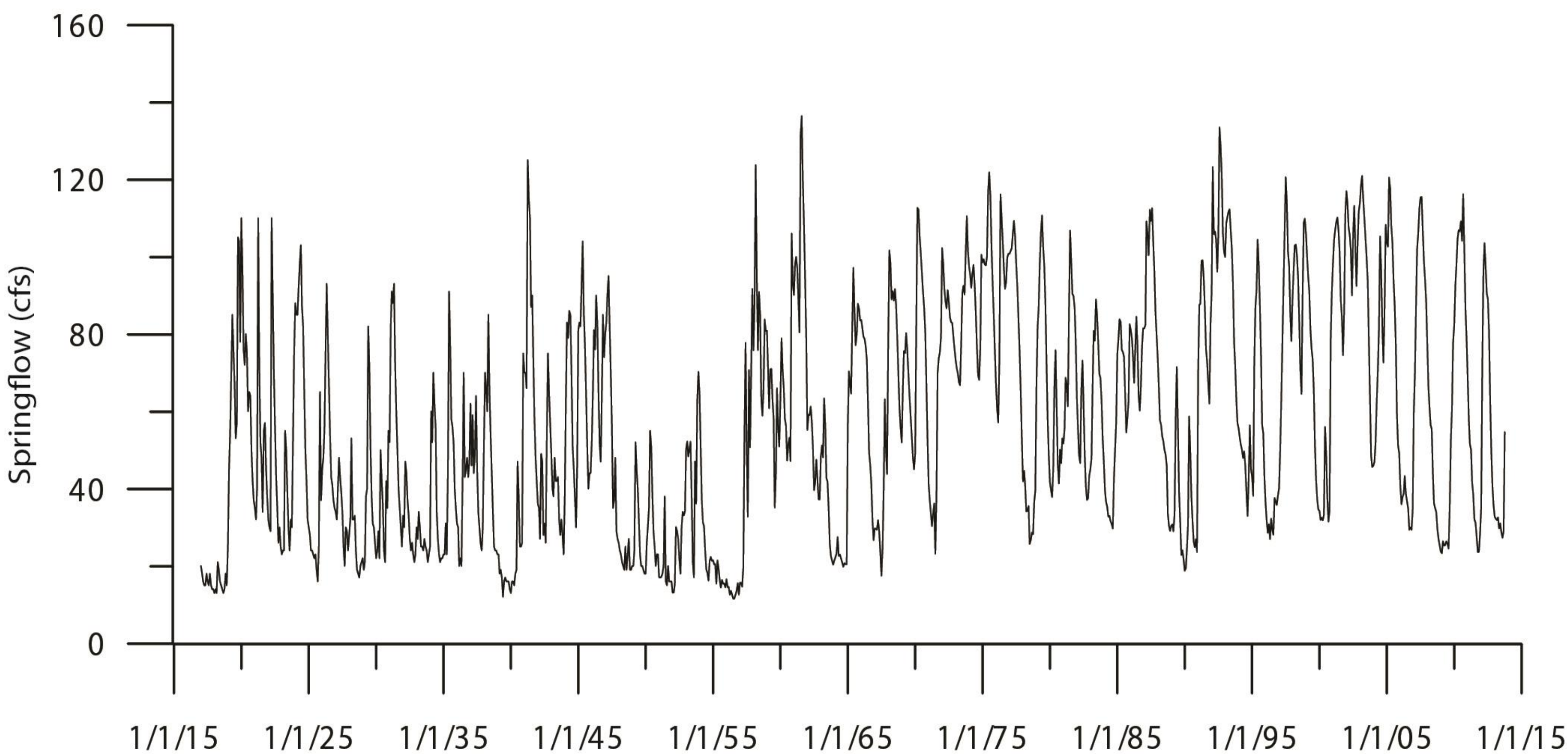

Figure 3-5: Hydrograph of total Barton Springs flow, 1917-2013.
Re-constructed Barton Springs hydrograph from 1917 to 2013 as if no pumping of the Aquifer had occurred during that time. Springflows reflect the many wet and dry periods in the Planning Area over this period of record, which cause Barton Springs to typically be above or below its long-term average discharge of about 53 cfs. The populations of the Covered Species have evolved and adapted to these natural fluctuations in flow and accompanying changes in water chemistry.

Table 3-2. Recurrence frequencies of naturalized springflows for specified drought management thresholds. The frequencies are based on the 1917-2013 period of record, and the thresholds are those currently used by the District for managing groundwater.

Groundwater Drought Threshold	Total Flow at Barton Springs (cfs)	Percent of Time Flow Not Exceeded
Average Flow	53	52%
Stage II –Alarm	38	36
Stage III – Critical	20	9
Stage IV – Exceptional	14	2
Emergency Response	10	<0.01
Regulated Minimum	6.5	0
No Springflow	0	0

This analysis shows that even without any non-exempt pumping, the Aquifer would be in a District-declared groundwater drought status, designated by the onset of Stage II-Alarm Drought, more than one-third (36%) of the time, and in a Stage III-Critical Drought almost 10% of the time. The computed frequencies for these threshold events, called recurrence frequencies, are calculated using monthly data, as pumping records used to construct the hydrograph are not reported on a more frequent basis. Strictly speaking, then, these recurrence frequencies correspond to springflows expressed as a monthly average (monthly flow duration), and daily or instantaneous springflows will be somewhat higher and smaller. But during a prolonged, severe drought , absent stormflow inputs, the natural flows of Barton Springs change very slowly day to day and week to week (Smith and Hunt, 2004). Accordingly, the recurrence frequencies for these monthly flow durations would be very similar to those for weekly or even daily flow durations during such times. Further, any differences actually observed would be expected to decrease the percentage of time at or below a given low springflow, as the changes would be derived from storm events that in the shorter terms would increase springflow rather than decrease it.

Discharge at Barton Springs decreases monotonically as aquifer water levels drop and the amount of groundwater in storage in the Barton Springs segment of the Edwards Aquifer decrease. Large declines in aquifer levels and storage have generally been caused by climate-related prolonged periods of rainfall deficit, which in turn reduce the amount of meteoric water recharging the aquifer for extended periods of time, rather than due to the continuing effects of groundwater withdrawal for public and private use. This is illustrated by the multi-year recent hydrograph for Barton Springs discharges in Figure 3-6, where the range of springflows in any one drought cycle (about 100 cfs) is roughly an order of magnitude larger than the amount of groundwater withdrawn during those times (about 10 cfs).

However, increased groundwater pumping will also reduce the quantity of water in the aquifer and therefore spring flow (Scanlon et al., 2001; Smith and Hunt, 2004). Water supply wells in the Aquifer include more than 1,200 active wells that pump water for public, domestic, industrial, commercial, irrigation, recreational, and agricultural uses (Hunt et al., 2006). As described in more detail in Section 4.1.1, only about 10 percent of these wells by number but approximately 96% of the total volume of water withdrawn from the Aquifer by wells is regulated by the District (Smith et al., 2013; Smith and Hunt, 2004). It is important to consider how such future groundwater withdrawals by wells will cause variations in springflows, especially during future droughts.

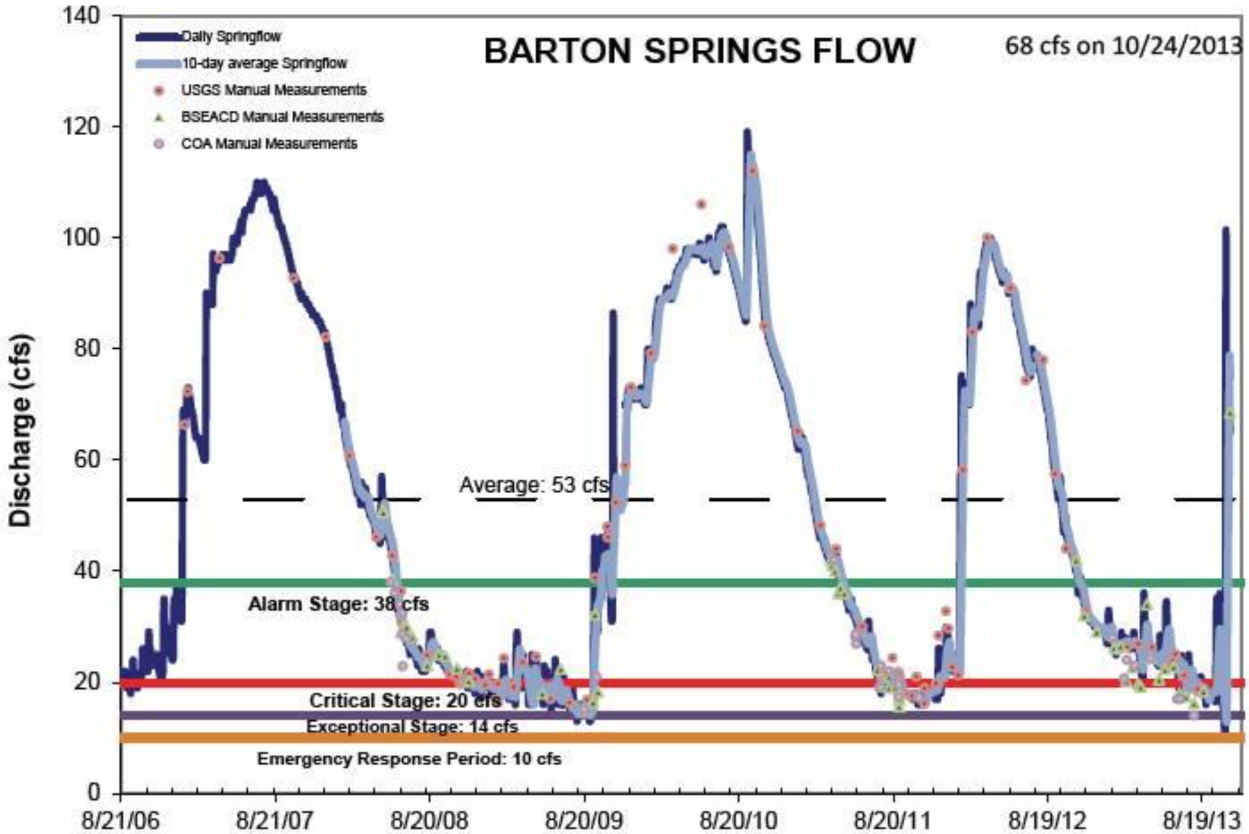

Figure 3-6: Hydrograph showing variable flows at Barton Springs, Sept. 2006 - Oct. 2013. Note the drought stage thresholds that have groundwater management significance. Source: BSEACD Drought Information page on website, accessed 11/8/2013.

Groundwater flow modeling by Scanlon et al. (2001) had indicated spring flow at Barton Springs could possibly cease as pumping in the Aquifer reaches about 10 cfs. In 2004, the BSEACD hydrogeologists performed additional modeling to determine the "sustainable yield" of water in this segment of the Aquifer based specifically on the possible recurrence of the DOR (Smith and Hunt, 2004, included herein as Appendix B). The BSEACD defined sustainable yield then as:

> "the amount of water that can be pumped for beneficial use from the aquifer under drought-of-record conditions after considering adequate water levels in water-supply wells and degradation of water quality that could result from low water levels and low spring discharge" (Smith and Hunt, 2004).

This study recalibrated the model used by Scanlon et al. (2001) to more accurately predict springflow and aquifer declines under DOR conditions. Pumping rates were projected for future years. This first-ever rigorous assessment of the sustainable yield of the Aquifer revealed that the then-authorized pumpage of the Aquifer, about 10.2 cfs, equivalent to 2.41 billion gallons per year, was essentially its sustainable yield, as that level of pumping during a recurrence of the DOR, *if un-curtailed*, would reduce the springflow at Barton Springs to less than 1 cfs and would cause some 19% of the wells in the shallower part of the Aquifer to experience substantial yield problems from declining water levels in wells. More specifically, the recalibrated model indicated that under DOR conditions, the then-current pumping levels of 10 cfs would result in a mean monthly springflow of about 1 cfs for about one month. It also indicated that under continuous DOR conditions, projected pumping rates of 15 cfs, *if un-curtailed,* would cause Barton Springs to cease flowing for at least four months (Smith and Hunt, 2004).

The Sustainable Yield Study was the impetus for rulemaking that established the District's conditional-use (interruptible-supply) permitting program for Aquifer permit applications initiated after September 2004. This study also demonstrated the one-to-one correspondence between changes in pumped volumes and changes in springflow during Extreme Drought conditions (Smith and Hunt, 2004). Taken together, these findings ultimately formed the underpinnings of the groundwater availability modeling for establishing modeled available groundwater (MAG) amounts related to the adopted Extreme Drought Desired Future Condition (DFC) of the Aquifer, which balances maintaining ecological habitat and well yields with being able to enforce as stringent curtailments as practicably possible.

At the time of the Sustainable Yield Study, the biological needs of the Covered Species were not explicitly and quantitatively addressed, other than the general recognition that nearly total cessation of springflow was not acceptable on ecological grounds. But the results of the numerical simulations had considerable implications for the Covered Species and their habitat. It suggested that, if central Texas again experiences drought conditions similar to that of the 1950s, without active groundwater management the viability of the species could be imperiled by critically low or no discharge at spring outlets. In that circumstance, the low flows at Barton Springs could cause substantial habitat degradation and a loss of plant and animal life (City of Austin, 2013).

Numerous effects of low flows have been observed in various parts of the Barton Springs complex (City of Austin, 2013). Upper Barton Spring ceases to flow when the combined discharge from the Barton Springs complex is about 40 cfs. Old Mill Spring experiences a relatively sharp decrease in dissolved oxygen (DO) concentration at about 20 cfs combined springflow and ultimately a virtual cessation of flow at lower levels of discharge (about 14 cfs) (City of Austin, 2013; Turner, 2004). Also, it was discovered by the City that Eliza Springs ceases to flow when the dam gates in Barton Springs Pool are opened and water is drawn down during periods of low spring discharge, which previously stranded and killed some salamanders. To prevent Eliza Springs from going dry while it is in its current configuration, the water in Barton Springs Pool is no longer drawn down when combined flows are less than 54 cfs (City of Austin, 2013). It is possible that not only Old Mill Spring but also Eliza Spring could cease to flow during an Extreme Drought under current pumping without additional curtailments, even if the gates of Barton Springs Pool remained closed. The effect of this circumstance on the Covered Species at Eliza Spring is unknown, but with no-flow conditions at Old Mill Spring, reproduction appears to cease, food becomes scarce, and seasonal higher temperatures in the surface environment causes mortality from respiratory distress.

Recent statewide initiatives that involve the establishment of a 50-year DFC and the associated amount of MAG have benefited the efficacy of the District's permitting program for managing the Aquifer under this HCP. In effect, the District was able to incorporate biological resource conservation into its drought management program and reset the "sustainable yield" of the Aquifer. Under these initiatives (House Bill 1763, passed by the 79th Legislature, now reflected in various sections of Chapter 36 of the Texas Water Code), the District worked with the TWDB to utilize new numerical and probabilistic models and scenarios that estimate long-term consequences for Barton Springs flow rates under various pumping and climatic scenarios (Hunt et al., 2011). Accordingly, the District has used the results of groundwater modeling and made concomitant revisions to the District's programs of groundwater management under its continuous incremental/rational planning approach for adaptive management. These activities are described in greater detail in Section 4.1.2 of this HCP; adaptive planning is described in Section 6.3.

At least three groundwater models for the Aquifer (Slade et al., 1985; Scanlon et al., 2001, as modified by Smith and Hunt, 2004; and Hutchison and Hill, 2010) now exist that have utility in assuring better management of the Aquifer and protection of the Covered Species. Each model has specific biases and assumptions, and differing means of generating outputs. One may be preferable for average aquifer conditions, while another may be better suited to analyzing conditions comparable to the DOR. No one model is ideal in predicting all present and future aquifer conditions and responses. All three of the models seem to confirm that, other factors equal, under prolonged severe droughts one unit of pumping reduces springflow by that same unit. For example, a regulatory program measure that reduces the total rate of pumpage during drought by 0.5 cfs from the amount that would otherwise be allowed, would correspondingly result in a springflow at Barton Springs that is higher by roughly the same amount (Smith, 2010).

The newest model, developed by the TWDB in support of the MAG determination (Hutchison and Hill, 2010), takes a probabilistic approach that is likely to represent actual long-term aquifer performance in a general sense. The new model is less a deterministic simulation model, as the previous models have been, and more a predictive tool that captures the range of uncertainty in real-world performance.

The two deterministic models (Scanlon et al., 2001; Smith and Hunt, 2004) addressed, via calibration to actual springflows, all extant sources of recharge during their calibration periods. However, as mentioned in Section 3.1.2, there is now evidence of two additional sources of recharge to the Barton Springs aquifer that none of the models explicitly incorporate, both of which have potential implications for estimating and managing extreme low flow and drought conditions at Barton Springs.

One is the notion that the southern groundwater divide is dynamic. Recent studies have shown surface water from the Blanco River can flow northward into the Barton Springs segment from the San Antonio segment during drought conditions (Smith et al., 2012). The effectiveness of the divide between the two Edwards groundwater segments dissipates at low flows, and recharge occurs preferentially to the lower elevation Barton Springs aquifer. While the Blanco River flowed continuously during the DOR, it should be noted that increased pumping of wells in its watershed now has adversely affected its base flow in the contributing zone, and such flows now may not be present during Extreme or Exceptional Droughts. Hunt et al. (2012) showed base flows in streams and low springflow are decreasing over the past 40 years. Part of that influence could be climate change, over which the District has no control, but also a likely large influence is the pumping in the contributing zone, affecting springflows and base flow of the creeks in that area. The District also has no control over that. Another recent study (Land et al., 2011) has shown the potential for a portion of the Edwards Aquifer groundwater in the southern San Antonio segment to bypass San Marcos Springs and flow toward Barton Springs under drought conditions. The induced recharge arising from this indicated "leaky divide" would tend to flatten the springflow recession curve at Barton Springs during severe drought events, even during exceedingly low groundwater levels in the hydrologically higher San Antonio segment. However, the amount of such recharge from these sources that would be expected to actually occur has not been adequately simulated, and its potential significance to the springflows at Barton Springs under severe drought conditions has not yet been determined, as that would require a recurrence of a prolonged, severe drought event.

The second source of recharge countervails the assumption that groundwater availability and springflow will decline as a result of urbanization and increased impervious cover in the recharge and contributing zones of the Barton Springs watershed. Investigators have determined that there is a substantial "indirect recharge," or leakage from utility networks (water mains, wastewater and storm sewers, and on-site sanitation systems), lawn irrigation return flow, and stormwater management infiltration devices constructed in the Barton Springs watershed. These indirect sources of recharge tend to offset the decrease of direct infiltration recharge arising from increased impervious cover (Wiles and Sharp, 2008; Garcia-Fresca and Sharp, 2005; and Sharp and Garcia-Fresca, 2004).

Leakage from pressurized water mains, for example, are typically known to result in utility-scale, unaccounted for water losses on the order of 10-30% (Foster et al., 1994); they have been measured on the order of 12% in the service area of the City of Austin (Sharp and Garcia-Fresca, 2004). Irrigation return flow, or overwatering of lawns, parks and other turfs and pervious landscapes, is especially common in summer months, when the impacts of drought and low flow on the Barton Springs complex may be severe (Garcia-Fresca and Sharp, 2005). Recent studies have indicated that the total recharge to the Barton Springs aquifer in a developed watershed is estimated to be nearly double that of its pre-urban conditions (Sharp and Garcia-Fresca, 2004). In addition, while it was estimated that on average only 4% of the total recharge in 1999-2009 was from anthropogenic recharge sources, the monthly proportions could vary greatly, ranging from less than 1% to some 59% of total recharge (Passarello, 2011). It should also be noted that this indirect recharge source has grown significantly since the DOR calibration period (Smith and Hunt, 2004), when the watersheds were much less developed than now. To date, this additional recharge has not been explicitly included in any of the Barton Springs aquifer availability modeling studies.

The quality of indirect recharge is likely to be poorer than native, meteoric Edwards groundwater. From a mass-balance perspective, there is a considerable amount of dilution and possibly attenuation of pollutants in such water by the time it reaches the water table. In fact, the studies above suggest that the present water quality issuing from the springs during low flow may be a result of the combination of native and indirect-recharge water sources.

In summary, some of the principal considerations related to flow conditions at Barton Springs that are important to the Covered Species are as follows:

- Springflow can be highly variable. It has varied as much as 15-fold since the time measurements have been taken (Figure 5-3).
- The lowest measured flow during the DOR (1950-56) was approximately 10 cfs. The lowest springflows in other seven-year periods not including the DOR years during the 1913-2013 period of record are considerably higher, typically in the mid-teens.
- There are over 1200 operational wells in the Aquifer. The maximum monthly pumpage rate was13.6 cfs in August 2008, and since then, under more recent regulatory constraints monthly pumpage rates of wells with permits have ranged between 4.3 and 12.2 cfs, averaging7.5 cfs.
- In recent years, several individual, severe droughts have produced observable adverse impacts on the Covered Species' habitat at all spring outlets, with DO-caused impacts at Old Mill Spring and Eliza Spring, and the habitat has typically not had time to recover from all those impacts between droughts (City of Austin, 2013).
- Groundwater flow models allow for predictions of future aquifer and springflow conditions; and they indicate that pumpage and springflow are related on a 1:1 basis during Extreme and Exceptional Droughts, and a recurrence of DOR climatic conditions with current levels of pumping would result in spring discharge rates considerably lower than the record low discharge of 10 cfs.
- It is not known whether and the extent to which newly ascertained mechanisms and sources of additional recharge to the Aquifer affect the quality of the habitat of the Covered Species during Exceptional Drought.

3.2.2.2 Ecological Setting

3.2.2.2.1 Overview of Habitat Characteristics and Supported Populations

The four spring outlets of Barton Springs and their associated subterranean areas form the only known habitats for the Covered Species. These habitats and other supported flora and fauna are described in substantial detail in Appendix C.

The salamander populations at Barton Springs experience relatively stable aquatic environmental conditions in their habitat, compared to typical lotic (flowing stream) ecosystems; changes in environmental parameters are typically gradual, and within fairly narrow ranges, with the extremes generally associated with flood events and prolonged drought. These conditions consist of perennially flowing spring water that is usually clear, has a neutral pH (~7), and maintains cool annual temperatures of ~21 ºC (~70 ºF) (Service, 2005). As is typical of large, groundwater-dominated, resurgences, the springs on the falling limb of the recession curve generally exhibit a narrow temperature range (stenothermal). In contrast, during wet periods spring flows on the rising limb of the recession curve may be more affected by the prevailing ambient temperatures of the local surface runoff that rapidly recharge the Aquifer immediately following many storm events (Mahler and Bourgeais, 2013). Flows of clean spring water with a relatively constant, cool temperature are essential to maintaining well-oxygenated water necessary for salamander respiration and survival (Service, 2013b; Service, 2005). DO concentrations differ somewhat among the spring outlets (City of Austin, 2013) and at the larger outlets of Barton Springs DO ranges between 4 and 7 mg/L and average approximately 6 mg/L (Service, 2005) and are directly related to springflow. At lower springflows with their reduced DO, the DO of water after it resurges will tend to increase, other factors equal, especially in spring run environments owing to re-aeration of the water with lower DO; however, the reduced DO solubility of higher temperature water during summer months, exacerbated by pool environments, may limit such DO concentrations increases seasonally and/or from time to time (City of Austin, 2013; Smith-Salgado, 2011).

The U.S. Geological Survey (USGS) has documented the increasing amount of nutrients and organic matter in the recharge streams of the Aquifer, which may have attendant DO demand, but to date there has not been a relationship established between such concentrations in recharging waters and reduced DO at the primary outlet within Main Springs during drought flows (Mahler et al., 2011). However, the City of Austin has recently shown a statistically significant overall downward trend in DO concentrations averaged over the range of Barton Springs discharges, from all individual outlets, from 5.7 mg/L in 2000 to no more than 4.5 mg/L in 2014 (Porras, 2014). This general trend presumptively relates to additional pollutant discharges in the recharging waters, although some part of that trend may also relate to deeper and more prolonged droughts during that time interval. Sustained lower DO concentrations occur primarily during periods of moderately low spring discharge (Herrington and Hiers, 2010; Turner, 2009; Service 2005). A recent USGS study of the water chemistry associated with spring flow extremes over the last several drought cycles (Mahler and Bourgeais, 2013) also shows that DO concentrations at Main Springs' primary outlet in this study period decrease on occasion during the more transient higher flows of some stormwater events, presumably arising from oxygen-demanding materials in the "first flushes" of runoff events, and/or also by seasonally warmer temperatures of recharging surface water. Other outlets may reasonably be inferred to experience similar effects in the future, if not now.

Owing to the factors described above, as well as to the natural drought- and pumping-induced variations in springflow, it is not unexpected that the habitat conditions will support variable numbers of individual salamanders from time to time, even for the same spring outlets and for similar springflows. This is reflected in the variability of the counts of the Covered Species conducted by biologists from the City of Austin. On the basis of their recurring observations for the various perennial spring outlets for each Covered Species, those biologists use a mean-plus-one-standard-deviation calculated metric based on organism abundance density[5] to represent the surface habitat-dwelling population of individual salamanders affected by the City's covered activities, i.e., their take. But unlike the City's covered activities, the District's Covered Activities potentially affect the entire populations of both Covered Species, at least during severe droughts, in both surface and subterranean habitats.

To account for the complex variability in population sizes in estimating take from its Covered Activities, the District HCP stipulates, similarly to the approach used by the City of Austin, that the surface-habitat component of the population for Covered Species is approximated by the observed mean abundance values plus one standard deviation. These statistics are based on the City's extensive salamander censuses, conducted using the same census standards and protocols approximately monthly over an 8-year period ending in 2011 (City of Austin, 2013). The resultant population estimates by spring outlet are shown in Table 3-3. At best, this is simply a first-order approximation of the surface-habitat

Table 3-3. Population Statistics of the Covered Species Based on Census Counts. These estimates are based on counts using a consistent methodology and do not include that portion of the population that is inaccessible to counting. The population size varies with time but for purposes of calculating take in this HCP, it is stipulated to be the sum of mean abundance plus one standard deviation. Data source: City of Austin (2013).

	Mean Abundance	SD	Population	Range of Counts
Barton Springs salamander:				
Main (Parthenia) Springs	74	86	160	5-447
Eliza Spring	349	275	624	3-1234
Old Mill Spring	15	22	37	0-73
Upper Barton Spring	6	12	18	0-100
Total Stipulated Population			**839**	
Austin blind salamander:				
Main (Parthenia) Springs	0.4	0.9	2	0-5
Eliza Spring	1.1	2.2	4	0-12
Old Mill Spring	15	22	37	0-73
Upper Barton Spring	0	0	0	0-0
Total Indicated Population			**43**	

population; in particular, the actual population of the largely subterranean Austin blind salamander is unreliably estimated by this count-based technique. The over-arching conclusion is that these are very small populations subject to stressful changes in habitat

[5] Salamander counts vary between sampling events and with environmental conditions. The mean plus 1 standard deviation metric is representative of the central tendency of the salamander estimates plus an estimate of the variance around that central tendency of salamander counts between sampling events and under variable environmental conditions. In effect, this metric is a way of representing some portion of the uncounted individuals in a particular population.

on a recurring basis, and therefore concern for their continued existence may be well-founded.

It is patently impossible to accurately determine population size of a subterranean salamander species based on number of individuals counted in surface habitat. So there is little confidence that the population numbers for the Austin blind salamander shown above, which are based only on such observations, are accurate. The small number counts for Austin blind salamander are almost certainly more a function of its inaccessible subterranean habitat than its actual population size. It may be postulated that the counting of Barton Springs salamander also encounters similar problems associated with accessibility of all individuals for counting, but it is likely to a much lesser degree; the District stipulates that the population estimate made above for the Barton Springs salamander accommodates such inaccessibility for this Covered Species.

But such a stipulation is considered by the District to be inappropriate for the Austin blind salamander. By using inference based on density calculated on the basis of observable substrate at Barton Springs and on similar density calculations for the morphologically and physiologically similar Texas blind salamander at San Marcos Springs in the Southern Edwards segment (EARIP, 2012), and applying a set of rational assumptions with respect to the hydrogeological setting in the vicinity of the spring outlets[6], the District estimates that a more realistic value of the Austin blind salamander population in its entire Service-designated 120 acres of Critical Habitat (Section 5.1.2.2) could be about 1000 individuals, considerably larger than the surface-habitat population indicated above. (This ignores the fact that the critical habitat designated for the Texas blind salamander is more than two orders of magnitude larger than that designated for the similarly subterranean Austin blind salamander.)

Further, the observation statistics for the Austin blind salamander are not considered indicative of the spatial distribution of their population within their subterranean Critical Habitat. It is possible that such distribution is not well-related to the springflow conditions at the various outlets. But for purposes of this HCP's take assessment, its population distribution indexed to Critical-Stage III drought flows at the individual outlets, using City of Austin measurements and analyses (City of Austin, unpublished data, 2014), is stipulated by the District, producing the following outlet-specific populations for this species:

Spring Outlet	Critical-Stage III Drought Flow	"Outlet Population"
Main Springs	17.53 cfs	877
Eliza Spring	2.23	111
Old Mill Spring	0.23	12
Upper Barton Spring	0	0
TOTAL	**20 cfs**	**1000**

[6] Basis for this calculated approximation: Austin blind salamander epigean density of 0.005 individuals per square foot (Table 11, City of Austin, 2013); subterranean density presumed to be one-half epigean density; active subterranean habitat at any one time presumed to be one-half the 120 acres of Critical Habitat designated by the Service (2012); portion of active habitat range that comprises inhabitable voids at the prevailing water table presumed to be 15% of the active habitat area, with balance either solid rock matrix or smaller, uninhabitable voids.

These initial outlet populations would be exposed to the DO regime associated with that particular outlet, although such exposure would be largely in the subsurface and is likely to be an ever-changing mix with time. Again, these estimates are only a first-order approximation.

For either species, the information available simply does not afford an unequivocal estimate of the sizes or spatial distribution at a given time of these populations, especially the Austin blind salamander. Further, the number of individuals in these generally small populations likely varies considerably with environmental conditions, presumptively indicating their sensitivity to habitat conditions.

The differences in the counts of observed individuals among the surveys reflect not only the variability in the population size but also the opportunistic life strategies of these species. The observed number of individuals of both Covered Species is relatively small, and the differences in the observed numbers of the two species is consistent with the Austin blind salamander's being more adapted as a subterranean species and spending the majority if not all of its life underground (Hillis et al, 2001), and only occasionally moving out into the epigean (found at or near the surface) environment where it is observable for counting. Conversely, Barton Springs salamander is more adapted to be an epigean species and the individuals observed in censuses are more likely to be closer to the total population.

The population estimates are given here by spring outlet because the distribution of the Covered Species and the DO regimes differ among the spring outlets. However, unlike the City of Austin's ITP, in which its covered activities differ among the spring outlets and even within various portions of the outlet habitats, the District's management of groundwater withdrawals cannot be parsed among the spring outlets. Nevertheless, the amount of take that results from the District's Covered Activities is partitioned among the individual spring outlets on the basis of their specific DO relationship with combined springflow. But simply put, the District's Covered Activities cannot "target" where take occurs and doesn't occur among the outlets, although it is readily apparent that the effects will be disproportionate among the outlets, and take estimates and impact assessment should account for those differences.

3.2.2.2.2 Water Chemistry and Spring Discharge Relationships

As noted above, water quantity, water chemistry, and water quality of springflows are inter-related. Higher flows, especially stormwater runoff, are generally poorer quality with respect to many water quality parameters, including suspended solids, nutrients, bacterial loadings, and oxygen-demanding material. But these runoff events also are rather transient. Such transient stormwater has water chemistry with smaller total dissolved solids concentrations (salinity), and also lower DO concentrations (Mahler and Bourgeais, 2013) that are below water quality standards for surface-water. The lower DO is likely caused by the higher oxygen demand and/or induced release of water from aquifer storage that is more depleted in oxygen, as well as to more variable, seasonal water temperature that affects DO solubility. On the other hand, while average flows and especially typical drought flows tend to be generally higher in quality, i.e., have smaller pollutant loads, as drought is prolonged and springflows decrease over an extended time, salinity tends to increase and DO tends to decrease over a somewhat restricted observed range (Herrington and Hiers, 2010). These phenomena during severe drought, when much less or no oxygenated surface recharge of the Aquifer is occurring, appear to be related to the amount of older, more saline water from the confined parts of the Aquifer, including possibly the hydrologically connected saline zone or underlying Trinity Aquifer, which have much lower DO (Mahler and Bourgeais, 2013; Lazo-Herencia et al., 2011; Johns, 2006). In addition, these studies suggest that the relative contributions to discharges at the individual spring outlets from various flow routes with different DO concentrations and possibly different salinities could vary with overall flow (Hauwert, 2004) and also contribute to the relationships observed. The natural introduction of water with higher salinity and lower DO, regardless of other factors that might be reflected in the water chemistry and quality, is caused in part by the Covered Activities. These are the two springflow-related water chemistry parameters that are believed to be of primary potential importance in determining the amount of take of the Covered Species in the spring habitats by the District's Covered Activities.

Dissolved Oxygen and Spring Discharges

The concentration of DO has been known for some time to correlate directly with spring discharge at Barton Springs (City of Austin, 2013; Herrington and Hiers, 2010; City of Austin, 1998). DO tends to be at relatively higher concentrations during periods of high recharge when a large volume of well-oxygenated surface water that is not stormwater enters the aquifer. DO levels are at their lowest when recharge is minimal or nonexistent and spring discharge is low (Herrington and Hiers, 2010; City of Austin 1997). Extended or frequent periods of low flow, therefore, can be detrimental to the development, reproduction, and even survival of the Barton Springs salamander, although Norris et al. (1963), while confirming the adverse effects of lower DO, also notes that some salamander species physiologically accommodate lower DO. Although the Barton Springs salamander persisted through the drought of the 1950s and likely earlier, even more severe and prolonged droughts (Cleaveland, 2009), its population may have been larger earlier in its history, perhaps even non-endemic, but its population size may have been adversely, possibly permanently affected by prolonged low flows at Barton Springs, particularly if DO levels were proportionally low. Depressed DO concentrations also may compound the effects of other stresses on the salamander's survival, such as increased pollutant loading during drought and low flow conditions. A key adaptive objective of this HCP is to increase the understanding of the relationships of spring flow and DO levels in the Barton Springs complex and further afield in the Aquifer, and to develop over time an enhanced capability to minimize or avoid anthropogenic lowering of DO through groundwater management during low flow conditions.

Science staffs at the City of Austin, TWDB, USGS, and BSEACD have collaborated for several years to collect, compile and analyze water quantity and quality data in the Barton Springs complex. These collaborations have included studying the correlation of DO, springflow and other relationships. There is considerable agreement that there are strong correlations between DO and discharge, within the ranges of spring discharge for which data have been collected. There is also some variability in the data collection instrumentation, methods of collection and analysis, and frequency and longitudinal extent of data collected by the different entities, all of which affects accuracy, precision, and/or utility of the collected data; such limitations in making inferences in this HCP have been noted in appropriate places. Further, it is clear that the relationships differ among the individual spring outlets. Appendix D summarizes the outcomes of several representative investigations of these relationships conducted by the City of Austin Watershed Protection Department, describing the results of these studies in more detail and also presenting summary statistical analyses of these data.

Reliably measuring in-situ DO concentrations of groundwater in an aquifer is a well-known challenge. In one such recent study of the Aquifer (Lazo-Herencia et al., 2011), it was determined that native groundwater in the unconfined (recharge) zone had a median DO concentration of 6.4 mg/L, while the confined zone had substantially lower DO, with a median value of 2.0 mg/L. These results are supportive of the notion that more water from the confined zone adjacent (both laterally and vertically) to the spring outlets discharges from the outlets at lower water levels, resulting in a decrease in the DO concentration with decreasing discharge. An even more recent USGS study (Mahler and Bourgeais, 2013) of the Aquifer and the discharges at the primary outlet of Main Springs in Barton Springs over a 6-year period with both high and low groundwater levels and springflows found DO concentrations fluctuating by a factor of two, generally related inversely to spring flow temperatures and directly with springflow discharge rates, both of which were noted to likely be exacerbated by climate change. Interestingly, the lowest DO concentration observed by those investigators was 4.0 mg/L, consistent with a water-provenance model of mixed types in sub-equal proportions. The Main Springs consistently has a higher DO regime than the other outlets, and considerably lower DO concentrations have been measured at the other outlets.

A salient aspect of the data and analyses that are in Appendix D is that relatively few paired combined springflow and DO data exist in the springflow domain below 20 cfs, which is the more critical region for assessing significant take. Figure 3-7 demonstrates the range in predictions of DO concentration that can be expected from various regression formulas, which were developed and published by City of Austin staff, under various boundary conditions in the zone of discharge below 20 cfs. These regression relationships are characterized in more detail and utilized in the analyses of Section 5.2.4.2.1.

Models of individual spring outlets, such as those shown in the figures in the appendix, do not (yet) have well-established, reliable predictors of DO with combined springflows in the zone below 20 cfs, owing to sparse or non-existent data. For example, from 1978 to present, the minimum DO concentration *observed* by the USGS at the primary outlet of Main Springs is approximately 4 mg/L, when the combined discharge was reported to be 13 cfs in August 2009 (the previously noted measurement difficulties notwithstanding). The regression

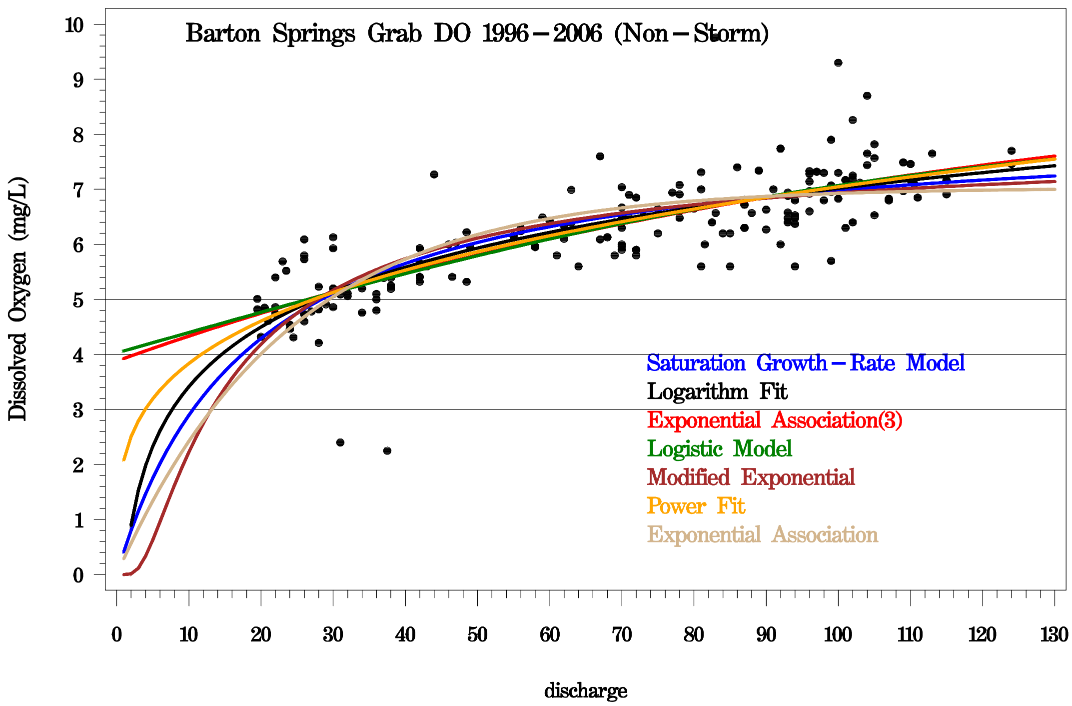

Figure 3-7: Various Regression Models Representing Flow-DO Relationships.
All of these curve-fitting regression models are based on data for combined springs discharge at Barton Springs that don't extend into extreme low flows. Source: Turner (2007).

model for Main Springs indicates that the *predicted* DO would be 3.4 mg/L at a discharge of 13 cfs, which is considerably lower than the actual observed values at that discharge (it should be noted; however, that the USGS collected its data at just one, albeit the primary outlet of Main Springs, but the regression relationships were developed by the City of Austin for the aggregated sub-outlets at Main Springs). The logarithmic function used in this and some others of the curve-fitting equations would predict that DO would decline to 0 mg/L at or above a discharge rate of 0 cfs. While this outcome is conceivable, the prediction is a product of the mathematics, not data at that level of springflow, which are unavailable. Other modeled equations predict different but equally conceivable outcomes, with DO declining only to between 3 and 4 mg/L, and those appear to be more in keeping with the trends established at higher flows where there are data to support the mathematical relationships. It is relevant here that USGS staff, using a rather sophisticated multi-variate model, has calculated that the DO at the primary outlet in the Main Springs would be 3.99 mg/L under no-flow conditions (Mahler and Bourgeais, 2013); the same caveats concerning lack of actual data at or near such conditions apply to these results as well.

In assessing the utility of the existing data and analyses for evaluating adverse effects and impacts of take on the Covered Species, their limitations and uncertainties should be considered. Some of the more important of these conclude this subsection.

In the laboratory study of salamander response to the stressor of depressed DO concentration (Poteet and Woods, 2007), which is presented in Section 5.2.1 of this HCP, there were only 35 DO observations for Main Springs below 4.5 mg/L in the available dataset of the USGS that was used to assess the utility of the laboratory results. Woods et al. (2010) extended that initial assessment with a probabilistic ecological hazard assessment and found no statistically significant relationship between these low flow and associated DO values for this more limited data set. Even less information for Eliza Spring and Old Mill precluded similar evaluations in those locations. The relationship between DO and springflow for flows less than 20 cfs is important to a quantitative assessment of take but is simply not known with certainty at this time.

Nevertheless, there is clear evidence of depressed DO with smaller spring discharges observed in the *overall* datasets at specific spring outlets. In particular, DO concentration at Old Mill Spring is known to plunge when the combined Barton Springs discharge approaches 20 cfs. The sustainable yield simulations conducted by the District in 2004 indicated that under 1950s DOR conditions and high rates of pumping, saline water from the "bad-water" zone has a greater potential to move into the freshwater portion of the aquifer (Smith and Hunt, 2004). Consequently, the intrusion of water with higher salinity, which also tends to be more depleted in DO than water in transit or storage in the unconfined and freshwater part of the aquifer, can cause specific conductance and salinity to increase somewhat in salamander habitat under low flow conditions. However, Old Mill Spring, which is noted above as having unusually low DO during low aquifer levels, tends to have the highest specific conductance levels of the four spring outlets, which is most likely attributable to its proximity to the "bad-water" zone and its influence on flow routes that provide a substantial portion of the water to that particular outlet (City of Austin, 1998). The consequences of the relatively small rise in average salinity on the Covered Species are not known.

As mentioned earlier, not all of the data available for the Barton Springs complex have been collected with the same instrumentation, over the same time period and frequency, or compiled and analyzed using the same protocols. Most of the DO data presented in the figures above were collected by the City of Austin, using both datasonde and grab sample data in the various spring orifices, some stationary and some mobile. If different data sources were to be used and compared to the results noted above, the outcomes in the zone of extreme low spring discharge may appear significantly different. In particular, the datasondes produce lots of data related to all flow conditions, and while useful for some purposes the inclusion of data from high (including storm event) flows, which can also have lower DO (Mahler and Bourgeais, 2013), confounds the analysis and prediction of DO during extremely low base flows, which is the flow regime of most import to the Covered Species in assessing take in this HCP.

Further, it should be recognized that at very low flows, the reliability of individual discharge/flow measurements is impaired, because of magnified effects of factors not related to true springflows, such as differences among measurement personnel, altered or unstable cross-sections, and changes in backwater effects from slight rises and falls in Lady Bird Lake elevation during discharge measurements . Hunt et al. (2012a), showed flow measurements can vary up to 30% during low flows. So there is a corresponding uncertainty in the correlation among flows at different times and in the correlation of flow to DO.

There is also uncertainty, if the DOR were to recur, as to how low and by which influences the combined springflow at the Barton Springs complex might decline. The current drought management program of the District and this HCP is designed to provide a base springflow during a DOR recurrence (refer to Section 6.2.1.8 for the desired outcome of proposed HCP measures). This regulatory program is indexed to authorized groundwater use, but actual groundwater use in aggregate has tended historically to be below the prevailing curtailed authorized use (as also reflected in Figure 3-9 below), allowing for higher-than-predicted springflow rates. Further, the regression models described above are limited by the lack of data under extreme low flow conditions as well as variations in source data and other factors noted. There are as of yet no scientific studies that integrate other independent but related factors into the predictions of DO concentration under extreme low flow conditions. Nevertheless, given the considerable uncertainty that must be addressed in such situations, these models produce better understanding and help frame and prioritize management alternatives on the basis of the possible consequences of various actions (or no action).

An analysis was conducted of DO concentration and several other water quality parameters at Barton Springs over a 25-year study period, adjusting for variations in spring discharge rates (Turner, 2000). The analysis of water quality records, collected by the City of Austin from 1975 to 1999, indicated statistically significant changes in DO over the course of the 25-year period, possibly related to watershed urbanization. DO was found to be decreasing over time, both at high and low discharge levels. The median DO concentration decreased by approximately 0.8 to 1.1 mg/L over 25 years (1975 -1999), from 6.4-6.8 mg/L in 1975 to 5.45-5.7 mg/L in 1999. This is a decrease of 12-16%. Sampling has been much more frequent recently, leading to a higher probability of observing extreme events. Therefore it is possible that the observed change is a sampling artifact (Turner, 2000). Enhanced nonpoint source pollution controls in the Barton Springs springshed have been initiated by the City of Austin, Travis County, and several municipalities to arrest or slow this decline, but the recent statistical analyses by the City of Austin suggest that the temporal trend in decreasing overall DO levels is continuing, and is now below 4.5 mg/L (Porras, 2014). A long-term change in DO of greater than 1.0 mg/L is likely meaningful in any isolated aquatic habitat. Trends in other water quality parameters such as nutrients and total suspended solids in the spring flows were not as clear or notable (Turner, 2000). A more recent USGS report on water quality trends in the Barton Springs recharge streams and at Barton Springs (Mahler et al., 2011) indicated that low flows during dry periods did not exhibit water quality impacts by suspended solids, nutrients, and bacteria at Barton Springs, but that wet periods and stormflows had significant increases in these parameters associated with watershed development in the streams, the Aquifer, and Barton Springs discharge.

Salinity and Spring Discharges

The specific conductance of the spring discharges, a measure of the concentration of TDS (i.e., salinity) in the water issuing from the Aquifer, as well as individual ion concentrations, have been known for some time to increase as springflow decreases (e.g., Slade et al., 1986; Senger and Kreitler, 1984). The general relationship is clearly shown in Figure 3-8, depicting paired data collected by the City of Austin over a seven-year period that includes very high and very low springflows (Herrington and Hiers, 2010). The salinity varies within a fairly narrow range, with the difference in conductance between average and lowest flows in this dataset being 75 µSiemens/centimeter; this corresponds to a variation in TDS of less than 50 mg/L. That level of overall variation with drought flows is not much more than the variation in TDS concentrations corresponding to any one typical springflow. Even at the lowest flows the highest TDS concentrations of springflows reflected by these data are about 475 mg/L, less than half the concentration still considered fresh water (less than 1,000 mg/L TDS) and supportive of aquatic life. However, TDS or specific conductance data for extreme low flows, such as would exist during a recurrence of the DOR, are not available, so the actual salinity of such DOR flows is unknown.

Researchers have postulated that the increase in salinity is caused by a greater proportion of the springflows being contributed by water from or influenced by the saline zone of the Edwards Aquifer, which is proximate to Barton Springs, as the water levels and potentiometric pressures in the Aquifer decline (Slade et al. 1986; Johns 2006). Similarly, the contributions of water from the deeper Trinity Aquifer that migrate upward along the faults that relate to the spring outlets cannot be ruled out, but there is no evidence of such inter-formational flows elsewhere in the District (Wong et al, 2013; Smith and Hunt., 2011), so the Trinity seems a less likely source of brackish/saline water resurging at the outlets. On the basis of hydrochemical data analysis and use of mixing models, Hauwert et al., (2004) suggested that about 3% of the springflow at Old Mill and 0.5% at Eliza and Main Springs might be derived from such sources during low flow (17cfs) conditions. This is consistent with the observed small but statistically significant differences in salinity among the various spring outlets, and not all spring outlets have such variation, presumably reflecting differences in source-water provenance, contributions of different flow routes, and degrees of mixing (Johns, 2006). This water is also likely to be much older and more depleted in DO than the younger water in the conduits and matrix of the freshwater Edwards Aquifer, and a proximate cause of the smaller DO concentrations observed in low flows.

3.2.3 Antecedent Conditions within the ITP Area

There are pre-existing conditions in the ITP Area, originating prior to the initiation of the HCP and continuing to the present day, that have a significant bearing on the affected environment of the Covered Species and on the ability of the District to manage the Aquifer. Accordingly, the consideration of the protective enhancements and conservation measures taken under this HCP must be framed within the context and realities of these pre-existing conditions.

Many of these conditions stem from historical patterns of development and associated water and land use, all of which have various legal protections under other law but nevertheless influence the quality and quantity of water discharging from Barton Springs. These historical land use and development trends in the ITP Area have contributed to a gradual but progressive degradation of surface recharge quality (Mahler et al., 2013) and consequently in the water quality of springflow discharging at Barton Springs (City of Austin, 2012), although so far such springflow degradation has been small. The District does not have authority to manage or control land use or the quality of Barton Springs discharges that arise from the impact of development on surface water that recharges the Aquifer.

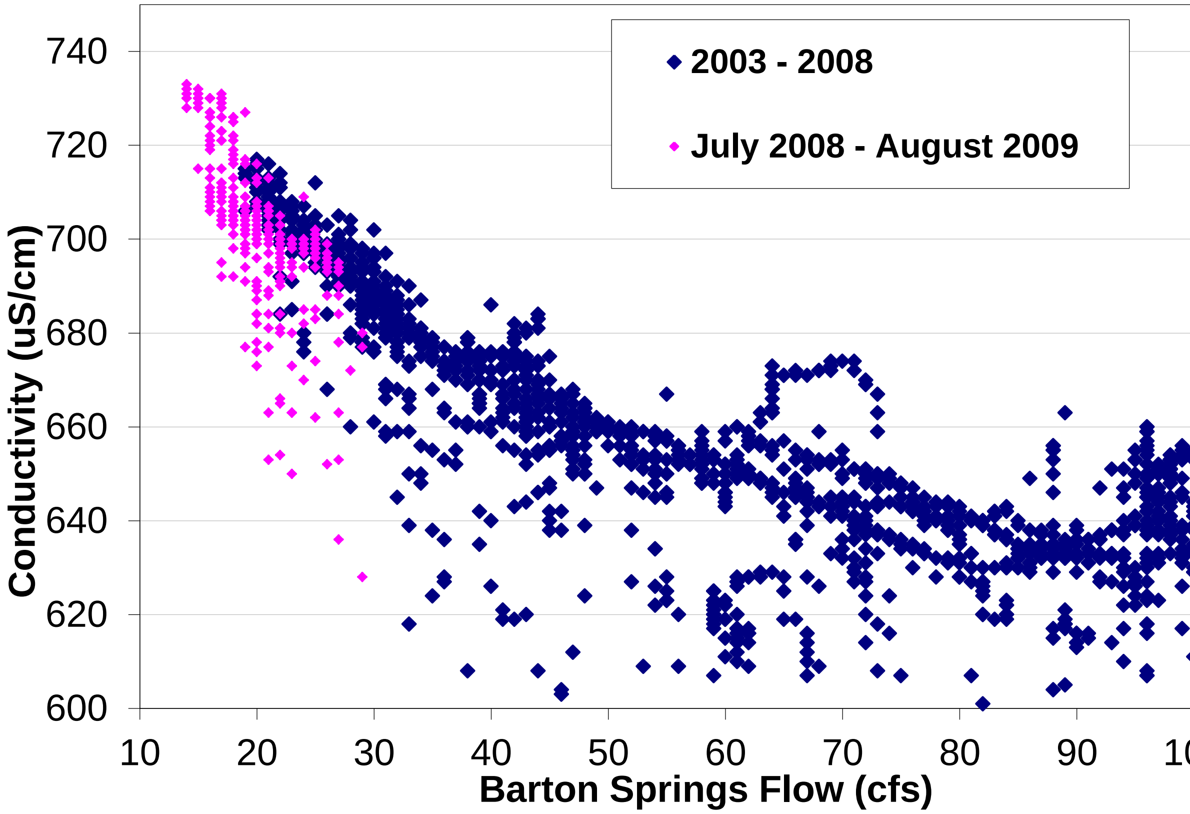

Figure 3-8: Inverse relationship of spring discharges and water salinity, expressed as specific conductance.
Note the rather small range of variation, which corresponds to about 70 mg/L of total dissolved solids. Source: Figure taken from Herrington and Hiers (2010).

Figure 3-9 illustrates the history of production from all permitted wells in the Aquifer, in association with several District milestones. Before the establishment of the District in 1987, there was no legal authority or ability to regulate groundwater production from the Aquifer. The Aquifer then was a readily available, sole source of high quality water that served a growing suburban and exurban population. Not until 1989, when the first groundwater management plan and rules were adopted by the District and meters began to be set on permitted wells, was there any operational permit program to manage groundwater production in this rapidly developing area. By 1989, the estimated average pumpage rate in the District was about 5 cfs.

Before the federal listing of the Barton Springs salamander in 1997, there was 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 the mid-1990s, when Barton Springs salamander was first described as a newly identified species and subsequently listed as endangered, *actual* pumpage under approved permits or exemptions to permits was already in the range of 5 to 6 cfs, contributing then to diminution of springflows along with their natural variations during drought cycles.

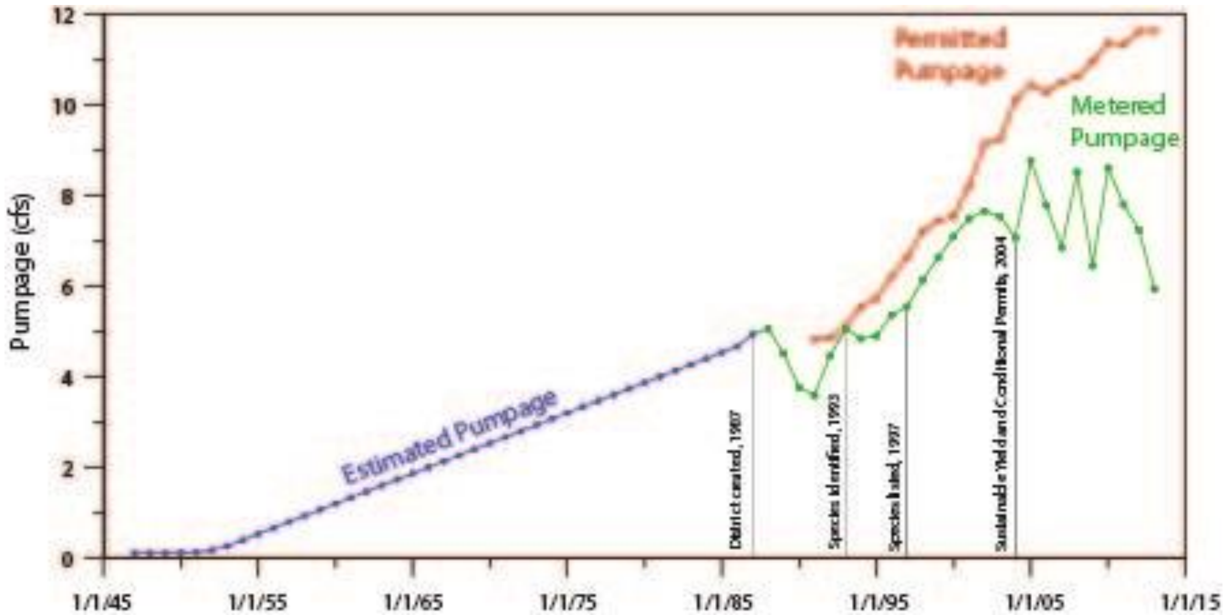

Figure 3-9: Pumpage history showing District milestones.
Actual Pumpage rates are annual averages, in cfs, for nonexempt wells in the District. Data before 1988, when wells first began to be metered, are estimated; after 1988 data are self-reported meter readings. Source: Data through 2006 are from: Hunt et al., 2006. Data after 2006 are unpublished BSEACD data.

From an historical perspective, the District's intent and actions in developing this HCP are a continuation of those the District has voluntarily and proactively followed, inasmuch as the District's mission was congruent with the Act's purpose, i.e., reducing water demand and/or increasing supply that results in source-substitution during drought to preserve aquifer water levels and springflows, and thereby generally reduce adverse impact to the habitats of the Covered Species. In 2004, when the District initiated the habitat conservation planning process, the *actual* total pumpage from the Aquifer, under approved permits and exemptions to permits, was about 7 to 8 cfs, even though authorized pumpage under permit was just over 10 cfs. This HCP, which is the result of this long-term planning process, now establishes the District's commitment to implement actions that avoid additional adverse impacts to the Covered Species and to minimize and mitigate those impacts of District activities that cannot be avoided.

Drought is another, different type of pre-existing condition that is also germane to this HCP. The ITP Area is prone to rather severe drought cycles, and the Covered Species are stressed "naturally" on a variable, generally cyclic basis by drought in exactly the same way the regulated withdrawals of groundwater by wells as a Covered Activity stress the species (refer to Figure 3-6 in Section 3.2.2.1.2 above for an illustrative hydrograph). So the effects of the Covered Activities, which represent a specific level of take that is analyzed in Section 5.2, are overprinted on similar but more variable effects from a natural drought cycle that exist regardless of whether and how much groundwater is withdrawn by wells in the Aquifer in the ITP Area.

3.2.4 Protected Species in the ITP Area

Table 3-1 lists those species that are federally protected in the three counties in which the ITP Area is located (Service database, http://www.fws.gov/southwest/es/ES_Lists_Main.cfm, accessed December 30, 2013). Most of these species are either endemic to areas of these counties that are well outside the ITP Area or otherwise are not known to exist in the ITP Area. Only the first two of the species listed are known to exist in the ITP Area and may reasonably be expected to have habitat affected by the proposed Covered Activities, and those two species are the proposed Covered Species for this HCP.

Table 3-1. Federally protected species in Travis, Hays, and Caldwell Counties, Texas. Status is denoted as endangered (E), threatened (T), candidate (C), and of concern (D) (Service, 2014).

Group	Species	Common Name	Status
Amphibians	*Eurycea sosorum*	Barton Springs Salamander	E
	Eurycea waterlooensis	Austin Blind Salamander	E
	Eurycea tonkawae *Eurycea nana* *Typhlomolge rathbuni*	Jollyville Plateau Salamander San Marcos Salamander Texas Blind Salamander	C T E
Birds	*Dendroica chrysoparia*	Golden-Cheeked Warbler	E
	Vireo atricapilla	Black-Capped Vireo	E
	Grus americana	Whooping Crane	E
Insects	*Texamaurops reddelli*	Kretschmar Cave Mold Beetle	E
	Rhadine Persephone *Heterelmis comalensis* *Stygoparnus comalensis*	Tooth Cave Ground Beetle Comal Springs Riffle Beetle Comal Springs Dryopid Beetle	E E E
Arachnids	*Texella reddelli*	Bee Creek Cave Harvestman	E
	Texella reyesi	Bone Cave Harvestman	E
	Tartarocreagris texana	Tooth Cave Pseudoscorpion	E
	Leptoneta myopica	Tooth Cave Spider	E
	Circurina wartoni	Warton's Cave Meshweaver	C
Plants	*Zizania texana*	Texas Wild Rice	E
Fishes	*Gambusia georgei* *Etheostoma fonticola*	San Marcos Gambusia Fountain Darter	E E

4.0 Proposed Actions

4.1 Proposed Covered Activities

The District seeks coverage under the prospective Incidental Take Permit (ITP) for withdrawal of groundwater from the Aquifer by well owners/operators holding a valid permit from the District for their groundwater supply that is managed by the District. These activities result from time to time in incidental take of the Covered Species by adversely affecting the quantity and associated chemistry of water that is naturally discharged from the aquifer at Barton Springs. The activities for which the District seeks coverage arise from groundwater withdrawals from nonexempt registered wells that are authorized and regulated under the District's permitting program. Limits on groundwater withdrawals apply only to District-permitted wells. The withdrawals are considered a Covered Activity only if the well and the permittee are in compliance with the District's rules, including permit conditions, prevention of waste, and water conservation plan and drought contingency commitments. These are lawful activities with a publicly beneficial purpose, and any associated take, as defined by the Endangered Species Act (Act), is incidental.

The Covered Activities directly relate to and affect primarily the groundwater resources and the groundwater-user community in the District. The withdrawal of groundwater from the Aquifer by this regulated community using wells registered and permitted by the District is a principal activity for which the ITP is sought. It is also important to the understanding of the Habitat Conservation Plan (HCP) that the District's regulatory program is the primary vehicle for the proposed conservation measures for the Covered Species.

The regulation of the groundwater-user community, which is accordingly also the focus of the HCP avoidance, minimization, and mitigation measures, is described in Section 4.1.1 below. The evolution and status of this regulatory program, its statutory and regulatory authorities, and the public participation in its development are then characterized in following subsections to provide a historical context and the current status of this vehicle under which compliance with the ITP provisions will be assured.

4.1.1 The Regulated Groundwater Community

The District is requesting coverage under the ITP for water withdrawals managed under its regulatory program, which controls the conditions under which groundwater is used in the District and especially the amount of groundwater withdrawn by permitted well owners. The end-user customers of water utilities using the Aquifer as public water supplies are not directly regulated by the District so they are not included in this community and their individual usage of the Aquifer water is not considered part of the Covered Activities (Table 4-1). Components of the District regulatory program include permitting, compliance monitoring, enforcement, assessment and administration of various District fees, user conservation planning, and user drought contingency planning and response. This program has the purpose of reducing withdrawals of groundwater from the Aquifer to those minimum volumes reasonably needed by well owners and permittees during both drought and non-drought periods to conserve the water supply for as long as possible and to maintain sufficient flows at Barton Springs to support the Covered Species. However, the maximum reductions in water withdrawals prescribed under this program are unable to completely avoid adverse effects on the Covered Species during severe drought periods.

Table 4-1: District Public Water System Permittees.

	Permitted Volume				
Permitted Utility	**Gallons/Year**	**CFS**	**# of Wells**	**Population (1)**	**# of Connections (1)**
Aqua Texas (Bear Creek)	12,098,000	16,711	2	276	92
Aqua Texas (Bliss Spillar)	51,500,000	71,136	21	2211	295
Aqua Texas (Leisurewoods)	88,764,000	122,608	6	1338	446
Aqua Texas (Mooreland)	6,000,000	8,288	2	156	52
Aqua Texas (Onion Creek)	36,300,000	50,140	3	696	232
Aqua Texas (Shady Hollow)	80,000,000	110,502	2	699	233
Arroyo Doble Water System	52,800,000	72,932	2	912	304
Cimarron Park Water Company	118,000,000	162,991	2	2058	686
City of Buda	275,000,000	379,852	4	9882	3,294
City of Hays Water Department	15,400,000	21,272	2	233	89
City of Hays Elliot Ranch	54,450,000	75,211	2	618	206
City of Kyle	330,000,000	455,822	1	24,261	8,087
City of Sunset Valley	18,590,000	25,678	1	1326	442
Creedmoor-Maha WSC	235,065,600	324,691	6	6819	2,273
Goforth Special Utility District	350,900,000	484,691	5	15,612	5,204
Huntington Utility LLC (SWWC)	18,000,000	24,863	1	378	126
Monarch Utility	324,400,000	448,087	4	6396	2,132
Mountain City Oaks Water System	43,164,000	59,622	1	696	232
Mystic Oak Water Co-op	7,700,000	10,636	2	132	44
Oak Forest Water Supply Company	25,500,000	35,223	2	321	107
Ruby Ranch Water Supply Company	52,300,000	72,241	5	699	233
Slaughter Creek Acres Water Company	14,000,000	19,338	2	273	91
Twin Creek Park	12,000,000	16,575	1	285	95
Village of San Leanna	31,651,200	43,719	3	497	213

(1) Data obtained from TCEQ Public Water System Database.
http://www14.tceq.texas.gov/iwud/index.cfm?fuseaction=showusermenu , accessed August 18, 2014.

More than 1200 water wells exist in the District's jurisdictional area (Figure 4-1). Nearly all of them are now registered with the District, and nearly all of their production (almost 97%) is currently from the Edwards Aquifer. Many more are in the HCP Planning Area outside the District boundaries, but none of those other wells are in the Aquifer. The large majority of wells in the District draw water only from the Aquifer. Moreover, usage of other aquifers in the District is currently very small. Most wells by number serve small-volume users, typically domestic wells for individual households and are exempt from permitting and therefore not regulated or monitored by the District as to the amount of water withdrawn. Water withdrawals from these wells are not Covered Activities.

The District classifies its registered wells into four major categories, which determine whether and specify how the District regulates its groundwater use (BSEACD, 2012). These are summarized in Table 4-2 and characterized in the four subsections below.

Table 4-2: Estimated/Authorized Amount of Groundwater Production.
Exempt use is estimated from geospatial analysis (Banda et al., 2010); others are 2013 use by the type of permit that authorizes production. The Nonexempt Historical production amount includes 91.525 MG per year from Trinity Aquifer permits; the remainder is from Edwards Aquifer permits.

Production Type	Number of Wells	Regulated by District?	Estimated/Authorized Production	
			1,000 gal./Year	CFS
Exempt Use	997	No	105,000	0.4
Nonexempt Domestic Use	77	Yes	21,020	0.1
Nonexempt Historical	110*	Yes	2,462,513	10.4
Nonexempt Conditional	30*	Yes	348,700	1.5

*Some wells may have authorized production under both historical and conditional production permits. Numbers shown are for the dominant type of authorized production.

4.1.1.1 Exempt Wells and Users

An exempt well by state law is not subject to the District's permitting program and therefore has no authorized production limit set by the District. However, they are registered by the District and are subject to District Rules related to well construction standards and avoidance of "waste" as defined by statute.

Individual exempt wells generally use only small volumes of groundwater. An exempt well is generally defined by statute as a well that is used solely to supply domestic use or for providing water for livestock or poultry if the well is: (1) incapable of producing more than 10,000 gallons of groundwater a day, *and* (2) located or to be located on a tract of land larger than 10 acres. Exempt wells also include by definition several other use types, including closed-loop injection wells, dewatering wells, oil and gas wells and monitor wells. There are no oil and gas supply wells or dewatering wells registered in the District and since injection and monitor wells are not designed for the purpose of groundwater production, aggregate withdrawals from these use types are negligible.

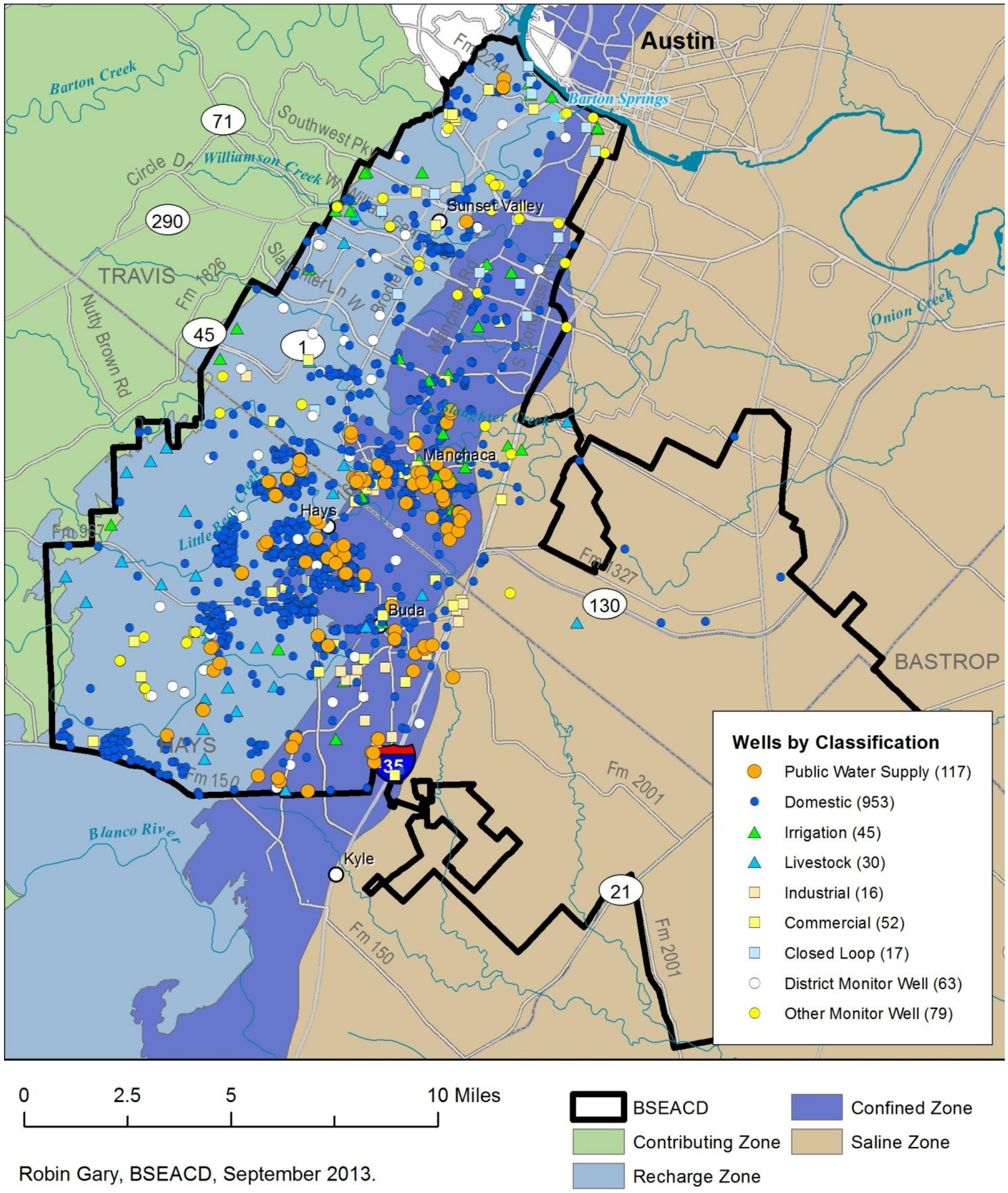

Figure 4-1: Location of wells in District and classification by use type.
Except for groundwater withdrawals from wells authorized for Nonexempt Domestic Use (See Table 4-2), withdrawals from domestic, livestock, monitor, and closed loop wells are exempt from permitting. The other use types are nonexempt and require a District permit to authorize withdrawals. See text for explanation of differently colored hydrologic zones. Source: BSEACD wells database, 2013.

Exempt wells are generally used as water supplies for livestock (including windmill-powered wells) and/or for residences on large-tract households, ranch, or farm lands. The District recently estimated on the basis of GIS analysis that there were about 1000 exempt wells in the District but they produced only about 4% of the total volume of groundwater withdrawn by all wells in the District (See Table 4-2). Further, the number of wells in service and amount of exempt production are likely decreasing as these wells age, deteriorate and are abandoned and as the ITP Area becomes more developed with centralized water systems (Banda et al., 2010). The specific number of the wells being abandoned typically goes unreported and therefore is difficult to estimate. Most existing exempt wells were in place at the time the District was formed in 1987. Very few new wells in the District meet all the criteria to be exempt.

Exempt wells are capable of only limited production because they are generally equipped to produce no more than 10,000 gallons per day or the equivalent pumping rate of about 7 gallons per minute. The amount of their production is limited by the well size and equipment, rather than by regulation. Actual withdrawals are estimated to be more typical of regional domestic use rates and are substantially less than this production capacity limitation (see Table 4-2). The volumes from these actual withdrawal are estimates and not known since these wells are not usually metered and are not required to report water use or charged for their water use at any time. Exempt wells do not have the permits that are used by the District as the vehicle to specify User Conservation Plan (UCP) and User Drought Contingency Plan (UDCP) requirements, so mandatory, enforceable drought-time curtailments are not applicable to them. Therefore, under Service regulations, exempt wells cannot be a Covered Activity for this HCP.

Even though water withdrawals from exempt wells by state law are not subject to limitation by the District, the total groundwater production by exempt wells does affect the allowable amount of water to be withdrawn by other wells during Extreme Drought conditions.

4.1.1.2 Nonexempt Wells and Users

Production by all nonexempt wells in the Aquifer is regulated through District production permits and is a Covered Activity. The permits are the vehicles for implementing the District's drought rules that form its Drought Contingency Plan.

All permittees must adopt UCPs and UDCPs, which are integral, mandatory parts of every permit. Templates for UCPs and UDCPs that have been developed by the District and made available to its permittees as guidance are included in Appendix E of this HCP. UDCPs in particular are central to the District's drought management program. This program involves a declaration by the District Board of the severity of groundwater drought on the basis of actual Aquifer conditions, as defined by the District's Drought Trigger Methodology developed for this HCP (see Appendix F for details on the drought trigger methodology, and Appendix G for the rule-based definitions of the various groundwater drought stages used by the District for drought management). Permittees are required to curtail their monthly groundwater use according to the declared drought stage and their approved baseline volume for a given month, as specified in their UDCP. All individual permittees are required to report their actual groundwater use monthly to the District, which data are used to assess compliance with monthly UDCP requirements and to initiate preenforcement and enforcement actions, if and as warranted, during drought, and to evaluate whether overpumpage of their annual authorized amount has occurred.

The requirements of UCPs and UDCPs and the penalties for non-compliance are specified by District Rules and the District's Board-approved Enforcement Plan; they are legally enforceable by the District. The District's enforcement scheme includes assessment of daily penalties, up to $10,000 per day, that are indexed to the amount of authorized use, the degree of non-compliance, and drought stage; more information on the District's Enforcement Plan is included in Section 6.5.1.4 of this HCP. The District typically achieves more immediate compliance, which is the objective, for those egregious and recurring violations of the monthly pumping limits through agreed settlement orders that apply early resolution incentives through a prescribed reduced percentage of the monetary penalties and the applicable sanctions and compliance requirements. But enforcement can also be achieved through litigation in district court, where the full amount of the penalty then becomes a matter before the court; the District has never had to instigate this latter step to achieve satisfactory compliance by permittees.

The relationship between production permit types and degree of curtailment under specified drought conditions is summarized in Table 4-3. The various regulatory drought stages and related curtailment provisions of the District's drought management program are explained in greater detail in the two appendices referenced above.

4.1.1.2.1 Nonexempt Domestic Use Wells and Users

A nonexempt 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 but that does not meet the criteria for exemption from permitting. These wells must be on a single-ownership plot smaller than 10 acres that contains a household. (If on a tract larger than 10 acres, these wells typically would be exempt.) NDUs typically operate under a "general permit by rule" which applies only to wells that:

1. Are used only for domestic use;
2. Were drilled and completed on or after August 14, 2003;
3. Are not located in an area in which a water supplier has a valid certificate of convenience and necessity (CCN) service area, unless that water supplier is not readily able to supply water;
4. Have a requested annual pumpage that does not exceed 500,000 gallons per household; and
5. Have a requested volume that does not exceed acceptable standards for both domestic use and landscape irrigation.

NDUs are required to have water meters and the owners must periodically report water usage. Presently, no water use fee is charged to NDUs for water withdrawals, but the District does charge their users a small one-time administrative permit application fee. As of the end of FY 2013 there were approximately 77 NDUs in the District.

4.1.1.2.2 Other Nonexempt Wells and Users

Most other nonexempt wells not authorized by general permits are required to have individual production permits from the District, to pay an annual water-use fee based on their authorized use, to be metered, and to report actual water use monthly. In 2014, nonexempt well users paid water use fees ranging from $0.17 to $0.46 per 1000 gallons of water used, depending on the type of permit (see below). The District has about 90 nonexempt permittees, not including NDUs. At the time of preparation of this HCP, an estimated 96 percent of all groundwater withdrawn in the District was by nonexempt wells.

Such wells are categorized by use type: agricultural, commercial, industrial, irrigation, and public water suppliers (see Figure 4-1). The permittees include churches, office parks, quarry operations, schools, community athletic fields, golf courses, municipalities, and water supply utilities. The largest use by far is for public water supplies. Type of use is one determinant of the provisions that the District Board considers when it examines the permittees' UCPs and UDCPs.

An example of a public water supply UDCP is the City of Buda's UDCP (see http://tx-buda.civicplus.com/DocumentCenter/View/103). The City of Buda amended its UDCP in early 2012, as did the other nonexempt permittees, to comply with 2011 amended requirements of the District's Rules and Bylaws, which called for enhanced curtailments or reductions of 40% of permitted pumpage during a District-declared Exceptional Stage Drought. The District amended its Rules again in October 2012, requiring even greater curtailment to 50% of permitted pumpage during a District-declared Emergency Response Period to implement a prospective HCP measure and to achieve the newly-established Desired Future Condition (DFC) of the Aquifer (described in Section 6.2.1.8). All permittees will be required to amend their UDCPs again to accommodate that new maximum curtailment which will become effective two years after the Rules were adopted, viz., October 11, 2015. In the example here, the City of Buda is in the process of developing a plan and amending its UDCP accordingly prior to the 2015 effective date.

There are two primary types of individual production permits for nonexempt wells: Historical Production Permits, and Conditional Production Permits. Each type has very different impacts on the habitats of the Covered Species.

Table 4-3: Mandatory curtailment of water withdrawals.

Curtailments established for different well permit types, aquifers, and drought conditions. (Curtailment expressed as percent of authorized monthly water production in designated drought stage.)

Drought Curtailment Chart

Aquifer	Edwards Aquifer						Trinity Aquifer			
Management Zone	Eastern/Western Freshwater					Saline	Lower	Middle	Upper	Outcrop
Permit Type	Historical	Conditional Class A	Conditional Class B	Conditional Class C	Conditional Class D	Hist.	Hist.	Hist.	Hist.	Hist.
Drought Stages										
No Drought	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Water Conservation (Voluntary)	10%	10%	10%	10%	10%	0%	10%	10%	10%	10%
Alarm	20%	20%	50%	100%	100%	0%	20%	20%	20%	20%
Critical	30%	30%	75%	100%	100%	0%	30%	30%	30%	30%
Exceptional	40%	50%[1]	100%	100%	100%	N/A	N/A	N/A	N/A	N/A
Emergency Response Period	50%[3]	>50%[2]	100%	100%	100%	N/A	N/A	N/A	N/A	N/A

Percentages indicate the curtailed volumes required during specific stages of drought.

[1] Only applicable to NDUs and existing unpermitted nonexempts after A to B reclassification triggered by Exceptional Stage declaration

[2] Curtailment > 50% subject to Board discretion

[3] ERP (50%) curtailments become effective October 11, 2015. ERP curtailments to be measured as rolling 90-day average after first three months of declared ERP.

Wells with Historical Production Permits
Withdrawals from existing wells that were nonexempt and registered with the District as of September 9, 2004, were designated with Historic-use Status and authorized under permits designated as Historical Production Permits. A large majority of the authorized withdrawals from the Aquifer are authorized under such permits. Withdrawals under Historical Permits are required to curtail monthly pumpage by 20, 30, and 40 percent during Stage II-Alarm, Stage III-Critical, and Stage IV-Exceptional Droughts, respectively, and after October 11, 2015, by 50% during a Board-declared Emergency Response Period (these groundwater drought status terms are defined and discussed in Appendix D, and the curtailment program is summarized in Table 4-2 above). Historical Permits amended after September 9, 2004, to increase authorized withdrawals from the Aquifer, as well as all new production permits after that date have groundwater production that is subject to conditional-permitting rules for the increase (see immediately below).

Wells with Conditional Production Permits
Withdrawals from wells that received initial permits or existing Historical Permits that have been amended to increase authorized withdrawals after September 9, 2004, were authorized under permits designated as Conditional Production Permits. This date was established by the Board following the findings and conclusions of the District's Sustainable Yield Study, as discussed in Section 3.1.2 above.   The distinction from Historical Production Permits is important, because unlike those permits, withdrawals under Conditional Production Permits are authorized by the District only on an interruptible-supply basis. That is, the water supply under that permit is authorized only on the condition that the allowed monthly production will be increasingly curtailed during prolonged groundwater drought, up to and including complete cessation of pumping during Extreme Drought (see Table 4-2 above).   These permits have UDCPs that provide for mandatory pumpage curtailments of 50, 75, or 100 percent of their authorized monthly usage during deepening stages of declared droughts. The District has further categorized Conditional Permits by whether they initially existed or were in processing on April 27, 2007 (Class A Conditional Permits), or after that date but before March 24, 2011 (Class B Conditional Permits), or on or after March 24, 2011 (Class C Conditional Permits). A fourth conditional-use category, Class D, is reserved for use in supplying water from the Aquifer to future aquifer storage and recovery facilities, but only during non-drought periods. Class B, C, and D Conditional Permits have an accelerated curtailment schedule during drought; certain Class As (generally those with access to alternate supplies) will be permanently converted to Class Bs upon declaration of a Stage IV-Exceptional Drought. All conditional production wells are expected under their permit terms to have ceased pumping during Stage IV-Exceptional Drought or deeper drought, which is the drought condition that is of most concern to the sustainability of the Covered Species.

4.1.2 Historical Perspective of the Covered Activities

4.1.2.1 Evolution of the Regulatory Program

The groundwater drought of the 1950s has become the basis for long-term water resource planning in most of Central Texas. This drought of record (DOR) signified that both surface-water and groundwater management programs needed to incorporate drought management as a principal goal. In the ITP Area, the DOR produced the lowest recorded flows at Barton Springs, with the lowest measured daily flow of 9.6 cfs and the lowest average monthly flow of 11 cfs. At that time, most water supplies in the area came from surface water; the USGS estimated that average groundwater use of the Barton Springs segment of the Edwards Aquifer then was only 0.66 cfs (Slade et al., 1986). So the lowest total monthly discharge from the Aquifer during the DOR was about 11.7 cfs.

But the area has grown rapidly since then and much of the new development was beyond the reach of the centralized surface water supply systems of the City of Austin or the Lower Colorado River Authority (LCRA). The Aquifer provided a readily accessible, high-quality, and cheap source of water for the area, and its use by individual residential users, developments, and smaller suburban cities increased rapidly. But there was no authority that could implement a drought management program that could protect the water levels in the Aquifer or the springflow at Barton Springs.

When the District was formed in 1987, there was no restriction of any kind on pumping from the Aquifer, or any other groundwater in the region. In fact, it was concern over that fact that led to the creation of the District. The District put into place its initial permitting program in 1989, which became fully implemented in 1990. This program was successfully used to identify and regulate pumping within the District, including notably a relatively novel drought management program with curtailments of up to 20% relative to normal, authorized use and based on declared drought stages (although those stages were then defined differently than now). But after a decade or so, the amount of water being pumped from the aquifer to serve the fast-growing area on the then-southern fringe of Austin had increased to the point where it created concern about its impact on Barton Springs during a recurrence of an Extreme Drought like in the 1950s. The District undertook a study (Smith and Hunt, 2004) based on the best science then available to ascertain the sustainable yield of the aquifer, and somewhat alarmingly discovered that during a recurrence of the DOR, the volume of water then authorized to be withdrawn from the aquifer, if un-curtailed, would cause almost one-fifth of the wells in the District to experience yield problems and Barton Springs flow would be reduced to near zero (Smith and Hunt, 2004).

These findings confirmed the need for changes in the District's regulatory and drought management program and, further, the need for even more accelerated and larger curtailments. It also marked the end of the first generation groundwater management program that is denoted herein as the "pre-HCP Program." That program comprised no upper boundary on the total amount of pumping under permit, and the drought curtailments were linked to percentiles of monthly flow at Barton Springs, with no curtailment above the 50th percentile (51 cfs); 10% curtailment below the 50th percentile; 20% curtailment below the 25th

percentile (30 cfs); and 30% curtailment at or below 10 cfs (which of course has only been reached during the DOR). In practice, little enforcement of these curtailment limits actually occurred, and the actual curtailments achieved then were likely considerably smaller while the amount of pumping grew steadily. A more effective drought management plan became a priority in the early 2000s.

The need for additional resources to help define the new drought management program and its ecological benefits led to several consultations with the U.S. Fish & Wildlife Service (Service) and eventually to the first HCP grant awarded to the District in 2004, marking the initial phase of the HCP. This work produced a more rigorous and meaningful drought trigger methodology and a more rigorous and stringent drought management program that was based on the imposition of a junior-senior permitting scheme that included conditional-use permits with interruptible production, as well as a preliminary integrated HCP and Environmental Impact Statement (EIS) document. Significant droughts in 2006, 2008-2009, and 2011 provided the impetus for a series of amendments to the permit-based drought rules, such that the drought management program became one of, if not the most stringent in the state. This regulatory program was developed under the Texas Open Meetings Act and in accordance with the statutory requirements for rulemaking, providing multiple opportunities for public and stakeholder input at each rulemaking step.

In the second phase of the HCP development, the pioneering experimental work concerning DO concentrations and salamander mortality (Poteet and Woods, 2007; Woods et al., 2010), funded by the District HCP and described in more detail in Section 5.2.1 of this document, strongly suggested that the discharge from Barton Springs needed to be still higher during Extreme Drought, and therefore the aggregate pumping needed to be less than what could be achieved by the then-current regulatory program. This result informed the District's 2010 recommendation to the Groundwater Management Area (GMA) 10 joint regional planning committee for a new, statutorily mandated set of groundwater planning objectives called DFCs of the Aquifer that a consensus of the GMA considered to be protective of the Aquifer, both as a water supply and as habitat for the Covered Species, and to be achievable (see TWDB (2014). The Aquifer now has two DFCs: (1) an effective upper limit of 16 cfs on all pumping from the Aquifer, so groundwater production would not unacceptably accelerate the Aquifer into drought; and (2) maintenance of springflow that is not less than 6.5 cfs during a recurrence of conditions like those of the DOR. Using the lowest total monthly discharge (springflow and a small amount of pumping) of 11.7 cfs reported during the DOR for reference, total withdrawals from all wells in the Aquifer during a recurrence of those times need to be no more than 5.2 cfs on an average annual basis to achieve those DFCs. The District's then-current regulatory program, which was developed after numerous informative consultations with other advisory groups and stakeholders, could produce a minimum of 6.7 cfs of pumping, rather than the 5.2 cfs needed.

The 1.5 cfs "gap," which is the difference between the modeled maximum 5.2 cfs of averaged annual pumping that could be allowed during DOR-like conditions and the 6.7 cfs authorized under the regulatory-mandated curtailment program at the time of the study was then addressed in a stakeholder process, which culminated in late 2012 with the phased measures that were incorporated or to-be incorporated into the current regulatory-based drought management program, along with a commitment to promote the long-term development of alternative supplies when and where feasible and where such supplies would provide benefit to management of the Aquifer during severe drought. The District anticipates that this level of curtailment, while very stringent, will be able to be achieved on an aggregate basis within the next three years; currently (2014) the gap has already been reduced to 0.5 cfs. This confidence that it will be completely closed is based on ongoing efforts to encourage the retirement of currently permitted historical production; new rules requiring higher levels of curtailment if a DOR-level drought should recur; new rules incentivizing higher curtailments during severe drought in exchange for proportional increases in permitted production during non-drought; historical experience with some permittees that voluntarily substitute available alternative supplies for authorized Aquifer production during severe drought; right-sizing provisions; as warranted, utilization of improved aquifer modeling to account better for all recharge sources, including urban recharge; and the District's and permittees' continuing efforts to develop and extend alternative supplies to historical-production permittees. Further, District hydrogeologists now consider it extremely unlikely that a recurrence of DOR-like conditions would be reached before the 2015 implementation date of these measures, when the key new rules would become effective and enforceable and permittees will have had an opportunity to take advantage of substitution incentives. Additional alternative supplies may help assure that outcome, but that will depend on the commitments of the individual permittees as much, if not more than the District. In aggregate, this robust and stringent regulatory program constitutes the groundwater management scenario denoted herein as the "HCP Program."

Through full implementation of the measures mentioned above, the small gap of less than 0.5 cfs that currently remains is expected to be bridged by the issuance date of the ITP, with or without factoring in the difference between smaller actual pumpage typically realized in aggregate and the authorized pumpage used in calculating the gap; this difference has routinely accompanied even severe droughts. As necessary and at the Board's discretion, some additional rulemaking and policy development, both currently undefined, as well as individual, stop-gap Board Orders may also be used, providing further assurance that the gap will be closed and the springflow-based DFC will be achieved in the future.

In 2011, the Texas Legislature passed Senate Bill 332, reinforcing the private property ownership of groundwater in place and also requiring that groundwater conservation be balanced by producing the maximum amount of water feasible. Then the Texas judicial system issued two decisions, one by the Supreme Court in mid 2012 in *EAA v. Day* (369 S.W.3d 814 (Tex. 2012)) and another by the 4th Appellate Court in early 2013 in *EAA v. Bragg* (No. 04–11–00018, 2013 WL 5989430 (Tex. App.—San Antonio, November 13, 2013)), that held unequivocally the possibility of compensable regulatory takings by groundwater regulation, even if a groundwater conservation district (GCD) is acting fairly and within its authority and rules. These two cases and their implications for groundwater management are discussed in more detail in Section 7.2.1.7 of this HCP.

4.1.2.2 Changes to Pre-HCP Baseline

Taken together, the internal and external developments in 2011-2013 described in the preceding subsection indicate the District may now be (or soon will be) essentially at the practical limit of what it can legally and statutorily accomplish with its regulatory-based demand reduction program, without incurring potentially catastrophic legal and financial risks associated with compensable regulatory takings. The District considers this program as currently proposed to represent minimization and mitigation "to the maximum extent now practicable," subject to possible future changes via statutory and adaptive management processes. The Service will consider and determine what is practicable in its Findings documentation as part of its intra-Service consultation process.

The beneficial effect that the District's drought-management regulatory program has on spring flows in the context of total springflow is shown in Figure 4-2. The figure depicts calculated hydrographs of discharges at Barton Springs for the current (2014) nonexempt pumpage now authorized by the District (11.6 cfs) and as regulated alternatively by the two groundwater management scenarios, viz., before and after HCP conservation measures and after the HCP measures were in place. It also includes a comparison to the springflows that would have existed at the time with only the small amount of unregulated groundwater withdrawals from exempt wells, designated as the "Exempt-only Pumping" scenario. The blue line in the figure presents a synthetic hydrograph at Barton Springs for the period from 1917-2013, which includes the DOR in the 1950s, that excludes the effects of nonexempt pumpage that actually occurred each month during this period; this approximates what the springflows would have potentially been with only exempt pumping from the Aquifer and is the baseline for comparison in this HCP. The red line, designated as the pre-HCP Pumping scenario, shows how the baseline hydrograph would have changed by regulating permitted pumpage with only the curtailment program as it existed up to 2004, when the District's conditional permitting program was instituted and the HCP development project was initiated. (At that time, there was 10.2 cfs of authorized-nonexempt use; with 0.45 cfs of exempt use, total withdrawals were about 10.6 cfs). The green line, designated the HCP Pumping scenario, corresponds to the hydrograph that reflects a regulatory program with the full complement of proposed HCP measures in place.

To facilitate comparison, both the pre-HCP and the HCP measures in Figure 4-2 are applied to the same amount of pumpage, viz., the 11.6 cfs that comprises the current year's (2014's) total permitted pumping (including both historical and conditional production). As noted above, each of those scenarios restricts pumping during drought in different ways and to different degrees, which in turn affect springflow differently. However there is another important distinction between the two pumpage scenarios that is not reflected in the graphs of Figure 4-2. The two scenarios would place substantially different management restrictions on the total amount of water that ultimately could be authorized to be withdrawn from the Aquifer in the future.

In the pre-HCP pumping scenario, there would be essentially no upper limit on the amount of water that could be authorized to be withdrawn from the Aquifer to meet demand, which of course would accelerate the onset of drought conditions within the Aquifer and also reduce springflow even further during future droughts even with the pre-HCP curtailments. For example, Scanlon et al. (2001), citing projections in the Region K Plan, indicated that by 2050, unregulated Aquifer use would increase to 210% of what it was in 2000, or about 19.6 cfs without effective limitation, even during a DOR recurrence. Without the District's current and proposed regulatory program, the growth in *total* pumpage from the Aquifer would have continued to be largely unchecked during the course of the ITP.

The proposed HCP program provides a regulatory mechanism to restrict the total amount of water authorized to be withdrawn from the Aquifer in the future, while providing for increased use of the Aquifer only during non-drought conditions. Only the proposed HCP program's management scheme has an upper limit on the amount of authorized pumpage, at 16 cfs, which has been established by the District Board to be an acceptable level of acceleration into drought, viz., approximately one month. The pre-HCP program imposes no such cap. Only the HCP program differentiates authorized pumping that is "Conditional" (all authorized pumpage greater than 10.2 cfs), which is interruptible and subject to accelerated curtailment up to and including complete curtailment, from authorized pumping that is "Historical" (up to 10.2 cfs) that is not interruptible but subject to curtailment that provides a minimum firm-yield supply during Extreme Drought. Thus, the proposed HCP program has an assured regulatory limitation on all pumpage to no more than 5.2 cfs (including 0.5 cfs of exempt use) during a DOR recurrence, even in the future. The pre-HCP program does not. These differences signify that the graph in Figure 4-2 for the HCP Scenario does not depend on what additional total pumpage is authorized, while the springflows under the pre-HCP Scenario may be further reduced from those shown in the figure, especially during severe drought.

4.1.3 Statutory and Regulatory Authorities for Covered Activities and Integrated Conservation Measures

The District's statutory authority and purpose are to preserve, conserve, and protect the groundwater resources of the District. A principal dimension in meeting this legislative charge is implementation of a regulatory program to manage the withdrawal of groundwater from the Aquifer during both drought and non-drought conditions. The District HCP relies on this authority, as elaborated in this section.

The powers vested in the District stem from the laws enacted by the State of Texas, namely Senate Bill 988, 70th Regular Session, the District's enabling legislation now codified in the Special District Local Laws Code, Chapter 8802, Barton Springs/Edwards Aquifer Conservation District; and the Texas Water Code, Chapter 36. Chapter 36 is the over-arching statutory authority for virtually all GCDs in Texas.

Except as specifically altered by the supervening statutory authority of enabling legislation, Chapter 36 establishes how groundwater is managed and administered by GCDs. Additional

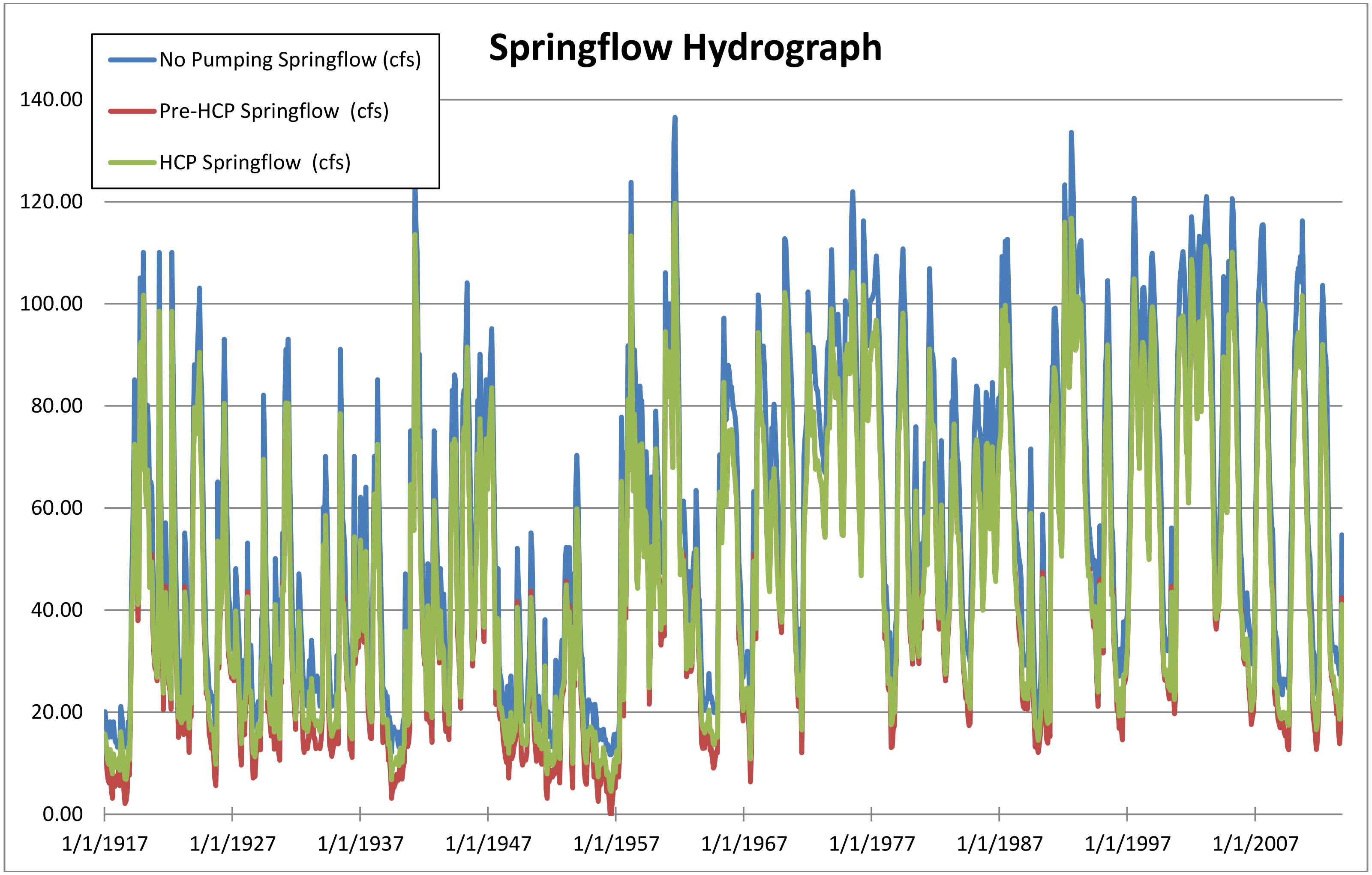

Figure 4-2: Computed hydrographs of Barton Springs flow from 1917 to 2013.
Computed hydrographs comparing the effect of two groundwater management scenarios relative to the springflow that would have existed with no nonexempt pumping. The benefit of the HCP pumping scenario is clearly seen, and is most effective in preserving springflow at the lower Barton Springs discharges, when the Covered Species are most stressed by severe drought conditions.

and revised authorities and requirements affecting the District were enacted by the Texas Legislature in Senate Bill 1212 (71st Session), Senate Bill 1 (75th Session), Senate Bill 2 (77th Session), House Bill 1763 (79th Session), Senate Bill 3 (80th Session), Senate Bill 747 (80th Session), and Senate Bill 433 (82nd Session). A listing of these bills with a brief summary description is provided below in Table 4-4.

Table 4-4: Legislation affecting GCDs and District authority.

Year	Bill No.	Caption
1987	SB 988	Related to validating the creation of the Barton Springs-Edwards Aquifer Conservation District and amending the powers and duties of that district; providing the authority to impose penalties and water use fees; and reducing the authorized level of taxation.
1989	SB 1212	Relating to the creation, administration, and operation of underground water conservation districts and of management and critical areas.
1997	SB 1	Relating to the development and management of the water resources of the state; providing penalties. (aka the "omnibus water bill")
2001	SB 2	Relating to the development and management of the water resources of the state, including the ratification of the creation of certain groundwater conservation districts; providing penalties.
2005	HB 1763	Relating to the notice, hearing, rulemaking, and permitting procedures for groundwater conservation districts. (was expanded to include groundwater planning provisions).
2007	SB 3	Relating to the development, management, and preservation of the water resources of the state; providing penalties.
2007	SB 747	Relating to the authority of the Barton Springs-Edwards Aquifer Conservation District to charge certain fees and limit groundwater production during a drought.
2011	SB 433	Relating to the de-annexation of land in Bastrop County by the Barton Springs-Edwards Aquifer Conservation District.

The District is governed by a five-member Board of Directors, elected by the voters in five single-member precincts (Figure 4-3.) The internal precinct boundaries may change through redistricting with any change in the external boundaries or with each decennial census. Upon decennial redistricting, the Board shall place no more than two of the precincts entirely within the full purpose boundaries of the City of Austin, as the boundaries exist at that time. Such redistricting is a normal, expected part of the District's governance and changes in director precinct boundaries are neither Changed Circumstances under the HCP nor proposed to require ITP amendment. Each elected Board ensures the management and policies of the District, including its groundwater management program, are aligned with local interests and are sworn to comply with all applicable federal, state, and local laws, which will include the prospective ITP and HCP.

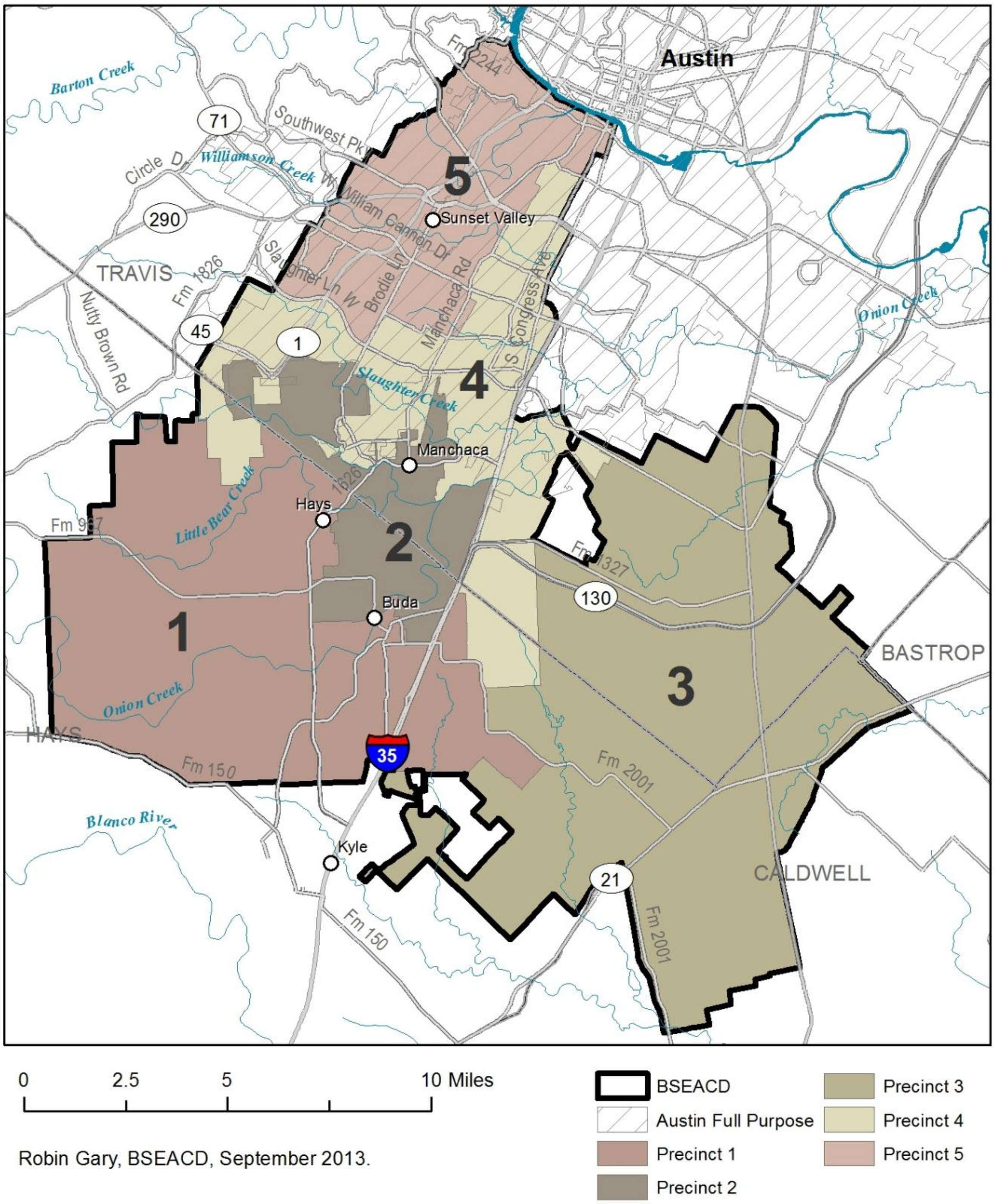

Figure 4-3: BSEACD director precinct boundaries.
Board members are elected by popular vote of all residents within their single-member precincts.

Under its statutory powers, the District's Board has adopted and from time to time amends a set of Rules and Bylaws (BSEACD, 2012), under which it has registered all known wells and has permitted those certain wells that are subject to its jurisdiction and are not exempted from permitting by law or rule. Rule changes that support or are otherwise not inconsistent with the biological goals and objectives of the District HCP in Section 6.1 of this document are also proposed to be neither Changed Circumstances nor a requirement for an amended ITP. Important to the success of the HCP is the fact that the large majority (approximately 95%) of the groundwater withdrawn from the Aquifer is nonexempt and therefore actively managed under District permit authorizations.

The production limits now imposed on wells in the District have been adopted and implemented in an effort to protect groundwater resources and reduce drought-stage groundwater production, to sustain water supplies for its permittees and to maintain springflow at Barton Springs, to the maximum achievable extent, subject to the limits of reasonable regulation and legal liability. The most current set of Rules and Bylaws pertaining to Barton Springs flow can be found on the District's website under the tabbed menu heading, "About Us/Governing Documents" (http://www.bseacd.org/about-us/governing-documents/); information on the permitting program and other regulations applicable to the Barton Springs segment of the Edwards Aquifer is under the "Regulatory Program" menu (http://www.bseacd.org/regulatory/).

The Rules and Bylaws are adopted in accordance with the District Management Plan (BSEACD, 2013), which is reviewed, revised as warranted, and readopted at least every five years; it was most recently amended and adopted by Board Resolution on September 27, 2012, and approved by the TWDB on January 7, 2013. (The Management Plan, in turn, is prepared in accordance with Texas Water Code, Chapter 36, Section 1071, and TWDB requirements under Texas Administrative Code, Chapter 356, Sections 5 and 6.)

The District's authority mainly relates to groundwater quantity; it has only limited and indirect authority to protect groundwater quality. Its ability to offer such protection derives primarily from its authority to avoid and minimize waste of groundwater, which by definition includes contamination or pollution of water that is within or recharges the Aquifer and that harmfully alters the character of the groundwater. GCD regulation to prevent the harmful alteration of groundwater more typically involves the prevention of pollution through the enforcement of well construction standards and setback distances from potential sources of contamination. The District does not have the explicit authority under its enabling legislation to regulate land-use, including subdivision restrictions.

As a practical matter, most groundwater quality protective measures are afforded by other regulatory entities with more explicit authority to regulate land-use activities, even for groundwater within the District's jurisdictional area. The programs and entities that are involved in groundwater quality protection are discussed in more detail in Appendix H.

4.1.4 Public Participation in Developing the Covered Activities and Integral Conservation Measures

As a political subdivision of the State of Texas, the District is obligated to operate in a highly transparent fashion and to routinely involve the public in its normal business operations, with only a few statutorily prescribed exceptions. Further, the "Five Point Policy" developed by the

Service as recommendations and guidance in developing HCPs prescribes "opportunities for public participation" as one of the five elements.

During the time period in which this HCP was being developed, the District held more than eighty (80) Board meetings, including work sessions, in which the HCP was specifically identified as a discussion item on the agenda. These were all public meetings under the Texas Open Meetings Act, with agendas posted with the Texas Secretary of State (until September 2011), at county courthouse bulletin boards, and at the District office typically six days (and no less than 3 days) in advance of the meeting. With few exceptions, all of these Board meetings offered opportunity for public comment and participation as desired on the ongoing HCP evolutionary process, including consideration of both the regulatory program and the proposed conservation measures, and their documentation. The HCP has had a webpage on the District website since 2007, which has been utilized as a communication vehicle for HCP project progress and documentation.

The District has provided additional opportunities for structured participation by stakeholders and the public, and it has utilized perspectives of other knowledgeable members of the scientific community in developing the HCP:

- During the active investigation and development stages of the HCP, the District used from time to time several external advisory groups to assist the District's efforts, including:

  a. a hydrogeological/technical advisory committee, in the evaluation of aquifer drought management options and drought trigger methodologies;
  b. a biological/technical advisory committee, in the planning and monitoring of needed research on stressor-responses, the effectiveness of potential conservation measures, and the assessment of residual harm to salamander organisms and populations;
  c. two topical stakeholder advisory committees on the efficacy of (1) options for stringent conservation measures that would take effect during Exceptional and Extreme Droughts, and (2) options for the District to promote development and use of alternative water supplies; and
  d. a public/stakeholder advisory committee, in determining the scope of the HCP, recommending possible avoidance, minimization, and mitigation measures, providing a forum for public discourse on HCP development and progress, and building consensus where possible.

  These advisory groups each met many times during the course of the HCP development, and nearly all of the meetings, which typically were attended by one or more District directors as well as staff, were posted as Texas Open Meetings, with publicized agendas and were open to the public at-large.

  - In the latter stages of the HCP development and documentation, the District voluntarily established, utilized, and intends to continue using a standing Management Advisory Committee (MAC, or Committee) of experts, stakeholders, and private citizens to provide independent initial reviews and annual assessments of the HCP and the progress being made toward the HCP goals, and to identify and evaluate additional minimization and mitigation measures or modification to existing ones that appear warranted, making appropriate recommendations to the District Board on a periodic basis. This Committee is an integral part of the District's continuous improvement process and adaptive management.

The Committee was formed by the Board in February 2013; its functions are characterized and its members are identified in Section 6.5.1.2. In effect, the MAC is the continuing advisory vehicle for the previous advisory groups, and quite a few of the MAC members earlier participated in one or more of those advisory groups during the HCP's active development. In addition to their prospective involvement in the annual review and reporting process, the District also used the Committee members to review and comment on preliminary drafts of the HCP before it was submitted as part of the ITP application, and to help the District (and the Service) respond to public and agency comments on this HCP, to ensure that responses address stakeholder and public needs. The MAC meetings are also posted as Open Meetings for encouraging public participation.

4.2 Requested Permit Duration

The proposed ITP for the District would be issued for a term of twenty (20) years and be renewable thereafter, subject to administrative procedures extant at that time.
Local, regional and state water-resources planning entities in Texas are mandated to use a 50-year time horizon for almost all water resource planning functions, ranging from the establishment of DFCs of a groundwater reservoir managed by a GCD, including the Aquifer, to the regional and statewide water resource planning programs of the TWDB. Water supply strategies are required to supplement the firm-yield supply available during a recurrence of the DOR within that planning horizon. In the HCP Planning Area, the DOR is the decade-long drought from1947-1956 (using the District's drought trigger definitions discussed in Section 4.1.1.2), and Cleaveland et al. (2011) has used tree-ring data and dendrochronological analysis to estimate that a decadal drought like the DOR has a recurrence interval in the HCP Planning Area of about 100 years. Conversely, the effects of climate change are just now being elucidated, especially at the regional level, but it is already clear that they may have a profound impact on drought management imperatives; that consideration may be particularly important to the habitat of the Covered Species, suggesting the advisability of a shorter permit term. A term of 20 years represents a rational balance between these two countervailing factors.

The groundwater management plans, regulatory strategies, and tactical measures used by water-resource management agencies like the District are continuing functions, requiring periodic updating through the course of longer-term planning horizons. As specified in Sections 6.3.2, 6.4, and 6.5.1 of this HCP, the measures to be implemented by the District to minimize or mitigate the impacts of take will be reviewed periodically throughout the term of the ITP and beyond. Since the ITP relates to a continuing groundwater management program's providing most of the HCP conservation measures, it is the District's intent to apply for renewal of an ITP, amended as appropriate, near the end of the initial term.

5.0 Analysis of Impacts Likely to Result from the Taking

5.1 Covered Species

This Habitat Conservation Plan (HCP) proposes incidental take coverage for two endangered species, Barton Springs salamander (*Eurycea sosorum*), listed as endangered in 1997; and Austin blind salamander (*E. waterlooensis*), listed as endangered in 2013. Both of these species are known only from the springs and outlets of the Barton Springs complex of the Edwards Aquifer. This section describes each species and provides information on life history, distribution, threats and reasons for decline, and the survival needs for each species in individual descriptive subsections. The following Section 5.2 assesses the taking of these Covered Species by the Covered Activities and its consequences.

The descriptions in the following subsections draw from several sources compiled by biologists with expertise in the Covered Species, especially the Barton Springs salamander --its life history, population characteristics, habitat, and the influences that may cause incidental take. Three of the principal sources referred to in this section include the Barton Springs Salamander Recovery Plan (Service, 2005); the U.S. Fish & Wildlife Service's (Service's) final rule that listed the Austin blind salamander (Service, 2013b); and the City of Austin's Amended Barton Springs Pool Habitat Conservation Plan (City of Austin, 2013.) Citations to the primary sources are made where warranted, as well as to the above referenced secondary sources.

5.1.1 Species Descriptions and Life Histories

5.1.1.1 Barton Springs Salamander

The Barton Springs salamander (Figure 5-1) 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 (Chippindale et al., 1993). They are aquatic and neotenic -they retain larval, gill-breathing morphology throughout their lives, and do not metamorphose and leave water. Instead, they live in water throughout their life cycle where they mature and reproduce. The species was first collected from Barton Springs in 1946 (Brown, 1950, Texas Natural History Collection specimens 6317-6321) and formally described in 1993 (Chippindale et al.). This species has been a continuing focus of various studies by the biologists of the City of Austin's Watershed Protection Department for more than a dozen years; these studies have been conducted both in the field around the spring outlets and in the specialized salamander laboratory/refugium operated by the City. Documentation of most of these studies is found in the City's approved HCP (City of Austin, 2013).

Figure 5-1: Above: *Eurycea sosorum*, Barton Springs salamander; Below: *E. waterlooensis*, Austin blind salamander.
Photo credit: City of Austin, Watershed Protection Dept

Adults reach about 2.5 to 3 inches (63-76 mm) in total length. The coloration on the adult salamander's upper body varies from light to dark brown, purple, reddish brown, yellowish cream, or orange. The characteristic mottled salt-and-pepper color pattern on the upper body surface is due to brown or black melanophores (cells containing pigments called melanin) and silvery-white iridiophores (cells containing pigments called guanine) in the skin. On either side of the base of the head is a set of three feathery gills that are bright red (Service, 2005).

Juveniles closely resemble adults (Chippindale et al., 1993). Newly hatched larvae are about 0.5 inch (12 mm) in total length and may lack fully developed limbs or pigment (Chamberlain and O'Donnell, 2003).

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).

The Barton Springs salamander is carnivorous and appears to be an opportunistic predator. Known prey items include ostracods, chironomids, copepods, mayfly larvae, amphipods, oligochaetes, and planarians (Chippindale et al., 1993; Gillespie, unpublished data). An analysis of the gastro-intestinal tracts of 18 adult and juvenile Barton Springs salamanders and fecal pellets from 11 adult salamanders collected from Eliza Springs, Barton Springs Pool, and Old Mill Springs were most commonly found to contain ostracods, amphipods, and chironomids (City of Austin, 2013).

Gravid females, eggs, and larvae of Barton Springs salamander are typically found at different times of the year in Barton Springs, which suggests that the salamander can reproduce year-round (Hillis et al., 2001), although they are generally not observed with the same frequency during drought periods.. The eggs hatch in 3-4 weeks. Hatchlings are about half an inch total length (snout to tip of tail), often still with yolk sacs and limb buds. Juvenile Barton Springs salamander become sexually mature at about 11 months (43-50mm total length) and grow to about 3 inches total length as adults (City of Austin, 2013). In captivity, Barton Springs salamander has been observed reproducing to an age of at least eight years (City of Austin, 2013). The representativeness of such characteristics in the wild is not well established.

Observations of courtship among captive pairs of Barton Springs salamanders (Chamberlain and O'Donnell, 2003) are consistent with Arnold's (1977) description of the tail-straddling walk which is a behavior unique to plethodontid salamanders (Service, 2005). Females of some salamander species may store spermatophores for up to 2.5 years before ovulation and fertilization occur (Duellman and Treub, 1986). In 2001, a captive Barton Springs salamander female laid viable eggs one month after being isolated, which indicates that females of this species can store sperm for at least this length of time (Chamberlain and O'Donnell, 2003).

Since the City of Austin began surveying salamanders in 1993, very few eggs have been found in the wild. The first egg was found detached near a spring orifice in Sunken Gardens Springs in May 2002. The other three eggs were found near spring orifices in Barton

Springs Pool (December 2002, May and August 2003) (City of Austin's Dee Ann Chamberlain, City of Austin, pers. comm., 2003). It is hypothesized that the Covered Species lay their eggs in the aquifer below the surface because only a few eggs have been found in the wild. Hatching of eggs in captivity has occurred within 16 to 39 days after eggs have been laid (Chamberlain and O'Donnell, 2003). Hatching success in captive Barton Springs salamanders may be highly variable as indicated by hatching rates of 0 to 100 percent that have been reported by the City of Austin (Chamberlain and O'Donnell, 2002, 2003). Egg mortality has been attributed to fungus, hydra (small invertebrates with stinging tentacles), and other possible factors such as infertility (Service, 2005).

Eggs are laid by female salamanders one at a time and receive no parental care. Although a female can lay a single egg in minutes, the entire egg-laying event may take several hours, depending on clutch size (Chamberlain and O'Donnell 2003). Biologists associated with the City of Austin's captive breeding program have observed clutch sizes ranging from 5 to 39 eggs with an average of 22 eggs as based on 32 clutches (Chamberlain and O'Donnell. 2003, City of Austin, unpublished data).

The first three months following hatching have been found by City of Austin biologists to be a critical period for juvenile survival (Chamberlain and O'Donnell, 2003). Newly hatched larvae have a yolk sac to sustain their nutritional needs in the early days after hatching. Larvae feeding on prey items have been observed 11 and 15 days after hatching (Lynn Ables, Dallas Aquarium, pers. comm., 1999). Although reproduction has occurred in captivity, it has been sporadic. No consistent methods or techniques have been found to enhance egg production (Service, 2005).

At times, females have held eggs for over a year before the eggs are either laid or reabsorbed. City of Austin biologists believe that stable environmental conditions, water quality, adequate space, habitat heterogeneity, and food availability may influence egg laying (Chamberlain and O'Donnell 2003). Providing substrates that have a rough surface (not smooth like glass) may facilitate successful spermatophore deposition and transfer (Service, 2005).

The life span of the Barton Springs salamander in the wild is unknown. Assuming that collected salamanders were at least one year old when collected, reported longevity for individual Barton Springs salamanders in captivity is at least 15 years (City of Austin, 2013).

Other than gas bubble trauma (see Service, 2005, section 1.6), only a few physiological anomalies have been reported in the wild for the Barton Springs salamander. They include an infection of one male adult and possibly one gravid female with immature trematodes (Chamberlain and O'Donnell, 2002), an unknown myxosporidian parasite, and bacteria in the genera of *Aeromonas* and *Pseudomonas* that have affected salamanders in captivity (Chamberlain and O'Donnell 2003). It is not known whether these pathogens are present in the spring habitats of the salamanders or what threat they may pose to salamanders in the wild (Service, 2005).

Predation on Barton Springs salamanders in the wild is probably minimal when adequate cover is available for salamanders to hide from predators. Most but not all of the potential predators that are native to the Barton Springs ecosystem for the salamanders are opportunistic feeders (Service, 2013). Crayfish (*Procambarus* sp.) and other large predatory invertebrates may prey on salamanders or salamander larvae and eggs (Gamradt and Kats, 1996). Predatory fish found at Barton Springs include mosquitofish (*Gambusia affiinis*), longear sunfish (*Lepomis megalotis*), and largemouth bass (*Micropterus salmoides*). Mexican tetras are non-native fish and are aggressive generalist predators that are occasionally found in Barton Creek, Barton Springs Pool, Upper Barton Springs, and Old Mill Springs (Service. 2005); they are reasonably inferred to be potential predators, but no observations of such predation on the salamander have been reported. The City of Austin (2013) also reports that the two *Eurycea* species at Barton Springs may opportunistically prey on one another.

The sex, age, and number of individuals of the Barton Springs salamander are not precisely known because the population is believed to be small and the habitat is underwater and from time to time subterranean, so some of it is inaccessible under any circumstances, making a complete population census impossible at any given time. As mentioned, the population size varies in a more or less repetitive but not regular fashion, typically in response to natural variations in resources and environmental conditions. Over the long-term, statistical trends can be inferred from the rather exhaustive and extensive censuses of observable individuals that are being conducted by the City of Austin, in association with recorded variations in climate, spring flow, dissolved oxygen (DO), and other relevant factors influencing habitat (City of Austin, 2013, 2007b).

5.1.1.2 Austin Blind Salamander

The Austin blind salamander was formally described by Hillis et al. (2001). The Service provides a rather comprehensive description of this species and its ecological requirements in its recent listing rule (Service, 2013b), which is incorporated by reference into this section.

The Austin blind salamander (Figure 5-1) is also a member of the Family Plethodontidae (lungless salamanders), one of the several Texas species within the genus *Eurycea* that inhabit springs, spring-runs, and water-bearing karst formations of the Edwards Aquifer (Chippindale et al., 1993). It is closely related to the Texas blind salamander (*Eurycea* [formerly *Typhlomolge*] *rathbuni*), found in the southern segment of the Edwards Aquifer in San Marcos, Texas (Hillis et al,. 2001).

The Austin blind salamander averages about 2 inches in length (Service, 2013), so it is slightly smaller than its sympatric species. Other morphological characteristics that distinguish the Austin blind salamander from the Barton Springs salamander include eyespots covered by skin instead of image-forming lenses, an extended snout, fewer costal grooves, and pale to dark lavender coloration (Hillis et al., 2001). In June 2001, the Austin blind salamander was designated a candidate for listing as endangered or threatened (Service, 2005). The species was listed as endangered on August 20, 2013 (Service, 2013b).

The Austin blind salamander is also carnivorous and appears to be an opportunistic predator. There is evidence of partial overlap in diet composition and egg deposition sites of the Covered Species, which has been interpreted as indicative of selection for ecological niche-partitioning to reduce competition (Vrijenhoek, 1979; Pianka, 1983). Austin blind salamander is believed to feed mostly on blind amphipods and isopods found within the aquifer, but when they are at the surface of the springs, will also consume other small invertebrates (City of Austin, 2013). These factors can maintain genetic divergence between these species (Paterson, 1985).

The eggs hatch in 3-4 weeks.

The uncertainties and limitations of surveying to determine the sex, age, and number of individuals of the Austin blind salamander are not precisely known because the population is believed to be small and the dominant habitat is subterranean and aquatic (Hillis et al., 2001), so most of it is inaccessible under any circumstances, making the species not reliably surveyable at any one time. Accordingly, less is known about these parameters and therefore life cycle characteristics for Austin blind salamander than for Barton Springs salamander.

5.1.2 Species Distribution

5.1.2.1 Barton Springs Salamander

Both species are observed in the vicinity of the Aquifer's spring outlets, although the epigean Barton Springs salamander is more likely to be found at and near the subaqueous surface of the substrate, including submerged rock ledges and gravelly areas. After the City of Austin completes the spring-run restoration efforts as part of its forerunner HCP program (City of Austin, 2013), those re-aerated areas typically will have higher DO than the groundwater issuing from the Aquifer at the outlet itself, especially during lower flow conditions. This is important, in that some researchers (for example, Turner, 2007) have suggested the salamanders appear to be able to migrate locally to areas of less stress (higher flow, higher water velocities, higher DO, more prey, fewer predators) in the Aquifer and in spring runs during certain times of even moderate drought. No Critical Habitat has been designated by the Service for the Barton Springs salamander.

The Barton Springs salamander is sympatric (occurs in the same or substantially overlapping range) with the Austin blind salamander (see discussion immediately below).

5.1.2.2 Austin Blind Salamander

The Austin blind salamander is sympatric with the Barton Springs salamander, probably in an incidental fashion in the epigean environment on the basis of its morphology. The Critical Habitat for Austin blind salamander, as designated by the Service (2013b), is depicted in Figure 5-2. Its range away from the spring outlets is in the subsurface, within the Aquifer, and is largely inferred from ranges reported for other similar species (Service, 2013b). Its presence and migration away from the spring outlets are implied by the Critical Habitat designation to contribute to assuring the redundancy, representation, and resilience of the Austin blind salamander (Service, 2013a); Hillis et al. (2001) also notes its ability to migrate locally to areas of reduced stress, as with the Barton Springs salamander. However, currently there are no data that suggest how far afield within the Critical Habitat Area, in the subterranean region away from the outlets, the organisms migrate or have migrated. Unlike Barton Springs salamander, Austin blind salamander has not been regularly observed at the non-perennial Upper Barton Springs. The hydrogeologic setting suggests the subterranean habitat close by the outlets is a complex, three-dimensional network of solution-enlarged openings, and because the Barton Springs complex resurges water from both confined and unconfined portions of the Aquifer (Hauwert et al., 2004), different DO regimes likely exist in the nearby subterranean environment (Lazo-Herencia et al., 2011). While both species have been observed in the vicinity of the other spring between the outlets and in the dissolution cavities in the rock matrix underlying spring outlets, Austin blind salamander is more likely to be in the subterranean portions of and between the outlets and in the dissolution cavities in the rock matrix underlying spring runs.

5.1.3 Reasons for Decline and Threats to Survival

The Service recently issued its final rulemaking on the Austin blind salamander (FR, vol. 78, no. 161, p. 51278 et seq.), which contains a rather comprehensive compendium of current information on, and analysis of stresses on and threats to, this species (Service, 2013b). Such a comprehensive assessment was not made in the much earlier listing process for Barton Springs salamander, but similar factors were identified and addressed in its Recovery Plan (Service, 2005).

In its listing rule, the Service has identified a relatively large number of specific stressors that are adversely affecting the Covered Species and that, either singly, in combination, or cumulatively over time, are reasons for decline and threats to survival of these species (Service, 2013b). These are summarized in Table 5-1, which also provides an indication of the District's ability (legal authority; regulatory purview; financial wherewithal) to take actions that affect each of the stressors and thereby have a role in responding to those threats. The District's Covered Activities do not relate to most of these threats; they are included herein primarily as an indication of the overall risks to the ecosystem of the Covered Species.

The primary threat for the Covered Species is seen to be the present and threatened degradation of the habitat by reduced water quality and quantity at the surface, in the subsurface, or both, and also by the physical disturbance of the spring sites' surface habitat (Service, 2013b). The Service has determined that in aggregate the threats identified are both imminent and high in impact on the Covered Species. For example, in its most recent listing rule documentation, the Service concludes that "…the Austin blind salamander is in danger of extinction now throughout all of its range…" and goes on to explain that this finding "…is based on our conclusions that this species has only one known population that occurs…in Barton Springs, the habitat of this population has experienced impacts from threats, and these threats are expected to increase in the future. We find that the [species]

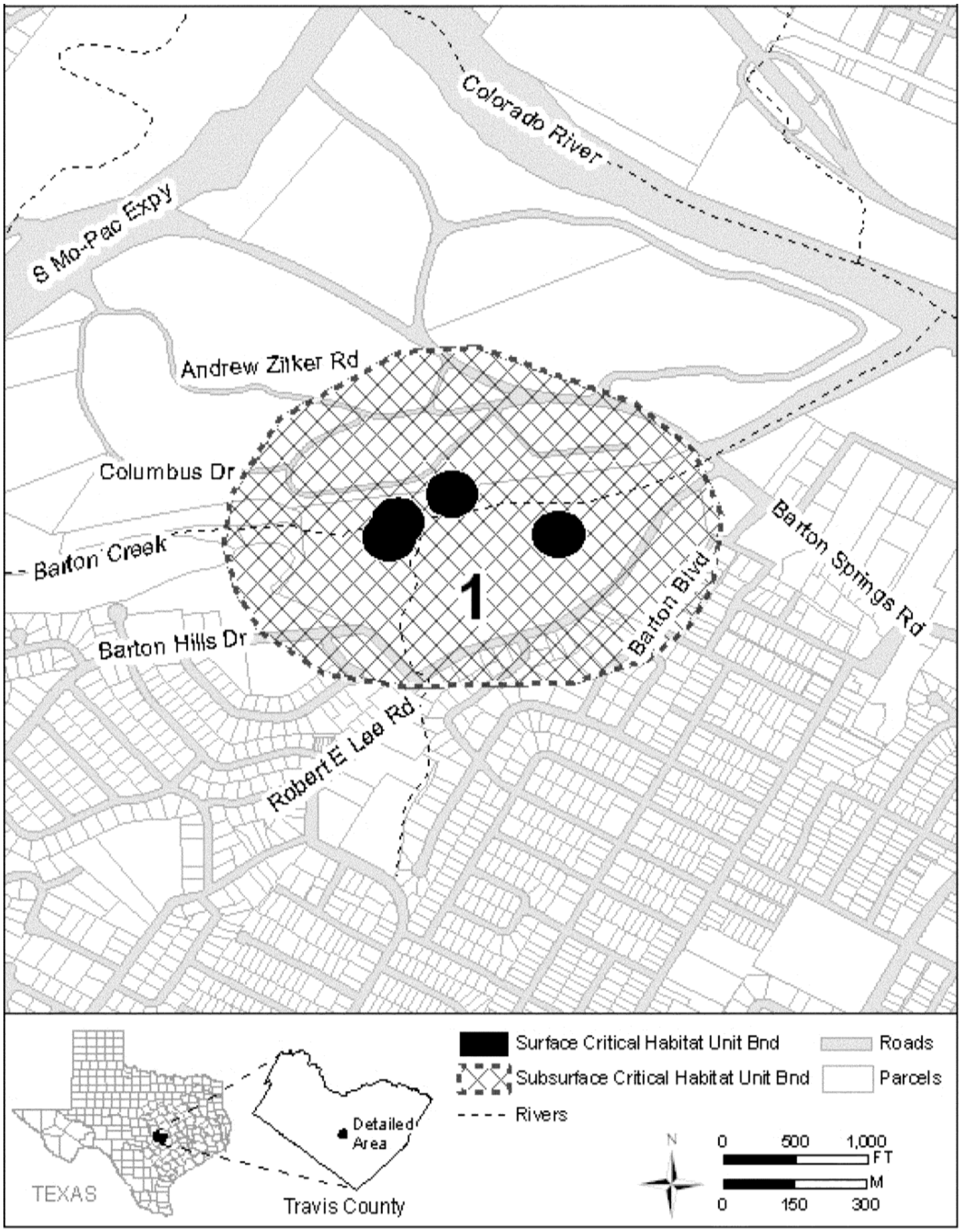

Figure 5-2: The Service-designated Critical Habitat for the Austin blind salamander. Designated Critical Habitat has both surface and subsurface components. All of the surface habitat and most of the subsurface habitat, totaling about 120 acres, are within the City of Austin's Zilker Park and protected from future development. Source: Service, 2013a.

is at an elevated risk of extinction now, and no data indicate that the situation will improve without significant additional conservation intervention" (Service, 2013b). While this specific determination addresses the Austin blind salamander, which was just recently listed, the same threats and stressors exist for the Barton Springs salamander population and that species is considered equally at risk for exactly the same reasons and in need of conservation to reduce the risk of extinction.

But as the table also indicates, most of the stressors and circumstances that are inimical to the two species are beyond the District's ability and authority to affect, avoid, ameliorate, minimize, or mitigate. Only those reasons for decline and threats to the survival of the Covered Species that the District's activities affect in either a positive or negative sense are addressed further in this section of the District HCP. The District HCP's Covered Activities relate solely to managed groundwater withdrawals from the Aquifer under its integrated drought management program. These directly affect only the amount of groundwater that issues from the spring outlets, since water that is not withdrawn from wells is discharged at the spring outlets, generally on an equivalent-volume basis (Smith and Hunt, 2004). In turn, as described in Section 3.2.2.2 above, as springflow decreases so does dissolved oxygen concentrations of the water discharged (Herrington and Hiers, 2010), while the total dissolved solids concentrations increase, as older, more saline water becomes a larger proportion of the spring flow (Johns, 2006). These changes in water chemistry are affected indirectly by the District's groundwater management program, which in turn affects the amount of take of the Covered Species.

5.1.3.1 Barton Springs Salamander

The threats to and stressors of the Barton Springs salamander that are addressable by the District actions and decisions and that potentially relate to the existence and amount of take and therefore its impact are the following (Service, 2013b):

1. Reduced springflow at the Barton Springs outlets during severe (Stage III Critical and Stage IV Exceptional) droughts, a type of stochastic (random expression of a probability-distributed series) event on which groundwater pumping is over-printed;
2. Decreased DO in springflows during severe drought; and
3. Somewhat higher ionic constituent concentrations (as expressed by conductivity) in springflows during severe drought.

The Service's Barton Springs Salamander Recovery Plan includes an examination of the various cultural/anthropogenic threats and stresses and recommends guidelines and action steps and an implementation program to minimize or avoid them as integral elements of the recovery measures (Service 2005). This District HCP is a complement to the Barton Springs Salamander Recovery Plan with respect to minimizing groundwater withdrawals during drought. It is also worth noting that because natural processes such as super-saturation of dissolved gases in the salamander's body have occurred in the past and may pose continuing threats to the salamander (City of Austin, 2013; Service, 2005; 2013), they may also bear on the efficacy of potential conservation measures for this HCP.

5.1.3.2 Austin Blind Salamander

The same factors identified and observations made above for the Barton Springs salamander are also pertinent to the Austin blind salamander. This is especially true for those aspects of habitat change that can be affected by the District's Covered Activities, viz., the quantity and resultant water chemistry of spring discharges during severe drought that in turn produce take and its impact:

1. Reduced springflow at the Barton Springs outlets during severe (Stage III-Critical and Stage IV-Exceptional) droughts, a type of stochastic event on which groundwater pumping is over-printed;
2. Decreased DO in springflows during severe drought; and
3. Somewhat higher ionic constituent concentrations (as expressed by conductivity) in springflows during severe drought.

Table 5-1: Summary of Threats to Covered Species
Adapted from: FR, vol. 78, no. 161, p. 51278 et seq.

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
Factor A: Present or threatened destruction, modification, or curtailment of its habitat or range	Water Quality Degradation	Urbanization	Increased impervious cover and chronic degradation of stream hydrology and contamination of aquatic habitat from expansion of roadways, residential, commercial and industrial development	No
			Increased magnitude and frequency of high flows and flashiness that disrupts biotic communities	No
			Changes in stream morphology and water chemistry, including increased contamination and toxicity	No
			Negative effects on prey base	No
			Increased sedimentation that covers graveled habitat	No
		Hazardous Materials Spills and Releases	Highway-transport accidents may release gasoline, chemicals, heavy metals like lead and arsenic, oil and grease, and toxic petroleum hydrocarbons to stream courses and then the Aquifer	No

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
			Releases of toxic organics and hydrocarbons from breaks in oil and gas pipelines and related facilities	No
Factor A (continued)	Water Quality Degradation (continued)	Hazardous Materials Spills and Releases (continued)	Leaking underground storage tanks that release gasoline and petrochemicals to the Aquifer	No
			Breaks and overflows in conveyance lines and failures of treatment facilities for water and sewage that introduce a panoply of contaminants to streams and the Aquifer	No
		Construction Activities	Siltation and increased sediment and chemical loads from excavations for roads, tunnels, pipelines, and shafts	No
			Siltation and increased sediment and chemical loads from excavation and operation of quarries and gravel pits	No
			Disruption of hydrologic pathways from excavations (although none are known or likely for these species)	No
		Introduced Specific Contaminants and Pollutants	Acute and chronic toxicity to Covered Species and prey, through sediment or water column	No
			Adverse effect on eggs and larvae	No
			Impaired reproduction, growth, and development of life cycle requirements	No

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
			Adverse effect on prey species availability	No
			Morphological deformities	No
			Altered capability for feeding, moving, and reproduction: loss of survivability	No
			Nutrient enrichment and subsequent changes in trophic state and biological growth- and decomposition-related oxygen availability problems	No
Factor A (continued)	Water Quality Degradation (continued)	Changes in Water Chemistry	Conductivity may indicate other pollutants as well as elevated ionic stress	No
			Salinity and its specific ions can alter the internal water balance and create mortality in various species, including prey species	**Yes**
			Dissolved oxygen depression reduces respiratory efficiency, metabolic energy, and reproduction rates, and ultimately survival	**Yes**
	Water Quantity Degradation	Urbanization	Change in magnitude, frequency, and duration of runoff reduces baseflow of recharge stream and concomitant decrease in aquatic community diversity	No

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
			Increased storm runoff increases erosion and sedimentation, and more easily flushes larvae from substrate	No
			Reduction in infiltration increases flashy runoff, reduces recharge and therefore decreases springflow	No
		Natural Drought	Reduced springflows are associated with lower dissolved oxygen, lower water velocities, higher salinity, higher temperature variations, and increased sedimentation of habitat, all of which adversely affect the Covered Species and availability of their prey	No
Factor A (cont'd)	Water Quantity Degradation (continued)	Climate Change	Increased drought period intensity and duration and higher average temperatures leads to more water demand, larger temperature variations, less recharge, smaller springflows, and more saline intrusion component, all of which adversely affect the Covered Species and availability of their prey	No
		Increased Well Use	Reduced spring flows may cause stranding and interference with feeding/predation, as well as somewhat reduced dissolved oxygen and slightly higher salinity	**Yes**

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
	Physical Modification of Surface Habitat	Modification of Existing Habitat	Flooding may alter substrate and channel morphology, adversely, remove protective vegetation, and flush individuals away from their habitat	No
			Sedimentation mobilizes silt and clays that are suspended in water column and make water turbid, which impairs breathing because of clogged gills and reduces ability to locate food or avoid predators	No
			Sedimentation mobilizes sediments, and associated contaminants, that are then re-deposited and cover/fill substrates necessary for life activities.	No
Factor A (continued)	Physical Modification of Surface Habitat (continued)	Modification of Existing Habitat (continued)	Impoundments alter stream morphology and flow regimes that allow increased siltation and support larger predators.	No
			Other human activities, including frequent human visitation and vandalism, result in habitat disturbance/destruction and loss of cover available for breeding, feeding, and sheltering of Covered Species	No

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
Factor B: Overutilization for commercial, recreational, scientific, or educational purposes	Reduction in population size	Significant population declines	Over-collection for scientific purposes could negatively impact the species in combination with other threats; not considered a serious threat at this time	No
Factor C: Disease or predation	Reduction in population size	Not considered a threat	No problems observed; not considered a threat to population	N/A
Factor D: The inadequacy of existing regulatory mechanisms	Past, current, and future impacts to species as noted above	Inability to prevent further impacts to species in the future	Federal and State laws have not sufficiently prevented such impacts	No
			Local laws, regulations, and ordinances are not sufficient to prevent such impacts.	No
			Groundwater Conservation District regulations are not sufficient to prevent such impacts.	**Yes**

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
Factor E: Other natural or man-made factors affecting continued existence of the species	Synergistic and additive adverse interactions among stressors above	Result of stochastic events on very small population size	Severe drought, abetted by groundwater pumping, may reduce quantity and change chemistry of springflows that exacerbate other impacts on species, especially as re-colonization is not probable	**Yes**
			Catastrophic contaminant spills or leaks of harmful substances that exacerbate other impacts on species	No
		Other natural factors	Ultraviolet-B radiation may exacerbate other impacts	No
			The highly restricted range (one location) and the entirely aquatic environment make the Covered Species highly vulnerable to stochastic events such as catastrophic spills, storm events, and severe droughts that could extirpate the species	No

5.1.4 Survival Needs Affected by Covered Activities

Both the Barton Springs salamander and the Austin blind salamander are believed to have very similar needs to ensure their survival. At the present time, there are insufficient data and information to distinguish major differences among them in this regard. Accordingly, the discussion in this section applies to both species.

Chief among their survival needs, as inferred from their sole habitat characteristics discussed in Section 5.1.1 and 5.1.2, are the following:

1. A supply of high-quality fresh water having a relatively narrow range of physicochemical conditions of pH, alkalinity, and water temperature: these conditions are met by groundwater continuously resurging from a non-polluted karst aquifer (City of Austin, 2013; Service, 2013b);

2. Sufficient DO flux, representing a combination of DO concentration and water velocity past the highly adapted salamander gill structures: the minimum flux required is unknown (Poteet and Woods, 2007; Mahler and Bourgeais, 2013);

3. Water with concentrations of ionic constituents (expressed as TDS concentration) that are sufficiently low such that it supports the egg and larval life stages of the salamander (Service, 2013b): the ionic constituent strength threshold is unknown but is not believed to be especially low, or so low that the minor amount of saline water incursion during severe drought flows and concomitant ionic-constituent increases of springflow affect those stages;

4. Interconnected, submerged surface and subsurface habitat for various life activities and from time to time for protection: given the morphological differences, the Austin blind salamander utilizes the submerged subsurface environment mostly, whereas the Barton Springs salamander utilizes the submerged surface and near-surface environment more, although their interconnected-ness may be critically important to both species for providing food and avoiding predation (Service, 2013b);

5. Given the small size of both populations and the lack of redundancy for each, the population's persistence (i.e., survivability) in the face of environmental and demographic challenges depend on the number, duration, frequency, and magnitude of those stochastic events not exceeding the resiliency of the species (Service, 2013b).

These survival needs and life history requirements are characterized in more detail by the Service (2013b), which should be referenced if further information is required.

The District's Covered Activities and conservation program affect and address the first, second, and third of these needs, at least indirectly, and its drought management program is intended to reduce incrementally the magnitude of that type of stochastic event that could affect the persistence of the population (the fifth need above.) In the following Section 5.2, the take by the Covered Activities is characterized and quantified, and then the impacts of take on the populations are described. The beneficial aspects of the conservation program on minimizing and mitigating take are addressed in Section 6.2.4.

5.2 Effects of Take on Covered Species

The assessment presented in Section 5.1.3 and 5.1.4 above strongly suggests that the scientific basis and factors for considering take by the Covered Activities are essentially the same for both Austin blind salamander and Barton Springs salamander, differing primarily in amount of supporting information available. The District HCP's Biological Advisory Team (BAT) has indicated on the basis of currently available information that the relevant measures that are protective of Barton Springs salamander are also reasonably inferred to be similarly protective of Austin blind salamander. Indeed, the City of Austin's Barton Springs Pool HCP (City of Austin, 2013) does not distinguish differences in the efficacy of protections afforded by its conservation measures between the two species. Further, substantially more information than is now known on the habitat requirements and life histories of both species, but especially Austin blind salamander, and their response to stressors would be needed in order to propose and assess differential requirements between the two species.

The unavoidable effects of the District's Covered Activities are also not able to be differentiated between effects on one of these species and not the other. Therefore, the effects on the species are addressed together in this section; however, potential differential impacts, i.e., consequential results of the take on each of the species populations, are addressed in the following Section 5.3. An important operational premise of this HCP is that the measures to be adopted for the conservation of Barton Springs salamander will not substantially harm Austin blind salamander and its habitat, and vice versa. The current state of knowledge appears to provide no compelling basis to refute this premise. In particular, there is no known difference in the sensitivity to DO concentrations and salinity between the two species, and while opportunistic predation may occur between the species, neither is known to be dominant in this regard (City of Austin, 2013).

Accordingly, in this section of the HCP addressing the effect of take, unless otherwise specified, the term "Covered Species" refers to both of the species and their attributes.

5.2.1 Experimental Assessment of Salamander Responses to Changes in Water Chemistry Related to Springflow

DO and specific conductivity (a measure of ionic constituent concentrations, or salinity) have been identified as potentially significant variable parameters that should be investigated during the course of the District HCP, to understand the levels of stress and mortality of the salamander to each (see, for example, Turner, 2004). Before this HCP was initiated, no scientific study of the physiological responses of either of the Covered Species to these variables was known to exist. To provide information that can be used to begin the evaluation of the species response to changes in these variables, a pioneering multi-stage laboratory study was commissioned and funded by the District as part of this HCP. The research was conducted by investigators at The University of Texas at Austin, Section of Integrative Biology, and later supplemented by researchers at Baylor University's Department of Environmental Science. The investigators evaluated stressor-response relationships and sensitivities important to conservation across a range of DO and conductivity levels on Barton Springs salamander and a surrogate species (Poteet and Woods, 2007). Approaches that identify such stressor-response thresholds are recognized as highly valuable for supporting robust environmental management decisions (Suter, 2006). Risk analysis in this toxicity study for the District HCP was designed to determine risks to individuals from just one of the stressors of the Covered Species, not all stressors for the entire population. As noted above, Covered Species are susceptible to cumulative risks from a variety of natural and anthropogenic stressors. Stress from incidental DO variability is considered the primary stressor to which the District's Covered Activities contribute. This approach is preferred when considering threatened and endangered species, for which an adverse impact on individuals of the population can be significant (Suter, 2006).

The original study documented in the final report by Drs. Mary Poteet and Art Woods (2007) was subsequently enhanced with further investigation, computations, and analysis as part of the HCP investigation, employing a Probabilistic Ecological Hazard Assessment (PEHA) approach to relate the study findings to threshold responses of salamanders to DO concentrations in spring habitats for the first time. This study thus provided a unique contribution to understanding DO stress to an endangered species in general, because a closely related salamander species (described below) and historical data allowed for robust analysis. The enhanced study has since been submitted to considerable peer review and has been published in *Copeia*, the journal of the American Society of Ichthyologists and Herpetologists (Woods et al., 2010); this peer-reviewed article is included in its entirety as Appendix I of this HCP. The HCP relies heavily on the conclusions in this peer-reviewed published report, but data included in the original study report are also instructive.

5.2.1.1 Laboratory Study Design

The investigators selected and used a closely related salamander species, the San Marcos salamander (*Eurycea nana*), as a surrogate for the Covered Species, because its genetics and life history are similar to those of the Barton Springs salamander (Chippindale et al., 2000). San Marcos salamander occupies similar karst-fed springs in central Texas, and the two species have similar physiologies. Both species are federally protected, but the captive population size of San Marcos salamander is considerably larger than that of Barton Springs salamander and especially Austin blind salamander (Poteet and Woods, 2007). On the basis of metabolic tests run on both species to evaluate response to changes in DO and conductivity, San Marcos salamander appeared to respond similarly to the Barton Springs salamander under a variety of test conditions. As noted above, the ready, nearby availability of a surrogate species that was so similar to the Covered Species, was quite fortuitous and exceptionally rare for stressor-response studies with endangered amphibians (Woods et al., 2010).

Experiments were performed to determine adult mortality and juvenile growth responses to DO. Survival and sub-lethal growth measurements are routinely used in ecological risk assessments because these response variables are highly relevant for population sustainability of threatened and endangered species (Suter, 2006). In fact, the work by Woods et al., (2010) is considered by those researchers to represent the most comprehensive investigation to understand adverse effects of DO on any salamander to date (Bryan Brooks, personal communication, February 2014).

The testing procedure generated 28-day mortality estimates and also described sub-lethal effects such as metabolic rate variation, growth rate, and behavioral response to various treatment levels under controlled laboratory conditions (Poteet and Woods, 2007) (see Figure 5-3). In addition, a 60-day study was conducted on juvenile San Marcos salamander, exposing individuals to various DO concentrations (Woods et al., 2010).

As mentioned in the preceding sections of the District HCP, the estimated response of the Barton Springs salamander population to changes in DO and conductivity addresses only two of the many cumulative stressors that influence the population during reduced discharge. However, these limitations notwithstanding, the models developed from these data, which examined more than one life stage, and particularly the juvenile stage, which is typically considered more sensitive to stresses than adults, provide the most robust method currently available for evaluating potential impacts of reduced discharge conditions on the salamander population in the wild.

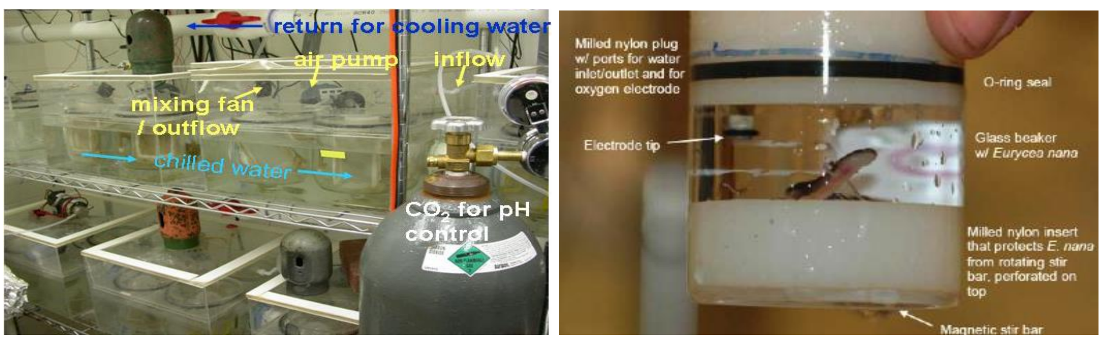

Figure 5-3: Example Setups for Studying Salamander Response to Toxicity
Representation of two laboratory experimental setups to measure salamander response in the University of Texas toxicity study. Image on left is for 28-day toxicity study; and image on right is for metabolic rate study. (Photo courtesy of M. Poteet and A. Woods).

The DO and spring discharge datasets examined by the PEHA approach were obtained from the U.S. Geological Survey. The procedures used across the dataset were uniform, which was a major criterion for the PEHA investigation. In these datasets, there were very few observations of DO concentration at low flows or values below 4.5 mg/L. The DO dataset for the primary outlet at Main Springs was the most robust. However, there were only 27 observed springflow-DO pairs below 20 cfs at that locality. Those low flow observations had a mean DO value of 4.69 ±0.28 mg/L. No statistically significant relationship was observed between flows below 20 cfs and associated DO levels. This understandably imposes some limitation on the general applicability of the findings and its comparability with findings from other, later-collected datasets at other outlets. No other PEHA for these outlets was known to exist during the development of this HCP.

5.2.1.2 Stressor-Response Study Findings and Applications

One of the primary findings of Woods et al. (2010) was that increases in conductivity (ionic constituent concentrations) do not result in salamander mortality, even at very high concentration. This finding is the result of what appears to be the most controlled, systematic, and replicable laboratory study available. Further, such an observation is not surprising, particularly for organisms adapting to natural habitat changes in the past. However, it should be noted that this finding relates only to adult and juvenile salamanders; it has been suggested by others that increased salinity could have adverse consequences on the egg and larval stages of the salamander (Service, 2013b). No empirical studies of this latter possibility have been documented. But given the relatively small increase in TDS concentrations (from about 400 mg/L to less than 500 mg/L) associated with low spring flows (Herrington and Hiers, 2010), and the adaptation of the Covered Species populations to this recurring natural phenomenon, any adverse outcome seems a likely *de minimis* ecological risk to the Covered Species. The Covered Species experience similar and even larger salinity variations on a recurring basis during high flow periods, although the durations of such events are over much shorter time intervals than severe drought. Accordingly, this variable was not considered by the investigators or the BAT to be nearly as important a factor as DO in affecting habitat quality for purposes of the biological evaluation in the District HCP. The narrative that follows consequently focuses only on DO. While many natural and anthropogenic chemical constituents that may occur in groundwater could adversely affect the Covered Species, the District's Covered Activities only affect the concentration of those few natural constituents that are specifically related to springflow. In this regard, only DO is judged to be quantitatively determinative of take of the Covered Species in the meaning of the Act.

In the 28-day adult stressor-response study, groups of salamanders were progressively exposed to several levels of DO exposure: 1.3, 2.4, 3.6, 4.6, and 7.5 mg/L, each in individual aquaria. Figure 5-4 presents a response curve to the varying DO exposure concentrations. Mortality rates fell abruptly between approximately 2 and 4 mg/L. Some salamander mortality occurred within 28-days in all three of the lowest three treatments (1.3, 2.4, and 3.6 mg/L), and there was 100% mortality within 48 hours of the two lowest treatments; no DO related mortalities were observed in either of the two highest treatments (4.6 and 7.5 mg/L).

Lethal Concentration (LC_x) values are computed threshold measurements of an environmental condition at which level a certain animal or organism has a given likelihood (% chance) of dying in a given amount of time, under constant controlled conditions. An alternate and usual way of considering LC_x values is that is the level in which x% of the organisms die. Woods *et al* re-computed a series of LC_x values of DO for the Barton Springs salamander in their earlier laboratory study -- the DO concentrations that would presumably cause 5%, 10%, 25% and 50% mortality for adult San Marcos salamander individuals if exposed continuously over a 28-day period (Woods et al., 2010):

$NOAEL_{Adult}$	-- 4.5 mg/L
LC_5	-- 4.5 ±0.5 mg/L
LC_{10}	-- 4.2 ±0.3 mg/L
LC_{25}	-- 3.7 ±0.1 mg/L
LC_{50}	-- 3.4 ±0.2 mg/L

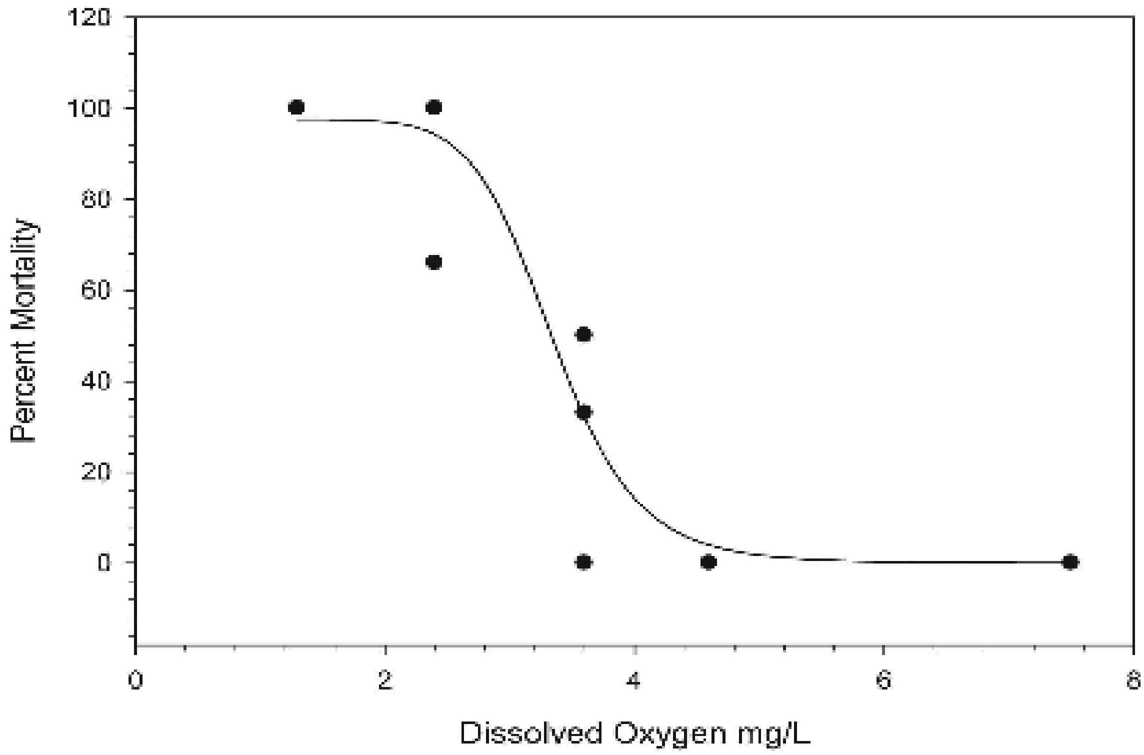

Figure 5-4: Percent mortality of San Marcos salamander exposed to varying dissolved oxygen concentrations in laboratory.
The data were modeled using a 3-parameter logistic model. Source: Woods et al (2010).

These DO concentrations form response thresholds for San Marcos salamander and, by inference, Barton Springs salamander and, for this HCP, also Austin blind salamander. In particular, the LC_{50} and the LC_5 or the No Observed Adverse Effect Level (NOAEL) each may provide useful benchmarks for estimating the quantity of take and *de minimis* ecological risk that is likely to occur under the anticipated discharge conditions of the District HCP. For example, the level of DO at LC_{50} (causing 50% chance of mortality after 28 days of exposure) was found to be approximately 3.4 mg/L which, if it occurred for a continuous 28-day period or longer in one of the springs, would pose a grave threat to salamander survival. On the other hand, DO levels at or above 4.5 mg/L showed no observable effects in any experiment (Woods et al., 2010), so little threat to salamander survival would be inferred. During prolonged severe droughts, the DO concentrations typically range between these two DO levels in a non-linear fashion (Woods et al., 2010), so evaluating take requires a dynamic assessment.

In this regard, other researchers have also noted that the Barton Springs salamander seems to be adapted to waters that are variably under-saturated with respect to DO (Turner, 2007), indicating some resiliency to DO variations.

The stressor-response study also determined the observed NOAEL threshold DO levels for juvenile as well as adult San Marcos salamander. Juvenile growth rate studies were conducted over a 60-day period to determine the effects of exposure to various DO levels on metabolic activity and growth. The lowest DO concentration set for the 60-day juvenile growth study was 4.4 mg/L.

The results of the analysis are presented in Table 5-2. Although juveniles in the lowest DO exposure concentration (4.4 mg/L) had growth rates that were approximately 30% lower than control salamanders, the growth rates were positive and were not statistically significantly different than the controls (Woods et al., 2010). Using a toxicological approach, the investigators determined that the specific growth rate NOAEL for juveniles was 4.4 mg/ L, the lowest DO level examined. Uncertainties should be considered, but on the basis of these unique laboratory studies salamanders frequenting spring localities with DO values at or higher than 4.44 mg/L are not expected to encounter stress on account of DO concentration.[7]

Table 5-2: Summary of growth rates of juvenile San Marcos salamander over 60 days in different dissolved oxygen concentrations.
Source: Woods et al., (2010).

Treatment	Dissolved Oxygen (mg/L)	Number	Growth Rate (mg/day)
1	4.44	5	0.15
2	5.17	4	0.33
3	5.31	4	0.26
4	6.35	5	0.24
5	8.22	4	0.23

[7] Some reviewers of early drafts of this HCP noted that a higher standard, specifically the 5.0 mg/L DO criteria for lentic systems should be used, in keeping with existing surface water quality standards and/or for providing a safety margin. These are not comparable standards and are employed for different purposes. The surface water quality standard is intended to provide a general condition that would support a diversity of aquatic life under all ambient conditions in lakes and reservoirs with other constituents and is applied only outside a mixing zone. In any event, it is not applicable to aquifer discharges per se or spring-fed pools. Further, it is not intended to be equivalent to a NOAEL for any specific aquatic species, nor is it designed to be used as a threshold for assessing take. Certainly sound environmental management incorporates margins of safety in actual enforceable standards whenever feasible to accommodate cumulative effects by all constituents. But standards that have such safety margins do not denote when physiological and/or behavioral effects for a given species are manifested, including in particular these Covered Species. Woods et al. (2010) assert that the typical 5.0 mg/L DO surface water quality criteria, if it were applicable, would likely be protective of the Barton Springs salamander, but those researchers are not maintaining that such a lake or reservoir standard is applicable nor even the minimum water quality criteria for the salamander, below which DO toxicity is manifested.

A PEHA was employed to develop an initial predictive understanding of the likelihood of encountering DO levels in springflows in Main Barton Springs, Eliza Spring, or Old Mill (Sunken Garden) Spring at or below San Marcos salamander thresholds to DO. The results of this assessment using the U.S. Geological Survey (USGS) springflow - City of Austin DO dataset, spanning a period of 30 years to be reasonably representative of most conditions, are presented in Table 5-3 (Woods et al., 2010).

Table 5-3: Lethal Concentrations (LC_x) of Dissolved Oxygen and Corresponding Springflows. DO levels required to cause mortality in 5, 10, 25, and 50% of adult San Marcos salamander after 28 days of exposure, and the No Observed Adverse Effect Level (NOAEL) for juvenile *E. nana* growth following a 60-day study, and corresponding total Barton Springs flow for perennial Spring outlets. Source: Woods et al., (2010).

Effect	Type of Study	Lethal Concentration of DO (mg/L)	Probability of Exceedence (% of values below threshold)		
			Main Springs	Eliza Spring	Old Mill Spring
LC_5	28-day	4.5 +/- 0.5	5.2	6.8	30
LC_{10}	28-day	4.2 +/- 0.3	2.3	3.024	--
LC_{25}	28-day	3.7 +/- 0.1	0.4	0.4	15
LC_{50}	28-day	3.4 +/- 0.2	0.08	0.1	11
NOAEL	60-day	4.4	4.5	5.8	28

The PEHA performed by these investigators determined that the exceedence probability statistic associated with the LC_5 for San Marcos salamander is 4.5 mg/L. This concentration has a Probability of Exceedence (the probability that DO concentration would fall below the specified biological threshold, of 4.5 mg/L in this case) of 5.2% for Main Springs; 6.8% for Eliza Spring; and 30% for Old Mill Spring. Similar computations are shown in Table 5-2 for the other LC_x values.

The probability of exceedence of the NOAEL for Main and Eliza Springs are 4.5% and 5.8%, respectively (i.e., there is a 4.5 % likelihood of encountering a DO concentration at or below 4.4 mg/L at Main Springs. Old Mill Spring had substantially higher exceedence estimates than the other two springs, largely on account of a flatter slope and lower measured DO values. However, the correlation coefficient for the regression line fitted to the Old Mill data was also much lower (0.65) than those for Main Springs and Eliza Spring, which may also be a factor (Woods et al., 2010).

The probability of exceedence of the LC_{50} concentration of 3.4 mg/L (the level at which 50% mortality of salamanders would be expected, if exposed continuously for 28 days) has a probability of occurring 0.1% of the time, or less, for the Main Springs and Eliza Spring. The LC_{50} has an 11% probability of occurring at Old Mill Spring (Table 5-2).

Results from the PEHA approach were also expressed in the form of toxicological benchmark concentrations (see Table 5-4). For example, only 5% of all DO observations in a representative typical period would be expected to be observed at or below a specific concentration of 4.5 mg/L DO in Main Barton Springs and 4.4 mg/L DO in Eliza Spring.

Table 5-4: Toxicological Benchmark Concentrations for low centiles
Benchmarks based on the dissolved oxygen (DO) distributions for Barton Springs, Eliza Spring, and Sunken Garden Spring. Estimates are based on the 28-day adult mortality and 60-day juvenile growth studies. Source: Woods et al., (2010).

	Dissolved Oxygen Concentration (mg/L)		
Likelihood that DO declines below specified amount	Main Springs	Eliza Spring	Old Mill Spring
≤ 1%	4.0	3.9	2.3
≤ 5%	4.5	4.4	2.9

The PEHA by Woods et al. and the probabilities reported in the study utilized a more limited but homogeneous data set. But it should be noted that the discharge statistics based on this study's dataset reflect the effect of an indeterminate and variable mixture of different regulatory conservation measures over this time period. Moreover, a more robust dataset that includes additional data, including low flow data, have been collected by the City of Austin, and both these data and the USGS data are now accessible and further analyzed (Turner, 2007; Turner, 2009). For these reasons, a different springflow-DO dataset, in conjunction with the lethal concentration statistics of Woods et al. (2010), is used to associate springflows and DO in estimating the frequency and amount of take for this HCP, as described in Section 5.2.4.2 below. However, as would be expected, the datasets are not dissimilar and the general relationships revealed by the earlier PEHA are considered valid, although some variations in values of various parameters accompany utilization of the larger dataset.

5.2.1.3 Implications and Limitations of the Stressor-Response Study

The PEHA and other methods applied in this research are helpful in characterizing some of the parameters of potential take of the Barton Springs salamander, and by extension the Covered Species, in the wild. There are; however, additional areas of uncertainty that should be acknowledged. As in all laboratory studies, the response of the test organisms under controlled conditions may not be the same as their response to DO variations in the wild. Response also varies among individuals, affecting the precision of mortality estimations. This potential variability is accounted for by presenting 95 percent confidence intervals around the mean value of each estimate of mortality. As described above, the surrogate species San Marcos salamander appeared to react similarly to Barton Springs salamander among laboratory treatments when metabolism was monitored, but San Marcos salamander mortality estimates may or may not align as well with those expected in the Covered Species populations in the wild, particularly in any given time period

(Woods et al., 2010). Mortality estimates are only for adult salamanders, so other life stages may have different or more variable sensitivities to reduced DO or elevated ionic constituent concentrations in groundwater.

Further gaps in knowledge that would have been useful to examine but were not able to be included within the scope of the project include how DO (and specific conductivity) affects reproduction, egg development, and hatching (Wood et al., 2010). If other stages—eggs or juveniles—are more sensitive (exhibit higher LC_{50}s), higher levels of DO than those determined for the adult NOAEL may still constitute a considerable threat. For example, no data are available to evaluate mortality responses of *Eurycea* eggs to DO.

Salamanders will occupy habitat containing higher and lower DO (or of other factors, such as water flow velocities, that affect DO availability). Although sensing and responding to such varying DO conditions may be irrelevant at high DO levels, it surely becomes more important at low DO. In this HCP's salamander stressor-response experimental program, salamanders clearly perceived and responded to low (or falling) DO -- the infrared detection system measured the onset of activity during falling DO and cessation of activity during subsequent rising DO. In the wild, counts of salamanders tend to decline in Barton Springs when DO falls below approximately 5 mg/L (Turner, 2004b). As such, salamanders in local pockets of low-DO water may migrate and find higher-DO water, either in the submerged surface environment outside the outlets (Turner, 2007) or inside the subterranean karst system (Service, 2013b; Hillis et al. 2001). Water flow rates in the salamander experiments were, for technical reasons, fairly low (1 cm/sec), likely giving substantial boundary layers. Consequently, another possible response mechanism to lower DO would be for salamanders to increase oxygen flux to sites of respiratory exchange by disrupting those boundary layers—e.g., by bobbing, flicking their heads, or swimming. Thus, the novel stressor-response thresholds observed by Woods et al. (2010) appear robust. But these may be effective only for shorter periods of time than a typical groundwater drought, in which the metabolic energy required eventually exceeds the energy gained by incremental benefits to respiration.

DO concentrations and conductivity measurements may be heterogeneous in the springs inhabited by the Covered Species, possibly due to poor mixing of waters from different flow routes resurging along the faults as well as differences in re-aeration potential between confined and unconfined aquifers adjacent to the spring orifices. Microhabitats may be higher or lower than data measured by the City of Austin collection methods. In addition, test organisms during the laboratory study were not able to move to higher quality habitat conditions (i.e., areas with higher flow velocities to increase oxygen exchange across the gills), as they can in the wild. On the other hand, 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 take and even the chances of mortality. Finally, reduced DO may significantly contribute to cumulative adverse effects with other changes in other springflow-related and non-springflow related water chemistry parameters during reduced discharge, which could not be accounted for in these tests.

Despite the uncertainties that affect the use of laboratory-derived mortality estimates to describe the mortality risk to the population in the wild, the data collected and analyzed by Woods et al. (2010) provide the best basis to describe the anticipated impact of low-discharge conditions at the Barton Springs complex to the Covered Species. As noted above, the Woods et al. (2010) study likely represents the most robust study of DO stress to any salamander. These study results can be used in conjunction with continuous water quantity and corresponding, appropriate water chemistry data and salamander survey data collected by the City of Austin, USGS, and the District to describe parameters of incidental take of the Covered Species under the District HCP. With an estimated response to changes in DO (Woods et al., 2010) and known relationships between DO and the combined discharge in the Barton Springs complex (City of Austin 2004, 2007, 2009 and 2010), and salamander survey data during a range of aquifer conditions, it is possible to estimate the response of the Covered Species to reduced DO concentrations from low flows in Barton Springs. These estimates form a rational and the best-available basis for determining adverse effects, and ultimately take.

5.2.2 Spatial and Temporal Extent of Take

Take of the species (as defined by 50 CFR 17.3) includes 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." It also includes harassment, defined as "annoying wildlife so as to significantly impair [those] behavioral patterns."

The District has identified two forms of take arising from its Covered Activities. The first and most far-reaching form is the physiological responses of the organisms to changes in the chemistry of the water in which both of the entire populations live. On the basis of research conducted for this HCP (described in Section 5.2.1 above), estimates of physiological take of the Covered Species at the perennial spring outlets are based primarily on two measurable life requirements of the species that serve as a proxy of counts of these cryptic (typically hidden from observation) individual organisms: 1) rate of springflow discharge, and 2) its related changes in water chemistry, especially the DO concentrations and ionic constituents of discharged groundwater at the spring outlets.[8] The degree and extent to which changes in these parameters arising from the District's Covered Activities cause harassment and harm to occur are the basis for their consideration under this Incidental Take Permit (ITP) as indicators of the take at the perennial outlets.

However, while the Covered Activities will be continuously occurring, they do not always produce this form of take. During non-drought conditions and also in continuing but non-

[8] Water temperature also may be important in defining the short-term temporal DO regime, owing to the reduction in DO solubility with higher temperatures; but its effects are reflected primarily in the variability of DO observed for a particular discharge amount. Under base-flow conditions, temperature of water discharging at the outlets tends to be cooler and more uniform and less likely to control DO than the proportion of saline and other older, less meteoric groundwater contributed to the springflow (Mahler and Bourgeais, 2013).

severe drought periods, the incrementally smaller perennial springflows that are partly a result of the Covered Activities are not accompanied by changes in water chemistry that have physiological relevance to the Covered Species, up to some point. More specifically, when no outlet has a DO concentration below 4.5 mg/L, which is the laboratory-established No Observed Adverse Effect Level (NOAEL) for DO where no investigated physiological response was elicited, the amount of water being withdrawn from the Aquifer by wells is immaterial to the water chemistry and no additional take is considered to occur from that circumstance and cause of take. Also noted in Section 5.2.1 above, an additional assumption is made in this regard: for purposes of this HCP, any other potential and adverse non-lethal effects of smaller DO concentrations on individuals (such as other physiological responses, impaired egg production and development, reduction in reproductive success, reduction in recruitment, and/or detrimental behavior) and those expressed at the population level (including reduction and cessation of reproduction, reduction and cessation of growth, reduction in prey abundance, and increased intra-and inter-specific competition) are considered to commence at the same time and under the same flow regime as conditions that produce take from physiological response, in the absence of quantitative flow-specific data to the contrary for these Covered Species.

While the Covered Activities (nonexempt permitted pumping) take place over the entire ITP Area, the resultant take will occur at or relatively close by the spring outlets, as described generally in Section 3.2.2 above, more numerically in Section 5.2.3.3 below, and in more detail in Appendix C. Take affects the populations at each outlet to somewhat different degrees and at slightly different times, dependent on the total spring discharge and resultant water levels and chemistry. However, at least one of the three perennial outlets reaches the 4.5 mg/L DO threshold for physiological response at a combined springflow of about 20 cfs regardless of groundwater management scenario, including the HCP management scenario (Table 5-5, and elaborated in Appendix J). This table shows the baseline flows and recurrence frequencies (percent of time flow is below a designated discharge amount) for each outlet that correspond to this physiological take threshold. Note that the flows and frequencies presented in the table pertain to the HCP pumping scenario, with current levels of authorized groundwater withdrawals and *after implementation of the set of HCP conservation measures* (described in Section 6.2 below). Combined flows above 20 cfs are considered to not annoy, harass, or harm the Covered Species at any perennial outlet as a result of the Covered Activities.

Table 5-5: Onset of take by spring outlet.
Flows and frequencies that correspond to initiation of physiological effects at perennial outlets and to habitat loss at the non-perennial outlet after the HCP conservation measures are implemented. Additional explanation is provided in Appendix J of this HCP.

Outlet	Total Barton Springs Flow When Take at Outlet Begins	Recurrence Frequency
Main Springs	19.0 cfs	18 %
Eliza Spring	19.9 cfs	20 %
Old Mill Spring	17.7 cfs	15 %
Upper Barton Spring	40.0 cfs	48 %

As drought becomes prolonged and deepens, the effects on *individual* organisms are deemed likely to proceed from an initial non-lethal, annoyance/harassment form of take for a few individuals to affecting larger numbers of individual organisms and being affected by a form of take that has an increasing harm component, ultimately including mortality. However, the entire extant populations of the Covered Species in and around the outlets are adversely affected physiologically by springflows at or below 20 cfs, and that is the reference threshold for purposes of determining the amount of take associated with the Covered Activities (nonexempt permitted pumping). The rationale and methodology used to develop these thresholds are discussed in more detail in Section 5.2.4.1.1 of the HCP. They are being summarized in this section to provide support for this discussion of the spatial and temporal context for take.

The second form of take is the incremental physical habitat loss caused by reduced springflow during recurring drought cycles. This is most noticeable in the temporary reductions and losses of the spring habitat at Upper Barton Spring, a non-perennial overflow spring with a small population of Barton Springs salamanders. As noted earlier, Upper Barton Spring stops flowing when the combined flows in the Barton Springs complex drop below 40 cfs , and then starts flowing again when the combined flows increase above 40 cfs.. This is a recurring condition related to the geohydrologic configuration of the Barton Springs complex. It would occur about 38% of the time without the Covered Activities, and will occur about 48% of the time with the Covered Activities and the HCP conservation measures in place.

As discussed above, there is likely no adverse physiological response associated with the water chemistry at these water levels and discharge amounts. This likelihood is buttressed by the re-appearance of relatively robust individual Barton Springs salamanders at this outlet when the Aquifer water levels rise and spring flows at Upper Barton Spring are re-established (City of Austin, 2013). But it is reasonable to presume that the physical loss of most of the surface habitat at Upper Barton Spring affects the entire salamander population at this outlet, by causing a retreat of this epigean species into the subterranean habitat, perhaps including a migration to other outlets for some part of the resident population. While no life functions are known to be permanently impaired for these species by this inherent and frequently recurring loss of physical habitat, the population is reasonably inferred to be annoyed and some adverse effects on feeding and sheltering behavior are not unlikely. Because pumping of the Aquifer contributes to the decline of water levels in the Aquifer, even though only a very small fraction at springflows of 40 cfs when this physical habitat loss occurs, some portion of the adverse effects on the Upper Barton Spring population, primarily a non-lethal form from annoyance and harassment, is attributable to the Covered Activities, and is therefore take.

5.2.3 Consideration of Take and Jeopardy

Because of the nature of the primary cause of take, viz., substantive changes in the characteristics of the spring flows in which all individuals of the Covered Species live and therefore may be affected, the entire population present at or near each of the outlets at a given time is at least potentially adversely affected by changes in its water chemistry. As described in Section 5.2.2 immediately above, at least a fraction of that adverse effect is created by decreased spring flow derived from pumping, a Covered Activity. That therefore constitutes take, and the amount of take depends on the size of the population that exists at a given time and the proportion of adverse effects that are associated with natural variations in spring flows that would be present regardless of the Covered Activities. When non-drought conditions are re-established, the adversely changed characteristics of the spring flow may no longer exist, but the take associated with that drought has already occurred and does not decrease. So the take is estimated on a District-declared drought event basis and is cumulative over multiple droughts that will be experienced in the ITP term.

5.2.3.1 Estimation of Sizes of Populations Adversely Affected

The District uses different approaches to estimate the sizes of the populations that govern take of the two Covered Species.

Barton Springs Salamander
The City of Austin has regularly conducted census surveys of the epigean Barton Springs salamander and since 2003 has used essentially the same protocols and standards for its surveys. The statistics on abundance, density, and their variation from these censuses (City of Austin, 2013) provides a robust, internally consistent, and extensive dataset to gauge the size of the surface population for this species at the time of each census. The District's estimate of Total Take for the Barton Springs salamander utilizes these data.

The City of Austin noted in its HCP that salamander abundance based on census counts varies with environmental conditions (City of Austin, 2013). Accordingly, the District considers the variable amount of the actual salamander population present in a particular perennial outlet's orifice during those times below its take-initiation threshold (Section 5.2.2) to be the adversely affected population. To reduce this to a single numerical estimate, as is required for the ITP, the District has designated the number of individuals experiencing adverse effects arising from DO-related physiological changes at the perennial spring outlets to be equivalent to the arithmetic mean-plus-one standard deviation of the abundance data from the City of Austin's census counts. This metric represents the population that experiences actual adverse physiological effects from DO related to springflow. (The City of Austin employs a similar "mean-plus-one-standard deviation (SD)" approach, indexed to a different statistic to facilitate evaluation of specific subareas of the Barton Springs complex, for the take estimates in its HCP (City of Austin, 2013). This incorporates and reflects a measure of variability from extant environmental conditions as well as a central tendency, and it also provides some accommodation for other factors affecting take, as discussed below, and the uncertainty of future environmental conditions than would be reflected in current salamander counts.

As described in Section 3.2.2.2.1, this HCP has designated the "stipulated population" of Barton Springs salamander that encounters adverse effects and its distribution among the perennial outlets to be as shown in Table 5-6 below.

Table 5-6: Total stipulated population of Barton Springs salamander distributed by perennial spring outlet.
In addition, 18 of this species are located at the non-perennial Upper Barton Springs.

Perennial Outlet	Stipulated Population
Main (Parthenia) Springs	160
Eliza Spring	624
Old Mill Spring	37
Total Stipulated Population	821

This HCP does not attempt to quantitatively differentiate other presumptive sub-lethal effects from those of variable DO (at any specific concentration) on reducing or cessation of reproduction, natality, and/or recruitment, reducing other growth, reducing prey/food abundance, and increasing intra-and inter-specific competition (Gillespie, 2011). Similarly, it does not quantitatively differentiate the potential adverse effects from either physiological response other than those that arise from changes in DO concentration, or non-physiological effects from changes in DO concentrations, and/or other effects from other water chemistry changes. To the District's knowledge, quantitative relationships between and among these factors for the Covered Species do not exist. Individually, they are assumed to be small relative to the physiological effects associated with DO reductions in the spring flows, but in aggregate and cumulative form, they may produce some appreciable amount of additional adverse effects. Further, again for simplicity, that portion of the Barton Springs salamander population with habitat that is inaccessible from the surface and therefore not accounted for directly in the City of Austin's censuses but that may be adversely affected is considered to be included in this expression of the size of Barton Springs salamander population at the perennial outlets. In absence of relevant data, the District has assumed in this HCP that the use of the mean-plus-one-SD metric accounts for all portions of the population that would be adversely affected, whether by lethal or sub-lethal effects.

For the non-perennial Upper Barton Spring, since the entire surface habitat is lost when the combined Barton Springs flows decrease below 40 cfs, its entire stipulated population is adversely affected; the mean-plus-one-SD metric representing that population is 18.

<u>Austin Blind Salamander</u>
The surface-habitat censuses of the Austin blind salamander conducted by the City of Austin (and that are useful for its covered activities) are not considered to accurately reflect the entire population of that subterranean species. For this reason, the mean-plus-one-SD approach used for the Barton Springs salamander is not appropriate for estimating

the population of this species adversely affected. As explained in Section 3.2.2.2.1, the District has made an evaluation of the size of this cryptic population by using a set of inferences and assumptions that yields a first-order approximation of the population size for purposes of this HCP. Accordingly, the District had designated this "stipulated population" of Austin blind salamander that encounters adverse effects and its distribution among the perennial outlets to be as shown in Table 5-7 below.

Table 5-7: Total stipulated population of Austin blind salamanders distributed by spring outlet.

Perennial Outlet	Stipulated Population
Main (Parthenia) Springs	877
Eliza Spring	111
Old Mill Spring	12
Total Stipulated Population	**1000**

5.2.3.2 Apportionment of Take to Adversely Affected Populations

In order to quantify actual take, the District has developed a monthly "take factor" that is applied to the stipulated population of each Covered Species during those times when both natural springflow variations and reductions in springflow caused by the Covered Activities are producing adverse effects. As described in this subsection, the District has determined that about 32 Barton Springs salamanders and about 38 Austin blind salamanders are taken on average each month that the natural springflow at Barton Springs, without the Covered Activities, would have been below 20 cfs.

To arrive at these factors, the District has integrated the laboratory results described in Section 5.2.1, long-term field observations, its regulatory program requirements, and statistical modeling to calculate the portions of the adversely affected populations that represent take, both in individual droughts of specified characteristics and cumulatively over the term of the ITP. A step-wise model and an implementing series of spreadsheets were developed to facilitate the numerous calculations on which these estimates are based (Appendix J). This model and its spreadsheets provide detailed information on the rationale and basic structure of the methodology and the calculations that are used to inform this and the following sections of the HCP. Those seeking more information should refer to this appendix. Additionally, the actual spreadsheets will be made available for public download from the District website after the District submits its ITP application and Draft HCP.

As described in detail in Appendix J and summarized here, the District has quantitatively established the following components used in the take analysis:

a. Groundwater Management Scenarios

   1. Exempt-only Pumping – a baseline scenario that produces spring flows without effects of the Covered Activities (nonexempt permitted pumping).

2. Pre-HCP – a scenario that represents conditions that existed in 2004, just before the HCP program was initiated.

3. HCP – the proposed conservation program for the Covered Activities, with all proposed HCP measures to avoid, minimize, and mitigate take of the Covered Species.

b. Reference Droughts

1. Drought of Record (DOR) – the Extreme Drought of the first seven years of the 1950s, as previously described.

2. Recent Severe Droughts (RSD) – a series of three severe droughts from mid-2005 to mid-2012, which contained the groundwater drought in 2009 that produced the lowest Aquifer water levels since the District was formed in 1987 and the 2011 drought that produced the driest, hottest single year in Texas history.

3. Hybrid Drought – a synthetic seven-year drought that was defined for this HCP and that combined springflows from the DOR and the RSD on a month by month basis, with DOR springflows weighted twice those of the RSD. The District considers this the worst drought reasonably expected to occur during the 20-year term of the ITP.

Figure 5-5 presents the recurrence frequency distributions of springflows over the 97-year period of record as they would exist under each of the three groundwater management scenarios. The benefit of the HCP measures when compared to the pre-HCP pumping scenario is particularly noticeable at the smaller springflows when adverse effects occur.

Similarly, the District related measured DO concentrations associated with the various combined springflows using linear regression analysis to develop DO non-exceedence frequency distributions for springflows under the three management scenarios. Each outlet has its own DO-springflow relationship, and therefore the frequency distributions are outlet-specific. The one for Main Springs is shown below in Figure 5-6 as an example; the ones for the other two perennial outlets are similar and are included in Appendix J.

Figure 5-7 focuses on the springflow variations that would be produced by the three groundwater management scenarios during the Extreme Drought conditions of a DOR recurrence and as they relate to the 20 cfs threshold for determining take.

The modeling analyses indicate that three circumstances control whether and how much take occurs during drought:

- Circumstance A, when HCP springflows are above 20 cfs at all perennial outlets, no take related to DO concentrations exists;
- Circumstance B, when HCP springflows are below 20 cfs but the exempt-only pumping baseline springflows would be above 20 cfs, <u>all</u> adverse effects related to DO are attributable to the Covered Activities and are therefore take; and

- Circumstance C, when both HCP springflows and the exempt-only baseline springflows would be below 20 cfs, both “natural variations” and the Covered Activities contribute to the adverse effects, and the adverse effects must be apportioned pro-rata on springflows to differentiate the amount of take from the Covered Activities from the adverse effects of exempt-only pumping.

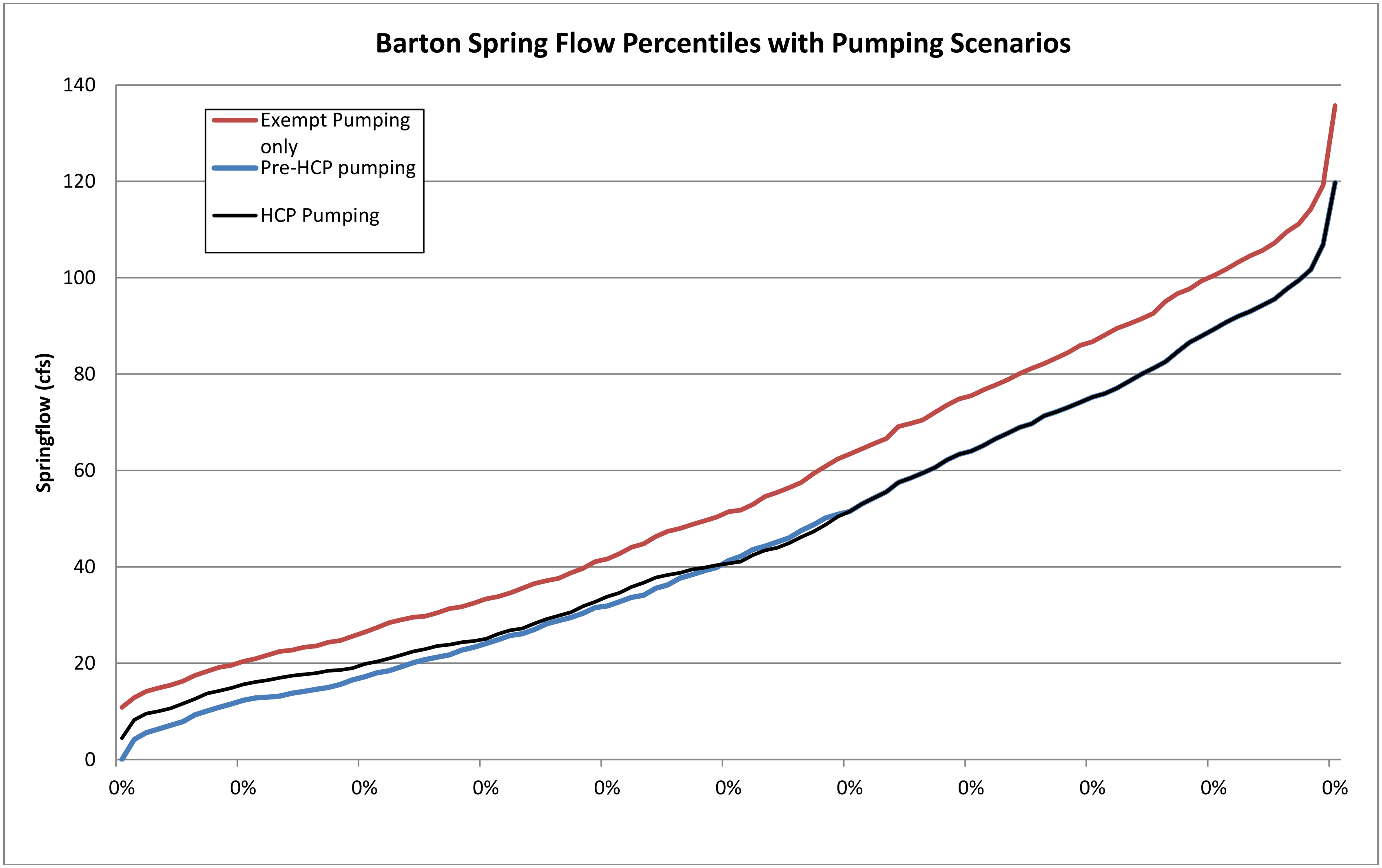

Figure 5-5: Recurrence frequency of springflows less than amounts shown under three groundwater management scenarios. The effect of the HCP conservation measures becomes increasingly more beneficial, especially when compared to the pre-HCP scenario, as the lower-than average springflows continue to decrease, where by design the Covered Species are benefited the most.

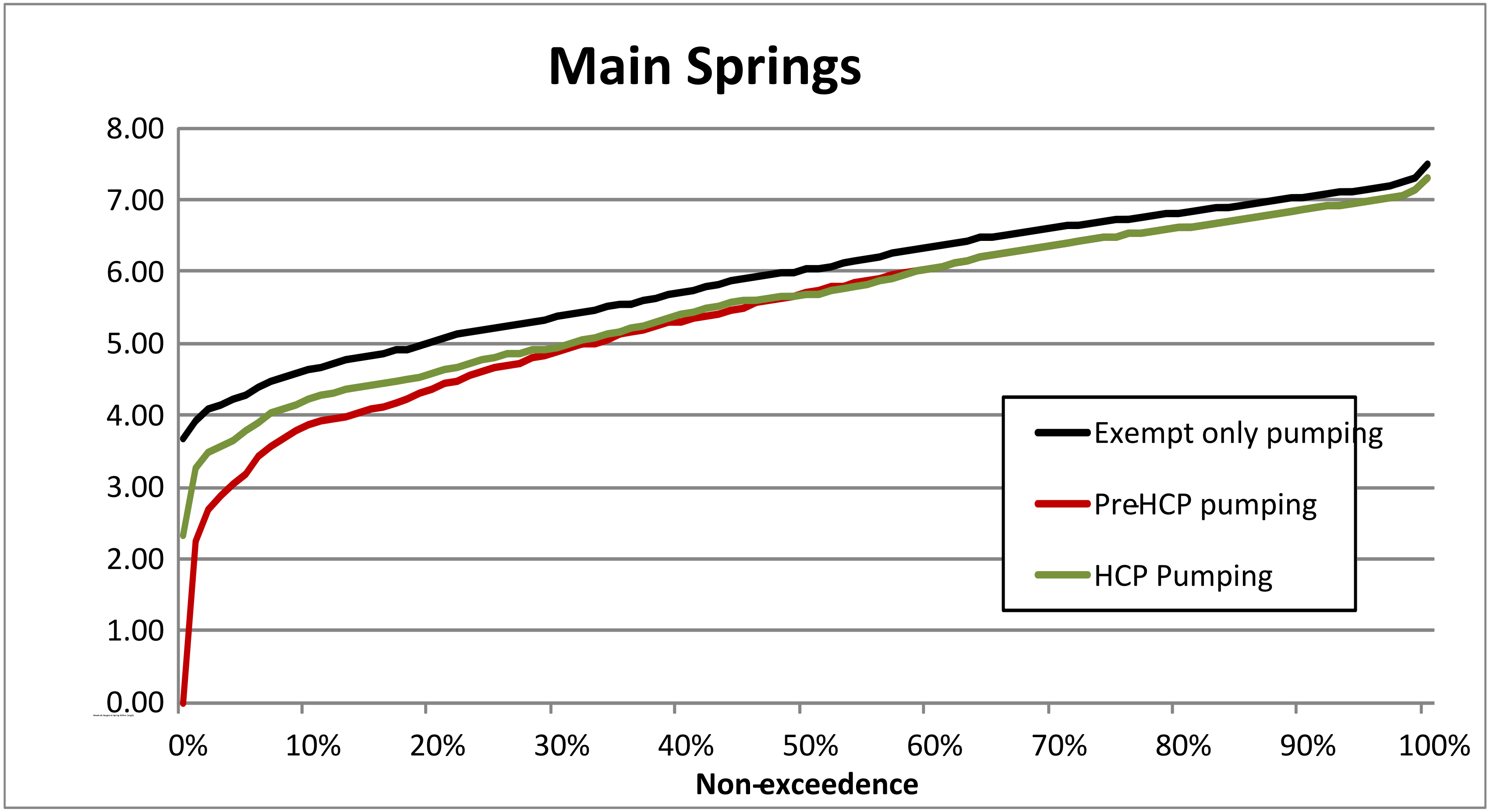

Figure 5-6: Non-exceedence frequencies for DO at Main Springs under three groundwater management scenarios for the period of record.

Non-exceedence frequency is the percentage of time a given DO value is equal to or below a given value. The HCP measures clearly reduce the frequency and associated degree of harm that would otherwise be associated with lower DO as a result of nonexempt pumping.

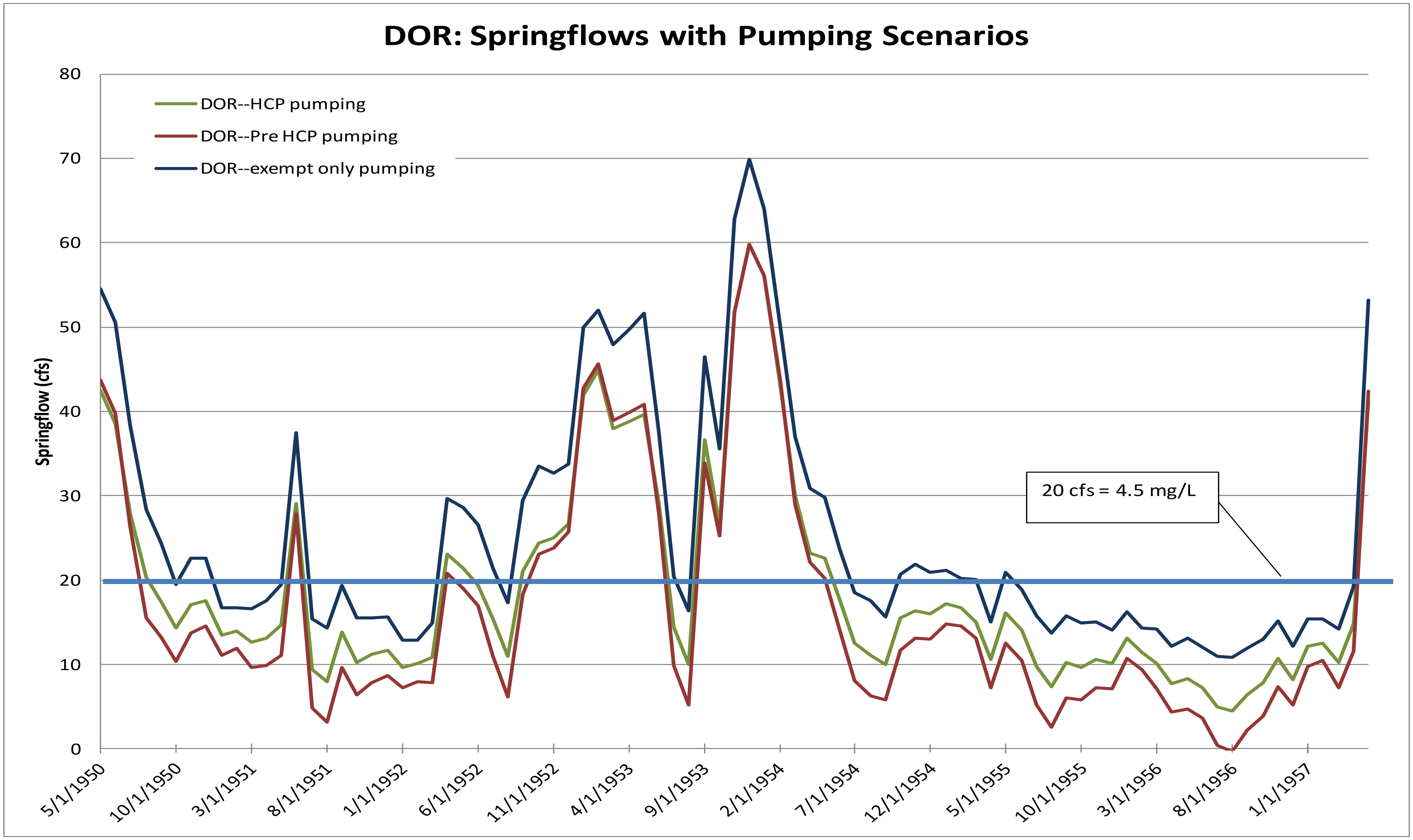

Figure 5-7: Modeled springflows under the Drought of Record
Hydrographs showing effects of three groundwater management scenarios and their relation to the 20 cfs threshold important to take estimates. In the deepest portions of very severe droughts, springflows produced by all three scenarios are below the 20 cfs threshold.

In any prolonged drought, all three of these circumstances are likely to occur at different times, and each of these circumstances would tend to be associated primarily with one of the District-declared drought stages. For example, Circumstance A would be associated with both Stage II-Alarm Drought and No Drought conditions, and Circumstance C would be associated with Stage IV-Exceptional Drought.

Even though the District considers it a remote possibility during the ITP term, the DOR was selected to be the reference drought used to calculate the apportionment factor for Circumstance C and an overall monthly take factor. In reality, each drought period would have a somewhat different monthly take factor, depending on drought duration, depth, and other characteristics like variability, But for simplicity, the District is calculating and using only one take factor in this analysis, a conservative but realistic one that is based on (1) one instance of Circumstance B (above) during the DOR period, and (2) one instance of Circumstance C, with its apportionment factor being the average ratio of monthly HCP pumping to exempt-only pumping over a 35-month period in the DOR when exempt-only springflows were consistently below the 20 cfs threshold (Figure 5-8).   A summary of the calculations used to determine this monthly take factor and its results for both Covered Species are presented in Table 5-8. Using these take factors, the District can estimate the cumulative take of the Covered Species that would occur over the term of the ITP, as discussed below, and also the estimated take during individual droughts that may arise over the next 20 years.

5.2.3.3 Cumulative Take Estimates

The take realized cumulatively over the entire term of the ITP will depend upon the drought conditions actually experienced over that 20-year period. The following cumulative scenario is proposed to be a basis for assessing cumulative take during the ITP term:

Table 5-8: Derivation of Monthly Take Factors For Covered Species During Droughts.
BSS = Barton Springs salamander; ABS = Austin blind salamander. Reference period is May 1954 - April 1957, with 35 months of total springflow below 20 cfs and ratio of Nonexempt Pumping to Total Aquifer Discharge of 34 percent, applied as apportionment factor for Circumstance C

During Reference DOR Take Period	Adversely Affected at Perennial Outlets			Reference Take[1]: All Outlets and Circumstances	Monthly Take Factor[2] (individuals)
	Stipulated Population	Circumstance B	Circumstance C		
BSS	821	821	279 (34% of 821)	1118	**31.9**
ABS	1000	1000	340 (34% of 1000)	1340	**38.3**

[2] This is the estimated total take for the 35 month period at the end of the DOR; includes BSS at Upper Barton Springs
[3] For reporting under the ITP, this is the take that will be assigned to every month with total Aquifer discharges below 20 cfs.

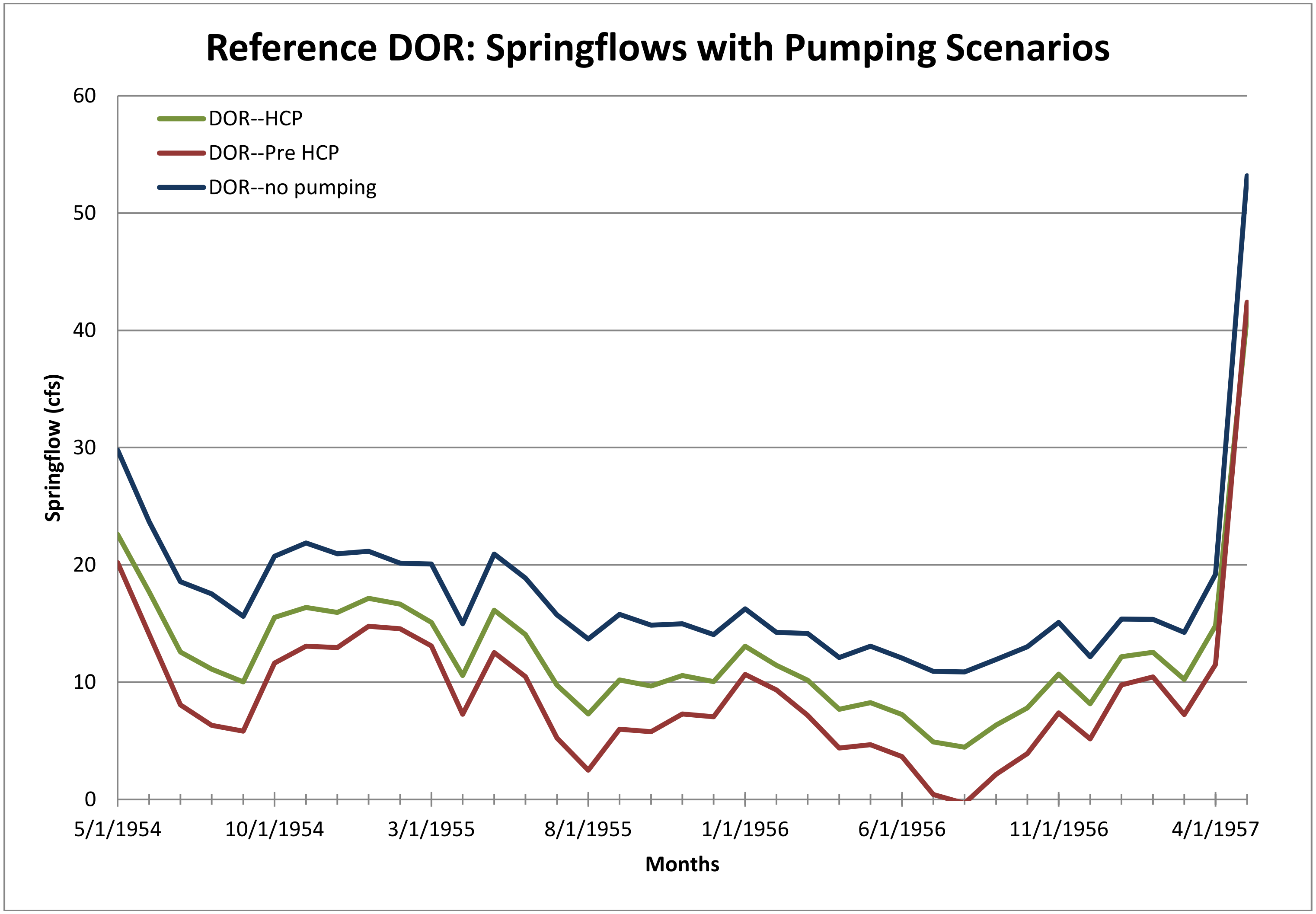

Figure 5-8: Reference period used for computing the take apportionment factor.
This three-year period, deep in the DOR, provided a long-term consistent basis for differentiating take from other adverse effects during the key periods of Exceptional and Extreme Droughts.

1. One (1) seven-year period of Extreme Drought, equivalent to the DOR;
2. One (1) seven-year period of Exceptional Drought, equivalent to the Hybrid Drought;
3. Three (3) years of non-severe drought, in which the Covered Species populations recover to their stipulated populations as modeled initial conditions (shown in Table 5-8 above), and the only take that occurs, nominally each drought year, is to the population at Upper Barton Springs; and
4. Three (3) years of no drought, where no take of any form occurs at any outlet.

This cumulative take scenario is obviously just one possible future for a 20-year period but it is atypically extreme, in the judgment of District hydrogeologists, and therefore a very conservatively worst-case one. For calculating the cumulative take, the District has modeled an initial 3-year period of moderate, but not severe drought, followed by a 7-year period with the Hybrid Drought, followed by a three-year period of no drought, and then ending with the 7-year period of the DOR. From the cumulative take estimate standpoint, the two 3-year periods are interchangeable and the two 7-year drought periods are interchangeable, so the order doesn't matter. This is because the District makes an assumption that either of the three years of no drought or non-severe drought is long enough for the Covered Species to rebound to the initial condition used in the model. However, the City of Austin's continuing low census counts after the recent severe drought period that ended three years ago suggests that at least some if not all outlets may need longer for their populations to recover. The slow recovery and continued low abundance numbers may also be exacerbated by exogenous factors not related to spring flow and/or not caused by the District HCP's Covered Activities, and therefore not considered take.

This scenario yields the cumulative take estimates shown in Tables 5-9 and 5-10, showing the number of individual organisms of each of the Covered Species that are adversely affected either lethally or non-lethally, or both, by the Covered Activities over the 20-year ITP term with the HCP conservation measures in place.

Table 5-9: Summary of cumulative take of Barton Springs salamander for 20-year ITP.

Drought/Springflows	No. Months below 20 cfs	Take/Month	Total Take
3 Years above 20 cfs*	0	0	54
7 Year Hybrid	28	31.9	893
3 Years above 40 cfs (no drought)	0	0	0
7 Year DOR	61	31.9	1946
Cumulative Total for ITP			**2893**

**assumes Upper Barton Spring goes dry and take of 18 individuals each year*

Table 5-10: Summary of cumulative take of Austin blind salamander for 20-year ITP.

Drought/Springflows	No. Months below 20 cfs	Take/Month	Total Take
3 Years above 20 cfs*	0	0	0
7 Year Hybrid	28	38.3	1072
3 Years above 40 cfs (no drought)	0	0	0
7 Year DOR	61	38.3	2336
Cumulative Total for ITP			**3409**

The actual amount of take that is incurred in any multi-year drought scenario will depend, other factors equal, on the actual initial size of the populations when the drought period begins. As these species' populations are typically variable, the take could be less than the amount shown, since the initial conditions used in this analysis are a best estimate corresponding to stipulated population sizes at or near the top of a cycle. The distribution of the take with time within the seven years of the severe droughts will depend upon the variability of their meteorological and hydrological conditions; it is no more likely that it will be spread evenly across the seven-year time span as it will occur over one or two years in that span.

The effect of the activities covered by the City of Austin's ITP, including specifically its HCP's conservation measures, must also be considered in the District's cumulative take estimate and impact assessment, and in the Biological Opinion by the Service. The City of Austin's covered activities are programmed, mostly recurring activities but many are subject to postponement or cancellation during periods of time when the Covered Species are under duress from natural or anthropogenic causes. While also subject to annual limits, the total cumulative take during the City of Austin's 20-year ITP is 38,365 Barton Springs salamanders and 1,025 Austin blind salamanders, reflecting the recurring, frequent, episodic, and to some extent discretionary covered activities associated with the City of Austin's HCP. The District's cumulative take estimates for its Covered Activities, which are continuous and largely non-discretionary, are 2,893, or 7.5% and 3,409, or 333% of the City of Austin's cumulative take of Barton Springs and Austin blind salamanders, respectively. (The disparity between the species is caused by the City of Austin's activities' causing take of only the incidental numbers of Austin blind salamanders in the epigean environments of the outlets, rather than affecting the entire subterranean population as the District's Covered Activities potentially do.)

However, in reality the City of Austin's and the District's takes are not likely to be completely contemporaneous and cumulative with each other. At those times when the District's take and its impact are at a maxima, the City of Austin is likely to have suspended, postponed, or cancelled its pool *maintenance* operations under the terms of its HCP/ITP (although the recreational activities may continue), and the City of Austin's take at those times will be near a minimum. Further, the City of Austin's committed mitigation measures will benefit the Covered Species even though not all of its covered activities are underway. The District and the City of Austin will strive to minimize all such cumulative impacts and memorialize those commitments and needed actions in the prospective Memorandum of Understanding/Interlocal Agreement (MOU/ILA) between the two government agencies.

5.2.3.4 "No Appreciable Reduction" Analysis

The effects of the incidental take associated with the Covered Activities must not appreciably reduce the likelihood of the survival and recovery of the Covered Species in the wild, per the Service's ITP issuance criteria (Section 2.3.2). The analysis of this criterion, designated by the Service as jeopardy, is referenced to the baseline conditions that include the incidental take of the same species from other activities under any other HCP as well as the avoidance, minimization, and mitigation measures associated with it.

As severe droughts deepen into Exceptional and Extreme Droughts (as defined in this HCP), the form of take changes from a principally non-lethal to lethal character. This phenomenon is characterized in detail in Appendix J and only highlighted in this section. The estimates of incidental take associated with the Covered Activities, even with the conservation measures in place but especially without those measures, indicate that during severe drought, the additional reduction in spring flows due to pumping, without mitigation, may have a disproportionate effect on mortality associated with physiological-related take (Figure 5-9, for the Barton Springs salamander during a *reasonably worst-case* seven-year Hybrid Drought). This effect is related to the non-linearity of changes in the DO concentrations in that domain, as shown in the lethal concentration curve in the preceding Figure 5-3. It also reinforces the importance of the conservation measures in avoiding, minimizing, and mitigating such losses.

Generally, the losses associated solely with natural flows and exempt-only pumping, i.e., without the Covered Activities, increase substantially as the droughts deepen and become more extreme. Figure 5-10 shows that the losses with the HCP measures, including the spring-run re-aeration improvements, are not much different than the losses without the Covered Activities during a recurrence of the DOR, which as previously mentioned is considered a worst case that is not reasonably expected during the ITP. And losses with additional mitigation, such as the DO augmentation projects proposed in this HCP as conditional mitigation, would actually be smaller than those that would occur without the Covered Activities.

Further, as suggested in Figure 5-10, because the earlier pre-HCP management scenario is essentially tantamount to a dire adverse situation for the Covered Species, possibly including extirpation, <u>any</u> groundwater management measures that minimize or mitigate take such that the situation is less adverse than it otherwise would be should not generally be considered to appreciably reduce the likelihood of survival and recovery of the species. This assertion is germane *even if those beneficial actions otherwise might jeopardize their survival and recovery*. The HCP for the Edwards Aquifer Recovery Implementation Plan (EARIP) in the Southern segment of the Edwards Aquifer reached a similar conclusion.

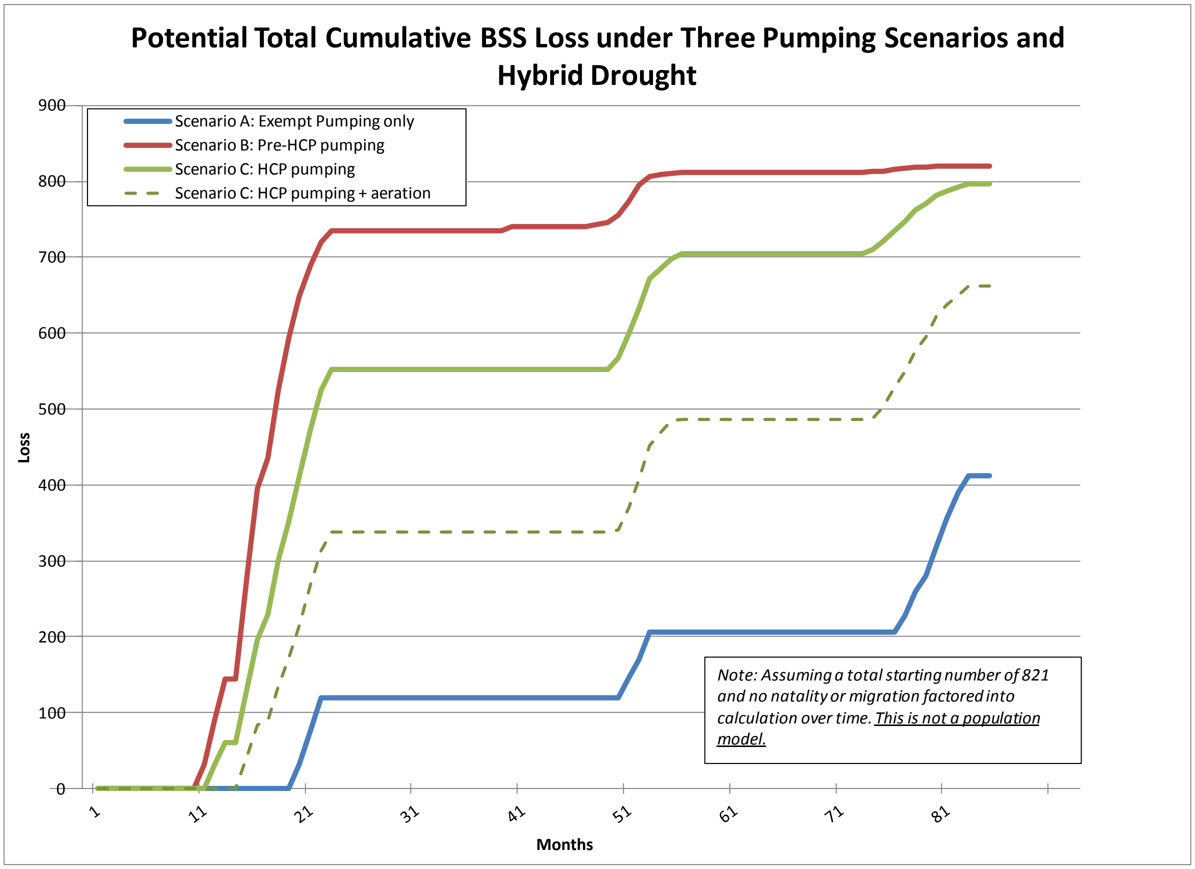

Figure 5-9a: Cumulative loss of Barton Springs salamander during prolonged, severe drought under three groundwater management scenarios.
These results are not based on a population model, rather are a comparison of the specific effects of three alternative sets of conservation measures for Covered Activities. The dashed line takes into account in a conservative fashion the potential benefit (at only +0.3 mg/L DO) of committed re-aeration projects ("day lighting" at Eliza Spring and spring-run rehabilitation at Old Mill Spring, only) under the City of Austin's HCP, a baseline condition for the District's HCP.

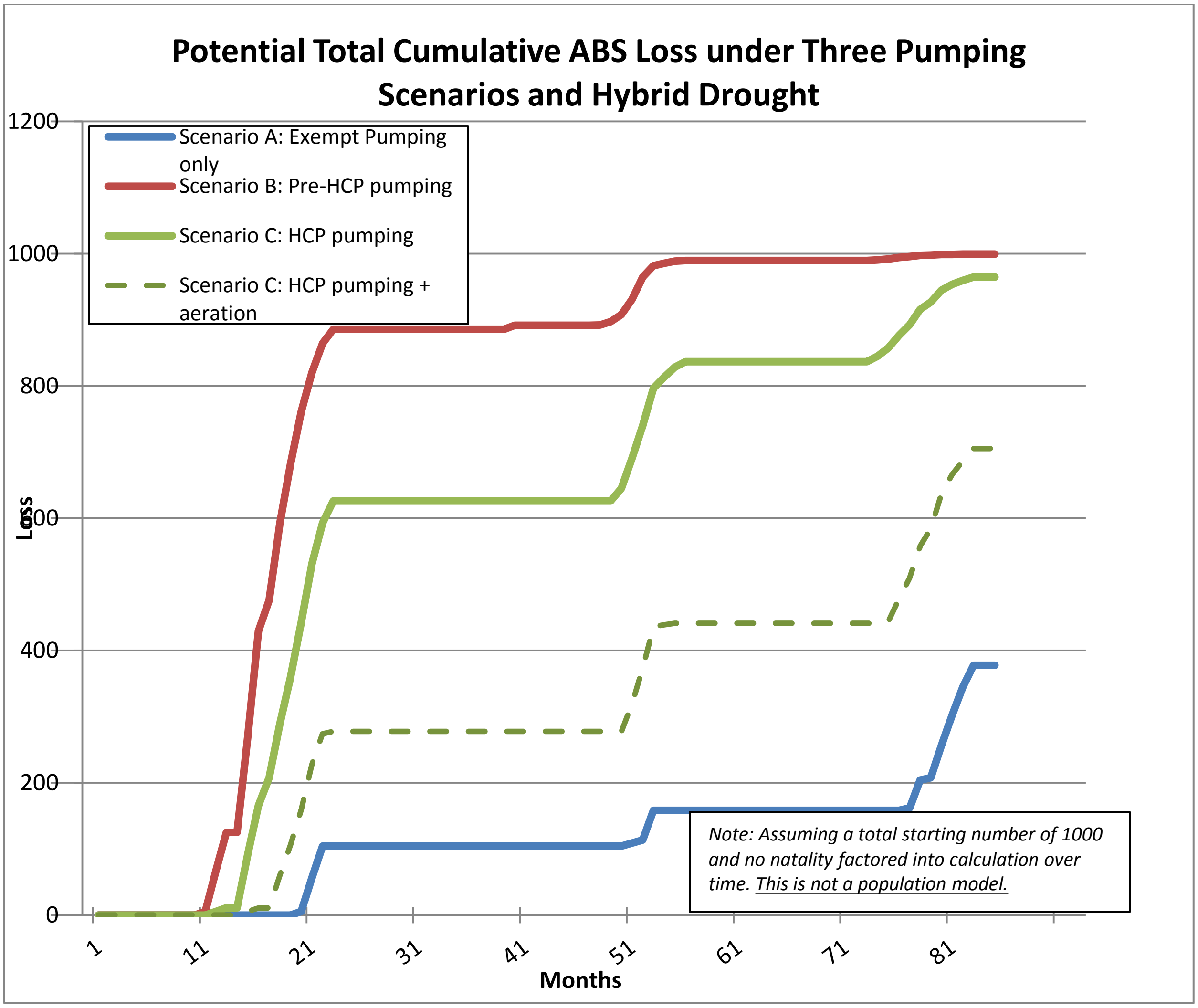

Figure 5-9b: Cumulative loss of Austin blind salamander during prolonged, severe drought under three groundwater management scenarios.

These results are not based on a population model, rather are a comparison of the specific effects of three alternative sets of conservation measures for Covered Activities. The dashed line takes into account in a conservative fashion the potential benefit (at only +0.3 mg/L DO) of additional aeration provided by subterranean migration to higher DO areas at or near the water table in the vicinity of all three outlets.

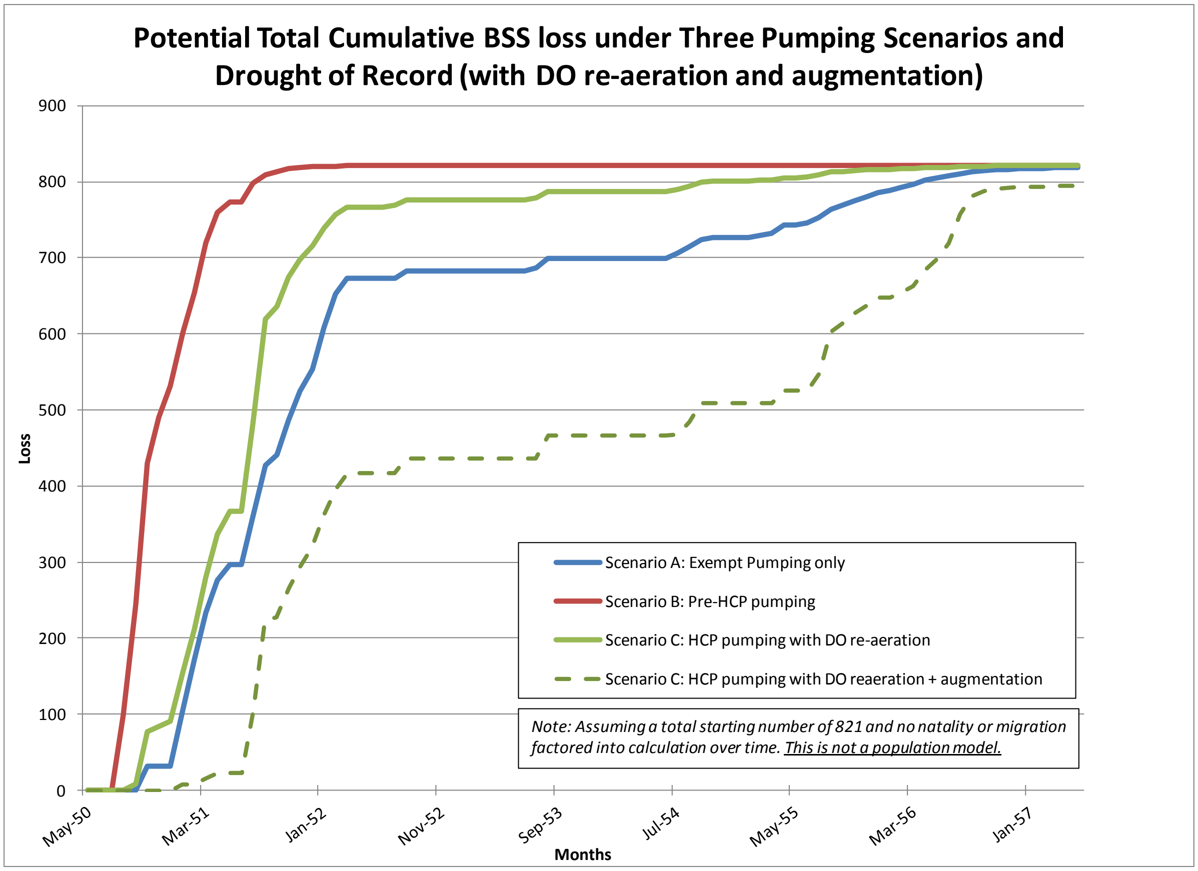

Figure 5-10a: Cumulative loss of Barton Springs salamander during DOR conditions under three groundwater management scenarios.

These results are not based on a population model, rather are a comparison of the specific effects of three alternative sets of conservation measures for Covered Activities. The solid HCP line takes into account planned DO re-aeration from spring-run improvements (+0.3 mg/L), and the dashed HCP line illustrates the effect of a modest amount of DO augmentation (at +0.5 mg/L DO) as proposed mitigation, improving estimated losses relative to the exempt-only pumping scenario.

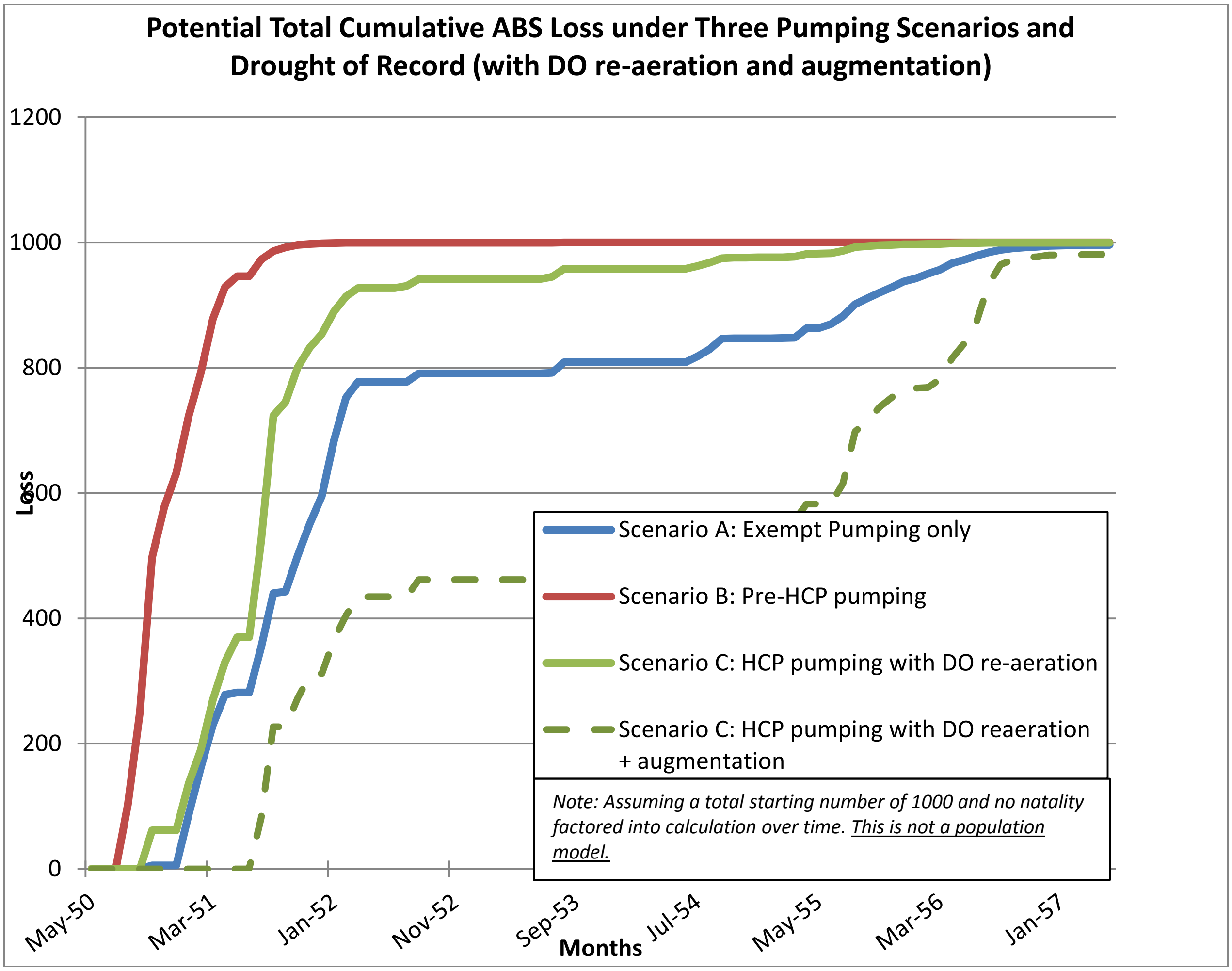

Figure 5-10b: Cumulative loss of Austin blind salamander during DOR conditions under three groundwater management scenarios.
These results are not based on a population model, rather are a comparison of the specific effects of three alternative sets of conservation measures for Covered Activities. The solid HCP line takes into account a modest amount of natural aeration from subterranean migration to higher DO conditions at the water-table (+0.3 mg/L), and the dashed HCP line illustrates the effect of a modest amount of DO augmentation (at +0.5 mg/L DO) as proposed conditional mitigation, improving estimated losses to be very similar to the exempt-only pumping scenario.

This HCP has noted elsewhere the many uncertainties, assumptions, and stipulations required in making a quantitative take estimate for these Covered Species by these Covered Activities. Several of these in particular bear on the likelihood of an appreciable reduction in survival and recovery, and are discussed below.

<u>Probabilities of recurrence of the modeled droughts</u> – The take estimate includes modeling of both a reasonable worst-case drought scenario for the 20-year ITP term (the Hybrid Drought) and an unreasonable worst-case drought scenario for the ITP term (the DOR). It is considered very unlikely that the adverse effects in the modeled cumulative scenario

would be manifested during the ITP. However, an Extreme Drought such as the DOR, while not considered *per se* a reasonable basis for take estimates, could be considered part of an assessment of jeopardy. But the DOR has been estimated to have a recurrence frequency of 100 years. The seven-year reference droughts (See 5.2.3.2 for reference drought definitions) utilized in this HCP have the following probabilities of occurrence during the 97-year of record used by the District in calculating recurrence frequencies:

Recent Severe Drought (2005-2012)	57%
Hybrid Drought	11%
Drought of Record (1950-1957)	1%

The likelihood that the Hybrid and DOR events considered here would occur in any single 20-year period within that 97-year period of record is much smaller even than those shown. In particular, it is so unlikely that there will be a DOR recurrence in any given 20-year period that its improbability must be taken into account when judging the likelihood of the risk of an appreciable reduction in survival and recovery.

Migration of animals to less-stressful portions of the habitat – The modeling used for the take estimation purposefully included only in a minimal fashion the reasonable likelihood but unquantifiable extent that both species would migrate to areas adjacent to the outlets where DO was higher and DO-related stress was lower. It seems reasonable that some portion of the Austin blind salamander population will move from the immediate vicinity of the outlets where depressed DO is measured to adjacent connected areas within the Aquifer, especially to subterranean areas at or near the water table with its atmospheric interface and generally higher DO, as previously discussed. In addition, the proposed DO augmentation project that is a conditional mitigation measure may provide supplemental benefits in the vicinity of the outlets. For the Barton Springs salamander, the benefit from re-aeration created by the planned but not yet available spring runs and by the conditional DO augmentation that is a potential mitigation measure has also been conservatively estimated in the cumulative loss evaluations. Sensitivity analyses conducted for this HCP, indicated in the results shown in Figures 5-9 and 5-10, suggests that the benefits of the population experiencing a larger but still relatively small amount of DO stress relief are disproportionately large, especially in that the mitigation provided by DO augmentation reduces cumulative losses to about the same or below the losses accompanying the baseline condition of exempt-only pumping.

Benefit of evolutionary life-history strategies - The Covered Species have population characteristics and individual organism traits that appear to represent more an "opportunistic" than "equilibrium" life-history strategy[9]. Some of these population characteristics include: relatively large swings in population sizes over multiple-

[9] These terms have been used as short-hand descriptors for a complex set of evolutionary life-history causative factors that in reality are not uniformly one paradigm or the other, and/or that may differ for different life-stages. A more mechanistic demographic framework includes interactions among age-specific mortality, density-dependent regulation, predation risk, as well as density-independent factors such as extrinsic mortality, resource availability, and environmental fluctuations (Reznick, et al., 2002). A model of this framework accounting for these many interactions for the Covered Species is not available.

generation time periods, rather than smaller fluctuations around a mean that is a defined "carrying capacity;" rapid growth and development of individual organisms; numerous offspring at a time; reproduction that is more or less continuous if environmental conditions are not limiting; and lack of post-natal and parental care (which otherwise would emphasize and promote better competition by individual offspring rather than depending on a "numbers game"). That connotes an evolutionary development in response to the not infrequent occurrences of disturbances like droughts and floods in their spring flow-dominated endemic environment, which cause rather indiscriminant, density-independent mortality and then recovery of the residual population from the temporally variable availability of resources in their habitats (Pianka, 2000). Opportunistic species generally may accommodate larger adverse effects related to constrained resources (such as lower DO, within limits) that governed their evolution without jeopardizing the species more than could equilibrium species.

> This aspect of the populations of the Covered Species may have been a key to the survival of the species during multiple prolonged and severe drought conditions through the millennia, and therefore to avoiding jeopardy. The pre-eminent dendrochronologist for the HCP area, Dr. Malcolm Cleaveland, recently noted, "When you study the historic record [as revealed by tree-ring data], you see there were multiple ten-year droughts worse than the so-called '50s DOR. There was a period in the 1500s and another in the late 1600s that make the 1950s look wet. You are going to have at least one major drought every century if you study the data." (Rivard, 2014).

In the long run, all of these factors are believed to militate against an appreciable reduction in the likelihood of survival and recovery of the Covered Species, which is one of the ITP issuance criteria (Section 2.3.2).

5.3 Impact of Take on Covered Species Populations

5.3.1 Assessment of Population Impacts

This section of the HCP contains a narrative summarizing the findings and conclusions of the District concerning take and mortality, and also an assessment of the consequences of the take on the Covered Species populations. There is considerable duplication with information presented in previous subsections and the appendices, as this is intended to be a stand-alone section.

In this habitat setting, the Covered Species are subjected on a recurring basis to highly variable springflows, accompanied at the lower flows by naturally smaller DO concentrations at the individual outlets having a direct correlation to springflow. During such times, data show the number of individuals observed diminishes in size, which is likely a combination of mortality of individuals, i.e., population reduction, and migration to areas in and near the spring outlets that are less accessible for observation. These low springflow episodes during drought are followed by extended periods of time of much higher than average springflow and the rapid return of DO to more normal ranges. The epigean Barton Springs salamander population is observed to increase substantially during these flow recovery periods after an apparent lag period of about six months, although the amount and rate of increase differ among the individual spring outlets and are also dependent on the timing of the droughts to one another. Rebound has been significantly retarded after the most recent droughts at all outlets but especially Old Mill Spring. In this situation, it is difficult to discern unequivocally an overall trajectory concerning either of the species' population's robustness with time; it varies naturally with the time step selected and its meteorological drought conditions, on which groundwater withdrawals by wells are overprinted. Some City of Austin biological staff members have recently hypothesized that the salamander population(s) may have established a new, smaller equilibrium population, with a lower average size and about which the population fluctuates in a more restricted fashion (City of Austin, 2013). This would constitute a remarkably rapid shift away from a population with more opportunistic life strategy characteristics toward one characterized more by an equilibrium life strategy.

Organismal responses to chemical stressors are inherently linked to the magnitude, frequency and duration with which organisms are exposed to the stressor(s) (Newman, 2009). For the Covered Species, data indicate that DO stress represents the primary factor influenced by the District's activity. But there is only a limited amount of protection for the Covered Species from regulatory institutions with respect to DO. In the State of Texas, surface water quality standards are intended to protect aquatic life and uses of surface-water bodies, and DO water quality criteria for high aquatic life use is historically defined by either lotic (rivers and streams) or lentic (lakes and reservoirs) habitats (Brooks et al., 2008). For example, a 24-hour DO minimum (3 mg/L) that does not extend beyond 8 hours and a 24-hour minimum mean (5 mg/L) during a 24-hour period is employed for lentic systems (TCEQ, 2003). However, habitats supporting the Covered Species are neither river nor lake, but aquifer, spring runs, and spring-fed pools. The current understanding of the oxygen requirements of the Covered Species (Woods et al., 2010) does not allow for a confident determination of whether existing DO criteria and standards are adequate to protect these spring-fed habitats. Similarly, in spite of the innovative investigations and adaptive management practices associated with the District's HCP, the protections provided by the HCP measures are also uncertain.

This is not an unusual circumstance. Environmental assessments of stressor-response relationships for threatened and endangered species are consistently limited by lack of experimental data for the covered species. In such cases, use of surrogate species is commonly employed owing to limited availability of protected species. Because closely related species are not necessarily common, United States Environmental Protection Agency (US EPA) developed the Web-based Interspecies Correlation Estimation (Web-ICE) to assist with such efforts (http://www.epa.gov/ceampubl/fchain/webice/). Unfortunately, data for aquatic salamanders within this software are not available, which prevented its application for the Covered Species. Further, before initiation and development of this HCP, a quantitative understanding of DO stress on *Eurycea* (and other salamanders) was poorly understood. Thus, to assess the suitability of San Marcos salamander serving as a surrogate for Barton Springs salamander, a laboratory stressor-response study was initiated to define metabolic rate relationships between Barton Springs and San Marcos salamanders (Woods et al., 2010). Owing to these metabolic rate data and also genetic and life history similarities between those two species (Chippindale, et al., 2000), San Marcos salamander was selected as a surrogate species for DO stressor response studies of relevance to the Covered Species (Woods et al., 2010). Use of this surrogate species for assessing take impacts on the Barton Springs salamander in particular seems well founded.

Survival and growth responses to stressors have high relevance to the population level of biological organization and are thus routinely employed as measures of effect to support ecosystem protection goals defined within ecological risk assessments (Suter, 2006). For DO, an adverse outcome pathway (AOP) framework can be used to examine stress caused by hypoxia and resulting impacts to individuals and populations of Covered Species (Figure 5-11). This AOP illustrates the large amount of information required to make confident judgments of stressor-response impacts in real-world settings but which for the most part currently does not exist in this instance; at the same time, it indicates specific areas of additional fruitful research.

To examine responses to DO by a surrogate species, Woods et al. (2010) identified mortality and growth DO thresholds during a 28 d study with adult and a 60 d study with juvenile San Marcos salamander, respectively. As described in Section 5.2.1 above, 60 d NOAEL for juvenile growth was 4.4 mg/L and a 28 d LC_5 estimate for adult mortality was 4.5 mg/L. These findings from Woods et al (2010) appear to represent the most robust data available for DO stress to any aquatic salamander, and thus provide a reasonable foundation for interpreting DO risks to the Covered Species. Nevertheless, these are the result only of controlled laboratory-based research investigations, not extensive field investigations.

The scientific investigations and analyses conducted for this HCP indicate that the salamander is not adversely affected by DO at 4.5 mg/L or above, and is only mildly

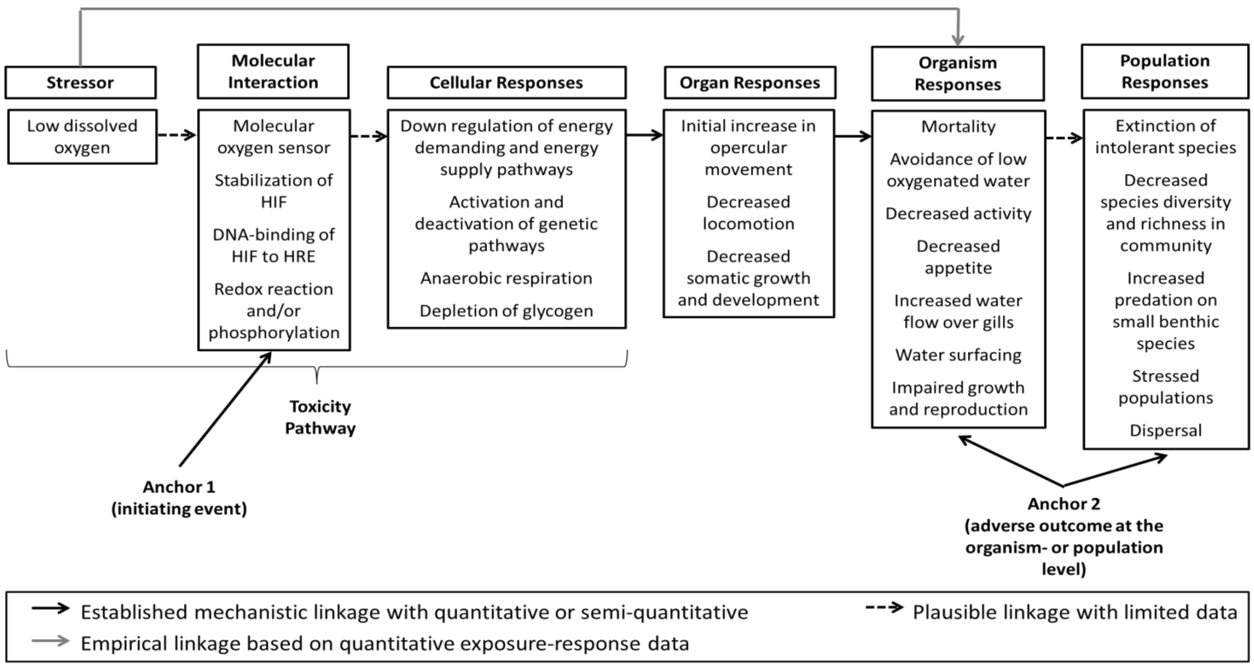

Figure 5-11: A proposed adverse outcome pathway (AOP) in the Covered Species for dissolved oxygen.

This AOP represents a conceptual model linking a molecular initiating event to adverse effects at higher levels of biological organization. Source: Modified from Saari and Brooks (2014).

affected by DO concentrations slightly lower, at 4.2 mg/L. Using available field and experimental data and inference, take is indicated to begin at about 20 cfs of springflow, which over the 97-year period of record would have occurred about 20% of the time, even with the proposed HCP measures in place. If DO declined to 3.9 mg/L for an extended period of time, lethal take as individual salamander mortality could be expected to be noticeable and of concern; if DO were to decline to less than 3.4 mg/L, the situation could be dire for individual salamander organisms, and if prolonged *without the mitigation as proposed in this and the City of Austin's HCPs*, for the population and recovery of the Covered Species. Given the ecological setting and the population characteristics, take under the District HCP must be inferred rather than directly observed, and the discharge-duration of flow at Barton Springs is a rational proxy for DO concentrations to be used for assessing take.

In addition to the physiological-related direct and indirect effects of DO reductions on the Covered Species, another potential source of incidental take is the small reductions in the wetted habitat area that might otherwise be attributable to the Covered Activities ("small" especially relative to habitat reductions attributable to "natural drought" conditions). However, the City of Austin's ongoing habitat restoration efforts are not yet implemented and therefore preclude the District's describing quantitatively the "new" wetted habitat, which will form a new baseline condition for the District's HCP. Consequently, it has not been possible to make an assessment of how much, if any, of the "new" habitat could be changed by pumping-induced springflow reductions at the reconfigured perennial springs during severe drought. In any event, these effects would likely be a more important factor to a dominantly density-dependent equilibrium species than to these species, where habitat size is less of a concern than habitat conditions. As noted above, the additional wetted habitat and re-aeration provided by re-establishing the spring runs would also tend to offset any concerns for the Covered Species arising from drought-induced wetted habitat loss, if any, at the perennial spring outlets.

The measures now proposed under the HCP are more protective of the springflows than any of the previous alternative management scenarios and, in fact, are believed to be the most protective that can be applied under current law and with the current state of knowledge. Nevertheless, during a repeat of the DOR and under the District's most stringent pumping-curtailment program, springflows as cfs will likely be in the mid- to high single digits, which would be unprecedented in the historical record. The DO concentration of such a spring-flow regime and the level of salamander mortality and the disruption of salamander life activities associated with that event are unknown, but will probably be appreciable, which simply underscores the importance of the proposed mitigation measures. The desired future condition (DFC) of ensuring that springflow during a DOR recurrence is no less than 6.5 cfs has been established by the District as its primary groundwater management objective, representing a balancing among various risks and uncertainties and also curtailments that are at the maximum extent practicable. The proposed HCP conservation measures intended to minimize and mitigate take and to avoid jeopardy are reasonably expected to achieve those objectives.

The foregoing discussion notwithstanding, in an absolute sense there is so much variability and uncertainty in this ecological system (as suggested by the AOP of Figure 5-11 above, and as elaborated further in Section 5.3.2 below) that they preclude making conclusive determinations regarding effects on organisms and impacts on the populations based upon empirical observations of the Covered Species. But in any event, it is also clear that the District HCP implements management and conservation measures intended on the basis of sound science to reduce risks of DO stress to the Covered Species, particularly those associated with naturally occurring severe droughts, more than would otherwise exist.

5.3.2 Uncertainties in Take and Impact Evaluations

These estimates of mortality are considered useful approximations that are based on a number of assumptions and stipulations to account for uncertainties. Many of the more important of these uncertainties have been discussed in various preceding subsections of the HCP; they and others are summarized below, in no particular order, in one place in this document, to facilitate identification and appreciation of their scope and significance to the take and mortality estimates and ultimately the avoidance-of-jeopardy determination.

Effect of All Recharge Sources on Groundwater Declines

The groundwater modeling described in Section 3.2.2.1.2 may not have explicitly included the effects of all significant sources of groundwater recharge on the recession of the Aquifer during severe drought. Recent information suggests that the 1:1 correspondence between pumping and springflow, on which the springflow analysis in this HCP is based, may be less than 1:1 during severe drought, in which less springflow reduction would be produced for a given unit of pumping. This uncertainty is conservative toward springflow and its calculated DO, but the actual DO regime associated with that extended recession curve is unknown.

Durations of Springflows Expressed as Other Than Monthly Averages
The natural flows of Barton Springs as well as the aggregate amount of pumping change very slowly during a prolonged, severe drought, and recurrence for these flow durations would be very similar to those for weekly or even daily flow durations. As discussed in Section 3.2.2.1.1, actual flows expressed as shorter flow durations would tend to increase the percentage of time at or above a given low springflow, because the changes would be derived primarily from storm events that in the shorter-term increase springflow.

Likely Differences Between Authorized and. Actual Pumpage by Permitted Groundwater Users
The relationship between pumping and springflow that was modeled for the HCP was based on use of the entire authorized amount each month by each permittee, which is a conservative assumption in the HCP. Even though curtailments during drought are more likely to increase the fraction of curtailed use represented by actual use, the District's recent experience in drought management indicates that actual use is still below the authorized curtailed usage otherwise permitted (Figure 3-9).

Springflow-related Factors Other Than Dissolved Oxygen Concentration
The District's Covered Activities, viz., managed pumping of the Aquifer, can only affect those physical and chemical habitat factors directly related to springflow. Of these, only DO was modeled, inasmuch as the quantitative influence of other factors, other than temperature, has not been established. Temperature variations are less controlled by the amount of springflow and more related to seasonality or the amount of higher stormflows in the springflow (Mahler and Bourgeais, 2013), neither of which are controlled by the Covered Activities; prolonged drought tends to reduce the amount of temperature variations in springflow. Concentrations of ionic constituents do exhibit some variation with springflow but even the highest are well within the freshwater range and vary over a rather narrow range of about 100 mg/L TDS (Herrington and Hiers, 2010), for which no physiological or behavioral changes have been attributed, even for non-adult life stages of the Covered Species.

Covered Species Population Size and Distribution
Because of their cryptic nature, spending an appreciable portion of their time in subterranean or otherwise inaccessible epigean habitats, the population sizes of both of the Covered Species have not been firmly established. This is especially pertinent to the Austin blind salamander, for which only a small part of its Critical Habitat is observable.

For the Barton Springs salamander, the District has assumed the maximum in the range of counts at Upper Barton Spring as the number that could be potentially harassed, i.e., non-lethally taken. The population sizes at the perennial outlets are based on the mean-plus-one-standard deviation observed metric that has been used in the City of Austin's approved

HCP for estimating such take. For all outlets, their distribution will vary with time and water chemistry conditions in an indeterminate fashion.

The population size of the Austin blind salamander is simply unknown. It was inferred on the basis of observed density of subterranean salamander species in epigean environments in both Barton and San Marcos Springs, adjustment for areal distribution of presumptive habitat-supporting conduits and fissures at the water table, and then extension to the Critical Habitat size. This approach is accompanied by substantial uncertainty in the overall population size, inasmuch as the incidental epigean density may not be representative of its subterranean density for such subterranean species and because the known habitat of other similar subterranean salamanders is more than two orders of magnitude larger (EARIP, 2012) than the Critical Habitat-designated area for Austin blind salamander.

Another related assumption that was made for both species has to do with the DO regime to which they are exposed and the location of that regime. The indicated DO at the spring outlets was applied to the entire extant populations for both species. The District believes that an unknown but likely substantial fraction of the Barton Springs salamander population will move away from the surface outlet into the subsurface environment to water that has higher DO concentrations, although how much higher is also indeterminate. The re-establishment of accessible spring runs at the spring outlet will, among other things, re-aerate the water and provide a driving force for such migration. Similarly, an unknown but likely substantial fraction of the Austin blind salamander population will either exist normally or move in the subsurface away from the outlet once DO concentrations decrease to stressful levels, seeking subterranean areas with a greater proportion of unconfined water at that outlet that has higher DO concentrations. It is not reasonable to assert that the entire population of either of these mobile species will continue to be exposed to the same DO regime at the outlet at any one point in time when DO stress is high and less stressful environments with higher-DO water are readily accessible to at least a portion of those populations.

However, because this tendency to migrate, the proportion of populations involved, and the degree of stress relief provided are all unknown and presently indeterminate, a very conservative assumption has been made that the entire population has no recourse to being exposed only to the DO at the outlet. Sensitivity analysis by the District in preparing this HCP suggests that such migration of a relatively small part of the population to areas that have slightly higher DO would produce substantially less take during Extreme Droughts like the DOR, other factors equal. The District considers it not unlikely that this may well be a primary mechanism that allows these endemic species to have persisted through many and more severe droughts during its natural history.

<u>Indirect Effects of Pumping on Other Species Important to the Covered Species</u>

The take estimates in this HCP are based on habitat changes as they relate directly to the Covered Species themselves, and not on the macroinvertebrate community on which the salamanders rely for prey (City of Austin, 2013). For example, the effect of depressed DO at smaller springflows on the size and predator avoidance behavior on the population of amphipod or other prey in the habitat has not been evaluated. The District is unaware of a *quantitative* relationship between springflows or DO concentrations and the macroinvertebrate prey that could be compared to the effects on the salamander species. (Given the comprehensiveness of the rest of the City of Austin's Barton Springs Pool HCP, the absence of any documentation of such an applicable relationship in that HCP that could be used in this HCP is telling, if not compelling.) In essence, the District is making an assumption that the macroinvertebrates either are present in sufficiently large population numbers that they are not a limiting factor for the salamanders, or are not impacted physiologically by lower DO to the same extent as the Covered Species, or both. The validity of this assumption is unknown, but it introduces uncertainty that can only be judged qualitatively, not quantitatively presently. The City of Austin has noted that some 100 taxa of macroinvertebrates have been catalogued at the outlets, and while the abundance of the macroinvertebrate community decreases with decreasing springflow, the decreases are not uniform across the entire community (City of Austin, 2013); such diversity would be beneficial to the predator Covered Species. Furthermore, the Covered Species are known as invertevores, which means that they do not discriminate as to what species of invertebrates become their prey, an adaptation that is especially useful in energy production and conservation during drought. Nevertheless, the relationship of springflow, DO, and macroinvertebrate abundance and diversity may be important to cumulative impacts and could be a useful focus of future research, although extreme low flows would be required for proper evaluation in the field.

<u>Non-modeled Differences Between the Two Covered Species</u>

Notwithstanding the differences in population sizes and their locations, for the most part the two Covered Species are considered to react and behave similarly, in absence of data to the contrary. However, Austin blind salamander is in a separate evolutionary branch from both the Barton Springs salamander and the San Marcos salamander that was used in the laboratory studies (City of Austin, 2013), so its similarity in DO stress-response to Barton Springs salamander is not assured. In fact, it seems to spend a substantially greater portion its life in a naturally somewhat lower DO regime than the Barton Springs salamander, so it could be not unreasonably asserted that it might be better adapted genetically to such environments. Again, because the existence, direction, and magnitude of differences in the mortality curves for the two species are indeterminate, no differences in the Austin blind salamander's lethality from that of the Barton Springs salamander is assumed in the modeling, which the District suggests may tend to overstate its mortality at a given DO level. That said, other assertions could be made that no differences are known to exist, and that lack of data requires no difference to be imputed.

<u>Lack of Data on DO Variations at Extreme Low Flows</u>

The relationship between springflow and DO was defined for each outlet by regression equations based on observed Outlet DO-Total Springflow pairs. There were very few pairs below 20 cfs, and no pairs below 14 cfs, which is the zone of most interest to salamander physiology and behavior. Relying solely upon trends established by data only in a higher-flow domain is problematic and introduces additional uncertainty into the modeling (but see immediately below).

Differences in DO Regimes Among the Individual Spring Outlets
Whether and what trends actually exist between DO and springflows and how they differ among the outlets in the extreme low flow realm is currently indeterminate, as the springflows have not been that low since DO measurements were initiated. For the HCP, the markedly different low-flow water chemistry exhibited at Old Mill Spring, in comparison to Eliza and especially Main Springs, along with its resurgence along a different fault (Hauwert, 2009; Johns, 2006) suggested that it might have a fundamentally different relationship in DO-springflow, as is observed in the field. Old Mill Spring was modeled using a different type of regression equation than the other two perennial outlets because of this tendency. But statistically there is not a basis to judge what regression relationship(s) should be used (Porras, 2014; Turner, 2007); in lieu of that, the hydrogeologic settings were used in this selection.

Effect of DO Variations on Other Life Stages
Funding limitations required the laboratory study in this HCP to focus on the life stages of the salamander typically encountered. Most of the stressor-response study addressed adult salamander stages, with a limited investigation of DO stress to juveniles. While these stages may be the lengthier stages and therefore are exposed to the largest range in DO variation, the effect of DO variations on egg and larval forms is potentially also important, but unaccounted for in this HCP. On the other hand, there are no known data or studies that suggest the Covered Species are especially susceptible to such variations of the magnitude introduced by the Covered Activities. This may be an area for future research..

Differences Between Predicted and Observed DO Concentrations
The DO concentrations predicted by the regression equations on total springflow systematically deviated from the DO concentrations actually measured for recent drought springflows by 0.6 mg/L, with the measured DO higher than that predicted (Turner, 2009). Some of this deviation may arise from within margins of variability and error associated with statistical manipulations (Porras (2014) indicates by statistical analysis that this may be on the order of ±0.2 mg/L), or the use of one sub-outlet for DO measurement but all sub-outlets in aggregate for developing the regression relationship, or simply the randomness and variability of any individual environmental event (in this instance, the 2008-2009 drought). But generally, this deviation suggests that some of the uncertainties mentioned in this section, such as the absence of extremely low flow DO data and regression relationships that are consequently skewed, are in fact conservatively accommodated in this HCP, and that actual effective DO is higher than predicted in the take estimate. Alternatively or additionally, this deviation supports this HCP's use of different regression equation families for Main and Eliza Springs than for Old Mill Springs and of using their upper-bound regression coefficients (Porras, 2014).

Application of Laboratory Data to In-the-Wild Conditions
Section 5.2.1.3 discussed the uncertainties in laboratory studies of natural biological systems, noting that the response of test organisms under controlled conditions may not be the same as in the wild.

Cumulative Risk Factors beyond the District's Control

Adverse effects on the Covered Species resulting from anthropogenic water quality changes, e.g., nonpoint-source pollution arising from watershed modification, may be exacerbated by or additive, synergistic, or antagonistic to adverse effects from springflow-related water chemistry changes such as DO variations. These may have significant consequence to the Covered Species, but the District has no control over the existence or magnitude of such factors, so those cumulative effects have not been considered in the take estimate *per se*, in accordance with the Service's guidance. Rather, the impacts of these sources of additional risk are to be addressed in the environmental assessment prepared by the Service under the National Environmental Policy Act (NEPA) for this HCP.

The sources of uncertainty and variation discussed in this subsection notwithstanding, the District is reasonably confident that the take estimates developed herein provide a relative sense of the overall benefit of the proposed HCP conservation measures. On the basis of the recent severe drought conditions, the District would suggest that in aggregate the take estimates are conservatively high; in reality using these estimates provides a buffer of additional protection.

5.3.3 Comparison with Take Impact Assessment in EARIP

The Final HCP for the Southern Edwards segment by the Edwards Aquifer Recovery Implementation Program (EARIP, 2012) covers a very large area and addresses many listed species and many activities. It includes *Eurycea* salamander species that are quite similar to the two Covered Species in this HCP, managed groundwater withdrawals are one of its Covered Activities as in this HCP, and its HCP conservation measures are underpinned in part by one of its implementing parties' groundwater regulatory program, as is the District's regulatory program in this HCP. The EARIP HCP was recently approved and an ITP issued by the Service in 2013. Generally, the bases for the take impacts and for the Service's findings as to jeopardy related to this particular activity and to those similar species should not be inconsistent. In that regard, the similarities and differences between the two HCPs should be noted:

- The EARIP acknowledges the uncertainties associated with life requirements of its salamander species vis a vis springflows. In fact, it related its minimum flow requirements for these species to those of a listed plant species, and documented that this requirement was supported by the rough approximations established by the Service in the early 1990s for gauging take and jeopardy for these species at Comal and San Marcos Springs. While these thresholds incorporated the best science then available for evaluating take and jeopardy of the salamander species, the Service acknowledged then that significant data gaps existed, requiring a more conservative approach and the mandatory use of more professional judgment than usual in setting the take and jeopardy thresholds. However, even though substantially more information and site-specific data exist today, the EARIP did not propose different thresholds for the listed salamander species. The Service developed the original thresholds on a rather quick-response basis as an outcome of federal litigation concerning Southern Edwards groundwater regulation, and no analogous thresholds exist for the Barton Springs segment. In their absence, and on the basis of data and science now available, this HCP proposes new groundwater-management thresholds that are specifically designed to protect salamanders at Barton Springs to the greatest extent practicable.

- The EARIP acknowledged that the indeterminate size of the actual total populations and the uncertainties as to factors affecting their natural variability confounded quantitative take estimates and impact analysis, necessitating use of assumptions and professional judgments. This HCP does the same.

- The EARIP concluded that the amount of uncertainty that existed about the impact of smaller springflows of varying durations on the salamander species precluded definitive statements as to the amount of take and its impacts. It essentially assumed that maintenance of continuous springflow at least above the lower of the Service's older, general thresholds (along with protection of water quality from pollution) would enable the species to survive a repeat of DOR-like conditions. This HCP expresses similar concerns about the uncertainties in evaluating take and population impacts, even though utilizing the new thresholds developed as part of this HCP and evaluating adverse effects informed by specific DO-springflow statistical relationships.

- The EARIP's take analysis for these species primarily focused on physical habitat changes and related effects by surface activities, which its participating entities can control. It did not quantitatively evaluate hydrochemical effects, such as DO and salinity changes, on salamander physiology related to springflows as performed in this HCP, which is the only aspect that the District can control.

- The EARIP essentially assumed that the subterranean species would retreat into the Aquifer even if springflow ceased and would generally not be adversely affected by smaller springflows, although potential risk associated with take was assumed qualitatively to increase at flows below the Service's older lowest-flow threshold. This HCP reaches a similar conclusion, but supports it with a more quantitative analysis of effects on organisms over time and impacts on populations.

- The EARIP, which is designed to be a phased program, used a 15-year initial term for its ITP, while this HCP is a non-phased program and proposes a 20-year term.

- The EARIP included in its cumulative take analysis a seven-year DOR recurrence plus eight "average" years for its ITP term. This HCP not only includes a seven-year DOR recurrence, but also a seven-year Exceptional Drought (the Hybrid Drought), plus three less severe drought years and three non-drought years in its cumulative take analysis for the ITP term. It is also noteworthy that Barton Springs is at a lower elevation and serves as the region's base outlet of the entire Edwards Aquifer, including the southern segment of the Aquifer; while its DOR springflows are smaller, the recurrence interval of DOR springflows at Barton Springs is likely longer (i.e., smaller frequency) than those at the higher springs addressed by the EARIP.

- The EARIP asserted that the uncertainties associated with the qualitative analyses for these species highlights the necessity of applied research, expanded biological and water quality monitoring, and ecological modeling, and that those future developments will be factors in assuring that the species are not jeopardized. This HCP does the same.

The analyses and assessments of the salamander species in both HCPs are best characterized as qualitative, with quantitative approximations only and with some significant uncertainties that are not readily accounted for or overcome. On the basis of best science available and not unreasonable assumptions and stipulations, both HCPs conclude that the proposed conservation measures are necessary and sufficient to minimize take to the maximum extent practicable and to avoid jeopardy.

6.0 Conservation Program

The District is seeking a Section 10(a) Incidental Take Permit (ITP) to cover use of the Aquifer as a water supply and management of the Aquifer by the District's regulatory program related to pumping of the Aquifer. Everything that the District does relates to responsible groundwater use and to management of the aquifers in its jurisdiction, including the Aquifer. By design, all District activities are intended to directly or indirectly benefit the Aquifer and therefore the habitats of the Covered Species, especially in comparison to the unregulated pumping conditions that would exist without them. So the Covered Activities integrate the conservation measures for the Covered Species. However, these activities will not completely avoid or prevent take of the species all the time, rather minimize and mitigate the take as it occurs, so the ITP is being sought to accommodate those circumstances.

As a groundwater conservation district (GCD) in Texas, these activities are derived from and authorized by inclusion in the District Management Plan (MP), and the District Rules. The District cannot legally perform any activities, not even conservation activities, that are not authorized by statute (Texas Water C Chapter 36, or the District's enabling legislation codified as Special District Local Laws Code Chapter 8802) *and* also that are not at least implicitly a part of the prevailing MP. The legal authority for the Rules & Bylaws (BSEACD, 2012) that comprise the District's regulatory program flows directly from the statutes under which the District operates and from the MP.

The MP must be reviewed; revised as needed to accommodate new information, priorities, and statutory requirements; re-adopted; and approved by the Texas Water Development Board (TWDB) at least every five years. The current MP was most recently revised and approved by the TWDB on January 7, 2013; it will now require review and re-adoption no later than November 2017. The current MP largely anticipates and includes the statutory-enabled regulatory authorities needed for the initial set of the proposed District Habitat Conservation Plan (HCP) measures described below; others that might be utilized to assure achieving planned objectives may or may not require additional authorities; a substantially revised set of measures in the approved HCP could necessitate an earlier-than-planned MP revision and re-adoption. This duality in authorities illustrates that the measures committed in the HCP and the requirements of the MP are intertwined: future revisions to the MP must honor the commitments and requirements of the HCP once approved, and the HCP's current measures and future adaptive measures are restricted to those that are authorized by statute and by the prevailing approved MP.

In addition, the District may carry out its statutory powers and responsibilities to amend rules from time to time and substitute alternative requirements for reduction in pumping and/or alternative practices, procedures, and methods for promoting enhanced groundwater levels. Such rulemaking is an anticipated part of the District's function as a regulatory agency. However, any rule amendments must not reduce the effectiveness of the restrictions on pumping described in the District HCP and incorporated in the ITP to protect springflows, unless the HCP and ITP are also amended.

6.1 Biological Goal and Objectives of the HCP

The biological goal and objectives of the District HCP are established in recognition of a) the direct relationship between the volume of water remaining in the Aquifer and the hydrochemistry of the natural discharges from the Aquifer as spring flows, and b) the life requirements of the Covered Species with respect to dissolved oxygen (DO) concentrations of the groundwater as it is discharged from the Aquifer.

The biological goals of the District HCP are to:

- Minimize drought-related decreases in size and health of the Barton Springs salamander population to greatest extent practicable,
- Minimize drought-related decreases in size and health of the Austin blind salamander population to greatest extent practicable, and
- Promote recovery of the populations from those decreases to levels required for their long-term viability.

The following objectives, supported by the impact analysis described in Section 5.2, underpin the HCP in pursuit of these overarching goals:

- Adopt and implement groundwater-management measures to minimize the areal extent, concentration range, and time duration that springflow-dependent DO concentration at the Aquifer resurgences is 3.3 mg/L or less under all Aquifer conditions;
- Adopt and implement groundwater-management measures to maintain minimum springflows that a consensus of a knowledgeable scientific advisory panel indicates correspond to DO concentrations with a 10-day average of at least 3.9 mg/L during all but Extreme Drought conditions; and
- Adopt and implement groundwater-management and related measures that do not cause other natural water chemistry parameters to exceed their historical ranges under all Aquifer conditions.

These objectives as they relate to managing groundwater withdrawals are believed to be consistent with the best scientific information currently available and within the District's statutory authorities for groundwater management. Their implementation is integrated directly into the operating conservation and management programs, policies, and rules of the District, evidencing a commitment to their achievement.

Specific measures to accomplish these objectives are discussed in more detail in the following section. These measures, both individually and in aggregate, represent the best attainable legal plan of the District to conserve the species and are designed to be commensurate with the scope of the HCP. The District believes these measures substantially improve the probabilities that all of these objectives are achieved throughout the life of the ITP.

6.2 Minimization and Mitigation Measures

The key to conserving and minimizing take of the Covered Species is maintenance of adequate habitat and ambient conditions to provide the necessary life requirements for the species. This goal can be accomplished (1) if exogenous factors beyond the District's control (e.g., substantial increases in oxygen-demanding material from point-source and non point-source pollutants in runoff) do not become determinative of habitat quality; (2) if the measures in the City of Austin's Amended HCP for Barton Springs Pool afford the designed protection during recreational use and maintenance of the pool; and (3) if the management of the aquifer as proposed in this District HCP protects and maintains springflows sufficient to provide minimum acceptable habitat consistent with those life requirements.

As mentioned previously, the nature of the Covered Activities is inconsistent with the avoidance of take in an absolute sense. However, it should be noted that the minimization and mitigation measures that have been established by the District reduce the amount of all groundwater withdrawals during the key Extreme Drought period to an amount that is about the same as existed when the District was formed and when an unfettered vested property right attached to such pumping (about 5 cfs, as described in Section 4.1.2). In this sense, the District's groundwater management program proposed herein not only minimizes take during all drought conditions, but during the most critical period for the Covered Species also avoids the take associated with all pumping that was initiated after the District was established and its regulatory program (one of the Covered Activities) began.

6.2.1 Direct HCP Measures

The conservation measures that will be undertaken directly by the District under the HCP to conserve the Covered Species, by minimizing and/or, under prescribed conditions, also mitigating take to the greatest extent possible, are identified and discussed in this section of the HCP. Because these measures are integral to the District as an operating GCD, they are discussed in categories that correspond to the overarching *statutory* goals for all GCDs in Texas. The numerical order of these goals in the subsections below conforms to their listing in statute, not in the order of importance to the HCP. These measures are now supported as District-specific objectives or performance standards in the District's 2013 MP. Taken together, they comprise the "Enhanced Best Attainable Management" alternative for the HCP that is the existing manifestation of the District's own, internal adaptive management process, as discussed in section 6.4 below. All of these measures are currently authorized and being performed or, for a few, will be initiated as of the issuance of the ITP. They include both ongoing (currently authorized and continuously operating, as warranted) and episodic avoidance/minimization measures. By design and as required by law, they provide a necessary balance between maximizing the amount of groundwater available for use and conserving and protecting the groundwater resource, including Covered Species protection.

During the 20-year term of the ITP, it is envisioned that some changes to these measures will be required or prudent, but unless the underlying ITP permit is amended, the effect of any changes to the measures will be at least as, if not more, protective of the Covered Species by reducing attendant incidental take.

The following subsections describe the direct minimization measures proposed by the District in its HCP. Other, indirect conservation measures, including research and mitigation measures, are identified and discussed in the next Section 6.2.2 of this HCP. Section 6.2.3 contains a synopsis of the HCP program, including a summary table of HCP commitments.

6.2.1.1 Providing the Most Efficient Use of Groundwater

This goal encompasses actions that assure the relevant statutory, regulatory, scientific, administrative, and education dimensions of the District programs promote a balance between the least consumption of groundwater for each type of use and the benefits of using groundwater for those uses. Such efficiency optimizes on a continuing basis using groundwater as a water supply and preserving, conserving, and protecting the groundwater resources for future uses, including as endangered species habitat. Therefore, all measures under this goal are ongoing Minimization Measures except 1-3, which is chiefly an adaptive prelude to adjusted minimization.

- HCP Measure 1-1: Provide and maintain on an ongoing basis a sound statutory, regulatory, financial, and policy framework for continued District operations and programmatic needs.

- HCP Measure 1-2: Monitor aggregated use of various types of water wells in the District, as feasible and appropriate, to assess overall groundwater use and trends on a continuing basis.

- HCP Measure 1-3: Evaluate quantitatively at least every five years the amount of groundwater used by exempt wells in the District to ensure an accurate accounting of total pumping in a water budget that includes both regulated and non-regulated withdrawals, so that appropriate groundwater management actions are taken.

- HCP Measure 1-4: Develop and maintain programs that inform and educate citizens of all ages about groundwater and spring flow-related matters, which affect both water supplies and salamander ecology.

6.2.1.2 Controlling and Preventing Waste of Groundwater

This goal encompasses functions related to ensuring that all groundwater that is withdrawn from wells is used beneficially, and that activities that may cause or contribute to wasteful use of groundwater and to the pollution or harmful alteration of the groundwater resource are prevented. Only reasonable demand for beneficial use can be authorized through the permitting process, and no well is allowed to waste groundwater, including allowing the commingling of poor-quality and high-quality groundwater. For purposes of the HCP, measures under this goal minimize the amount of groundwater withdrawn without purpose or reasonable use and that allows subsurface deterioration of the reservoir, and thereby maximizes high-quality spring flow for salamander habitat. Therefore, all measures under this goal are ongoing Minimization Measures.

- HCP Measure 2-1: Require all newly drilled exempt and nonexempt wells and all plugged wells to be registered and to comply with applicable District Rules, including Well Construction Standards.

- HCP Measure 2-2: Ensure permitted wells and well systems are operated as intended by requiring reporting of periodic meter readings, making periodic inspections of wells, and reviewing pumpage compliance at regular intervals that are meaningful to the existing aquifer conditions.

6.2.1.3 Addressing Conjunctive Surface Water Management Issues

This goal promotes measures and policies that utilize joint surface water – groundwater systems effectively, without imposition of adverse quantity or quality impacts on either the surface or groundwater resource. In the context of the HCP, conjunctive use is alternative water use in lieu of utilizing the fully subscribed Edwards resource as a water supply and that allows for needed pumpage curtailments, especially during Extreme Drought. The District itself may be able to undertake certain of these activities directly, either on its own or as part of a partnership, thereby providing a potential model or framework by which its permittees could undertake such actions.

- HCP Measure 3-1: Assess the physical and institutional availability of existing regional surface-water and alternative groundwater supplies and the feasibility of those sources as viable supplemental or substitute supplies for District groundwater users. This is an ongoing Minimization Measure that is an adaptive prelude to a Research and possibly a Mitigation Measure.

- HCP Measure 3-2: Encourage and assist District permittees to diversify their water supplies by assessing the feasibility of alternative water supplies and fostering arrangements with currently available alternative water suppliers. This generally is an ongoing Minimization Measure, but depending on the specific arrangements pursued, it could also be an episodic Minimization Measure.

- HCP Measure 3-3: Demonstrate the importance of the relationship between surface water and groundwater, and the need for implementing prudent conjunctive use through educational programs with permittees and public outreach programs. This is an ongoing Minimization Measure.

6.2.1.4 Addressing Natural Resource Management Issues

This goal focuses on protecting the natural resources of the Aquifer and of other aquifers within the District's jurisdiction, including not only the groundwater of those aquifers but also soils and agriculture; air quality; economic resources such as sand and gravel and oil and gas; and the flora and fauna dependent on them, including endangered species. By using sound science to increase the understanding of the natural resource systems, including relationships with underlying and overlying reservoirs and up-gradient surface waters, and to delineate the impacts associated with the amount and location of pumping, recharge, and discharge, appropriate and acceptable policies and rules can be developed and effective regulatory decisions can be made by the District.

- HCP Measure 4-1: Assess ambient conditions in District aquifers on a recurring basis by (1) sampling and collecting groundwater data from selected wells and springs, (2) conducting scientific investigations to better determine groundwater availability for the District aquifers; and (3) conducting studies to help increase our understanding of the Aquifer and, to the extent feasible, detect possible threats to water quality and evaluate their consequences. This is an ongoing Minimization Measure that is also an adaptive prelude to Research and possibly a Mitigation Measure.

- HCP Measure 4-2: Evaluate site-specific hydrogeological data from applicable production permits to assess potential impact of production to groundwater quantity and quality, public health and welfare, contribution to waste, and unreasonable well interference. This is an ongoing Minimization Measure.

- HCP Measure 4-3: Implement separate management zones and as warranted different management strategies to address more effectively the groundwater management needs for the various aquifers in the District, particularly the Aquifer. This is an ongoing Minimization Measure.

- HCP Measure 4-4: Actively participate in the joint planning processes for the relevant aquifers in the District to establish and refine Desired Future Conditions (DFCs) that are protective of the Aquifer and other aquifers and the Covered Species. This is an ongoing Minimization Measure that is an adaptive prelude to an episodic Minimization Measure.

6.2.1.5 Addressing Drought Conditions

This goal involves developing and implementing policies that effectively manage groundwater drought conditions in the Aquifer. The regulation of pumpage and its curtailment during drought, especially during prolonged severe drought, is the principal institutional minimization tool that allows the otherwise lawful pumpage of the Aquifer to occur while being protective of the Covered Species. For example, now the only permits available to withdraw water from the Aquifer are Conditional Production Permits, which is an interruptible supply that is subject to complete cessation of pumping during drought and is issued only if an alternative supply is available. All these are ongoing Minimization Measures, although during severe drought, the step-wise implementation of increasingly stringent curtailments of water withdrawals could also be considered episodic Minimization Measures; over time they also would inform an adaptive outcome.

- HCP Measure 5-1: Adopt and keep updated a science-based drought trigger methodology and frequently monitor drought stages for the Aquifer on the basis of actual aquifer conditions, and declare drought conditions as determined by analyzing data from the District's defined drought triggers and from the existing and such other, new drought-declaration factors, especially the prevailing DO trends at the spring outlets, as warranted.

- HCP Measure 5-2: Promulgate a drought management program that step-wise curtails Aquifer use to at least 50% by volume of currently (2014) authorized aggregate monthly use during the Extreme Drought stage, and that designs/utilizes other programs that provide an incentive for additional curtailments where possible (for example, cap-and-retire of historical production permits; accelerated and/or larger severe drought curtailments in exchange for additional authorized use during non-drought periods).

- HCP Measure 5-3: Inform and educate permittees and other well owners of Edwards groundwater, about the significance of declared drought stages and the severity of drought and encourage practices and behaviors that reduce water use by a stage-appropriate amount.

- HCP Measure 5-4: Assist and, where feasible, incentivize individual historic-production permittees in developing drought planning strategies that foster compliance with promulgated District drought rules, including step-wise demand curtailment by drought stage to at least 50% of currently (2014) authorized use, on a three-month rolling average basis, during Extreme Drought; "right-sizing" authorized use over the long term to reconcile actual water demands and permitted levels; and as necessary and with appropriate conditions, the substitution by surface water, reclaimed water, and/or other groundwater resources such as the Trinity Aquifer to achieve curtailments.

- HCP Measure 5-5: Promulgate a Conservation Permit that is held by the District and accumulates and preserves production from the Aquifer that was previously authorized with historic-use status and that is retired or otherwise additionally curtailed during severe drought, for use as ecological flows at Barton Springs during Extreme Drought and thereby increase spring flows for a given set of hydrological conditions.

6.2.1.6 Addressing Demand Reduction through Conservation

This goal encompasses all activities that strive to reduce consumption of groundwater of the Aquifer by educating District stakeholders about water conservation and extraordinary demand-reduction measures. This initiative provides tools by which all end-users of the Aquifer can preserve springflow and the quality of habitat of the Covered Species, as well as

Aquifer water levels in wells, by reducing their per-capita water use during non-drought times as well as episodically during severe drought. These are primarily ongoing Minimization Measures once developed, although the temporary demand reductions during drought that are enabled here have an episodic Minimization aspect as well.

- HCP Measure 6-1: Develop and maintain programs that inform, educate, and support District permittees in their efforts to educate their end-user customers about water conservation and its benefits, and about drought-time temporary demand reduction measures.

- HCP Measure 6-2: Encourage use of conservation-oriented rate structures by water utility permittees to discourage egregious water demand by individual end-users during declared drought.

- HCP Measure 6-3: Develop and maintain programs that educate and inform District groundwater users and constituents of all ages about water conservation practices and resources.

6.2.1.7 Addressing Supply through Structural Enhancement

This goal encompasses various structural activities, i.e., typically engineered solutions, that are undertaken by the District directly to increase the amount of water in the Aquifer than would otherwise be available. By increasing the water in storage and by providing means of supply enhancement, either at all times or during certain times, impacts of droughts can be less frequent, less severe, and of shorter duration, springflows can be preserved, and endangered-species habitat impairment can be minimized. These are generally adaptive preludes to Research Measures and Mitigation, as the ability to deploy them varies with knowledge and with time, but to the extent they are deployed from time to time, they have either or both ongoing and episodic Minimization dimensions as well.

- HCP Measure 7-1: Improve recharge to the Aquifer by conducting studies and as feasible and allowed by law, physically altering (cleaning, enlarging, protecting, diverting surface water to) discrete recharge features that will lead to an increase in recharge and water in storage beyond what otherwise would exist naturally.

- HCP Measure 7-2: Conduct technical investigations and, as feasible, assist water supply providers in implementing engineered enhancements to the regional supply portfolio, including desalination, aquifer storage and recovery, and effluent reclamation and re-use, to increase the options for water-supply substitution and reduce dependence on the Aquifer.

6.2.1.8 Addressing Quantitatively the Established Desired Future Conditions

This goal involves developing, supporting, monitoring, and keeping updated the adopted DFCs for the Aquifer that are protective of water-well yields in the more vulnerable parts of the Aquifer and of springflows, and consequently of the Covered Species. The DFCs for the

Aquifer provide the statutory and regulatory basis, in the consensus of all GCDs in the State's Groundwater Management Area (GMA)10, for mandatory curtailments of pumpage and aggregated firm-yield pumpage caps and increases in recharge so that the DFCs are achieved. They are perhaps best considered the first-order HCP measures, and all the others are supportive of these two measures; the DFCs are also continuing adaptive management measures, as they are statutorily iterative and re-adopted at least every five years. Achieving these two measures is the principal metric for gauging success of the District's groundwater management program and HCP.

- HCP Measure 8-1: As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable, the total amount of groundwater authorized to be withdrawn annually from the Aquifer to an amount that will not substantially accelerate the onset of drought conditions in the Aquifer; this is established as a running seven-year average springflow at Barton Springs of no less than 49.7 cfs during average recharge conditions. This is an ongoing Minimization Measure.

- HCP Measure 8-2: As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable and as legally possible, the total amount of groundwater withdrawn monthly from the Aquifer during Extreme Drought conditions in order to minimize take and avoid jeopardy of the Covered Species as a result of the Covered Activities, as established by the best science available; this is established as a limitation on actual withdrawals from the Aquifer to a total of no more than 5.2 cfs on an average annual (curtailed) basis during Extreme Drought, which will produce a minimum springflow of not less than 6.5 cfs during a recurrence of the drought of record (DOR). This is an episodic Minimization Measure that operates during the most severe stage of drought when the Covered Species are under highest stress.

6.2.2 Other HCP Measures and Strategies

As a complement to the direct HCP measures identified in the preceding subsection 6.2.1, the District will employ a number of other measures and strategies primarily to research and mitigate consequences of groundwater use in the District's jurisdiction on the Covered Species. These other measures and strategies, collectively termed "indirect HCP measures" herein, are characterized in this section of the HCP.

To a substantial extent, all of these indirect measures require the involvement of other parties in addition to the District. Such measures will be further defined and undertaken through available and appropriate mechanisms, which may include grant funding, other external funding, in-kind contributions, partnerships, and negotiation of requisite interlocal and other agreements. In particular, the prospective interlocal agreement (ILA) with the City of Austin offers strategic benefits to the District in conducting these indirect HCP measures in multiple ways. Some of these indirect measures may be continuing commitments of in-kind and other resources for a specified beneficial purpose, and others may be participation in various ways for discrete special-purpose projects that are authorized in prospect by the HCP but will be subject to future Board approval of scope, funding sources and amounts, and opportunity costs. While to a considerable extent these indirect measures are HCP-specific, they leverage existing information from other parties and avoid redundant efforts, are consistent with the District's charge to expand the knowledge of the Aquifer system, and are beneficial to the District's permittees in helping to acquire a legal shield against assertions of violating the Endangered Species Act (Act).

6.2.2.1 Research Measures

Substantial uncertainties continue to exist concerning a number of factors that at least potentially affect take: the hydrologic performance of the Aquifer, especially during extreme low-flow conditions; the relationship between springflow and its DO concentrations, especially at extreme low-flow conditions; the ecological effects and physiological impacts of antagonistic contaminants in recharge water; and salamander behavior, both individually and as a population, under ecological stress. The Research Measures identified in this subsection are intended to address some of these uncertainties.

- HCP Research Measure R-1: The District from time to time during the term of the ITP will consider working with universities, the City of Austin, and other qualified parties on projects to better inform and determine the level of risk associated with springflow-related changes in water chemistry affecting the viability and recovery of the Covered Species' population, by supporting:

  1. surveys of the temporal and spatial DO variability of the Aquifer and the surface environments around Barton Springs complex,
  2. continuing the support of laboratory stressor-response studies of salamander species, or
  3. efforts to restore the spring-run habitat to allow improved re-aeration at the springs outlets.

- HCP Research Measure R-2: The District from time to time during the term of the ITP will consider working with the U.S. Geological Survey (USGS), the TWDB, universities, the City of Austin, Edwards Aquifer Authority, and other qualified parties to:

  1. develop a refined conceptual model to improve the numerical models for the District aquifers, and
  2. improve geohydrological characterization of aquifer performance during extreme low flows, including assessments of new potential recharge sources from urban recharge and bypasses from the San Antonio segment, and their changes over the term of the ITP.

6.2.2.2 Mitigation Measures

The District recognizes that the proposed conservation program is unable to avoid take at all times. Consequently, it proposes the following Mitigation Measures:

- HCP Mitigation Measure M-1: The District may support the operations of an existing refugium with facilities capable of maintaining backup populations of the Covered species to preserve the capacity to re-establish the species in the event of the loss of population due to a catastrophic event such as an unexpected cessation of springflow or a hazardous materials spill that decimates the species habitat. Such supplemental support would be provided through a commitment of in-kind, contracted support, and/or cash contributions or other appropriate means of support that would contribute to:

1. continuing the study of salamander physiology and/or behavior, and/or
2. conserving wild and captive populations.

Commitments of in-kind, contracted support, and/or cash contributions to the support of the refugium and its research program may be authorized by the Board.

- HCP Mitigation Measure M-2: The District, in cooperation with the City of Austin, will participate in conducting feasibility studies and, as warranted, pilot and implementation projects to evaluate the potential for beneficial subsurface DO augmentation of resurging water in the immediate vicinity of the spring outlets and improved surface DO augmentation in the outlets (only) during Extreme Drought conditions. In-kind, contracted support, and/or cash contributions, deployed in a phased fashion for the feasibility studies and, if the project is feasible, for the pilot study and implementation of the augmentation project, may be authorized.

- HCP Mitigation Measure M-3: The District will extend the currently committed time period to operate the Antioch Recharge Enhancement Facility to continue after the 319(h) grant commitments (September 2014 or later), thereby improving recharge water quality and reducing non-point source pollution at the outlets from runoff events during that time.

- HCP Mitigation Measure M-4: The District will establish a fund to be applied towards an abandoned well plugging program that will serve to eliminate high risk abandoned wells as potential conduits for contaminants from the surface or adjacent formations into the aquifer with priority given to problematic wells closer to the Barton Springs outlets. The fund would be established within the first year after issuance of the ITP with repurposed seed money currently held in the Drought Reserve Account which would be re-designated as a new Aquifer Protection Reserve Account. The new account would exist solely to fund the abandoned well program and would be replenished with any collected enforcement penalties and an annual budgeted supplement at the discretion of the Board.

- HCP Mitigation Measure M-5: Throughout the term of the ITP, the District commits to provide leadership and technical assistance to other government entities, organizations, and individuals when prospective land-use and groundwater management activities in those entities' purview will have, in the District's assessment, significant effects on the quantity or quality of groundwater from the Aquifer, to include responding actively and appropriately to legislative initiatives or projects that affect Aquifer characteristics, provided such actions are not inconsistent with established District rules, ongoing initiatives, or existing agreements.

(Examples include contesting unsustainable wastewater management or actions that contravene the District's consent decree(s) that are projected to adversely affect the Aquifer, and providing technical support to GMA 9 and other GCDs whose practices may affect the Aquifer).

6.2.3 Summary of HCP Measures to Minimize and Mitigate Take

A summary of all the direct and indirect measures that comprise the heart of the District HCP is presented in Table 6-1. Each measure is designated as to whether it is a more or less continuously operating Minimization Measure for implementing the HCP, an episodically or periodically deployed Minimization Measure, whether the measure is adaptive in nature, and/or a Research or Mitigation Measure. Taken together, these are an explication of the District's preferred option for HCP Conservation Measures that are proposed in this HCP. In addition, the table specifies the applicable performance standard(s) from the District's approved 2013 MP as they correspond to each measure. The applicable performance standards essentially authorize the District to perform that HCP measure, and also provide success metrics (measures of achieved effectiveness) for each standard. The MP, which is revised as necessary and re-approved by the TWDB at least every five years, is found on the District website, at: http://www.bseacd.org/about-us/governing-documents/.

Table 6-1: Summary of HCP Measures, Classification as to Type, and Relation to Management Plan Performance Standards

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
1-1	Provide and maintain on an ongoing basis a sound statutory, regulatory, financial, and policy framework for continued District operations and programmatic needs.	●		●	PS 1-3, PS 2-1	
1-2	Register and monitor aggregated use of various types of water wells in the District, as feasible and appropriate, to assess overall groundwater use and trends on a continuing basis.	●			PS 2-3, PS 2-4, PS 3-1, PS 6-1, PS 6-2	
1-3	Evaluate quantitatively at least every five years the amount of groundwater used by exempt wells in the District to ensure an accurate accounting of total pumping in a water budget that includes both regulated and non-regulated withdrawals so that appropriate groundwater management actions are taken.			●	PS 4-2	Exempt well use is not a managed Covered Activity, but in aggregate potentially affects allowable non-exempt well use

[10] Designates those measures that over time may have an adaptive dimension that affects the implementation of that and/or other conservation measures. It does not refer to measures that are to be pursued using the DOI/FWS Adaptive Management Plan protocol (discussed in Section 6.4).

[11] Corresponding Performance Standards designated in the District's 2013 Management Plan, at http://www.bseacd.org/about-us/governing-documents/

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
1-4	Develop and maintain programs that inform and educate citizens of all ages about groundwater and spring flow-related matters, which affect both water supplies and salamander ecology.	●			PS 3-3, PS 4-4	
2-1	Require all newly drilled exempt and nonexempt wells and all plugged wells to be registered and to comply with applicable District Rules, including Well Construction Standards.	●			PS 2-2, PS 2-3 (Existing wells)	Includes compliance with Well Construction Standards
2-2	Ensure permitted wells and well systems are operated as intended by requiring reporting of monthly meter readings, making periodic inspections of wells, and reviewing pumpage compliance at regular intervals that are meaningful to the existing aquifer conditions.	●			PS 2-3, PS 2-4, PS 3-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
3-1	Assess the physical and institutional availability of regional surface-water and alternative groundwater supplies, and the feasibility of those sources as viable supplemental or substitute supplies for District groundwater users.			●	PS 5-1	
3-2	Encourage and assist District permittees to diversify their water supplies by assessing the feasibility and availability of alternative water supplies and fostering arrangements with currently available alternative water suppliers.	●	●		PS 5-1	Depending on arrangements, e.g., shifts only during severe drought, could also be an Episodic Measure

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
3-3	Demonstrate the importance of the relationship between surface water and groundwater, and the need for implementing prudent conjunctive use, through educational programs with permittees and public outreach programs.	●		●	PS 4-4, PS 5-4	
4-1	Assess ambient conditions in District aquifers by (a) sampling and collecting groundwater data on a recurring basis from selected wells and springs, (b) conducting scientific investigations to better determine groundwater availability for the District aquifers; and (c) conducting studies to help increase our understanding of the Aquifer and, to the extent feasible, detect possible threats to water quality and evaluate their consequences.	●		●	PS 6-1 PS4-2 5-1, 5-2, 5-3, 6-2 PS4-2, 5-3, 6-2	Some aspect of this measure is informing adaptive changes for future rulemaking

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
4-2	Evaluate site-specific hydrogeological data from applicable production permits to assess potential impact to groundwater quantity and quality, public health and welfare, contribution to waste, and unreasonable well interference.	●		●	PS2-2, 2-3, 4-3, 6-2	
4-3	Implement separate management zones, and as warranted different management strategies to address variable groundwater management needs for the various aquifers in the District, particularly the Barton Springs aquifer.	●			PS 2-1, PS 5-1	
4-4	Actively participate in the joint planning processes for the relevant aquifers in the District to establish and refine Desired Future Conditions that are protective of the Barton Springs and other aquifers and the Covered Species.	●		●	PS 4-2	Ongoing activities related to HCP Measures 8-1 and 8-2

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
5-1	Adopt and keep updated a science-based drought trigger methodology and frequently monitor drought stages for the Aquifer on the basis of actual aquifer conditions, and declare drought conditions as determined by analyzing data from the District's defined drought triggers and from the existing and such other, new drought-declaration factors, especially the prevailing DO trends at the spring outlets, as warranted.	●	●	●	PS 3-2	
5-2	Promulgate a drought management program that step-wise curtails Aquifer use to at least 50% by volume of currently (2014) authorized aggregate monthly use during the Extreme Drought stage, and that designs/utilizes other programs that provide an incentive for additional curtailments where possible (for example, cap-and-retire of historical production permits; accelerated and/or larger severe drought curtailments in exchange for additional authorized use during non-drought periods).	●	●	●	PS 3-1, PS 4-2, PS 5-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
5-3	Inform and educate permittees and other well owners of Edwards groundwater, about the significance of declared drought stages and the severity of drought and encourage practices and behaviors that reduce water use by a stage-appropriate amount.	●	●	●	PS 3-1, PS 3-3, PS 4-4, PS 5-4	
5-4	Assist and, where feasible, incentivize individual historic-production permittees in developing drought planning strategies that foster compliance with promulgated District drought rules, including step-wise demand curtailment by drought stage to at least 50% of currently (2014) authorized use, on a three-month rolling average basis, during Extreme Drought; "right-sizing" authorized use over the long term to reconcile actual water demands and permitted levels; and as necessary and with appropriate conditions, the substitution by surface water, reclaimed water, and/or other groundwater resources such as the Trinity Aquifer to achieve curtailments.	●	●	●	PS 3-1, PS 5-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
5-5	Promulgate a Conservation Permit that is held by the District and accumulates and preserves production from the Aquifer that was previously authorized with historic-use status and that is retired or otherwise additionally curtailed during severe drought for use as ecological flows at Barton Springs during Extreme Drought and thereby increase spring flows for a given set of hydrological conditions.	●		●	Objective 3, PS 4-5	The outcomes of this goal's other measures produce an adaptive dimension over time
6-1	Develop and maintain programs that inform, educate, and support District permittees in their efforts to educate their end-user customers about water conservation and its benefits and drought-time temporary demand reduction measures.	●	●		PS 3-3, PS 5-4	Increased intensity during severe droughts has an Episodic dimension

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
6-2	Encourage use of conservation-oriented rate structures by water utility permittees to discourage egregious water demand by individual end-users during declared drought.	●		●	PS 3-1	Will be a Minimization Measure if/once deployed by water supply permittees
6-3	Develop and maintain programs that educate and inform District groundwater users and constituents of all ages about water conservation practices and resources.	●	●		PS 5-4	Increased intensity during severe droughts has a Mitigation dimension
7-1	Improve recharge to the Barton Springs aquifer by conducting studies and as feasible, physically altering (cleaning, enlarging, diverting surface water to, and protecting) discrete recharge features that will lead to an increase in recharge and water in storage beyond what otherwise would exist naturally.	●		●	PS 5-2	Some aspect of this measure is taking place nearly all of the time

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
7-2	Conduct technical investigations and, as feasible, assist water supply providers in implementing engineered enhancements to the regional supply portfolio, including desalination, aquifer storage and recovery, and effluent reclamation and re-use, to increase the options for water-supply substitution and reduce dependence on the Aquifer.	●		●	PS 5-1, 5-3,	Some aspect of this measure is taking place nearly all the time
8-1	As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable, the total amount of groundwater authorized to be withdrawn annually from the Aquifer to an amount that will not substantially accelerate the onset of drought conditions in the Aquifer; this is established as a running seven-year average spring-flow at Barton Springs of no less than 49.7 cfs during average recharge conditions.	●		●	PS 4-5	Established via the joint planning process of GMA 10, with major but not sole input by the District; statutory adaptive dimension

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [10]	Management Plan Standards[11]	Comments
8-2	As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable and as legally possible, the total amount of groundwater withdrawn monthly from the Aquifer during Extreme Drought conditions in order to minimize take and avoid jeopardy of the Covered Species as a result of the Covered Activities, as established by the best science available; this is established as a limitation on actual withdrawals from the Aquifer to a total of no more than 5.2 cfs on an average annual (curtailed) basis during Extreme Drought, which will produce a minimum spring flow of not less than 6.5 cfs during a recurrence of the drought of record.	●	●	●	Objective 3, PS 4-2, PS 4-5	Established via the joint planning process of GMA 10, with major but not sole input by the District; statutory adaptive dimension

RESEARCH MEASURES				
R-1	The District from time to time during the term of the ITP will consider working with universities, the City of Austin, and other qualified parties on projects to better inform and determine the level of risk associated with springflow-related changes in water chemistry affecting the viability and recovery of the Covered Species' population, by supporting: a. surveys of the temporal and spatial DO variability of the Aquifer and the surface environments around Barton Springs complex, b. continuing the support of laboratory stressor-response studies of salamander species, or c. efforts to restore the spring run habitat to allow improved re-aeration of the water at the spring outlets.	●	PS 6-2	
R-2	The District from time to time during the term of the ITP will consider working with the U.S. Geological Survey (USGS), the Texas Water Development Board, universities, the City of Austin, Edwards Aquifer Authority, and other qualified parties to: a. develop a refined conceptual model to improve the numerical models for the District aquifers, and b. improve geohydrological characterization of aquifer performance during extreme low flows, including assessments of new potential recharge sources from urban recharge and bypasses from the San Antonio segment, and their changes over the term of the ITP.	●	PS 6-2	

MITIGATION MEASURES				
M-1	The District may support the operations of an **existing refugium** with facilities capable of maintaining backup populations of the Covered Species to preserve the capacity to re-establish the species in the event of the loss of population due to a catastrophic event such as an unexpected cessation of springflow or a hazardous materials spill that decimates the species habitat. Such supplemental support would be provided through a commitment of in-kind, contracted support, and/or cash contributions that would contribute to: a. continuing the study of salamander physiology and/or behavior, and b. conserving wild and captive populations.	●	Within authority; no related standard; implemented at Board's discretion	
M-2	The District, in cooperation with the City of Austin, will participate in conducting feasibility studies and, as warranted, pilot and implementation projects to evaluate the potential for beneficial subsurface **DO augmentation** of resurging water in the immediate vicinity of the spring outlets and/or improved surface DO augmentation within the outlets, (only) during Extreme Drought conditions. In-kind, contracted support, and/or cash contributions, deployed in a phased fashion for the feasibility studies and, if the project is feasible, for the pilot study and implementation of the augmentation project may be authorized.	●	Within authority, no related standard; implemented at Board's discretion	
M-3	Extend the currently committed time period to operate the **Antioch Recharge Enhancement Facility to continue** after the 319(h) grant commitments (September 2014 or later), thereby improving recharge water quality and reducing non-point source pollution at the outlets from runoff events during that time.		PS 5-2	

M-4	Establish a fund to be applied towards an **abandoned well plugging program** that will serve to eliminate high risk abandoned wells as potential conduits for contaminants from the surface or adjacent formations into the aquifer with priority given to problematic wells closer to the Barton Springs outlets. The fund would be established within the first year after issuance of the ITP with repurposed seed money currently held in the Drought Reserve Account which would be re-designated as a new Aquifer Protection Reserve Account. The new account would exist solely to fund the abandoned well program and would be replenished with any collected enforcement penalties and an annual budgeted supplement at the discretion of the Board.		Within authority; no related standard; implemented at Board's discretion	
M-5	Throughout the term of the ITP, the District commits to provide **leadership and technical assistance** to other government entities, organizations, and individuals when prospective land-use and groundwater management activities in those entities' purview will have, in the District's assessment, significant effects on the quantity or quality of groundwater from the Aquifer, to include responding actively and appropriately to legislative initiatives or projects that affect Aquifer characteristics, provided such actions are not inconsistent with established District rules, ongoing initiatives, or existing agreements.	●	PS 1-6, PS 4-3	

6.3 Monitoring Activities

All of the District operations are based on the philosophy that "you can't manage what you don't measure." The HCP program will be no different, and the District will routinely and regularly monitor a suite of parameters that delineate its progress and outcomes, and the continuing deployment of the adaptive management process (Section 6.4) to improve performance. These monitoring activities, many of which are already being performed, address Aquifer characteristics, Covered Species status, and overall conservation program management and performance. The monitoring program to be used by the District is described in more detail in the following subsections of this document. In addition, the monitoring data will be reported to and assessed annually by the Board and by the HCP Management Advisory Committee (MAC), as described in Section 6.4.1 and 6.4.2, respectively, as part of the HCP compliance monitoring and reporting initiatives.

6.3.1 General Groundwater Management Actions

Aquifer management will focus on an array of conservation measures directly or indirectly affecting the production of water from wells in the Aquifer to maintain springflows in Barton Springs, as outlined in Section 6.2.1.

A validation monitoring program will be developed and implemented to measure future success of Aquifer-management activities, and to modify management actions based on the availability of new information. This program will be conducted in collaboration with the City of Austin under an ILA for each entity's HCP monitoring reports. The following data and information will be compiled by the District for this HCP each year and reviewed annually by the Board and the HCP MAC:

- Survey data on the Covered Species, collected bimonthly by the City of Austin; water quality and other habitat data collected by the District, City of Austin, and/or other entities, and their trends, to consider the need to re-evaluate biological risk during low flow conditions;
- Results of any numerical and analytical modeling of both the Aquifer and of the salamander population dynamics on which the HCP is based that are reported each year, to assess the currency and continuing validity of such tools and concepts; and
- Available data on the total annual discharge of Barton Springs, its temporal and spatial variations, and the aggregate production from wells in the Aquifer, to inform periodic water-balance modeling.

In the first year of the ITP term, the District will collaborate with the City of Austin to formulate a methodology for monitoring and evaluating take associated with the District's Covered Activities. This methodology will use existing springflow gaging, water chemistry monitoring, and salamander censuses, supplemented as needed by new data-collection and analyses. Following review by the MAC and subsequent review and approval by the Board, the monitoring methodology will be submitted to the U.S. Fish & Wildlife Service (Service) for its concurrence before or along with the Annual Report issued after the first full year of operating under the ITP. The activities required by the collaborative take monitoring methodology will be an element in the prospective ILA between the City of Austin and the District.

6.3.2 General Performance Metrics and Reporting

A process will be developed to evaluate performance of the District HCP measures and groundwater management strategies, including:

- Frequency or necessity of Stage II Alarm-, Stage III Critical-, and Stage IV Exceptional-Drought Measures;
- Levels of the Aquifer as measured by springflow and indicator wells;
- Total (of all outlets) daily discharge from Barton Springs;
- Through coordination with the City of Austin staff, reporting of:
  - current and historic biological data to evaluate responses to groundwater management actions during any low flow conditions;
  - availability of suitable habitat during various low flow conditions;
  - relative salamander abundance and population characteristics based on observations during low flow and other conditions;
  - water-chemistry characteristics related to flow through the spring orifices during normal and low flow conditions; and
- Educational outreach program summaries, including quantity, quality, and timeliness of information disseminated to the general public and stakeholder interests about water use, demand management, and aquifer conditions.

These performance metrics, generally comprising the HCP effectiveness monitoring program, will be compiled, analyzed, and presented in a report to the HCP MAC and to the Service on or before the third year anniversary of ITP issuance and every five years or less thereafter, for the duration of the ITP.

6.3.3 Implementation Monitoring

The District will ensure that all management objectives are realized to meet requirements specified in the Performance Metrics through execution of the MP and the reporting procedure outlined in Section 6.5.1.1 below.

6.3.4 Effectiveness Monitoring

The District determines actual groundwater withdrawals through required monthly water-use reports from all nonexempt users. The Board reviews reported metered data on a periodic basis during declared drought, and confirms/clarifies production trends in the District, both overall and by permittee. Setting of the meters and their calibration are required to be in compliance with standards and rules of the District. The results of comparisons of metered groundwater withdrawals relative to then-authorized amounts, including both aggregate and individual permittee performance, are the fundamental tool used to monitor effectiveness of the District HCP and MP with respect to aquifer water withdrawals.

The District will, in coordination with the City of Austin and under the auspices of the ILA that both entities intend to inform their respective HCPs, obtain and report biological survey data and analyses being evaluated on a continuing basis by the City of Austin. The District believes the City of Austin's biological data collection activities under its HCP are sufficient for the purposes and needs of the District HCP, with no benefit in duplicative efforts nor need to augment the frequency or extent of current City of Austin data-collection efforts. As specific data needs and gaps are identified that may require a focused research effort, commensurate with adaptive management measures specified in Section 6.2 or in the Adaptive Management Plan (AMP), the District will consult with the Service and the City of Austin and commit resources for such research, to the extent that additional funds and in-kind labor are available (see Section 8 for more details on funding).

6.4 The District HCP Adaptive Management Process

The District reasonably believes that the initial HCP conservation measures to be funded by the District for its HCP will be effective in conserving both habitats and the Covered Species for the term of the ITP. However, monitoring the implementation of these measures, including the proposed Research Measures, will continue to provide feedback on the efficacy of those measures and also may continue to produce data and information that can be used to identify and evaluate improvements and other management options. In addition, over time changed and unforeseen circumstances (see Section 7 below) may affect the status of habitats and the condition of the species within the Barton Springs ecosystems, and the uncertainties identified in Section 7.2.1 of this HCP may be resolved or clarified.

The District has historically used an "incremental/rational planning" approach to adaptive management as an accepted resource management practice and as an integral part of rulemaking as its drought management planning has evolved (as described in Section 4.1.2). For the HCP, the District has evaluated the specific AMP protocols promulgated by the U.S. Department of Interior (DOI) in its Adaptive Management Implementation Policy (DOI, 2008) and stipulated for use in HCPs by the Service, a part of DOI. Passive adaptive management in a general sense has been a primary vehicle by which the District evaluates and incorporates alternative management actions. This will continue under the HCP as the proposed measures are implemented, as monitoring data are collected, and as uncertainties in the natural systems are resolved, essentially adding new management activities under the direct measures for avoidance, minimization, and mitigation as they prove prudent, feasible, and warranted, using the DOI/Service AMP protocol if and when appropriate and the District's own incremental/rational planning approach when it is not.

The DOI/Service AMP protocol is an active, structured process and a defined method for addressing uncertainty in natural systems when:

a) one or more issues can be articulated as outcomes of management options,

b) a relatively frequently *recurring* decision must be made (which allows for regular and controlled testing and therefore optimization of results),
c) various management approaches or strategies can be applied by an agency to the system to affect observable results on a planned, iterative basis,
d) uncertainty can be expressed in terms of testable hypotheses or models of management options, and
e) monitoring can be designed and implemented to reduce uncertainty and deliver timely conclusions that can affirm or be used to adjust resource management outcomes for the next iteration of testing.

Section 7.2.1 of this HCP identifies in some detail a number of uncertainties that may affect the HCP during the term of the ITP. At a fundamental level, the overarching management issues for the District HCP arising from these uncertainties are:

1. What are the hydrographic and hydrochemical responses of the Aquifer system during Extreme Drought conditions that are equivalent to a recurrence of the DOR, as those conditions have not been experienced since the Covered Species were first identified?

2. Does the current DFC of the Aquifer during Extreme Drought, i.e., springflows no less than 6.5 cfs averaged on a monthly basis, actually provide, as intended, a water chemistry that allows the populations of the Covered Species to survive and to recover?

3. Does the ability of the Covered Species to migrate into the subsurface environment between and around spring outlets provide a safe harbor when the surface environment is critically deficient in one or more of their life requirements?

4. Does provision of alternative water supplies to existing users of the Aquifer translate confidently into actual reductions in pumping of the Aquifer during drought periods and into increased springflows?

These issues comprise the focal points and potential objectives for this HCP's adaptive approaches.

The Covered Activities in this HCP constitute a natural resource management program itself, specifically designed to address the system variations (aquifer water levels and springflows) induced by a natural driver (drought, along with water supply demand) and that occur in a natural system (the Aquifer). There is a mandate for protection of the Covered Species, and the District has the institutional stability and legal wherewithal to be a resource management agency. Such characteristics *per se* might otherwise suggest that this program could be a candidate for the defined adaptive management planning protocol that is described in the DOI Technical Guidance for Adaptive Planning (DOI, 2008); further, there are several "AMP success factors" present, including committed executive leadership, long-standing stakeholder involvement, and a perceived high value associated with new information for reducing uncertainty.

However, there are a number of other factors that, in aggregate, militate against deploying the more active AMP protocol under the DOI guidance for this HCP:

a. Despite best science and sound resource management practices, it is difficult in this instance to confidently gauge effects and responses of alternative management actions of various types without forcing changes in some variable, e.g., allowing higher, shorter-term pumping under some specified condition, that may put the Covered Species' populations at mortal risk.

b. The District cannot control the existence and variable recurrence frequency of either the forcing functions or the Aquifer system responses to provide useful information on impact to the Covered Species, especially in the time periods of interest for an AMP.

c. The District cannot control the variable magnitude of the forcing functions, except within some fairly narrow limits, that would yield useful interpretative information on management options.

d. Monitoring of the response of the Covered Species to management actions is confounded by the small and not easily observable populations of the Covered Species and by the multiple environmental factors that affect that population, only one of which (groundwater withdrawals) is within the District's statutory purview.

e. As discussed elsewhere in the HCP (Section 4.1.2), as an outgrowth of recent state legislation, the District now has a statutory obligation to allow the maximum practicable level of groundwater production while administering a drought management program that is consistent with achieving the DFCs of the Aquifer; that is to say, it cannot arbitrarily (from a groundwater owner's perspective) reduce the amount of otherwise authorized pumping as part of a hypothesis-testing program.

Therefore, the District has concluded that the primary direct HCP measures that are the proposed components of this management system (Section 6.2.1) are not amenable to the Service's active, structured AMP protocol implementation and that this AMP is inappropriate for use in the District's HCP. In lieu of using the structured, active adaptive processes of the AMP for these measures, the District will continue to evaluate its proposed HCP conservation measures using its currently employed incremental/rational planning approach to help resolve the fundamental issues articulated above. For example, if pertinent new statutory authority is provided by the Texas Legislature to GCDs such that the District could differentiate levels of curtailment during Extreme Drought by groundwater use type (currently not legally possible), the District would consider and then could adjust its drought curtailment program to reduce pumping even further by certain types of permittees and thereby further minimize take of the Covered Species.

6.5 Implementation Roles of the Plan Participants

The District is applying for a 20-year ITP to allow incidental take of Covered Species in the Barton Springs ecosystem. Responsibilities of the participant and cooperating entities are outlined below. The ITP generally will specify responsibilities of the permit holder, conservation and mitigation measures to be implemented, monitoring and research procedures, and any other permit conditions that may be required, and the District will ensure they are addressed during HCP implementation.

6.5.1 Barton Springs/Edwards Aquifer Conservation District

The District, or BSEACD, is the applicant for the ITP and is the only Participant, as the term is defined by the Service, in the District HCP. The District will be the ITP holder. The ITP will cover the District, as the groundwater management entity, and all groundwater producers in the District's jurisdiction that hold production permits from the District, as the authorized users of groundwater being managed by the District.

As the District issues and renews groundwater production permits, the permittees' water-use fees and other fees paid by the City of Austin that are associated with use by the permittees will generate funding for the HCP. Typically and generally, this funding will support the implementation of the HCP conservation program and of the administration and reporting associated with the HCP by offsetting the direct and indirect cost of internal labor and other direct costs. The bulk of the funding commitment discussed in Section 8 of the HCP will be utilized in this fashion. Beyond the internal support needs of the HCP, the District will provide the administrative framework to distribute part of this revenue to other entities, if and as authorized by bilateral contractual agreements, or to pay for both in-kind services of the District and for external goods and services provided by other entities, so that mitigation and minimization measures and adaptive management strategies, as are specified under the ITP and in the HCP, can be implemented efficiently.

The District will be responsible for implementing drought-stage management as well as comprehensive management of the aquifer, using its rules and statutory authorities, and for monitoring compliance and effectiveness.

The District will report no less frequently than annually to the Service on the status of Aquifer pumping, drought-stage management, results of monitoring programs, efficacy and issues associated with minimization and mitigation measures, and adaptive management needs and opportunities.

More details on each of these processes are presented in the following subsections.

6.5.1.1 Administration and Reporting

The District will provide to the Service an annual report on the progress of and plans for implementing the District HCP at the same time each year as specified by the Board. More specifically, this report will summarize information on the management and monitoring of the Aquifer including:

- Reported groundwater withdrawals from permitted wells;
- Reference well levels;
- Springflows at Barton Springs;

- Total Aquifer discharges, measured for permitted wells, estimated for exempt wells, gaged/measured for Barton Springs; and estimated for Cold & Deep Eddy Springs;
- Drought-stage management reductions;
- Estimated actual take, if any, for the annual reporting period, and total cumulative take for the ITP term;
- Adaptive management activities undertaken during the year or indicated as prudent by outcomes of the conservation program;
- Expenditures by the District on implementation activities; and
- Proposed activities for the next year.

In addition, the report will summarize any groundwater management actions undertaken by the District and any species-specific research reports compiled or completed by investigators in the reporting year that relate to the biological objectives identified for the Covered Species or improvements in the assessment of and appropriate responses to actual take. This annual report may also contain other, non-HCP information and may also be used to report the progress and plans of the District as a GCD to the Texas Commission on Environmental Quality (TCEQ), as required by District bylaws.

This annual report will be submitted simultaneously to the Service and to the HCP MAC, described in the subsection immediately following, for their respective review and comment by February 28th of each year.

6.5.1.2 District HCP Management Advisory Committee

The District has established an HCP MAC to advise and assist the Board in the coordination of conservation activities affecting Covered Species at Barton Springs, and in monitoring and helping the Board improve the implementation of the District HCP for the District. This MAC is an additional measure of ensuring continued improvement of the HCP and compliance with the ITP as well as ensuring the Board is aware of any stakeholder concerns concerning the execution of the HCP and revisions to the HCP. The primary role for the MAC is to review and comment to the District's Board of Directors on the District's HCP annual reports, in a manner of the MAC's choosing. At the Board's discretion, the MAC may also be utilized to:

- Provide a forum for exchange of information relative to Covered Species,
- Provide advice on Covered Species management activities,
- Advise the District on priorities for conservation actions, and
- Provide input and recommendations, as warranted, on the development and implementation of actions through the adaptive management program.

The MAC was appointed by the District Board in early 2013, and includes independent volunteer representatives with biological or natural-resource management roles from designated interest groups. MAC composition focused on perspectives useful to the active management of the Aquifer and the habitat of Covered Species at Barton Springs. The interest groups that comprise the MAC are:

Texas Parks and Wildlife Department (TPWD)
City of Austin Watershed Protection Department (COA WPD)

Environmental community
Technical/ecological research expertise
Salamander biologist/expert
Public water supply permittee
Large private-sector permittee
Aquifer-using landowner
Private property conservation interests
River authority
County government
Interested private citizen/public at-large (2)
District technical staff

The Service was also requested to provide a non-voting representative to be in a liaison role between the District, the Service, and the MAC.

This MAC is a standing advisory group to the Board for the HCP. The individuals serving as MAC members are reasonably expected to change from time to time over the 20-year term of the ITP. However, provided replacement members are appointed by the District Board from the same interest group, such changes are proposed to be considered administrative in nature.

The MAC will convene in some manner appropriate to the purpose of each meeting and no less frequently than annually, and at such other times as requested by the Board. The MAC at its discretion may form subcommittees to address specific issues or topical areas pertinent to the HCP and the MAC's charge. It will receive and review the District's annual progress report and associated other documentation pertaining to the ITP. In a forum of its discretion each year, it will evaluate the HCP progress and identify any concerns that a consensus of the MAC finds important to convey, and at its discretion report its findings in a presentation directly to the District Board each year.

In addition, every five years the MAC will review the District-prepared report on the performance of the HCP measures, as described in Section 6.3 above, and make recommendations for adjustments or improvements, as warranted, in a letter-style report to the District's Board.

6.5.1.3 Adaptive Management Process

The District may employ an adaptive management process as appropriate to address:

- 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 uncertainties and other 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 Covered Species,
- Providing information to stakeholders regarding the potential impacts and benefits of various flow regimes in the Barton Springs ecosystem.

Certain direct and indirect measures, especially the research measures, as presented in Table 6-1, and the actions taken in response to Changed or some Unforeseen Circumstances, as described in Section 7, may identify needs for a specific adaptive management response. These needs will be characterized and future action recommended, if feasible, in the Annual Report. As appropriate, a future AMP project will conform to the DOI/Service technical guidance document, as discussed in the preceding Section 6.4.

6.5.1.4 District Enforcement Program

The District has established an aggressive enforcement policy and program under District Rule 3-8, Enforcement (Appendix K provides the entire District Board-approved Enforcement Plan). 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, in typical order of their use: warning letters, assessment of fines and penalties through agreed enforcement orders, show-cause hearings, "red-tagging" of wells that limit or prohibit production from permitted wells, temporary suspension of permits, revocation of permits, and finally litigation in District court (which is rarely needed). Under the District policy, enforcement priorities in any one drought stage focus first on the most egregious non-compliant users, those with the largest amounts of permitted pumpage and/or those with the largest percentage of monthly over-pumpage.

Of particular note with respect to the District HCP 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 User Conservation Plan (UCP) and a User Drought Contingency Plan (UDCP) as an agreed part of the permit, specifying both voluntary and mandatory actions that the permittee and end users, as warranted, will take under various drought stages. The UDCPs include drought-time curtailment charts that specify the allowed pumpage each month during various drought stages and emergency response periods of various durations. Penalties related to pumpage violations during Critical-Stage and Exceptional-Stage drought carry twice the dollar fines as those during Alarm-Stage Drought. These penalties have been determined to have considerable deterrent value and success in attaining compliance with District pumpage regulations. The daily penalties for violations related to failure to reduce pumpage during District-declared drought are shown in Table 6-2 below. Changes to the penalty structure and amounts that do not affect compliance and therefore take would be a proposed administrative change under the HCP and not require an HCP or ITP amendment.

Table 6-2: Daily Penalties for Violations of District Drought Rules

Table 6-2a: Daily Penalties During Stage II-Alarm 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

Table 6-2b: Daily Penalties During Stage III-Critical and Stage IV-Exceptional 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

Table 6-2c: Definition of Tiers of Permitted Pumpage and Levels Of Overpumpage During All Drought Stages

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%

6.5.2 Cooperating Federal and State Agencies

6.5.2.1 U.S. Fish and Wildlife Service

The Service is the federal agency responsible for issuing the ITP and monitoring compliance with the ITP conditions. The Service, as the regulatory agency for the District ITP, will review and comment on the Annual Report and other HCP monitoring reports provided by the District.

6.5.2.2 Texas Parks and Wildlife Department

The Covered Species are also species listed by the TPWD as Species of Greatest Conservation Need (TPWD, 2012), and therefore the TPWD is a supporting governmental entity of this HCP. Involvement by the TPWD as well as other state governmental agencies and political subdivisions in the development of HCPs is guided by provisions of Subchapter B, § 83.011 through §83.020 of the Texas Statutes, Parks and Wildlife Code. These subsections lay out definitions of HCP; regional HCPs; land development standards; and plan participants, structure and function of advisory committees; while providing guidance in the acquisition of habitat preserves. TPWD is also providing a member of the proposed MAC to assist the District in the implementation of the District HCP. Other TPWD activities—including biological consultation, coordination, or participation in future adaptive management strategies — remain unspecified and will be consistent with their authorities and needs during the implementation of the HCP.

6.5.3 City of Austin and Barton Springs Pool HCP

The City of Austin is not an applicant in the District HCP. However, the City of Austin, which is traditionally a collaborative partner with the District in many of its programs, is currently providing a substantial portion of the total funding for the District, including in part the conservation measures of the District HCP. In addition, the City of Austin has a complementary HCP for operation and maintenance of Barton Springs Pool (City of Austin, 2013.) The District intends to take advantage of the opportunities that likely exist for synergies between the two related HCPs. Under the District HCP, the District and the City of Austin propose to collaborate through an ILA and/or an MOU in the following areas, as one of the Indirect HCP Measures arising from the District's adaptive management process:

- Provision of data and evaluation reports, in preliminary and final formats, to the District so that mutual interests on the viability of the Covered Species and on 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 District HCP planning area in lieu of the Aquifer water supply; and

- Collaboration and participation in a variety of investigations, mitigation measures, and adaptive management measures, as specified in Section.6.2.2, as well as the continuing collaboration with the City of Austin in dye tracing, springflow measurements, and the adjustment and validation of low springflow-discharge rating curves.

While perhaps not included explicitly in the ILA provisions, the City of Austin representative(s) on the MAC will be invaluable in conveying the results and conclusions of the City of Austin's complementary investigations to other members of the MAC.

6.5.4 Other Entities

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 HCP measures. If they become an essential condition in maintaining ITP compliance, specific responsibilities of the parties would be identified in District HCP contracts or implementation agreements with the District. The current statutory and/or management roles of certain entities could either directly or indirectly affect HCP implementation:

- U.S. Geological Survey – This agency is expected to continue to administer programs monitoring aquifer recharge, springflows, aquifer levels, and water quality. The USGS currently operates monitoring wells and telemeters water level data at both locations that the District uses in its drought trigger methodology for assessing drought stages.

- Texas Commission on Environmental Quality – This agency has, as a primary responsibility, management and protection of water quality through regulation of point- and nonpoint sources of water pollution in the Edwards Aquifer and the contributing surface watershed. TCEQ also serves as the administrative regulatory authority for all GCDs in the state, including the District.

- Texas Water Development Board – This agency will review and approve the District's MP and provide additional support to the District on compliance with state laws pertaining to groundwater management, especially those related to specifying the Modeled Available Groundwater associated with DFCs.

- Other Groundwater Conservation Districts – The five other GCDs in GMA 10 are statutorily charged with establishing and reviewing the DFCs for the Aquifer at least every five years. A two-thirds super-majority is required to amend and approve (and re-adopt) the DFCs set by the GMA. In addition, GCDs in GMA 9, especially the Hays Trinity GCD and Blanco Pedernales GCD, authorize the pumping from the Trinity Aquifer in the contributing zone of the Barton Springs segment of the Edwards Aquifer, which may affect the quantity and quality of contributions of base flow to the up-gradient creeks that recharge the Aquifer.

7.0 Changed and Unforeseen Circumstances

Regulations implementing Section 10 of the Endangered Species Act (Act) [50 CFR 17.22(b)(2)(iii)] require that a Habitat Conservation Plan (HCP) specify the procedures to be used for dealing with changed and unforeseen circumstances that may arise during HCP implementation. In addition, the HCP 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 obligations of the permittees and the U.S. Fish & Wildlife Service (Service) under such circumstances.

7.1 Responding to Changed Circumstances and Unforeseen Circumstances

The District has made a concerted effort to anticipate the minimization and mitigation measures (conservation measures) and monitoring that are necessary to conserve the Covered Species and preserve the habitats that support the species and that are within its statutory authorities. To that end, the District has relied upon the best scientific and experiential information available in preparing this HCP. The District also sponsored and contracted for original research and for relevant new data to be collected, as a part of the District HCP development process, to provide new information and complement existing knowledge where necessary, to manage groundwater production and springflow for the benefit of the Covered Species. In addition, the flexible provisions regarding the expenditure of funds authorized by the District Board for specific mitigation measures, including the indirect measures described in Section 6.2.2 and specifically the Adaptive Management Plan (AMP) measures in Section 6.4.2 of this HCP, are designed to address future exigencies and emergency situations in a beneficial fashion. Thus, the District HCP intends to minimize the potential for adverse changed or unforeseen circumstances on the Covered Species and its habitat.

However, these provisions notwithstanding, changed or unforeseen circumstances may occur during the course of a long-term permit program like the Incidental Take Permit (ITP). So provisions for addressing such conditions are part of each HCP. In this context, only those circumstances that the Covered Activities may affect or may be affected by are relevant to the District HCP.

The District HCP's AMP, described in Section 6.4 above, is one mechanism that the District will use to anticipate optional responses and evaluate outcomes to certain changed circumstances and unforeseen circumstances. Additional information on how the District will respond to these circumstantial elements is presented in the following sections and subsections of this chapter.

7.1.1 Resolving Adverse Changes

A principal aspect of the HCP is a commitment by the District that a) should certain changed or unforeseen circumstances result in or threaten a substantial adverse change in the population of the Covered Species or the overall quality of any habitat of the species, and b) should it be determined that the Covered Activities in the District HCP contribute to either the cause or the resolution of the adverse change, as determined pursuant to the procedure outlined herein, the District and the Service shall cooperate to resolve the adverse impacts in accordance with the definitions and guidance provided by the Services' HCP Assurances ("No Surprises") Rule:

- **For Changed Circumstances –** If additional conservation and mitigation measures for the Covered Activities are deemed necessary to respond to changes in circumstances provided for in the District HCP, the District as the ITP permittee will be expected to implement the responsive measures specified in the HCP, but only those measures and no others; and

- **For Unforeseen Circumstances –** The Service statutorily may not require the commitment of additional land or water resources or financial compensation - including 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 may have only limited ability to require additional measures or modifications within the conserved habitat areas that are inconsistent with the District's approved Management Plan (MP) that authorizes its groundwater management program and the District HCP. 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.

Consultation between the Service and the District also may indicate that the adverse changes may be most appropriately addressed through an amendment of the ITP and HCP.

7.1.2 Method for Developing Criteria for Changed *Versus* Unforeseen Circumstances

The District has determined that changes in several specific circumstances are reasonably foreseeable and therefore should not be considered unlikely to occur during the course of the HCP and the term of the ITP. The District has made a determination of which of these are related to Covered Activities of the District HCP and are therefore actual Changed Circumstances under the Act. These circumstances are discussed in more detail in Section 7.2.2 immediately below. Not reasonably foreseeable and unforeseen circumstances (discussed in Section 7.3) could also affect the District HCP, as provided for under the Service's HCP rules and guidelines. In addition, several dimensions of the ecosystem are either not known or only poorly known, as characterized in Section 7.2.1; the likelihood of those factors affecting the efficacy of HCP conservation measures is uncertain. They could result in either changed or unforeseen circumstances. The District will consult with the Service and seek a determination by the Service whether a particular event or change in a relevant circumstance or factor constitutes a changed or unforeseen circumstance under the District HCP, generally on the basis of the likelihood of the change or event reasonably being anticipated to occur during an average 20-year period (the proposed term of the District HCP) and reasonably being related to the Covered Activities. The responsibilities of the District and the role of the Service in determining unforeseen (and therefore not "changed") circumstances are discussed in Section 7.3.1.

7.2 Changed Circumstances and Uncertainties

The Service defines the term "changed circumstances" to mean "changes in circumstances affecting a species or geographic area covered by a conservation plan…that can reasonably be anticipated by plan…developers and the Service, and that can be planned for" (40 CFR §17.3). Examples provided include listing of new species in the plan area (as discussed in Section 7.2.2.1) or some extreme event in areas prone to such events, most notably drought severity equivalent to the so-called "drought of record."

Substantial uncertainties exist in the various bases for developing conservation measures for the Covered Activities, and to the extent these uncertainties manifest themselves in unplanned ways that affect the ITP during the term of the ITP, they may produce changed circumstances. These uncertainties are addressed in the next section of this HCP.

7.2.1 Considering Specific Uncertainties

A number of issues and uncertainties could create changed circumstances, including the uncertain existence and magnitudes of various factors that could affect the ITP, HCP effectiveness, or that are not otherwise quantifiably taken into account in the District HCP. Under the District HCP, District staff will continue to monitor and to develop new information that will address and resolve known issues, elucidate others, reduce uncertainties, and mitigate impacts associated with the Covered Activities, and consult with the Service as warranted to evaluate the need for amendments to the HCP and ITP. This subsection identifies the more important of these and their possible effects and impacts, without attempting to characterize or evaluate them in detail.

7.2.1.1 Global Climate Change: Effects and Probabilities

Probably the largest uncertainty that may substantively affect the long-run effectiveness of the District HCP measures relates to "climate change" in the larger sense. The uncertainty isn't related to whether climate change is now occurring in an extraordinary fashion. As reported by the Service (2013),

> The U.S. Climate Change Science Program (CCSP) has concluded that the global climate is changing. Effects of this change on the existing environment has been evaluated in a 2008 U.S. national scientific assessment (National Science and Technology Council, 2008) which integrates, evaluates, and interprets the findings of the CCSP and draws from and synthesizes findings from previous assessments of the science, including reports and products by the Intergovernmental Panel on Climate Change (IPCC).

> The conclusions in the National Science and Technology Council assessment build on the vast body of observations, modeling, decision support, and other types of activities conducted under the auspices of CCSP and from previous assessments of the science, including reports and products by the IPCC, CCSP, and others. This assessment and the underlying assessments have been subjected to and improved through rigorous peer reviews. According to CCSP's Synthesis and Assessment Product (SAP) 4.3 (Backlund et al. 2008), it is very likely that temperature increases, increasing carbon dioxide levels, and altered patterns of precipitation are already affecting U.S. water resources, agriculture, land resources, biodiversity, and human health, among other things. SAP 4.3 also concluded that it is very likely that climate change will continue to have significant effects on these resources over the next few decades and beyond.

The IPCC has also determined that warming of the global climate is unequivocal, and emissions of greenhouse gases emitted by humans are largely responsible for the warming over the past 100 years (IPCC, 2007; 2013). In the future, the net global effect of the warming, even if no additional greenhouse gases are emitted, will be increased precipitation, though with variable spatial distribution and intensity. Extreme weather events, such as heat waves, flooding, and drought, will continue to increase in frequency and intensity, as well as adverse impact (IPCC, 2007, 2013; USGCRP, 2014).

The uncertainties arise as to what that means for the HCP region generally and for the Covered Species particularly. The Summary for Policy Makers prepared by the IPCC (2007b, and reinforced in 2013) suggests there is high confidence (8 out of 10 chances) that drought and flooding will be both more severe and frequent, and those conditions will have mostly negative consequences for ecosystem structure, function, inter-species interactions, and therefore biodiversity. It includes more detailed predictions of long-term changes in precipitation patterns, at both global and regional levels (IPCC 2007a). The impacts that have been predicted for central Texas, according to one model (A1B), would result in a 10-20% reduction in precipitation during the winter months by 2090-99, relative to 1980-99 conditions; but no clear trend in the direction of change for precipitation during the summer months by 2090-99. These slight and variable differences are reflected in Figure 10-1 below from modeling of these data by the Nature Conservancy (Maurer et al., 2007), which shows the sensitivity of the precipitation projections by this model to emission scenarios, especially in Central Texas.

Joseph Alcamo, a lead author of many IPCC publications on climate change and water resources, has developed and applied another global water model to analyze the impacts of climate change and socio-economic driving forces on future global water stress, derived from the A2 and B2 scenarios of the IPCC (Alcamo et al., 2007). The investigators define "water stress" as the intensity of pressure put on water resources and aquatic ecosystems by external drivers of change. The principal cause of *increasing* water stress, where it occurs, is growing water withdrawals. Alcamo and other investigators show increases in water stress for the central Texas region of between 50% and 100% by the time of the 2050s, under two different IPCC scenarios (A2 and B2). This work and other more local, as well as large-scale scenarios indicate that significant additional challenges and competition for water consumption, and correspondingly less water availability for wildlife and other in-stream functions, must be anticipated and confronted.

The uncertainty in climate change effects on local precipitation has been underscored by Nielson-Gammon (2011), who noted that observed variations in precipitation over the past century in Texas are larger than most future climate projections of precipitation changes by mid-century.

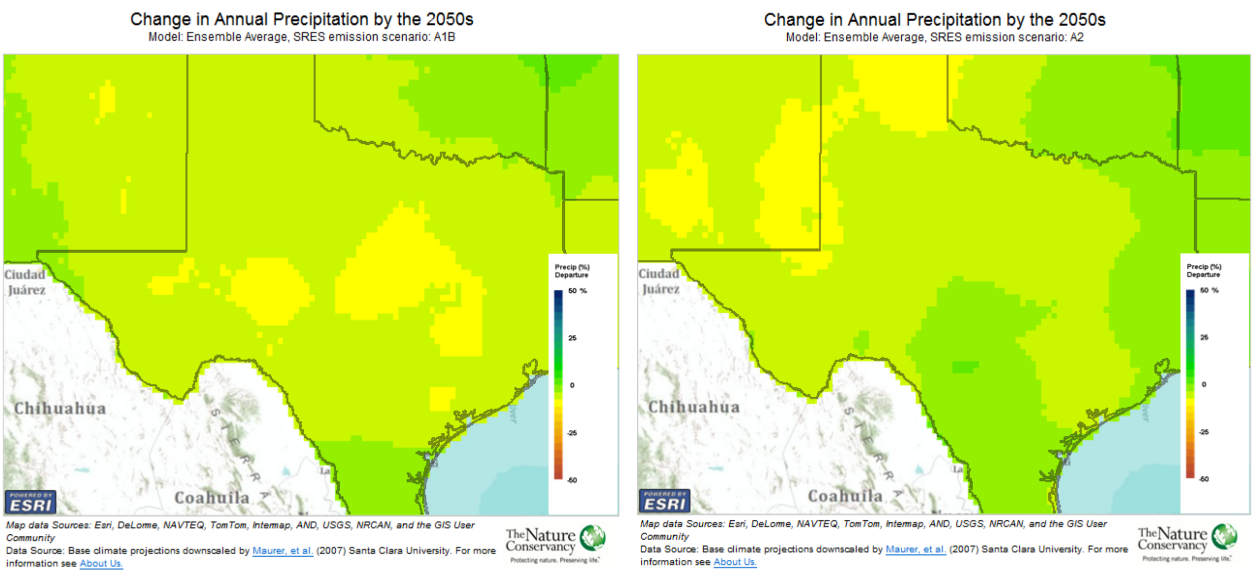

Figure 7-1: Change in annual precipitation projected over Texas by mid-century.
Changes based on the ensemble average (median value) of models used in the IPCC Fourth Assessment and the A1B emissions scenario (medium) on the left and the A2 (high) on the right. Areas in darker shades of green are projected to increase by half the models and areas in yellow and lighter shades of green are projected to decrease by half the models (Maurer et al., 2007).

Nevertheless, governmental agencies and other organizations that participate in water resource planning are either currently planning for the potential changes due to climate change, or they intend to incorporate that into future planning. Hirsch (2008) recommended the following approach to water resource managers: 1) collect more data, 2) consider paleoclimate records, 3) keep an eye on climate science and change, and 4) don't lose sight of other stresses (e.g. population & demand, urbanization, return flows, etc.).

7.2.1.2 Effects of Extant Climate Change on Regional Groundwater Systems and the Aquifer

A growing consensus among climatologists suggests that the next 50 years is likely to be warmer and drier *in the HCP Planning Area* than the previous 50 years (Seager 2007a, 2007c), especially if anthropogenic climate changes continue to accelerate, but also even if atmospheric carbon dioxide concentrations stay at current levels (Seager et al., 2007a):

> According to research compiled by the IPCC, from 1970 to 2004, much of the region that includes central Texas has encountered a warming trend on the order of 0.2-1.0°C (IPCC, 2007a). The IPCC findings include new and stronger evidence of observed impacts of climate change on unique and vulnerable systems, with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction is projected. Confidence has increased that a 1 to 2°C increase in global mean temperature above 1990 levels (about 1.5 to 2.5°C above pre-industrial levels) poses significant risks to many unique and threatened systems including many biodiversity hotspots.

While Global Circulation Models (GCMs) are a key tool for predicting and analyzing climate change, and regional predictions for Texas are reported (Seager et al., 2007), GCMs are not yet useful enough for predicting and assessing impacts in regional areas such as Texas. For example, rainfall is a key variable to assess environmental impacts (Leung, 2008). However, rainfall predictions from GCMs have the lowest confidence of simulated results and a lot of variability. Most GCM models suggest a "general drying" for Texas (Washington, 2008), but this is not consistent with Texas's regional rainfall and stream flow trends (Hunt et al., 2012; Nielson-Gammon, 2008; Singh, 2008; Leung, 2008). The last 30 years have been warming faster than the global average, and have been accompanied by an unusually wet period in Texas, punctuated with more extreme events that are expected to continue into the future (Nielson-Gammon, 2008; North, 2008).

Texas will get hotter and climate change will exacerbate stresses already imposed upon water resources (Hayhoe, 2008). Climate in Texas continues to change, although current impacts from those changes have not been observed as they have in the U.S. Southwest such as Arizona (Woodhouse). Generally, it is expected that rapidly responding aquifers, such as the Edwards Aquifer, will be more sensitive to changes in climate (Mace, 2008). However, to date, no trends have been observed, either up or down, in recharge since the 1930s for the San Antonio segment of the Edwards Aquifer (Loaiciga, 2008). A study of hydrologic and geohydrologic responses by Hunt et al., (2012) in the Central Texas area concluded that while there has been an overall increase in the amount of water in water budgets of various stream systems, the base flows of streams and springflows have slightly decreased over the past several decades since the drought of record, likely owing to increased use of the groundwater resources (Hunt et al., 2012). This is particularly germane for the rather poorly controlled pumping from the Trinity Aquifer up gradient from the ITP Area, which will tend to produce lower base flows and flows of shorter duration in the creeks that contribute recharge to the Aquifer. But a study of global warming impacts on the San Antonio segment of the Edwards Aquifer by Chen et al., (2001) predicts that annual temperatures will rise (~3F) and annual rainfall will decrease (~4 in) by 2030 resulting in a 20% decrease in recharge during droughts. However, these effects and their impacts are both uncertain. Increasing demand due to population growth and rising temperatures will be the dominant factors impacting springs and water availability (Mace, 2008; Loaiciga, 2008). It seems clear that climate change will likely exacerbate these impacts, and vice versa.

As the Service (2013) summarizes,

"Climate change could impact groundwater resources by affecting recharge, pumping, natural discharge, and saline intrusion (Mace and Wade 2008). They suggest that climate change will more adversely affect karstic aquifers (like the Edwards Aquifer) that recharge locally from streams and rivers in comparison to dripping aquifers where effective recharge is increased through pumping and the capture of intermediate and local groundwater flow paths. A warmer, dryer climate will increase demand for water to support agriculture, municipal, and industrial use. This will result in greater demand for both surface and groundwater. Decreases in surface water supply due to climate change may also increase demand for groundwater use (Kundzewicz et al., 2007; Mace and Wade 2008). Natural aquifer discharge to springs and seeps is affected by recharge to the aquifer, discharge by pumping, and changes in groundwater gradients as affected by plants, including phreatophytic species that demand higher amounts of water.

Mace and Wade (2008) and Loáiciga et al., (1996) suggest that the Edwards Aquifer is probably Texas's most vulnerable aquifer and groundwater resource with respect to climate change and variability and if there is a long-term drying of the climate in south-central Texas, area groundwater users can expect to be under more frequent drought restrictions.

Loáiciga et al., (2000) studied the climate change impacts on the Edwards Aquifer. Climate change scenarios were created from scaling factors derived from several general circulation models to assess the likely impacts of aquifer pumping on the water resources of the Edwards Aquifer. Aquifer simulations using GWSIM IV indicate that, given the predicted growth and water demand in the Edwards Aquifer region, the aquifer's ground water resources appear threatened under 2×CO_2 climate scenarios. Their simulations indicate that 2×CO_2 climatic conditions could exacerbate negative impacts and water shortages in the Edwards Aquifer region even if pumping does not increase above its present average level. The historical evidence and the results of this research indicate that without proper consideration to variations in aquifer recharge and sound pumping strategies, the water resources of the Edwards Aquifer could be severely impacted under a warmer climate."

It is possible that progressive increases in the ambient atmospheric temperature in central Texas would lead to seasonal or year-round increases in the temperature of springflow at Barton Springs, possibly causing increased stress and vulnerability to disease for the salamander species there and possible reductions in dissolved oxygen (DO) saturation levels. Such temperature increases could be moderated to some variable, though unquantifiable extent by the long residence time of groundwater issuing from the Aquifer, especially during severe drought. It is also possible that any reduction in the long-term average precipitation in central Texas during the winter months could result in reduced storage in the Edwards Aquifer at the onset of spring- and summer-time periods when water losses through natural and cultural processes are elevated. Such a condition could also exacerbate the reduction in summertime springflow during droughts.

Further, while the State of Texas mandates use of the drought of record (DOR) for water-planning purposes, such DORs may not represent the worst-case condition that actually could be experienced in the ITP permit period (Cleaveland 2006; Nielsen-Gammon 2008; Woodhouse 2008; see also the discussion in Section 7.2.1.3 immediately below). Put another way, it is possible that the DOR 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 lowest expected flows at Barton Springs could be concomitantly lower, other factors being equal. On the other hand, the DOR has been estimated to have a recurrence interval about five times longer than the 20-year duration of the District HCP, as described in Section 4.2. These factors suggest that a recurrence of a drought causing Barton Springs discharge to diminish to a level lower than has ever been recorded during the course of the ITP permit period is not likely.

Nevertheless, taken together these are trends for which additional attention and concern are warranted. There is a finite, albeit indeterminate likelihood that an extreme record event would occur during the term of the ITP, and that while still probably small, the likelihood will increase under recent climatic trends to some indeterminate degree.

7.2.1.3 Ecological Significance of Paleoclimatic 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 DOR during medieval times and even in prerecorded history (e.g., Cleaveland et al., 2006; Seager et al., 2007b and 2007c). 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 District HCP 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. The size and distribution of the Covered Species populations before the historic and prehistoric droughts are unknown, so it is not known if the populations are particularly persistent or are the last surviving remnants of much larger populations at one time. Clearly the additional stresses contributed by cultural factors in the last century (e.g., increased impervious cover and urban storm runoff) distinguish current and future responses from those of historic or prehistoric times.

7.2.1.4 Lack of Water Chemistry, Water Quality, and Flow Data to Calibrate Models During Extreme Low Springflow Conditions

Modeling efforts to predict springflow conditions as described in Section 3.2.2.1.2, like any modeling exercise, produce outcomes of predicted springflow values that are not absolute. Rather, they are theoretical, predicted estimates 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 alternative groundwater management strategies in a broad sense, not in a precise replication of a future scenario that is currently indeterminate. While they are instructive, use of the predicted springflow values beyond the described analyses should be exercised with caution.

Because the lowest recorded flow at Barton Springs is just under 10 cfs, 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, almost all of this type of information comes from flows that are no lower than about 14 cfs. Accordingly, extrapolation of trends in flow, chemical components, and their relationships to flows less than 14 cfs is problematic. It is not known, for example, whether DO continues to decline with flow or whether it “plateaus” at some small sub-saturated concentration. Water temperature, even though it varies over a relatively small range in the Aquifer, may play a role in the level of DO of springflows independent of spring discharges and water levels, as it relates to DO saturation (Mahler and Bourgeais, 2013). These same investigators note that critically low DO levels can be caused by recharge from storm flows, especially during hot months. It is also not known whether and at what rate the flow itself continues to decline under prolonged Extreme Drought, or plateaus as a result of induced recharge of water that would otherwise be in the larger and topographically higher San Antonio segment. A statistical analysis of correlations between DO and springflow between 1993 and 2011 by the City of Austin may indicate a minimum concentration under ambient conditions that could be as high as 3.5 mg/L or as low as 0 mg/L DO (City of Austin, 2013). While the City of Austin has inferred, not unreasonably, a worst-case scenario, there currently is no unequivocal basis for reliably projecting the DO concentration at extremely low flow.

7.2.1.5 Cumulative Negative Effect of Pollutants in Groundwater Discharges on Salamanders

In development of the District HCP, studies funded by the District have focused on the relationship of DO and specific conductance with toxicity and other adverse effects on the Covered Species. Of these parameters, DO and springflow are now believed to be controlling. However, the Service recently has suggested that conductance, indicative of the relative salinity of the resurging groundwater, may also be important, especially to eggs and larvae (Service, 2013b), although it is not known if the relatively small increases in salinity at lower flows produce adverse effects. 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 importance in times of depressed DO concentration). The DO and salinity (and water temperature) are variations of the natural system, not pollutants, but sources of contamination and pollutants may produce adverse effects either on their own or in combination with the changes in natural water chemistry.

Little information exists in the biological literature on impacts of other chemical constituents and physical conditions to the Covered Species. But nonpoint-source pollution in the contributing and recharge zones of the Aquifer is already increasing the amount of anthropogenic pollutants like pesticides, domestic wastewater from decentralized and centralized treatment facilities, fertilizers and other nutrient sources, other oxygen-demanding constituents such as pet waste, suspended sediment, and some heavy metals in spring discharges (Mahler et al., 2011). Concentrations of those pollutants are likely to increase with time along with development, as additional volumes of treated domestic wastewater (sewage) and its oxygen-demanding waste loads are discharged directly and indirectly to streams that recharge the Aquifer. However, Mahler and Bourgeais (2013) suggests that there has been more recently a trend toward increasing DO concentrations overall in the Aquifer, indicative of the complex controls on this parameter.

There has been no attempt in this HCP or in any other investigation to assess the impacts of different concentrations and mixes of these water quality pollutants or their possible adverse impacts on the Covered Species, primarily owing to their vulnerability. Since management and control of land uses and associated development activities that generate these pollutant loads are beyond the authority of the District and the scope of its possible programs, they are therefore not proposed for management or research under the District HCP.

7.2.1.6 Response of Salamanders to Variations in Habitat Condition

By necessity, status of the Covered Species' populations is based on counts of observable individuals at the spring outlets and in spring runs. Lower counts clearly are associated with stress-related impacts, including population declines (City of Austin, 2013). As noted in Section 5.1.2.1; however, it has been suggested by other experts that salamanders appear to be able to migrate locally to areas of less stress in the Aquifer and in spring runs during certain times, but to some unknown extent. It seems not unreasonable that migration into the Aquifer and even to and from Main Springs is partly responsible for the re-emergence of a substantial portion of the population of salamanders at Upper Barton Spring when that outlet starts flowing again after many months of no flow and no observable organisms during the earliest stages of drought. On the other hand, during very severe prolonged drought conditions, the populations of both Covered Species at Old Mill Spring outlet decline substantially to no or just a few individual organisms after extremely low flow at the outlet. Those very low observable numbers continue to persist for months to years, even with re-establishment of some springflow.

The difference in behavior and ability to accommodate drought of these two populations maybe related to known differences in their hydrogeologic conditions at their outlets. In turn, that may be associated with the amount of subsurface migration that is possible. For the subterranean Austin blind salamander especially, lower observable numbers during prolonged and/or severe drought may not be an indicator of mortality, although some population decline during such periods of DO stress is reasonably expected. But the areal extent and proportional amount of such migration and their differences for either species, while inferred to occur, are largely unknown. These factors confound the quantitative interpretation of salamander reactions to stress and population impacts. . It seems clear that these uncertainties probably reduce the reliability of stress and quantitative take estimates determined on counts. However, no other deterministic approach currently exists.

Other, more hydrological uncertainties may relate to migration. The majority of water naturally discharging from the Aquifer resurges at Barton Springs. However, smaller springs have been noted that release directly into Barton Creek, upstream of Upper Barton Springs and also into the Colorado River. The springs upstream of Upper Barton Springs only discharge under moderate to high-flow conditions. Some small springs (e.g., Cold Springs) are visible on the south shore of Lady Bird Lake at the level of the water in the lake. Other discharges into the riverbed, but below the lake level, are also possible, but are difficult to discern either by direct observation or by monitoring temperature differences in the lake. The elevation of the lowest point in the Colorado River near the confluence with Barton Creek is about 412 ft msl. With an elevation of the main discharge point at Main Springs of about 420 ft msl, there is the potential for discharge of water into the Colorado River along some of these likely pathways owing to the head difference between the spring outlets and the base level of the river (TWDB, 1999). Although the presence of small springs below the lake level is unproven and would likely be only a very small component of the water balance for the aquifer system as a whole, 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 not unlikely that small discharges occur where these faults, fractures, and bedding planes intersect the riverbed. Such discharges into the Colorado River may be foreseen to occur even at no flow at the major spring outlets. They may offer alternative groundwater flow paths and therefore possible flow environments with sufficiently high water velocities to support the salamander ecosystem.

In addition, the conceptual model used by the District for the take estimate is that the spring outlets are hybrid springs, where both confined and unconfined waters resurge. The relative proportion of each of those groundwater types has been shown to vary with time and to differ among outlets.   In the unconfined portion, the access for the salamanders from the outlets to various conduits and fissures at the water table, which is in contact with the atmosphere and provides a source of re-aeration within the Aquifer, seems likely to characterize the subterranean-only habitat of the Austin blind salamander.

However, this is simply hydrogeologically informed conjecture at this point, as no studies have been performed to address this uncertainty in subsurface flow environments and suitability and use as habitat of the Covered Species.

7.2.1.7 Recent Texas Court Decisions and Aftermath

In a series of decisions, culminating in the *EAA v. Day and McDaniel* opinion in 2012, the Texas Supreme Court has now clarified that 'groundwater in place' below the surface of the land is real property owned by the owner of the surface estate. It follows from the Court's decision that as real property, it is severable from the land and may be sold separately, although no specific amount of owned groundwater can be inferred *a priori*. Further, the Court has determined that, even though its withdrawal is subject to reasonable and equitable regulation by a groundwater conservation district (GCD), a GCD's regulation that arguably produces an inequitable or unfair economic burden on a landowner with investment-backed expectations may outweigh the public interest in managing groundwater and is potentially regulatory "taking," subject to compensation.

Moreover, a recent appellate court ruling, in *EAA v. Bragg*, suggests that even rational, well-considered groundwater regulation may in fact be a taking for which the regulating GCD is financially liable. The assessment of compensable takings will be determined by future legislative action and judicial opinions, including likely appeals to the Supreme Court.

While the actual implications of these decisions for the District's operations are almost certainly to be elaborated further during the term of this HCP and ITP, it clearly represents a new factor in the authority with which the District, or any GCD, may be able to limit groundwater production, without putting at risk its financial wherewithal to manage the groundwater resources in an overall sense. It also should be mentioned that should the latter scenario be manifested with the District, it is not clear whether such a fundamental change in the District's regulatory capability is a changed circumstance or an unforeseen circumstance for its HCP or, alternatively, a basis for suspension or termination of the ITP by the Service. Ultimately the Service will be expected to make the determination of what sort of HCP circumstance exists for that eventuality.

7.2.2 Responding to Changed Circumstances

While the District believes that the initial measures to be funded by the District HCP will be effective in conserving both habitats and the Covered Species, it is anticipated that conditions within the aquifer, the status of habitats, and the overall condition of the species over time will change. In addition, it is likely that additional and different conservation measures, not contained within the District HCP, will be suggested and be proven to be effective during the term of the District HCP. Finally, it may be found that measures currently funded by the District HCP may prove to be ineffective to conserve either the species or the habitats in which they dwell. All these situations potentially constitute changed or unforeseen circumstances. Therefore, the District is proposing to monitor and gauge the effectiveness of existing conservation measures on an ongoing basis, to evaluate alternatives in accordance with the monitoring reporting in Section 6.3.2 and the adaptive management processes described in Section 6.4, and to propose modifications, additions, or alternative conservation measures that could be implemented or supported by the District within its regulatory purview, including dealing with different circumstances as described below.

Events or situations likely to occur or that could be reasonably anticipated during an average 20-year period and to affect the ITP would be considered "changed circumstances." Events not reasonably expected to occur, or anticipated to occur less frequently than once during an average 20-year period (such as a drought worse than the DOR itself) would be "unforeseen circumstances." For changed circumstances reasonably related to the Covered Activities and the proposed conservation measures in the District HCP, the District includes in this section of the HCP a specific proposed response plan, in keeping with 50 CFR §17.22(b)(5)(i) for such changed circumstances. Except as noted in the subsections below, the contingency actions described as part of the response plans are able to be implemented within the funding commitments of the District discussed in Section 8 of this HCP, by reprogramming internal labor of District staff and/or certain contracted support.

7.2.2.1 Listing of New Species Not Covered by HCP

The listing of a new species by the Service as threatened or endangered within the ITP Area and that is determined to be not covered by the District HCP may constitute a changed circumstance. The two ecoregions of the HCP Planning Area have numerous vulnerable aquatic and terrestrial species (see Appendix A for a current listing), but none of those vulnerable species (or others) are known to exist in the ITP Area. The Service is statutorily required to notify the District and/or publish notice in the *Federal Register* upon becoming aware that a species associated with the habitats found in Barton Springs and not a Covered Species (but rather an "Uncovered Species") that may be or has been proposed for listing.

Proposed Response:

a. Upon receipt of notice of the listing of an Uncovered Species, the District will seek to partner with the Service regarding confirmation of this circumstance as a Changed Circumstance for the District HCP as determined by the Service, and the necessity of modification and amendment of the District HCP. If the District elects to pursue amendment of the applicable permit, the District will ask the Service to provide technical assistance to the District in identifying any modifications to the District HCP warranted by the changed circumstance and necessary to amend the applicable federal permit.

b. The District shall assess the efficacy of the conservation and mitigation measures as already provided in the District HCP as they provide for avoidance, minimization, and mitigation of take of the Uncovered Species, and provide that analysis to the Service.

c. The District shall seek guidance from the Service in determining whether any further conservation or mitigation measures are required and whether the District ITP requires an amendment to authorize any incidental take of such Uncovered Species.

d. The District shall provide the Service with an assessment of whether the District's Covered Activities and the proposed response to the listing of the Uncovered Species will adversely affect take of Covered Species, consistent with section 10 of the Act.

e. The District will incorporate any needed conservation measures that are within its regulatory authority and financial wherewithal into its amended HCP and ITP.

7.2.2.2 Drought with *Unexpectedly*, Sustained Low DO Levels

It is conceivable, though not likely, that a range of drought and non-drought springflows during the term of the ITP could exhibit DO concentrations related to springflows that were substantially different across-the-board and/or significantly more adverse to the Covered Species than now anticipated on the basis of current knowledge, which has been developed over more than a decade from existing data, current models, and inferred relationships. If this were to occur on a systemic, sustained basis without other apparent exogenous causes, the District would propose that this be considered an Unforeseen Circumstance. However, it is also possible that severe droughts during the term of the ITP could suddenly degrade the habitat substantially more than anticipated in this HCP on a shorter-term, rapid-onset basis and in a way that had immediate adverse consequences for the Covered Species. This circumstance would be considered a Changed Circumstance. It would be associated with a persistent declared Stage III-Critical or more severe drought condition, indicating the likely relationship of the DO to springflows, and would be triggered by confirmed daily measurements of DO levels in the Main (Parthenia) and/or Eliza spring outlets that averaged below 3.4 mg/L, the *laboratory* LC_{50} concentration, for more than one month, to eliminate transient and non-springflow related causes of low DO.

<u>Proposed Response</u>:

Following consultation with the Service as to the need for immediate and extraordinary mitigation, the District Board could provide one or both of two sequential responses:

a. If the DO Augmentation Project, developed as a Mitigation Measure and described in Section 6.2.2.2, proved feasible and had been implemented in its planned stand-by mode at the time of this circumstance, the Board would trigger its deployment under the terms of its Implementation Agreement with the City of Austin, and monitor the response of the spring outlets with respect to DO concentrations, until it improved to the point where the extraordinary stress on the species was relieved, as indicated by weekly average dissolved oxygen levels in Main and Eliza Springs' increasing above 4.5 mg/L.

b. If the DO Augmentation Project was not deployable for any reason or failed to provide the intended benefit, the Board is committed to induce selected individual permittees that have unused alternative water supplies to voluntarily agree to temporary pumping curtailments greater than otherwise required by District Rules until the extraordinary stress on the species was relieved, as indicated by weekly average DO levels in Main and Eliza Springs' increasing above 3.7 mg/L, the LC_{25}, on a sustained basis. The inducement for such temporary curtailments could be temporary increases in the permittees' permitted volumes once drought ends. This provision will require a change in the District's Rules but not its MP, to be initiated upon ITP approval for ready implementation.

7.2.2.3 Substantial Change in Statutory, Legal, or Financial Wherewithal to Execute the Conservation Measures According to the ITP

A change in the District's legal authority or a substantial reduction in the level of annual revenues available to the District for implementation of the District HCP 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 statutory mandate. These revenues may vary somewhat each year, as explained in Section 8, and

they are not anticipated to be curtailed or terminated during the course of the ITP; but neither are they guaranteed sources or amounts of revenue. GCDs are currently the Legislature's preferred means of managing groundwater, but the scope of this authority is subject to both legislative pressures and constitutional challenges in court. It is not unforeseeable that during the term of this HCP; in particular, legislative changes could affect both, and legal defense expenses, such as noted in subsection 7.2.1.7 above, could adversely affect the District's financial condition. However, the District maintains funds in a contingency account as a routine policy of fiscal management to provide protection from emergency conditions affecting its revenues or expenses, and it will deploy them as needed to maintain the necessary funding of conservation measures and other ITP requirements.
Proposed Response:

If the District's statutory authority was substantially reduced, or its normal annual revenues were to be curtailed by more than 25 percent, or its non-labor related expenses net of capital expense increased by more than a factor of 1.5 in any two-year period, but not to a level at which the District would be unable to maintain the funding levels specified in the District HCP, the District will notify and enter into consultation with the Service to develop an analysis of the impact on proposed take of the Covered Species and a mechanism to prioritize measures and resolve the changed circumstance as it relates to take. In the alternative, following consultation and Board action, the District may request the Service to amend the District ITP and HCP.

7.2.2.4 Other Changes in Circumstances

There are other changes in circumstances that are foreseeable and that might affect the status of the Covered Species. For example:

- Intentional, illegal human activities (e.g., vandalism; terrorism) that are destructive to the Covered Species and/or their habitat.
- Major accidental pollution events in the ITP Area (e.g., toxic chemical spills; wastewater spills; petroleum and petrochemical pipeline leaks) that are destructive to the Covered Species and/or their habitat.
- Acute effects from increased pollutant discharges from either or both point-sources or nonpoint sources.
- Floods, erosion, and sedimentation of Barton Creek that, via a single event or by cumulative effect, degrade the health of the Covered Species or adversely change the quality of their habitat throughout a substantial portion of their distribution.
- Changes in non-abiotic factors such as increased predation and inter-species competition that alter the present ecological conditions.
- Decreased recharge to the Aquifer arising from smaller base flows in the creeks in the contributing zone over time, owing to the effects of climate change and especially the

impacts of pumping up gradient that reduces the amount of Trinity groundwater discharging to those streams.

- Alternative water supply benefits in the form of prospective reduced pumping of the Aquifer are not realized.

However, unlike the others identified in the subsections above, these changes are not related to the Covered Activities and the District is not able to address them directly as they are not within the statutory authority of the District, nor does the District have the financial resources available for their remediation or even evaluation. Accordingly, these are not considered Changed Circumstances for the District HCP, and no specific contingency plan is provided in this HCP as part of the proposed response for other changes.

Proposed Response:

Should events or changes such as these occur, each will be evaluated jointly by the District and the Service as to significance to the Covered Species and confirm whether or not they are, in fact, changed circumstances and circumstances that the District is able to address. It is also anticipated that the District will coordinate with the City of Austin in making such evaluations, as the changes could represent changed (or unforeseen) circumstances under that entity's HCP as well.

7.3 Unforeseen Circumstances

The Service defines the term "unforeseen circumstances" to mean "changes in circumstances affecting a species or geographic area covered by [an HCP] that could not reasonably be anticipated by plan developers and the Service at the time of the HCP's negotiation and development and that result in a substantial and adverse change in the status of the covered species" (50 CFR §17.3.) Such circumstances are not "unimaginable," rather simply unreasonable to be expected during the term of the ITP. Unlike identified Changed Circumstances, the Service rather than the Applicant (the District) is responsible for Unforeseen Circumstances and responding to them. In addition, the necessity to make amendments, clarifications and minor administrative amendments to the ITP and HCP forms a special class of unforeseen circumstances.

7.3.1 Responding to Unforeseen Circumstances

In making the determination that such an event constitutes an unforeseen circumstance, under its statutory obligations 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 HCP and whether failure to adopt additional conservation measures that within the District's regulatory authority and financial ability would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

7.3.1.1 Procedure for Determining Occurrence of Unforeseen Circumstances

In making a determination regarding the occurrence of any unforeseen circumstance, the Service has developed and will follow the procedures set forth in its applicable regulations (50 CFR 17.22(b)(1)(iii)). These are summarized below, but the statutory language is controlling:

<u>Notice to Applicants and Participants</u>
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 support the allegation. In addition, the notice shall include any proposed conservation measure(s) believed to address the unforeseen circumstance, an estimate of the cost of implementing such a 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.

<u>Responses as a Result of New Information Derived Through Adaptive Management</u>
The research and investigative measures that the District commits to undertake as a part of its adaptive management efforts may indicate or otherwise call for specific other responses to changed or unforeseen circumstances. As new information is obtained during the course of the ITP period and in consultation with the Service, the District and the Service may agree to modify or redirect existing conservation measures to mitigate the effects of unforeseen circumstances, within the scope of existing approved and funded conservation actions and ITP terms. To the extent that these modified or redirected conservation measures do not affect conservation of other species or habitats, this approach may be deemed an adequate response to the unforeseen circumstance. However, if the proposed modifications or redirected conservation actions could affect the conservation of another Covered Species or its habitat, the procedure outlined below will be followed.

Submission of Information by Others
The District shall have a meaningful opportunity to submit information to the Service and shall do so within 60 days of the written notice, as provided above. Upon the written request of the District or any other participant in the District HCP, the time for submission of said information may be extended by the Service, and the request will not be unreasonably denied.

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 that 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.

Findings
The Service has 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 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 its own expedited analysis of the changed or unforeseen circumstance and the information provided by the District or other participants in the District HCP, the Service must 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 HCP.

7.3.1.2 Response to Determination of Unforeseen Circumstances

In accordance with the Service's statutory authorities and obligations, which are controlling (50 CFR 17.22(b)(1)(iii)), after the conclusion of the process outlined above, the Service would determine that an unforeseen circumstance has occurred, and that additional conservation measures are likely required to address the circumstance but are not contemplated or capable of implementation by the District HCP. Then, provided that the District has fully complied with the terms of the District HCP, any proposed additional conservation measures by the District would be limited, to the maximum extent possible, to those within the terms of the District HCP and its ITP.

Under the Service's "No Surprises" rules, additional conservation measures may not require the payment of additional compensation by the District or its permittees. If additional expenditures are required, the Service or any other federal agency must 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 are intended to be borne by the Service or any other federal agency. However, prior to undertaking or attempting to impose any actions or conservation measures, the Service may consider all practicable alternatives to the proposed conservation measures, and adopt only such actions or conservation measures that 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.

7.3.2 Clarifications, Minor Administrative Amendments, and Amendments

Circumstances may arise that necessitate HCP and/or ITP amendments. Such circumstances have been interpreted by the Service to be a special category of unforeseen circumstances that may be triggered by either changed or other unforeseen circumstances or otherwise, and therefore must comply with 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 HCP or ITP and would require consent of the Service. Generic examples of amendments include but are not limited to the following (although none are currently planned or imminently envisioned):

- Addition of parties to the ITP;
- Changes in the ITP areal boundaries, with possible material effect on Barton Springs flows during Extreme Drought;
- Additions to or deletions from the species protected under the HCP;
- Changes in state or local legislation that materially 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 likely to affect the level of incidental take of species; and
- Renewal of the ITP beyond the initial term.

In considering whether a prospective amendment is a minor or a major amendment of the existing ITP, the District will provide the Service with its analysis of whether the prospective take of the Covered Species would increase, decrease, or stay the same with the amendment, and the basis for that assessment. The District will then seek to consult with the Service as to its concurrence with the findings of that analysis. Any amendment that increases take is to be considered a "major amendment" under the Service's statute, requiring execution of the procedures described in subsection 7,3.1.3.2 below, before the amended ITP would be approved and issued. Further, renewal of the ITP beyond its then-current term or the issuance of a new ITP for the Covered Species will trigger a review under National Environmental Policy Act (NEPA) and by rule is considered a major amendment.

7.3.2.1 Clarifications and Minor Administrative Amendments

From time to time, it may be necessary for the Service and the District, as Administrator of the District HCP, to clarify provisions of the District HCP or the ITP to deal with issues that arise with respect to the administration of the process; or the District may find it necessary to be more specific regarding the precise meaning and intent of the language contained within the HCP or ITP 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.

The District HCP 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 increased from those analyzed when the ITP was issued.

In addition, 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 but that may be necessary or convenient over time to 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 of the Service and, after review by the District, the General Manager or President of the Board of Directors of the District and shall be memorialized by letter agreement or by substituted Plan Documents modified to contain only the Clarification or Minor Administrative Amendment.

7.3.2.2 All Other Amendments

Except as provided for in Clarifications and Minor Administrative Amendments in the subsection above, and subject to the Service's concurrence with the District's assessment of changes in take for an existing ITP, all other amendments are considered major amendments and will follow the procedures summarized in this subsection. The District HCP, ITP, or any (future) Implementation Agreement with other parties may not be amended or modified in any way without the written approval of the District (as Administrator of the District HCP), all signatories (currently, only the District), 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 Act and regulations at 50 CFR Parts 13 and 17, and shall be subject to appropriate environmental review under NEPA provisions.

Amendments of the District HCP and ITP permit would be required for any change in the following: (a) the listing under the Act 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 and adversely 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 HCP 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 HCP 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 District HCP or ITP can be initiated by the District or Service, or by other participating entities executing an Implementing Agreement, if they are approved for addition after the initial ITP and HCP are authorized. A proposed amendment would be submitted as a formal proposal to the District and Service for possible action. The proposal must state the reason the amendment is being requested, description of the proposed change, and an analysis of the potential effects of the proposed revision on the Covered 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 Board must approve or deny the request,

- The plan amendment would be referred to other potentially affected Section 10(a)(1)(B) permit holders (here, the City of Austin) for review and comment, and

- A plan amendment approved by the District Board (and any other parties to a future Implementation Agreement, if any) would then be forwarded to the Service for action consistent with its rules, regulations, and policy.

As specified by Service regulations, 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 District HCP terms and conditions.

8.0 District HCP Funding Assurances

Essentially all of the Habitat Conservation Plan (HCP) measures to be put into practice by the District (including the prospective avoidance, minimization, mitigation, and monitoring measures and their administration) are now specified in and authorized by the District's revised, approved Management Plan (MP) (BSEACD, 2013). Most of the direct measures called for in the HCP, including the District's well permitting and drought management programs, are already part of the MP and annual budget. As such, the funding for these measures over the 20-year term of the District HCP comprises a significant share of the District's annual operating budget that is already being expended in these efforts. The District's budgeted revenue is based on water-use fees from permittees and other related fees that are authorized statutorily and collected from the District's groundwater production permittees, and also from a statutorily mandated, very substantial supplemental fee paid by the City of Austin, which amount is linked by formula to the water-use fees paid by the permittees. These revenues will be augmented from time to time by enforcement penalties and by other external funds for special initiatives, such as grants, neither of which are under District control and therefore are not considered a part of the sustainable operational funding of the District. Accordingly, because the entire continuing-operations budget of the District is by law established to serve the District's statutory purpose through implementation of the District's MP (and nothing else), a major share of the normal District operating budget provided by continuing water-use fees paid to the District by its permittees and supplemented by the City of Austin will in effect be committed to implementing the HCP incorporated within the MP.

Because the HCP conservation measures are integrated with the Covered Activities, in that both are groundwater-use management, it is not possible to differentiate funds for groundwater management between Covered Activities and conservation measures. Similarly, there is no separate or additional funding represented by the conservation measures in the HCP and the pre-HCP periods; the difference is not how much is being spent but how those funds are being deployed. Simply put, the District's regulatory program has evolved over the past decade such that the District funds now support a much more effective groundwater management program than the program that existed before the HCP, for essentially the same amount of dollars.

The District HCP conservation measures, including the overhead associated with their provision, will require a variable amount of expenses year to year, but always substantially more than one half of the total level of effort in executing the District's MP. Some flexibility in annual funding of the HCP is needed by the District to ensure its continuing operations, which also contributes to the variability in expenditures among the years. The actual level of effort and that portion associated with the HCP are expressed by the composition of each annual budget, which is already being used by the District to defray the costs of the personnel, programs, and special projects required to implement and manage most of the conservation measures in the proposed HCP, as they are integrated with the Covered Activities. The component parts of these budgets related to the HCP may also be expected to vary from year to year in the types of expense involved. Because of these factors, the District considers it more appropriate to commit to some minimum level of annual funding associated with the HCP conservation measures, rather than an average level or the specification of an exact amount each year of the Incidental Take Permit (ITP).

The District is committed to fully implementing the proposed HCP and meeting ITP requirements. Therefore, the District stipulates funding of the District HCP via its MP elements during the term of the ITP will be no less than 60% of each year's annual budget that is derived from its statutorily authorized annual operating revenues related to Aquifer use (i.e., not including use of financial reserves). For example, in Fiscal Year 2014, the District's Board-approved annual budget is approximately $1,717,000, of which $198,000 is from reserves, so the nominal HCP Funding Commitment would be $911,000. In most years during the term of the ITP, the actual dollar value of expenditures for the HCP will be substantially greater than this minimum amount, as the MP is executed in a robust fashion. The funding by the District includes both in-kind labor provided by District staff and directors, and cash contributions and expenditures for other goods and services, all in support of the HCP conservation measures. The District's annual financial audit report will be the used for documenting actual operational expenditures as being equal to or greater than the percentage-based commitment to funding groundwater management and conservation under the HCP.

Barring significant changes in the statutory authorities and/or legal landscape, which would likely require a major amendment to the ITP and this HCP, the District anticipates being able to continue annual funding from these sources in that same or greater amount, since the revenue is statutorily authorized. State law requires the District's expenditures to be approximately equivalent to its revenues (which may include use of financial reserves) each year. However, also by State law the District cannot commit funds in advance to any purpose except those budgeted each fiscal year, and it is allowed to budget for only one year at a time. These restrictions notwithstanding, it is the District's intent, as demonstrated by its Board's agreement to the ITP terms, to continue to fund all of the activities that support the District HCP measures in the committed amount, as a minimum, throughout the life of the ITP and HCP. The District will report the actual funding provided for implementing the HCP each year in its annual implementation monitoring report to the U.S. Fish & Wildlife Service (Service).

The District will implement the HCP program in the form of District labor, program expenditures, and/or cash each year for the aggregated HCP program in that year, which will include various measures that may be individual time-phased projects active in that year. For example, in the third year following ITP issuance, some of the HCP funding might be earmarked to fund two project-oriented measures that are active in the third year, say, one research project and one mitigation initiative, just as illustrative examples.

Specific conservation-, research-, and mitigation-project measures will be identified and funded in the out-years, as other collaborating parties are identified and become involved, as required funds from other parties are committed, and/or as participation agreements are negotiated. However, it should be understood that the actual years and the committed amounts (of in-kind and/or cash contributions) under which any specific project measure is undertaken are largely indeterminate now, because the ability and efficacy to conduct those project-oriented measures and the timing of them are uncertain. The District will identify in its HCP annual report those specific conservation, research, and mitigation projects that have been and/or will be initiated and the project-specific District in-kind services and funding (and funding from other sources, if applicable) that are planned for the then-upcoming year(s), once such clarity is available during the course of the ITP term. Similarly, if, say, because of exigencies beyond the District's control some planned project was unable to be started when planned and/or was not able to be funded at the planned level in one or more years, the District would explain the source of the deviation from plan in its implementation monitoring report to the Service. Provided the Service subsequently determines that explanation to be adequate and that the overall District funding commitment is achieved, such deviation from the planned funding is proposed to not require an amendment to the HCP/ITP.

9.0 Alternatives to the Taking

The Endangered Species Act (Act) requires that each Habitat Conservation Plan (HCP) address "the alternative actions to [the proposed incidental] taking the applicant considered and the reasons why such alternatives are not being utilized."

The Covered Activities in this HCP relate exclusively to groundwater withdrawals by third-party well owners and the District's own regulatory program concerning such withdrawals, which is overprinted on the natural variability of the Aquifer. The natural variation in Aquifer storage and springflows by itself produces a condition in which any amount of groundwater withdrawal during severe droughts will constitute take. Simply put, there is no alternative action that allows use of the Aquifer as a water supply without producing take of the Covered Species for substantial periods of time. Accordingly, any alternative that could completely *avoid* take of the Covered Species would require imposition of a regulatory program by the District that allows no use of the Aquifer as a water supply during severe drought.

9.1 Analysis of Potential Alternatives to Avoid Take

Two basic options were considered by the District in assessing the efficacy of an alternative approach that could eliminate the use of the Aquifer as a water supply and thereby avoid, not just minimize take: reduction in demand for Aquifer water, and water supply enhancement and substitution. Under certain conditions, each of these, either individually or in combination, could comprise an alternative to the taking; they are evaluated in this subsection.

9.1.1 Demand Reduction Alternative

The District's authority allows it to mandate reductions in demand for Aquifer water, but only in a limited sense. More particularly, the District's permitting program provides the means by which pumping of the aquifer by larger-capacity wells and other wells of certain types can be controlled, both in absolute-use terms and especially in response to drought conditions. These regulatory curtailments, backed with effective enforcement to ensure compliance, provide a non-structural, assured vehicle for increasing the water levels in the aquifer, which benefit well owners/users in the western part of the District where saturated thicknesses of the Aquifer are relatively thin, and also, of critical importance to this HCP, such curtailments will benefit the amount of flow and the dissolved oxygen (DO) concentrations of water issuing from Barton Springs, which is the habitat of the Covered Species.

However, the District's authority does not extend to ordering complete cessation of pumping of all wells in the Aquifer, even during Extreme Drought. Under State law and recent court interpretations, landowners have a vested property right to withdraw groundwater under their land as a real property interest. Further, the District's regulatory program is underpinned by permitting that is based on actual reasonable and non-speculative demand such that there is very little permitted pumping that is not committed to being fully utilized for beneficial use, especially after factoring in severe drought curtailments. So the Demand Reduction Alternative *per se* legally and practically must allow some amount of existing and future freshwater Edwards Aquifer groundwater withdrawals from wells to continue. It also should be noted that the Aquifer has been designated as a "sole-source water supply" for many residents in the ITP (Incidental Take Permit) Area, which imposes certain protections and considerations applicable to other federal programs, including those of the Service. District regulation-mandated curtailments during drought that minimize but do not prevent withdrawals and that are authorized under an ITP would be consistent with applicable state and federal statutes. Such an alternative mitigates but does not avoid take.

9.1.2 Supply Enhancement and Substitution Alternative

During drought, if the District could mandate that all Aquifer users stop pumping their wells during drought in favor of switching over completely to another, standby supply, then the wells in the Aquifer would not be decreasing the springflows and increasing the amount and frequency of take. The enhanced availability of alternative water supplies would facilitate and allow the substitution for Aquifer water. But as explained below, this Supply Enhancement and Substitution Alternative *per se* is not statutorily, economically or even physically feasible in aggregate for all groundwater users across the District – the District is not legally authorized to make such demands on all of its permittees, or even to require its permittees to develop alternative water supplies.

Some well-resourced permittees have voluntarily broadened their water-supply portfolios to include alternative sources of water, and some of them do voluntarily curtail their pumping of groundwater from the Aquifer during drought and utilize substitute supplies. But there are simply not enough firm-yield alternative water supplies available now to all groundwater users, either at any price or at something less than prohibitive cost for their situations. In any event, the District cannot legally mandate such substitutions *per se* for existing, authorized supplies of Edwards groundwater; it can only encourage and incentivize acquiring such replacement water by its scientific investigations and regulatory programs. With one minor exception, the District itself does not own any alternative water rights, and its financial resources do not allow it to acquire others, at least on the scale that would be meaningful to having an effect on springflows.

The District is actively working with its stakeholders, especially its permittees that are water supply providers, and with others to foster development of alternative supplies of water. The District's regulatory programs can be a driver in that, and so the proposed option can work for some permittees in concert with the Demand Reduction Option described in 9.1.1 to provide a means for greater curtailments while meeting water demands, or a greater likelihood of being able to meet the regulatory required curtailments. As new water supplies become available, for example through desalination of brackish groundwater, aquifer storage and recovery, and water reclamation, there will then be increased opportunities to substitute those waters for freshwater Edwards water. But the time frame for that is not immediate, it is not likely to be available over a wide geographic area, and it will be much more expensive than the greatly under-valued and -priced freshwater Edwards groundwater. Even if it were technologically possible, the

District does not own or control those alternative water resources, and even if it did, the cost of such alternative supplies that could provide complete replacement of Edwards Aquifer water is orders of magnitude greater than the District's existing and likely future financial resources. So for those reasons, while the Supply Enhancement and Substitution Alternative might support the proposed option that is mostly based on demand reduction in something of a hybrid fashion on a case-by-case basis, it is not *per se* an alternative that could be deployable as the primary, preferred option in this HCP and avoid take.

The District has for years also worked to enhance the amount of recharge that can enter the Aquifer through its natural openings in streambeds, to maximize the amount of water available from natural rainfall/runoff events. It continues to do so, to preserve if not increase the recharge capacity and prevent the discrete recharge features from getting clogged with sediment-laden runoff. However, the number of those features available to the District for such operations is limited, too few to make a real difference as *additional* supply. And the same dearth of alternative water supplies described above prevents introduction of such alternative water into the recharge features during severe drought conditions, which is when the additional supply is most needed.

While structural projects and alternative water supply projects such as those described above can play a useful, supporting role in management of the Aquifer, such activities are typically not under District control or always available to the District. Provision of the entire volume of currently permitted pumping (nearly 2.9 billion gallons annually) with alternative water supplies from non-Aquifer sources to even the current Aquifer users would be prohibitively expensive (into the hundreds of millions of dollars), and further there is no mechanism available to the District to recover most such costs. So simply put, to a substantial extent, the District cannot afford the level of infrastructure development that would replace all of the current water supplies of the Aquifer and allow large-scale substitution of water supplies. Without such complete substitution with alternative water, take of the Covered Species would continue to occur during drought periods. Moreover, the District has no legal authority to force an existing groundwater user to stop using that groundwater supply in favor of another; further, the District cannot legally unilaterally reduce the property interest in groundwater from the Aquifer even if a substitute supply is provided.

9.2 Basis of Proposed Groundwater Management Program

The District has concluded that the primary option that produces the needed balance between legal groundwater production/use and conservation of the Covered Species is the non-structural regulatory program that comprises the Covered Activity, viz., the Enhanced Best Available Alternative measures described in Section 6. The basis for this determination and selection is discussed in this section.

The District is a political subdivision of the State of Texas, a groundwater conservation district (GCD) charged by the State legislature to preserve, conserve, protect, and prevent waste of the groundwater resources within its jurisdictional area, <u>and</u> to allow use of the groundwater resources to the maximum extent feasible by well owners in that area. More importantly, the District is the only governmental entity that is able to serve that mission, as the groundwater is owned by the surface landowner, rather than the State or the public, and the landowners have a legal right to produce the groundwater from the Aquifer for their own beneficial uses. Without the District's programs, the groundwater withdrawals in the District would be unregulated, and the discharges from Barton Springs would not be able to be managed, raising the specter of zero springflows for many months at a time during Extreme Drought. And concomitantly, without the District's regulatory restrictions, there could be no control on the impacts associated with the springflow-induced stress on the Covered Species.

Further, the District as a GCD has a legal requirement to manage the groundwater and protect other related natural resources, including the Covered Species at Barton Springs. An ITP's required HCP offers a vehicle that can provide longer-term, more systematic assurance of such protection than would otherwise be available to the District without the permit. (It also provides a legal shield for not only the District but its permittees against claims that could otherwise be asserted against them, as they exercise their legal right to use their "fair share" of groundwater, under the Act, which obligates real property owners to protect endangered species.)

Within this selected approach are sub-options, related to balancing risks to continued District operations and rewards in terms of aquifer and habitat protection, which the District evolved through over time in developing this HCP; that evolution was described above, in Section 4.1.2. The District Board considered several of the intermediate steps as potential options for the HCP program, each having differing levels of curtailment and resulting springflow but also with differing implementation challenges and probabilities of success. But ultimately the Board determined that the District had an obligation to provide the maximum protection to the endangered species that it legally and financially could at the current time, so the only acceptable optional level of demand reduction in the final analysis is the Enhanced Best Attainable Alternative demand reduction option aided by alternative-supply enhancement and substitution where feasible,, which comprises the minimization, mitigation, and adaptive management measures described in Sections 6.2, 6.3, and 6.4. There is a practical limit on how much regulatory curtailment of water use by any one permittee is feasible, and also a legal and financial limit on how much curtailment is "reasonable" and "fair," before a *regulatory* takings ensues that arguably represents compensable loss to the groundwater owner/user. The Board considers the current expression of this option at that limit, comprising conservation measures equivalent "to the greatest extent practicable."

Therefore, the Enhanced Best Attainable Alternative, based on a hybrid of demand reduction and alternative supply development, is considered the preferred and proposed option for groundwater management in the District that affects the Covered Species, both now and over the term of the ITP. At its maximum curtailment expression, this alternative, which constitute the Covered Activities, essentially produces water levels and spring flows that would meet the Desired Future Condition of the Aquifer, which is specifically promulgated to minimize take during a recurrence of the drought of record (DOR) to the maximum extent feasible.

In summary, the Covered Activities of this HCP provide the primary vehicle to minimize the risks of both incidental take of the Covered Species and compensable regulatory take of real property. The District's regulatory program is the only statutorily authorized option that the District can use to balance both, and therefore it is considered the principal option for groundwater management in the HCP.

10.0 Other Information That the Secretary May Require

This section of the Habitat Conservation Plan provides assurance that no other information besides that contained elsewhere in this document is required to be presented for compliance with Section 10(a)(2)(A)(iv) of the Endangered Species Act. The Secretary of the Interior, and the Director of the U.S. Fish & Wildlife Service have not identified other specific informational or other requirements of the District for this HCP at this time.

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