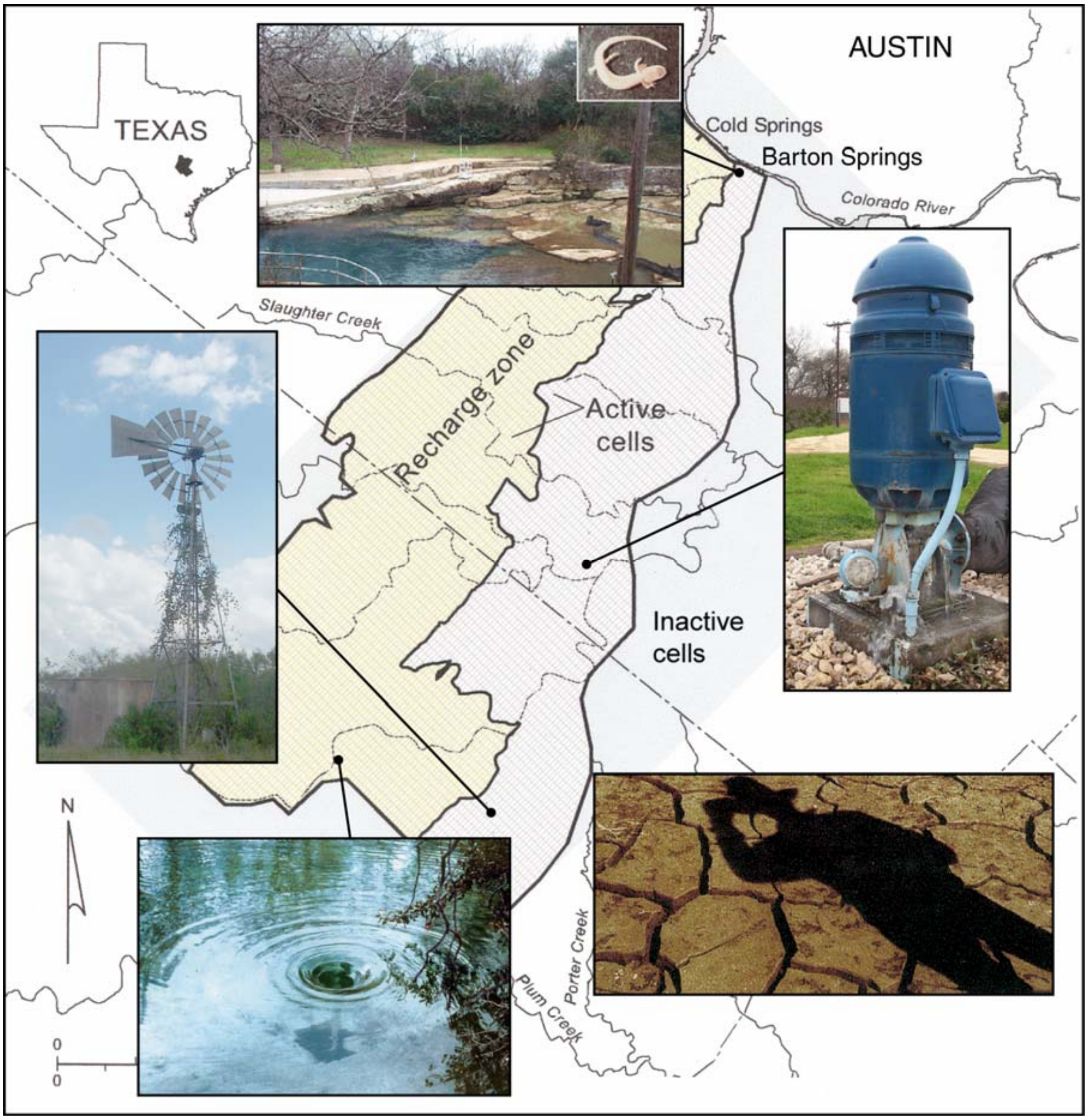
DRAFT HABITAT CONSERVATION PLAN AND PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STUDY
Volume Two - Appendices



Prepared By

Barton Springs/Edwards Aquifer Conservation District

For

U.S. Fish & Wildlife Service

August 2007

APPENDIX A

Participating Individuals and Organizations

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A.1 Citizens Advisory Committee

The passage of Senate Bill 1272 during the 76th Texas Legislature in 1999 requires the District to appoint a Citizens Advisory Committee (CAC) to assist in preparing the regional HCP. The purpose of the CAC is to advise the District in development of the HCP, assist in determination of the scope of the HCP, recommend mitigation measures and other HCP conditions, provide a forum for public discourse and conflict reconciliation, help meet public disclosure requirements, oversee HCP progress and development, and most importantly, build consensus among diverse organizations and interests. Accordingly, the CAC was appointed by the District in a manner to assure representation by all affected interests in the Edwards Aquifer region. Participants include private landowners, irrigators, water purveyors, conservation and environmental organizations, private consultants, representatives from major cities, federal, state, and local governmental agencies, and universities. Members of the Citizens Advisory Committee as of July 2007 are listed in Table A-1, below.

A.2 Biological Advisory Team

The passage of Senate Bill 1272 (referenced above) also requires that the District, together with the Texas Parks and Wildlife Commission and landowner members of the Citizens Advisory Committee [CAC], appoint a Biological Advisory Team [BAT], at least one member of which shall be appointed by the Commission and one member by the landowner members of the Citizens Advisory Committee. The member appointed by the Commission serves as presiding officer of the team. The team shall assist in the calculation of harm to the endangered species and the sizing and configuring of habitat preserves, as needed. The District has appointed a seven-member committee to fulfill this function. Members of the Biological Advisory Team are listed in Table A-1.

Table A-1. Citizens Advisory Committee and Biological Advisory Team (July 2007)

First	Last	Phone	E-mail
Sarah	Baker		sarah@sosalliance.org
Jon	Beall	512-454-8090	jonbeall1@onr.com
Valerie	Bristol	512-494 9559 x5	vbristol@tnc.org
Jim	Camp	512 431-1120	jcamp@bedfordstmartins.com
Jeff	Goldman		jeff@brokerforhire.com
Ryan	Mattox		ryan.mattox@lennar.com
Sharon	Michaelis	512-268-2241	N/A
John	Mikels	512-445-3433	geos-jkm@swbell.net
Scott & Gini	Nester	512-295-5811	rnester1@austin.rr.com
John	Noell	512-347-0040 x105	jnoell@udg.com
John	Orr	512-262-2099	janieorr@yahoo.com
Bill	Russell	512-940-8336	whrussell@gmail.com
Diane	Senterfit	512-487-4014	dsenterfitt@hswww.com
Joe	Vickers	512-894-4424	joe.vickers@verizon.net
Carl	Urban		carleurban@aol.com
Jennifer	Walker	512-477-1729	jennifermwalker@earthlink.net
Geoff	Weisbart	512-487-4012	weisbart@hswww.com
Ira	Yates	512-292-6197	yatespct3@aol.com
Designated Governmental Representatives (ex-officio)			
Andrew	Backus	512-913-3156	aback@austin.rr.com
Charles	Laws	512-243-2113	cmwsc@swbell.net
Nancy	McClintock	512-974-2652	Nancy.McClintock@ci.austin.tx.us
David	Meesey	512-936-0852	david.meesey@twdb.state.tx.us
Cat	Quintanilla	512-892-1383	catq@earthlink.net
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Terry	Tull	512-858-2148	totalltull@aol.com
Todd	Votteler	830-379-5822	tvotteler@gbra.org
Nora	Mullarkey		Nora.mullarkey@lcra.org
Biological Advisory Team			
Bryan	Brooks	254-710-6553	Bryan_Brooks@baylor.edu
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David	Hillis	512- 471-5792	DHillis@mail.utexas.edu
Lisa	O'Donnell	512-974-2204	lisa.o'donnell@ci.austin.tx.us
Andrew	Price	512-912-7022	andy.price@tpwd.state.tx.us
Walter	Rast	512-245-3554	wr10@txstate.edu
John	Sharp	512-471-3317	jmsharp@mail.utexas.edu

APPENDIX B

Characterization of HCP/EIS Alternative Measures Used in Impact Assessment

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Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
1.0 MEASURES UNDERTAKEN DURING All CONDITIONS					
1.1 Establish and Implement a Permitting Program in the District to Maintain and Improve an EDWL ("Aquifer Cap")[2].	District Board will establish a program of EDWL on pumping Edwards groundwater; Board will establish more rigorous measures for the conditional permitting program; Board will incorporate EDWL in Groundwater Management Plan, which will be submitted to TWDB for approval.	As statutory or regulatory authorities change or every five years, whichever is earlier, review and revise the specified EDWL as needed, to maintain or improve effectiveness of pumpage reductions during droughts. By 2010: The adoption of "Desired Future Conditions," as required by the TWDB, are set for the state-designated "Groundwater Management Area," so that MAG incorporates the EDWL. Note: The EDWL program is to be implemented by rules and regulations applicable to various drought and non-drought stages and other conditions, as noted throughout this table	Proposed Rule: Section 3-1.23. The EDWL for the Barton Springs Segment of the Edwards Aquifer Proposed Rule: *Section* 3-1.6. District Action on Permits A. Permits. (9). The approved UDCP for the well yields a maximum volume of authorized groundwater production that does not exceed the EDWL specified in Section 3-1.23 of District Rules.	F: High/Very High E: Very High/ Very High	EDWL is implemented by District Rules before ITP issuance. Groundwater Management Plan containing EDWL is approved by TWDB within one year of ITP issuance, and every five years thereafter. Authorized Edwards Aquifer pumpage in aggregate less than cap (individual permits wouldn't be adjusted in Alternative 2, as this is not currently legal),

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1.2 Ongoing/Continuing Demand Reduction Measures					
1.2.1 Implement a new database of registered wells that contains estimates of groundwater withdrawal for a subset of exempt (i.e., non-permitted) wells to better gauge location and amount of pumpage from all exempt wells[2].	**Before ITP Issuance:** Relate census tract data and/or COA estimates of population, "Living Unit Equivalents," and number/location of exempt wells; District Board will authorize a new database of registered wells that includes geographically representative subsets of exempt well owners who voluntarily characterize current uses of groundwater, and number of customers or persons using groundwater, and rates of withdrawal for each well.	**Within First Year of ITP Permit**: Confirm or modify estimated withdrawals by aggregating results of well-by-well assessments. Board authorizes a new well registration process that requires exempt owners to identify current uses and number of users.	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management." Depends on voluntary cooperation of exempt well owners.	F: High/High E: High/High	At least 50 exempt wells and their data will be entered into the new database within 2 years of date of ITP issuance. At least 150 exempt wells and their data will be entered into the new database within 5 years of date of ITP issuance.
1.2.2 Institute a new, voluntary metering and water use monitoring program for non-permitted (exempt) wells[2].	Purchase inventory of meters to lend to exempt non-metered well users; Educate all registered well owners about the program and the benefits to them; Provide small cash incentives to exempt users for temporary metering with District-owned meters on representative sample of exempt wells. Provide cash incentives to others for temporary metering with District-owned meters on representative sample of exempts.	**Within First Year of ITP Permit:** Develop a reporting method, for use by water supply providers, to report the water use of their end-use customers anonymously; Establish use profiles for all groundwater users in the District. District mandates nonexempt "excessive users" must install meters and report monthly water use as do exempts.	**Note**: This is a voluntary Program, whereby District will seek cooperation from a reasonable number of well owners who are not currently metered. **Note:** All nonexempt (permitted) users and their customers, as relevant, are already metered and report monthly. District purchase inventory of meters. Requires voluntary participation by otherwise compliant users, and political will to ask.	F: High/Low E: Low/Mod	A budget commitment of at least $20,000 will be made in the first year, and $10,000 in each of the succeeding two years, not including in-kind District labor, to cover the costs of equipment and small cash incentives to obtain cooperation of exempt, currently un-metered users to participate in the assessment program. At the end of five years from ITP issuance, the District will produce a report on exempt and non-exempt domestic and public water supply use in the District, including estimates of total withdrawals, monthly/seasonal variations,

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					and geographic area variations. Develops better estimation of total amounts of water withdrawn from aquifer during all aquifer conditions.
1.2.3 Require nonexempt users (permittees) to identify and encourage them to employ measures in their adopted UCPs and UDCPs so that they may voluntarily achieve at least a 10% reduction during the summertime Water Conservation Period, and encourage and all other groundwater users to implement similar conservation measures[2].	Develop water-conservation templates for various use types to include in permittees' UCPs/ UDCPs for the summertime WCP, applicable during No-Drought status; Align the water conservation plans of the Texas Commission on Environmental Quality's CCN with the District's UCPs/UDCPs; Require adoption of new UCPs/UDCPs on the next annual permit renewal.	None	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC, Sec. 356.5, "Groundwater Management." Rule language change.	F: Very High/- E: Low/-	All permits of nonexempt wells will incorporate appropriate new UCPs/ UDCPs template measures or their negotiated equivalents. Actual monthly water use during summertime WCP (measured as a percentage of authorized monthly usage) is at least 10% lower than the authorized usage experienced in other months, averaged over the WCP. Better water use awareness by all groundwater users.
1.2.4 Require permittees to identify and commit to mandatory measures in UDCPs to achieve specified levels of curtailment during District-declared drought[2].	Develop new drought-management templates for various water use categories, to be included in permittees' UDCPs for drought stages and periods; Align the TCEQ's mandated CCN DCPs and the District's UDCPs; Require adoption of new UDCPs on the next annual permit renewal cycle.	None	**New Rule:** Section 3-7.5 UDCP D. Consistency with CCN DCPs. Any permittee that is also a holder of a CCN issued by TCEQ shall assure that all drought-management provisions in the TCEQ DCP and in the District permit's UDCP are aligned and internally consistent. The CCN holder shall modify its TCEQ DCP to conform to requirements of the District UDCP, if necessary, upon the earlier of twelve (12) months from	F: Very High/- E: Moderate/-	All District well permits shall incorporate appropriate new UDCP template measures or their negotiated equivalents by end of FY 2008. Overall, the cumulative compliance with specified levels of curtailment will not exceed 5% of the targeted volume during declared drought. Smaller demand for water by individual users than would otherwise occur.

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			the effective date of this provision or when the DCP is next amended.		
1.2.5 Conduct a continuing water conservation and demand reduction education program with a specified minimum budget directed at all groundwater users in the District[2].	Become sponsoring member of the regional Water IQ program; Perform survey and audit of current state of knowledge, reach, and District program awareness; Contract with a communications consultant to help design, budget, and execute a continuing educational campaign, and develop new program materials targeted at individual groups (builders, homeowners, homeowners associations) for drought-time practices; Offer educational assistance to noncompliant permittees during droughts.	**Within 3 Years of ITP Issuance:** Develop demonstration-scale water conservation projects, including drought-tolerant, water-wise landscaping plots and functional rainwater-harvesting system associated with the District's new office. Maintain budget and staff commitment to the program.	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management." Additional funding for part-time professional. Receptivity of groups for new information.	F: Very High/- E: Moderate/-	A budget commitment of at least $40,000 per year for salary, overhead and expenses for implementing this program will be made and expended in each of the next three years, increasing thereafter (a) with inflationary indexes or (b) in proportion to the District's annual budget increase, whichever is less. The number of referrals to the District from other organizations and other parties seeking water conservation information will increase on an annual basis for the first five years of the HCP, as the District becomes better known as an information resource. Referrals to other similar organizations. Assumes that some water use arises from ignorance or lack of awareness, rather than conscious decisions by users.

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1.2.6 Seek authority for, and if successful implement, higher water use fees for non-exempt groundwater users as necessary to promote conservation and substitution of alternative water supplies for Edwards Aquifer water[2,3].	This legislative initiative or an equivalent incentive-based measure will be sought in at least one out of every two legislative sessions until enacted or for the duration of the Incidental Take Permit (ITP); Conduct a study to determine range and conditions for raw water costs for other supplies; Develop a strategy of charging higher water costs and permitting terms to promote shifting to other supplies; Seek higher water use fees initially on conditional permittees.	**Within 3 Years of ITP Issuance:** Refine strategy for water use fee increases; Seek higher water use fees on historic non-exempt permittees on certain, then-defined conditions.	**Pending State Legislation:** *SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature:* Increase water use fees on new conditional permits to a level comparable to the raw water rate of surface water. **Note:** This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. government ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law. Involvement and support of purveyors of alternative supplies. Development of political will of District Board and of area Legislators.	F: Moderate/ Very High E: Very High/ Very High	Average conditional water use fees, on a dollars per thousand gallons basis, will be comparable to the prevailing raw (untreated, undelivered) wholesale water rates for surface water by end of FY 2008, or within 18 months of the time that authorization is granted to implement this measure.
1.2.7 Seek conformance, to the maximum extent legally possible, of the requirements of "Managed Available Groundwater" limits, as established by TWDB, with the limits imposed under this ITP[4].	Participate in Groundwater Management Area planning in order to including appropriate Desired Future Conditions in joint planning; Advocate for Desired Future Conditions that are protective of	**No later than 2010:** Adjust EDWL in Measure I.A [1.1] above, as required and to the extent legally possible, to be consistent with MAG, and incorporate into revised and submitted	**See:** Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management." GMA 10 agrees to include	F: Very High/ Very High E: Very High/ Very High	The District will obtain approval by TWDB of District's Groundwater Management Plan that includes applicable Desired Future Conditions and Managed Available

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	spring flows and endangered species; assist TWDB in providing boundary conditions for modeling that are consistent with best available, most representative groundwater modeling.	Groundwater Management Plan. Continue promulgation of HCP-derived needs in regional planning of GMA 10.	endangered species protection in setting DFCs. Current GAM modeling is basis for MAG determination.		Groundwater. Assumes caps in Measure 1.1 above are more stringent than TWDB's "managed available groundwater."
1.2.8 Seek authority for, and if successful implement, programs to limit groundwater production by all permittees under certain prescribed[2, 3].	**Before/After ITP Issuance:** This legislative initiative or an equivalent incentive-based measure will be sought in at least one out of every two legislative sessions until enacted or for the duration of the Incidental Take Permit (ITP). Define "excessive use" in practical terms. Promulgate rules that enforce a non-excessive use standard on all users, not just permittees.	Review and revise as necessary criteria and variances for excessive use standard.	**Pending State Legislation:** *SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature:* Allow different restrictions among uses during (severe) drought. **Pending State Legislation:** *HB 1699, 80th Legislature (Hilderbran)*. Among other provisions, allows Ground-water Conservation Districts to apply definitions of "waste" more broadly. **Note:** This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.	F: High/High E: Moderate/ Moderate	Less than 2% of the total volume of Edwards groundwater actually pumped in the District each year will be classifiable as "undesirable use for the prevailing aquifer conditions" Enforcement of users that waste water will reduce demand by all, during drought.

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1.2.9 Work with public water utilities and other governmental entities to enhance plans and regulations that protect both the quantity and quality of Edwards groundwater[2, 4].	**Before/After ITP Issuance*:*** Attempt to enter into MOU with various major public water utilities to participate in and extend the water conservation programs into the District; Provide requested technical assistance whenever requested within the District or upstream from the District, on model guidelines and ordinances from other water utilities; Actively participate in municipal processes for developing and adopting development ordinances; Actively participate in reviewing pollution abatement plans and permit applications for both point-source and non-point source sources of potential pollution in the Contributing and Recharge Zones. As deemed necessary by the Board, oppose those facilities at those locations that are inconsistent with protection of recharge quality.	**After ITP Issuance:** Work with individual permittees that are public water utilities to showcase and demonstrate the effectiveness of conservation plans and ordinances; Promote stronger state-wide minimum planning and infrastructure design criteria.	**See**: Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC, Sec. 356.5, "Ground-water Management." Education and outreach programs that reach the customer base of most of District's permittees. Need to document some clear examples that demonstrate feasibility and benefit of achieving demand reduction and water quality improvement.	F: High/Very High E: High/Very High	Within five years of ITP issuance, the District will seek to cooperate with and provide technical assistance to at least 10 public or private water utilities and/or public agencies to implement the measures described herein. Plan implementation effectiveness is evaluated through analysis of responses in metered well production over time Determination of compliance with ordinances is monitored and enforced.
1.2.10 Adopt authorized production limits on a monthly as well as annual basis for all District permittees under all aquifer conditions[2].	None.	**Within 1 Year of ITP Issuance:** Define peak monthly pumpage volumes for each annual permitted withdrawal; Clarify any variances to account for unusual circumstances in defining 'peak' pumpage volumes	**See**: Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB, TAC 356.5, "Groundwater Management." Anticipation of issues in defining 'peak' in context of new land development and	F: Very High/Very High E: Very High/Very High	The District will promulgate Rules implementing this new program no later than the end of FY 2008. Permittee responses involving 'peak shaving' techniques (e.g., construction of rainwater collection systems,

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		(in context of new land development and construction activity, leaks, emergencies, etc.); Develop and publicize new plan; Modify the District's Groundwater Management Plan to accommodate the new monthly limits regulatory program. 1 Year: Document and notify permittees of peak monthly volumes and consequences for rates and surcharges. 2 Years; Begin imposing surcharges if peak limits are exceeded.	construction activity, leaks, emergencies, etc.		connections to surface water utilities, etc.).
Minimum Effect of Continuing Demand Reduction Measures (cfs)	***Spring flow increases from 0.5 cfs under existing management to a range of 1.2 cfs to 1.7 cfs***				
1.3 Ongoing/Continuing Water Supply Enhancement Measures					
1.3.1 Provide support to recharge enhancement projects of all types, if they are deemed effective and have minimal negative ecological impacts.	**Before/After ITP Issuance:** Commit in-kind services, e.g., for hydrogeological assessment and project/task management, to facilitate those projects that are determined to be feasible and beneficial; Retain an engineering consultant, when necessary, to assist staff in evaluating efficacy of significantly increased recharge or amount of significantly reduced recharge through new small-scale	Lobby Region K planning to include reservoirs if review indicates feasibility of a significant sustained yield.	Board must approve contracting an engineer to do this review on a surface water supply, which may be outside District's authority.	F: Low/High E: Low/High	The Board will authorize the District's staff to participate in each specific recharge enhancement project that is judged to be cost-effective with respect to improving aquifer conditions during drought. District will consider any additional water available to well users from this measure not available during actual extreme drought but a means

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	structural features; Attempt to enter into MOUs with large-tract landowners, including COA, Travis County, Hays County, and Hill Country Conservancy, for providing such support; seek other grant funds to defray capital/operating costs of worthwhile projects.				to postpone or avoid going into an extreme drought condition.
1.3.2 Provide support to clean, maintain and protect recharge features in natural drainage-ways in the District[2].	**Before/After ITP Issuance:** Attempt to enter into MOUs with large-tract landowners, including COA, Travis County, Hays County, and Hill Country Conservancy, for access to and participation in cleaning debris and sediment from major recharge features; Seek other grant and contract funds to protect and maintain those features. Staff surveys periodically all known recharge features for feasibility of adding recharge structures; install WQ-based automation to recharge structures to minimize clogging of aquifer; clean out features as needed; public education and participation in both ID-ing and cleaning up.		EPA/TCEQ 319h non-point source pollution grants will leverage District resources so it can do more, more often.	F: Very High/Very High E: Low/Low	A budget and personnel commitment to assist in such projects will take place on a continuing basis, providing the equivalent of at least $5,000 per year of in-kind support of debris removal and other recharge feature maintenance. Number of recharge features cleaned out annually; number of features with automated valves installed.
1.3.3 Provide technical assistance and cooperation in the acquisition of open space in the contributing and recharge zone of the Edwards Aquifer[2,4].	Commit in-kind services, e.g., for hydrogeological assessment and related projects/tasks, to determine the feasibility and benefit of proposed acquisitions of land; Explore opportunities to enter into	Respond to specific opportunities and needs, as feasible.	Conservation Districts," and TWDB Rules, TAC Section 356.5, "Groundwater Management." Management Plan must be modified and approved. May require bonded	F: Moderate/ Low E: Very Low/ Low	MOUs with partnering entities involved in land acquisition, by the end of FY 2009, to provide in-kind technical assistance and cash contributions to MOU partners, as appropriate.

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	MOUs and to partner with other entities, including those named in B.1 and B.2 above, that are involved in acquiring land for conservation easements and that will also preserve recharge quality. Determine legal constraints on using water usage fees for land or easement acquisition for WQ protection.		indebtedness or enabling legislation to pay for land management. Political will to use groundwater use fees in this fashion.		The District will participate in at least one cooperative program each year, in support of open space acquisition for contribution of recharge to the aquifer, for the next five years. Will likely require additional revenue that requires legislative changes on current fee structure.
1.3.4 Promulgate programs to prevent waste, including contamination and excessive use, of groundwater[2]. (Note: These measures serve to implement those actions described in Measure 1.2.8 above).	Actively promote inter-jurisdictional cooperation in implementing recommendations of the Regional Water Quality Protection Plan for the Barton Springs Segment; Establish and promulgate by rule, enforceable criteria for wasteful "excessive water use" by end-users (on a per connection basis), e.g. limiting residential water connections to a maximum production of 20,000 gallons per month during extreme drought conditions; Develop procedures, including reporting and penalties, for enforcement against individual users' excessive use through production permit of permittee; Seek authority for establishing, and if successful implement, new definitions of groundwater waste that include proscribed uses during certain, declared drought stages by end users as well as	Promulgate rules, applicable at all times, that apply excessive water use standards to end-users of permittees as well as permittees; Review and revise, as necessary, the criteria and variances for the excessive water use standard.	**New Rule:** Section 3-3.7 PROSCRIBED WATER USE DURING DECLARED DROUGHTS…C. Domestic use that meets the following criteria is presumed to be excessive use that harms the groundwater reservoir and aquifer resources and is therefore proscribed use. **Pending State Legislation:** *HB 1699, 80th Legislature (Hilderbran):* Among other provisions, allows groundwater conservation districts to define waste more broadly. **Pending State Legislation:** *HB 3039, 80th Legislature (Rose)*: Prohibits direct discharge of treated effluent in contributing and recharge zones of the Barton Springs segment. **Note**: This commitment to enhanced management is	F: High/- E: Moderate/-	Less than 1% of the total volume of Edwards groundwater actually pumped in District each year will be classifiable as "excessive use." No direct discharges of treated wastewater will be allowed into contributing or recharge zones of the Barton Springs Edwards Aquifer. Legal basis for doing this is uncertain. Benefit is primarily on water quality preservation, rather than on amount of water available.

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	permittees, e.g., limitations on selected outdoor water uses; Establish or adopt a set of desired BMPs for land use and development in the Edwards Aquifer contributing and recharge zone; Review and comment on subdivision and site development plans in the Edwards contributing and recharge zones, in relation to Edwards Aquifer recharge; Seek authority by statute or rules for establishing, and implement as needed, rules for prohibiting point source discharges in the contributing and recharge zone of the Aquifer Change Rules to apply "Waste" rules to end users as well as permittees; Actively advocate BMPs in our review of TCEQ WPAPs and of other agreements.		contingent on gaining and maintaining the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law. **Note***:* The District cannot commit to adopting policies and programs directly regulating and protecting water quality from urban storm runoff pollution without significant additional legal authority.		
Minimum Effect of Continuing Supply Enhancement Measures (cfs)	Spring flow increases from 0.4 cfs under existing management to a range from 0.8 cfs to 1.8 cfs.				
1.4 Ongoing/Continuing Water Supply Conversion Measures					
1.4.1 The District will initiate, support, and participate in conjunctive use initiatives to increase use of surface water supplies with existing Edwards groundwater providers in the District[2,4].	Convene and/or actively participate in meetings with surface water purveyors and providers to exchange information about future plans for utility construction and growth generally; Monitor and facilitate actions of developers who catalyze utility	Execute MOAs or modified permits with purveyors of alternative water supplies as feasible, to enable and enforce conversion to surface water during drought; Consider delimiting this	**See**: Texas Water Code, Chp. 36, "Groundwater Conservation Districts," and TWDB Rules, TAC Sec. 356.5, "Groundwater Management." **Note***:* This commitment to accomplish conjunctive use	F: High/Very High E: High/Very High	Within five years from the date of ITP issuance, the District will reduce the authorized peak demand for Edwards groundwater during severe drought by at least 10% from the amount previously authorized five

Alternative HCP Measures	Activities Likely Performed <u>before</u> and Included in ITP Application	Activities Likely a<u>fter</u> ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
	system extensions; Prohibit new Edwards withdrawals without conjunctive use plans in place; Develop a policy framework concerning designation of "groundwater management zones" with different hydrogeologic and water availability/use situations, and incorporate them in a revised Groundwater Management Plan submitted to TWDB.	policy to apply to selected management zones, whereby supply substitutions are promoted in some areas and not in others (i.e., address the unanticipated consequences of providing new water supplies in sensitive aquifer zones).	management is contingent on obtaining and maintaining the statutory and common law authority to carry them out, as well as negotiating mutual agreements with permittees to commit to conjunctive use management. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement and enforce these measures, they will necessarily be adjusted to comply with applicable law. Development of a policy framework concerning "groundwater management zones," whereby alternative supplies are promoted in some areas and not in others (i.e., address the unanticipated consequences of providing new water supplies in sensitive aquifer zones).		years earlier in the same season, by substitution with surface water supplies. Within 10 years from the date of ITP issuance, the District will reduce the authorized peak demand for Edwards groundwater during severe drought by at least 20% from the amount previously authorized 10 years earlier in the same season, by substitution with surface water supplies. MOAs are adopted with <u>*X*</u>% (or all) of future purveyors of surface or alternative water supply. Affirmative action measures taken (meetings, letters, etc.) to encourage developers to develop or seek other sources than the Edwards Aquifer.
1.4.2 The District will <u>initiate planning and assess feasibility</u> of long-range plans, policies and programs concerning designation of defined water management zones with different hydro-geologic and water availability	Conduct feasibility study, in cooperation with wholesalers, to identify roles and responsibilities of all parties, likely impacts of instituting alternative measures, and appropriate role of the District.	Establish ongoing/standing multi-party implementation committee to assess, recommend, and support implementation of measures.	Same as for 1.4.1 above.	F: Moderate/ High E: Moderate/ High	Planning/feasibility study is completed. Water wholesalers are engaged in conducting the study.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
/use situations and incorporate them in a revised Ground-water Management Plan[2,3,4].					
1.4.3 Initiate, support, and participate in policies and plans to increase use of other alternative water supplies (e.g., units of the Trinity Aquifer, other aquifers, desalinated water, harvested rainwater) with existing Edwards groundwater providers in the District[2,4].	Convene and/or actively participate in meetings with water purveyors and providers to exchange information about future plans for utility construction and growth generally; Assist providers in making feasibility studies of alternative water supply availability; Monitor and facilitate actions of developers who catalyze utility system extensions; Prohibit new permits for Edwards withdrawals without enforceable conjunctive use plans; Promote rainwater harvesting through education programs, demonstration units at District facilities, and referral of users to grants and low-cost loan programs available for such systems.	Execute MOAs or modified permits with water supply providers to enable conversion to alternative water supplies during drought; Consider delimiting the application of this policy to selected management zones (as described in Measure 1.3.1. above). The parties (including developers) will cost-participate in construction of conjunctively managed utilities. Determine legal and institutional feasibility of a buy-back program for ground water pumpage permits (or rights) to induce conversion to surface water or alternative water supplies.	**Proposed Rule:** Section 3-7.5 User Drought Contingency Plans. A. Contents of UDCP…8. UDCP special provisions for Conditional Production Permits shall include… **Proposed Rule:** Section 3-1.11. Permit Conditions and Requirement S…N Permittees holding Class B conditional permits under Rule 3-1.24(B)(2) must maintain at all times the certain ability and binding commitment to switch from the to-be-permitted volume of groundwater to some alternate water supply source(s) on a 100% basis, including a) all necessary physical infrastructure and supporting agreements, rates, and tariffs required for such substitution, and b) the commitment to use the alternative supply as warranted by District-declared drought conditions. ***Note**:* This commitment to accomplish conjunctive use management is contingent on obtaining and maintaining the statutory	F: Low/ Moderate ***** E: Low/ Moderate * * Role of the District will evolve and will need to be specified at a later date.	Plans for selected groundwater management zones are adopted. Standing interagency committee is created to engage parties in these plans and programs (see 1.4.2 above—Activities concerning creation of standing committee.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
			and common law authority to carry them out, as well as negotiating mutual agreements with permittees to commit to conjunctive use management. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement and enforce these measures, they will necessarily be adjusted to comply with applicable law. Same as 1.4.2		
1.4.4 Seek authority for, and if successful implement, a new regulatory program element that requires existing groundwater users, under certain prescribed conditions, either to convert from Edwards groundwater to alternative water supplies, and/or to encourage such conversion using higher water usage fees and longer term permits as an economic incentive[2,] possibly [3,4].	***Before/After ITP Application/Issuance:*** This legislative initiative will be sought in at least one out of every two legislative sessions until enacted or for the duration of the Incidental Take Permit (ITP); Establish rules that require permittees for water uses that are not essential to human health and welfare to be curtailed during extreme drought; Establish rules that accomplish more rapid curtailment of withdrawals by new conditional permit holders during declared extreme drought; Require the demonstration of availability and commitment to using alternative water supplies by holders of new conditional	Implement transfer or buy-back of permitted groundwater pumpage to convert to alternative sources and reduce demand on aquifer.	***Proposed Rule:*** Section 3-1.24. Conditional Production Permits..E. Term of Conditional Production Permit (2). All Class B conditional produc-tion permits are effective for the fiscal year of issu-ance and, unless otherwise stated on the permit, are automatically renewable annually for an aggregate term up to 40 years, provided… ***Pending State Legislation:*** *SB 747 (Watson) and HB 3572 (Rose), 80th Texas Legislature:* Increase water use fees on new conditional permits to a level comparable to raw water rate of surface water;	F: Very Low/ Low E: Very Low/ Low	New permit applicants will be issued Class B Conditional Permits, or a comparable type that achieves the same goal, requiring curtailment or cessation of Edwards groundwater withdrawals during extreme drought.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
	permits.		Allow different restrictions among uses during drought. ***Note**:* This commitment to enhanced management is contingent on having the statutory and common law authority to carry them out. If the Texas Legislature or the courts of Texas or the U.S. ever overrules the authorities of the District that are needed to implement these measures, they will necessarily be adjusted to comply with applicable law.		
1.4.5 Encourage and facilitate the construction of excess pumpage and storage capacity within alternative water supply systems by District permittees, to promote the use of alternative water supplies during drought conditions in lieu of groundwater[2,] possibly[3,4].	Adoption of a policy in support of providing additional surface water or alternative water utility capacity to high pumpage zones; Develop program to implement the policy and amend the Groundwater Management Plan to incorporate and authorize its use; Educate historic use permittees of prospective incentives available to them if they participate.	***Within Three Years After ITP Issuance:*** Implement rules that provide incentives in the District's permitting and rate provisions to encourage switching to surface or alternative water sources during droughts for any one historic use permittee or among permittees, provided that Edwards Aquifer levels and spring discharge are expected to benefit at all times; Consider delimiting the application of this policy to selected management zones (as described in Measure 1.3.1. Participate in the planning and projecting of future	Constraint: Reserving excess capacity may require prepayment (take-or-pay provisions), thereby limiting the ability to reserve capacity. However, there are ways to work around this constraint.	F: High/Very High E: High/Very High	The amount of Edwards groundwater able to be effectively "retired" from any use by historic-water users during extreme drought will increase through time. . Actual increase in pumpage of surface or alternative water capacity pumped, in lieu of ground water.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
		water demands.			
Minimum Effect of Continuing Supply Conversion Measures (cfs)	Spring flows increase from 0.3 cfs to a range of 0.8 cfs to 2.3 cfs.				
ESTIMATED MINIMUM CUMULATIVE EFFECT OF CONTINUING MEASURES DURING NON-DROUGHT (cfs)	Spring flows will increase under all conditions from 1.2 cfs under existing measures to a range from 2.8 cfs to 5.8 cfs under HCP measures.	*Notes on Minimum Cumulative Effects*: Generally, the beneficial effects on spring flows will be considerably larger than those shown. The changes shown here are conservatively the minimum effects that would exist under the two Alternative sets of measures.			
2.0 ADDITIONAL MEASURES EMPLOYED AFTER DECLARING ALARM STATE DROUGHT					
2.1 Develop a drought trigger methodo-logy that can be effectively used to signal timely curtailment of groundwater withdrawals[2].	Promulgate and use new, science-based drought triggers for declaring drought stages and actions.	Consider and, if needed, develop drought triggers for Trinity Aquifer.	***New Rule:*** Section 3-7.3. Drought Stages and Triggers Ultimately will require a revision and approval of the Management Plan.	F: Very High/ High E: Very High/ High	The new drought trigger methodology was developed, peer-reviewed, adopted, and put into operation during 2006.Triggers are set sufficiently far in advance to give other measures of this section an opportunity to be effectively deployed.
2.2 Define trigger conditions that require a mandatory 20% reduction in monthly groundwater withdrawals by permittees ***Alarm Stage*** = 20% reduction when Lovelady Well level is less than 180.8' below land surface or when 10-day avg. discharge of Barton Springs is equal to or less than 38 cfs[2].	*Before/After ITP Application/ Issuance* Evaluate and then promulgate by Rule pumping restrictions requiring 20% reduction in monthly pumpage allocation when Lovelady Well level is equal to or greater than 180.8' below the land surface, or when the 10-day average discharge of Barton Springs is equal to or less than 38 cfs; enforce compliance with permittees' UDCPs. Monitor effectiveness during intervening drought period and revise as necessary.		***New Rule:*** Section 3-7.3. Drought Stages and Triggers	F: Very High/- E; Very High/-	The total volume of water actually withdrawn by permittees, in the aggregate, will comply with the 20% target of demand reduction, as authorized in the UDCPs. Monthly monitoring of permittee compliance with monthly limits established in their UDCPs.
2.3 Define additional	Establish more rigorous	None.	Rule 1.24 Conditional	F: Very High/-	Renewal of all such permits

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
reductions that will be required of certain conditional production permittees under certain conditions[2].	conditional permit application requirements for new (Class B) conditional permittees; Promulgate by Rule more aggressive curtailment targets for Class B conditional permittees in an Alarm Stage drought, including the demonstration of an effective alternative supply arrangement if a higher-percentage curtailment or cessation is ordered by the District.		Production Permits F. Compliance with Drought Stages…(2) Alarm Stage Drought…(ii) Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and shall curtail monthly groundwater production by a mandatory 50% drought reduction requirement.	E: High/-	with these provisions in place Compliance with conditional permit curtailment/cessation may depend on actual timely availability of alternative water supply.
2.4 Seek legislation, and if successful implement, authorities to apply additional enforcement measures for ensuring/improving drought period compliance with withdrawal restrictions [2, possibly 3].	***Before/After ITP Issuance**:* This legislative initiative or an incentive-based measure will be sought, if required by court actions in the application of the defined regulatory program, in at least one out of every two legislative sessions until enacted or for the duration of the ITP; If authorized, implement an administrative fines program; Implement a regulatory compliance fee for non-compliant permittees; Use tiered penalty matrix to multiply fines and penalties based on amount of water used in excess of authorized amount, providing an elastic response to higher demands; Develop additional enforcement strategies for non compliance, as necessary.	1 years: Seek statutory change to hold end-users legally responsible during declared drought period for complying with permittee's overall pumping restrictions on an individual use, pro-rata basis. 2 Seek authority to impose administrative fines and penalties.	***New Rule:*** **Section** 3-7.9. Imposition of Regulatory Fees ***New Rule:*** Section 3-7.11. Enforcement /Penalties During Drought . Longer-term changes will require legislative approval.	F: High/Low E: Very High/ Very High	Success will be measured by ability to both bring and defend court cases successfully.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
NET EFFECT OF MEASURES EMPLOYED DURING ALARM STAGE DROUGHT (cfs)	Spring flows will increase under Alarm Stage conditions from 2.0 cfs under existing management measures to a range from 2.8 cfs to 3.8 cfs under HCP measures.				
3.0 ADDITIONAL MEASURES EMPLOYED AFTER DECLARING CRITICAL STAGE DROUGHT					
3.1 Define trigger conditions that require a mandatory 30% reduction in monthly groundwater withdrawals by permittees ***Critical Stage*** = 30% reduction when Lovelady Well level is less than 192.1 ft. below land surface or when 10-day avg. discharge of Barton Springs is equal to or less than 20 cfs [2].	Monitor effectiveness during intervening drought period and revise as necessary.	Evaluate on the basis of new data or management experience attained from prior implementation, and then modify, as warranted, these measures to achieve groundwater demand reductions equal to or greater than what is anticipated by using the measures specified here.	***New Rule:*** Section 3-7.3. Drought Stages and Triggers	F: Very High/- E: Very High/-	The total volume of water actually withdrawn by permittees, in the aggregate, will comply with the 30% target of demand reduction, as authorized in the UDCPs.
3.2 Pumping reductions beyond those of Measure 2.3 above and based on drought triggers will be applied to certain (currently undefined) Historic Exempt Users [3].	Investigate the feasibility and likely benefit of redefining Exempt Historic Use.	If feasible and effective, lobby for legislation that will enable this change.	Statutory change will be difficult to acquire.	F: Very low/ Very Low E: Very low/ Low	Adding larger small users to permitted universe will be viewed as unfair.
3.3 Define additional reductions that will be required of certain conditional permittees under certain conditions[2].	Establish and promulgate in the District Rules more rigorous conditional permit application requirements for new (Class B) conditional permittees; Promulgate more aggressive curtailment targets for Class B conditional permittees in Critical Stage drought, including the demonstration of an effective alternative supply arrangement upon a high percentage	None	***Proposed Rule****:* Section 3-1.24 CONDITIONAL PRODUCTION PERMITS…F. Compliance with Drought Stages…(3) Critical Stage Drought…(ii) Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, “Drought,”	F: Very High/- E: High/-	Renewal of all such permits with these provisions in place Compliance with achieving mandated curtailments by all Class B conditional permittees.

Alternative HCP Measures	Activities Likely Performed <u>before</u> and Included in ITP Application	Activities Likely a<u>fter</u> ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
	curtailment or cessation order by the District.		and shall curtail monthly groundwater production by a mandatory 75% drought reduction requirement.		
3.4 Define an Emergency Response Period, deep within the Critical Stage drought period, in which both a) water withdrawals under certain conditional permits may be further curtailed or prohibited, and b) if legislative authority is granted, certain historic use permits not directly essential to human health and safety may be curtailed.	Establish a new *Emergency Response Period* that will be declared at the discretion of the District's Board and generally when the 10-day average flow at Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days; If legislative authority is given, develop and communicate a regulatory program to curtail certain non-essential uses, as described in I.3.3 above; Initiate conversion program for historic-use permittees described in I.3.4 above; If and as available from adaptive management measures, implement programmed structural or other non-structural measures as last-resort initiatives to avoid irrecoverable damage to the aquifer and its uses.	Modify Rules that would allow effective use of temporary measures.	***New and Proposed Rules:*** Section 3-1.24 Conditional Production Permits… F. Compliance with Drought Stages…(4) Emergency Response Period.	F: Indeter-minate E: Indeter-minate	Any such measures represent a "last resort" attempt that is solely designed to preserve the salamander population above its jeopardy level.
3.5 An ***Emergency Response Period*** will begin when the 10-day average discharge of Barton Springs is equal to or less than 14 cfs and which will continue for a minimum of 90 days; The	See 3.4 above.	Conduct limited trials of any such measures, to confirm and fine-tune their utility.	**New Rule:** (i) Upon declaration of an Emergency Response Period (ERP) under Rule 3-7.3(F) Biological studies must establish a scientifically defensible flow condition	F: Indeter-minate E: Indeter-minate	Renewal of all permits with these provisions in place. Any such measures represent a "last resort" attempt that is solely designed to preserve the

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
District would also order mandatory reductions for all Class A conditional permits of 50% for the 1st 3 months, 75% for the next 3 months, and 100% thereafter, until Barton Springs flow rises above 14 cfs, then the next less severe stage of reduction would be declared until either the 30% use reduction on all permitted wells is reached or the Critical Stage Drought is no longer declared. less than the minimum spring flow required to sustain the BS salamander as determined by biological studies; emergency actions that could include additional pumping reductions and/or measures identified in Measure 4.0 below will be implemented at the discretion of the District's Board [2].			that is neither too high nor too low.		salamander population above its jeopardy level.
3.6 As negotiated in individual conditional-use permits, require mandatory switching to alternative water supplies by groundwater users during an Emergency Response Period, as enabled through prior agreements with current or other water suppliers with excess capacity	***Before/After ITP Issuance:*** Hold work sessions with utilities and water supply providers that are most likely to construct surface or alternative water systems, to discuss feasibility and options, and possible nonstructural incentives by the District that might promote availability of such excess capacity; contract with engineering specialist to evaluate economic and engineering studies by permittees, to determine the			F: Very Low/ Low E: Very Low/ Moderate	An increased amount of "excess capacity" potentially available to or in District permittees' systems. Monitor and evaluate the actual discharge rate and length of time, during a drought, that surface or alternative water is distributed in lieu of ground water.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
	efficacy of the multi-source systems.				
NET EFFECT OF MEASURES EMPLOYED DURING CRITICAL STAGE DROUGHT (cfs)	Spring flows will increase under Critical Stage conditions from 2.8 cfs under existing management measures to a range from 4.2 cfs to 5.3 cfs under HCP measures				
4.0 STRUCTURAL MITIGATION INVESTIGATIONS AND MEASURES (To Ameliorate Extreme Conditions That Are Not Able To Be Mitigated By Other Means)					
4.1 Coordinate with the City of Austin to investigate feasibility of re-circulating water discharged from Barton Springs to specific habitat protection zones within the spring ecosystem during periods of critically low flows.	Hold technical work sessions with Austin biologists and engineers to discuss the merits of this measure, based on the HCP Fatal Flaw Study.	Secure funding for studies. Establish project scope and select investigator. Complete the studies.	Prepare and execute an interlocal agreement with Austin to conduct the study.	F: Very Low/Moderate E: Very Low/ Moderate	An inter-local agreement with Austin to conduct studies is executed. A scope of work is prepared and funding is secured. The studies are completed.
4.2 Based on feasibility determined from Measure 4.1 above, a pilot project to re-circulate discharged groundwater to specific habitat protection zones within the spring ecosystem will be planned, designed, and implemented.	See 4.1 above. There would be no activity on this measure until and unless measure 4.1 affirms the feasibility and benefit.	Secure funding for project. Establish project scope and select investigator. Complete the project.	See 4.1 above. Obtain grant or budget appropriation sufficient to conduct the study. Measures 4.2, 4.3 and 4.4 and 4.5 are interdependent, in that the findings and results of one may cancel or provide support for another.	F: Very Low/ Low E: Very Low/ Very Low	See 4.1 above.
4.3 A detailed investigation based on results of the HCP Fatal Flaw Study will be performed to determine feasibility of augment-ting spring flow or elevating dissol-ved oxygen concentrations using *another groundwater* source.	See 4.1 above.	See 4.1 above.	See 4.2 above.	F: Very Low/Moderate E: Very Low/ Moderate	The investigation is completed.

Alternative HCP Measures	Activities Likely Performed <u>before</u> and Included in ITP Application	Activities Likely a<u>fter</u> ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
4.4 A detailed investigation based on results of the HCP Fatal Flaw Study will be performed to determine feasibility of augmenting spring flow or elevating dissolved oxygen concentrations using *supplemental surface water*.	See 4.1 above.	See 4.1 above.	See 4.2 above.	F: Very Low/Low E: Very Low/ Low	See 4.3 above.
4.5 A project to supplement spring flow during severe drought will be planned, designed, and implemented, based on 1) feasibility determined from results of investigations obtained by Measures 4.3 and 4.4 above and 2) other conditions stipulated by the District Board and the City of Austin, in consultation with USFWS.	See 4.1 above. There would be no activity on this measure until and unless measures 4.3 or 4.4 affirm its feasibility and benefit.	See 4.2 above. Project implementation if and as required, under proscribed conditions.	See 4.2 above.	F: Very Low/ Low E: Very Low/ Very Low	The protocol is prepared. Agreements between Austin, the District, and USFWS to conduct the protocol are executed; and the protocol is in effect to implement when necessary. The net enhancement of spring flow or elevation of dissolved oxygen concentration as a result of implementing the project is determined.
4.6 The District will seek to enter into an Inter-local Agreement (ILA) between the District and the City of Austin to support the Salamander Conservation Program to manage the species during all conditions	See 4.1 above. **Before ITP Issuance**: This Inter-local Agreement may be a master MOU that describes roles and responsibilities of the City and the District on this and several additional areas of collaboration, including those described elsewhere in this table and also those that are eventually authorized as part of the City's Barton Springs Pool Master Plan, possibly including extension of spring runs, re-aeration, more accurate spring flow measurements, and others	Implementation of the protocol and harvesting of *E. sosorum* if and as a severe low spring flow occurs.		F: Moderate/ High E: Moderate/ High	If the ILA/MOU is authorized, a cash contribution of some amount to be determined and commensurate with the scope of the programs included in the MOU will be made to the Barton Springs Salamander Conservation Fund.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
	to be identified. Hold work sessions with USFWS to determine the need and appropriateness of this measure, under the District's HCP.				
4.7 Enter into an inter-local agreement between the District and the City of Austin, under both entities' HCPs, to establish a protocol, including conditions of use, to augment spring flow or elevate dissolved oxygen concentrations during periods of severely low spring flow or flow cessation.	See 4.6 above.	See 4.6 above.	Austin's HCP might also have to require this type of measure in order for both parties to establish and conduct this protocol.	F: Very Low/ Low E: Very Low/ Very Low	See 4.6 above.
No quantitative effect estimated for Structural Mitigation Measures					
5.0 ADAPTIVE MANAGEMENT STRATEGIES (To Be Undertaken as Funds, Partners, and Permissions Are Identified – Not Governed by Declared Drought Stage)					
5.1 The District will refine and improve its Groundwater Availability Model (GAM) to serve as a planning and evaluation tool when implementing new groundwater management programs.	Obtain approval of the District's GAM and newer groundwater data sets, as equivalent to the State's official groundwater availability model for the Barton Springs aquifer.	Use and apply the model to develop and evaluate specific management techniques, such as the effect of new conditional permit requirements and the aquifer's transient response to various short-term drought scenarios. Evaluate new models for future use as GAMs.			The model was completed, and submitted to extensive peer review in 2005 and 2006. The District's model is used by TWDB to define the amount of Managed Available Groundwater once GMA 10 submits its agreed Desired Future Conditions.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
5.2 The District will work with universities, the City of Austin, and other qualified parties to extend toxicity studies on salamander species to determine the level of risk and toxicity of depressed Dissolved Oxygen and elevated Conductivity levels affecting salamander viability in spring water.	Incorporate final peer-reviewed results of the salamander toxicity studies into HCP biological impact assessments.				HCP Studies were completed in 2006 and reported in 2007.
5.3 Additional studies will be conducted on the potential for the augmentation of water supplies in the brackish water zone (including desalination and aquifer storage & recovery) and from other freshwater (e.g. Trinity aquifer).	***Before/After ITP Issuance:*** Consider participation with the City of Austin and/or other entities in feasibility studies of various water augmentation approaches. If feasibility study is positive, plan and execute programs to evaluate desalination, aquifer storage and recharge, rainwater harvesting, Trinity Aquifer production, etc.; Install a multi-port monitoring well system in Edwards and Trinity Aquifers to evaluate potentiometric relationships; Continue evaluation of geophysical tools for assessing saline zone properties.				Complete feasibility study on one or more of the more viable alternatives within one year of ITP issuance.

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
5.4 The District will work with the USGS, universities, the COA, and other qualified parties to develop a more sophisticated sediment transport model for the Barton Springs segment, which will be used to examine the influence of sediment inputs on the spring ecosystem and evaluate the capability of individual spring openings to flush excess sediments deposited during flood events.	***Before/After ITP Issuance:*** Commit in-kind or matching cash support in the amount of at least $30,000 over a two-year period to USGS or other District-approved studies.				Commitment of in-kind and cash support of $30,000 annually for two years in support of these studies.
5.5 A survey of aquifer biota will be conducted in sampling wells dispersed throughout the Barton Springs Segment of the Edwards Aquifer in order to improve understanding of species richness and diversity.	***Before/After ITP Issuance:*** Commit in-kind or matching cash support in the amount of at least $20,000 over a two-year period. This would entail a MOU with the COA and/or TPWD, and would likely involve seeking a Sec. 6 grant from USFWS.				Commitment of in-kind and cash support of $20,000 over two years in support of 5.5 and 5.6
5.6 The District will work with universities, the COA, and other qualified parties to conduct a study of the movements of the Barton Springs salamander and associated biota within the Barton Springs Ecosystem, and possibly other relevant studies to be determined.	Same as 5.5 above				Same as 5.5 above

Alternative HCP Measures	Activities Likely Performed before and Included in ITP Application	Activities Likely after ITP Issuance (Time-phased Adaptive Management)	Prerequisite Needs or Constraints	Overall Feasibility (F) and Effectiveness (E) Before/After ITP Issuance	Notes on Success Metric(s), Outcomes, and/or Assumptions
ESTIMATED CUMULATIVE EFFECT OF ALL MEASURES DURING EXTREME DROUGHT (cfs): (This is the sum of applicable measures in 1.2, 1.3, 1.4, and 3.0; it does not include structural mitigation or adaptive management strategies.)					

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

****Alternatives Definitions:***

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

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

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

APPENDIX C

Fatal Flaw Evaluation of Alternative Augmentation Strategies at Barton Springs

FATAL FLAW EVALUATION OF ALTERNATIVE AUGMENTATION STRATEGIES AT BARTON SPRINGS

A Working Task for the Barton Springs Habitat Conservation Plan (HCP)

Prepared For

Barton Springs / Edwards Aquifer Conservation District

Prepared By

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April 2006

Fatal Flaw Evaluation of Alternative Augmentation Strategies at Barton Springs

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EXECUTIVE SUMMARY

Under severe drought conditions in the Barton Springs Segment of the Edwards Aquifer, the Barton Springs/Edwards Aquifer Conservation District's (the District's) Drought Stage pumpage reduction alone may not be sufficient to maintain minimum springflow needed for the Barton Springs salamanders. An alternative approach is to consider spring recirculation and augmentation strategies in conjunction with the District's Drought Stage pumping regulation. These spring augmentation strategies are intended as ‘safety net’ for the Barton springflow and considered only for dire conditions. A fatal flaw analysis of these strategies was performed.

First, spring augmentation scenarios were identified through studies of the physical settings of the springs complex, historical springflow conditions that could result in take or jeopardy of salamanders, and the hydrological system and relation between springs and aquifer. The relation between aquifer water levels and total and individual spring discharges were obtained from past studies and used to establish the conditions when spring augmentation should be considered, and to estimate flow discharge that might be needed for the augmentation under severe drought conditions.

Four basic approaches for implementing recirculation and flow augmentation at Barton Springs were considered for the Main, Eliza and Old Mill Springs. They are:

1. Capturing water flowing from the spring system and recirculating the water back through parts of the spring complex, and other engineering solutions within the spring complex;
2. Importing surface water to the spring complex, either injecting the water directly into the Barton Springs complex, or injecting the water upstream into Barton Creek;
3. Importing groundwater to be discharged directly into Barton Springs complex or upstream of the springs into Barton Creek; and,
4. A combination of recirculation and augmentation.

Flow recirculation and augmentation alternatives for Barton Springs were developed and evaluated. This evaluation indicates that none of the alternatives considered have fatal flaws based on conceptual engineering. Any of these alternatives could provide varying amounts of

water to the springs during severe drought conditions. However, the level of probable cost based on a conceptual engineering, as well as other requirements, consideration and concerns, which were part of the fatal flaw analysis, could affect the cost-effectiveness of these alternatives. The alternative measures were further evaluated against likely project constraints that may arise, including political/institutional/legal issues, impacts to downstream surface water and groundwater, and public acceptance. A qualitative rating and scoring system was used for the evaluation. The results of the constraints evaluation along with probable cost formed the basis for ranking the alternatives.

1.0 PURPOSE

Under severe drought conditions in the Barton Springs Segment of the Edwards Aquifer, The District's Drought Stage pumpage reduction alone may not be sufficient to maintain minimum springflow needed for the Barton Springs salamander. An alternate approach is to consider spring recirculation and augmentation strategies in conjunction with Drought Stage pumpage regulation. These spring augmentation strategies are intended as ‘safety net’ for the Barton springflow and only use for dire conditions.

Four recirculation and augmentation approaches have been identified and are listed below:

1. Recirculation of Barton Springs water and other engineered solutions within the spring complex;
2. Importing surface water from Town Lake, Lake Austin, or Lake Travis to the spring complex and either injecting the water into the Barton Springs Aquifer upstream from the springs or discharging the water directly into Barton Springs Pool;
3. Importing groundwater to be discharged directly into the Barton Springs complex or upstream of the springs into Barton Creek; and
4. Combination of recirculation and augmentation.

This report also presents a fatal flaw analysis of the above alternatives. In order to evaluate augmentation strategies, spring augmentation scenarios were identified through the consideration of physical settings, springflow conditions that could result in take or jeopardy of salamanders, and the hydrological system of the springs and aquifer.

2.0 BARTON SPRINGS

Barton Springs is an aquifer-fed system consisting of four separate but hydrologically connected springs: the Main Springs (also known as Parthenia Springs or Barton Springs Pool), Eliza Springs (also known as Concession Springs or Elks Pit), Old Mill Springs (also known as Sunken Garden or Walsh Spring), and Upper Barton Spring (Figure 2-1).

The following section describes important aspects of the four springs that comprise Barton Springs.

2.1 Physical Settings

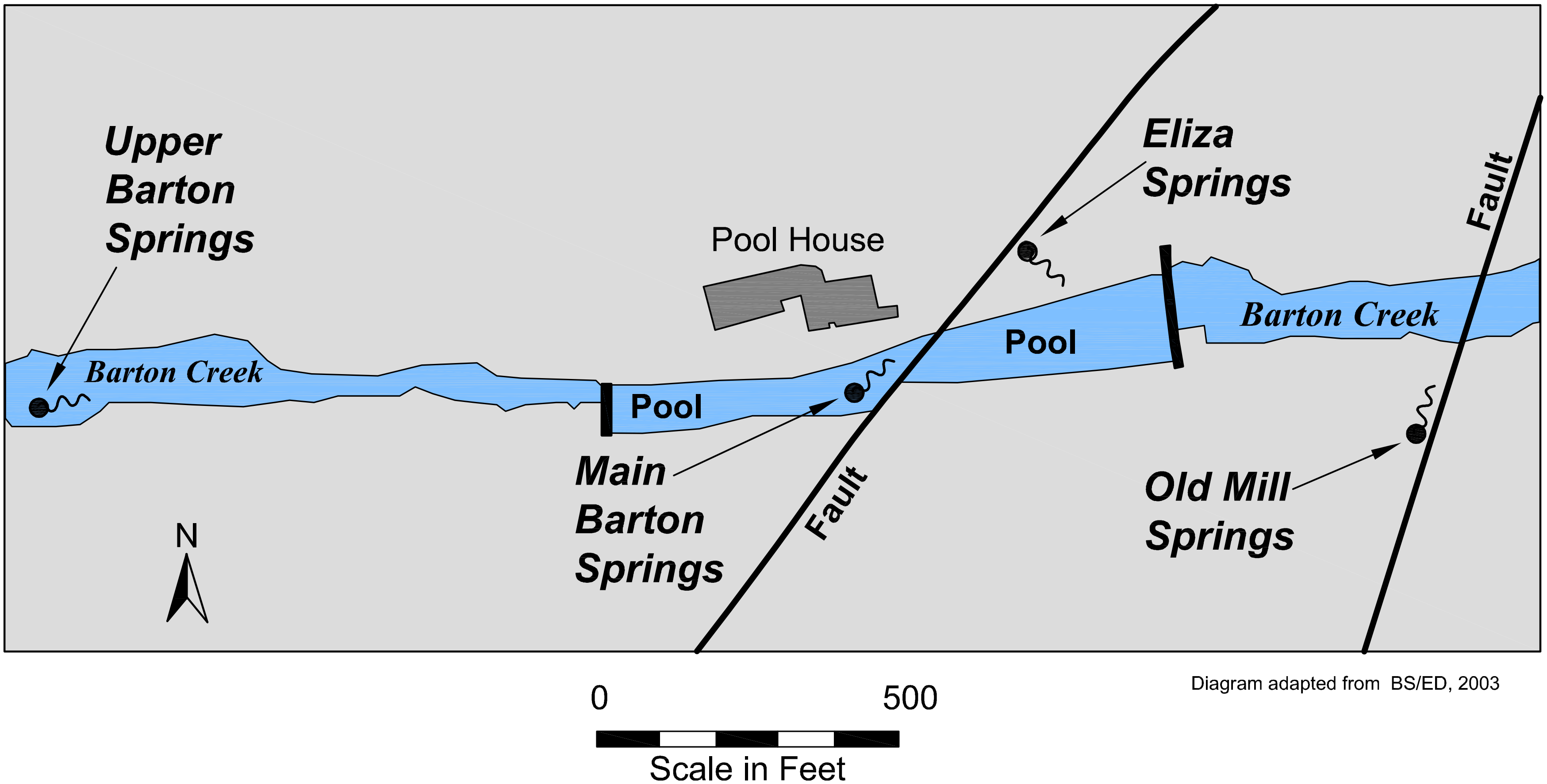
2.1.1 Main Springs

Main Springs is the largest of the four springs. Water enters the pool from local faults and fractures, including the fault line located just south of the diving board. The water then flows out of the pool primarily at one of two locations:

1. Most of the water flows downstream through the openings of the lower dam or through a gate near the base of the dam when opened, and;
2. A small portion of the flow may exit the pool by leaking into the bypass tunnel.

The dam and many of the structural features that form the current Barton Spring Pool were built during the 1920s. Other major developments or modifications, such as the bathhouse, upstream dam and skimmer drain, were added during the following decades. In 1932, the City of Austin added an upper dam. The Barton Creek bypass tunnel located under the sidewalk on the north side of the pool was constructed between 1974-1976 to divert creek flow around the pool. Surface water from Barton Creek no longer enters the pool except under flood conditions. The pool is kept full with the spring water alone most of the time, so the water remains clear and at about a constant temperature of 68^{o}F.

As part of the City of Austin's Habitat Conservation Plan (HCP) for the Barton Springs salamander, the portion of the pool referred to as the Beach Area, the southern part of the pool, was reconfigured in 1999. Water depth in the Beach Area was increased from approximately 4 feet to 5-to-5 1/2 feet, an increase of 1 to 1 1/2 feet. This was done to reduce the possibility of salamanders being stepped on by bathers. The volume of the pool is approximately 4.4 million gallons (APAI, 2002). When the springflow is 25 to 30 cfs (a low flow period), the pool turnover rate is approximately four times per day, only about half of the turnover rate expected during average flow conditions.



Barton Springs Location Map

Figure 2-1

LBG-GUYTON ASSOCIATES

Until 1997 the pool was partially drained once a week to clean the pool walls. As a result of the listing of the salamander as endangered, the water level in the pool is no longer lowered on a weekly basis to aid in cleaning algae off the walls. Now the pool can be lowered no more than four times per year and only when the springflow at the main springs is above 54 cfs.

2.1.2 Eliza Springs

Eliza Springs is located on the north bank near the lower end of the pool, issuing from a cave-like sinkhole, and discharging into the bypass tunnel and exiting from there to Lower Barton Creek.

Located behind the concession stand by the main entrance of Barton Springs Pool, Eliza Springs is housed in an amphitheater shaped concrete structure built in 1917, which was used as a summer meeting place for the Elks Club in the 1920s.

The springflow of Eliza was a major source of drinking water for Austin citizens during the drought of 1917. Since the original construction of the Elks Pit, a concrete bottom was installed with 15 centimeter (6 inch) diameter holes to allow for spring discharge from the aquifer and an additional 0.5 - 1 meter (1.6 - 3.3 feet) of concrete was added to the top of the original concrete wall. For many years, Eliza Springs was open to the public and their pets for swimming and leisure. Public access is now restricted as salamander restoration and enhancement projects are underway.

In 2003, the City of Austin staff substantially improved Eliza Springs as habitat for the Barton Springs salamander, primarily by lowering the static water level in the pool and increasing the flow velocities. During monthly salamander surveys, the highest counts of salamanders are found at this spring.

2.1.3 Old Mill Springs

Also known as Sunken Gardens, Old Mill Springs issues from a sinkhole on the south bank below the swimming pool. It is currently fenced to protect the Barton Springs salamander. Water flows into a circular pool through multiple upwellings in the gravel bottom, through an outfall pipe and down a small tributary to Lower Barton Creek.

During the 1980's an outfall pipe was installed to route springflow directly from Old Mill Springs underground to Lower Barton Creek. During periods of moderate to high aquifer levels, water in Old Mill can reach a depth of 2.0 meters (6.6 feet) and surface flow exists between the springs and the discharge point into lower Barton Creek. Under low flow conditions, surface flow from Old Mill Spring will cease because springflow is routed into the outfall pipe. Various sections of the original stone structure around the springs are in disrepair and much of the structure is in need of extensive restoration.

2.1.4 Upper Springs

Upper Barton Springs is located approximately 100 meters (328 feet) upstream of Barton Springs Pool near the south bank of Barton Creek.

This is the smallest of the four springs and frequently ceases to flow when the total discharge from Barton Springs is less than about 53 cfs. Although springflow is ephemeral, Barton Springs salamanders are frequently found at this site.

2.2 Salamanders and Spring Discharges

The only known surface habitats of the Barton Springs salamander are Barton Springs Pool, Eliza Springs, Old Mill Springs, and Upper Barton Springs. The endangered salamanders depend on the cool flowing spring waters for food and dissolved oxygen supply and thus for their survival. Maintaining an adequate spring discharge to the surface water at the individual spring locations is important for their subsistence.

Several studies have been conducted on the salamanders in the Barton Springs (City of Austin, 2006; USFWS, 2005). For the purpose of this study, a literature review was conducted on the Barton Springs salamander in the following four areas:

- Salamander occurrence;
- Population size;
- Hydrologic requirements related to springflows (especially in a drought condition); and
- Aquifer conditions when springs cease to flow.

Table 2-1 summarizes this review of the salamanders in the four springs. Main Pool, Eliza and Old Mill Springs are the primary salamander habitats. Based on the populations found, Eliza Springs appears to be the most critical habitat among the three. The review also showed the historical aquifer conditions when the springs cease to flow and suggesting flow conditions to be considered for the springs augmentation. Additional flow augmentation information related to salamanders is given in Section 3.0 - Springs Augmentation Scenarios.

2.3 Spring Discharges and Aquifer Water Levels

For the purpose of springflow augmentation a relation is needed between total spring discharge and individual springs as well as between the flows of Main Springs and the separate flows from Eliza and Old Mill Springs, in that the salamander is found at each of the spring locations.

The relation between the water level of the USGS monitoring well (well 58-42-903), located about 200 feet SE from the Main Springs, and the discharge has been developed for total springs discharges and Old Mill Springs discharges (see Figure 4-9 & 4-10 in Senger, 1983, and Figure 36 in Slade, 1986).

The above relations were duplicated below in Figures 2-2 and 2-3.

Table 2-1. SUMMARY OF LITERATURE REVIEWS OF SALAMANDERS IN FOUR SPRINGS OF THE BARTON SPRINGS

	Main Springs	Eliza Springs	Old Mill Springs	Upper Springs
Number of Salamanders	Between 25 to 150	Mean population since 2003 is near 300	Between 0 to 60 individuals	Between 0 to 14 (adult salamanders)
Locations of Salamanders Found	Primarily near the spring outlets, the fissures area west of the diving board, and the beach area on the north side of the pool.	In vegetation, gravel, beneath pottery plates in pool concrete floor and lowest step	Sporadically in the bottom of Old Mill Springs and in the surface flow from Old Mill Springs to the main stem of lower Barton Creek.	Under small rocks at the springs location
Common Requirements Related to Springflow, in Drought Condition	• Habitat at the springs not to be exposed (above water), and • Quality of water sustained at current status			
Conditions When the Springs Cease to Flow	No such event has occurred based on historic record	Eliza Springs ceases flowing twice: 1) During main pool drawdown experiment (1997) while the total Barton Springs discharge is less than 53 cfs, and 2) when the total discharge is less than 20 cfs	When the total discharge is less than 20 cfs	Usually when the total Barton Springs discharge is less than 53 cfs

Sources: City of Austin, 2006; COA Meeting Notes (see Appendix A-1); Senger, 1983; Slade, 1986; Dries, 2006.

Figure 2-2. Relation Between Water Levels In Well 58-42-903 And Total Discharge In Barton Springs (Pool Full) (Modified from Slade, 1986)

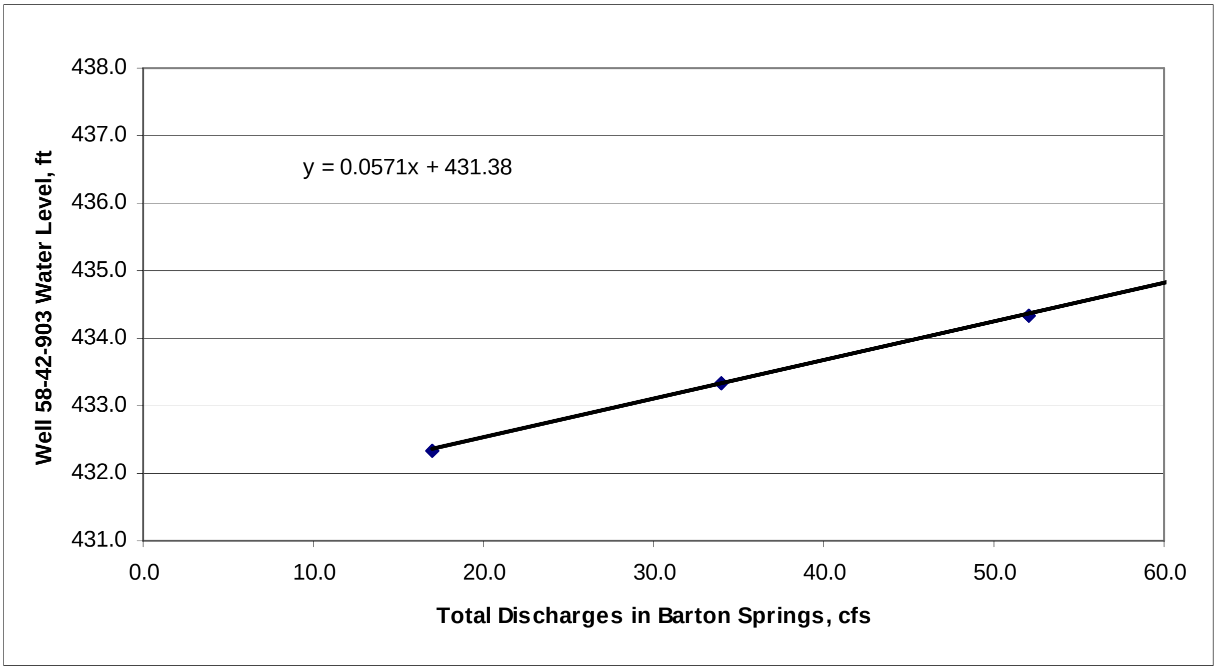
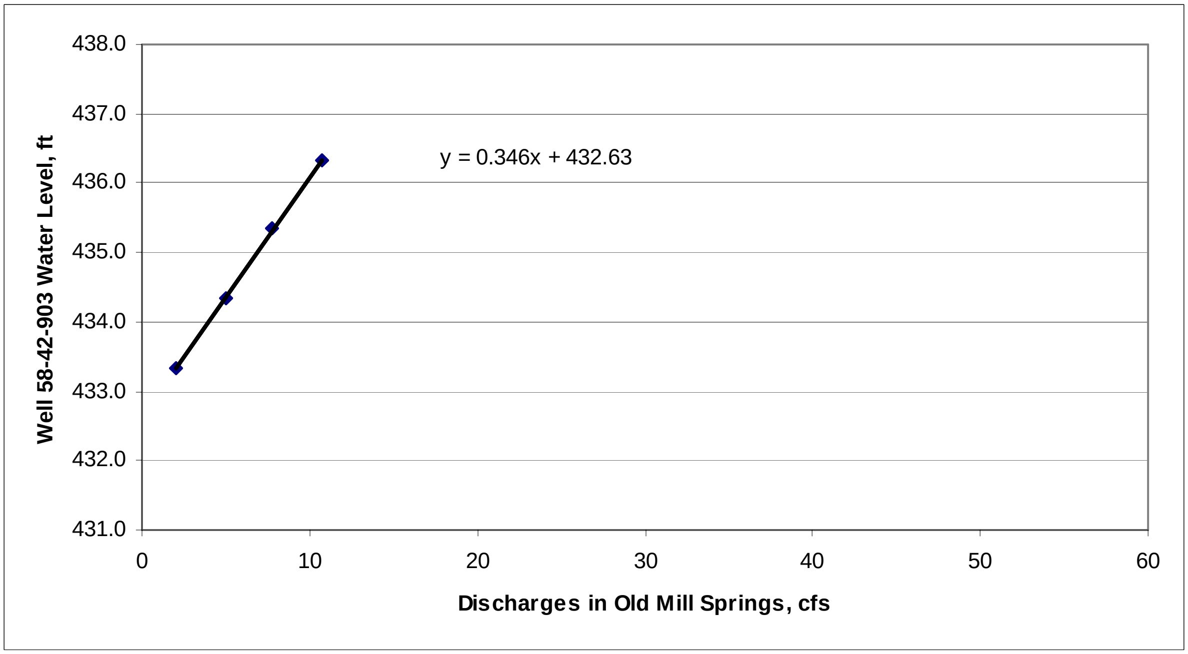
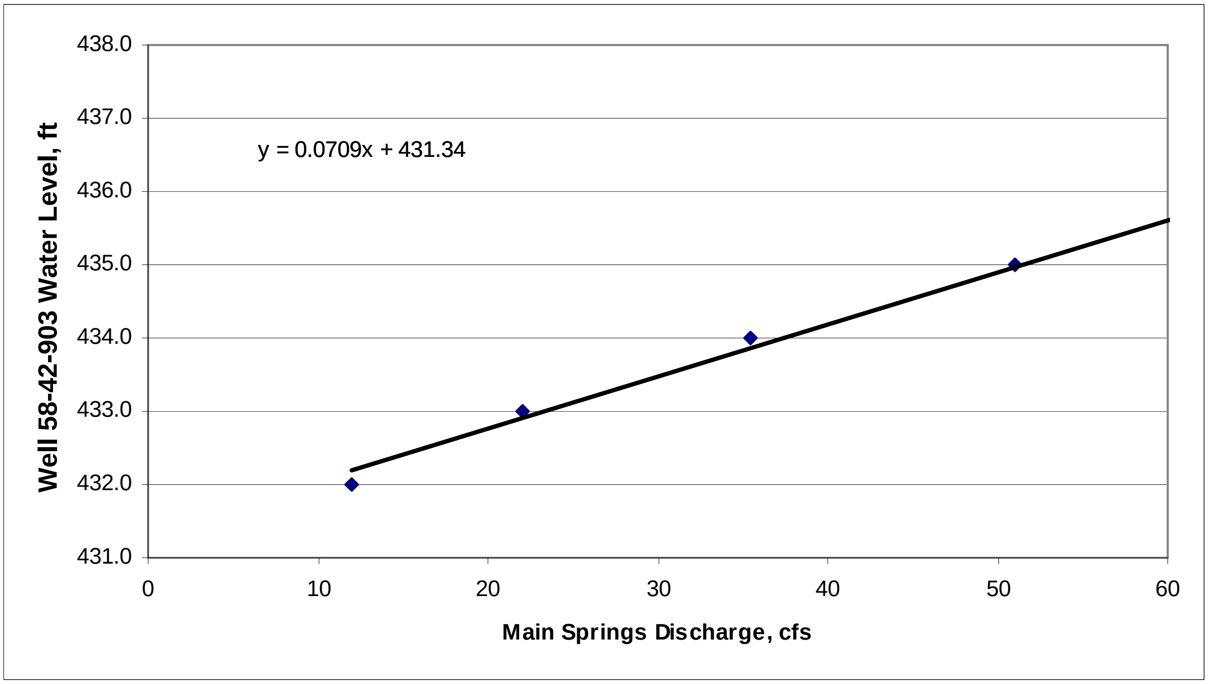


Figure 2-3. Relation Between Water Levels In Well 58-42-903 And Individual Discharge Of Old Mill Spring (Pool Full) (Modified from Senger, 1983)



The relation between water levels in well 58-42-903 and Main Springs discharges, can also be extracted from Figure 36 in Slade, 1986, and is shown in Figure 2-4.

Figure 2-4. Relation Between Water Level In Well 58-42-903 and Main Springs Discharges (Pool Full) (Modified from Slade, 1986)



Once the above relation is defined, the relationship between water levels in well 58-42-903 and Eliza Springs discharges can be obtained by the following equations:

$$Q_{\text{Eliza}} = Q_{\text{Total}} - Q_{\text{Main}} - Q_{\text{Old Mill}}$$

Where

Q_{Eliza} is the Eliza Springs discharge;

Q_{Total} is the Total Barton Springs discharge; and

$Q_{\text{Old Mill}}$ is the Old Mill Springs discharge

Computed result for Eliza Springs discharges at given water levels is shown in Table 2-2.

Table 2-2. The Computed Eliza Springs Discharge Data And The Corresponding Well 58-42-903 Water Level (Pool Full)

Well 58-42-903 Water Level (ft)	Pool Full Eliza Springs Discharge (cfs)
434.03	4.2
433.75	4.1
433.47	4.0
433.25	3.9
433.18	3.9
432.90	3.8
432.76	3.7
432.24	2.4
431.95	1.4
431.84	1.1
431.67	0.5

The above data showed two linear relationships with an inflection point occurring between well water level, 432.76 ft. and 432.24 ft. Figure 2-5 gives the plot of the relation between the aquifer water levels (above 432.76 ft) and Eliza Springs discharge. Figure 2-6 gives the plot of the relation between the aquifer water levels (below 432.76 ft) and Eliza Springs discharge. There is a sharp change in slope between the regression line shown in Figure 2-5 and 2-6. The flow conditions at Eliza Springs are dominated by orifice flow when orifice is submerged and the discharge (Q) is then related to the square root of head (h) by the equation, $Q = C A (2gh)^{1/2}$, where

C - the discharge coefficient,

A - the area of the orifice, and

g - the gravitational acceleration.

This change in flow condition explains the change in slope when the water level at Eliza Springs reach above a level about 432.76 ft.

Figure 2-5. Relation Between Water Level Of Well 58-42-903 (above 432.76 ft) and Individual Discharge Of Eliza Springs (Pool Full)

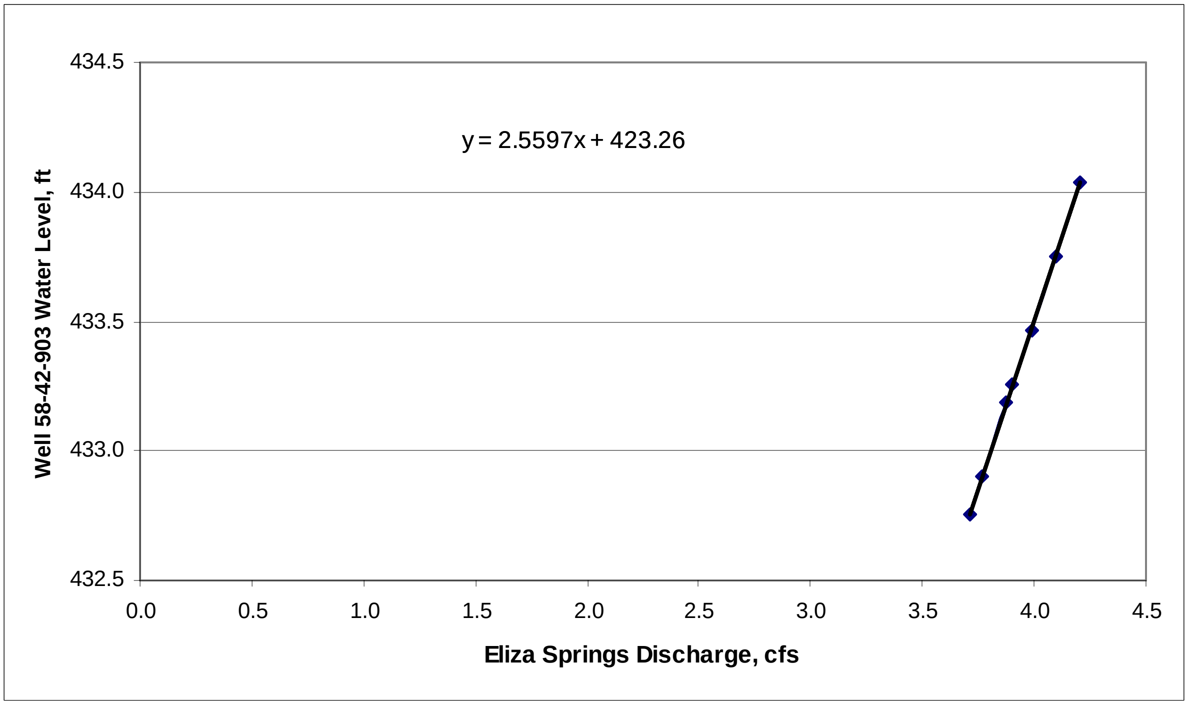


Figure 2- 6. Relation Between Water Level Of Well 58-42-903 (above 432.76 ft) and Individual Discharge Of Eliza Springs (Pool Full)

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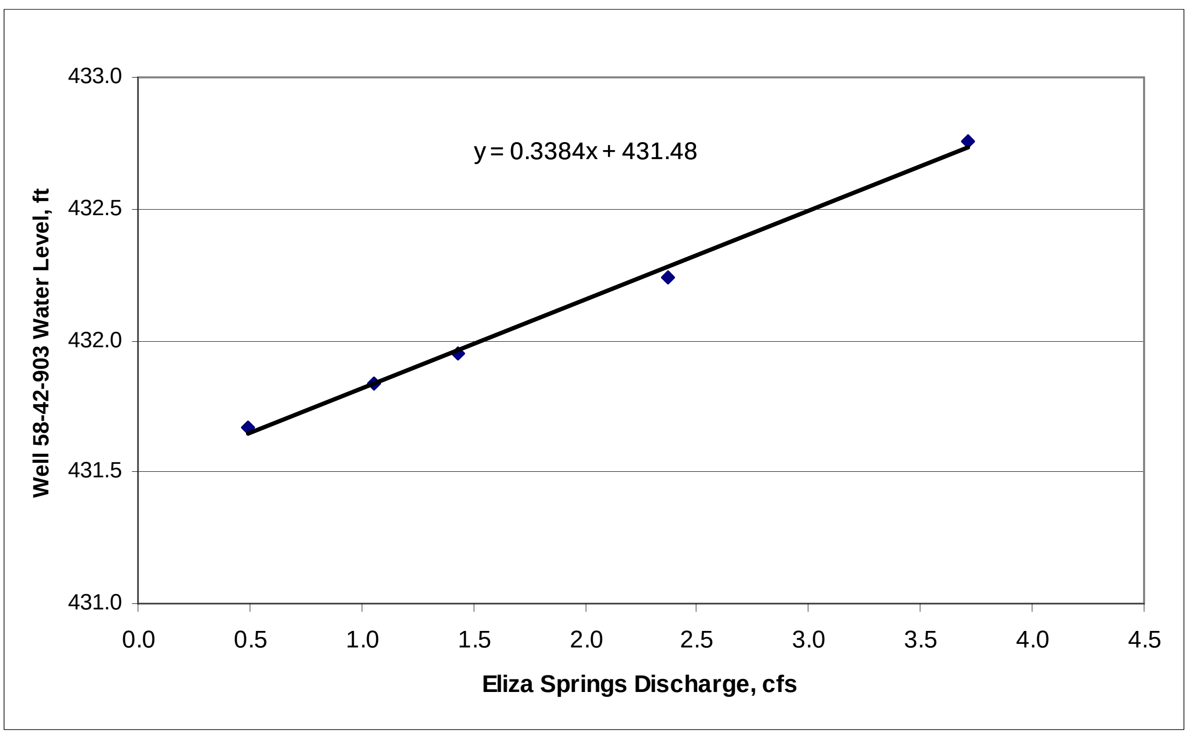


Based on the above relations, estimates of the total springs discharge and the individual discharge in Main, Old Mill and Eliza Springs can be computed for any given aquifer level represented by well 58-42-903. Table 2-3 gives the resultant springflows in the Barton Springs for various low flow stages.

Table 2-3. Estimated Springflows In Barton Springs At Low Flow Or Drought Stages

Data are computed using the 'water level - dishcarge' regression equations

	Flow (cfs)				
Aquifer Water Level (ft)	Total Barton Springs	Main Springs	Old Mill Springs	Eliza Springs	BSEACD Conservation Stage
434.46	54.0	44.1	5.3	4.4	**average flow**
434.35	52.0	42.0	5.0	4.3	
434.03	46.5	38.0	4.1	4.2	
433.75	41.5	34.0	3.2	4.1	
433.55	38.0	31.2	2.7	4.0	**alarm drought**
433.47	36.5	30.0	2.4	4.0	
433.25	32.8	27.0	1.8	3.9	
433.18	31.6	26.0	1.6	3.9	
432.90	26.6	22.0	0.8	3.8	
432.76	24.1	20.0	0.4	3.7	
432.52	20.0	16.7	0.0	3.3	**critical drought**
432.41	18.0	15.1	0.0	2.9	
432.24	15.0	12.6	0.0	2.4	
431.95	10.0	8.6	0.0	1.4	
431.93	9.6	8.3	0.0	1.4	
431.84	8.0	7.0	0.0	1.1	
431.67	5.0	4.6	0.0	0.5	
431.61	4.0	3.8	0.0	0.3	

The green color band marks the average flow stage of the aquifer, when the total Springs discharge is 54 cfs corresponding to an aquifer water level of 434.46 ft. The corresponding discharge at Main, Old Mill and Eliza Springs is 44, 5 and 4 cfs, respectively. The yellow color band marks the Alarm Drought Stage of the aquifer (BSEACD, 2006) when the total Springs discharge is 38 cfs. The corresponding aquifer water level is 433.55 ft. The red color band marks the Critical Drought Stage of the aquifer with the total Springs discharge of 20 cfs. The corresponding discharge at Main Springs is about 17 cfs and is about 3 cfs at Eliza Springs. The Old Mill Springs is estimated to stop flowing at a total springflow of 18 cfs.

The data in Table 2-3 links the individual spring discharges to aquifer water levels and with each other. The regression equations provide a means to interpolate or extrapolate the historical discharge observations to spring discharges in the infrequent drought stages. Table 2-4 summarizes the discharges in four spring locations in the Barton Springs under various hydrologic conditions. Spring augmentation should be considered when the Old Mill Springs is below 1.6 cfs, a flow level where the springflow may decline rapidly. This flow level corresponds to a total spring discharge of 32 cfs.

Table 2-4. Summary Of Relation Of Aquifer Water Level And Flow Conditions (Assuming Full Pool Condition) In the Four Main Springs Of Barton Springs

Hydrologic Condition	Aquifer Water Level (Well 58-42-903)	Total Springs Discharge	Main Springs	Eliza Springs	Old Mill Springs	Upper Springs
	(ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Normal Condition	Water level is between 434.35 to 436.34 ft (depth to water is between 26 to 28 ft)	About 53 to 87 cfs	About 42 to 70 cfs	About 4 to 6 cfs	About 5 to 10 cfs	About 1 to 2 cfs
Low Flow to the Beginning of Drought Condition	Water level is between 433.18 to 434.35 ft (depth to water is between 28 to 29 ft)	Between 32 to 51 cfs	Between 26 to 42 cfs	About 4 cfs	Between 2 to 5 cfs	Springs cease to flow
Measured Condition When the Springs Cease to Flow	Water level is below 434.35 ft and rapid drawdown occurs at the pool	The lowest measured discharge was 9.6 cfs	Springs have never ceased to flow based on historical data	Springs ceased flow once during rapid pool drawdown while the total Barton Springs discharge was below 53 cfs, and a second time when the total spring discharge is below 20 cfs (no record of pool level)	Ceased flowing when the total discharge was below 20 cfs (no record of pool level)	Ceased flowing usually when the total Barton Springs discharge was below 53 cfs
Conditions When Spring Augmentation Should Be Considered	Water level falls below 433.18 ft (depth to water is greater than 29 ft)	Below 32 cfs	Below 26 cfs	Below 3.9 cfs	Below 1.6 cfs and the spring flow may decline rapidly	No augmentation is recommended at this time until the habitat adjacent to this spring is found to be critical

3.0 SPRING AUGMENTATION SCENARIOS

The purpose of this section is to identify flow scenarios for which spring augmentation might be considered. Currently, the U.S. Fish and Wildlife Service (USFWS) has not designated a discharge level for each spring or for the total Springs in which "take" of the Barton Springs salamander population will occur. Nor have they designated the level of discharge at which "jeopardy" of the salamander population will occur. These "take" and "jeopardy" impact levels are based on the available life-history information, including distribution and habitat requirements for the Barton Springs salamanders and will be established in the forthcoming biological studies.

For practical purposes, a minimum discharge rate for each spring is estimated based on the reported historical flows under low discharge conditions. In the Barton Springs case, three scenarios were selected for each of the following low discharge conditions:

Scenario A	Total discharge is 38 cfs when Barton Springs enters 'Alarm Drought' Stage
Scenario B	Total discharge is 20 cfs when Barton Springs enters 'Critical Drought' Stage
Scenario C	Total discharge is 11 cfs (simulated by MODFLOW) for the "drought of record" discharge scenario

For each scenario the total spring discharge is adjusted by four levels of aquifer pumpage and coupled with or without a Drought Stage reduction factor. The four pumping rates used are as follows: null (o cfs), current permitted demand (11 cfs), projected future demand I conditions (15 cfs), and projected future demand II conditions (19 cfs). These rates are identical to those used in the MODFLOW runs (BSEACD, 2004).

Past modeling results have found that there is a one-to-one relation between total aquifer pumpage and the total discharge (BSEACD, 2004). This relationship makes the total discharge adjustment straightforward. The Drought Stage pumpage reduction factors are taken from the District's drought trigger methodology (BSEACD, 2006) and they are 20% and 30% for the Alarm and the Critical Drought Stages, respectively.

The estimation of the total spring discharge in each scenario is inferred by the previous MODFLOW modeling results. For example, under the drought-of-record scenario, current pumping levels of 10 cfs would result in a mean monthly springflow of about 1 cfs for about one month. For a null pumping rate, the total discharge would be 11 cfs. The total discharge would be 4 cfs for the scenario representing 70% of current pumping.

After the total discharge is estimated, the corresponding aquifer water level is computed by the previously developed linear equation. Then the individual discharge in each spring is computed by its relation with the resulting aquifer water level. Table 3-1 gives an estimated total discharge and individual spring discharge in Barton Springs under all three scenarios of hydrologic and pumping conditions. The amount of flow augmentation needed can be estimated from the difference between the estimated spring discharge data and the suggested protection level of discharge conditions given in Table 2-4. The results are also shown in Table 3-1. During the Alarm Drought Stage, augmentation needs range from 0.0 cfs to 2.6 cfs. During the Critical Drought Stage, augmentation needs range from 2 to 20 cfs.

Table 3-1. Estimated Volume Needed For Springs Augmentation In Barton Springs Under Drought Conditions

							from Table 2-4			
							Main Springs cfs	Eliza Springs cfs	Old Mill Springs cfs	Total Barton Springs Discharge cfs
Flow conditions below which spring augmentation is considered							**26.0**	**3.9**	**1.6**	**31.5**
Scenario A	**Barton Springs enters 'Alarm Drought Stage' (BSEACD, 2005)**						**Augmentation Needs Analysis**			
	Pumping Rate	Total Barton Springs Discharge	Aquifer Water Level	Main Springs	Eliza Springs	Old Mill Springs	Main Springs	Eliza Springs	Old Mill Springs	Total Flow Needed
	cfs	cfs	ft	cfs	cfs	cfs	cfs	cfs	cfs	cfs
No Pumping	0.0	48.0	434.12	39.2	4.2	4.3	**0.0**	**0.0**	**0.0**	**0.0**
Normal Pumping										
Current Rate	10.0	38.0	433.55	31.2	4.0	2.7	**0.0**	**0.0**	**0.0**	**0.0**
Projected Future Rate I	15.0	33.0	433.26	27.1	3.9	1.8	**0.0**	**0.0**	**0.0**	**0.0**
Projected Future Rate II	19.0	29.0	433.04	23.9	3.8	1.2	**2.1**	**0.1**	**0.4**	**2.6**
Reduced Pumping										
80% of Current Rate	8.0	40.0	433.66	32.8	4.1	3.0	**0.0**	**0.0**	**0.0**	**0.0**
80% of Projected Future Rate I	12.0	36.0	433.44	29.6	4.0	2.3	**0.0**	**0.0**	**0.0**	**0.0**
80% of Projected Future Rate II	15.2	30.8	433.14	25.4	3.9	1.5	**0.6**	**0.0**	**0.1**	**0.8**
Scenario B	**Barton Springs enters 'Critical Drought Stage' (BSEACD, 2005)**						**Augmentation Needs Analysis**			
	Pumping Rate	Total Barton Springs Discharge	Aquifer Water Level	Main Springs	Eliza Springs	Old Mill Springs	Main Springs	Eliza Springs	Old Mill Springs	Total Flow Needed
	cfs	cfs	ft	cfs	cfs	cfs	cfs	cfs	cfs	cfs
No Pumping	0.0	30.0	433.09	24.7	3.8	1.3	**1.3**	**0.1**	**0.3**	**1.7**
Normal Pumping										
Current Rate	10.0	20.0	432.52	16.6	3.1	0.0	**9.4**	**0.8**	**1.6**	**11.8**
Projected Future Rate I	15.0	15.0	432.24	12.7	2.3	0.0	**13.3**	**1.6**	**1.6**	**16.5**
Projected Future Rate II	19.0	11.0	432.01	9.5	1.6	0.0	**16.5**	**2.3**	**1.6**	**20.4**
Reduced Pumping										
70% of Current Rate	7.0	23.0	432.69	19.0	3.6	0.2	**7.0**	**0.3**	**1.4**	**8.7**
70% of Projected Future Rate I	10.5	19.5	432.49	16.2	3.0	0.0	**9.8**	**0.9**	**1.6**	**12.3**
70% of Projected Future Rate II	13.3	16.7	432.33	14.0	2.5	0.0	**12.0**	**1.4**	**1.6**	**15.0**

4.0 SPRING RECIRCULATION AND AUGMENTATION MEASURES

Table 3-1 indicates that augmentation measures should be considered after Barton Springs enters 'Critical Drought Stage.' Under the current pumping rate, the estimated augmentation needs for the Main, Eliza, and Old Mill Springs are 13.4, 1.7 and 1.6 cfs, respectively; for as long as the springs remain in the Critical Drought Stage. A total flow augmentation amount is 16.6 cfs and this is assuming that all springs will be augmented rather than the selected ones. If only Eliza and Old Mill Springs, or just Eliza Springs were augmented as an example, then the flow augmentation amount would be reduced significantly down to 1.7 or 3.3 cfs.

Four basic approaches for implementing recirculation and flow augmentation at Barton Springs were considered for the Main, Eliza and Old Mill Springs. They are:

1. Capturing water flowing from the spring system and recirculating the water back through parts of the spring complex and other engineering solutions within the spring complex;
2. Importing surface water to the spring complex, either injecting the water directly into the Barton Springs complex, or injecting the water upstream into Barton Creek;
3. Importing groundwater to be discharged directly into Barton Springs complex or upstream of the springs into Barton Creek; and,
4. A combination of recirculation and augmentation.

In contrast to discharging directly into the spring complex, discharging upstream into Barton Creek would augment all four springs. However, it may be more important, from a biological perspective, to augment water to specific springs rather than to augment all of them. For example, less supplemental water would be needed to augment Old Mill and Eliza Springs than to augment the Main Springs. Accordingly, various flow augmentation options are formulated for the Barton Springs and they are presented in the following sections.

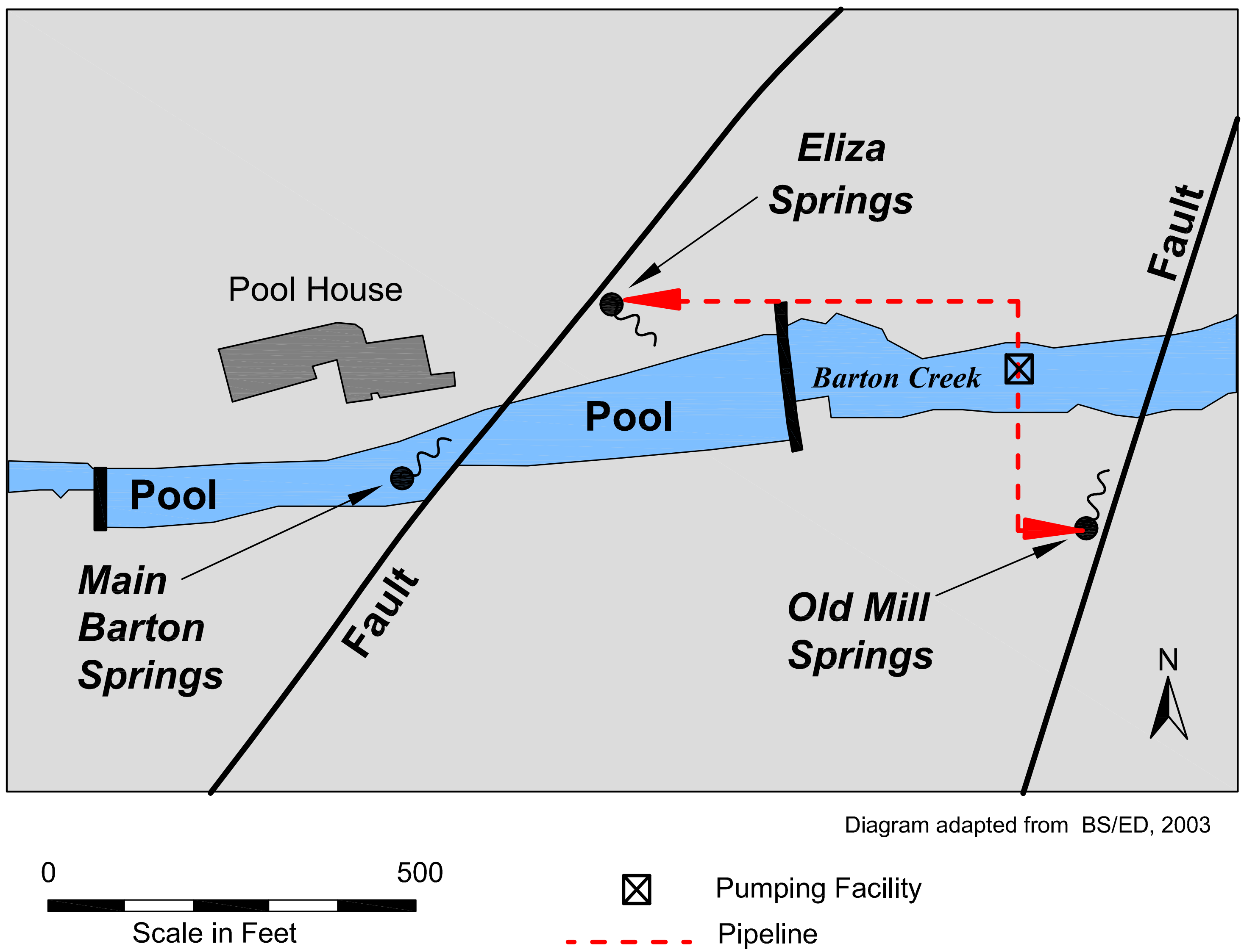
4.1 Recirculation (Option 1)

Based on the results shown in Table 3.1, the Old Mill Springs will go dry first during drought conditions. The total flow in the lower Barton Creek below the Pool outlet dam would be about 14.8 cfs during drought conditions and a portion of that flow (1 to 3 cfs, or 450 to 1,350 gpm) could be used to augment the flows in Old Mill and Eliza Springs, or just the Old Mill only.

Figure 4-1 shows a schematic diagram of a proposed recirculation system. Water would be pumped from lower Barton Creek and recirculated back to Old Mill and Eliza Springs. The same recirculation scheme could be used to augment the flows in the Main Pool by recirculating additional water to the Main Pool. However, the amount of the augmented flow needed to significantly increase discharge from the Main Pool would be many times larger than the needs for the other two springs.

An alternative “engineering” approach might be to raise the water level in the pool. Installing barriers across the sluice gates in the lower dam to raise the pool and aquifer water level, would theoretically raise spring discharges at Eliza and Old Mill Springs, because drained and full pool conditions at Barton Springs definitely show correlations between the three springs, Main, Eliza and Old Mill Springs (Senger and Kreitler, 1983; Slade, 1986). For example, a rise of aquifer water level from 433.18 ft to 433.55 ft, a difference of only 0.37 ft, could increase the discharges of the Main Springs – from 27 cfs to 31.2 cfs, but more importantly increase discharge in the Old Mill Springs – from 1.6 cfs to 2.7 cfs. At low flow it may be more important to get additional water to Eliza Springs even though losing it from the Main Springs.

Recirculation of spring water is a temporary flow augmentation approach. The effectiveness of the spring water recirculation option is limited by how much water is available in the aquifer and how long the aquifer could sustain its water level as it continues to decline during a prolonged drought.



Capturing Barton Creek Flow and Recirculating Directly Back to Spring System

Figure 4-1

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4.2 Importing Water (Options 2 and 3)

Importation of water (Option 2 – surface water; Option 3 – groundwater) is the second major approach considered for maintaining springflow at Barton Springs. Major considerations for importation of water are:

- Volume and quality of water needed;
- Source of imported water; and,
- How the imported water would be recharged into the spring complex.

In order to meet both water supply and ecosystem demand during low flow or drought of record condition, an additional 6 to 26 cfs (for total springflow) will need to be brought in from outside sources. Likely outside sources, including both surface water and groundwater, are addressed in the following section.

4.2.1 Surface Water (Option 2)

Surface water sources being considered are sources currently available or planned within the next five years to serve areas in close proximity to Barton Springs and/or the Recharge Zone.

Candidate surface water sources for importation to Barton Springs are:

- City of Austin water distribution system;
- Town Lake;
- LCRA's U.S. 290 pipeline (a part of the West Travis County Plan); and
- GBRA's San Marcos to Kyle and Buda pipeline.

Meetings and conversations with the City of Austin and LCRA have been conducted as part of this evaluation process. Detailed system and project status and information have been referenced from the 2005 Region K Water Supply Plan (TWDB, 2006a) and Region L Water Supply Plan (TWDB, 2006b), which have recently been adopted by the respective Regional Planning Groups. General source information such as available quantity, corresponding owner concerns and issues for providing the necessary quantity of water will be presented as part of the flow augmentation alternatives in the following sections.

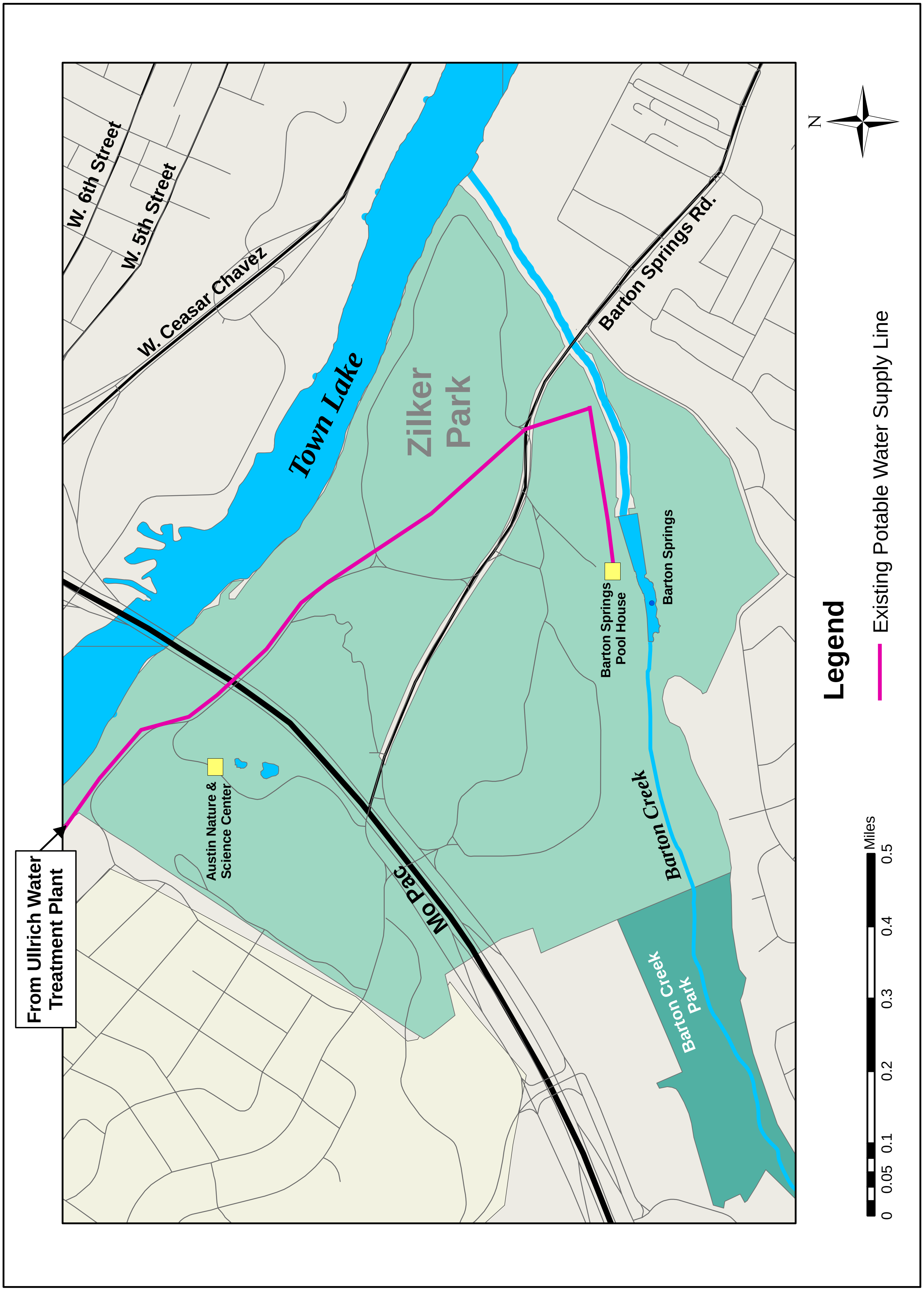
4.2.1.1 City of Austin Water

The City of Austin (COA) has run-of-river water rights to divert and use water from the Colorado River. Hydrologic conditions are such that the full authorized amount of diverted water under their rights would not be available to Austin under all hydrologic conditions, including the drought of record. As a result, the City of Austin has entered into a contract (COA, 1999) with Lower Colorado River Authority (LCRA) to firm up these water rights with water stored in the Highland Lakes.

The City's 1999 water supply agreement with LCRA secures a water supply of 325,000 acre-feet/year (ac-ft/yr) for the City. Under this agreement, the LCRA has agreed to firm up the COA's run-of-river rights with stored water in the Highland Lakes. The COA has pre-purchased a portion of this water under the contract and will not pay LCRA further for water used until the COA's water use exceeds 201,000 ac-ft/yr for two years in a row, at which point it will incur an additional annual cost for municipal diversions in excess of 150,000 acre-ft/year. The COA has experienced significant growth within its water service area and anticipates that this growth will continue in the future. Therefore, water conservation, reuse, and the deferring of the diversion of water under its contract with LCRA are major management and planning policies of the Austin Water Utility. The COA would therefore have additional concerns in supplying Barton Springs flow augmentation water if such supply would count toward the 201,000 acre-ft/year diversion payment trigger level in the 1999 Agreement.

Existing COA Potable Water Supply

An eight-inch pipeline, along Stratford Drive, northwest of the springs, delivers water from the Ullrich Water Treatment Plant to Zilker Park (Figure 4-2). The Park is in the COA's water distribution system's Central Pressure Zone (which typically operates in a hydraulic gradeline range of 720 – 790 ft., in that vicinity). This line delivers potable water to the Barton Springs Pool and the Bath House. There is currently no other significant demand placed on this line. A water distribution system simulation indicates that about 1,000 gpm or about 1.5 cfs (with water pressure at 20 psi, simulating emergency or fire flow conditions) of treated potable water may be available at the pool. Field verification would be necessary to confirm this estimate.



Importing Exisiting City of Austin Potable Water Supply

Figure 4-2

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The feasibility of using highly treated drinking water to augment flow in Barton Springs is unknown, as the need for augmentation would likely occur at the same time that the City's potable drinking water system would be stressed from dry, hot conditions. There would also be water quality and compatibility issues with regard to salamander tolerance of treated water. A non-chlorinated water supply probably would be needed. If water from the City's distribution line were used for flow augmentation, it most likely would be used only in emergency flow conditions.

Treated COA Wastewater Effluent

A major component of the City's water conservation program is the use of non-potable water supplies (reclaimed water) for irrigation in place of potable water. The COA has identified a large concentration of irrigation demands for parkland surrounding Town Lake. Under current policy, the COA has temporarily transferred 1,000 ac-ft/yr of raw water allocated for municipal use to irrigation uses in this area. Long-range planning for the area includes the construction of reclaimed water lines to supply these irrigation needs in place of the use of either potable or raw water, both of which count toward the 201,000 ac-ft/yr diversion payment trigger level in the 1999 Agreement.

Treated wastewater effluent could be considered for Barton Springs flow augmentation purpose, however, water quality concerns about use of reclaimed water over the aquifer recharge zone have been raised. The Austin Water Utility (AWU) has identified potential customers in the Barton Creek Watershed and in the Edwards Aquifer Recharge Zone. However, out of concerns of inadvertently introducing reclaimed water into the aquifer, the AWU has decided not to pursue customers in that area. As a result, currently there is neither a reclaimed water pipeline nor a near term plan that would make this source of water available to the Barton Springs area.

4.2.1.2 LCRA Water

From LCRA's perspective, raw water from Town Lake, even if withdrawn for ecosystem use such as flow augmentation for Barton Springs, would not be considered as a non-consumption use and would thus be considered a diversion under existing water rights. The LCRA, however, has expressed interest in protecting Barton Springs and willingness to consider alternatives for using water under its rights for Barton Springs flow augmentation. It has suggested that the District provide a proposed augmentation plan to the LCRA Board outlining the proposed LCRA role (especially where needed facilities are already in place). The LCRA has requested that the proposed augmentation (salamander protection) plan should include at least the following information:

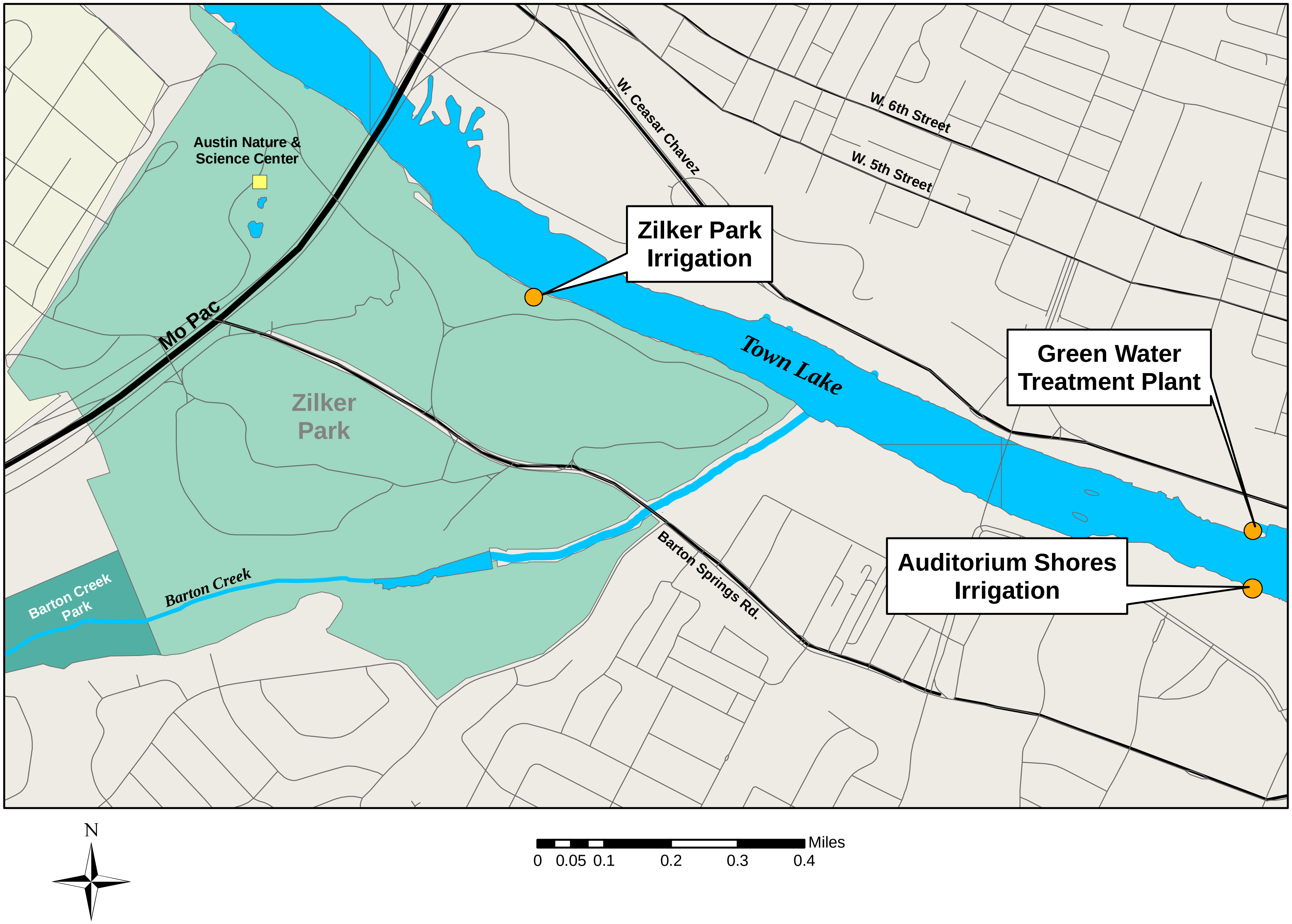
- Amount of water needed;
- When the water will be needed;
- LCRA role as part of a regional solution, (e.g. involving regional entities such as LCRA, COA, and District); and,
- A conjunctive water use plan.

Raw Water Supply from Town Lake

There are currently several raw water supply systems along Town Lake that supply raw water to several users (Figure 4-3), including the Seaholm Power Plant, the Green Water Treatment Plant, Auditorium Shores Irrigation, the Lions Municipal Golf Course, and Zilker Park (APAI, 2002). Raw water from Town Lake has been used primarily for steam electric cooling and irrigation water use. Town Lake water is characterized by high temperature, pH, chloride, and nutrients and algal bloom issues, and may be less than an ideal water source for flow augmentation to Barton Springs.

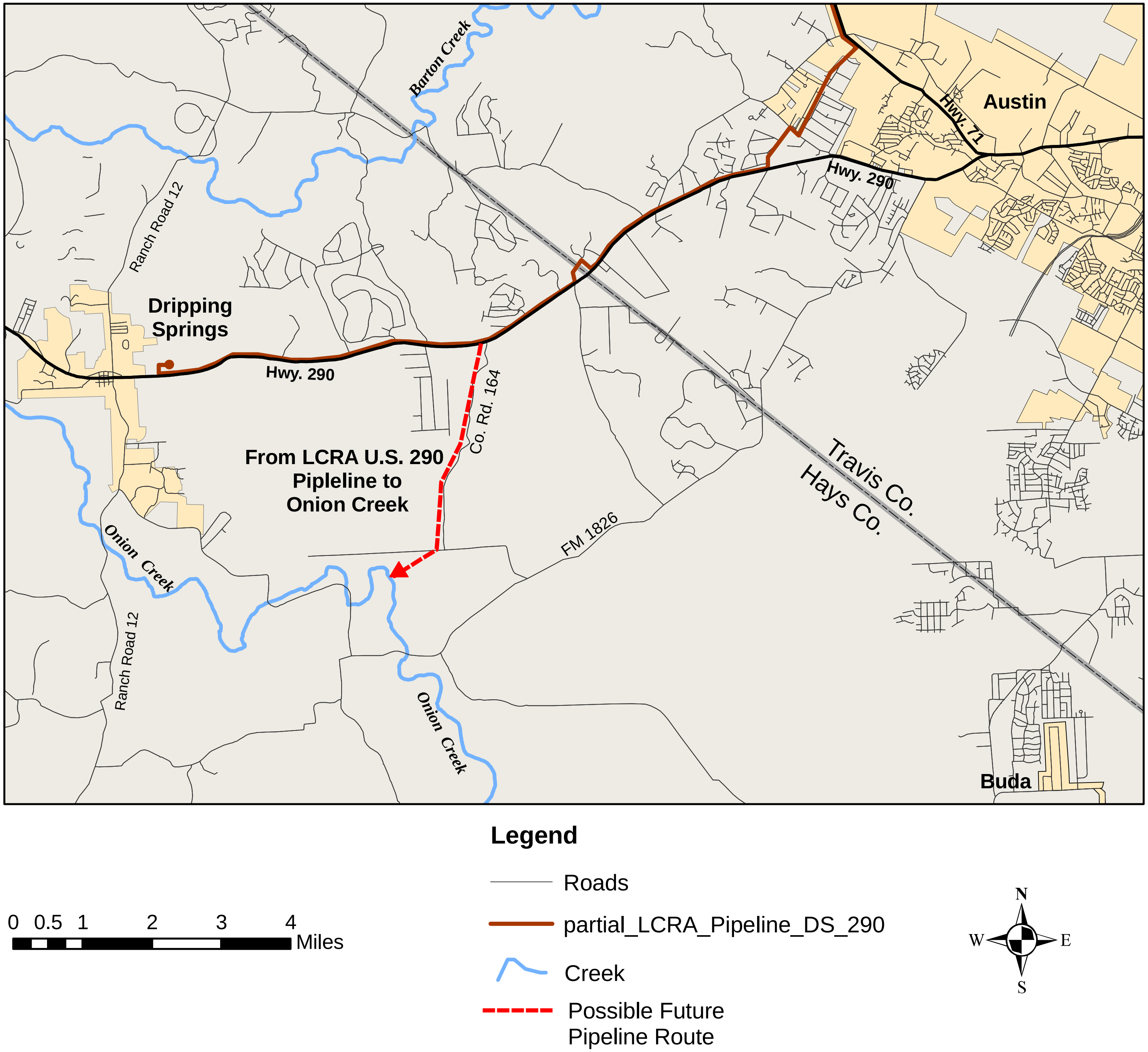
LCRA's U.S. 290 Water Supply Pipeline

LCRA's U.S.290 water supply pipeline (Figure 4-4), built in easements alongside U.S. Highway 290, is a 15-mile water transmission line and pump system that conveys treated water from the LCRA's West Travis County Regional Water System at the Village of Bee Cave to western Travis County and northern Hays County. With improvements to the water treatment plant, the water line has the current capacity to serve about 10,000 households. The capacity has increased from 8 to 10 million gallons per day (MGD), or about 10,000 ac-ft/yr.



Importing Raw Water from Town Lake

Figure 4-3



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Importing Potable Water Supply from Existing LCRA's U.S. Hwy. 290 Pipeline in West Travis County Supply System

Figure 4-4

Water service from the U.S. 290 water line began in 2002. A little less than half of the line's capacity is available for developments that existed in May 2000. So far, about 180 households in the Sunset Canyon subdivision have connected to the line. The LCRA also has a contract to provide the Dripping Springs Water Supply Corporation with enough water for 1,100 households.

The water line's remaining capacity is available for new developments that have obtained written authorization from the U.S. Fish and Wildlife Service (USFWS). The USFWS has authorized seven developments that would add about 6,000 households to the water service area over a number of years. The LCRA Board has approved water service agreements for all of the developments. The current supply system has an available supply of 6 MGD (about 10 cfs), about equal to the present pumpage demand in the Barton Springs Edwards Aquifer Conservation District.

The price of the LCRA water in 2006 was $115 per ac-ft and is expected to increase to $135 per ac-ft in the next few years. Customers must pay a reservation fee of 50% of the water rate times the contract amount every year whether one takes less than 50% of the contracted amount of water or not.

Water from the LCRA U.S. 290 pipeline could be used to augment Barton Springs flow in two ways: a) discharge water into Upper Onion Creek and therefore continuously recharge the aquifer, or b) provide water to current Edwards groundwater users and reduce the current pumping demands in the Barton Springs Segment of the Aquifer. For these options, pumping permits would have to be reduced or limited for conversion to LCRA surface water to be effective.

4.2.1.3 GBRA's San Marcos to Kyle and Buda Pipeline

Hays County has begun to experience rapid growth as Austin continues to expand. Currently, groundwater is the primary source of water for Hays County residents. The groundwater supplies in Hays County (TWDB, 2006b) are presently showing signs of stress as a result of this intense growth. Therefore, a strategy involving the transfer of surface water from the Guadalupe-Blanco River Authority (GBRA) system to Eastern Hays County was identified and evaluated in the Region L Water Supply Plan.

The GBRA and the City of San Marcos have previously constructed a regional raw water transmission system and a regional surface water treatment plant near San Marcos. The GBRA is currently proceeding with a treated water transmission pipeline along the I-35 corridor which will extend to Buda. This project is already underway with completion anticipated in late 2005.

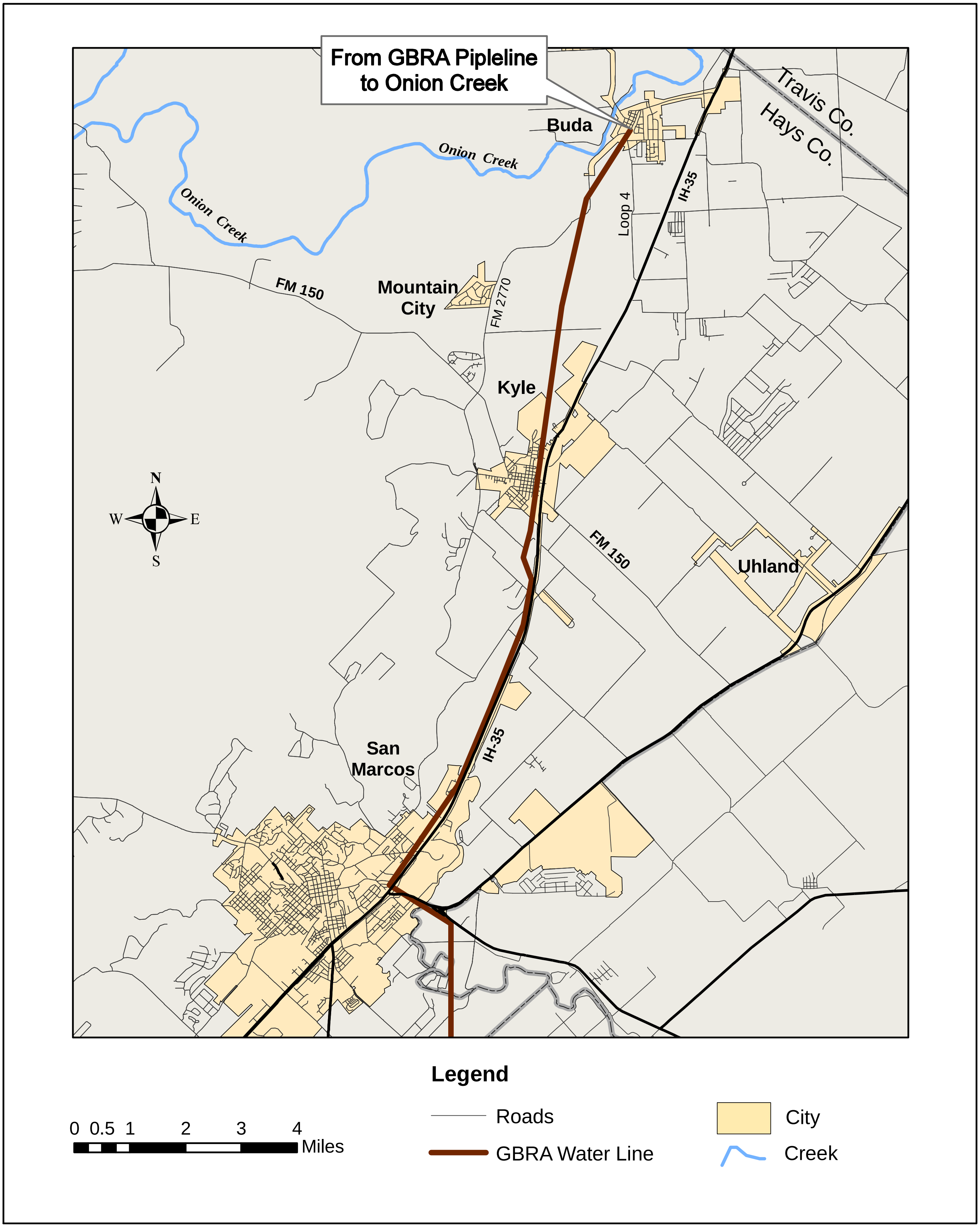
The City of Buda has an existing commitment with GBRA for 1,120 ac-ft/yr of treated water from this pipeline. There is an additional 1,680 ac-ft/yr of treated water available through this line which is allocated to the Region K portion of Hays County. Total yield of the line to the Region K entities is estimated at approximately 2,800 ac-ft/yr through 2050, increasing slightly to 2, 982 ac-ft/yr in 2060 to meet an increased need in Buda. This equates to approximately 2.2 million gallons per day through 2050 and 2.3 million gallons per day in 2060. This system (Figure 4-5) could provide up to 4 to 5 cfs flow to Barton Springs, directly through recharge to Onion Creek or indirectly by swapping with the present pumpage.

System participants would be required to assume their pro-rata share of the debt retirement obligations for the raw water delivery system. Additional capacity at the treatment plant, treated water transmission mains approximately 20 miles in length, and a new booster station are currently under contract (TWDB, 2006b). The transmission main will range in size from 12 to 30 inches and would run generally parallel to IH-35. The system is designed to provide average day base flow with recipients providing peak day needs through their existing supplies.

4.2.2 Groundwater (Option 3)

Groundwater sources considered in this analysis are aquifers adjoining the Barton Springs Segment of the Edwards Aquifer, candidate groundwater sources for importing to Barton Springs are:

- Colorado River Alluvium Aquifer (in Town Lake)
- Rollingwood Segment of the Edwards Aquifer



Importing Potable Water Supply From Existing GBRA's San Marcos To Kyle-Buda Pipeline **Figure 4-5**

The above aquifers appear to be hydrogeologically independent of the Barton Springs section of the Edwards aquifer. Currently, wells have been developed from both parts of the aquifers. TWDB well database (TWDB, 2006c) in a Travis County quadrant (1 mile by 1 mile) provided information on wells located in the Barton Springs area. All existing wells, mostly COA wells, produce less than 500 gpm (1.1 cfs). Some representative wells or springs in these two aquifers are:

Colorado River Alluvium Aquifer	Rollingwood Segment of the Edwards Aquifer
• Deep Eddy Pool Wells • Auditorium Shore Wells	• Cold Springs • Wells in the Austin Nature and Science Center (ANSC)

4.2.2.1 Deep Eddy Pool Wells

Deep Eddy Pool wells provide water for the City-owned Deep Eddy swimming pool. They are two Rainey (radial – horizontal) wells from the Colorado River Alluvium located near Town Lake, on Lake Austin and Deep Eddy Ave. One is located downstream of the Deep Eddy pool, about 100 to 150' from Town Lake and the other is upstream of the pool, about 40' from the Lake. The water temperature of the well closer to the lake fluctuates around 75F during the summer months, and the other well has a water temperature between 68-72F (Nelson, personal communication). The water quality data from the TWDB (TWDB, 2006c) well database also show signs that the water in these wells is primarily from Town Lake.

Both wells have an average of 300 gallons per minute (0.7 cfs) production capacity and a maximum of 400 gallons per minute (0.9 cfs). These wells are already in full production providing water to the swimming pool, however, they could provide an emergency source of water for Barton Springs augmentation.

4.2.2.2 Auditorium Shore Wells

The COA's Auditorium Shore wells listed in the TWDB well database (TWDB, 2006c) are shallow wells, with depth less than 50 ft, located east of the Barton Springs pool, that once withdrew water from the Colorado River Alluvium Aquifer. The wells' capacities were in the order of 500 to 750 gallons per minute (0.7 to 1.0 cfs). The water chemistry is predominately influenced by the lake water. These wells were supplying irrigation water for the park area but they are currently plugged due to old age. During emergency they could be considered as sources of water for Barton Springs augmentation.

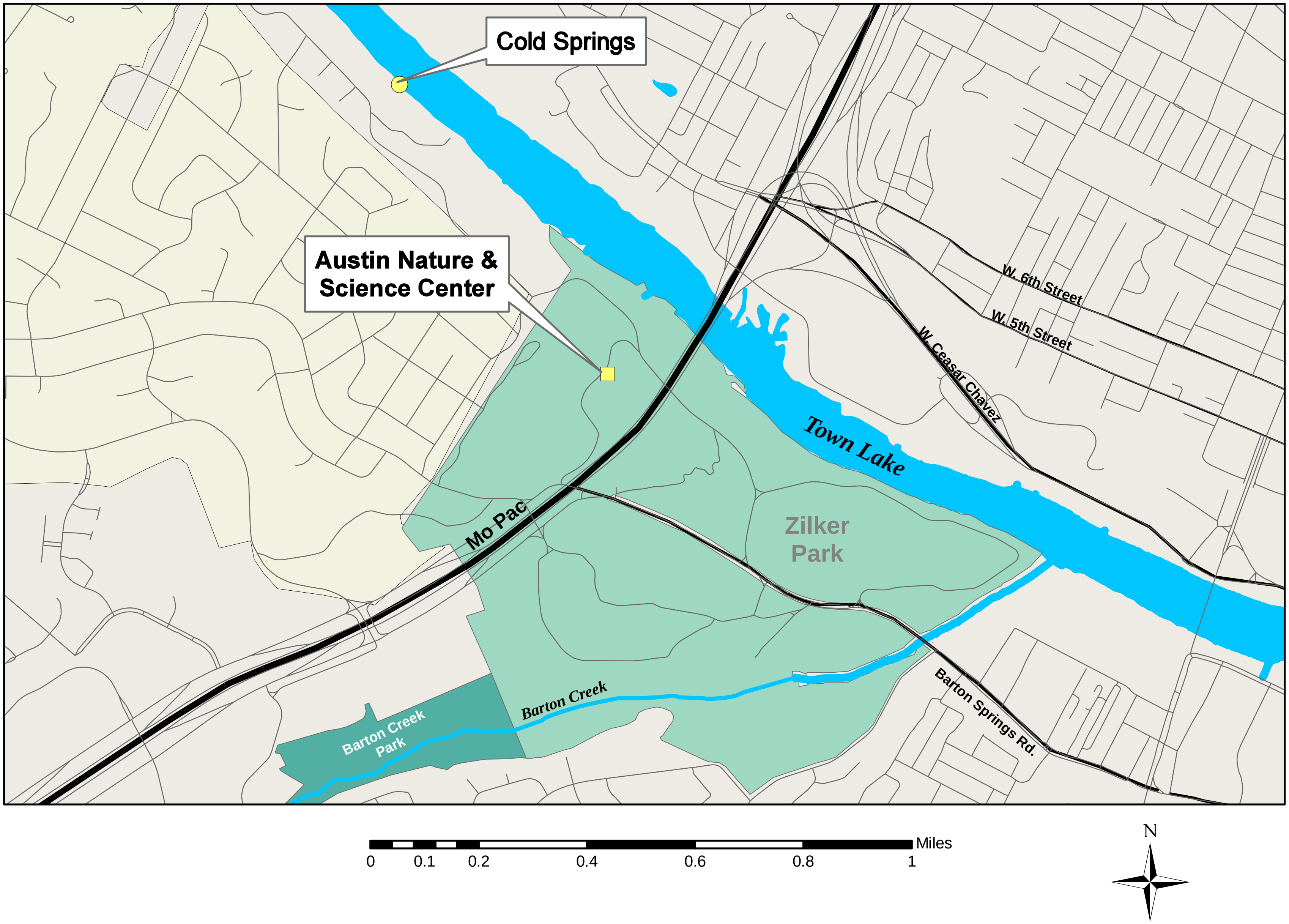
4.2.2.3 Cold Springs

Additional springs with small discharges are present along Town Lake. The largest of these is Cold Springs (Figure 4-6), which is located on the south bank of the Colorado River about 1.5 miles upstream of the mouth of Barton Creek. Cold Springs is fed by conduit flows in the Rollingwood portion of the Edwards Aquifer on the west side of the MoPac (Loop1). Measurements of springflow from Cold Springs are limited and imprecise but range from 2.6 to 6.8 cfs (Brune, 2002; Hauwert et al, 2005). The Cold Springs conduit can produce 15 cfs normally and 2 to 3 cfs in a drought (Hauwert, 2005).

4.2.2.4 Austin Nature and Science Center Wells

Wells serving the Austin Nature and Science Center (ANSC) are deep wells similar to other Edwards wells. They withdraw water from the Rollingwood portion of the Edwards Aquifer. These wells are located on the ANSC, less than a mile from the Barton pool. The ANSC is located in Zilker Park next to the eighty-acre Zilker Preserve.

Water from these two wells is currently feeding two ponds, one of which is a salamander rearing pond maintained by the City. Prior to entrance into the rearing pond, the water is filtered for the removal of organic compounds. There is no additional capacity in these wells.



Importing Groundwater from Cold Springs and New Wells in Zilker Park, East of the Austin Nature and Science Center

Figure 4-6

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4.2.2.5 New Wells in Zilker Park, East of ANSC

City staff has suggested that there is a potential well site in Zilker Park just east of the ANSC (Figure 4-6) (Johns, Personal Communication). The suggested site is mapped to be in the Rollingwood portion of the Edwards Aquifer and appears to have greater aquifer thickness than the ANSC wells and would be closer to Barton Springs pool. A well would need to be drilled, constructed and tested to quantify the well capacity and water quality.

In summary,

- Both the Colorado Alluvium in Town Lake and the Rollingwood section of the Edwards Aquifers could provide additional groundwater to the Barton Springs during low flow or drought periods.
- The Rollingwood portion of the Edwards groundwater is colder (already being used in the salamander rearing pond) and has a better water quality than the Colorado Alluvium water along Town Lake.

During low flow or drought period, the available augmentation water from the Rollingwood section of the Edwards Aquifer is estimated to be in the range of 2 to 3 cfs (Hauwert, Personal Communication). Additional studies, drilling and testing a well at this location are needed to confirm the actual well capacity and the compatibility with the water in Barton Springs.

Table 4-1 summarizes the flow augmentation alternatives.

Each of the alternatives has been further developed with conceptual engineering requirements, probable cost, and noted water quality and management concerns. This information is presented in Table 4-2.

Table 4-1. SUMMARY OF RECIRCULATION AND AUGMENTATION ALTERNATIVES FOR BARTON SPRINGS

Source and Owner of Supplemental Water		**Quantity of Water Available during Drought Conditions**
Option 1 - Recirculation		
Adding Barriers Across the Sluice to Raise Water Level	No supplement water necessary	N/A
Barton Springs Discharges	Springflows in lower Barton Creek immediately downstream of the Pool Outlet	2 to 3 cfs
Option 2 - Surface Water		
City of Austin Water		
Existing Potable Water Supply	An existing 8 inch distribution line from Ullrich WTP to Zilker Park	1.5 cfs
Treated Effluent	Reclaimed Water Distribution Lines	Treated wastewater effluent currently is not available
LCRA Water		
Raw Water Supply	Town Lake	43 cfs (31,000 ac-ft/yr)
Existing Potable Water	U.S. 290 pipeline in West Travis County Water Supply System	Current - 10 cfs (7 MGD); Future - 543 cfs (350 MGD) @78 cfs (50 MGD) / stage
GBRA Water		
Existing Potable Water	San Marcos to Kyle/Buda pipeline	Current - 4 to 5 cfs (3 MGD)
Option 3 - Groundwater		
Existing Wells		
Deep Eddy Pool Well	Colorado River Alluvium	No available capacity
Auditorium Shore Well	Colorado River Alluvium	Well has been plugged
Austin Nature and Science Center Wells	Rollingwood Segment of Edwards	No available capacity
Others		
Cold Springs	Rollingwood Segment of Edwards	2 to 3 cfs
New Well Site		
Zilker Park, East of Austin Nature and Science Center	Rollingwood Segment of Edwards	Unknown, but likely production from a high yield wells, > 2 to 3 cfs

Table 4-2. SUMMARY OF CONCEPTUAL ENGINEERING REQUIREMENTS FOR RECIRCULATION AND AUGMENTATION ALTERNATIVES FOR BARTON SPRINGS

Alternative Measures	Quantity of Water Used in Severe Drought Conditions	Conceptual Engineering	Probable Level of Capital Cost
Option 1 - Recirculation			
Adding Barriers Across Sluice Gates at the Main Pool's Outlet Dam to raise water level	N/A	Install **barrier boards** or **inflatable dams** at the pool outlet	$50,000
Capturing Barton Creek Flow and Recirculate Back to Springs Complex Directly	3 cfs	**Pumping the water** from lower Barton Creek and **piping** it to the Old Mill, or Eliza Springs	$500,000
Option 2 - Surface Water			
Importing Existing City of Austin Potable Water Supply	1.5 cfs	**Piping the water** from the existing distribution line through **dechlorination** to the Barton Springs	< $500,000
Importing Raw Water from Town Lake	2 to 20 cfs	**Pumping** the water out of the lake via existing intake (e.g. Green WTP) or new skid mounted pump facilities, **water treatment**, and then **piping** it to the Springs using as much Green WTP facilities as possible	> $1 million
Importing Potable Water Supply from Existing LCRA's U.S. 290 Pipeline in West Travis County Water Supply System	5 cfs	**Piping** the water from the existing water line and **recharging** it to upper Onion Creek (may need **dechlorination)** or replace the pumping demands in the Barton Springs watershed	> $5 millions
Importing Potable Water Supply from Existing GBRA's San Marcos to Kyle/Buda Pipeline	5 cfs	**Piping** the water from the existing water line and **recharging** it to upper Onion Creek (may need **dechlorination**) or replace the pumping demands in the Barton Springs watershed	> $5 millions
Option 3 - Groundwater			
Importing Groundwater from Cold Springs	3 cfs	**Pumping** the water from the springs and then **piping** it to Barton Springs (about a mile from the pool)	< $500,000
Importing Groundwater from a New Well in Zilker Park, East of Austin Nature and Science Center	3 cfs	**Production from a new well** and then **piping** the water to the springs (about a mile from the pool)	< $500,000

5.0 CONSTRAINTS EVALUATION

Alternative measures identified in Table 4-2, could provide varying degrees of flow to Barton Springs during severe drought conditions. None of the alternatives are considered to have any fatal flaws based on conceptual engineering. However, probable costs to implement these measures and other noted requirements, considerations and concerns, listed in Table 5-1, need to be addressed.

Table 5-1. NOTED REQUIREMENTS, CONSIDERATIONS, AND CONCERNS FOR ALTERNATIVE MEASURES

Alternative Measures	Noted Requirements, Considerations and Concerns
Option 1 - Recirculation	
Adding Barriers Across Sluice Gates at the Main Pool's Outlet Dam to Raise Water Level	Available for emergency use, temperature and water chemistry similar to spring discharge
Capturing Barton Creek Flow and Recirculate Back to Springs Complex Directly	Available for emergency use, temperature and water chemistry similar to spring discharge
Option 2 - Surface Water	
Importing Existing City of Austin Potable Water Supply	Dechlorination, available for emergency use, and compatibility of spring's water chemistry, and temperature
Importing Raw Water from Town Lake	Water rights issues, compatibility with spring's water chemistry, temperature, nutrients, total dissolved solids (TDS)
Importing Potable Water Supply from Existing LCRA's U.S. 290 Pipeline in West Travis County Water Supply System	Dechlorination, compatibility with spring's water chemistry, temperature, alternate existing and future demands for water
Importing Potable Water Supply from Existing GBRA's San Marcos to Kyle/Buda Pipeline	Dechlorination, compatibility with spring's water chemistry, temperature, alternate existing and future demands for water
Option 3 - Groundwater	
Importing Groundwater from Cold Springs	Springs are submerged under Town Lake and may have water right issues
Importing Groundwater from a New Well in Zilker Park, East of Austin Nature and Science Center	Further study and exploration

The alternative measures were compared by their implementation constraints. Listed below are the constraint categories used for the evaluation and comparison:

- Cost (dollars per yield);
- Political, Institutional and Legal Issues;
- Impact to Downstream Surface Water;
- Impact to Downstream Groundwater; and
- Public Acceptance

For each constraint a three-tier rating, low (L), medium (M), and high (H), was used. For the first four constraints, the range of scores for each tier is: 7 to 10 for low, 4 to 6 for medium, and 1 to 3 for high. For the 'Public Acceptance' constraint, the range of scores is reversed, where 7 to 10 for high, 4 to 6 for medium, and 1 to 3 for low. Table 5-2 gives the results of the constraints evaluation that shows the rating (L, M, or H) for each constraint category, the total score and the ranking of the alternative measures.

Table 5-2. CONSTRAINTS RATING AND RANKING OF RECIRCULATION AND FLOW AUGMENTATION MEASURES

Alternative Measures	Ranking	Total Scores	Cost ($ per Yield)		Political/Institutional/Legal Issues		Impacts to Downstream Flows		Impacts to Adjacent Wells		Public Acceptance	
			Scoring:		L (7 to10)						H (7 to 10)	
					M (4 to 6)						M (4 to 6)	
					H (1 to 3)						L (1 to 3)	
Adding Barriers Across Sluice Gates at Main Pool's Outlet Dam to Raise Water Level	1	48	L	9	L	9	L	10	L	10	H	10
Capturing Barton Creek Flow and Recirculate Back to Springs Complex Directly	2	41	L	8	L	8	M	7	L	9	H	9
Importing Groundwater from a New Well in Zilker Park, East of Austin Nature and Science Center	3	40	L	7	L	9	L	9	M	6	H	9
Importing Existing City of Austin Potable Water Supply	4	37	M	5	H	3	L	10	L	10	H	9
Capturing Barton Creek Flow and Injecting to Upstream Recharge Zone	5	34	M	5	M	6	M	6	L	8	H	9
Importing Groundwater from Cold Springs	6	31	L	8	M	6	M	6	M	6	M	5
Importing Raw Water from Town Lake	7	26	M	5	H	3	H	2	L	10	M	6
Importing Potable Water Supply from Existing LCRA's U.S. 290 Pipeline in West Travis County Water Supply System	8	24	H	1	M	5	M	6	L	9	L	3
Importing Potable Water Supply from Existing GBRA's San Marcos to Kyle/Buda Pipeline	9	24	H	1	M	5	M	6	L	9	L	3

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APPENDIX D

Groundwater Quality Data

Appendix D
Groundwater Quality Data

The following Tables D-1 through D-5 summarize water quality data collected and compiled by the U.S. Geological Survey as part of Barton Springs Water Characterization Project (USGS 2007). Figures D-1 through D-5 summarize changes in water quality components including discharge, temperature, DO, specific conductance, and turbidity for a 31-day period from February 10, 2007 through March 13, 2007. This time period is characterized by generally dry conditions that contain two substantial rainfall events that occurred in mid-February and March 11-13. During the latter rainfall event, 3 to 4 inches of precipitation fell over the Barton Creek Watershed during a 24-hour period.

Table D-1. Pesticide concentrations in main Barton Spring

	Description Parameter					
Collection Date	Atrazine (µg/L) (3 µg/L)	Deethylatrazine (µg/L)	Carbanyl (µg/L)	Diazinon (µg/L)	Prometon (µg/L)	Simazine (µg/L) (4 µg/L)
8/6/2003	< 0.007	E 0.005	< 0.041	< 0.005	< 0.01	< 0.005
8/20/2003	< 0.007	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
9/3/2003	E 0.006	E 0.006	< 0.041	< 0.005	< 0.01	< 0.005
9/16/2003	0.013	E 0.006	< 0.041	< 0.005	< 0.01	< 0.005
9/30/2003	E 0.006	E 0.004	< 0.041	< 0.005	< 0.01	< 0.005
6/21/2004	0.019	< 0.006	< 0.041	< 0.005	< 0.01	E 0.005
7/7/2004	0.017	< 0.006	< 0.041	< 0.005	< 0.01	< 0.01
7/21/2004	0.011	< 0.006	< 0.041	< 0.005	< 0.01	0.007
8/4/2004	0.011	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
8/25/2004	0.01	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
9/15/2004	0.012	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
10/4/2004	0.013	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
10/23/2004	< 0.01	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
10/24/2004	0.068	< 0.006	< 0.041	< 0.005	M	0.019
10/25/2004	0.07	< 0.006	< 0.041	< 0.005	E 0.01	0.026
10/26/2004	0.053	< 0.006	< 0.041	< 0.005	< 0.01	0.015
10/27/2004	0.024	< 0.006	< 0.041	< 0.005	E 0.01	0.009
10/28/2004	0.017	< 0.006	< 0.041	< 0.005	E 0.01	0.008
10/30/2004	0.014	< 0.006	< 0.041	< 0.005	< 0.01	0.008
11/5/2004	0.018	< 0.006	< 0.041	< 0.005	< 0.01	< 0.01
11/24/2004	0.021	< 0.006	< 0.041	< 0.005	< 0.01	0.015
12/14/2004	< 0.007	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
1/3/2005	E 0.005	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
1/26/2005	E 0.004	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
2/16/2005	E 0.005	< 0.006	< 0.041	< 0.005	< 0.01	0.009
3/9/2005	0.037	< 0.006	< 0.041	< 0.005	< 0.01	< 0.015
3/30/2005	0.017	< 0.006	< 0.041	< 0.005	< 0.01	E 0.004
4/20/2005	0.009	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
5/11/2005	0.021	< 0.006	< 0.041	< 0.005	< 0.01	E 0.002
5/30/2005	0.013	< 0.006	< 0.041	< 0.005	M	E 0.004
5/31/2005	0.036	< 0.006	< 0.041	< 0.005	< 0.01	E 0.003
6/1/2005	0.03	< 0.006	< 0.041	< 0.005	< 0.01	E 0.003
6/2/2005	0.044	< 0.006	< 0.041	< 0.005	< 0.01	E 0.003
6/4/2005	0.026	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005
6/6/2005	0.017	< 0.006	< 0.041	< 0.005	< 0.01	E 0.003
6/9/2005	0.012	< 0.006	< 0.041	< 0.005	< 0.01	< 0.005

***Maximum Contaminant Level, if applicable; E = Estimated, <= Less than**
Source: USGS (2007)

Table D-2. Volatile organic compound concentrations in main Barton Spring

Parameter Description (units) (MCL)								
Collection Date	1,1,1 Trichloro-ethane (µg/L) (200 µg/L)	Acetone (µg/L)	Bromo-dichloro-methane (µg/L) (80 µg/L)	Carbon disulfide (µg/L) (80 µg/L)	Chloroform (µg/L)	Tetrachloro-ethylene (µg/L) (5 µg/L)	Toluene (µg/L) (1,000 µg/L)	Trichloro-ethylene (µg/L) (5 µg/L)
8/6/2003	E 0.01	< 7	< 0.05	< 0.07	E 0.04	E 0.04	< 0.05	< 0.04
8/20/2003	< 0.03	< 7	< 0.05	< 0.07	E 0.07	E 0.06	< 0.05	< 0.04
9/3/2003	< 0.03	< 7	< 0.05	< 0.07	E 0.04	E 0.06	< 0.05	< 0.04
9/16/2003	< 0.03	< 7	< 0.05	< 0.07	E 0.07	0.18	< 0.05	E 0.01
9/30/2003	< 0.03	< 7	< 0.05	< 0.07	E 0.05	E 0.06	< 0.05	< 0.04
6/21/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.25	< 0.05	E 0.02
7/7/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.29	< 0.05	E 0.03
7/21/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.11	< 0.05	< 0.04
8/4/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.08	E 0.08	< 0.05	< 0.04
8/25/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.06	E 0.09	< 0.05	< 0.04
9/15/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.24	< 0.05	E 0.01
10/4/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.13	< 0.02	< 0.04
10/23/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	E 0.06	< 0.02	< 0.04
10/24/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.21	< 0.02	< 0.04
10/25/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.18	< 0.02	< 0.04
10/26/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.15	< 0.02	< 0.04
10/27/2004	< 0.03	< 6	< 0.03	E 0.03	E 0.04	0.11	< 0.02	< 0.04
10/28/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.04	0.12	< 0.02	< 0.04
10/30/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.03	E 0.1	< 0.02	< 0.04
11/5/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.12	< 0.02	< 0.04
11/24/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.8	< 0.02	E 0.04
12/14/2004	< 0.03	< 6	< 0.03	< 0.04	E 0.04	0.11	< 0.02	< 0.04
1/3/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.04	0.19	< 0.02	E 0.01
1/26/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.03	E 0.1	< 0.02	< 0.04
2/16/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.17	< 0.02	E 0.01
3/9/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.07	0.33	< 0.02	E 0.03
3/30/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.14	< 0.02	E 0.01
4/20/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.11	< 0.02	< 0.04
5/11/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.1	< 0.02	< 0.04
5/30/2005	< 0.03	< 6	< 0.03	E 0.02	E 0.04	0.17	< 0.02	E 0.01
5/31/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.18	< 0.02	E 0.01
6/1/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.15	< 0.02	E 0.01
6/2/2005	< 0.03	< 6	< 0.03	E 0.02	E 0.06	0.19	< 0.02	E 0.01
6/4/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.06	0.12	< 0.02	< 0.04
6/6/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.05	0.11	< 0.02	< 0.04
6/9/2005	< 0.03	< 6	< 0.03	< 0.04	E 0.04	E 0.07	< 0.02	< 0.04

*Maximum Contaminant Level, if applicable; E = Estimated, <= Less than
Source: USGS (2007)

Table D-3. Nitrate Concentrations in Main Barton Springs 2003-2005

Collection Date	Parameter Description (units) nitrogen, nitrite + nitrate (mg/L)
8/6/2003	1.45
8/20/2003	1.47
9/3/2003	1.46
9/16/2003	1.44
9/30/2003	1.5
6/21/2004	1.05
7/7/2004	1.02
7/21/2004	0.958
8/4/2004	1.06
8/25/2004	1.17
9/15/2004	1.31
10/4/2004	1.33
10/23/2004	1.43
10/24/2004	1.38
10/26/2004	0.963
10/27/2004	0.979
10/28/2004	0.967
10/30/2004	0.966
11/5/2004	0.886
11/24/2004	1.65
12/14/2004	1.18
1/3/2005	1.22
1/26/2005	1.2
2/16/2005	1.18
3/9/2005	1.11
3/30/2005	1.18
4/20/2005	1.21
5/11/2005	1.21
5/30/2005	1.31
5/31/2005	1.26
6/1/2005	1.27
6/2/2005	1.11
6/4/2005	1.24
6/6/2005	1.26
6/9/2005	1.29

Source: USGS (2007)

Table D-4. Major Ion Concentrations in Main Barton Springs

Parameter Description (units)									
Collection Date	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	pH, laboratory (pH)	Potassium (mg/L)	Silica (mg/L)	Sodium (mg/L)	Strontium (ug/L)	Sulfate (mg/L)
8/6/2003	84.5	25.7	18.4	7.2	1.3	11.7	14.5	812	27.7
8/20/2003	89.3	25.4	21.7	7.2	1.29	13	14.4	957	27.1
9/3/2003	84.3	26.4	22.4	7.4	1.18	11.8	14.3	1090	27.5
9/16/2003	90.8	26.6	22	7	1.52	11.9	15.7	1220	25.9
9/24/2003	92.5	28.1	23.6	7.4	1.36	11.9	16.8	1290	28.7
9/25/2003	94.1	31.9	24	7.4	1.39	11.9	19.4	1330	29.4
9/30/2003	91.1	27.9	23.8	7.2	1.37	11.9	17.1	1380	28.5
6/21/2004	90.7	25.5	19.5	7	1.4	12.4	14.6	701	33.8
7/7/2004	95.6	23.7	18.8	7.1	1.3	12.2	13.8	563	33.9
7/21/2004	91.4	24.7	20.2	7.1	1.29	12	13.5	666	33
8/4/2004	85.3	23.9	20.7	7.3	1.21	11.7	13.5	736	29.7
8/25/2004	89	23.1	21.8	7.3	1.23	11.7	13.9	827	27.5
9/15/2004	87.6	22.7	22.2	7.2	1.39	12.1	12.8	882	26.6
10/4/2004	90.6	23.7	22.5	7.1	1.35	12.1	14	1000	26.1
10/23/2004	89.4	22.2	23.1	7.2	1.33	12.2	13	1130	25.8
10/24/2004	88.2	16.6	20.1	7.1	1.64	12	10.4	826	23.4
10/25/2004	87.8	16.6	17.6	7.2	1.82	11.8	10.6	686	24.6
10/26/2004	88.5	16.5	17.4	7.2	1.78	11.9	10.9	708	23.4
10/27/2004	90.4	18	18.1	7.2	1.63	11.8	11.5	750	25.3
10/28/2004	89.5	18.2	17.9	7.3	1.61	12.3	11.5	753	26.1
10/30/2004	84.9	19.9	17.9	7.2	1.56	12.1	12.3	754	28.7
11/5/2004	93.8	19.9	18.9	7.2	1.5	12.1	12.4	775	29.2
11/24/2004	95.2	16	12.2	7.1	1.66	12.4	11.1	424	27
12/14/2004	100	20.7	19.9	7.2	1.32	12.6	12.9	631	29.5
1/3/2005	95.3	22.4	20.8	7.1	1.21	11.8	13.8	688	30.1
1/26/2005	97.2	22.3	22.2	7.3	1.26	11.8	13.6	738	29.4
2/16/2005	96	24.1	20.8	7.2	1.21	11.3	13.8	692	32.8
3/9/2005	104	24.8	20.1	7.3	1.28	11.9	15.5	613	35.1
3/30/2005	99.7	24.7	21.3	7.1	1.23	12.3	15.5	676	32.7
4/20/2005	100	24	21.4	7.2	1.34	11.9	15	703	29.1
5/11/2005	94.5	22.5	21.5	7.2	1.2	12.2	13.6	689	27.9
5/30/2005	94.3	21.1	22.4	7.2	1.31	13	13.4	716	27
5/31/2005	90.5	20.3	21.5	7.2	1.36	12.3	13.6	678	26.5
6/1/2005	91.7	20.8	21.9	7.2	1.35	12.6	14.1	697	27.3
6/2/2005	89.4	20.8	21	7.2	1.37	12.7	13.3	680	26.7
6/4/2005	93.3	21.7	22.1	7.2	1.33	12.3	13.2	716	27.7
6/6/2005	93.2	21.9	22.4	7.2	1.3	12.4	13	719	27.7
6/9/2005	87.6	22	22.1	7.2	1.26	12.7	12.9	709	27.7
6/28/2005	92	22.3	23.4	7.4	1.24	12	12.7	749	27.2
7/5/2005	92.7	21.8	22.2	7.3	1.17	12	12.9	779	26.7
7/14/2005	94.5	22.2	23.1	7.5	1.19	11.9	13.4	810	26.6
7/20/2005	93.3	21.8	21.8	7.3	1.22	12	13.2	789	26.4
8/3/2005	86	21.5	21.6	7.3	1.19	11.5	14.2	821	26.6
8/17/2005	88.3	23.7	21.2	7.3	1.19	12.2	13.6	832	26.2

Source: USGS (2007)

Table D-5. Trace metals concentrations in Main Barton Springs, 2003

Collection Date	Parameter Description (units) (MCL)/(AL)*						
	Arsenic (µg/L) (MCL = 10 µg/L)	Cadmium (µg/L) (MCL = 5 µg/L)	Chromium (µg/L) (MCL = 100 µg/L)	Copper (µg/L) (AL = 1.3 µg/L)	Lead (µg/L) (AL = 15 µg/L)	Nickel (µg/L)	Zinc (µg/L)
8/6/2003	0.4	< 0.04	< 0.8	0.6	< 0.08	1.94	E 1
8/20/2003	0.4	< 0.04	< 0.8	0.4	< 0.08	3.12	< 1
9/3/2003	0.4	< 0.04	< 0.8	0.8	< 0.08	1.16	E 0.5
9/16/2003	0.4	< 0.04	< 0.8	0.6	< 0.08	0.58	< 1
9/30/2003	0.5	< 0.04	< 0.8	0.4	< 0.08	1.08	< 1

* Maximum Contaminant Level or Action Level, depending on relevancy; E = Estimated, < = Less than

Source: USGS (2007)

Figure D-1. Discharge of Barton Springs during the period February 10 through March 13, 2007 (USGS 2007)

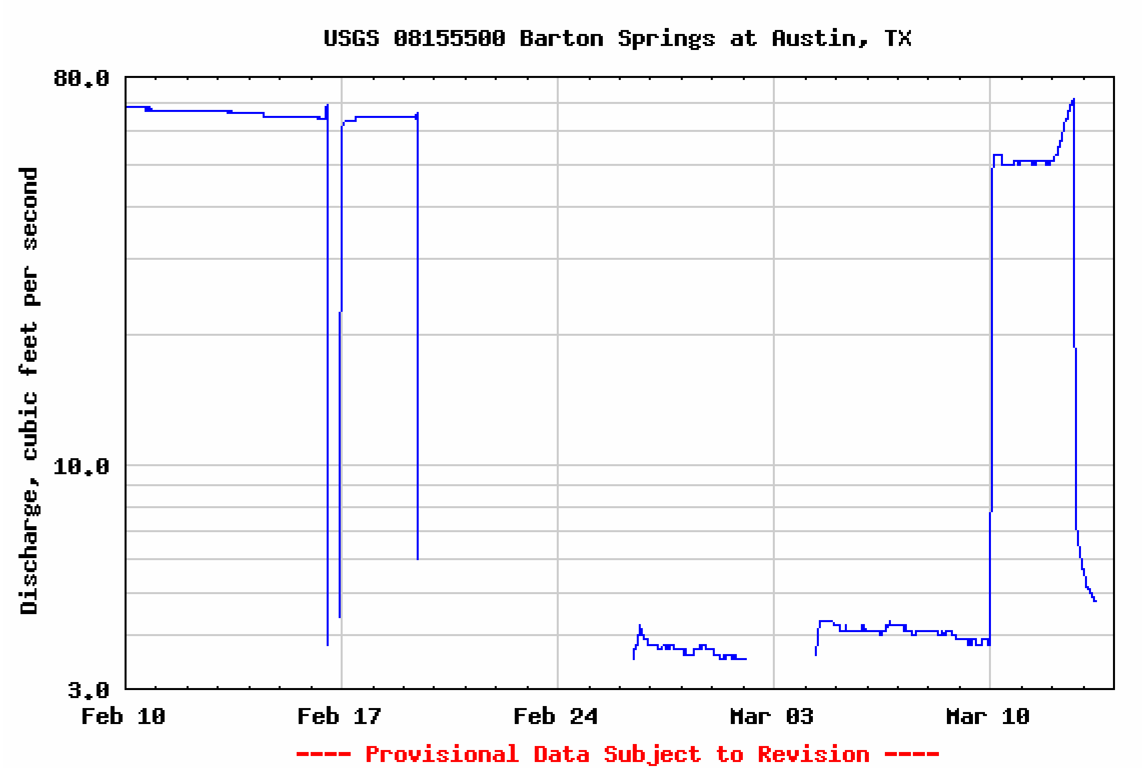


Figure D-2. Temperature at Barton Springs during the period February 10 through March 13, 2007 (USGS 2007)

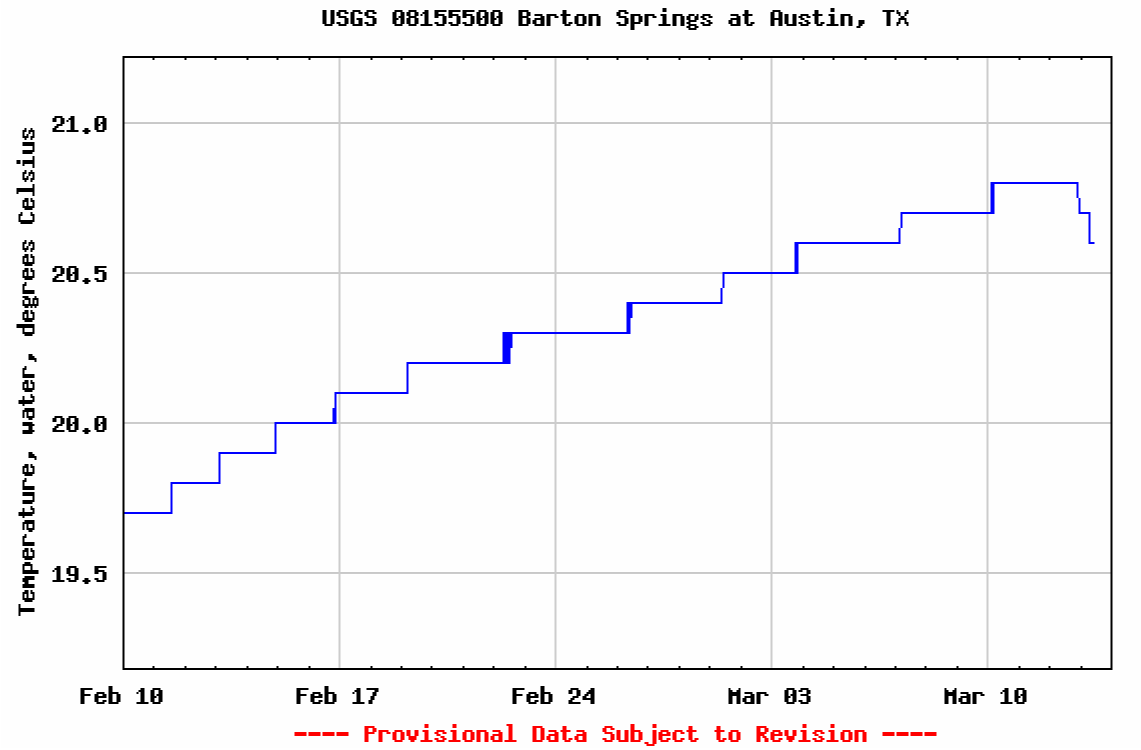


Figure D-3. Specific conductance at Barton Springs during the period February 10 through March 13, 2007 (USGS 2007)

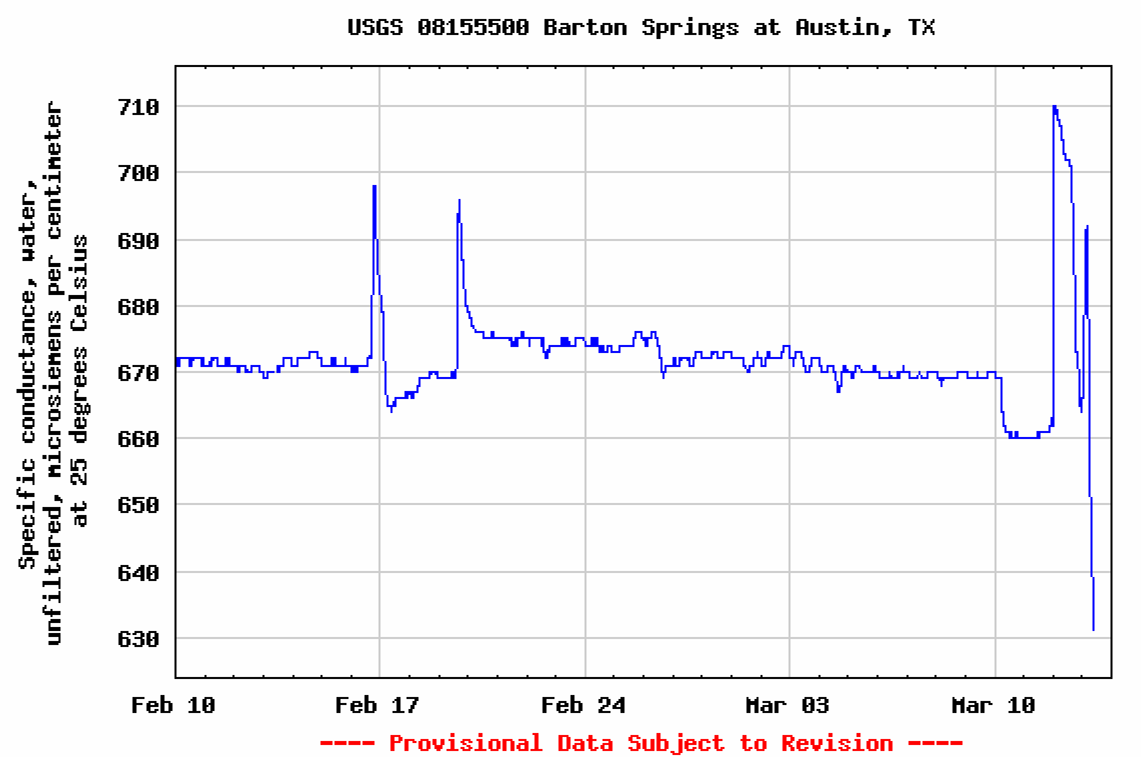


Figure D-4. Dissolved oxygen at Barton Springs during the period February 10 through March 13, 2007 (USGS 2007)

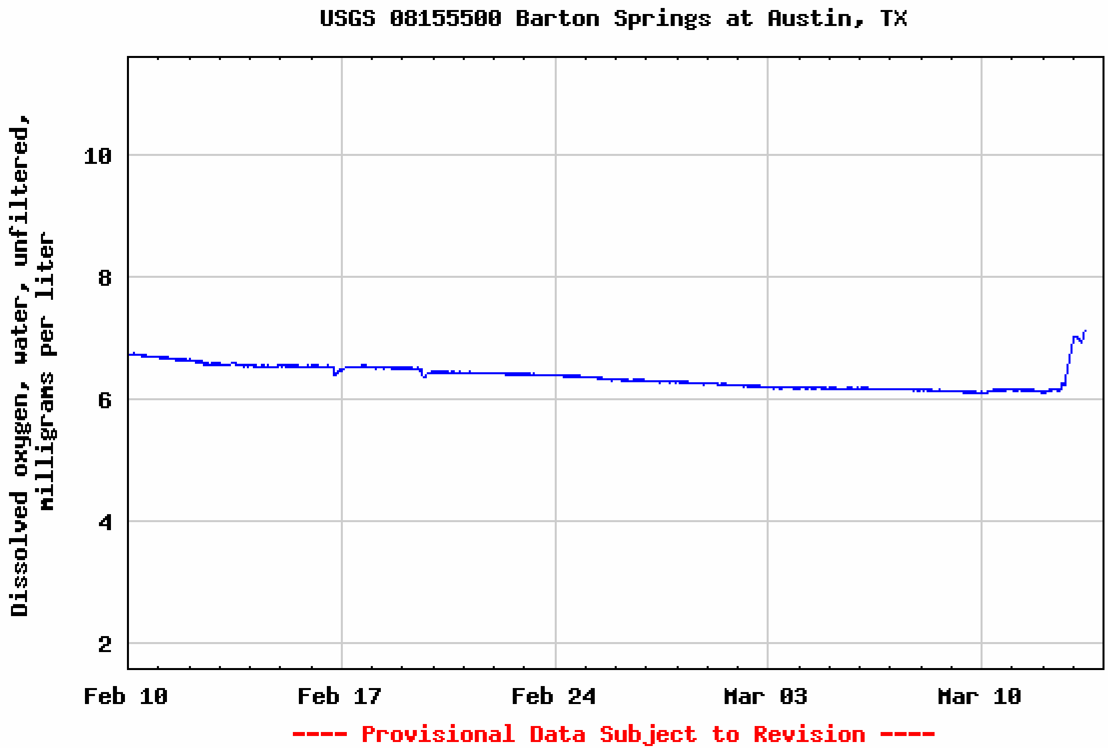
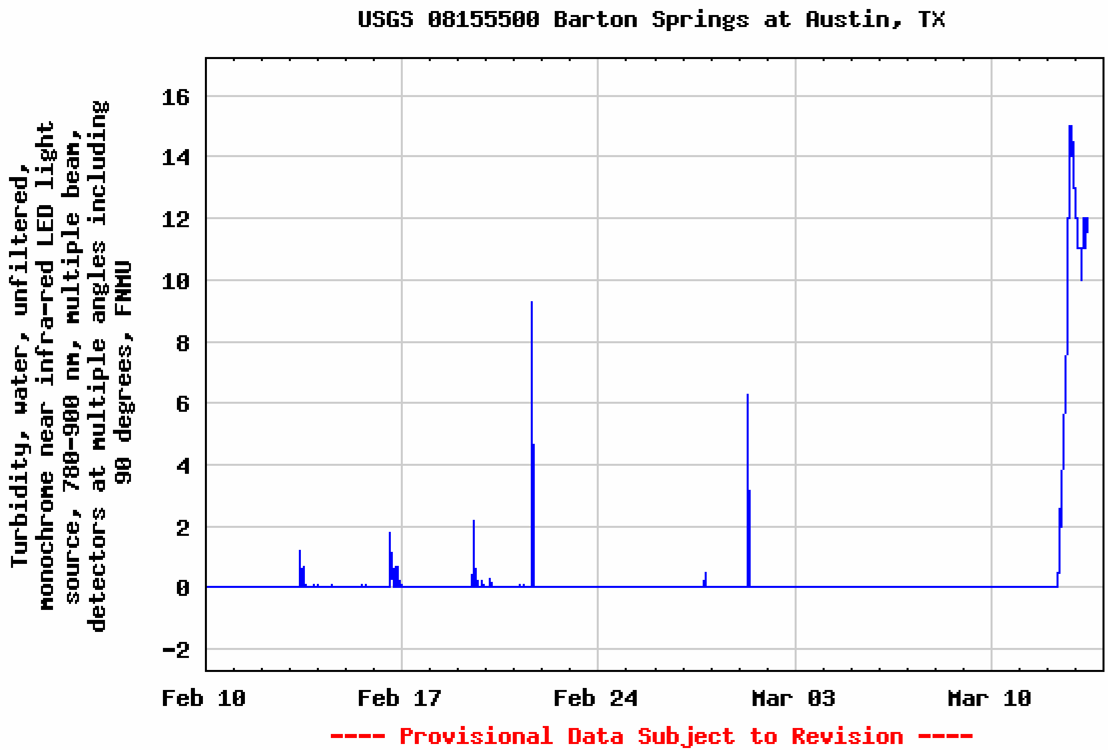


Figure D-5. Turbidity at Barton Springs during the period February 10 through March 13, 2007 (USGS 2007)



Reference

U.S. Geological Survey

2007 Barton Springs Water Characterization Project. Prepared in cooperation with the Texas Commission on Environmental Quality. http://tx.usgs.gov/aquifer/projects/bartonsprings/data.html, accessed March 13, 2007.

APPENDIX E

Groundwater Quality Management and Planning Efforts in the HCP Planning Area

Appendix E
Groundwater Quality Management and Planning Efforts in the HCP Planning Area

E.1 Edwards Aquifer Protection Program

The Edwards Aquifer was designated as a sole source aquifer, and TCEQ promulgated rules regulating development activity in the Edwards Aquifer recharge, transition, and contributing zones (30 TAC Chapter 213). Subchapter A applies to all regulated activities (defined as construction-related or post-construction activity) within the recharge zone, to certain activities within the surrounding transition zone that stretches along the eastern and southern boundary of the recharge zone, and to other activities that may potentially contaminate the aquifer and hydrologically connected surface streams. Persons or entities subject to the rules must submit an Edwards Aquifer protection plan to the TCEQ prior to certain types of construction in the recharge or transition zones of the Edwards Aquifer. The plan must include a geological assessment report identifying pathways for movement of contaminants to the aquifer and a report on BMPs and measures to prevent and abate pollution of the aquifer. After the plan is approved, notice must also be filed in the county deed records that the property is subject to an approved Edwards Aquifer protection plan. Certain facilities are also prohibited from being built in the recharge or transition zones, such as Type 1 municipal solid waste landfills and waste disposal wells; direct discharge of wastewater to streams in the recharge (but not contributing) zone is also prohibited.

30 TAC Chapter 213 Subchapter B applies to regulated activities in the Edwards Aquifer contributing zone. All activities that disturb the ground or alter a site’s topographic, geologic, or existing recharge characteristics are subject to regulation, which would require either sediment and erosion controls or a Contributing Zone Plan to protect water quality during and after construction. Exemptions include construction of single-family residences on lots larger than five acres where no more than one single-family residence is located on each lot; agricultural activities; oil and gas exploration, development, and

production; clearing of vegetation without soil disturbance; and maintenance of existing structures not involving additional site disturbance.

E.2 U.S. Fish and Wildlife Service Concurrence on Optional Enhanced Measures for the Protection of Water Quality in the Edwards Aquifer

In February, 2005, the USFWS and the TCEQ entered into a joint agreement (TCEQ 2005e) with regard to a set of development guidelines for the Edwards Aquifer Protection Program. In a letter to Governor Rick Perry, the USFWS notified the State of Texas that the federal government will recognize that new, optional water quality measures serve to protect certain federally listed endangered species, including the Barton Springs salamander, if voluntarily implemented in developments over the Edwards Aquifer (USFWS 2005c). The letter further stated that non-federal landowners using these practices would have the USFWS support that no "take" under the ESA would occur provided certain conditions are met (USFWS 2005c).

E.3 U.S. Fish and Wildlife Service Recovery Plan for the Barton Springs Salamander (*Eurycea sosorum*)

The Final Rule listing the Barton Springs Salamander as endangered (62 FR 23377-23392) identified the primary threats or reasons for listing as "the degradation of the quality and quantity of water that feeds Barton Springs" as a result of urban expansion over the watershed. The restricted range of this species makes it vulnerable to both acute and chronic groundwater contamination. These threats could result in the "destruction, modification, or curtailment of the species habitat or range" through "chronic degradation, catastrophic hazardous materials spills, increased water withdrawals from the aquifer, and impacts to the surface habitat." The USFWS has completed a Recovery Plan for the Barton Springs salamander (USFWS 2005) that addresses water quality and quantity concerns for the species.

The Final Rule listing the salamander identifies a comprehensive regional plan as a means to protect the Barton Springs salamander from the above-mentioned threats. Although such a plan had not been developed at the time the Recovery Plan was completed, certain state and local entities, including the City of Austin (COA), have taken actions to protect the salamander and its habitat, such as adopting water quality protection ordinances and acquiring thousands of acres of open space in the Barton Springs watershed.

The goal of the Recovery Plan is to ensure the long-term viability of the Barton Springs salamander in the wild, allowing initially for reclassification to threatened status and, ultimately, recovery of the species to a point where it is a secure, self-sustaining component of its ecosystem, so that the protections of the ESA of 1973, as amended, are no longer necessary.

According to the Recovery Plan, the Barton Springs salamander should be considered for reclassification when:

(1) the Barton Springs watershed is sufficiently protected to maintain adequate water quality (including sediment quality) and ensure the long-term survival of the Barton Springs salamander in its natural environment;

(2) a plan is implemented to avoid, respond to, and remediate hazardous material spills within the Barton Springs watershed such that the risk of harm to the Barton Springs salamander is insignificant;

(3) an aquifer management plan is implemented to ensure adequate water quantity in the Barton Springs watershed and natural springflow at the four spring outlets that comprise Barton Springs;

(4) a healthy, self-sustaining natural population of Barton Springs salamanders is maintained;

(5) surface management measures to remove local threats to the Barton Springs ecosystem have been implemented; and

(6) genetically representative captive breeding populations have been established, and a contingency plan is in place to ensure the survival of the species should a catastrophic event destroy the wild population.

The Recovery Plan identified five recovery strategies for the species:

(1) Protect water quality (including sediment quality) within the Barton Springs watershed;

(2) Sustain adequate water quantity at Barton Springs;

(3) Manage surface habitat at Barton Springs;

(4) Maintain a captive population of Barton Springs salamanders for research and restoration purposes; and

(5) Develop and implement an education and outreach plan.

With a concerted effort to meet all of the recovery criteria, including full cooperation of all partners needed to achieve recovery, the Recovery Plan envisions that reclassifying the status of the species from endangered to threatened could be met within ten years, and delisting could be accomplished within ten years following reclassification.

The Recovery Plan identifies the District as the relevant entity to establish pumping limits that should be an integral part of an aquifer management plan. The Recovery Plan concludes that groundwater pumping from the Barton Springs segment of the Edwards Aquifer should be limited, particularly during drought, when pumping should be reduced by aquifer management such that springflow at Barton Springs does not drop below that level which would support the long term survival of the Barton Springs salamander in its natural environment. According to this plan, aquifer management should ensure that natural springflows are continuous at Main Springs, Eliza Springs, and Sunken Gardens Springs even in the most severe drought, and that flows should not fall below the historic low flow of 10 cfs, as measured by the USGS for all four sites combined. However, the Recovery Plan does not address the statutory, legal, and institutional constraints on reducing pumping for such purposes.

The Recovery Plan also recommends that the District develop a Proposed Habitat Conservation Plan that would identify the effects of groundwater pumping on the Barton Springs and Austin blind salamanders and would include measures to avoid, minimize, and mitigate for those impacts resulting from permitted groundwater pumping. The Recovery Plan noted that the District staff would collaborate with experts and various agencies to develop an HCP that addresses the needs of the salamanders, groundwater demands and sustainability, and includes appropriate planning and aquifer management strategies needed to protect the Barton Springs and Austin blind salamanders from degradation of water quantity.

E.4 Local Groundwater Quality Programs

Local municipalities, especially the COA, have also imposed aquifer protection requirements. The COA has imposed watershed ordinances to require development standards for erosion and sedimentation control, impervious cover limits, stream or creek setback requirements and water quality control within its boundaries and extraterritorial jurisdiction (COA, 2005a; Land development restrictions instituted by the COA are codified in the Austin City Code, Title 25, “Land Development”).

The COA is a home-rule city that derives its land use control and development authority from the Texas Constitution. That authority is articulated in the City Charter that stipulates that development must conform to a comprehensive plan (COA 2005a, 2005b).

Comprehensive plans integrate social, economic and environmental planning into a framework to which zoning and subdivision ordinances must conform. The COA's current comprehensive plan, known as the Austin Tomorrow Plan (1979), articulated many of the city’s watershed protection goals. The COA protects water quality through the Land Development Code (LDC) that governs zoning, subdivision and the site plan process. The city's watershed protection ordinances are codified, particularly in those sections of the LDC that address subdivision and site plan (COA 2005a).

Although the COA does not use zoning expressly for water quality purposes, the reduced density or impervious cover percentage requirements for various zoning districts may in fact provide water quality benefits. Subdivision regulations have become one of the most important regulatory tools that cities possess and have historically governed the division of land into two or more separate parcels for future sale or use. Projects that require subdivision or site plan approvals must comply with the COA's watershed ordinances. These ordinances have evolved over time to: 1) reflect current understanding of water quality and stormwater hydrology and 2) cover all 45 watersheds within the city's planning area, either wholly or in part.

The COA has adopted fewer than 10 watershed ordinances since 1980. These include: Lake Austin, Lake Austin Peninsula, Barton Creek, Williamson Creek, Lower Watersheds, Comprehensive, Interim, Composite, and Save Our Springs Ordinance. Several of those ordinances have been amended on more than one occasion. The following descriptions are intended only to highlight the major watershed ordinances and may include discussions of: impervious cover, density, transfer of impervious cover or development rights, stormwater treatment and detention requirements, construction site management and stream setbacks or buffer zones.

The Lake Austin Watershed Ordinance (LAWO) was adopted permanently in January 1980 and represents the COA's first major attempt to address water quality degradation in the face of increasing urbanization. Key features of the ordinance included: slope based impervious cover limits of up to 30 percent that were eventually raised to a maximum of 80 percent with transfers, a provision for water quality and quantity structural controls when minimum ordinance standards were not met and a requirement for an erosion/sedimentation control plan prior to subdivision application approval. It should be noted that all of the city’s watershed ordinances include provisions for an erosion/sedimentation control plan. The LAWO did not require stream setbacks or buffer zones. The ordinance did, however, prohibit building sites within the 100-year floodplain of any creek or tributary in the watershed. The District HCP Planning Area is not subject to LAWO.

The Barton Creek Watershed Ordinance (BCWO) was passed in 1980 and represented a significant departure from the LAWO. Key features of the ordinance included: impervious cover limits capped at 35 percent for commercial and multi-family development, and the use of density limits that varied with the location of the development. The BCWO did not require water control structures, nor did it provide a mechanism whereby an applicant could increase impervious cover using alternate methods. This ordinance relied entirely on non-structural water quality controls and introduced stream set-back requirements that created five water quality zones with enumerated development restrictions for each one. The ordinance also provided incentives (increased density) for the transfer of development rights that included the conveyance of land in the critical water quality zone, for water quality protection, to the city as parkland.

The Williamson Creek Watershed Ordinance (WCWO) applied to that part of Williamson Creek crossing the recharge zone and was passed in December 1980. The WCWO included a requirement for stormwater treatment, a departure from previous ordinances. Key features of the ordinance included: impervious cover limits for single- and two-family homes of 40 percent and limits of up to 65 percent for commercial and multi-family developments, the use of stream setbacks based on the present concept of major, intermediate and minor waterways and the inclusion of a critical water quality zone that was to remain free of all but certain types of development.

The Lower Watersheds Ordinance (LWO) was adopted in 1981 and extended water quality protection into the Slaughter, Bear, Little Bear, and Onion Creek watersheds. The LWO resembles the WCWO in many ways, except that it reduces impervious cover allowances for commercial development to 40 percent and 55 percent with transfers, and for residential development, reduces it to 30 percent and 40 percent with transfers. The LWO introduced a water quality buffer zone, and set impervious cover limits of up to 18 percent and 15 percent, respectively, for single-family and commercial development in this zone.

The Comprehensive Watersheds Ordinance (CWO) was adopted in 1986, superceded previous watershed ordinances, and extended water quality protection throughout the COA's planning area to all but the urban watersheds. While similar in some respects to its predecessors, the CWO contained a number of significant innovations. For the first time, watersheds that do not provide a portion of our drinking water received significant water quality protection. The CWO was also the first ordinance to use net site area (NSA) impervious cover calculations instead of calculations based on gross site area (GSA). GSA includes the entire site, while NSA requirements include only a site's buildable areas and can reduce overall impervious cover. The ordinance included other firsts too, such as the designation of critical environmental features and provisions for their protection. The CWO also began to organize watersheds into groups based on their relationship to 1) the city's water supply, in particular Lake Austin, 2) the Barton Springs Edwards Aquifer recharge zone and to some extent the Northern Edwards Aquifer, and 3) the degree of urbanization within a watershed, i.e. urban, suburban, or rural.

The SOS Ordinance was adopted in 1992 and differed from its predecessors because it became law by citizen initiative. Two ordinances worth noting preceded the SOS Ordinance: the Interim and Composite Ordinance. These ordinances addressed development in the Barton Springs Zone, which includes Barton Creek and the other creeks draining to, or crossing, the Edwards Aquifer recharge zone. Highlights of these ordinances included: the first requirements for non-degradation (based on stormwater discharge concentrations) and provisions that excluded variances, unless a demonstrable improvement in water quality was shown. Variances, which made departures from an ordinance permissible, were a general feature of watershed ordinances up until this time.

The SOS Ordinance, applied throughout the Barton Springs Zone, required: non-degradation (based on total average annual loading), reduced impervious cover to 15-percent NSA for all development in the recharge zone, 20-percent NSA for development in the Barton Creek portion of the contributing zone, and 25-percent NSA for development in the remaining portions of the contributing zone in Williamson, Slaughter, Bear, Little Bear, and Onion Creeks.

The SOS Ordinance has withstood a number of legal challenges. Efforts to protect water quality in Austin and throughout Texas are still beset by a State law that provides "grandfathering" of some developments from current regulations. The most recent enactment of this state law was as House Bill 1704 by the 76th legislature. H.B. 1704 is the culmination of previous legislation that essentially freezes regulations on the date the first permit application is filed until the project is complete.

While no major watershed ordinances have been passed since the SOS ordinance, other efforts that may result in new ordinances or ordinance amendments include the city's Smart Growth initiative, an effort to reshape urban and suburban growth so that it will enhance our communities, strengthen the economy, and protect the environment. Akin to earlier comprehensive planning efforts, Smart Growth concepts were originally described by the Citizen's Planning Committee beginning in late 1994. An important Smart Growth principle is the city's division into Drinking Water Protection and Desired Development Zones. This division is a reflection of the sensitivity of watersheds that are located over, or adjacent to, the Barton Springs Edwards Aquifer recharge zone or that supply water to Lake Austin. Smart Growth initiatives seek to direct growth away from these areas into less environmentally sensitive areas, while at the same time seeking LDC amendments and policy changes that will protect or enhance watershed water quality throughout Austin.

The *Environmental Criteria Manual* (COA 2005a) is the fifth volume in Series One of the City of Austin’s Development Criteria Manuals. The rules contained in the manual apply to tracts of land within the corporate limits of the COA and its extraterritorial jurisdictional areas as defined in the Austin City Code. The rules are designed, intended and are to be administered in a manner to not contravene the provisions of the Austin

City Code and to promote uniformity, clarity and stability in the application of development regulations.

The rules have been promulgated to administer and implement the technical criteria necessary to accomplish the environmental protection and management goals of the Austin City Code. The guidelines and design criteria presented in this manual address the issues of water quality management, landscaping, preservation of trees and natural areas, the underground storage of hazardous materials and construction activity in city parks.

The City of Austin Watershed Protection and Development Review Department collects water, sediment and other samples throughout the Austin area, including Barton Springs Pool. City of Austin staff has collected water quality information from Barton Springs Pool since 1986 for a variety of different parameters. The Water Resource Evaluation (WRE) Section of the City of Austin collects and stores environmental quality data from throughout the local area. More than 42,000 samples of water, sediment, and biological data collected by City Staff at over 1,100 sites in the Austin area are currently stored in the Water Resource Information System (WRIS) database (COA 2005b).

The LCRA also has existing water quality protection ordinances applicable to portions of Travis County. The LCRA's regulatory authority derives from the state of Texas. Its responsibility to control pollution of groundwater and surface water extends through 10 counties. LCRA divides its regulatory programs into two general categories: those that deal with land-based activities and those that address the water surface. The land-based activities include the installation and upkeep of septic systems and construction that can result in increased runoff, or nonpoint-source pollution. LCRA oversees the installation and operation of on-site sewage treatment and disposal systems within, in general, 2,200 feet of the Highland Lakes. The OSSF staff reviews plans, issues permits and licenses, and inspects new construction and septic system repairs.

In 1986, LCRA actively supported the state's ban on all pollutant discharges, or point-source pollution, into the Highland Lakes. A construction boom around the Highland Lakes drew attention to nonpoint-source pollution (NPS) issues. LCRA's response was the NPS Program that consists of two ordinances. These ordinances do not limit impervious cover; instead, the program is performance-based. Landowners and developers must show that standards are met before moving forward with projects (LCRA 2005).

On July 25, 2005 the Travis County Commissioners Court adopted interim subdivision rules (Travis County 2005) for the areas outside of municipalities' extra territorial jurisdictions. A small area of the HCP Planning Area along Hamilton Pool Road and Crumley Ranch Road in the southwestern portion of Travis County would be affected by these interim subdivision regulations (if the Barton Creek watershed were to be considered part of the Town Lake watershed). These interim regulations provide for construction and post-construction water quality measures for residential subdivisions exceeding 20 acres and all commercial developments. These provisions include best management practices for stormwater control, stream bank erosion control, buffer zones for environmentally valuable features, protection for recharge features, and permanent water quality control measures to remove variable percentages (based upon three slope categories) of total suspended solids, total phosphorus, oil and grease.

E.5 Regional Water Quality Plan

Rapid growth and development in northern Hays County and southwest Travis County have created concerns about an increasing potential for pollution of groundwater and surface waters. These concerns included not only the impacts to drinking water supplies but to the threatened or endangered species that reside in the area (Naismith Engineering 2005).

In December, 2002, officials of Hays County and the City of Austin convened a Regional Summit to begin discussions on the impacts development was having on the region and particularly to water quality in the Barton Creek Watershed. From this initial effort a Regional Group was established to address the water quality issues facing the area of the Barton Springs segment of the Edwards Aquifer and its contributing zone and the desire to preserve water quality in this area. The Regional Group was comprised of an Executive Committee and Core Committee whose members were made up of representatives from the cities of Dripping Springs, Austin, Buda, Kyle, Rollingwood, Sunset Valley, the Village of Bee Cave; Hays and Travis counties; and the Barton Springs/Edwards Aquifer Conservation District and the Hays Trinity Groundwater Conservation District.

It was determined by the group that there was a need to develop a regional approach to water quality protection within the Barton Creek watershed in order to protect the quality of drinking water and the endangered species in the aquifer and springs ecosystem, particularly the Barton Springs salamander. The group believed that the completion of a regional water quality protection plan would provide the basis for political subdivisions, to the extent allowed by law, to implement local water quality protection plans and ordinances and provide best management practices that could be adopted by local stakeholders for water quality protection.

The planning process used to develop the regional plan was a very public, stakeholder-driven process involving public input in every aspect of the development of the plan. Building consensus as the plan was developed was seen as critical to producing a plan that could be adopted and implemented by local governments and stakeholders. Elements of the planning process included:

- Stakeholder involvement in all phases of development of the Water Quality Protection Plan;

- Identification of the best management practices for the protection of water quality in the area;

- Identification of entities that can implement water quality protection measures within the planning area;

- Development of model ordinances to implement and enforce water quality protection plans for the area; and,

- Development of a consensus-based Water Quality Protection Plan including best management practices, water quality protection strategies and regional planning tools to protect both surface and groundwater quality.

The planning effort was funded by grants from the Lower Colorado River Authority and the TWDB and through in-kind services from many other entities. The planning area is the Barton Springs segment of the Edwards Aquifer and its contributing zone. The area covers northern Hays County, southwest Travis County and a small section of Blanco County. The area includes the cities of Dripping Springs, Austin, West Lake Hills, Buda, Hays City, Kyle, Mountain City, Rollingwood, Sunset Valley, the Villages of Bee Cave and Bear Creek and the areas of the Barton Springs/Edwards Aquifer and Hays Trinity Conservation Districts. This study area comprises a large part of the District HCP Planning Area.

At a meeting of the Executive and Core Committees on June 13, 2005, the following resolution was adopted:

> "The Core Committee of the Regional Water Quality Planning Project for the Barton Springs Segment of the Edwards Aquifer and its Contributing Zone endorses the final draft of the Regional Water Quality Protection Plan, including the amendments dated June 3, 2005, as a framework for adoption of water quality standards by the local governments represented on the Core Committee, recognizing that each has a unique role to play in achieving the regional solution and that it will take more time and a continuing strenuous effort by government and the public to reach the level of water quality protection described in the Plan."

The 2005 document is considered the final version of the plan.

E.6 Barton Springs/Edwards Aquifer Conservation District

The Barton Springs/Edwards Aquifer Conservation District strongly supports a collaborative, cooperative approach to ensuring the availability of aquifer water in sufficient quantity and quality to meet all uses (Kirk Holland, General Manager, BS/EACD, personal communication). These uses include high-quality drinking water supply (including the sole source for several tens of thousands of citizens), critical ecological habitat of many plant and animal species (including some that are threatened or endangered), and an iconic recreational and aesthetic resource. The District believes that it is vital to the protection and enhancement of the uses of the Barton Springs Segment that a regional, multi-agency approach be used for planning, studying and evaluating effects, impacts, and mitigation strategies, and also for coordinating among regulatory programs.

As noted above, a consensus plan, the "Regional Water Quality Protection Plan for the Barton Springs Segment of the Edwards Aquifer and its Contributing Zone" (Naismith Engineering 2005) has been developed to provide the basis for the implementation of needed measures. The District participated in developing the regional plan and supports not only its consensus-building approach but also its conclusions and recommendations, as a balanced, scientifically sound, and politically acceptable plan to protect uses of the aquifer. The District considers all sponsors and stakeholder groups involved in creating the plan as cooperating entities that will now use the plan as a guide for action.

The District is concerned about all impacts on the Edwards Aquifer water system, whether related to quantity or quality. It fully understands the interest possible impacts evoke in various stakeholder groups and the not unreasonable concerns of interested parties that possible effects might prove to be actual effects, and that postulated impacts (i.e., consequences) of those effects might prove to be not just potential but real, adverse, or even irreversible or irretrievable. These effects are, however, currently uncertain and this ongoing HCP study is designed to better assess the impacts of low aquifer water-level conditions, springflow and corresponding water quality conditions that are unequivocally and directly related to the current flow regime, even apart from other, possible man-made stresses. The District considers the HCP as a necessary and reasonable step in evaluating existing conditions and the efficacy and consequences of structural and non-structural mechanisms that affect flow quantity and quality.

Specific programs that are underway at the District and are intended to improve groundwater management in the long term include: (1) the Drought Management Plan; (2) the well permits program; (3) conservation and education programs; (4) groundwater availability model formulation; and (5) major work elements of the USFWS grant to develop the Draft HCP/PDEIS.

These studies and programs will also establish a scientific baseline for gauging the necessity for, and scope of, other studies, identified in Chapter 6: The District Habitat Conservation Plan, that might be required, either by the District itself or in association with (or by) other entities to further evaluate degradation. The District will continue to provide leadership in a rational, systematic, regionalized initiative to address the use, conservation, protection, and enhancement of the segment's ground water resource and the uses dependent on it.

E.7 Other Municipalities

The Cities of Buda, Sunset Valley, Dripping Springs and the Village of Bee Caves have water quality protection ordinances. The City of Sunset Valley has very strong aquifer-related regulations, and most importantly, the City of Dripping Springs has subdivision and site development watershed ordinances that cover more than 100 square miles of the HCP Planning Area.

APPENDIX F

Species Endemic to the Edwards Aquifer Region and Associated Springs and Karst Ecosystems

Appendix F
Species Endemic to the Edwards Aquifer Region and Associated Springs and Karst Ecosystems

Common Name	Scientific Name	USFWS Status	TPWD Status
AQUATIC ECOSYSTEMS			
Southern Segment			
Comal Springs dryopid beetle	*Stygoparnus comalensis*	E	
Comal Springs riffle beetle	*Heterelmis comalensis*	E	
Ezell's Cave amphipod	*Stygobromus flagellatus*		
Horseshoe liptooth (snail)	*Daedalochila hippocrepis*		
Mimic cavesnail	*Phreatodrobia imitata*		
Peck's Cave amphipod	*Stygobromus pecki*	E	E
San Marcos saddle-case caddisfly	*Protoptila arca*		
Texas Cave diving beetle	*Haideoporus texanus*		
Texas Cave shrimp	*Palaemonetes antrorum*		
Blanco River Springs salamander	*Eurycea pteraphila*		
Comal blind salamander	*Eurycea tridentifera*		T
Comal Springs salamander	*Eurycea sp. 8*		
Robust (=Blanco) blind salamander	*Eurycea robusta*		T
San Marcos salamander	*Eurycea nana*	T	T
Texas blind salamander	*Eurycea rathbuni*	E	E
Texas salamander	*Eurycea neotenes*		
Fountain darter	*Etheostoma fonticola*	E	E
San Marcos gambusia	*Gambusia georgei*	E	E
Toothless blindcat	*Trogloglanis pattersoni*		T
Widemouth blindcat	*Satan eurystomus*		T
Texas wild-rice	*Zizania texana*	E	E
Barton Springs Segment			
Austin blind salamander	*Eurycea waterlooensis*	C	
Barton Springs salamander	*Eurycea sosorum*	E	E
Northern Segment			
Jollyville salamander	*Eurycea tonkawae*		
Georgetown salamander	*Eurycea naufragia*	C	
Salado salamander	*Eurycea chisholmensis*	C	

Species Endemic to the Edwards Aquifer Region and Associated Springs and Karst Ecosystems (continued)

Common Name	Scientific Name	USFWS Status	TPWD Status
TERRESTRIAL (KARST) ECOSYSTEMS			
Southern Segment			
Bracken Bat Cave spider	*Cicurina venii*	E	
Cokendolpher Cave harvestman	*Texella cokendolpheri*	E	
Government Canyon Bat Cave meshweaver	*Cicurina vespera*	E	
Government Canyon Bat Cave spider	*Neoleptoneta microps*	E	
Madla’s Cave meshweaver	*Cicurina madla*	E	
Robber Baron Cave meshweaver	*Cicurina baronia*	E	
Barton Springs Segment (and vicinity including karst areas in western and northwestern Travis County)			
Bee Creek Cave harvestman	*Texella reddelli*	E	
Bone Cave harvestman	*Texella reyesi*	E	
Coffin Cave mold beetle	*Batrisodes texanus*	E	
Kretschmarr Cave mold beetle	*Texasmaurops reddelli*	E	
Tooth Cave ground beetle	*Rhadine persephone*	E	
Tooth Cave pseudoscorpion	*Tartarocreagris texana*	E	
Tooth Cave spider	*Neoleptoneta myopica*	E	
Wharton’s Cave meshweaver	*Cicurina wartoni*	C	

E: Endangered (in danger of extinction throughout all or a significant portion of its range)
T: Threatened (likely to become endangered within the foreseeable future)
C: Candidate; information supports listing as endangered or threatened
(Blank): Apparently rare, but no official protection at present
Sources: USFWS (2005a); TPWD (2005a)

APPENDIX G

Cultural Resources in the Vicinity of the Lower Barton Creek and Barton Springs

Appendix G
Cultural Resources in the Vicinity of the Lower Barton Creek and Barton Springs

G.1 Archeological Surveys

Following Barton Creek from the confluence of the Short Spring Branch and Barton Creek to the Colorado River, several archeological surveys have been conducted in the vicinity of Barton Springs and Barton Creek. Five such surveys took place in the immediate Barton Springs/Zilker Park area: 3 surveys (1988, 1989 and 1992) took place on behalf of the City of Austin for a proposed water line for South Austin that followed the left bank of the Springs/Creek through Site 41TV1364. The initial survey resulted in the discovery of the major site while the following two phases attempted to find viable alternatives to the proposed route, eventually concluding (in 1992) that deep tunneling through the site area was best. In 1996, the City of Austin sponsored a shovel test survey of the right Barton Springs/Creek bank for proposed improvements to the Zilker Loop Trail. Through the course of investigations, archeologists visited Sites 41TV2, 689 and 690. Site 41TV2 was found to contain artifacts and was recommended for testing before any improvements in the area were to proceed. The remaining survey is located southeast of Site 41TV2, but no documentation of the survey could be located.

Moving away from the main Barton Springs area, archeologists conducted a series of eight surveys between Zilker Park and the Short Spring Branch confluence. Two of these surveys were visits and assessments of a number of the sites discussed below. In 1974 the EPA conducted a survey of several sites along the Barton Creek banks, visiting Sites 41TV384-386, 388-389, 391, and 324. No records were available regarding this survey. In 1979, TPWD conducted a similar survey and assessment of several of the same sites. Among those visited were Sites 41TV384-386, 991, 386, 389, 391, 324 and 398. Also, this survey covered a large area west of Site 41TV324. The survey was a brief assessment of each of the visited sites and recommendations for each. Site descriptions below are largely excerpts from these site discussions. Another EPA survey was conducted in 1981 for a proposed waterline along Lost Creek Boulevard at the northeastern terminus of the discussion area. This survey visited Site 41TV345 and found it to be largely destroyed by road construction and vandalism. The State Department of Highways and Public Transportation (SDHPT, currently TxDOT) conducted two surveys that overlap Barton Creek, both in the vicinity of the intersection of MoPac Expressway (Loop 1) and Loop 360 (Capital of Texas Highway). In December of 1976, SDHPT surveyors assessed Loop 360 from MoPac south to Lamar Boulevard. No records are available for this survey; however no sites lie within the survey corridor so it is likely that all visited terrain was clear of significant archeological materials. In April of 1983, SDHPT surveyed a proposed 1.5 mile extension of MoPac from Loop 360 to US 290. Through the course of this survey archeologists revisited Sites 41TV386 and 338. These sites were found to be intact enough to warrant further testing. Finally, Espey Huston and Associates surveyed a proposed 138-kV electrical transmission line that would extend from the Barton Substation, cross Barton Creek, and run to the Oak Hill Substation. The survey located (among others) Sites 41TV579-580 and found both to be minor lithic scatters of nominal import.

G.2 NRHP/SAL Properties in Close Proximity to Barton Springs and Barton Creek

G.2.1 Barton Springs Area National Register of Historic Places/State Archaeological Landmark Properties

Nearest the confluence of Barton Creek and the Colorado River, the Barton Springs area, is a series of four recorded historic and prehistoric archeological sites. All of these sites are listed as either NRHP or State Archeological Landmark (SAL) Properties. The right bank of Barton Springs in this area is part of a Barton Springs National Register of Historic Places Archeological and Historical District while Zilker Park, which encompasses both sides of the waterway, is its own National Register Historic District.

Vara Daniel Site (SAL) – 41TV1364 – The Vara Daniel Site is located on the northern promontory of Barton Creek and Colorado River. Site recorders describe it as an “immense, intact, stratified, multi-component, primary subsistence location with at least two distinct cultural horizons.” The massive site covers at least a 1,650-feet-diameter area that extends from the Creek bank almost to the Colorado River. There are no defined site boundaries as all 11 subsurface trenches dug to investigate the site (in anticipation of a proposed subsurface waterline) were positive for archeological materials. Within the mapped site boundaries archeologists noted a wide array of prehistoric artifacts including shell, burned rock, groundstone, bifaces and unifaces, Paleoindian and Archaic period dart points, and extensive lithic debitage. Deposits ranged in depth from 24 inches to 12 feet in depth. One Paleoindian period hearth feature was recorded intact at a depth of 9 feet below the surface. The site was recommended for avoidance or testing, if the proposed waterline could not be diverted. It is part of the Zilker Park Historic District.

Barton Springs Site (SAL) – 41TV2 – The Barton Springs Site, located opposite 41TV1364 between Barton Springs Pool and Campbell's Hole, is a burned rock midden and lithic scatter site first investigated in 1928 and revisited in 1979. It is the main component of the Barton Springs National Register Archeological and Historical District. The site is composed of a series of smaller lithic concentrations of cores, flakes, burned rock hearths, and rock shelters that extends along Barton Creek's right bank over a distance of approximately 1,650 feet. No diagnostics were observed during site investigation. As of its 1979 revisit, the site was found to be at least 70 percent intact.

Gail Rabb House Site (NRHP/SAL) – 41TV689 – The Gail Rabb House Site is located on a terrace overlooking a small southern tributary of Barton Creek. It is included in the Barton Springs National Register Archeological and Historical District. The house site is attributed to the Gail Rabb family who moved to the area in 1860 and owned the land until 1958. The site itself is composed of three distinct features including a limestone cistern (now filled with sediment and a tree), two rubble piles (one pile composed of limestone and one of dirt), and a cluster of domestic vegetation (irises and crepe myrtle). No evidence of the actual house structure remains (vandals burned it down in 1962), however archival documents indicate that it was a Greek Revival style home with two stories and an array of outbuildings (also no longer extant). At the time of its recording in 1983, the site area was used as a baseball field.

41TV690 (NRHP/SAL) – This small historic mill site is located approximately 220 yards west of the Gail Rabb House Site and extends across both the left and right bank of Barton Creek near the Barton Springs Pool dam. Among the historic elements observed in association with the site are a limestone ashlar masonry foundation with coursed rubble fill built into the terrace on the south (right) bank and a possible foundation and rubble pile on the left. The right bank feature is probably a mill; the left bank feature may have been a bridge or crossing above the mill. The ashlar blocks are slanted after the third course (a support course for the mill machinery). No individual historic artifacts were found in the site area. Mr. Gail Rabb, who owned much of the land in the area, likely built the mill; however, some records also name Henry Stern (who bought some of the land from Mr. Rabb) as the mill's builder.

Sunshine Camp Site – 41TV197 – Very little information is available for Site 41TV197, the Sunshine Camp Site. According to available data, the site is located somewhere "just north of Barton Springs Pool," however, THC library files (less clear on its exact location) have placed it in a 0.25-square-mile area throughout the main portions of Zilker

Park, fully encompassing 41TV1689 and 1690, and almost entirely covering 41TV2 and 1364. Scant site records simply state that the site was "surface collected by boys at camp" in 1956, and that the camp boys retained the artifacts (whatever artifacts they may be). With such scant data, it is unclear if this site truly qualifies for NRHP or SAL designation, however, since it lies within the Zilker Park historic district and encompasses several National Register properties and SALs it is included in this portion of the discussion.

G.2.2 Barton Creek Area NRHP/SAL Properties

From the western edge of Zilker Park and Barton Springs to the confluence of Barton Creek and the Short Spring Branch there are three listed archeological sites. One of these sites, 41TV324, is a historic ranch site, while another, 41TV1379, is an extensive prehistoric burned rock midden site. The third site, 41TV1762, is a combination rockshelter and occupation site spanning both banks of a Barton Creek tributary. Below is a brief description of each of these sites.

Andrew M. Cox Ranch/Barton Creek Corrals (NRHP) – 41TV324 – The Andrew Cox Ranch (also known as the Barton Creek Corrals Site) is found on both the left and right banks of Barton Creek, extending southwest from Loop 360 to the immediate western bank of the creek. The National Register property covers an area of approximately 70 acres. The mid to late 19th century historic ranch site is primarily composed of a series of dry-laid stone wall enclosures and corrals with no occupational buildings extant. Several wagon-wheel rutted limestone roads are evident along the left bank side of the property. It is unclear what the current condition of the site is, however, according to the 1975 National Register listing, several of the walls/corrals had toppled over the years. In addition to the historic ranching component, the Cox Ranch site also has a minor prehistoric lithic scatter component. There is only cursory discussion of this portion of the site in any of the reports.

The Hidden Hollow Site (SAL) - 41TV1762 – This lithic scatter and rockshelter site is found on a promontory overlooking Barton Creek and an unnamed east-west Barton Creek tributary. The site lies on both the north and south banks of the tributary with the northern component containing two open rockshelters and the southern side composed of an open lithic scatter with two associated hearth features. One Perdiz arrow point was observed within the site boundaries along with a core, though all other artifacts were minor lithic debitage. Numerous looters' holes were present throughout the site area. The Hidden Hollow Site covers an area of about 0.6 acre. The site was recommended for formal SAL listing and its accompanying legal protection. It received this designation in 1995.

The Pot Luck Site (SAL) – 41TV1379 – This extensive burned rock midden site covers an area of approximately 1.8 acres and is situated on a high terrace overlooking the right bank of Barton Creek, approximately 231 feet to the east. Surveyed in November 1991, the extensive single midden (or tight complex of smaller middens) contained deposits that were estimated to extend up to one meter in depth. The site bore evidence of years of repeated looting (site recorders actually scared off two looters as they approached the site) with numerous deep potholes and spoil piles throughout the area. While there was little remaining of the site, archeologists estimated that at least some deposits were still intact. Site recorders recommended formal SAL designation for the site to afford it greater legal protection. The site received that designation in 1992.

G.2.3 Archeological Sites in Close Proximity to Barton Creek

G.2.3.1 Sites Potentially Eligible for NRHP/SAL Listing

Six archeological sites, found within 500 feet of the main Barton Creek Waterway, are described as potentially eligible for inclusion in the NRHP or as a SAL. All sites whose records either contained strong indications of eligibility or formal recommendations for testing (or any other more detailed analysis) are considered potentially eligible NRHP/SAL sites. Of the six sites described below, two are likely associated with the NRHP Cox Ranch Site (41TV324), and the remainders are prehistoric occupation sites and rockshelters.

41TV357 – This site sits on two southern terraces overlooking Barton Creek and is composed of a series of small rock shelters five to ten meters above the cliff base. Within the shelters, recorders noted several rock hearths with soot staining the ceilings. The majority of artifacts encountered within the site are primary flaking debitage. Site data do not include any formal recommendations; however if the shelters remain intact, they could be potentially eligible for NRHP/SAL listing

41TV338 – This site covers approximately 0.75 acre and is situated on a terrace overlooking the creek. The light lithic scatter was defined as having deposits reaching depths of up to 20 inches. It was recommended for testing, if any future impacts were anticipated.

41TV588 – This surficial lithic scatter occupies an area of approximately 24,240 square feet (20,200 square meters) and lies at the foot of a ridge overlooking Barton Creek to the southwest. Artifacts include cores, bifaces, unifaces and lithic debitage. The site was recommended for testing to determine how intact the cultural materials were within the site boundary.

41TV389 – This historic archeological site covers approximately 0.5 acre and contains several stone features including large worked stones, a stone wall, columns, and a possible road remnant. At the time of its initial recording, researchers postulated that the site could be related to the NRHP Cox Ranch Site (41TV324), which lay to the immediate north. The site was recommended for formal testing for defined association with the Cox Ranch Site.

41TV391 – This historic and prehistoric site covers approximately 6.2 acres and is partially overlapped by the Cox Ranch. The historic elements of the site are most likely also associated with the Cox Ranch but were not described within the survey report. The prehistoric elements are classified as a minor upland lithic scatter. The site was recommended for survey and mapping, citing its direct relation to Site 41TV324.

41TV398 - This prehistoric lithic scatter site is located on the right bank of Barton Creek at the confluence of the creek and two of its small, unnamed tributaries. One San Marcos point was recovered during site investigations; however, all other artifacts were limited to lithic debitage. Situated on a sandy promontory, site recorders maintain that 41TV398 could contain enough stratification to potentially produce local chronologies, contributing to understanding of local prehistory. The site was recommended for avoidance.

G.2.3.2 Archeological Sites

Twelve minor prehistoric and historic archeological sites were documented within 500 feet of the main Barton Creek waterway between the western edge of Zilker Park and the confluence of Barton Creek and the South Spring Branch. Of these, the overwhelming majority (n=11) are defined as minor, surficial lithic scatters and procurement areas with nominal deposition and very little definable patterning. The remainder is a once-significant burned rock midden site (now destroyed by development). Mostly situated within the Barton Creek Greenbelt and thus subject to frequent foot traffic, a number of the sites contain evidence of repeated looting. Below is a brief discussion of each of these sites, moving upstream along Barton Creek from Zilker Park to the South Spring Branch confluence.

41TV993 – Located on a wooded terrace approximately 0.5 mile southwest of the Hollow Creek confluence, this 2.4-acre site is described as an open, surficial lithic scatter. No diagnostics were observed on the surface or in either of the two site shovel tests excavated, but one uniface was documented. A moderate dirt roadway that cuts through the site area has disturbed much of the main site components. 41TV993 was not recommended for further work, and planned office development in the area has likely destroyed any remnants of the site.

41TV992 – This 1.5-acre surficial lithic scatter site is located along the left bank of Barton Creek, approximately 0.5 mile southwest of the Hollow Creek confluence.

Situated in a wooded area clearing, the site did not contain any diagnostic tools; however, one worked flake was observed on the surface. At the time of recording, the site was defined as disturbed and eroded and did not display any visible patterning. The site was not recommended for any further work.

41TV385 – This site occupies an area of approximately 94 acres in an eastern oxbow of Barton Creek east of Loop 360. It is composed of three smaller light lithic scatters with flakes, tested cobbles, a core, and biface. Shallow soils are found throughout the site area and the site recorders recommended no further work.

41TV384 – This small lithic quarry and primary manufacturing site covers approximately 0.1 acre. Artifacts encountered include tested cobbles, cores, and dense lithic debitage. The site area has no soil deposition, and surveyors recommended no further work for the site.

41TV991 – This site is a Paleoindian period prehistoric open campsite with evidence of multiple components. The surficial lithic scatter occupies an area of approximately 11 acres. Among the items collected during a surface survey are: one Angostura dart point, one Midland dart point, and one stemmed dart point base. The site does not appear to be intact and is likely wash from the higher landform. It has no deposition and has been recommended for no further work.

41TV977 – This light surficial lithic scatter covers about 2.5 acres. Artifacts found within the site boundaries include one small biface fragment and lithic debitage extending to a depth of approximately five centimeters below the ground surface. No further work was recommended for this site.

41TV386 – This site occupied an area of approximately 37 acres in 1979 and just 12 acres seven years later. The site sits on a terrace overlooking a southward oxbow of Barton Creek immediately west of Loop 360. The site is described as a surficial lithic scatter with extremely shallow deposits of lithic debitage, early Middle Archaic dart points (Nolan, Pedernales), and other bifaces and biface fragments. In 1979, recorders recommended that, if affected by any future work, the site should be surface-collected and possibly tested. In 1984, the site was defined as approximately one percent intact and not recommended for any further investigations.

41TV387 – This site occupies an area of 1.2 acres and is defined as a lithic scatter site with heavy scatters of expended cores, bifaces, and flakes. It lies on a terrace overlooking the creek to the east. The site was recommended for surface collection and possible testing (if affected by future impacts) to determine the depth and extent of site deposits.

41TV704 – This 198-square-foot site sits atop a high bluff overlooking Barton Creek and one of its small tributaries. The “L”-shaped prehistoric lithic scatter site contains a variety of cores, biface fragments, and plentiful lithic debitage. The site is, however, entirely surficial and was not recommended for any further work following its initial recordation.

41TV580 – This 4-acre surficial lithic scatter is found surrounding an electrical substation on a bluff overlooking Barton Creek to the west. The site did not contain any features nor were any formal tools recorded, however, the presence of numerous primary flakes and cores indicates that the site is likely the remnant of lithic procurement activities. The site was not recommended for any other work.

41TV579 – This site occupies an area of approximately 2.8 acres and is characterized as a surficial lithic procurement and scatter site. No formal tools were found within the site boundaries, and archeologists recording the site did not recommend that any further work was warranted.

41TV345 – This site was studied in two phases over the span of four years. In 1975, the site was characterized as a relatively extensive burned rock midden site situated on a high terrace overlooking the creek to the east, immediately south of the confluence of Barton Creek and Short Spring Branch. Among the materials observed on the 0.5-acre site were the midden itself, numerous hearth features, and "flint," all within the main site boundaries. At that time it had been heavily looted with potholes throughout. The site was recommended for intensive testing. By the time of a 1979 follow-up survey, the site was described as being "in the process of being totally destroyed." Development in the area had severely impacted the site, and looting had continued. A planned expanded roadway was scheduled to completely destroy the remnants of the site. It is likely that this site is no longer extant.

APPENDIX H

Methodology for Calculating Daily Water Balances Used for Springflow Impact Evaluations

Appendix H
Methodology for Calculating Daily Water Balances Used for Springflow Impact Evaluations

For each of the more than 10,000 days in the period of record (1917-present) with Barton Springs recorded flow under 40 cfs, a calculation was made for the quantitative effect of each of the three alternatives on the aquifer flow regime that existed on that day. This calculation was a step-wise process that accounted for the following factors on a daily basis:

1. First, a zero-pumpage baseline was established by adding back the estimated groundwater withdrawals that occurred on that day in the period of record to the recorded springflow, yielding a hypothetical natural springflow, with no pumpage, for that day.
2. Because Alternative 1 had no specified upper cap, the current aquifer pumpage was escalated using a reasonable growth factor (3.5% from recent experience) and any time period, in years, of interest. (As a practical matter, unconstrained growth over more than about ten years is likely to produce sufficiently high pumpage that it would no longer be "unconstrained" and would be subject to additional District regulation.)
3. Alternative 2 and 3 effectively had caps placed on pumpage for calculation purposes, with Alternative 2 being calculated as capped at either 10 or 13 cfs as its two scenarios, and Alternative 3 being calculated as capped at 7 or 10 cfs in its scenarios.
4. For all Alternatives, the pumpage was adjusted a) to account for additional pumpage from Non-exempt Domestic Users and from (estimated) Exempt Users, and b) to take out the pumpage that would occur under the alternatives for Trinity Aquifer use, to get to average Edwards Aquifer usage, before any regulatory restrictions and programs were applied.

5. For each alternative, since the average pumpage was stated on an annual average basis, an adjustment was made to express the pumpage on a shorter-term basis by multiplying the monthly average by 1.59. (This factor was derived by looking at long term relationships between annual pumpage, monthly pumpage, and a limited amount of daily or weekly pumpage data.) This step purposefully overstates the pumpage such that every day is essentially a worst-case condition reflecting a maximum short-term pumpage situation; actual pumpage on those days is more likely to be considerably smaller.
6. For each of the Alternatives, the various measures that comprised the various categories were then applied to reduce the short-term unrestricted pumpage by the accrued effects, as estimated by groundwater professionals, of demand reduction, supply enhancement, and source conversion during non-drought conditions.
7. Then a second reduction was made to apply the applicable Alarm or Critical Stage drought conditions (if and as indicated by the calculated springflow condition) for the various drought measures included in each of the Alternatives.
8. By convention, no benefit was ascribed to any structural mitigation measures.
9. Finally the total amount of regulatory benefit, expressed as demand reduction from the maximum short-term pumpage, is subtracted from the hypothetical zero-pumpage baseline, to yield a projected flow at Barton Springs for that day under the three Alternative regulatory frameworks.
10. These results, aggregated for all days, were then used to develop frequency distributions to illustrate the effects on the ecological systems represented by Barton Springs, with respect to the flow regime through time. Frequency distributions were developed for both the period of record and for the drought of record, and were examined with respect to various durations of specified flow conditions.

These water-balance calculations are based on the results of the District's Sustainable Yield Study, whose modeling demonstrated that there was a one-for-one correspondence between pumpage reductions and increases in springflow.

The following page shows an example water balance calculation, taken from the spreadsheet solution developed to facilitate all these calculations, for one hypothetical day in the period of record. On this day, the recorded flow at Barton Springs was 29 cfs, and the estimated pumpage was 0.4 cfs; it must have been an early day in the period of record with that low pumpage! In this example, the water balance calculation was only looking five years out for Alternative 1; still it illustrates the different benefits to calculated springflow among the three alternatives. (Also, in this example the Alternative 2 cap happened to be set at 12 cfs, rather than the 10 and 13 cfs used in the actual impact analyses for Alternative 2. Alternative 3 uses the upper 10 cfs cap scenario.)

Daily Water Balance Calculations for Impact/Risk Assessments

Enter data only in shaded areas on this worksheet

		Alternative 1		**Alternative 2**		**Alternative 3**	
	Average Daily Flow on Day X	29.0		29.0		29.0	
plus	Historic Pumpage for Day X	0.4		0.4		0.4	
equals	**Natural Baseline Flow (cfs)**		**29.4**		**29.4**		**29.4**
	Pumpage Growth Rate Used	**3.5%**		**3.5%**		**3.5%**	
	Years in Future of Interest	**5**		**5**		**5**	
	Pumpage under Permit Now	11.1		11.1		11.1	
extend	Pumpage under Permit in Future	12.7		12.0		10.0	
plus	Authorized Pumpage by NDUs	0.0		0.1		0.2	
plus	Estimate for Exempt Wells	1.1		1.1		1.1	
minus	Pumpage from Trinity and others	0.2		0.3		0.4	
equals	Total Average Pumpage, Unrestricted		13.6		12.9		10.9
	Maximum Short-term Pumpage		**21.6**		**20.4**		**17.3**
plus	Non-drought Demand Reduction	0.5		1.2		1.7	
plus	Non-drought Supply Enhancement	0.4		0.8		1.8	
plus	Non-drought Source Conversion	0.3		0.8		2.3	
equals	**Effect of Non-drought Measures**		**1.2**		**2.8**		**5.8**
if/plus	**Alarm** Drought measures:						
	From Alternatives Table, low estimate	2.0		2.8		3.8	
	or						
if/plus	**Critical** Drought measures:						
	From Alternatives Table, low estimate	2.8		4.2		5.3	
plus	**Effect of Drought Measures**		**2.8**		**4.2**		**5.3**
if/plus	**Emergency Response Measures**		**0.0**		**0.0**		**0.0**
	Pumpage After Mitigation		**17.6**		**13.4**		**6.2**
equals	**Calculated Flow at Barton Springs**		**11.8**		**16.0**		**23.2**
	Indicated Category of Risk		**Critical**		**High**		**Moderate**
			For Day X		For Day X		For Day X

APPENDIX I

Biological Impact Assessment Methodology

Appendix I
Biological Impact Assessment Methodology

Prepared for:
Barton Springs Edwards Aquifer Conservation District

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I.1 Hydrologic Basis

For the impact assessment, daily discharge values for Barton Springs that were less than or equal to 40 cfs from the available period of record (1917-2004) were used. Data from the period of record are assumed to provide a reasonable approximation of conditions that will occur into the future (during the timeframe of the Habitat Conservation Plan). This dataset also includes a severe drought during the mid-1950s that provide a means of evaluating impacts from severe low recharge conditions, should such conditions recur during the life of the permit. This dataset was gathered from two sources. Daily values before 1978 are estimates based on irregular instantaneous discharge measurements and interpolation using the recession curve of diminishing spring discharge, as well as other hydrologic factors, for any day where total Barton Springs discharge was less than or equal to 40cfs. Estimation and compilation of the dataset using this methodology were performed by Raymond Slade (retired USGS hydrologist). For the period since the USGS gage was installed in 1978, a continuous record of daily discharge values is available and has been validated by the USGS through 2004 as of the initiation of this project.

From these historic daily discharge values (which include progressively increasing groundwater withdrawals) a synthetic hydrograph was created that has the influence of then current groundwater withdrawals removed. This "baseline" hydrograph was developed to provide an objective comparison tool for the HCP alternatives and to provide a base discharge condition to which conditions for each of the individual HCP alternatives could be applied and daily discharge values for that alternative estimated. This hydrograph was developed by adding the estimated amount of water that was removed by pumping back into the historic discharge values. Historic withdrawal data are available on a monthly basis since 1988, but had to be estimated prior to that date. The daily discharge values in the baseline dataset were adjusted by the net groundwater withdrawal scenarios in various HCP alternatives, including those with restrictions on pumping during drought, to predict future daily discharge values. Because there is an approximate 1:1 relationship between water removed from groundwater storage and discharge from the springs (Slade et al. 1986), every cubic foot per second (cfs) withdrawn from the aquifer was estimated to reduce baseline flow from the springs by 1 cfs.

I.2 Species Evaluated

The first step in the impact assessment of HCP alternatives on Barton Springs was to select the target organisms. There are numerous terrestrial and aquatic organisms that are dependent to varying degrees on springflow from the four springs that make up Barton Springs. Biologists from the City of Austin Watershed Protection Department have compiled a list of approximately 130 aquatic invertebrate species that have been identified in the four springs and Barton Creek downstream of the springs (COA 2006). This includes one apparent endemic, the Barton Cavesnail (*Stygopyrgus bartonensis*), which has only been collected in Eliza Spring to date. In addition to the comprehensive list of aquatic macroinvertebrates found in the Barton Springs complex, the City of Austin has identified 23 species of fish, 3 species of turtles, and 2 species of salamanders in Barton Springs Pool (COA 1998, COA 2006).

Of these, only the two salamander species are restricted to these springs and are identified as endangered or potentially endangered by the U.S. Fish and Wildlife Service. The Barton Springs salamander (BSS) (*Eurycea sosorum*) is listed as a federally endangered species, while the Austin blind salamander (ABS) (*Eurycea waterlooensis*) is a candidate for classification as endangered (USFWS 2002). Due to their highly limited range and water quality requirements (USFWS 2004) these species were the focus of the impact assessment. Protection of habitat for these species should also maintain suitable habitat for other organisms dependent on springflow from Barton Springs. Of the two salamanders, the subterranean nature of the ABS has prevented extensive research into its ecology or even basic life history traits, but it appears that the ABS occurs in similar (though deeper) habitats as the BSS. The impact assessment of HCP alternatives assumed that discharge conditions that maintain suitable habitat for the BSS will also support adequate ABS habitat.

I.3 Ecological Stressors Considered

A literature search was conducted to evaluate ecological risk factors that may influence the BSS and neotenic salamanders in general, during periods of reduced discharge. Using the information obtained from this review, along with water quality and BSS population data from the City of Austin, individual risk factors were selected for use in evaluating potential impacts of reduced discharge on BSS for each of the HCP alternatives.

One of the stressors associated with a reduction in springflow is a reduction in the velocity of water moving through each spring orifice. Reduced velocity affects the ability of the salamanders to take up oxygen from the surrounding water. When water velocity decreases around a salamander a thicker "boundary layer" of water with low dissolved oxygen (DO) concentration develops immediately surrounding the organism. This boundary layer may require individuals to move to ensure adequate oxygen uptake and this movement may increase the threat of predation (Booth and Feder 1991). Reduced flow is also directly related to a reduction in DO concentration of water issuing from Barton Springs (COA 2004). This reduced DO level affects the salamanders directly and may also reduce available forage (prey) species. Low DO increases ventilation and metabolic rate (Norris et al. 1963, Boutilier et al. 1992, Sheafor et al. 2000), affects blood chemistry (Talbot and Stiffler 1991) and reproductive success in salamanders (Hillman and Withers 1979).

In addition, dissolved constituents become more concentrated at lower flows, reflecting an influx of water of somewhat different chemistry and a smaller volume of water for dilution as they move through the aquifer. During the early stages of the HCP development, it was believed that specific conductance (salinity) may rise to concentration levels that could reduce salamander survival as flow decreases to critically low levels. Water salinity is an environmental stressor for amphibians because of the high permeability of their skin and gills to the surrounding water (Boutilier et al. 1992). Also, as salinity increases the solubility of oxygen decreases, which further reduces the ability of the salamanders to obtain the oxygen needed for respiration. When salinity exceeds the ability of the organism to osmoregulate, it becomes sluggish, loses balance and ultimately dies (Harfenist et al. 1989). Gomez-Mestre and Tejedo (2003) also found that osmotic stress caused decreased survival probability, slower developmental rate, and/or growth rate in larval amphibians (frogs). However, results presented by Poteet and Woods (2007) did not support the hypothesis that increased salinity (within the ranges expected in Barton Springs) would negatively impact survival of the salamanders in Barton Springs.

Although there are many changes in BSS habitat suitability that result from reduced flows, certain factors (stressors) are likely to have more direct impacts on the species. These stressors were chosen as indicators for the impact assessment, since they are among the more influential factors on survivability of the species. Although other stressors may influence population dynamics of the BSS during reduced discharge, many parameters are extremely difficult to measure or model. Those selected for the impact assessment provide an opportunity to quantify a direct response in the BSS population to changes in habitat suitability that result from reduced flow conditions. One of the chosen stressors was dissolved oxygen (DO), a water chemistry parameter for which there is an extensive dataset (although data are limited during low discharge conditions). The reduction in DO is a critical factor that may directly influence survival or have indirect effects such as reduction in food availability. Using a regression model of the relationship between discharge and DO (COA 2007) where DO = -0.95 + 1.65*log(discharge) (R^2 = 0.64), DO can be predicted at any discharge (with lower confidence below 16 cfs due to lack of data). The Texas Commission on Environmental Quality (TCEQ) has DO criteria for water bodies throughout the state based on a system of ranking the “aquatic life use” of a body of water. In surface waters that rank as “high” aquatic life use, the TCEQ requires that the minimum 24-hour mean DO value should not be lower than 5.0 mg/L, and that the DO should not decline below a minimum of 3.0 mg/L for more than 8 hours in any 24-hour period. A minimum of 3.0 mg/L is also recommended for stream segments classified as “intermediate” for aquatic life use. The DO requirements are higher during the spring to protect spawning fish and are 5.5 mg/L and 4.5 mg/L, respectively in high aquatic life use segments (TCEQ 2000). A closely related species to the BSS, the San Marcos salamander (*Eurycea nana*) is found in abundance in water that maintains approximately 4 mg/L or greater DO concentration (USFWS 1995).

The relationship between BSS and DO was evaluated by the City of Austin using their monthly BSS survey data and water quality dataset (COA 2004). These data show that when DO has declined below 5.0 mg/L, BSS survey counts did not exceed 20 individuals in the main spring (<12 large BSS and <8 small BSS in all samples), whereas samples during higher DO conditions had a much wider range of counts, including some as high as 80 individuals (COA 2004). While this dataset is valuable, there is wide variability in BSS numbers that is difficult to relate directly to any single parameter. The laboratory study to evaluate DO and salinity provide the opportunity to evaluate the impact of each parameter in a controlled setting (Poteet and Woods 2007). The results of that study have been incorporated into this analysis to predict mortality over the range of anticipated DO conditions present in Barton Springs. The means of incorporating these results is described in section 4 of the EIS/HCP document.

Reduced DO may also affect BSS prey items; Irving et al. (2004) conducted 10-day trials of reduced DO on an amphipod (*Hyalella azteca*) which is a food source for BSS and found highest- and no-observed-effect concentrations of 1.2 (+/- 0.1) and 2.9 (+/- 0.1) mg/L DO, respectively.

A second stressor that was initially selected for the biological impact evaluation was salinity, but the results of Poteet and Woods (2007) suggest that the range of anticipated salinity conditions in Barton Springs pose minimal risk to these salamander species.

I.4 Impact Assessment Methodology

The methodology used for the biological impact assessment involved using threshold discharge values for comparing conditions among HCP alternatives. These threshold discharge values are each associated with some level of biological impact due to anticipated change in habitat conditions at or near these flows. Comparing the frequency and duration that total Barton Springs discharge would be at or below the selected discharge levels provided a means of comparing relative impact of the HCP Alternatives. The threshold values were selected to provide a range of anticipated impacts from minimal to substantial reductions in habitat and high BSS mortality risk. With this range of impact levels, an analysis of cumulative risk during increasing flows is possible rather than relying on a single indicator of impact for comparisons. Though many factors influence the risk to the BSS at any given discharge as described above, two stressors were identified during development of this evaluation methodology that were suspected of having a strong relationship on BSS habitat suitability during low flow conditions. These stressors, DO and salinity, were used to characterize the anticipated impact of a given discharge on BSS. Other factors such as sedimentation and the presence of sufficient algae to support a prey base for BSS are also likely important determinants of the risk of low discharge, but no data were available to quantify these and other potential stressors.

The thresholds and anticipated impacts were initially determined based on observations from the BSS survey data collected by the City of Austin, and anticipated response of BSS to low DO and high salinity conditions. One analysis of the survey data suggested that a shift in BSS abundance in Old Mill spring occurs around 33cfs and a similar shift occurs in Eliza at around 25cfs (COA 2004). These discharge values correspond to approximately 5 and 4 mg/L DO concentration using the regression equation presented in COA (2004). Anecdotal information suggested that 3 mg/L was another threshold value below which there may be substantial impacts to BSS. However, there is great variability in these data and it is difficult to establish a direct relationship between BSS abundance and any observed water quality or habitat characteristic. The laboratory study in which impacts of elevated salinity and reduced DO were evaluated on a surrogate salamander species (Poteet and Woods 2007) provided a more precise model of the relationship between salamander mortality and each of these parameters. With this data, mortality estimates could be generated over a range of DO and salinity concentrations and compared to anticipated conditions in the wild under each EIS alternative. Though there are many uncertainties in transferring these estimates to wild populations of BSS, these models provide the most robust dataset available to conduct an evaluation of potential impacts associated with individual alternatives (Figure I-1).

The methodology of the laboratory study is described in detail in Poteet and Woods (2007) but to summarize, adult salamanders were maintained in one of several treatments with differing DO or salinity concentration over a 28-day period and proportion of mortality recorded in each treatment (Table I-1). The percent mortality observed in each treatment, which spanned a range of DO or salinity concentrations, provided the means to develop a continuous response curve of anticipated mortality over the range of conditions evaluated in the study.

One of the findings of the study was that the salamanders did not respond negatively to even very high salinity concentration (Poteet and Woods 2007). Therefore this factor poses little risk to the BSS population in Barton Springs in the range of possible conditions and it was not included in the final selection of threshold discharge values. From the DO results, a curve was developed that describes the anticipated percent mortality of BSS within the range of DO conditions that may occur in Barton Springs (Table I-2; Figure I-2).

Table I-1. Experimental treatments for dissolved oxygen tests conducted by Poteet and Woods (2007). The study included five treatments over a range of DO concentrations and the number of test animals that died was converted into percent mortality and adjusted for the mortality percentage observed in the control treatment.

Treatment	Target DO Percent	Target DO (mg/L)	Number of Test Animals	Number Died	Percent Mortality	Adjusted Percent Mortality
1	1.5	0.64	12	12	100.0	100.0
2	3	1.27	12	11	91.7	90.8
3	6	2.54	10	4	40.0	34.0
4	10	4.24	11	1	9.1	0.01
Control	21	8.90	9	1	11.1	0.0

Figure I - 1 Barton Springs Discharge Thresholds and Levels of Impact

Total Springflow (cfs)	Historical Frequency of Occurrence Over the Period of Record	Drought Stage	Predicted Flow Among Individual Springs (cfs) [1]			Predicted Dissolved Oxygen Concentration at Main Spring (mg/l) [2]	Predicted Mortality From Laboratory DO Toxicity Study [3]		
			Main Spring	Eliza Spring	Old Mill Spring		Main Spring	Eliza Spring	Old Mill Spring
53 [4]	50%	No Drought	44	4	5	5.6	Minimal or No Impacts	Minimal or No Impacts	Minimal or No Impacts
38	36%	38 cfs	31	4	3				
33	31%	Alarm Stage	27	4	2	4.8	<5% Mortality	<5% Mortality	<5 - 100% Mortality [5]
20	17%	20 cfs	17	3	0	4.0			
18	11%	Critical Stage	15	≤3	0	3.8	5 - 15% Mortality	5 - 15% Mortality	100% Mortality
16	5%		13	≤3	0	3.6 (Lowest Historical Flow w/ Available Water Quality Data; Water Quality Results Below 16 cfs are Extrapolated)			
		14 cfs							
10 [6]	0.2%	Emergency Response Period	9	≤1	0	≤3.6 [7]	>15% Mortality	>15% Mortality	100% Mortality
6	0%		5	≤1	0	≤3.6 [7]	>15% Mortality	>15% Mortality	100% Mortality
4	0%		4	<1	0	≤3.6 [7]	>15% Mortality	>15% Mortality	100% Mortality

Impact Categories (Lowest to Highest)

Note: Colors are used only for clarity to highlight categories and associated effects at designated springflow discharge levels.

Category I	Category II	Category III	Category IV	Category V Highest Risk

1 Flow estimates derived from interpolating values in Table 2-3, Appendix C.
2 Estimates derived from data provided by City of Austin (2007).
3 Mortality estimates for the Barton Springs salamander (*Eurycea sosorum*) were determined from dissolved oxygen toxicity studies using surrogate salamanders (*Eurycea nana*) (Poteet and Woods, 2007). The mortality estimates assume that the *E. sosorum* remain in place and are subjected to low DO and reduced flow. In the wild, the salamanders may avoid stressful conditions by moving to locations within the ecosystem that have higher quality habitat conditions.
4 Average historical flow over the period of record 1917 - 2004.
5 Estimates of 100% mortality in Old Mill Spring are based on loss of surface flow. Salamanders may avoid lethal conditions by moving deeper into the aquifer or laterally to higher quality habitat conditions.
6 Historical low flow (9.6 cfs) occurred on March 29, 1956.
7 Predicted DO values below 3.8mg/l (16 cfs) (Categories III, IV, and V) and resulting *E. sosorum* mortality have not been verified by field observation. However, Poteet and Woods (2007) were able to estimate mortality rates of *E. nana* in the laboratory at dissolved oxygen levels lower than 3.8mg/l. These mortality rates and associated Impact Categories III, IV, and V are discussed in Section 4.3.4

Table I-2. Predicted mortality of BSS resulting from Poteet and Woods' (2007) experimental design. The dissolved oxygen (DO) concentration associated with each predicted mortality value is shown as well as the upper and lower 95% confidence intervals (C.I.).

Predicted Mortality	DO Concentration	Upper 95% C.I.	Lower 95% C.I.
1	5.0	66.7	3.1
5	3.9	28.6	2.7
10	3.4	17.9	2.4
15	3.1	13.2	2.3
50	2.1	4.0	1.6
85	1.5	1.9	0.7
90	1.3	1.8	0.5
95	1.2	1.6	0.3
99	0.9	1.3	0.2

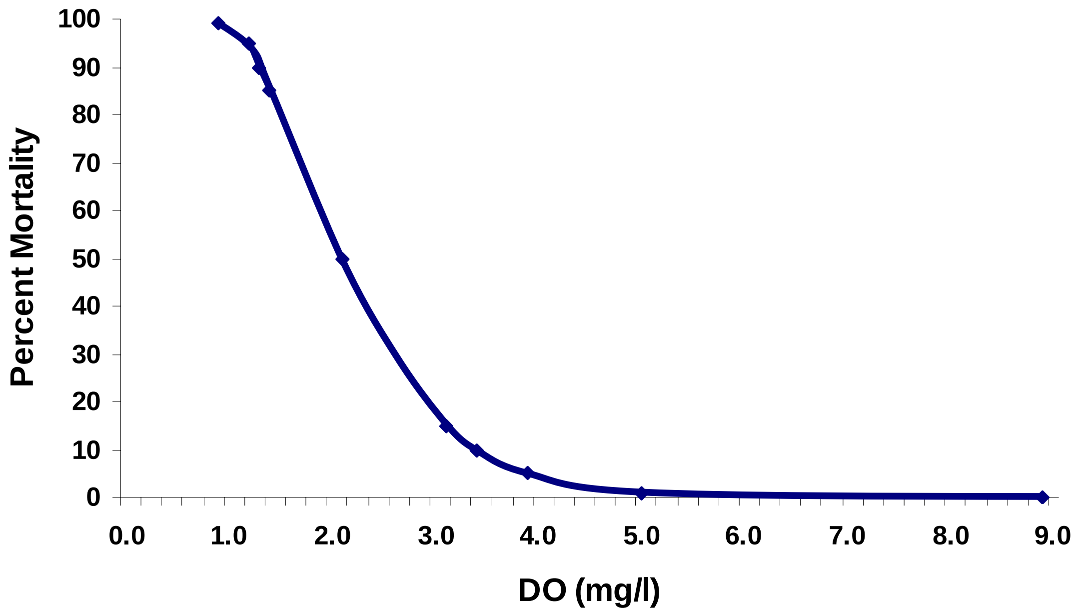

Figure A-2. Curve of predicted mortality over a range of DO concentrations (modified from Poteet and Woods 2007).

Five thresholds were selected to represent a range of biological impacts for the comparison of HCP alternatives; these are referred to as Impact Categories I-V. The percent mortality associated with these are approximately 1, 5, 15, 50, and 90 percent of the BSS population (a modification to the DO-to-discharge model for Barton Springs near the conclusion of this analysis effort slightly modified the mortality estimates associated with the selected discharge thresholds). The concentration of a toxic substance that results in 50 percent mortality is referred to as the LC_{50} and is often used as a threshold for describing the acute or chronic toxicity of the substance to the test species. The other levels of mortality risk were chosen to provide a complete evaluation that spans nearly the full range of potential mortality risk. With these mortality estimates selected, the DO concentrations were estimated using the information from Poteet and Woods (2007). These correspond to approximately 4.8mg/L, 3.8mg/L, 2.9mg/L, 2.0mg/L, and 1.3mg/L, respectively.

The final step in correlating mortality with discharge is to use a model that predicts what Barton Springs discharge should yield a given DO concentration in Barton Springs. Using a regression model that describes the relationship of discharge to DO in main spring over the period 1993-2006 (COA 2007), the discharge values that would result in the DO concentrations described above are approximately 33 cfs, 18 cfs, 10 cfs, 6 cfs, and 4 cfs, respectfully (Table I-3). As described in the preceding section, all predictions of DO from discharge conditions below 16cfs are derived using the best model that fits the range of available data and extrapolated beyond this range of values. There are many different possible models of the relationship between discharge and DO below 16cfs, so the lowest three thresholds have greater uncertainty surrounding their estimates of DO concentration and mortality. The selected threshold values are also presented in Figure I-1, which also describes drought stage, anticipated discharge among individual springs, predicted DO in the main spring, and mortality for each.

Table I-3. Thresholds selected for biological evaluation, including percent mortality, DO concentration, and total Barton Springs discharge associated with each.

Impact Category	Predicted Mortality	Approximate DO Concentration	Approximate Barton Springs Discharge
Category I	1	4.8	33
Category II	5	3.8	18
Category III	15	2.9	10
Category IV	50	2.0	6
Category V	90	1.3	4

I.5 Alternatives Comparison

The frequency of occurrence of each of the five discharge thresholds were used to compare anticipated biological impacts between each EIS alternative and the “baseline” condition. Alternatives with lower frequency of occurrence of discharge at each of the selected threshold values were interpreted as having lower overall risk compared to other alternatives. Because of the higher biological impacts associated with lower discharges, the focus was on interpreting the frequency of occurrence of the lower threshold discharge conditions.

I.6 Estimation of Take

In the District HCP, the estimation of the quantity of "take" of the BSS population is presented and discussed for the various alternatives as well as the proposed measures in Section 6.4 of the HCP. More detail concerning the predicted time durations over which take might occur, based on the hydrologic period of record, are presented and discussed in Section 4.2.4. These estimations rely on the findings of Poteet and Woods (2007) and focus on mortality estimates associated with reduced DO concentrations under controlled laboratory conditions. As acknowledged in the comparison of alternatives, this is not the only component of habitat for the BSS population that is affected by reduced discharge. In addition, there are several uncertainties associated with the transfer of laboratory-derived estimates of mortality into the wild that are discussed in that section of the document. Several levels of mortality estimates (and 95% confidence intervals around each) are presented in the analysis and the frequency of occurrence predicted over a repeat of the period of record and a repeat of the drought of record. The information provides a clear description of the potential impacts (take) of the proposed alternative over the life of the requested incidental take permit.

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APPENDIX J

Physiological, Survival, and Growth Responses of *Eurycea nana* to Variation in Levels of Conductivity and Dissolved Oxygen

Technical Progress Report No. 3: February 1, 2006

Physiological, survival, and growth responses of *Eurycea nana* to variation in levels of conductivity and dissolved oxygen; including physiological responses of *Eurycea sosorum* to conductivity and dissolved oxygen.

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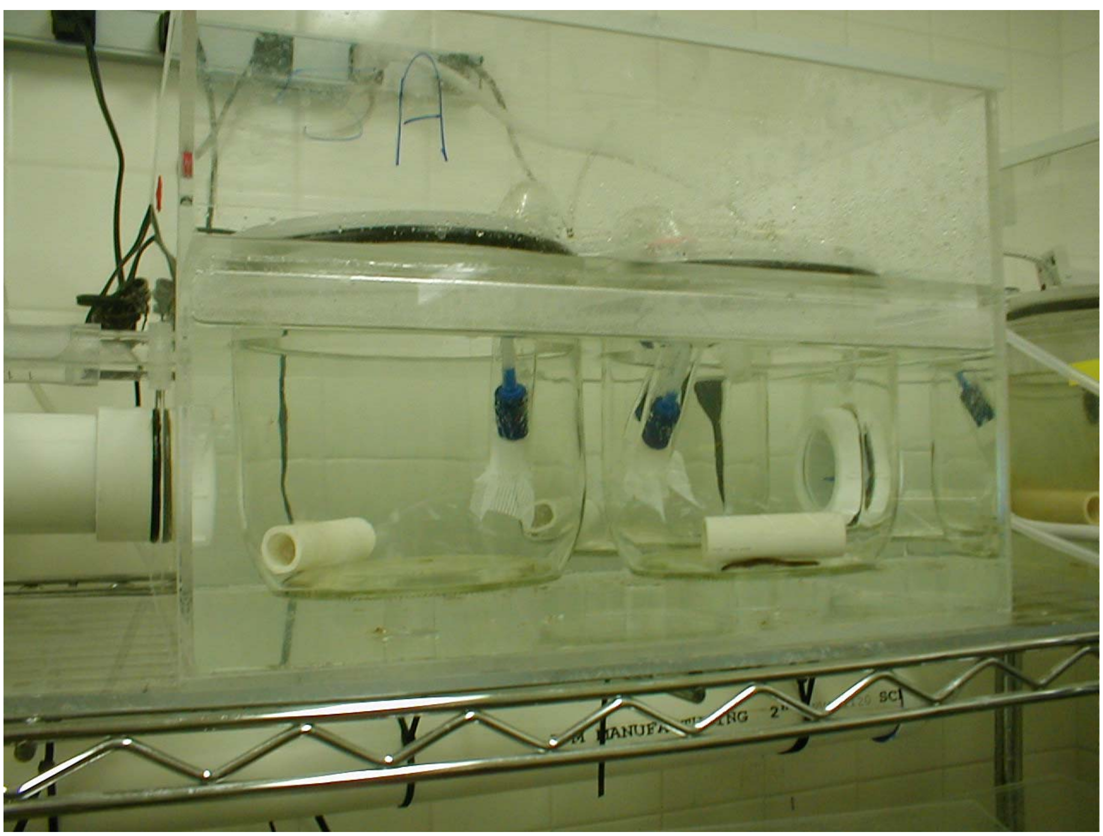
Work funded by the Barton Springs / Edwards Aquifer Conservation District



Summary

This report summarizes the final experiments and analyses. These cover all activities conducted between 24 August 2006 and 18 December 2006. The studies in this report include:

- the physiological and survival responses of adult *Eurycea nana* to 28 day oxygen toxicity tests,
- the short-term physiological responses of adult *E. nana* and *E. sosorum* to conductivity,
- the short-term physiological responses of adult *E. nana* and *E. sosorum* to dissolved oxygen,
- the growth responses of juvenile *E. nana* to conductivity, and
- the growth responses of juvenile *E. nana* to dissolved oxygen.

In addition, this report presents analyses of the physiological similarities between *E. nana* and *E. sosorum* that provide a basis for using *E. nana* as a surrogate species of *E. sosorum*.

Overall Conclusions:

As in the last report, we found that *E. nana* is sensitive to changes in dissolved oxygen but has no significant response to conductivity. In 28 day toxicity experiments, only 50% of the adult *E. nana* survived in dissolved oxygen concentrations = 2.12 mg/l (95% CI 3.968 - 1.582). At the lowest oxygen level (0.64 mg/l), 67% of the salamanders died within 24 hours. In addition, our physiological measurements suggest that *E. nana* do not acclimate to low oxygen levels. Our sample sizes for the acclimation tests were low and we would suggest further studies.

Similar to adults, juvenile *E. nana* were not significantly affected by high levels of conductivity, but their growth rates declined significantly when exposed to low levels of dissolved oxygen.

In our physiological experiments, neither *E. nana* nor *E. sosorum* showed any metabolic response to varying levels of conductivity.

Both *E. nana* and *E. sosorum* responded to dissolved oxygen with decreased metabolic rates. The IC_{50} for *E. nana* is 1.31 mg O_2/L (95% CI 1.01 – 1.70). The IC_{50} for *E. sosorum* is 1.62 mg O_2/L (95% CI 0.86 – 3.04). The range of IC_{50} in *E. sosorum* is greater than for *E. nana* due to greater variability in response curve shapes. Nonetheless, the estimated values for asymptotic metabolic rate and IC_{50} are broadly consistent.

Based on a comparison of metabolic rates across a range of dissolved oxygen concentrations, our conclusion is that overall, *E. nana* and *E. sosorum* have very similar metabolic rates and respond similarly to declining DO—in other words, these metabolic analyses suggest that *E. nana* is a good surrogate species for *E. sosorum*.

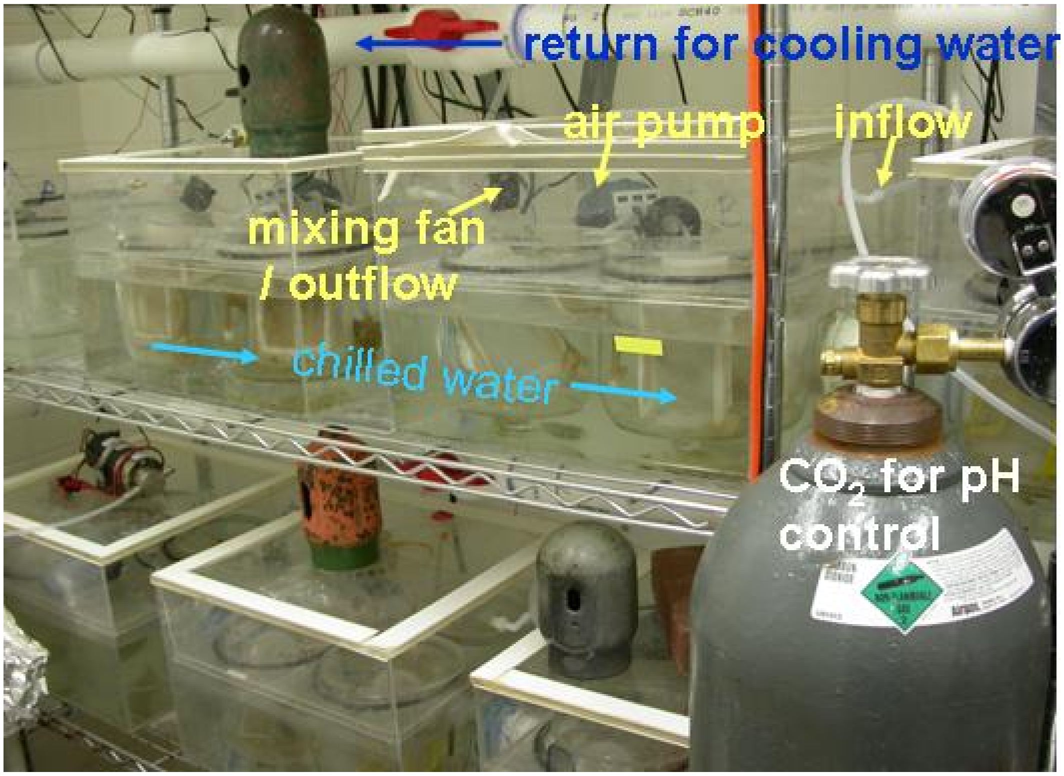
CONTENTS

28 day dissolved oxygen toxicity experiment – adult *Eurycea nana* Lethal Concentrations

We measured percent mortality of 60 adult *E. nana* in a 28 day oxygen toxicity test from August 24 through September 22, 2006. This study provides data on the lethal concentrations and no observable effect concentrations (NOEC) of dissolved oxygen (DO) on salamanders. Twelve salamanders were placed in each of 5 oxygen treatment levels as follows:

TRT	DO%	DO (mg O_2/l)	N
1	1.5	0.635714	12
2	3	1.271429	12
3	6	2.542857	10
4	10	4.238095	11
control	21	8.9	9

Dissolved oxygen levels were maintained by placing individual aquaria in controlled atmosphere boxes. Each of 20 boxes contained three aquaria and one air pump. Each aquarium held one salamander. The atmospheric boxes were constructed of Plexiglas and consisted of two sections. The lower section contained recirculating water chilled to 20°C by an aquarium chiller to maintain aquarium temperature. The upper, dry chamber was sealed to the room atmosphere by a heavy lid and to the chilled water by a watertight Plexiglas partition. The lower two thirds of each aquarium were immersed in chilled water while the upper one third was open to the controlled atmosphere of the box.



The atmosphere in each box was controlled with a Sable Systems ROXY-8 multichannel oxygen regulator. Since the ROXY-8 could not control all 20 boxes individually, we set it up to control each treatment simultaneously. There were 4 boxes in each treatment. We connected the boxes within the same treatment through a system of tubing that created a looped atmosphere that was controlled by the ROXY. The atmosphere was mixed among the boxes with small fans that we placed at the outflow of each box.

The oxygen treatments were stratified among the boxes in a modified latin squares design. For treatments 1 through 5, the set-up was as follows with each row representing 1 rack of the experiment and each square representing 1 box. For example, all of the “1” boxes were connected with a system of tubing and the atmosphere within those boxes was controlled by the ROXY-8.

1	2	3	4	5	1		
5	1	2	3	4	5		
2	3	4	5	1	2	3	4

An air pump in each box then forced the air mixture from the box into the individual aquaria. The air was diffused through air stones that were placed in a hydraulic lift tube. The hydraulic lift tube was added to each aquarium to decrease the likelihood of the salamander getting gas bubble disease. pH was controlled in each aquarium by slowly bubbling CO_2 into the atmosphere of each chamber.

We started the ROXY-8 before adding salamanders to the treatment to allow equilibration between the atmosphere in the boxes and water in the aquaria.

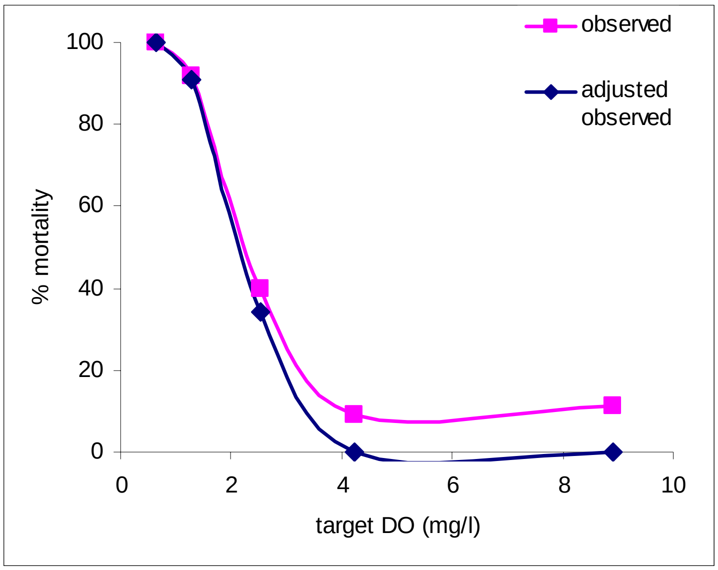
Salamanders were weighed and measured (SVL, snout to vent length) before being placed in the treatments. Once in the treatments, salamanders were checked every day, fed every other day and aquarium water was changed every 5 days.

Results

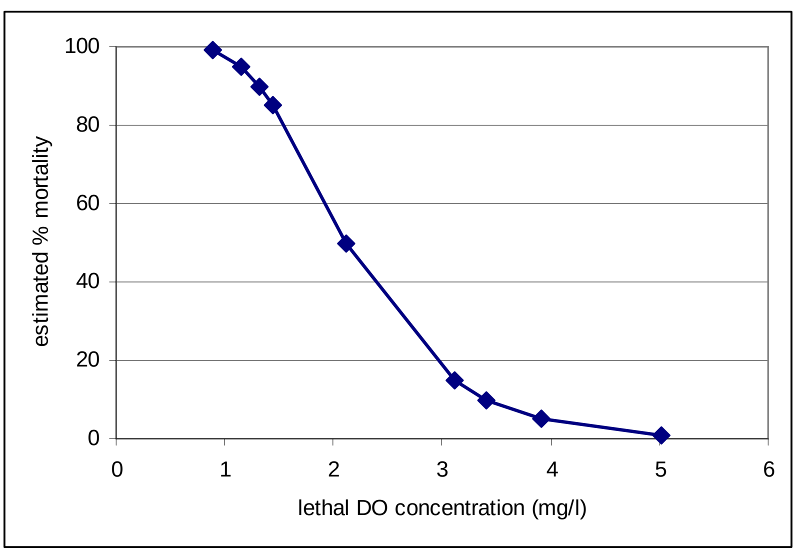
Salamanders escaped from and died in TRTs 3 and 5 so that the final # of replicates per treatment was uneven. This did not affect our ability to interpret the data. At the end of the 28 day test, we observed 100% mortality in the lowest level of dissolved oxygen (1.5% DO), and only 11% mortality in the control treatment (21% DO).

The control treatment measures mortality of salamanders due to factors other than the treatment – here the level of dissolved oxygen. Since we had 11% mortality in the control treatment, all other treatment effects were adjusted for mortality due to non-treatment factors (USEPA 2002).

TRT	DO%	N	# dead	observed % mortality	adjusted % mortality
1	1.5	12	12	100	100
2	3	12	11	91.67	90.83
3	6	10	4	40.0	34.01
4	10	11	1	9.09	0.01
control	21	9	1	11.11	0



We used probit analyses to estimate lethal concentrations of DO that kill a certain percentage of the salamanders over a period of 28 days. The lethal concentration of DO that killed 50% of the salamanders was 2.12 mg/l. The no lethal effect concentration (NOEC) is 13% (5.5 mg O_2/l) dissolved oxygen or greater.



The lethal concentrations of dissolved oxygen for % mortality of the population that were calculated with the probit analyses are presented below with 95% C.I. The confidence intervals are higher, in part, at the lower mortality estimates because of the unexplained mortality that we observed in the control treatment.

estimated % mortality	lethal DO concentration (mg/l)	95% confidence limits upper	lower
1	5.025125628	66.66667	3.1152648
5	3.90625	28.57143	2.6455026
10	3.412969283	17.85714	2.4154589
15	3.115264798	13.15789	2.2624434
50	2.123142251	3.968254	1.5822785
85	1.445086705	1.912046	0.6906077
90	1.319261214	1.745201	0.524109
95	1.153402537	1.552795	0.3407155
99	0.896860987	1.29199	0.1469724

Although the toxicity experiment is designed to measure the amount of mortality over a period of 28 days, we found that salamanders died rapidly in the two lowest oxygen levels. Within 24 hours, 66% of the salamanders were dead in the lowest oxygen level. One hundred percent of the animals died within 5 days. In treatment 2, 75% of the animals had died within 24 hours and 92% died within 48 hours.

TRT	DO (mg O_2 / l)	# days in TRT	# E. nana dead	# *E. nana* in TRT	cumulative proportion dead
1	0.635714	1	8	12	0.67
1	0.635714	2	2	12	0.83
1	0.635714	5	2	12	1.00
2	1.271429	1	9	12	0.75
2	1.271429	2	2	12	0.92

28 day dissolved oxygen toxicity experiment – adult *Eurycea nana* physiological acclimation

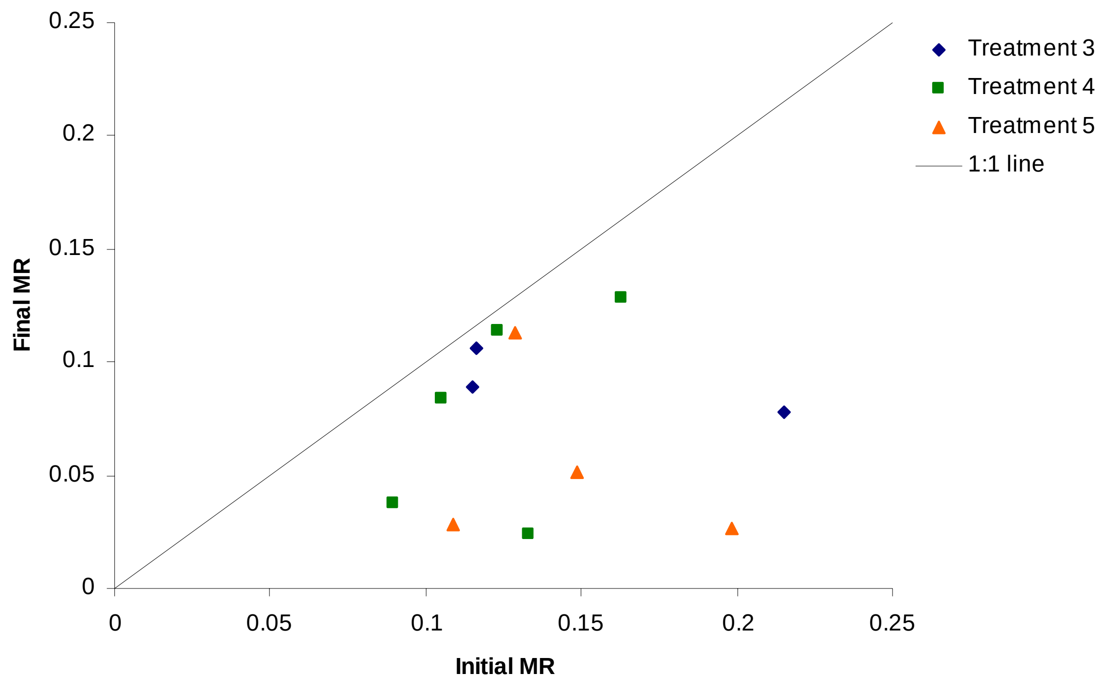
An analysis of metabolic rates before and after the 28-day oxygen toxicity experiment.

Rationale: Many organisms are able to respond to variation in oxygen availability by physiological acclimation. We took advantage of the scheduled 28-day oxygen toxicity test to ask whether *E. nana* shows any systematic acclimation effects.

Nutshell finding: Overall, surviving salamanders had lower metabolic rates after the toxicity experiment than before. However, there was no identifiable 'acclimation effect.'

For technical reasons, we measured initial metabolic rates of only half (30) of the 60 salamanders in the experiment—those measured were a random subsample. What happened over the course of the toxicity experiment? Of the 30 salamanders initially measured, 12 survived the experiment. We re-measured the survivors' metabolic rates in the few days following the experiment.

The measurements suggest no systematic effects. However, there were overall large changes in metabolic rate. Surviving salamanders had significantly lower metabolic rates after the toxicity experiment than before (paired t-test: t = 4.75, df = 11, P = 0.0006):



The cause of the decline is unclear. There was no systematic association with treatment—i.e., salamanders in air-saturated water (Trt 5) exhibited declines as large as those in much lower DOs. We suggest either (1) that salamanders were less stressed by laboratory conditions by the end of the 28-day experiment, and lower stress was manifest as lower metabolic rates; or (2) that laboratory conditions, regardless of DO, caused declines in salamander health, which were manifest as decreases in metabolism. The second possibility seems unlikely, as salamanders maintained body mass (pair t-test: $t = 0.69$, $df = 11$, $P = 0.50$). Moreover, juveniles under similar conditions grew rapidly.

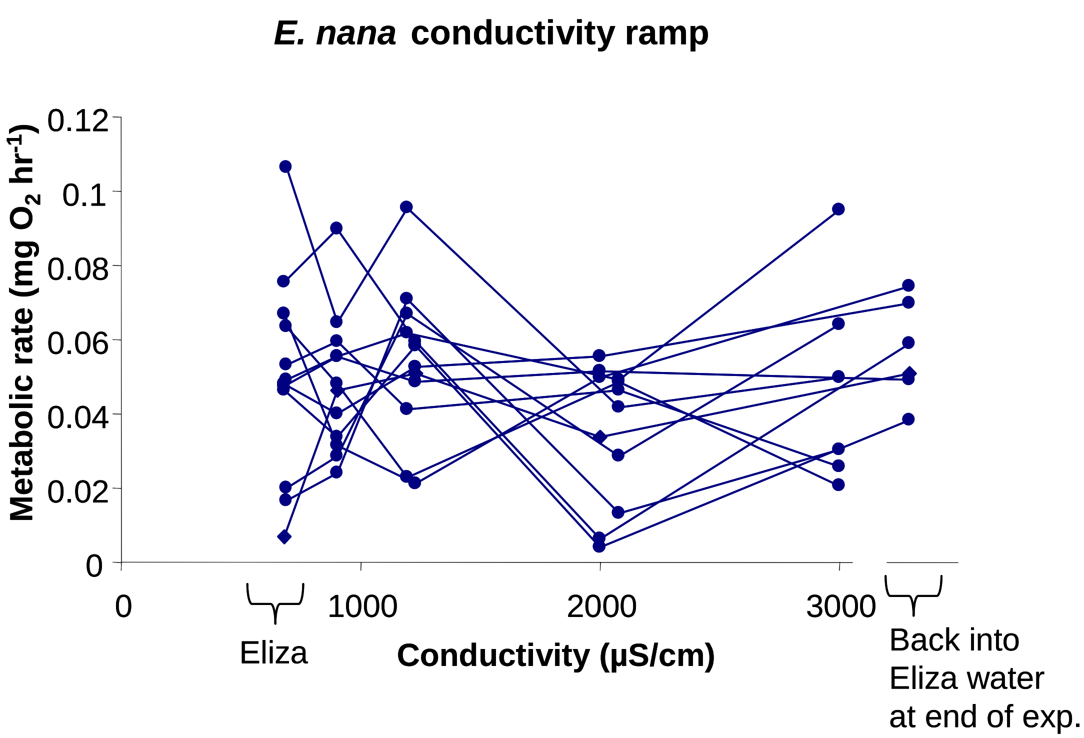
Short-term physiological response to conductivity

Nutshell conclusion: Neither *E. nana* nor *E. sosorum* showed any metabolic response to conductivities between 600 & 3000 µS/cm.

Experimental protocol: See technical Progress Report #2 for description of methods for manipulating & measuring conductivity and for measuring metabolic rates.

<u>*E. nana*</u>

E. nana showed no apparent short-term response to conductivity. There was substantial variability in metabolic rates, within and between salamanders, which could have obscured a relationship—but the data show no trend. The graph below shows all data, with repeated measurements across salamanders connected by lines. Individuals were exposed to a series of increasing conductivity in 5 steps, from Eliza water initially (~700 µS/cm) to pure St. Albans well water (~3000 µS/cm). After this series, half of the salamanders were re-exposed to Eliza water and their metabolic rates measured. This final exposure was to control for the possibly confounding effects of time in the metabolic chamber.



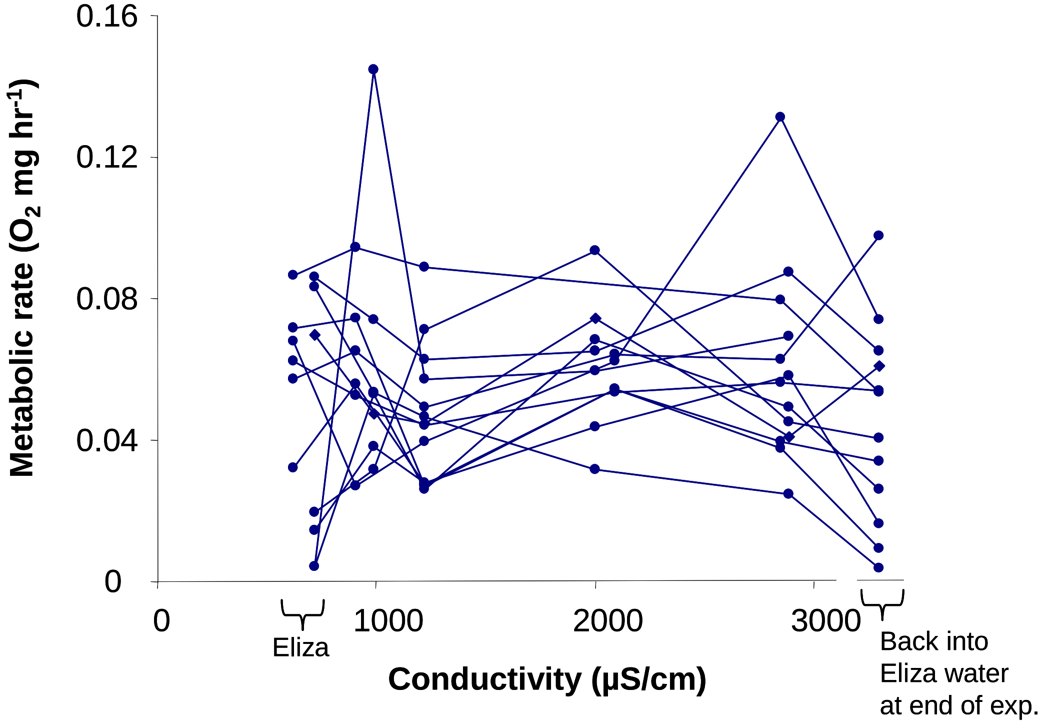
We analyzed the data with linear mixed-effects models, which permit easy accounting of repeated measures from individual salamanders. The analysis confirmed our visual impression that there was no effect of conductivity.

ANOVA summary of linear-mixed effects model fit to the data shown above.

	numDF	denDF	F	P
Intercept	1	41	166.2	<0.0001
Conductivity	1	41	1.5	0.23

E. sosorum

E. sosorum also showed no apparent short-term response to conductivity. The graph below shows all data, with repeated measurements across salamanders connected by lines. Individuals were exposed to a series of increasing conductivity in 5 steps, from Eliza water initially (~700 µS/cm) to pure St. Albans well water (~2900 µS/cm). After this series, each salamander was re-exposed to Eliza water and its metabolic rate measured.



A linear mixed-effects analysis confirmed our visual impression that there was no effect of conductivity.

ANOVA summary of linear-mixed effects model fit to the data shown above.

	numDF	denDF	F	P
Intercept	1	62	168.2	<0.0001
Conductivity	1	62	2.1	0.15

Two other features of the data (see figure above) were worth exploring. First, were metabolic rates the same during initial exposure to Eliza water and in the final exposure (after the conductivity ramp)? Excluding all data except the pre vs post Eliza exposure suggests no difference:

	numDF	denDF	F	P
(Intercept)	1	12	44.1	<0.0001
Pre vs. Post Eliza	1	11	0.68	0.43

Second, the figure suggests that metabolic rates may be lower in Eliza water and higher in all other tested conductivities (i.e., the metabolic rates are higher at conductivities $\geq$ 900 µS/cm). But again, the modeling found no statistical support for this possibility:

	numDF	denDF	F	P
(Intercept)	1	62	169.6	<0.0001
Eliza versus other treatments	1	62	2.88	0.095

Short-term physiological response to dissolved oxygen

Nutshell conclusion: Both *E. nana* and *E. sosorum* respond to dissolved oxygen with decreased metabolic rates. The IC_{50} for *E. nana* is 1.31 mg O_2/L (95% CI 1.01 – 1.70). The IC_{50} for *E. sosorum* is 1.62 mg O_2/L (95% CI 0.86 – 3.04). The range of IC_{50} in *E. sosorum* is greater than for *E. nana*, due to greater variability in response curve shapes. Nonetheless, the estimated values for asymptotic metabolic rate and IC_{50} are broadly consistent.

Experimental protocol: See technical Progress Report #2 for description of methods for measuring metabolic rates.

Statistical analysis: We used non-linear mixed-effects models, implemented in S-Plus, to examine relationships between DO and metabolic rate. Visual inspection of the data suggested that metabolic rates fell at lower levels of DO. We therefore chose to fit what is called the BOD model in Bates and Watts (1988), where BOD means ‘Biochemical Oxygen Demand’:

$$y(x) = \phi_1[1 - \exp(-\exp(\phi_2)x] \qquad \text{Eq. 1}$$

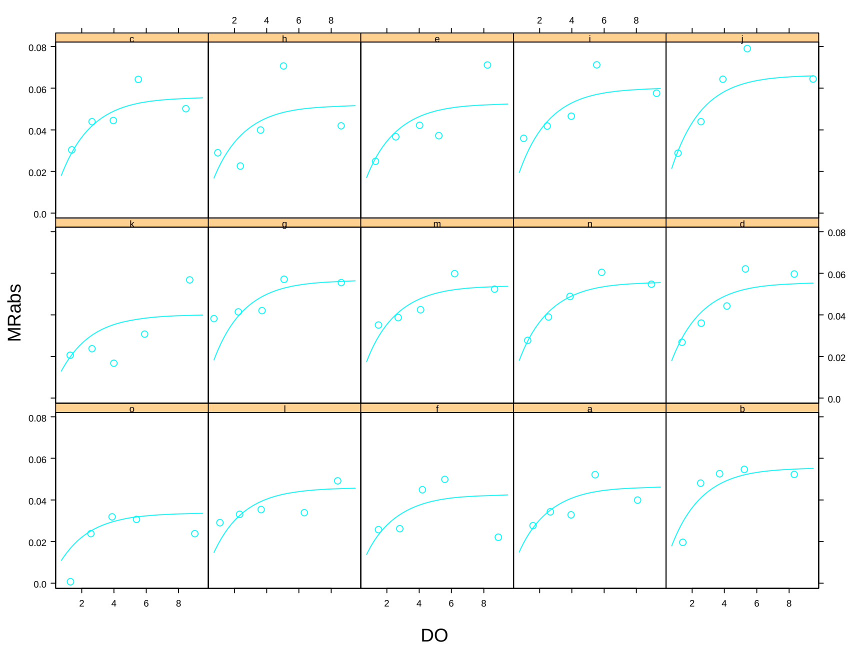
Where ϕ_1 is the asymptote (in our case, the asymptotic metabolic rate) and ϕ_2 describes how sharply the curve transitions from zero to the asymptote. With fitted values of ϕ_2 one can calculate IC_{50} (the DO giving a 50% reduction in metabolic rate) as

$$IC_{50} = \log 2 / \exp(\phi_2) \ . \qquad \text{Eq. 2}$$

We followed Pinheiro & Bates’ (2000) iterative strategy for fitting such models in S-Plus, using the function SSasympOrig (from their Appendix C.3).

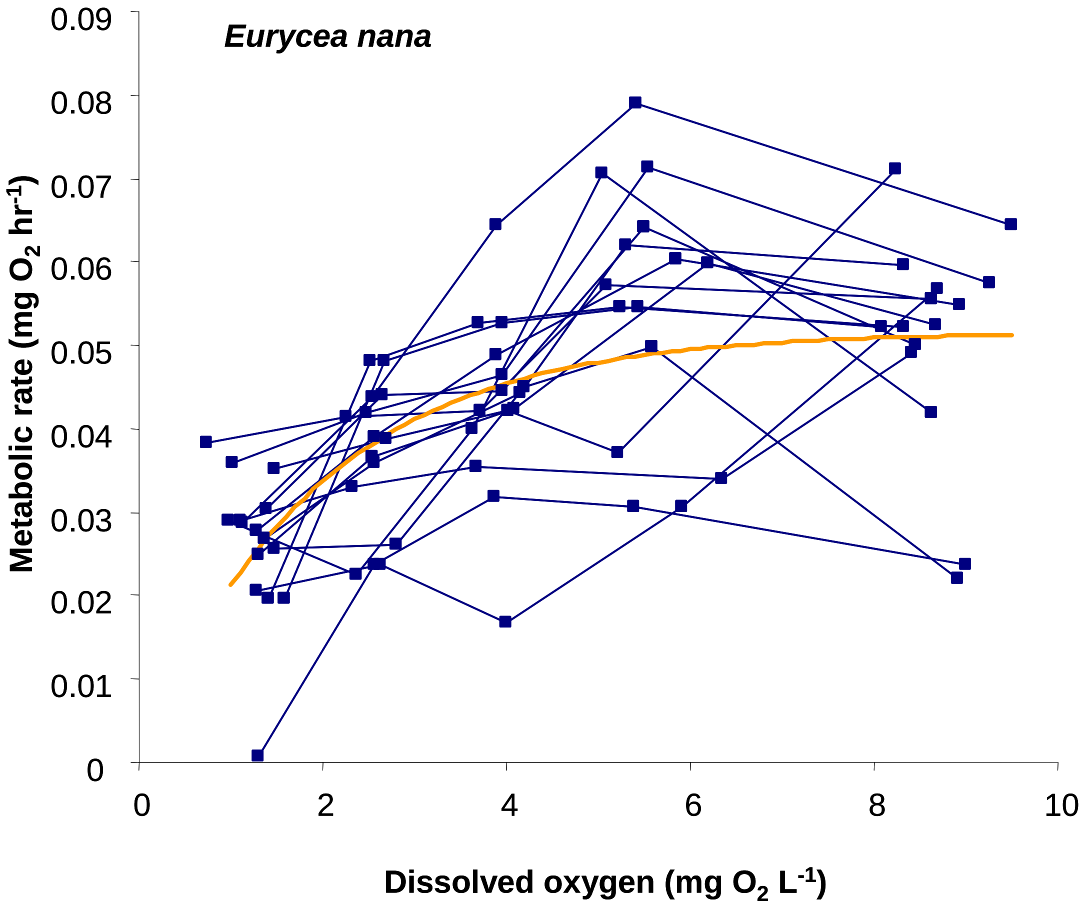
E. nana

The metabolic data contained substantial variability, both within and between salamanders. Nonetheless, we obtained a good fit between the data and the model above. The best model treated ϕ_2 as fixed across salamanders but allowed ϕ_1 (the asymptotic metabolic rate) to vary from



salamander to salamander (i.e., ϕ_1 was treated as a random effect). The residuals from this fit showed no troublesome patterns. The graph to the right shows the model fit to each salamander in the experiment ($N = 15$).

Here is the overall fitted model (in orange) superimposed onto the entire data set (repeated measurements from individual salamanders connected by lines).



Both parameters in the model were highly significant:

	numDF	denDF	F	P
ϕ_1	1	59	251.6	<0.0001
ϕ_2	1	59	23.5	<0.0001

The fitted values of the parameters are:

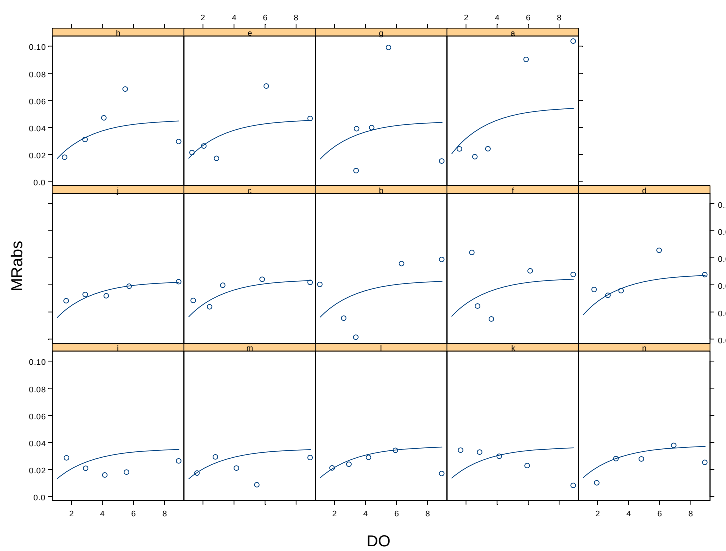
ϕ_1 = 0.052 (95% CI 0.045 – 0.058)

ϕ_2 = -0.64 (95% CI -0.37 to – 0.90)

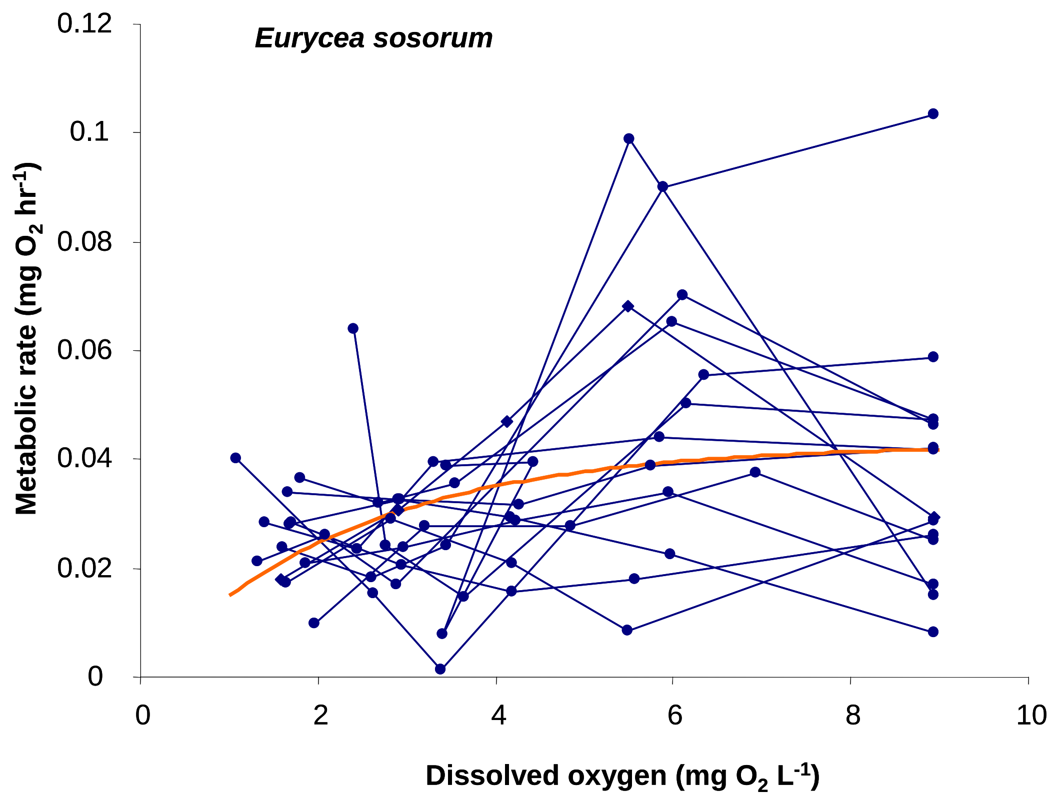
In other words, the estimated metabolic rate at non-limiting levels of DO is 0.052 mg O_2 hr^{-1} (95% CI 0.045 – 0.058). Using Equation 2 (above) we can also estimate the IC_{50}, the level of dissolved oxygen (mg/L) giving a 50% depression of metabolic rate: IC_{50} = 1.31 mg O_2/L (95% CI 1.01 – 1.70).

E. sosorum

Analogous analyses were done on data from *E. sosorum*. Overall, the metabolic data on *E. sosorum* were more variable. We were still able to obtain a good fit to the model (Eq. 1) but could account for less of the overall variance. The residuals from this fit showed no troublesome patterns. The graph to the left shows the model fit to each salamander in the experiment (N = 14). Clearly, the model fits some salamanders well and others poorly.



Here is the overall fitted model (in orange) superimposed onto the entire data set (repeated measurements from individual salamanders connected by lines).



Both parameters in the model were significant:

	numDF	denDF	F	P
ϕ_1	1	55	85.7	<0.0001
ϕ_2	1	55	7.03	0.0104

The fitted values of the parameters are:

ϕ_1 = 0.043 (95% CI 0.032 – 0.053)

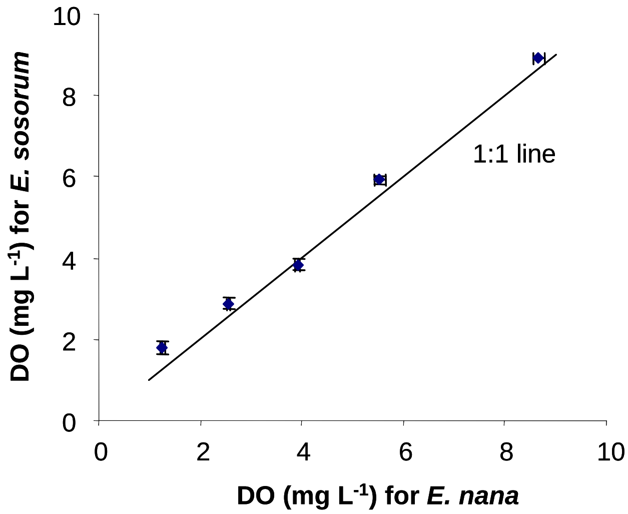
ϕ_2 = -0.85 (95% CI -1.48 to – 0.22)

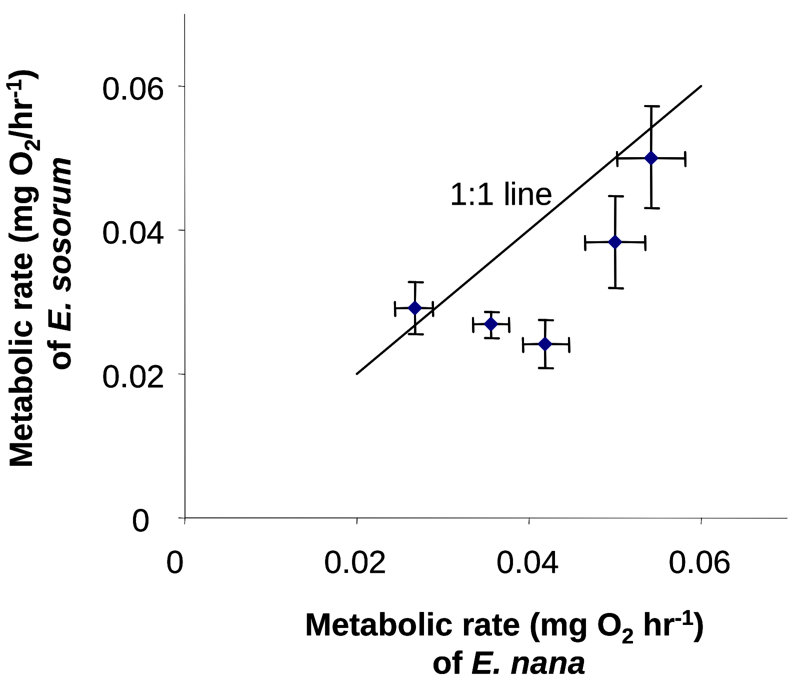
In other words, the estimated metabolic rate at non-limiting levels of DO is 0.043 mg O_2 hr^{-1} (95% CI 0.045 – 0.058). Using ϕ_2 we calculate IC_{50} = 1.62 mg O_2/L (95% CI 0.86 – 3.04). Clearly for *E. sosorum*, the range of IC_{50} is greater than for *E. nana*, reflecting the greater variability in curve shapes. Nonetheless, the estimated values for asymptotic metabolic rate and IC_{50} are broadly consistent:

	E. nana	*E. sosorum*
ϕ_1 (units of mg O_2 hr^{-1})	0.052 (0.045 – 0.058)	0.043 (0.032 – 0.053)
IC_{50} (units of mg O_2 L^{-1})	1.31 (1.01 – 1.70)	1.62 (0.86 – 3.04)

Physiological comparison between *E. nana* and *E. sosorum*

Here we directly compare experimental treatments and measured metabolic rates for the two species. The first issue is whether the experimentally generated levels of DO were similar between the species, as the experiments were run on different days. Comparison of the measured DO levels from the different target levels shows a very close correspondence, so we conclude that salamanders from the two species experienced very similar conditions





This graph confirms our visual impression from above that compared to *E. nana* the metabolic rates of *E. sosorum* dropped off more rapidly at intermediate levels of DO (also reflected as a estimated IC_{50}), but then at the lowest DO were very similar.

Our conclusion is that overall, *E. nana* and *E. sosorum* have very similar metabolic rates and respond similarly to declining DO—in other words, these metabolic analyses suggest *E. nana* is a good surrogate species for *E. sosorum*.

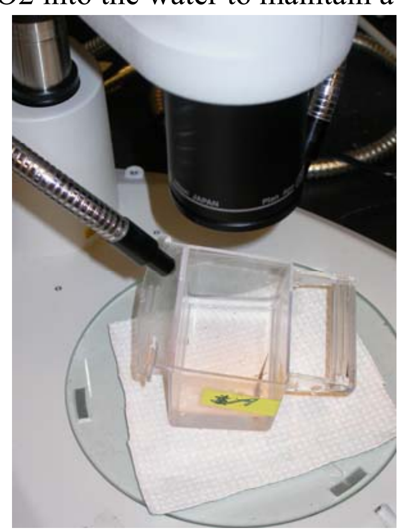
Growth response of juvenile *E. nana* to conductivity

Rationale: Juvenile salamanders might be more sensitive to environmental conditions than adults. We tested whether the growth rates of juvenile salamanders were affected by levels of conductivity or dissolved oxygen over a 60 day period.

Nutshell conclusion: We measured a small effect of conductivity on the growth rate of juvenile *E. nana*. The rate of salamander mass gain declined by 10% at 867 uS/cm and 20% at 955 uS/cm. However, there was no statistically significant difference in growth rates of either mass or length across the conductivity treatments.

Experimental protocol:

This 60 day experiment began on August 31, 2006 and was completed on October 30, 2006. Forty juvenile *Eurycea nana* were randomly assigned to one of five conductivity treatments (see Progress Report 2 for choice of conductivity levels) for an initial N = 8 in each treatment. The juveniles were obtained from Joe Fries, who manages the captive breeding program for *E. nana* in San Marcos. All juveniles were oviposited in June 2006. We set up two aquaria for each treatment level and distributed the 8 salamanders for each treatment randomly and evenly among the aquaria. We kept track of individual salamanders by placing each one in a flow-through bottle within the aquarium. The aquaria were in a cold room maintained at 20^{o}C. PH of each aquarium was controlled by a pH stat that injected CO_2 into the water to maintain a pH ≈ 7.4. Each aquarium had a 3-stage filter, a bubbled air stone, and the pH meter. The water was changed weekly.



This is an example of the flow-through bottles and aquaria that were used in this experiment. In the actual experiment, each aquarium had 4 bottles,

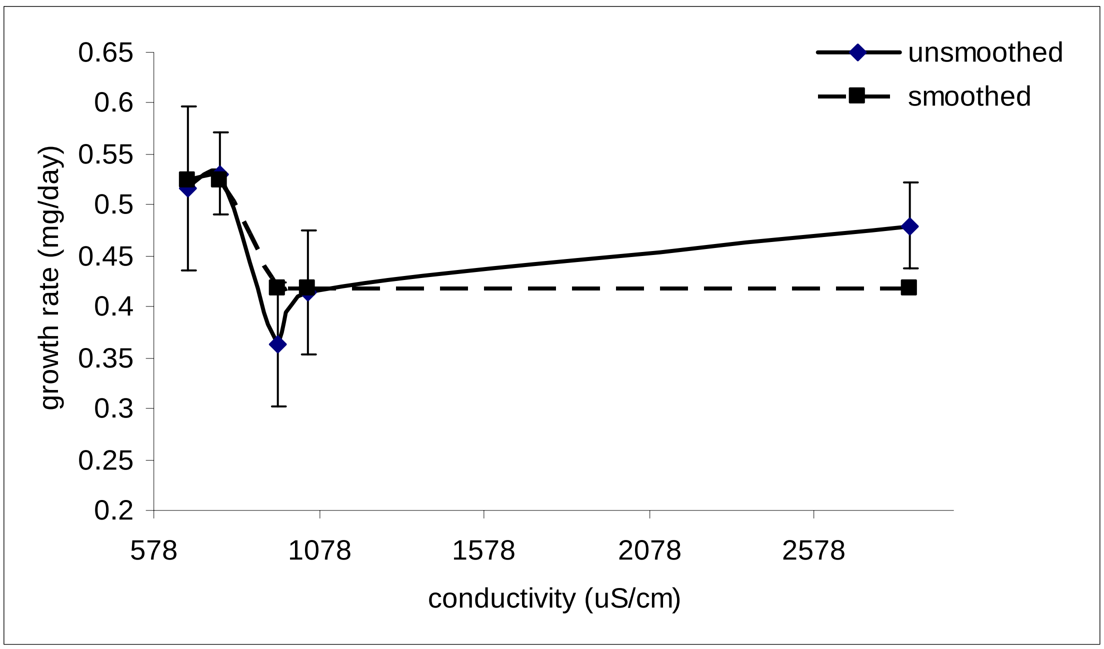
To record growth rates, we measured the length (SVL (mm)) and mass (mg) of each salamander every 5 days. We measured length of juveniles by capturing digital images through a camera/microscope set-up. The images were processed with the image analysis software Lucia.

Salamander mass was recorded using a Sartorius microbalance.

Growth Response to conductivity -- Mass

We calculated 60 day growth rates as the slope of the regression between time and mass gain. These data were smoothed (USEPA 2002) so that we could estimate, through linear interpolation, the % decrease in growth due to levels of conductivity.

TRT	conductivity (uS/cm)	% "bad water"	growth rate in mass (mg/day)	N	growth rate (smoothed)	% decrease in growth rate	% decrease from control (smoothed)
1	678	100% Eliza	0.51655	8	0.5234625	0	0
2	778	2%	0.530375	8	0.5234625	-2.6764108	0
3	955	4%	0.3627833	6	0.419070635	29.7680121	19.94256801
4	1044	5%	0.4144286	8	0.419070635	19.769902	19.94256801
5	2869	100 % St Alban's	0.48	8	0.419070635	7.07579131	19.94256801



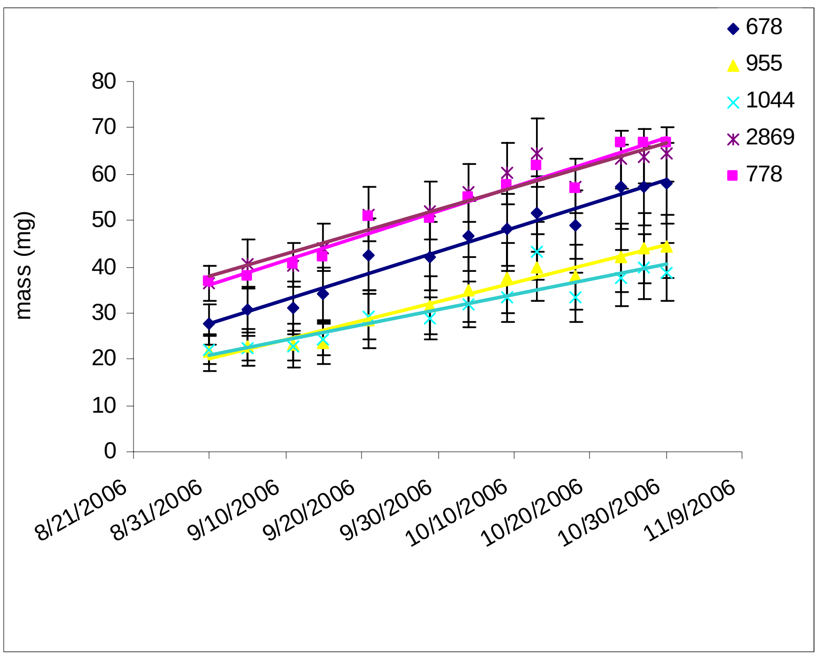
Mean growth rate by treatment. The solid line represents the measured data points. The dashed line represents the smoothed curve for linear interpolation (USEPA 2002).

Linear interpolation of the data suggests that juvenile *E. nana* growth rate declines by 10% at a conductivity of 867 uS/cm, or approximately 3% “bad water”.

decrease in growth rate	conductivity (uS/cm)	growth rate (mg/day)
10%	867	0.47111625
20%	955	0.419
25%	> 2869	0.39259688
50%	>2869	0.26173125

I tested whether the growth rates were significantly different across conductivity treatments. The ANOVA shows that there was no statistical effect of conductivity on growth rate. In addition, the lack of a significant interaction term between the treatment level and the aquarium shows that there was no difference in effect between aquariums within the same treatment.

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
TRT	4	0.1376	0.0344	1.2104	0.3293
aquarium x TRT	5	0.0611	0.0122	0.43044	0.8233
Residuals	27	0.7675	0.0284		



Regression lines showing the mean change in juvenile salamander mass through time by treatment.

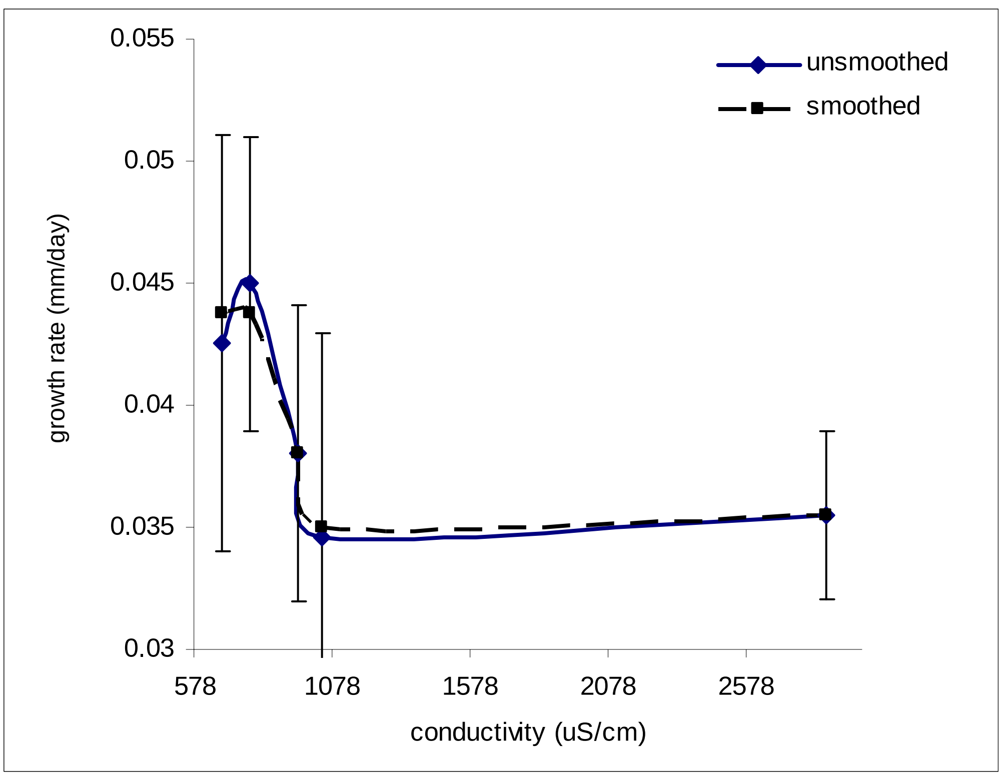
Growth response to conductivity -- Length

Analyses on increase in salamander length through time showed similar patterns as mass. Although there was a detectable decrease in growth rate at high levels of conductivity, these decreases were not statistically significant.

E. nana juvenile growth rate (SVL) over 60 days

TRT	Conductivity	% "bad water"	growth rate in SVL (mm / day)	N	growth rate (smoothed)	% decrease in growth rate	% decrease in growth rate (smoothed)
1	678	100% Eliza	0.042525	8	0.04375	0	0
2	778	2%	0.044975	8	0.04375	-5.76131687	0
3	955	4%	0.0380333	6	0.038033333	10.5624143	13.06666667
4	1044	5%	0.0346125	8	0.0352	18.6067019	19.54285714
5	2869	100 % St Alban's	0.035475	8	0.0352	16.5784832	19.54285714

This graph of the rate of increase in SVL (mm) per day shows that growth rate does decline with higher levels of conductivity.



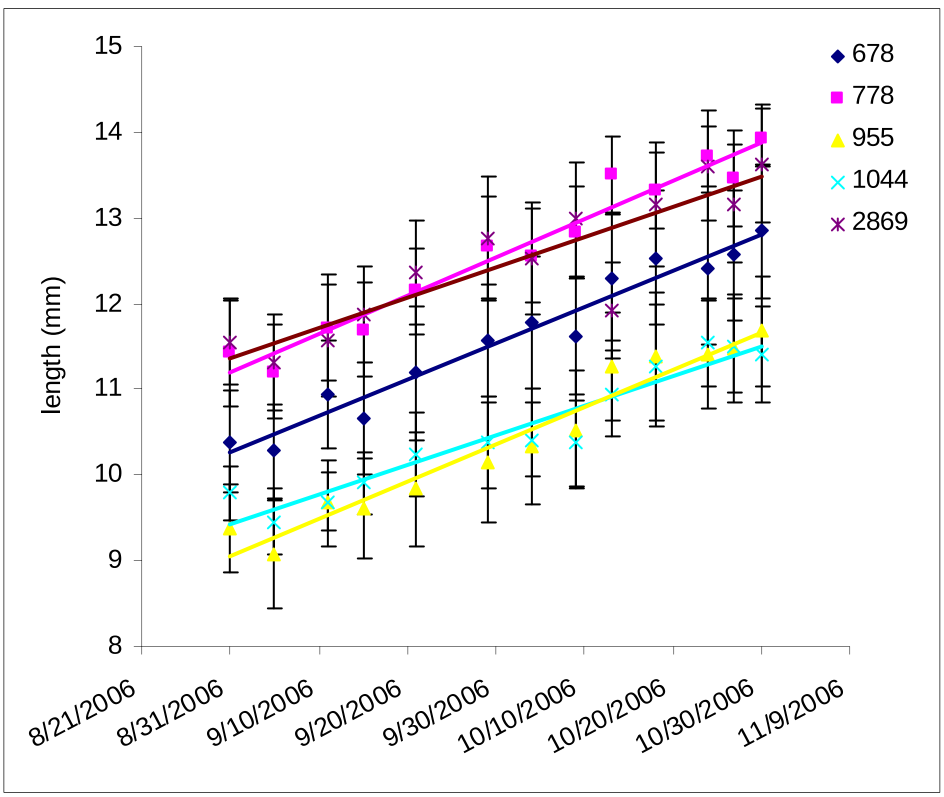
However, ANOVA shows that there is not a statistically significant effect of conductivity on the rate of increase in salamander length through time.

```
                 Df        Sum of Sq        Mean Sq        F Value     Pr(F)
               TRT       4 0.000595551    0.0001488879   0.3795056   0.8210929
aquarium %in% TRT       5 0.001557557    0.0003115113   0.7940223    0.5641611
         Residuals      25 0.009808016    0.0003923206
```

Linear interpolation of the smoothed data suggests a 10% decrease in growth rate at a conductivity of 913 uS/cm.

E. nana juvenile growth rate (SVL) over 60 days

decrease in growth rate	**conductivity (uS/cm)**	**growth rate (mm / day)**
10%	913	0.039375
20%	1050	0.035
25%	>2869	0.032813
50%	>2869	0.021875



Regression lines showing the mean change in juvenile salamander length through time by treatment.

60 day juvenile growth study – dissolved oxygen

Rationale: Dissolved oxygen significantly affected survival of adult *E. nana*, with 50% mortality occurring at DO = 2.12 mg/l. We would expect that juvenile salamanders would incur similar high levels of mortality at low levels of dissolved oxygen. However, we also expected that non-lethal levels of DO could affect growth rate of salamanders. Decreased growth rate could increase the time to first reproduction and potentially fitness in amphibians. This experiment tests whether non-lethal levels of DO affect growth rate in juvenile *E. nana*.

Nutshell conclusion: Dissolved oxygen caused a significant decline in juvenile growth rate with a 25% reduction in mass gain at 3.28 mg O_2 / l.

Experimental Protocol: Juvenile salamanders were placed in the same atmospheric chambers as described in the 28 day oxygen toxicity experiment. The juveniles were observed under these conditions for 60 days. During that time, we weighed (mg) and measured (SVL (mm)) each salamander every 5 days. Initially, we were able to replicate each treatment level only 5 times due to availability of juvenile *E. nana*. In early October, Joe Fries donated all the juvenile salamanders that he had: 26. We started the experiments on October 5. On November 6, we added 40 more juvenile *E. nana* to this study. This second set of *E. nana* was from the 60 day conductivity growth study. We kept track of salamander history along with growth data. The first set of salamanders was removed from the treatments on December 5th. The second set of salamanders was removed from the treatments on December 15.

We determined IC (inhibition concentration) levels for growth rates in mass using the linear interpolation method (USEPA 2002). This document outlines a method to smooth the data into a monotonic series. We present the unsmoothed and smoothed data. All of the ICs are based on the smoothed data.

We tested whether salamanders that had initially been in the conductivity treatment had different growth rates from the first set of salamanders. There was not an effect of pre-experiment history on growth rate. Neither was there an interaction between dissolved oxygen treatment and the conductivity treatment. This is not surprising since conductivity had no significant effects on the salamanders.

ANOVA results for effects of conductivity and TRT x conductivity on growth rate

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Conductivity	1	0.012	0.012	0.609	0.440
TRT x Conductivity	8	0.207	0.026	1.357	0.245
Residuals	40	0.761	0.019		

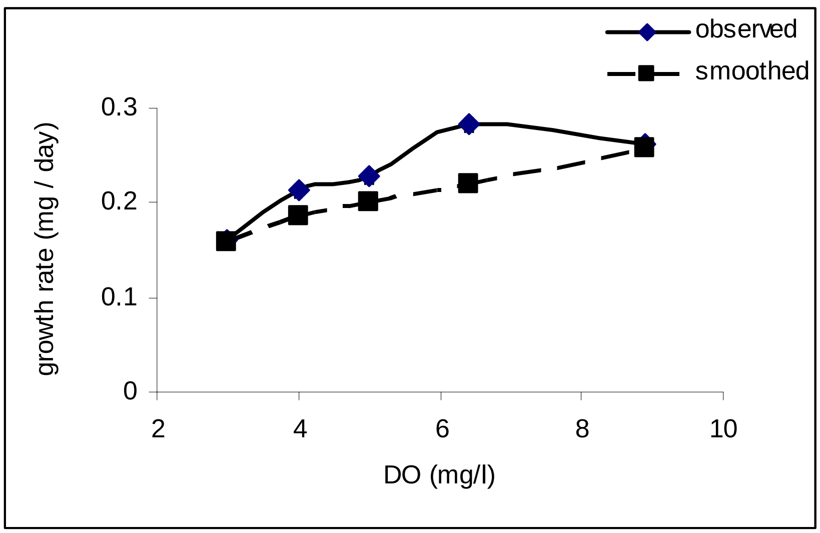
Since the salamanders that had initially undergone the conductivity treatment did not respond to the oxygen treatment differently, we lumped the two groups of salamanders for the following analyses.

Growth response to dissolved oxygen -- mass

Growth rates and inhibition concentrations (IC) as measured by change in juvenile mass (mg) in response to oxygen levels.

TRT	DO (mg O_2/l)	% DO	growth rate (mg/day)	N	smoothed	% decrease in growth rate	% decrease in growth rate (smoothed)
1	3	7	0.160167	9	0.15844	38.98154	38.47502748
2	4	9	0.21245	10	0.186308	19.06324	27.65327513
3	5	12	0.22803	10	0.200216	13.12775	22.25286194
4	6.4	15	0.282045	11	0.220673	-7.45044	14.30887323
5	8.9	21	0.262489	9	0.257521	0	0

Growth rate was depressed below 6 mg/l. We used the smoothed data to estimate the level of dissolved oxygen that would decrease population growth.

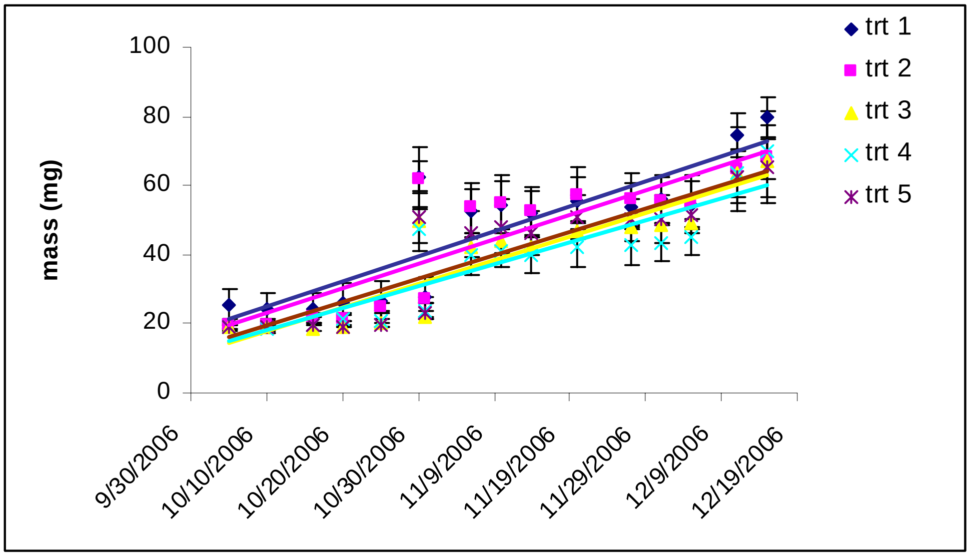


% decrease in growth	DO (%)	DO (mg O_2/l)	growth rate (mg/day)
50%	5.79	2.45	0.1207
30%	7.35	3.11	0.1690
25%	7.74	3.28	0.1811
20%	8.13	3.45	0.1932
15%	8.53	3.61	0.2052
10%	8.92	3.78	0.2173

We used linear mixed effects models in S-Plus to measure the effects of dissolved oxygen on change in mass through time. These models take into account the repeated measures on salamanders through time. As we predicted from the linear interpolation model, dissolved oxygen had a significant effect on growth rate.

	numDF	denDF	F-value	p-value
Intercept	1	644	68.22778	<.0001
Dissolved Oxygen	4	644	2.50457	0.0412

The jump in mass on November 5, is due to the addition of the second set of older salamanders. Even so, there was a detectable effect of dissolved oxygen on growth rates.



Literature Cited

Bates, D.M. & D.G. Watts (1988) *Nonlinear Regression Analysis and Its Applications*, Wiley, New York.

Pinheiro, J.C. & D.M. Bates (2000) *Mixed-Effects Models in S and S-Plus*. Springer, New York.

USEPA (2002) Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. 4th edition. US Environmental Protection Agency. EPA-821-R-02-013. http://www.epa.gov/waterscience/WET/disk3/

APPENDIX K

User Conservation Plans and User Drought Contingency Plans

Appendix K
User Conservation Plans and User Drought Contingency Plans

The District requires User Conservation Plans and User Drought Contingency Plans for all of its non-exempt well owners/operators (i.e., permittees). These plans differ for the five categories of users: agricultural, commercial, industrial, public water suppliers, and general. The UDCP is guided by the Drought Contingency Plan of the District and must comply with the Drought Contingency Rules of the District, sections 3-7.6 and 3-7.7. The UDCP will enable permittees to manage their water system and water resources during drought conditions in a conscientious, fair, and appropriate manner. Its intent is to maintain an adequate supply of water during the various stages of drought conditions that may occur from time to time. The District believes that significant reductions in water usage can be achieved through voluntary efforts, and its educational programs are focused on providing information to achieve that outcome. Voluntary reductions in water usage are encouraged at all times, but especially so during pending or early drought conditions. Voluntary efforts, if sufficiently effective, may delay the need to implement more restrictive and mandatory water use measures and curtailments. Should drought conditions reach more critical stages, the permittee must be prepared to restrict or curtail certain types of usage.

When the District is in a condition of No Drought, permittees operate under normal conditions, in accordance with their User Conservation Plans, also an integral part of each permit. The District encourages water conservation practices at all times and recommends the installation of “low flow” fixtures during repairs, retrofit, or new construction. Employees of permittees are urged to water lawns on a five-day schedule from 8 p.m. to 8 a.m. to avoid unnecessary and excessive watering and to keep evaporative losses to a minimum. Permittees must provide timely information on pumpage and, upon request, water levels. In addition, they must conduct a Leak Detection Survey and repair all identified leaks. Implementation of this program is an ongoing effort by the permittee.

K.1 Agriculture Users

Agricultural users or permittees must adopt a UCP as required by the District to comply with District Rule 3-6.7 (November 1991). The permittee must:

1. Investigate and implement efficient irrigation practices and utilization of alternate watering sources where possible.

2. Follow a schedule of watering in morning and evening times.

3. Continue an on-going program of system leak detection and repair which shall include the consideration and utilization of improved technology when possible.

4. Assist the District in the distribution of conservation and educational materials to employees and customers.

5. Promote and encourage voluntary conservation measures to employees and customers.

6. Periodically review and evaluate this conservation plan and implement revisions to the plan as necessary.

Agricultural Drought Stage Responses

Drought Stage responses required of agricultural permittees are set out in Table K-1 below:

Table K-1. District agricultural drought stage responses

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Upon notification by the Barton Springs Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 1 - Alert Status, each permittee will activate Stage 1 of its UDCP.	Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 2 - Alarm Status, each permittee will activate Stage 2 of its UDCP. Permittees will notify employees of this change in status within 4 days of notification of District declaration of Stage 2 - Alarm Status.	Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 3 - Critical Status, permittees will activate Stage 3 of their UDCP. Permittees will notify employees of this change in status within 2 days of notification of District declaration of Stage 3 - Critical Status.

Table K-1. District agricultural drought stage responses (continued)

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Goal		
A 10% reduction in water use.	A 20% reduction in water use.	A 30% reduction in water use.
Actions Required by the User		
Voluntary reduction in water use.	Continued voluntary reduction in water use in general. Mandatory compliance with restrictions listed below.	Continued voluntary reduction in water use in general. Mandatory compliance with restrictions listed below.
Suggested Reductions		
• Install float device on livestock water troughs to reduce waste and overflow. ▪ Check existing floats for proper functioning. • Adopt a practice of water use which saturates soils and reduces plant stress. • Stop regular washing of farm or ranch vehicles and wash only when actually needed. • Water lawn, garden, trees, or flower beds with hand-held hose. • Check for and fix leaks. • Inform employees of need to reduce water use. • Use water displacement device in toilet tank. • Install aerators on faucets.	• Inform employees of need to reduce water use. • Use water displacement device in toilet tank. • Install aerators on faucets.	• Inform employees of need to reduce water use. • Use water displacement device in toilet tank. • Install aerators on faucets.
Required Reductions		
• None.	• Install float device on livestock water troughs to reduce waste and overflow. ▪ Check existing floats for proper functioning. • Comply with 5 day schedule for lawn watering. • Stop regular washing of farm or ranch vehicles and wash only when actually needed. • Water garden, trees, or flower beds with hand-held hose. • Check for and fix leaks.	• Install float device on livestock water troughs to reduce waste and overflow. • Check existing floats for proper functioning. • No lawn or landscape watering. • Stop regular washing of farm or ranch vehicles. • Check for and fix leaks. • No non-essential use.

Table K-1. District agricultural drought stage responses (continued)

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Penalties or Consequences		
• Warnings for excessive consumption.	• Warnings for excessive consumption. • Possible installation of flow restrictors on connections with excessive demands.	• Installation of flow restrictors after 2nd Violation of connections with excessive demands. • Service cut-off if leaks exist, waste of water is observed, or excessive demands continue. • 3rd Violation will incur Service cut-off with a Reconnection Fee. • Increase in Aquifer Fees if Barton Springs/Edwards Aquifer Conservation District institutes higher water use fees as part of District drought contingency rules to reduce demand. • Possible prioritization of water users. • Domestic and livestock needs take precedent.

Source: BSEACD (2005)

K.2 Commercial Users

For commercial UCPs, permittees must:

Employees

1. Notify all employees of UCP.

2. Post signs at all faucets, sinks, outdoor spigots, and other water sources reminding employees to use water wisely.

3. During staff meetings and when appropriate, suggest ways for employees to reduce water consumption in order to promote and encourage voluntary conservation measures.

4. Require employees to report all faulty fixtures or leaks to maintenance for repair.

Indoors

5. Implement an on-going program of system leak detection and repair which shall include the consideration and utilization of improved technology when possible.

6. Require low flow/low volume fixtures to be installed in all new construction.

7. When replacing old fixtures, do so with low flow/low volume products.

Outdoors

8. Use water-efficient landscape practices including Xeriscaping®, drip irrigation, and automatic sprinkler systems.

9. Adopt a five-day watering schedule during the summer irrigation season. This may be based on a municipal or area-wide published calendar related to street addresses.

General

10. Assist District in the distribution of conservation and educational materials.

11. Periodically review and evaluate this conservation plan and implement revisions to the plan as necessary.

12. Develop policies to monitor, mediate and enforce compliance with this UCP.

Commercial Drought Stage Responses

Drought Stage responses required of commercial permittees are set out in Table K-2 below.

Table K-2. District commercial drought stage responses

Drought Stage 1 – Alert Status	Drought Stage 2 – Alarm Status	Drought Stage 3 – Critical Status
Upon notification by the Barton Springs Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 1 - Alert Status, each permittee will activate Stage 1 of its UDCP. This status will be prominently noted on signs and bulletin boards in company buildings.	Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 2 - Alarm Status. Permittees will activate Stage 2 of its UDCP. Permittees will notify employees of this change in status within 4 days of notification of District declaration of Stage 2 - Alarm Status.	Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 3 -Critical Status, Permittees will activate Stage 3 of its UDCP. Permittees will notify its employees of this change in status within 2 days of notification of District declaration of Stage 3 - Critical Status.
	Goal	
• A 10% reduction in water use.	• A 20% reduction in water use.	• A 30% reduction in water use.
	Actions required by the User	
• Voluntary reduction in water use. ▪ Permittees must assist in the distribution of water conservation information and drought alert notices. • Permittees will repair all identified leaks. • Permittees will monitor any construction activity and require contractors to report line breaks immediately or shut off flow if possible. • Permittees will evaluate system pressure needs and reduce pressure where excessively high.	▪ Continued voluntary reduction in water use in general. ▪ Mandatory compliance with restrictions listed below.	▪ Continued voluntary reduction in water use in general. ▪ Mandatory compliance with restrictions listed below.
	Voluntary Reductions	
• Comply with 5 day schedule for lawn watering, between 8 p.m. - 8 a.m. • Stop regular washing of company vehicles and wash only when actually needed. • Water garden, trees, or flower beds with hand-held hose. • Check for and fix leaks. • Inform employees of need to reduce water use. • Use water displacement device in toilet tank. • Install aerators on faucets.	• Use water displacement device in toilet tank. • Install aerators on faucets. • Utilize water reuse where possible. • Inform employees of need to reduce water use.	• Use water displacement device in toilet tank. • Install aerators on faucets. • Utilize water reuse where possible. • Inform employees of need to reduce water use.

Table K-2. District commercial drought stage responses (continued)

Drought Stage 1 – Alert Status	Drought Stage 2 – Alarm Status	Drought Stage 3 – Critical Status
Required Reductions		
• None.	• Washing of company vehicles limited to once a month with bucket or hand-held hose with automatic shut-off, or use commercial car wash which recycles water. • Water garden, trees, or flower beds with hand-held hose. • Check for and fix leaks. • Comply with 5 day schedule for lawn watering, between 8 p.m. - 8 a.m. • No washing of driveways, sidewalks, or streets. • No non-essential use, i.e., decorative fountains.	• No washing of cars, drives, streets, sidewalks. • Permittees will not flush lines. • No lawn or landscape watering. • Check for and fix leaks. • No non-essential use, i.e., decorative fountains.
Penalties or Consequences		
• Warnings for excessive consumption.	▪ Warnings for excessive consumption.	• Increase in Aquifer Fees if BS/EACD institutes higher water use fees as part of District drought contingency Rules to reduce demand. • Possible prioritization of water users. • Domestic and livestock needs take precedent.

Source: BSEACD, 2005.

K.3 Industrial Users

Industrial users or permittees are required by the District to comply with District Rule 3-6.7 (November 1991). The industrial permittee UCPs will:

Employees

1. Notify all employees of UCP and of notification of drought stage declarations.

2. Post signs at all faucets, sinks, outdoor spigots, and other water sources reminding employees to use water wisely.

3. During staff meetings and when appropriate, suggest ways for employees to reduce water consumption in order to promote and encourage voluntary conservation measures.

4. Require employees to report all faulty fixtures or leaks to maintenance for repair.

Operations

5. Implement an on-going program of system leak detection and repair, which shall include the consideration and utilization of improved technology when possible.

6. Require low flow/low volume fixtures to be installed in all new construction and when replacing old fixtures, do so with low flow/low volume products.

7. Use water-efficient landscape practices including Xeriscaping®, drip irrigation, and automatic sprinkler systems.

8. Adopt a five-day watering schedule during the summer irrigation season. This may be based on a municipal or area-wide published calendar related to street addresses.

9. Investigate and promote water reuse and recycling, especially the feasibility of its inclusion in water reuse systems on new construction.

General

10. Assist District in the distribution of conservation and educational materials.

11. Periodically review and evaluate this conservation plan and implement revisions to the plan as necessary.

12. Develop policies to monitor, mediate and enforce compliance with thisUCP.

Industrial Drought Stage Responses

Drought Stage responses required of industrial permittees are set out in Table K-3 below:

Table K-3. District industrial drought stage responses

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Upon notification by the Barton Springs Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 1 - Alert Status, permittees will activate Stage 1 of their UDCP. This status will be prominently noted on signs and bulletin boards in company buildings.	Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 2 - Alarm Status, permittees will activate Stage 2 of their UDCP. Permittees will notify their employees of this change in status within 4 days of notification of District declaration of Stage 2 - Alarm Status.	Upon notification by the District that the District has declared the aquifer to be in a Drought Stage 3 - Critical Status, permittees will activate Stage 3 of its UDCP. Permittees will notify their employees of this change in status within 2 days of notification of District declaration of Stage 3 - Critical Status.
Goal		
• A 10% reduction in water use.	• A 20% reduction in water use.	• A 30% reduction in water use.
Actions Required by the User		
• Voluntary reduction in water use. • Permittee will assist in the distribution of water conservation information and drought alert notices. • Permittee will repair all identified leaks. • Permittee will monitor any construction activity and require contractors to report line breaks immediately or shut off flow if possible. • Permittee will evaluate system pressure needs and reduce pressure where excessively high.	• Continued voluntary reduction in water use in general. Mandatory compliance with restrictions listed below.	• Continued voluntary reduction in water use in general. Mandatory compliance with restrictions listed below.
Voluntary Reductions		
• Comply with 5 day schedule for lawn watering. • Stop regular washing of company vehicles and wash only when actually needed. • Water garden, trees, or flower beds with hand-held hose. • Check for and fix leaks. • Inform employees of need to reduce water use. • Use water displacement device in toilet tank. • Install aerators on faucets.	▪ Use water displacement device in toilet tank. • Install aerators on faucets. • Utilize water reuse where possible. • Inform employees of need to reduce water use.	▪ Use water displacement device in toilet tank. • Install aerators on faucets. • Utilize water reuse where possible. • Inform employees of need to reduce water use.

Table K-3. District industrial drought stage responses (continued)

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Required Reductions		
• None.	▪ Washing of company vehicles limited to once a month with bucket or hand-held hose with automatic shut-off, or use commercial car wash which recycles water. • Water garden, trees, or flower beds with hand-held hose. • Check for and fix leaks. • Comply with 5 day schedule for lawn watering, between 8 p.m. - 8 a.m. • No washing of driveways, sidewalks, or streets. • No non-essential use, i.e., decorative fountains.	▪ No washing of cars, drives, streets, sidewalks. • Permittees will not flush lines. • No lawn or landscape watering. • Check for and fix leaks. • No non-essential use, i.e., decorative fountains.
Penalties or Consequences		
• Warnings for excessive consumption.	• Warnings for excessive consumption.	• Increase in Aquifer Fees if District institutes higher water use fees as part of District drought contingency Rules to reduce demand. • Possible prioritization of water users. • Domestic and livestock needs take precedent.

Source: BSEACD (2005)

K.4 Public Water Suppliers

Public water supply permittees must adopt a User Conservation Plan as required by the Barton Springs/Edwards Aquifer Conservation District to comply with District Rule 3-6.7 (November 1991). The permittees' UCP must:

For Customers

1. Promote and encourage installation and use of water saving plumbing fixtures in existing homes. Promotion will take place through information mail outs and/or distribution of water saving devices.

2. Promote the replacement of water-using appliances with more water-efficient varieties. Promotion will take place through mail outs and creation of incentive programs.

3. Promote customer household leak detection and repair.

4. Promote and encourage water efficient landscape practices such as Xeriscaping®, drip irrigation, and automatic sprinkler systems.

5. Implement a five day watering schedule during the summer irrigation season, based on street addresses of the customers.

For System Operations

6. Implement and continue an on-going program of system leak detection and repair which shall include the consideration and utilization of improved technology when possible. Cut off vacant houses, verify there are no leaks.

7. Monitor high usage customers and provide additional support and encouragement to promote efficient and effective use and application of water by those customers to reduce wasteful practices.

8. Limit flushing of dead-end mains and fire hydrants.

   - Dead-end mains—drain only as needed to prevent stale water and/or customer complaints.

   - Fire hydrants—open twice yearly to maintain proper operation.

9. Make application for a conservation-oriented rate structure in next rate case for consideration by the Texas Natural Resource Conservation Commission (TNRCC).

10. Require applicants for service from the permittee to comply with the permittee rules, plans, and regulations as approved by the District and theTNRCC.

11. Continue program of customer meter testing and meter replacement or repair.

12. Add backflow preventers on customer’s side of meter as service is required to those meters not presently equipped.

General

13. Promote and encourage voluntary conservation measures through example at Company office(s) both indoors and outdoors.

14. Send a copy of the UCP and the UDCP to each customer.

15. Include drought stage and conservation information in customer billings.

16. Assist the District in the distribution of conservation and educational materials.

17. Periodically review and evaluate this conservation plan and implement revisions to the plan as necessary.

Public Water Suppliers Drought Stage Responses

Drought Stage responses required of public water suppliers are set out in Table K-4 below:

Table K-4. District public water suppliers drought stage responses

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Upon notification by the Barton Springs/Edwards Aquifer Conservation District that the District has declared the aquifer to be in a Drought Stage 1 - Alert Status, permittee will activate Stage 1 of its UDCP. This status will be prominently noted on the next regular billing cycle but not more than 20 days following declaration of the drought.	Upon notification by the District that the District has declared the aquifer to be in a Drought Stage 2 - Alarm Status, Permittees will activate Stage 2 of its UDCP. Permittees will notify their customers of this change in status by a special mailing or hand delivery within 7 days of notification of District declaration of Stage 2 – Alarm Status.	Upon notification by the District that the District has declared the aquifer to be in a Drought Stage 3 - Critical Status, permittee will activate Stage 3 of its UDCP. Permittee will notify its customers of this change in status by a special mailing or hand delivery within 2 days of notification of District declaration of Stage 3 - Critical Status.
Goal		
• A 10% reduction in water use. • Warnings for excessive consumption.	• A 20% reduction in water use.	• A 30% reduction in water use.

Table K-4. District public water suppliers drought stage responses (continued)

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Actions Required by the User		
• Voluntary reduction in water use.	▪ Continued voluntary reduction in water use in general. ▪ Mandatory compliance with restrictions listed below.	▪ Continued voluntary reduction in water use in general. ▪ Mandatory compliance with restrictions listed below.
Voluntary Restrictions		
▪ Comply with 5-day schedule for lawn watering (and wash cars over the lawn areas). • Reduce car washing to no more than one time every other week, or use a commercial car wash which recycles water. • Use hand held hose on garden, trees, & flowers. • Check for and fix water leaks. • Draw less water for bath or reduce shower time. • Do not let water run while shaving, dish washing, brushing teeth, etc. • Keep pool covered. • Use water displacement device in toilet tank. • Install aerators on faucets. Replacement or retrofits with ultra low flow fixtures is encouraged.	▪ Water garden, trees & flowers with hand-held hose. • Draw less water for bath or reduce shower time. • Do not let water run while shaving, dishwashing, brushing teeth, etc. • Keep pool covered. • Use water displacement device in toilet tank. • Install aerators on faucets. • Utilize water reuse where possible.	▪ Draw less water for bath or reduce shower time. • Use water displacement device in toilet tank. • Install aerators on faucets. • While waiting for hot water to reach faucet, catch cold water in a container and use on plants. • Hand wash dishes in a tub, then use water on plants or trees. • Utilize water reuse where possible.
Required Restrictions		
• None.	▪ Per Capita consumption limited to 4,000 gallons per month. • Car washing with bucket or hand-held hose with automatic shut-off only. • Comply with 5 day schedule for lawn watering, between 8 p.m. - 8 a.m. • No washing of driveways, sidewalks, or streets. • Check for and fix leaks. • No new filling or refilling of pools, but topping off of existing pools allowed. • No non-essential use, i.e., decorative fountains.	• Maximum allowable per Capita consumption limited to 2000 gallons per month. • No washing of cars, drives, streets, sidewalks. • No lawn or landscape watering. • Check for and fix leaks. • No new filling, refilling, or topping off of pools. • No non-essential use, i.e., decorative fountains.

Table K-4. District public water suppliers drought stage responses (continued)

Drought Stage 1 - Alert Status	Drought Stage 2 - Alarm Status	Drought Stage 3 - Critical Status
Penalties or Consequences		
• Warnings for excessive consumption.	• Warnings for excessive consumption. • Possible installation of flow restrictors on connections with excessive demands.	• Installation of flow restrictors after 2nd Violation of connections with excessive demands. • Service cut-off if leaks exist, waste of water is observed, or excessive demands continue. • 3rd Violation service cutoff & Reconnection Fee. • Increase in Aquifer Fees if the District institutes higher water use fees as part of District drought contingency Rules to reduce demand.

Source: BSEACD (2005).

K.5 General Permit

The General Permit UCP includes the following:

1. Replace faulty or unusable plumbing fixtures or appliances with water saving devices such as low-flow toilets, shower and faucet aerators, water-efficient dishwashers and clothes washers.

2. Choose and install water-efficient appliances and fixtures in new construction.

3. At least every six months check for leaks in toilets.

4. Repair dripping faucets and leaky plumbing promptly.

5. At least once each year, cease all water usage and check meter to determine if leaks exist in underground transmission lines.

6. Select vegetation from the list of appropriate native and naturalized plants compiled by the Lady Bird Johnson Wildflower Center when installing new or replacing landscape vegetation.

7. Implement the five-day watering schedule promoted by the District based on street address and including watering restrictions for hose-end and underground irrigation systems.

8. Wash vehicles using a hose-end sprayer with an automatic shut off or with buckets full of water and not allowing the water to continue to run from the hose when not in use.

9. Use a cover on swimming pools when possible to minimize evaporative loss of water.

10. When possible, consider alternative water supplies including but not limited to rainwater collection and alternative irrigation strategies including but not limited to drip irrigation to improve conservation of water on site.

11. Maintain record of submitted meter readings as record for future determination of possible system leaks and to quantify success of conservation practices and steps for usage reduction during drought conditions.

General Permit Drought Stage Responses

Drought Stage responses required of general permit users are set out in Table K-5 below:

Table K-5. District general permit drought stage responses

Stage I - Alert Drought	Stage II - Alarm Drought	Stage III - Critical Drought
	Goal	
• A voluntary 10% reduction in water use.	• A mandatory 20% reduction in water use.	• A mandatory 30% reduction in water use.
Actions to be Implemented	Actions to be Implemented in addition to those under Stage I	Actions to be Implemented in addition to those under Stage I and Stage II
• Observe needs of landscape and extend time between watering to more than five days. • Draw less water for bath or reduce shower time. • Do not let water run while shaving, dish washing, brushing teeth, etc. • Use variable water level setting of washing machine if available for size of load or wash only full loads of laundry.	• Water garden, trees & flowers with hand held hose. • Use water displacement device or cycle diverter in toilet tankwhen possible and function of toilet is not impaired. • Refrain from car washing. • Install aerators on faucets. • Utilize water reuse where possible. • No washing or “sweeping” of driveways, sidewalks, or streets. • Check for and fix leaks. • No new filling or refilling of pools, but topping off of existing pools allowed. Keep pool	• No lawn or landscape watering. • Refrain from car washing. • While waiting for hot water to reach faucet, catch cold water in a container and use on plants. • Hand wash dishes in a tub, then use water on plants or trees. • Utilize water reuse where possible. • No washing of cars, drives, streets, sidewalks. • No topping off of pools. • Keep pool covered.

Table K-5. District general permit drought stage responses (continued)

Stage I - Alert Drought	Stage II - Alarm Drought	Stage III - Critical Drought
Actions to be Implemented (continued)	Actions to be Implemented in addition to those under Stage I (continued)	Actions to be Implemented in addition to those under Stage I and Stage II (continued)
• Wash only full loads of dishes and use water efficient settings if available. • Reduce vehicle washing to no more than once every other week, or use a commercial car wash.	covered. • No non-essential use, i.e., decorative fountains.	

Source: BSEACD (2005)

APPENDIX L

District's Sustainable Yield Study

Note: The District conducted a sustainable yield study for the Barton Springs segment of the Edwards Aquifer in 2003-2004, as a precursor to the analyses performed as part of the District Habitat Conservation Plan. The body of the main study report, including both text and figures, is included in its entirely on the following pages as Appendix L. However, several of that report's appendices, including detailed descriptions of the groundwater availability models and modeling runs that were the basis for the sustainable yield study, are quite voluminous. They are not included here, but interested parties may access them through the District's website, at: http://www.bseacd.org/research2.html. They are identified on this link as Appendices A, B, and C:

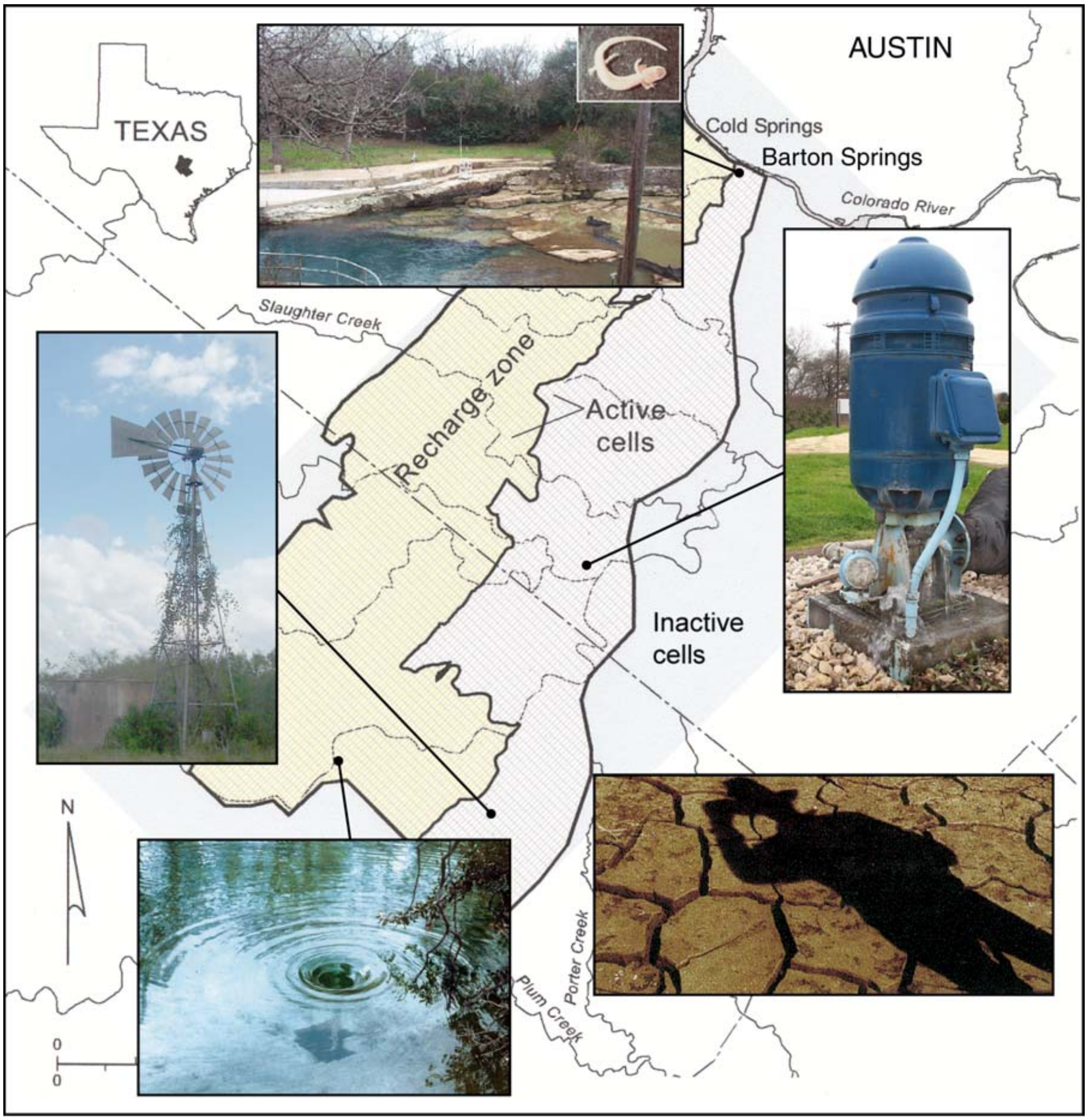
Appendix A: "Groundwater Availability of the Barton Springs Segment of the Edwards Aquifer, Texas: Numerical Simulations through the Year 2050"

Appendix B: "Sensitivity Analysis of the Southern Groundwater Divide"

Appendix C: "List of Participants and Affiliations at Sustainable Yield Meetings at the BSEACD".

Other links on this webpage may also be of interest to those needing additional information about groundwater availability modeling in general and the modeling that was initially performed by TWDB for this segment and modified in the Sustainable Yield Study.

EVALUATION OF SUSTAINABLE YIELD OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS



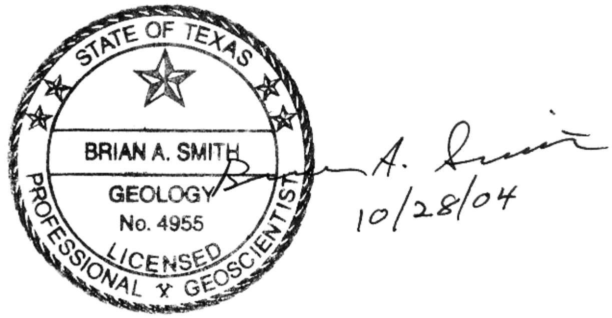
Barton Springs/Edwards Aquifer Conservation District

October 2004

Cover Illustration

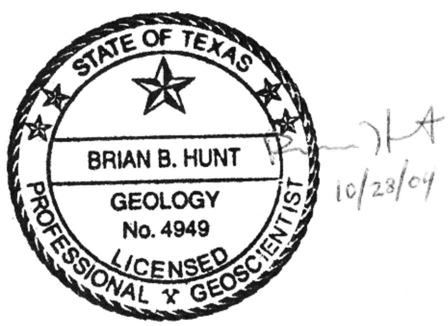
Background image of the numerical model area was modified from Scanlon et al. (2001). Photographs (clockwise from the top) include: Barton Springs Pool with low water level during cleaning and image of the endangered Barton Springs Salamander, photograph of spring by Brian A. Smith; turbine pump in the Creedmoor-Maha well field, photograph by Brian B. Hunt; mudcracks and farmer's shadow during a drought, photograph by Mike Rayner ('The Age'); whirpool formed above Cripple Crawfish Cave in Onion Creek, photograph by David Johns; windmill that serves as the District's Mountain City observation well for drought declaration, photograph by Brian B. Hunt. Cover illustration arranged by Brian B. Hunt.

EVALUATION OF SUSTAINABLE YIELD OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS



Brian A. Smith, Ph.D., P.G.

Senior Hydrogeologist, Assessment Program Manager



Brian B. Hunt, P.G.

Hydrogeologist

Barton Springs/Edwards Aquifer Conservation District

October 2004

EVALUATION OF SUSTAINABLE YIELD OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS

Barton Springs/Edwards Aquifer Conservation District
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Edited by Board Subcommittee on Sustainable Yield
Dr. Robert D. Larsen
Dr. David R. Carpenter

Technical Editing
Lana Dieterich, Bureau of Economic Geology, The University of Texas at Austin

October 2004

STATE OF TEXAS §

§ **RESOLUTION # 102804-01**

COUNTY OF TRAVIS §

A RESOLUTION OF THE BOARD OF DIRECTORS, BARTON SPRINGS EDWARDS AQUIFER CONSERVATION DISTRICT, ACCEPTING AND ENDORSING THE REPORT ENTITLED *EVALUATION OF SUSTAINABLE YIELD OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS*, BEING A SCIENTIFIC STUDY PREPARED BY DISTRICT STAFF

WHEREAS, the Barton Springs Edwards Aquifer Conservation District (the District) is a Groundwater Conservation District created by an act of the 70th Legislature and subject to various requirements of State Law governing groundwater districts, including Texas Water Code Chapter 36; and

WHEREAS, the District was established for the purpose of providing for the conservation, preservation, protection, recharging and prevention of waste of groundwater and of groundwater reservoirs in the Barton Springs segment of the Edwards Aquifer (Aquifer), and to control subsidence caused by withdrawal of groundwater from those groundwater reservoirs or their subdivisions; and

WHEREAS, the Aquifer is either a sole source or primary source of drinking water for approximately 44,000 people living and working in the central part of this state, and is a vital resource to the general economy and welfare of the State of Texas; and

WHEREAS, the District's Management Plan defines sustainable yield as the amount of water that can be pumped for beneficial use from the Aquifer under a reoccurrence of the drought of record conditions, after considering adequate water levels in water wells and degradation of water quality that could result from low water levels and low spring discharge; and

WHEREAS, the Board of Directors in 2003 instructed staff to develop and conduct a scientific investigation relative to determining the sustainable yield of the Aquifer and revising the Texas Water Development Board's currently approved Groundwater Availability Model for the Aquifer; and

WHEREAS, staff has developed and completed a report responsive to all charges assigned by the Board of Directors; and

WHEREAS, the report was subjected to an independent peer-review process by members of the Groundwater Model Advisory Team, who included, Renee Barker, Senior Hydrogeologist, United States Geological Survey; Nico Hauwert, Hydrogeologist, City of Austin and Doctoral Candidate, University of Texas at Austin; David Johns, Senior Hydrogeologist, City of Austin; Dr. Robert Mace, Director Groundwater

Resources Division, Texas Water Development Board; Dr. Bridget Scanlon, Senior Research Scientist, Bureau of Economic Geology, University of Texas at Austin; Dr. Jack Sharp, Chevron Centennial Professor in Geology, University of Texas at Austin; Raymond Slade, United States Geological Survey (retired) and Consulting Hydrologist; Eric Strom, Assistant District Chief, United States Geological Survey;

NOW, THEREFORE BE IT RESOLVED by the Board of Directors of the Barton Springs Edwards Aquifer Conservation District, that:

SECTION I

The Board of Directors accepts and endorses the report prepared by staff entitled, *Evaluation of Sustainable Yield of the Barton Springs Segment of the Edwards Aquifer, Hays and Travis Counties, Central Texas*.

SECTION II

Furthermore, the Board of Directors declares that the information presented in the report is the best science and information currently available for evaluating the sustainable yield of the Barton Springs segment of the Edwards Aquifer.

The motion passed with 5 ayes, and 0 nays.

PASSED AND APPROVED THIS THE 28th DAY OF OCTOBER, 2004.

Dr. Robert D. Larsen, Board President

Jack Goodman, Board Vice-President

David Carpenter, Board Member

Chuck Murphy, Board Member

ATTEST:

Craig Smith, Board Secretary

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PREFACE

A statutory mandate charges the Barton Springs/Edwards Aquifer Conservation District (District) with the responsibility of conserving, protecting, and enhancing groundwater resources of the Barton Springs segment of the Edwards Aquifer. Part of this responsibility is to determine the amount of groundwater available for use in the aquifer. The District considers the amount of groundwater available for use as the "sustainable yield" that is defined in Section 1.2 (Concepts and Definitions of Sustainable Yield). So that this amount may be readily determined, Texas Water Code (§ 36.1071(h)) requires the District to use results of a groundwater availability model (GAM) in conjunction with other studies or information of the aquifer. Additionally, to ensure that future water needs are met during times of severe drought, the regional water planning process (§ 16.053(a)) requires water planning to be based on drought-of-record conditions.

To fulfill these mandates, at the May 22, 2003, board meeting, the District's Board of Directors charged the Assessment Program staff with conducting an evaluation of sustainable yield of the Barton Springs segment of the Edwards Aquifer. Assessment Program staff made 11 presentations to the District's board and 2 board workshops were held during the evaluation process. Results of the evaluation were presented to the board on February 5, 2004. The purpose of this report is to present the results of that evaluation and to provide a scientific foundation for establishing sustainable-yield policies by the District for resource management.

This report is based on research conducted by many scientists and represents decades of work. Numerical modeling presented herein expands on that knowledge, specifically building on the research and modeling of Slade et al. (1985), Wanakule (1989), Barrett and Charbeneau (1996), and Scanlon et al. (2001). To assist in the evaluation of sustainable yield, the District's Assessment Program staff assembled a Groundwater Model Advisory Team (GMAT) consisting of expert scientists from the Austin area. GMAT met monthly between September 2003 and February 2004 and provided critical input and comments throughout the modeling and sustainable-yield evaluation process. GMAT is made up of:

Rene Barker, Senior Hydrogeologist, U.S. Geological Survey

Nico Hauwert, Hydrogeologist, City of Austin; Ph.D. candidate, The University of Texas at Austin

David Johns, Senior Hydrogeologist, City of Austin

Dr. Robert Mace, Director, Groundwater Resources Division, Texas Water Development Board

Dr. Bridget Scanlon, Senior Research Scientist, Bureau of Economic Geology, The University of Texas at Austin

Dr. Jack Sharp, Chevron Centennial Professor in Geology, The University of Texas at Austin

Raymond Slade, U.S. Geological Survey, retired, and Consulting Hydrologist

Eric Strom, Assistant District Chief, U.S. Geological Survey

Technical meetings were held on September 10, 2003, and March 24, 2004, for the District to receive input from a broad group of technical specialists (Appendix C). From March through April 2004 results of these studies were presented to various stakeholder groups, including the Lower Colorado River Authority (LCRA), U.S. Fish and Wildlife Service (USFWS), District permittees, news media, environmental groups, and representatives from the City of Kyle.

It is the authors' professional opinion, and the consensus of GMAT members, that the information presented herein is the best science and information currently available for evaluating sustainable yield of the Barton Springs segment of the Edwards Aquifer.

EVALUATION OF SUSTAINABLE YIELD OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS

Brian A. Smith, Ph.D., P.G. and Brian B. Hunt, P.G.

EXECUTIVE SUMMARY

The combined effects of drought and substantial pumping can result in a decline in water levels and spring flow in an aquifer. This report evaluates potential impacts on groundwater availability in the Barton Springs segment of the Edwards Aquifer (Barton Springs aquifer) during a recurrence of drought-of-record (1950's) conditions and various rates of pumping. A numerical groundwater model and hydrogeologic data were the primary tools used in this evaluation.

The Barton Springs aquifer is an important groundwater resource for municipal, industrial, domestic, recreational, and ecological needs. Approximately 50,000 people depend on water from the Barton Springs aquifer as their sole source of drinking water. Additionally, various spring outlets at Barton Springs are the only known habitats of the endangered Barton Springs salamander. The amount of groundwater available to meet current and future needs is limited, however.

A statutory mandate charges the Barton Springs/Edwards Aquifer Conservation District (District) with the responsibility of conserving, protecting, and enhancing groundwater resources of the Barton Springs aquifer. Part of this responsibility is to determine the amount of groundwater available for use in the aquifer, referred to as "sustainable yield" by the District. State law requires water planning for drought conditions and use of groundwater modeling information in conjunction with other studies or data about the aquifer. The purpose of this report is to provide scientific foundation and documentation for policy makers' use so that future water needs are met during times of severe drought.

The Barton Springs aquifer is located within parts of Travis and Hays Counties in Central Texas. It lies along the Balcones Fault Zone and is generally bounded to the north by the Colorado River, to the south by the southern groundwater divide near the City of

Kyle, to the east by the interface between the fresh- and saline-water zones, and to the west by the Balcones Fault.

A numerical model was developed for the Barton Springs aquifer (Scanlon et al., 2001; Appendix A). However, the model was constructed to match water levels and spring flow from a period wetter than that of the 1950's drought. Because the model was calibrated to a relatively wet period, it overestimates spring flow and underpredicts water-level elevations compared with measurements taken during the 1950's drought of record. The model was recalibrated so that simulated and measured spring-flow and water-level data from the 1950's drought matched better. The recalibrated model was then used to predict spring-flow and water-level declines under 1950's drought conditions and various future pumping scenarios. Hydrogeological data, such as saturated-thickness maps, potentiometric-surface maps, and well-construction and yield data, were evaluated alongside the model results so that impacts to water-supply wells under 1950's drought conditions and various rates of pumping could be estimated.

Results of the evaluations indicate that water levels and spring flow are significantly impacted by 1950's drought conditions and projected pumping. The model indicates that 10 cubic feet per second (cfs) of pumping, combined with 1950's drought conditions, produces a mean monthly spring flow of about 1 cfs. According to a minimum daily discharge of 9.6 cfs, such as that measured in 1956, spring flow could temporarily cease for periods less than 1 month. At 15 cfs of pumping, spring flow would cease for at least 4 months. Simulations indicate that a given pumping rate applied under 1950's drought conditions would diminish Barton Springs spring flow by an amount equivalent to the pumping rate. As many as 19% of all water-supply wells in the District may be negatively impacted under 1950's drought conditions and a pumping rate of 10 cfs. Negative impacts might include wells going dry, water levels dropping below pumps, or intermittent yield due to low water levels. Finally, under 1950's drought conditions and high rates of pumping, potential for saline water to flow from the saline-water zone into the freshwater aquifer would increase, impacting water-supply wells and endangered species.

Information presented herein is based on the best science and information currently available for evaluating sustainable yield of the Barton Springs segment of the

Edwards Aquifer. Results of this sustainable-yield evaluation will be considered in District sustainable-yield policies for resource management.

1.0 INTRODUCTION

The Barton Springs segment of the Edwards Aquifer (Barton Springs aquifer) is a part of a prolific karst aquifer on which approximately 50,000 people depend as their sole source of drinking water. As part of the Barton Springs/Edwards Aquifer Conservation District's (District's) role of managing groundwater extraction from the Barton Springs aquifer, the District has conducted groundwater modeling of the aquifer to help determine the amount of groundwater available for pumping from the aquifer. The principal tool for this evaluation has been a groundwater availability model developed for the Lower Colorado Regional Water Planning Group (LCRWPG) and the Texas Water Development Board (TWDB). Modifications were made to the model to evaluate the amount of spring flow at Barton Springs and potential impacts to water-supply wells during a recurrence of 1950's drought-of-record conditions using various rates of projected pumping. Aquifer conditions from the 1950's were used in this evaluation because the regional water-planning process ((Texas Water Code, § 16.053(a)) requires that water planning be based on drought-of-record conditions.

The model indicates that under 1950's drought conditions and current (2004) pumping rates of about 10 cubic feet per second (cfs), flow from Barton Springs would decrease to less than 1 cfs or cease altogether. Low flows or a lack of flow from the springs is likely to have a negative impact on Barton Springs as a recreational resource and on the endangered salamanders that live in the springs. An analysis of hydrogeologic data and model-simulated water-level drawdown due to pumping shows that, under 1950's drought conditions and current (2004), permitted pumping rates, as many as 19% of the water-supply wells in the District would be dry or experience a reduction in yield. Results of these model simulations will be used by the District to establish policies with the objective of minimizing impacts of high rates of pumping during a recurrence of 1950's drought conditions.

1.1 Purpose and Approach

The purpose of this study was to evaluate impacts of pumping and 1950's drought conditions on spring flow and water levels in wells in the Barton Springs aquifer. The evaluation was based on modification of a Groundwater Availability Model (GAM) developed for the Barton Springs aquifer by Scanlon et al. (2001) (hereafter referred to as the 2001 GAM). That model evaluated long-term groundwater availability in response to future pumping and potential future droughts. A GAM first developed in 2000 established the model framework (Scanlon et al., 2000). Modifications were made to the 2000 GAM to meet standards set by TWDB for the Barton Springs GAM. The 2001 GAM, the foundation for numerical modeling in this study, was recalibrated to better simulate 1950's drought conditions.

The approach to evaluating sustainable yield of the Barton Springs aquifer consisted of:

I. Numerical Modeling (Section 2)

- The 2001 GAM was recalibrated (hereafter referred to as the *recalibrated GAM*) by changing hydraulic conductivity and storage values to better match spring-flow and water-level data from the 1950's drought;
- The recalibrated GAM was then used to predict spring-flow and water-level declines under 1950's drought conditions and various rates of projected future pumping.

II. Water-Supply-Well Impacts (Section 3)

- A potentiometric map of water levels measured during the 1950's drought was superimposed on simulated drawdown maps for various rates of pumping to create a series of saturated-thickness maps.
- Well yield and construction data were evaluated using the potentiometric and saturated thickness maps to estimate the number of wells that might be negatively impacted under various simulated pumping rates. Negative impacts might include wells going dry, water levels dropping below the pumps, or intermittent yield due to low water levels.

1.2 Concepts and Definitions of Sustainable Yield

One commonly used definition of safe yield of an aquifer is “the amount of water which can be withdrawn from it [the aquifer] annually without producing an undesired result” (Todd, 1959). The potential for “undesired results” from excessive pumping of an aquifer is an important concept that the District considers in its role of protecting and enhancing groundwater resources of the Barton Springs aquifer. The term *sustainable yield* is used more commonly today to acknowledge limits to aquifer pumping that need to be considered in the management of an aquifer in order to minimize or eliminate undesired results (Sophocleous, 1997). The District’s task is to determine quantitatively the undesired results and what policies can be developed to minimize them.

The District defines sustainable yield 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* (Barton Springs/Edwards Aquifer Conservation District, 2003). During periods of severe drought the District is concerned about sufficient yield from water-supply wells, quality of groundwater, and quantity and quality of groundwater discharging from Barton Springs. Low-water-level conditions brought about by 1950’s drought conditions combined with high rates of future pumping could cause Barton Springs and some water-supply wells to undergo water-quality degradation because of migration of saline water from the saline-water zone into the freshwater part of the aquifer.

2.0 SETTING

The Barton Springs aquifer is an important groundwater resource for municipal, industrial, domestic, recreational, and ecological needs. Approximately 50,000 people depend on water from the Barton Springs aquifer as their sole source of drinking water, and the various spring outlets at Barton Springs are the only known habitats for the endangered Barton Springs salamander. The following sections provide the geologic and hydrogeologic framework needed for evaluating sustainable yield.

2.1 Study Area

The Barton Springs aquifer constitutes the study area. Located within parts of Travis and Hays Counties in Central Texas, the aquifer lies within the Balcones Fault Zone and is generally bounded to the north by the Colorado River, to the south by the southern groundwater divide near the City of Kyle, to the east by the interface between the fresh- and saline-water zones, and to the west by the Balcones Fault (Figure 2-1).

2.2 Previous Aquifer Studies

Previous investigations in the Barton Springs aquifer have concentrated primarily on characterizing the geology and hydrogeology of the Edwards Aquifer system. Brune and Duffin (1983) discussed the availability of groundwater during a drought in terms of spring flow and recognized that withdrawals (pumping) equal to, or greater than, the lowest recorded spring-flow measurement of 9.6 cfs (March 29, 1956) would dry up all spring flow at Barton Springs. Similarly, Guyton and Associates (1979) reported a one-to-one relationship of pumping to spring flow at Comal and San Marcos Springs in the San Antonio segment of the Edwards Aquifer (San Antonio aquifer). Senger and Kreitler (1984) discussed the hydrogeology and hydrochemistry of the aquifer.

Slade et al. (1986) presented a series of potentiometric maps, including two that represented drought conditions from 1956 and 1978. Slade et al. (1985) used a numerical groundwater-flow model calibrated to average aquifer conditions in order to simulate the effects of pumping on groundwater availability. Transient-model simulations were calibrated to a limited period (164 days) under average flow conditions and did not focus on 1950's drought conditions or the effects on spring flow. Results of their future simulations, with increased projected demand (pumping of 12.3 cfs), indicate that water levels would decline more than 100 ft in the vicinity of Kyle and that significant portions of the western aquifer would be completely dewatered.

A groundwater-flow model was developed by Wanakule (1989) to be used as an aquifer-management tool for the Barton Springs aquifer. This study identified dewatering of parts of the aquifer and decreasing spring flow as major issues to be considered in any aquifer-management scenarios.

Barrett and Charbeneau (1996) developed a lumped-parameter model of the Barton Springs aquifer that divided the aquifer into five cells, each representing a surface drainage basin associated with creeks flowing across the recharge zone. The lumped-parameter model was calibrated to 1989 through 1994 conditions. Although this model was more simplistic than the finite-difference model prepared by Slade et al. (1985), it did not simulate water levels, but showed a good match between simulated and measured spring flow for the period of simulation of 1989 through 1998. However, the lumped-parameter model appears to overpredict spring flow slightly during the 1996 drought period, when compared with measured values.

Sharp and Banner (1997) discussed hydrogeology and critical issues with regard to the Edwards Aquifer as a resource, such as endangered species and legal, political, and economic management problems. Sharp and Banner pointed out that demand on groundwater in 1996 exceeded historical availability during the droughts between 1947 and 1956 and that continued demand at or above this level would cause considerable hardship on the region when severe drought conditions recur.

The 2000 and 2001 GAMs were developed to evaluate groundwater availability and predict water levels and spring flow in response to increased pumpage and 1950's drought conditions (Scanlon et al., 2000, 2001). The 2001 GAM reduced a bias in the 2000 GAM that overpredicted spring flow during 1950's drought conditions by about 10 cfs. Good agreement was found between measured and simulated flow at Barton Springs and between measured and simulated water levels (Scanlon et al., 2001). Results of the simulations indicated that under average recharge conditions, with future pumpage conditions of 19 cfs,, water-level drawdown is small (less than 35 ft). Water-level declines are large (up to 270 ft) under future pumpage (19 cfs) and drought conditions.

The 2001 GAM predicts that spring flow would cease at a pumping rate of 15 cfs under drought-of-record conditions. However, both the 2000 and 2001 GAMs were calibrated to data from the 1990's, a period wetter than that of the 1950's drought. Because the model was calibrated to a wetter period, the 2001 GAM overestimated spring flow and generally underpredicted head elevations compared with those of measured 1950's drought conditions (Smith and Hunt, 2004). Results of the 2000 GAM, corrected for an apparent 10 cfs bias during 1950's drought conditions, predicts that spring flow will decline to rates of 4 cfs at a pumping rate of 6.3 cfs under drought-of-record conditions. The 2001 GAM model, uncorrected for an estimated bias of 2 cfs (Section 3.1—Purpose and Approach of Modeling), showed drying of Barton Springs at 15 cfs of pumpage combined with 1950's drought conditions. Both models indicate that during drought conditions, spring flow declined in direct proportion to increases in pumpage. Therefore, when corrected for estimated bias, both models indicate that under 1950's drought conditions, Barton Springs begins to experience drying at pumping rates of about 10 to 11 cfs.

Scanlon et al. (2003) demonstrated that equivalent porous media models are capable of simulating regional groundwater flow and spring discharge in a karst aquifer.

2.3 Geology

The Edwards Aquifer is composed of the Cretaceous-age Edwards Group (Kainer and Person Formations) and the Georgetown Formation (Figure 2-2; Figures 6 and 7 in Appendix A). Sediments making up the Edwards Group accumulated on the Comanche Shelf as shallow marine, intertidal, and supratidal deposits. The Georgetown Formation, disconformably overlying the Edwards Group, was deposited in a more openly circulated, shallow-marine environment (Rose, 1972).

The prolific Edwards Aquifer evolved over millions of years as the result of numerous geologic processes such as deposition, tectonism, erosion, and diagenesis. The formation of the aquifer was influenced significantly by fracturing and faulting associated with the Balcones Fault Zone (BFZ) and dissolution of limestone and dolomite units by infiltrating meteoric water (Sharp, 1990; Barker et al., 1994; Sharp and Banner, 1997).

Mapping of the Barton Springs aquifer has delineated geologic faults and several informal stratigraphic members of the Kainer and Person Formations of the Edwards Group (Rose, 1972), each having distinctive hydrogeologic characteristics (Small et al., 1996; Barton Springs/Edwards Aquifer Conservation District, 2002). The limestone units generally step down to the east, primarily because of faulting. Most faults trend to the northeast and are downthrown to the southeast, with total offset of about 1,100 ft across the study area. As a result of faulting and erosion, the aquifer ranges from about 450 ft at its thickest along the east side, to 0 ft along the west side of the recharge zone (Slade et al., 1986).

2.4 Hydrogeology

2.4.1 Aquifer Boundaries

The areal extent of the Barton Springs aquifer is about 155 mi^2. Approximately 80% of the aquifer is unconfined; the remainder is confined (Slade et al., 1985). The aquifer is bounded on the north by the Colorado River, the regional base level and location of spring discharge (Slade et al., 1986) (Figure 2-1). The east boundary 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) and a decrease in permeability (Flores, 1990). The west boundary of the aquifer is defined by the western limit of Edwards Aquifer hydrogeologic units and the BFZ (Slagle et al., 1986; Small et al., 1996) and is limited locally by saturated thickness of the aquifer.

The southern hydrologic divide between the Barton Springs aquifer and the San Antonio segment of the Edwards Aquifer (San Antonio aquifer) is estimated to occur between Onion Creek and the Blanco River, according to potentiometric-surface elevations and recent dye-tracing information (LBG-Guyton Associates, 1994; Hauwert et. al, 2004).

2.4.2 Recharge

2.4.2.1 Surface Recharge

Estimates of recharge based primarily on 3 years of continuous flow data from five of the six major creeks show that as much as 85% of the water that recharges the Barton Springs aquifer occurs within six major creek channels (Slade et al., 1986). The remaining recharge is attributed to upland areas, which include tributary streams. Recent investigations have demonstrated that most recharge infiltrates via discrete features, such as caves, sinkholes, fractures, and solution cavities within stream channels (Barton Springs/Edwards Aquifer Conservation District and City of Austin, 2001). Additional flow and recharge data are currently being collected by the USGS, City of Austin, the District, and The University of Texas at Austin to verify and further refine quantification of sources of recharge to the Barton Springs aquifer. The recharge zone is about 90 mi^2. East of the recharge zone, the aquifer is overlain by less permeable clay and limestone units, which hydraulically confine the aquifer farther east in the confined, or artesian, zone (Figure 2-1).

2.4.2.2 Subsurface Recharge

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

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

Flow (or leakage) from the Trinity Aquifer into the Barton Springs aquifer is thought to be relatively insignificant. In fact, estimates based on water quality at Barton Springs suggest that less than 1% of flow to the springs is from the Trinity Aquifer (Hauwert et al., 2004). Although leakage from the Trinity Aquifer is thought to be insignificant compared with total recharge rates, leakage may nevertheless locally impact water quality and influence water levels (Slade et al., 1986). A groundwater model of the Trinity Aquifer includes lateral groundwater leakage into the Edwards Aquifer in the San Antonio area in order for the model to simulate observed hydrogeologic conditions (Mace et al., 2000). However, where the Trinity Aquifer is in contact with the Barton Springs aquifer, the Trinity model indicates little or no lateral flow into the Barton Springs aquifer. Upward "leakage" from the Trinity Aquifer into the Edwards Aquifer is also thought to be limited and to occur locally along high-permeability fault zones (Slade et al., 1986). The District investigated the local vertical flow potential between the Edwards and (upper-middle) Trinity Aquifers using a nested well pair in the west part of the recharge zone. Results of that local investigation support the idea of limited vertical leakage from the Trinity to the Edwards Aquifer, demonstrating that actual potential for vertical flow is from the Edwards to the Trinity in the vicinity of the nested wells.

2.4.3 Discharge

Discharge from the aquifer is primarily from spring flow and pumpage from wells in the study area. Amount of subsurface discharge occurring through adjacent aquifers is unknown, although it is thought to be relatively small on the basis of a water-budget analysis for surface recharge and surface discharge (Slade et al., 1985).

2.4.3.1 Spring Flow

The largest natural discharge point of the Barton Springs aquifer is Barton Springs, located in Barton Creek about ¼ mi upstream of its confluence with the Colorado River (Figure 2-1). Barton Springs consists of four major outlets, the largest discharging directly into Barton Springs pool, a major recreational attraction of the City of Austin.

Long-term mean discharge from Barton Springs is 53 cfs (Figure 26 in Appendix A). The lowest instantaneous spring-flow measurement of 9.6 cfs was made on March 29, 1956 (Baker et al., 1986; Brune, 2002). The lowest monthly mean spring flow of 11 cfs was reported at the end of the 7-yr drought-of-record (1950's drought) during July and August of 1956 (Slade et al., 1986). Comal Springs in the San Antonio aquifer ceased flowing for about 4 months in 1956 during that drought.

Additional springs with small discharge are present along Town Lake. The largest of these is Cold Springs, which is located on the south bank of the Colorado River about 1.5 mi upstream of the mouth of Barton Creek. Measurements of spring flow from Cold Springs are limited and imprecise but range from 2.6 to 6.8 cfs (Brune, 2002; Hauwert et al., in press).

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

2.4.3.2 Pumpage

Water-supply wells in the Barton Springs aquifer include about 970 active wells that pump water for public, domestic, industrial, commercial, irrigation, and agricultural uses. About 10% of these wells have annual pumping permits issued by the District, which have so far totaled about 2.3 billion gallons (7,060 acre-ft per year, 9.75 cfs) of water in 2004. Most permitted pumpage is for public-supply and industrial purposes. Nonpermitted pumpage, such as agricultural and domestic supply, is estimated to be less than 10% of the permitted pumpage volume, or about 200 million gallons per year. The most significant volumes of permitted pumping occur in the southeast part of the aquifer (Figure 28 in Appendix A). Combined, these pumping volumes are about 2.5 billion gallons per year (7,818 acre-ft per year) and equate to a mean pumping rate of about 10.8 cfs for 2004 (Figure 2-3).

Scanlon et al. (2001) estimated that pumping would increase linearly from 9.3 cfs in 2000 to 19.6 cfs by the year 2050. Future pumping projections are described in Appendix A (Scanlon et al., 2001). These rates are rough estimates that are based on projections from LCRWPG and the Capital Area Metropolitan Planning Organization (CAMPO).

2.4.4 Groundwater Storage and Flow

The Edwards Aquifer is geologically and hydraulically heterogeneous and anisotropic, both of which strongly influence groundwater flow and storage (Slade et al., 1985; Maclay and Small, 1986; Hovorka et al., 1996; Hovorka et al., 1998). Karst aquifers, such as the Barton Springs aquifer, are commonly described as triple porosity (and permeability) systems consisting of matrix, fracture, and conduit porosity (Ford and Williams, 1992; Quinlan et al., 1996; Palmer et al., 1999). Most storage of water in the Edwards Aquifer is within the matrix porosity (Hovorka et al., 1998); therefore, volumetrically, flow through the aquifer is dominantly diffuse. However, groundwater dye-tracing studies demonstrate that significant components of groundwater flow are rapid and influenced by conduits (Hauwert et al., 2002). Hydraulic conductivity values from aquifer tests range from 0.40 to 75.3 ft/day and are log-normally distributed (Figure 27 in Appendix A). Storativity values range from 0.05 to 0.00078, reflecting unconfined to confined aquifer conditions, respectively (Scanlon et al., 2001). Heterogeneity of the aquifer is further expressed in terms of well yields, which range from less than 10 gallons per minute (gpm) to greater than 1,000 gpm. Well yields in the confined part of the Edwards Aquifer are often limited more by pump size than by aquifer properties (Schindel et al., 2004). Pump setting and well depth can also limit well yields.

The Edwards Aquifer is dynamic, with rapid fluctuations in spring flow, water levels (Figures 14 and 15 in Appendix A), and storage, reflecting changes in recharge (climatic conditions) and pumpage (demand). Water-level measurements and groundwater dye-tracing studies provide insight into groundwater-flow paths from source areas (recharge locations) to wells and springs. Groundwater generally flows west to east across the recharge zone, converging with preferential groundwater-flow paths subparallel to major faulting, and then flowing north toward Barton Springs. Although regional groundwater flow in the aquifer occurs largely under diffuse conditions, preferential flow paths were traced along troughs in the potentiometric surface, indicating zones of high permeability. Rates of groundwater flow along preferential flow paths, determined from dye tracing, can be as fast as 4 to 7 mi/day under high-flow conditions or about 1 mi/day under low-flow conditions (Hauwert et al., 2002).

2.4.5 1950's Drought

The worst drought on record for central and other parts of Texas occurred from 1950 through 1956 and is referred to as the "1950's drought" (Lowry, 1959). The mean annual precipitation of 23.1 inches during the 7-yr drought was about two-thirds of the long-term annual precipitation of 33.5 inches (Figure 4a in Appendix A). Mean annual precipitation during the last 3 years of the drought was 16.5 inches, about half the long-term average precipitation (Scanlon et al., 2001). During the 1950's drought, spring flow reached historic lows at Barton Springs and ceased at Comal Springs.

2.4.6 Trinity Aquifer

The Edwards Aquifer overlies the Trinity Aquifer system in the BFZ (Figure 2-2). Along the west part of the study area, where the Edwards Aquifer is thin, water-supply wells commonly penetrate the lower Edwards units and are completed in the Upper Trinity Aquifer. The Upper Trinity Aquifer comprises the Upper Glen Rose Formation, which satisfies, almost exclusively, domestic and livestock needs with very small (less than 5 gpm) to small (5–20 gpm) yields of highly mineralized water (relative to the Edwards Aquifer) in the Central Texas Hill Country west of the BFZ (DeCook, 1960; Ashworth, 1983; Muller and McCoy, 1987). The Upper Trinity Aquifer, consistently about 350 to 400 ft thick in Hays County, has hydraulic properties (storage and hydraulic conductivity) substantially lower than those of the Edwards Aquifer (Ashworth, 1983; Barker et al., 1994). Seasonal variations in heads in the Upper Trinity Aquifer are most dramatic in wells less than 250 ft deep. These aspects make the Upper Trinity Aquifer more susceptible than the Edwards Aquifer to the effects of drought (Barker et al., 1994).

3.0 NUMERICAL GROUNDWATER MODELING

A numerical model was developed for the Barton Springs aquifer (Scanlon et al., 2001; Appendix A) as an aquifer-management tool to help evaluate the effects of pumping on the aquifer. The numerical model was developed by The University of Texas at Austin, Bureau of Economic Geology, and the District for the Groundwater Availability Model (GAM) initiative of TWDB. GAM models are part of an effort to develop state-of-the-art, publicly available, numerical groundwater-flow models for major and minor aquifers in Texas. The 2001 GAM was recalibrated to better match spring-flow and water-level data from the 1950's drought and was used to predict spring-flow and water-level declines under 1950's drought conditions and various rates of pumping.

3.1 Purpose and Approach of Modeling

The District reviewed the 2001 GAM (Scanlon et al., 2001) to evaluate its effectiveness as a tool for helping determine groundwater availability during conditions similar to those of the 1950's drought. The District conducted extensive reviews and analyses of hydrogeologic data collected by numerous individuals and organizations over many years. The Groundwater Model Advisory Team (see Preface), a team of scientists from the Austin area, assisted the District in reviewing the data and the model.

After reviewing the results of the 2001 GAM, the team decided that the model could not simulate spring-flow or water-level conditions of the 1950's drought as well as it could simulate conditions of the 1990's. The 2001 GAM indicated that monthly mean spring flow under 1950's drought conditions with no pumping would be 13.7 cfs. The lowest monthly mean measured flow from the springs was 11 cfs in July and August 1956 (Slade et al., 1986). Subtracting a pumping rate of 0.66 cfs from 13.7 cfs gives a discrepancy of about 2 cfs between the 2001 GAM simulated results and mean measured values of spring flow. Because the 2001 and recalibrated GAMs are based on stress periods of 1 month, they may not be able to simulate conditions equivalent to those represented by instantaneous spring-flow measurements. This limitation of resolution of the models precludes a direct comparison of the model results for lowest spring flow with the lowest instantaneous measurements at Barton Springs of 9.6 cfs (Figure 3-1).

The 2001 GAM underpredicted water levels by as much as 150 ft in some parts of the aquifer relative to actual water-level measurements from the 1950's. Table 3-1 shows data representing the lowest water levels measured in nine wells during the 1950's drought and the amount of water-level adjustments necessary for model results to match measured water levels. Because of the discrepancy between measured and simulated values for spring flow and water levels of 1950's drought conditions, the District decided to recalibrate the 2001 GAM to emphasize conditions during the 1950's drought. The recalibrated model is hereafter referred to as the recalibrated GAM. The following approaches were taken in recalibrating the model:

- Hydraulic conductivity and storage values were modified from values used in the 2001 GAM to provide a better match between simulated and measured heads and simulated and measured spring flow. All other model parameters were unchanged.
- Pumping rates were set at 0.66, 10, 15, and 19 cfs for each simulation to represent 1950's pumping, current pumping, and two future-pumping scenarios, respectively.

3.2 Previous Work: 2001 GAM

A GAM was developed for the Barton Springs segment of the Edwards Aquifer by The University of Texas at Austin, Bureau of Economic Geology (BEG), and the District on behalf of the LCRWPG and TWDB (Scanlon et al., 2001). The conceptual model, design, and boundaries are described in Appendix A (Scanlon et al., 2001), and parts of the report are described only briefly here.

The GAM is a two-dimensional (one-layer), finite-difference model based on the U.S. Geological Survey's (USGS's) MODFLOW code (Harbaugh and McDonald, 1996). Processing MODFLOW for Windows (PMWIN) v. 5.1.7 was used as a pre- and postprocessor for running MODFLOW (Chiang and Kinzelbach, 2001). The model consists of a single layer with 120 rows, 120 columns, and 7,043 active rectangular cells 1,000 ft long and 500 ft wide (Figure 29 in Appendix A).

The north boundary of the model is the Colorado River, which is the regional base level (Slade et al., 1986). The east boundary is the bad-water line that is thought to have minimal contribution via leakage (Senger and Kreitler, 1984; Slade et al., 1986; Hauwert et al., 2004). The south boundary is a hydrologic divide along Onion Creek in the recharge zone and between the cities of Buda and Kyle in the confined part of the aquifer (LBG-Guyton Associates, 1994). The west boundary is the Mount Bonnell fault, which acts as a hydrologic barrier to flow (Senger and Kreitler, 1984). All boundaries are simulated as no-flow boundaries in the model, as described earlier in Section 2.4.2.2 (Subsurface Recharge).

Ten zones of hydraulic conductivity resulted from steady-state calibration, with values ranging from 1 to 1,236 ft/day (Figure 30 in Appendix A). Recharge values were distributed to stream cells across the recharge zone on the basis of recharge estimates from flow-loss studies. Interstream recharge was set at 15% of the total recharge (Slade et al., 1986). For 7-yr drought-of-record simulations, recharge was assumed to equal discharge (1950 through 1956).

As required by TWDB for its GAM contracts, the model was run in five 10-yr periods to simulate aquifer conditions from 2001 through 2050. Each 10-yr period simulated 3 years of average flow conditions, followed by 7 years of drought conditions, which mimicked the drought of the 1950's. Monthly stress periods were used for transient simulations, resulting in a total of 120 stress periods for a 10-yr simulation. Recharge and pumpage were set for each stress period. Pumping rates were increased linearly over that period, with pumping at the end of 2050 (19 cfs) representing 2.1 times the pumping rate at the beginning of 2001.

Transient simulations of the 2001 GAM were calibrated to conditions from 1989 through 1998. Simulated values for spring flow during this period, plotted with measured spring-flow values, are shown in Figure 36 in Appendix A. Spring flows ranged from 17 cfs in August 1997 to about 123 cfs in 1992. For this calibration period, peak spring-flow values might have been higher than those shown in Figure 36 in Appendix A for 1992 because floodwaters overtopping the upstream pool dam may have distorted accurate measurement of spring flow.

Pumping from permitted wells was assigned to cells on the basis of pumping records at the District. Estimates of exempt well pumping were calculated from countywide estimates and assigned equally to all active cells. During each simulation, pumping rates changed monthly as a result of seasonal demand.

The Drain package of MODFLOW represents Barton Springs and Cold Springs, with a high drain-conductance value to allow unrestricted discharge. To estimate spring flow from Barton Springs, spring flow output from the model was reduced 6% to account for flow discharging from Cold Springs.

3.2.1 2001 GAM Simulations

Good agreement was found in the 2001 GAM between measured and simulated flow at Barton Springs and between measured and simulated water levels (Scanlon et al., 2001). The root mean square (RMS) error between measured and simulated discharge for the transient model is 12 cfs, which represents 11% of the range in discharge measured at Barton Springs (1989 through 1998). Spring flow during periods of high flow (more than 100 cfs of spring flow) is overpredicted by the 2001 GAM (Figure 36 in Appendix A). The 2001 GAM generally reproduced water levels monitored continuously in wells throughout the study area (Figures 38 and 39 in Appendix A). The RMS error of 29 ft represents 11% of the water-level drop in the model area during low-flow conditions (March and April 1994) (Figure 40 in Appendix A).

Results of the simulations indicated that under average recharge and future pumpage conditions (19 cfs) water-level drawdown is small (less than 35 ft). Water-level declines are large (as much as 270 ft) under future pumpage (19 cfs) and when combined with 1950's drought conditions. Predicted spring flow is 0 cfs in response to pumping 19 cfs under 1950's drought conditions.

3.3 Transient-Model Recalibration

Incremental changes were made through trial and error to specific yield, specific storage, and hydraulic conductivity values to recalibrate the transient portion of the 2001 GAM to 1950's drought conditions. The recalibrated GAM was run with the adjusted parameters, and model output was reviewed for spring-flow and water-level responses to parameter changes. Between model runs, changes were made to one parameter at a time. Further adjustments were made to parameters until simulated spring flow and water-level values were deemed to agree adequately with measured values from the 1950's drought.

By the end of recalibration, specific yield was decreased from 0.005 to 0.0021, and specific storage was decreased from 1.0×10^{-6} to 5.0×10^{-7}. Revised hydraulic conductivity values range from 0.3 to 740 ft/day (Table 3-2 and Figure 3-2), compared with a range of 1 to 1,236 ft/day in the 2001 GAM. Hydraulic conductivity and storage values for the aquifer under 1950's drought conditions were expected to be lower because of differences between the shallow part of the aquifer, where dissolution of the limestone and conduit development would be greater than at greater depths in the aquifer (Ogden et al., 1986; Maclay, 1995; Small et al., 1996). Additionally, specific-capacity tests have been performed in one well in the Barton Springs aquifer during high- and low-flow conditions. Results indicated that hydraulic parameters were lower under low-flow conditions (Raymond Slade, personal communication).

3.3.1 Water Levels

Nine wells were identified as having an adequate number of water-level measurements from the 1950's to recalibrate the 2001 GAM to low-flow conditions. An additional well measurement from the 1978 drought was added to this data set for better geographic coverage. Table 3-1 shows the lowest measured values for water levels in 10 wells with 1950's water-level data, plus simulated water-level values from the 2001 GAM and from the recalibrated GAM. The RMS error between measured water levels and simulated water levels in the 10 wells was improved to 6% using the recalibrated GAM, compared with 25% using the 2001 GAM. TWDB contract requirements request less than a 10% RMS error in water levels for the steady-state model. Water levels from the end of simulated 1950's drought conditions are plotted against measured values from the 1950's drought in Figure 3-3. In addition to a lower RMS error for results of the recalibrated model, the coefficient of determination (R^2) value of 0.94, using linear regression procedures, indicates a good match between simulated and measured values. The R^2 value for a perfect fit between data sets would be 1.0. For this same time period, R^2 value of the 2001 GAM results is 0.64.

The recalibrated GAM provides a good match between simulated water levels and measured water levels during periods of lowest flow, particularly during July and August 1956 (Figure 3-4). The simulation of 1950's drought conditions includes periods when recharge increases to near-average conditions, such as in 1953, which brought the aquifer briefly out of severe drought. During these periods, simulated water-level elevations in the recalibrated GAM are overpredicted when compared with measured values. This overprediction of water levels during these periods may be due to the inability of the model to simulate high rates of conduit flow during high water-level conditions. However, the recalibrated GAM succeeds in adequately simulating periods of low flow, such as during 1952 and 1954 through 1956 (Figure 3-4).

3.3.2 Spring Flow

Simulated and measured monthly mean spring-discharge values from the 1950's drought show good agreement in both the 2001 and recalibrated GAMs (Figure 3-5a), with very good agreement for periods when spring flow is below 20 cfs in the recalibrated GAM (Figure 3-5b). In the recalibrated GAM, RMS error between measured and simulated discharge for the entire 1950's drought is 13.8 cfs, which represents 23% of the range of measured discharge fluctuations. The 2001 GAM data set has an RMS error of 12.4 cfs, which represents 21% of the range of measured discharge for the same period. However, for periods of low flow below 18 cfs, the recalibrated GAM data set has a better match to measured values than the 2001 GAM, achieving an RMS of 6.0 cfs, or 10% of the range of measured discharge. The 2001 GAM achieves an RMS of 9.7 cfs, or 16% of the range of measured discharge for the same low flow period.

Amount of pumping estimated for the 1950's of 0.66 cfs (an annual rate of 478 acre-ft/yr) was incorporated into the recalibrated GAM (Brune and Duffin, 1983). The 2001 GAM indicated that spring flow under 1950's drought conditions with no pumping would be 13.7 cfs. The lowest monthly mean flow from the springs was 11 cfs from four flow measurements in July and August 1956 (Slade et al., 1986). The lowest daily flow measurement ever recorded was 9.6 cfs, which occurred on March 29, 1956 (Brune, 2002). Subtracting a pumping rate of 0.66 cfs from 13.7 cfs gives a discrepancy of about 2 cfs between 2001 GAM simulated results and measured values of spring flow. The recalibrated GAM was able to produce a spring-flow value of 11 cfs, matching the lowest monthly mean for measured spring flow.

3.3.3 Sensitivity Analyses

Following TWDB requirements for GAM contracts, sensitivity analyses were conducted on the recalibrated GAM to assess the impact of varying certain aquifer parameters, such as recharge, specific yield, and specific storage, on simulated spring flow and water levels in various wells. Because of convergence problems with the 2001 GAM for adjustments of some parameters, only those analyses that were reported in the 2001 GAM report (Scanlon et al., 2001) were tested during evaluation of the recalibrated model. Results of these sensitivity analyses are presented in Figures 3-6 through 3-9. Sensitivity analyses were not conducted to test responses to variations in pumping because the scenarios for future conditions use various pumping rates. Of the parameters tested, changes in recharge had the most significant impacts on spring flow and water levels. Changes to specific yield and specific storage had similar impacts on spring flow, although water levels are more sensitive to changes in specific storage than specific yield. By changing specific storage from 5.0×10^{-7} to 5.0×10^{-6}, range of simulated water levels was reduced considerably. Spring flows were not impacted significantly by increasing specific storage and specific yield by a factor of 10, but lower end spring-flow values increased slightly. Because concerns about the aquifer are primarily for low-flow conditions, small changes in spring flow under these conditions are significant.

3.4 Predictions

3.4.1 Pumping

Pumping data for each simulation incorporated changes in pumping due to seasonal demand, as originally constructed in the 2001 GAM. The 2001 GAM considered impacts to spring flow and water levels over a 50-yr period, with steadily increasing pumpage. Because a drought similar to that of the 1950's could occur at any time in the future, the recalibrated GAM simulates 1950's drought conditions under pumping rates mentioned earlier. The purpose of this approach is to avoid any implication that any particular set of aquifer conditions or impacts might occur at a particular future date.

3.4.2 Impacts to Spring Flow and Water Levels

For effects of specific pumping rates on water levels and spring flow under 1950's drought conditions to be determined, pumping rates of 0.66, 5, 10, 15, and 19 cfs were evaluated in the recalibrated GAM. At a pumping rate of 0.66 cfs, the model predicts flow at Barton Springs to be 11 cfs, which is the same as the measured monthly mean flow (Figure 3-10), but 1.4 cfs more than an instantaneous flow measurement of 9.6 cfs reported for March 29, 1956. At 5 cfs of pumping (not shown in Figure 3-10), simulated spring flow decreases to a monthly mean of about 6.5 cfs. At 10 cfs of pumping, which is the estimated amount of pumpage in 2004, the model predicts that spring flow will be about 1 cfs averaged over 1 month. According to a minimum daily discharge of 9.6 cfs measured in 1956, spring flow may temporarily cease for periods less than 1 month. At a pumping rate of 15 cfs, simulated spring flow will be 0 for at least 4 months. Model simulations suggest a nearly one-to-one relationship between pumpage and spring flow. This relationship is in agreement with the conceptual model of previous investigators (Brune and Duffin, 1983) and historical water-balance analysis (Sharp and Banner, 1997).

To illustrate the impacts to spring flow from the combined effects of 1950's drought conditions and pumping, two potentiometric surface maps were prepared comparing the effects of 19 cfs pumping during both average flow conditions and 1950's drought conditions (Figure 3-11). The equipotential lines for average flow conditions with 19 cfs of pumping show that groundwater flow in the west part of the aquifer is primarily from west to east. Near the boundary between recharge and confined zones, flow turns to the northeast, toward the springs. This pattern of flow matches well with potentiometric surface maps prepared from measured water levels in as many as 175 wells across the aquifer. Under 1950's drought conditions with 19 cfs of pumping, flow in the west part of the aquifer is again from west to east. However, near the boundary between the recharge and confined zones, flow is to the southeast. This is the area in which primary pumping wells are concentrated (Figure 28 in Scanlon et al., 2001). Potentiometric surface lines show that flow is converging on a broad area north and south of Buda. Under these conditions there is no flow from the springs, and water levels are about 18 ft below the elevation of Barton Springs. Section 4.0 (Impacts to Water Levels and Water-Supply Wells from 1950's Drought Conditions and Pumping) discusses in detail potential impacts to water-supply wells due to pumping at various rates under 1950's drought conditions.

Under low-flow conditions, additional gains and losses of groundwater could affect availability of usable groundwater for wells and flow at Barton Springs. Other potential sources include the Trinity Aquifer, part of the Edwards Aquifer south of the southern groundwater divide, the saline-water zone, cross-aquifer flow via poorly constructed wells, and urban leakage (water and wastewater). The volume of contributing flows from Trinity leakage, the saline-water zone, and gains and losses in groundwater from the San Antonio aquifer appears to be less than 1% of the total spring flow during droughts (Hauwert et al., 2004). Additionally, during periods of drought, water levels in the Trinity and San Antonio aquifers will also be low, with a low potential for substantial flow from these sources. However, the quality of water from the saline-water zone, the Trinity Aquifer, or infrastructure leakage may be poor and significantly degrade water in the Barton Springs aquifer, potentially rendering it unsuitable for drinking or for endangered species. Future studies are required to quantify these influences.

Although these factors that could potentially affect spring flow were not specifically simulated in the 2001 and recalibrated GAMs, simulation results can be compared with historic measured values of Barton Springs flow to examine whether the sum of recharge sources was accurately assessed. Because discharge is assumed to equal discharge for the 1950's drought, the 2001 and recalibrated GAMs indirectly account for these potential additions of water at spring-flow rates as low as 11 cfs. Furthermore, pumpage increases within the Trinity Aquifer source area west of the Barton Springs aquifer can be expected to reduce contributions that were experienced in the 1950's.

3.5 Qualifications and Data Needs

All models have limitations on how they simulate a real system. Because this model simulates a karst aquifer that consists of diffuse, fracture, and conduit flow of groundwater, its limitations are associated primarily with its ability to simulate conduit flow. The 2001 and recalibrated GAMs use zones of high hydraulic conductivity near the springs to approximate conduit flow. This works well for simulating potentiometric maps, spring flow, and regional groundwater flow, but it is unsuitable for simulating travel times (Scanlon et al., 2003).

The 1950's simulation period contains times when rainfall and recharge increase to near-average conditions, such as in 1953, bringing the aquifer briefly out of severe drought. During these periods, simulated water-level elevations are overpredicted when compared with measured values, owing to the dynamic nature of the karst system and the inability of MODFLOW to explicitly simulate conduit flow. It is recommended that the District evaluate the potential of new groundwater models, as they become available, that can incorporate conduit flow. In the future, a karst groundwater modeling initiative at the Southwest Research Institute may provide such a model (Ron Green, personal communication). Another option may be a revision to the modeling pre- and postprocessor, Groundwater Vistas, which will allow for variable hydraulic conductivities as a function of saturated thickness (Robert Mace, personal communication).

Any future groundwater model in the Barton Springs aquifer will be limited by the number of surface and subsurface recharge data available. The 2001 GAM uses stream-flow and stream-loss data to estimate surface recharge for the transient period of 1989 through 1998. Future scenarios were based on 1950's drought conditions for which no recharge data are available. To estimate recharge, the 2001 GAM had spring discharge equal to recharge, and the recalibrated GAM incorporates this same assumption. Recharge may be slightly overestimated during low recharge periods because some of the water being discharged may be coming from aquifer storage rather than directly from recharge (Scanlon et al., 2001). The District, City of Austin, and the Texas Commission on Environmental Quality (TCEQ) are currently funding USGS flow stations on all major upstream and downstream locations of the recharge zone in order to gauge recharge.

Additional studies are needed to better characterize the potential for flow in or out of the aquifer at its boundaries. These areas include:

(1) *Southern groundwater divide*. The groundwater model currently being developed for the San Antonio aquifer could be used to quantify the amount of water that might flow between Barton Springs and San Antonio aquifers under various

aquifer conditions. This model incorporates the Barton Springs aquifer within the model area. A water flux could be determined for a line of cells near the groundwater divide. Simulated water levels from the San Antonio model could be used to establish a time-varying specified-head boundary for the Barton Springs model (Appendix B). Additional groundwater dye tracing coupled with detailed potentiometric map studies may also provide further insight into flow along the boundaries.

(2) *Edwards-Trinity connection*. Additional monitor well pairs could be installed to measure head differences between Edwards and Trinity Aquifers. An effective method for determining vertical hydraulic gradients between aquifers would be to install one or more multiport monitoring wells. Such a well would be completed with multiple zones in both the Edwards and Trinity Aquifers that could indicate the potential for flow between different hydrogeologic units. Synoptic water-level data could be collected from wells in areas for which both Edwards and Trinity wells are available to compare potentiometric surfaces between aquifers. Potential impacts on water quality at Barton Springs and in water-supply wells due to flow from the Trinity into the Edwards Aquifer are poorly understood. Losses and gains of water via interaquifer flow due to poorly constructed wells are also unknown.

(3) *Saline-water line*. Additional studies are needed to determine potential for migration of saline water into the freshwater part of the aquifer and potential impacts on water quality at Barton Springs and in water-supply wells near the saline-water line.

(4) *Influence of urban recharge*. Studies currently being conducted at The University of Texas at Austin suggest that a significant amount of subsurface recharge due to losses from water-supply, storm-water, and sewer lines could be occurring. During periods of severe drought (1950's drought conditions), the amount of water available from urban recharge might make up a significant part of recharge to the aquifer. Potential impacts on water quality at Barton Springs and in water-supply wells from urban recharge are poorly understood. As those studies are completed, results could be incorporated in the District's modeling.

3.6 Major Findings

- The recalibrated GAM provides a better match between simulated and measured spring-flow and water-level values under 1950's drought conditions than does the 2001 GAM.

- Recalibrated GAM simulations indicate that for each 1 cfs of groundwater pumped from the aquifer under 1950's drought conditions, discharge from Barton Springs will diminish by about 1 cfs.

- The recalibrated GAM simulates a mean monthly spring flow of about 1 cfs, with the present (2004) pumping rate of 10 cfs under 1950's drought conditions. According to a minimum daily discharge of 9.6 cfs measured in 1956, spring flow may temporarily cease for periods of less than 1 month. At 15 cfs of pumping, spring flow will cease for at least 4 months.

- Simulations of 1950's drought conditions with present (2004) and future rates of pumping indicate that significantly lower water levels will occur in most parts of the aquifer, resulting in an increased potential for flow from sources with poor water quality, such as the saline-water zone.

4.0 IMPACTS TO WATER LEVELS AND WATER-SUPPLY WELLS FROM 1950'S DROUGHT CONDITIONS AND PUMPING

The combined effects of drought and significant pumping can result in a decline in water levels and spring flow in an aquifer. Municipal water supplies in some areas of Texas declined or were exhausted completely during the 1950's drought (Lowry, 1959). Declining water levels due to drought and pumping will have negative effects on water-supply wells in a variety of ways, including increased energy costs, deterioration of water quality, water levels declining below pumps or well bores, and well yields that decline below usable rates (Bartolino and Cunningham, 2003). For the Barton Springs aquifer, these effects will profoundly impact wells that partly penetrate the aquifer and where dewatering of the aquifer occurs. Earlier discussion stated that current demand on groundwater in the Edwards Aquifer may exceed the historical availability during the 1950's drought and would cause considerable hardship on the region when severe drought conditions recur (Sharp and Banner, 1997).

To assess these potential hardships, this section describes methods used to characterize and quantify impacts to water-supply wells under 1950's drought conditions with increasing demand on groundwater. Hydrogeological, structural, and well data were used, along with results from the recalibrated GAM to estimate potential impacts to water-supply wells due to 1950's drought conditions and increasing rates of pumping. Results of this study indicate that water levels are significantly impacted by 1950's drought conditions alone and that even greater impact occurs when effects of pumping are combined with 1950's drought conditions.

4.1 Methods

About 970 active water-supply wells are in the District that pump water from the Barton Springs aquifer for public, domestic, industrial, commercial, irrigation, and agricultural purposes. Pumping from the Barton Springs aquifer under 1950's drought conditions could negatively impact many of these wells. In general terms, *negative impacts* to wells occur when instantaneous demand from a well is not met. The number of wells that could be negatively impacted by low water levels was evaluated using two methods:

- Saturated aquifer thickness analysis: assessing the number of wells having low specific capacity that are located in areas having less than 100 ft of saturated aquifer thickness in the unconfined zone and
- Saturated borehole thickness analysis: assessing the total number of wells throughout the study area that partly penetrate the aquifer, resulting in less than 25 ft of saturated borehole.

Each of these methods requires evaluation of changes in saturation of the aquifer and well boreholes using measured and model-simulated data. Data sets used in the evaluation, including structure-contour maps, potentiometric maps, simulated drawdown, and well information, are described in the subsections following.

A small number of the same wells may be included within each evaluation. However, attempts to eliminate duplicate counts of wells do not appear possible because one is a broad, percentage-based evaluation and the other is a well-by-well evaluation.

4.1.1 Data Sets

An evaluation of saturated aquifer thickness and saturated borehole thickness relies heavily on several key data sets and maps described in the subsections following. Contouring of all surfaces was done using the grid-based graphics program Surfer® in the UTM-feet coordinate system (NAD 83). Kriging was used for generating contour surfaces because it produced the most realistic contours. Grid size of cells was about 1,200 × 1,500 ft, according to distribution and density of data sets within Surfer®.

4.1.1.1 Structure-Contour Maps

The primary data set (245 wells) for the structure-contour surface of the bottom of the aquifer was derived from driller's descriptions, geophysical logs, geotechnical logs, and core data (Figure 4-1). Geologic contacts and geologic maps (Small et al., 1996) were also used for control. Faulting was not incorporated into the gridding process; limited faulting incorporated into the gridding process did not appear to have a profound effect on contour shapes owing to the relatively high density of data. The top of the basal nodular member of the Kainer Formation was used as the effective bottom of the aquifer in this study. This member is about 50 ft thick in the study area and, despite localized karst development where exposed at the surface, it appears to have low permeability and storage compared with that of the rest of the Edwards Group (Small et al., 1996). These hydraulic characteristics of the basal nodular are evident from a few widely spaced well-drilling observations. In contrast, at many localities where the basal nodular is exposed at the surface, the unit characteristically contains light-toned, recrystallized rock having abundant springs and solution cavities that suggest a high permeability. Furthermore, in many driller's and geophysical logs, the top of the basal nodular member can be distinguished more readily than the top of the Glen Rose Formation. For the purposes of estimating the bottom of the aquifer, the top of the basal nodular was assumed to be the base of the Edwards Aquifer, even though the basal nodular is clearly a part of the Edwards Aquifer. In many areas elevation of the bottom of the aquifer was derived by applying known total aquifer thickness and unit thicknesses from well-defined, stratigraphic control points.

To characterize change in thickness of the aquifer as it relates to groundwater availability, an isopach (thickness) map of the lithologic units in the recharge and confined zones was created (Figure 4-2).

4.1.1.2 Potentiometric Maps

For a potentiometric map representing 1950's drought conditions to be constructed, water-level data since 1937 were collected from the TWDB database and reports and USGS reports (Follet, 1956; DeCook, 1960; Slade et al., 1986). Limited water-level data from the 1950 through 1957 drought period exist. A composite potentiometric-surface map was constructed using July and August 1956 water-level data as the base data set. Additional 1950's water-level data were adjusted in elevation to better match the July and August 1956 period when possible, and additional water-level data from low-spring-flow periods were used. The final data set used to construct the composite potentiometric-surface map representing 1950's drought conditions has about 50 control points within the District boundaries (Table 4-1; Figure 4-3).

The composite potentiometric-surface map generally contains a steep west-east gradient along the west (unconfined) part of the aquifer. The gradient decreases toward the confined part of the aquifer, and direction of flow changes from W-E to SW-NE, which is similar to other potentiometric-surface maps that were constructed with many more data points. The composite potentiometric-surface map created by these procedures is similar in shape, gradient, and elevation to the 1950's map in Slade et al. (1986). However, most significant differences in the maps occur in the area of interest along the western Edwards Aquifer, with some elevations being more than 50 ft higher in elevation in the Slade et al. (1986) map. The map constructed in this study contains more control data in this area, which may account for these differences.

4.1.1.3 Simulated Drawdown

The recalibrated GAM was used to simulate drawdown in 41 wells at pumping rates of 5, 10, 15, and 19 cfs (Table 4-2). Some of these wells also have historical water-level data. Simulated drawdown was calculated as the difference in water levels between simulated 1950's drought conditions (with 0.66 cfs pumping) and simulated 1950's drought conditions for each pumping scenario listed earlier. Data were gridded and contoured to create drawdown surfaces. Figure 4-4 is an example of the drawdown contour map with 10 cfs pumping. Each of these simulated drawdown surfaces was subtracted from the potentiometric map representing measured 1950's drought conditions. Resulting potentiometric maps were created to quantify impacts under drought with pumping scenarios described earlier. Figure 4-5 is an example of a potentiometric map representing combined effects of 1950's drought and 10 cfs of pumping.

4.1.1.4 Well Data

Specific capacity is defined as well production per unit decline in head and is a function of the aquifer and well setting and pumping rate and duration (Mace et al., 2000). In this study, specific-capacity data throughout the aquifer were used to characterize the percentage and magnitude of drawdown in wells from pumping. Specific-capacity data were assembled from well schedules and pumping-test reports and reviewed to improve data quality. A total of 168 measurements were compiled from various hydrologic conditions, 29 of which are from long-term aquifer pumping tests, and they have a broad distribution of values. No attempts were made to normalize the specific-capacity data to aquifer thickness (unit specific capacity). The data show heterogeneity distributed across the aquifer; however, the lowest values are located primarily within the western, unconfined area of the aquifer and along the saline-water zone on the east side of the aquifer (Figure 4-6a and 4-6b).

Wells drilled to produce water in the Edwards Aquifer range in depth from 40 to 800 ft, with an average well depth of about 400 ft. Distribution of well depths is not systematic across the aquifer. A District review of wells reported to have "gone dry" or that had yield problems during a drought revealed that cable-tool drilling, a drilling technology largely unused today, was responsible for many shallow-penetrating wells.

4.1.2 Saturated Aquifer Thickness Analysis

Maps of saturated aquifer thickness were created from three types of data: (1) the structure contour of the bottom of the aquifer, (2) potentiometric maps representing measured 1950's drought conditions, and (3) simulated drawdown for various pumping rates. Saturated-thickness maps in the unconfined zone were created using the following mathematical relationship at each grid node:

$$b_{wt} = (H_t - s) - A_b \quad (1)$$

where b_{wt} is saturated thickness of the water-table aquifer (in feet), H_t is the total measured hydraulic head representing 1950's drought conditions in feet above mean sea level (msl), s is the hydraulic head loss due to pumping (in feet), and A_b is the elevation of the bottom of the aquifer in feet above msl.

For purposes of this evaluation, 100 ft of saturated aquifer thickness was defined as sufficient to derive adequate water supplies for wells in the unconfined aquifer. This number is a reasonable thickness based on distribution of wells on nondrought saturated-thickness maps and amount of drawdown that occurs for low-yield wells along the west part of the aquifer. Specific-capacity data were compiled and mapped to determine range and distribution of well yields in the unconfined aquifer (Figure 4-6a and 4-1b). In the unconfined zone, 13% of 113 specific-capacity values were less than or equal to 0.17 gallons per minute per foot (gpm/ft). These wells have more than 100 ft of drawdown for a constant pumping rate of 15.9 gallons per minute (gpm). From 184 measurements, average pumping rate for domestic supply wells was determined to be 15.9 gpm.

According to this general approach, those wells will most likely experience problems producing water because drawdown in the borehole will exceed the saturated thickness of the aquifer under these conditions. For example, under 1950's drought conditions with minimal pumping (0.66 cfs), it is estimated that 230 wells may have less than 100 ft of saturated aquifer thickness, and it is estimated that of that total number, 13%, or 30 wells, will experience yield problems. It is assumed that all wells in this analysis penetrate the entire thickness of the aquifer because these wells are generally in the thinnest part of the aquifer.

4.1.3 Saturated Borehole Thickness Analysis

Quantification of the number of wells that would be impacted by combined effects of lower head and partial penetration of the aquifer by a well requires three types of data: (1) location and elevation of the bottom of the well borehole, (2) a corresponding potentiometric surface elevation representing 1950's drought conditions, and (3) drawdown from pumping scenarios. The saturated borehole for each well was determined using the following mathematical relationship:

$$b_s = H_t - W_b \tag{2}$$

where b_s is saturated borehole thickness (in feet), H_t is total hydraulic head (in feet above msl), and W_b is elevation of the bottom of the borehole (in feet above msl). Hydraulic head for each well having sufficient depth and location information (614 wells) was determined from residuals on potentiometric surface maps in Surfer®.

As in the saturated-thickness evaluation, it is recognized that a negative impact to a well would likely occur before the saturated thickness of a well borehole reached 0 from drought and regional pumping. For this part of the evaluation, 25 ft of saturated borehole was defined as sufficient for deriving adequate water supplies. This number results from recognition that well pumps are generally not set at the bottom of the borehole and the confined part of the aquifer generally has specific-capacity values that are higher than those of the unconfined zone. Therefore, wells in this area would experience less drawdown. For example, under 1950's drought conditions with minimal pumping (0.66 cfs), it is estimated that 43 of the 970 water-supply wells in the District may have less than 25 ft saturated borehole thickness and will therefore have problems with yield.

4.2 Results

The saturated thickness of the aquifer is shown in Figure 4-7 under 1950's drought conditions and minimal pumping (0.66 cfs). The cross-sectional expression of this surface is shown in Figure 2-2. A significant part of the unconfined aquifer in the recharge zone is likely to have little to no water available for water-supply wells under 1950's drought conditions. Figure 4-8 is a composite map of the 100-ft saturated-thickness contour lines under 1950's drought conditions with various pumping scenarios (0.66, 5, 10, 15, and 19 cfs). This figure shows effective drawdown of the aquifer with each scenario of increased pumping under 1950's drought conditions as the 100-ft saturated-thickness contour line moves east with higher rates of pumping. The most significant decrease in saturated thickness occurs along the southwest part of the unconfined aquifer, with the greatest shift in contours between high flow and 1950's drought conditions (Figure 4-8). Drawdown of water levels is small in the north part of the aquifer near the springs and the Colorado River, although even small changes in water levels in this area are associated with significant changes in spring flow. Table 4-3 lists the number of wells located west of the saturated aquifer contour line, which indicates that they have less than 100 ft of saturated aquifer thickness available. For given demand (15.9 gpm) and well yield (Sc= 0.17 gpm/ft), these wells will most likely have insufficient yield as a result of drawdown of the aquifer from 1950's drought conditions and increased pumping. Under 1950's drought conditions and minimal pumping (0.66 cfs), it is estimated that 230 wells may have less than 100 ft of saturated aquifer thickness, and it is estimated that of that total number, 13%, or 30 wells, will experience yield problems.

Under 1950's drought conditions and increased demand, water levels in the confined zone decrease. Although saturated thickness of the aquifer is not severely impacted in the confined zone under these scenarios, decreases in water levels under 1950's drought conditions and increased pumping shift the boundary of unconfined to confined conditions to the east (Figure 2-2). Under 1950's drought conditions and 19 cfs of pumping, nearly the entire aquifer is hydraulically unconfined.

Water-level decreases will leave some wells with less than 25 ft of saturated borehole (Table 4-4). These wells will most likely have insufficient yield owing to the dewatering of the well borehole primarily because of lower water-level values and partial penetration of the aquifer by the borehole. Under 1950's drought conditions with minimal pumping (0.66 cfs), it is estimated that 43 of the 970 water-supply wells in the District may have less than 25 ft of saturated borehole thickness and will therefore have problems with yield.

Total number of wells estimated to be impacted by drawdown of water levels is shown in Table 4-5 and in Figure 4-9. Public water-supply systems in operation in the District at the time this report was generated were evaluated to determine whether there was likely to be any impact under 1950's drought conditions and various rates of pumping. Only two public water-supply systems in the southwest part of the aquifer were found to have insufficient aquifer saturation under 1950's drought conditions alone. Those two systems serve areas of Oak Forest and Ruby Ranch Subdivisions. Most other public water-supply systems are located in the highly transmissive, confined part of the aquifer and penetrate most of the aquifer thickness. Some small public-supply systems rely primarily on the Trinity Aquifer. Effects of drought and pumping on the Trinity Aquifer are beyond the scope of this investigation.

4.3 Discussion

Hydraulic properties of this karst aquifer are heterogeneous and anisotropic. Wells in the unconfined zone have lower and more variable specific-capacity values than those of the confined zone (Figure 4-6b) and are more susceptible to variations in saturated thickness (Figure 2-2). In the unconfined zone we expect transmissivity and, therefore, specific-capacity values to be lower under lower water-level conditions (drought). Therefore, the percentage of wells with more than 100 ft of drawdown would most likely increase during drought. Accordingly, results presented should represent a minimum estimate of negative impacts to wells from drought and various pumping rates that were evaluated.

Wells in the confined zone are negatively impacted by the combination of decreases in hydraulic head and partial penetration of wells into the aquifer. Many shallow wells were drilled using cable-tool technology before rotary drilling became commonplace.

A significant decrease in hydraulic head in the freshwater zone will increase the potential for flow from the bad-water zone into the freshwater zone (as shown in Figure 2-2), resulting in potential water-quality implications for water-supply wells and Barton Springs. More investigations are needed to characterize this potential.

The compounded effects of drought and significant pumping have been characterized as “negative impacts” in this report. Negative impacts do not necessarily mean that wells will “go dry.” If water levels drop below the pump or bottom of the borehole, air would enter the system, causing the well to cease production.

Potential remedies to these negative impacts could include deepening the well farther into the Edwards Aquifer or into the Middle Trinity Aquifer, lowering the pump, setting a lower pumping rate, and obtaining more storage capacity. Other solutions for municipalities or large public-supply corporations include conservation; cross connections to other water sources, such as surface-water lines; desalination of saline water; or an aquifer storage and recovery facility.

Most public-supply wells are drilled to sufficient depth, are located in the confined part of the aquifer, and will not likely be impacted negatively. Generally speaking, public water-supply systems are more capable of mitigating impacts during a drought owing to their ability to control pumping rates, store water, and to cross connect with other water-supply sources.

In the unconfined zone it is common for wells to penetrate into the underlying Upper Trinity Aquifer, as illustrated by wells 5857204 and 5857609 in Figure 2-2. In general these wells penetrate less than 250 ft into the Upper Glen Rose and most likely derive their water from both the Edwards and Upper Trinity Aquifers. The Upper Trinity has negligible contribution to these hybrid wells compared with the Edwards, according to the literature (Barker et al., 1994). However, during drought conditions with high rates of pumping, the Upper Trinity may locally provide sufficient supplies to wells that penetrate through the Edwards. Accordingly, this analysis overestimates impacts on such hybrid wells. Further investigations are needed for us to understand the Trinity Aquifer system's hydraulic connection to the Edwards and its potential as a source of water.

Although the District has the most complete and comprehensive database for the study area, many wells are likely to remain undocumented. In general, these wells predate the existence of the District (pre-1987) and could represent a higher number of wells that partly penetrate the aquifer. Accordingly, our estimates would underestimate impacts of these additional wells during drought conditions and with the various pumping rates evaluated in this report.

The heterogeneity of the karst aquifer system necessitated some assumptions to quantify an "impact" to wells. Primary assumptions that have a direct bearing on the number of wells impacted include specific definitions of impact (e.g., how much saturated aquifer and borehole are sufficient for supplies?). For this study we chose 100 ft of saturated aquifer and 25 ft of saturated borehole, generally corresponding to the recharge and confined zone, respectively. We think that this approach gives a reasonable qualitative and quantitative evaluation of potential impacts. Although all measured data sets (structure, water level, specific capacity) and contour surfaces have implicit assumptions, the results of this study rely heavily on measured data for the impacts of a recurrence of 1950's drought conditions to be assessed. The only data set that uses model-simulated results is effects of pumping on drawdown.

As discussed in Section 3.0, other sources of water may not be accounted for in drawdown simulations, which might overpredict drawdown, such as influx from the saline-water zone, San Antonio and Trinity Aquifers, or recharge from urban infrastructure, such as leaking water and sewer lines. These evaluations may also underpredict drawdown by not accurately estimating pumping from exempt wells, overpumping from permitted wells, or water discharging from the Edwards into the Trinity owing to poor well construction. However, these gains and losses of water from various sources are thought to be small (Hauwert et al., 2004) and may have only a local influence on wells or springs.

Previous studies have not quantified the impacts of drought and various pumping rates. Results of this investigation should assist in policy decision-making on aquifer management and protection of water-supply wells in the District.

4.4 Major Findings

- As many as 7% of the wells in the District, including two public water-supply systems, may be negatively impacted with insufficient yield under 1950's drought conditions alone (with minimal pumping of 0.66 cfs).
- Under 1950's drought conditions and the present pumping rate of 10 cfs, as many as 19% of the wells in the District may go dry or have reduced yields. Most of these negative impacts will be due to a combination of decreased hydraulic head and partial penetration of wells into the aquifer.
- Wells in the confined part of the aquifer that partly penetrate the aquifer are susceptible to negative impacts owing to decreases in water levels during a recurrence of 1950's drought conditions, with or without pumping from other wells.
- Because of low saturated thickness of the southwest part of the unconfined aquifer and low permeability compared with other parts of the aquifer, wells in this area are the most susceptible to negative impacts under 1950's drought conditions. As pumping rates increase, so will potential impacts in this area.
- Under 1950's drought conditions and high rates of pumping, potential for saline water to flow from the saline-water zone into the freshwater aquifer will increase.

5.0 CONCLUSIONS

Results of the sustainable-yield evaluation will be considered in District sustainable-yield policies for resource management.

- The recalibrated GAM provides a better match between simulated and measured spring-flow and water-level values under 1950's drought conditions than the 2001 GAM.
- For each 1 cfs of groundwater pumped from the aquifer under 1950's drought conditions, discharge from Barton Springs will diminish by about the same rate.
- The recalibrated GAM indicates that with the present (2004) pumping rate of 10 cfs combined with 1950's drought conditions, mean monthly spring flow will be about 1 cfs. According to a minimum daily discharge of 9.6 cfs measured in 1956, spring flow may temporarily cease on a daily basis. At 15 cfs of pumping, spring flow will cease for at least 4 months.
- Under 1950's drought conditions and the present (2004) pumping rate of 10 cfs, as many as 19% of the wells in the District may be negatively impacted. Most of those negative impacts will be due to a combination of decreased head and partial penetration of wells into the aquifer.
- Because of low saturated thickness of the southwest part of the unconfined aquifer and low permeability compared with other parts of the aquifer, wells in this area are the most susceptible to negative impacts under 1950's drought conditions. As pumping rates increase, so will potential impacts in this area.

5.1 Acknowledgments

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7.0 GLOSSARY OF HYDROGEOLOGIC TERMS

Modified from:
Sharp, J. M., Jr., 1999, A Glossary of Hydrogeological Terms: The University of Texas at Austin, Department of Geological Sciences, 35 p.

Anisotropy – variation of a property at a point with direction.
Aquifer – consolidated or unconsolidated geologic unit (material, stratum, or formation) or set of connected units that yields a significant quantity of water of suitable quality to wells or springs in economically usable amounts.

Confined (or artesian) – an aquifer that is immediately overlain by a low-permeability unit (confining layer). A confined aquifer does not have a water table.

Unconfined (or water-table) – the upper surface of the aquifer is the water table. Water-table aquifers are directly overlain by an unsaturated zone.

Aquifer system – intercalated permeable and poorly permeable materials that comprise two or more permeable units separated by aquitards that impede vertical groundwater movement but do not affect the regional hydraulic continuity of the system.
Artesian – hydrostratigraphically confined. In the common usage, it implies the existence of flowing wells, but all flowing wells are not artesian nor do all artesian wells flow.
Attributes – nonspatial, usually alphanumeric, data that are linked to a spatial element (e.g., points depicting well locations may be linked to attribute files containing data on stratigraphy, water levels, water chemistry, etc.).
bad water line- eastern boundary of Edwards Aquifer water in the Barton Springs aquifer of the Edwards Aquifer characterized by having more than 1,000 milligrams per liter (mg/L) of total dissolved solids (Barton Springs/Edwards Aquifer Conservation District, 2003).
Baseflow – groundwater flow to a surface-water body (lake, swamp, or stream).
Bedrock – consolidated rock at various depths beneath the Earth's surface.
Boundary condition – specified conditions at the edges or surfaces of a groundwater system.
Model calibration- involves changing input parameters until the model results match field (measured) observations.
Coefficient of determination (R^2) – percentage of variation of the dependent variable that is explainable by the regression line.
Conceptual model – clear, qualitative physical description of how a hydrogeological system behaves.
Conduit – high-permeability pathway most commonly associated with dissolution features.
Cross-formational flow – vertical groundwater flow from one hydrostratigraphic unit to another.
Diagenesis – process that alters sediment with its burial; temperatures are low, definitely less than metamorphic (°C).
discharge – (1) volumetric flow rate [$L^3 t^{-1}$] of a stream, spring, or groundwater system; (2) water leaving a groundwater system.

Mean discharge – arithmetic mean of discharges over a given time period.

Divide – topographic high (or ridge) separating surface watersheds (catchments). A groundwater divide is an elevated area, line, or ridge of the potentiometric surface separating different groundwater flow systems.
Domestic use – water 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. Ancillary use may include watering of domestic animals (Barton Springs/Edwards Aquifer Conservation District, 2003).
Double (or dual) porosity – when two porosities may be associated with a hydrogeological system. An example is a porous rock with a fracture set; such a system may then have two.
Drawdown (s) – drop in head from the initial head caused by pumping from a well or set of wells.

Drought – prolonged period of low (lower than average) rainfall. For the purposes of this study, drought corresponds to a prolonged period of low recharge, water-level elevations, and spring discharge values.

Drought of record (1950's drought) – worst drought on record for Central Texas, which occurred from 1950 through 1957.

Equipotential – line connecting points of equal hydraulic potential or hydraulic head.

Exempt well – well may be exempt if it is (Barton Springs/Edwards Aquifer Conservation District, 2003):

1. used solely to supply the domestic needs of five or fewer households, and a person who is a member of each household is either the owner of the well, a person related to the owner, or a member of the owner's household within the second degree by consanguinity, or an employee of the owner, which is drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day on a tract of land larger than 10 acres; or
2. used to provide water for livestock or poultry, which is drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day on a tract of land larger than 10 acres.

Fault – fracture that has experienced translation or movement of the fracture walls parallel to the plane of the fracture.

Flow path – path a molecule of water takes in its movement through a porous medium.

Formation – body of rock strata that consists of a certain lithology or combination of lithologies.

Fracture – subplanar discontinuity in a rock or soil formed by mechanical stresses.

Fresh water – water with a salinity <1,000 mg/L; drinkable or potable water is implied.

Groundwater availability modeling (GAM) – initiative by the Texas Water Development Board to develop state-of-the-art, publicly available, numerical groundwater flow models for aquifers in Texas.

Groundwater – generally all water beneath the land surface. Sometimes, it is more narrowly defined as phreatic water or water beneath the water table.

Head (h) – fluid mechanical energy per unit weight of fluid, which correlates to the elevation that water will rise to in a well [L]. Also hydraulic head.

Heterogeneity – condition in which the property of a parameter or a system varies with space.

Hydraulic conductivity (K) – volume of fluid that flows through a unit area of porous medium for a unit hydraulic gradient normal to that area.

Hydraulic head (h) – elevation in a well in reference to a specific datum; the mechanical energy per unit weight of water [L].

Hydrostratigraphic unit – formation, part of a formation, or group of formations of significant lateral extent that compose a unit of reasonably distinct (similar) hydrogeologic parameters and responses.

Isopach map – map indicating, usually by means of contour lines, the varying thickness of a designated stratigraphic unit.

Karst – geologic terrain with distinctive characteristics of relief and drainage arising primarily from dissolution of rock (or soils) by natural waters. Such terrains are underlain by rocks that have undergone significant dissolution by groundwater flow.

Kriging – geostatistical method of contouring using weighted averages of surrounding data points.

Leakage – flux of fluid from or into an aquifer or reservoir. Commonly refers to cross-formational flow.

MODFLOW – finite-difference, numerical model for groundwater flow developed by the U.S. Geological Survey.

Observation (monitor) well – well that is used to measure the elevation of the water table or the potentiometric surface.

Outcrop – point at which a formation is present at the Earth's surface.
Parameter – (1) defined physical quantity with a numerical value or a value within a certain range; (2) characteristic of a population (e.g., the mean).
Permeability – ease with which a porous medium can transmit water or other fluids.
Permit or pumpage permit – authorization issued by the District allowing withdrawal of a specific amount of groundwater from a nonexempt well for a designated period of time, generally in the form of a specific number of gallons per District fiscal year. Under normal or nondrought conditions, this volume of water may be pumped at any time during the course of the fiscal year at the convenience of and based on the needs of the permittee. However, during times of District-declared drought, monthly pumpage target-reduction goals for specific drought stages are designated in the permittee's UDCP. Achieving these target-reduction goals may result in a permittee pumping less than the permittee's annual permitted pumpage volume (Barton Springs/Edwards Aquifer Conservation District, 2003).
Porosity – volume of voids divided by total volume of a porous medium.
Potential – potential energy per unit mass of fluid.
Public water supply well – well providing groundwater for public water-supply use; nonexempt well (Barton Springs/Edwards Aquifer Conservation District, 2003).
Potentiometric surface – surface of equal hydraulic heads or potentials, typically depicted by a map of equipotentials, such as a map of water-table elevations.
Precipitation – (1) water condensing from the atmosphere and falling in drops or particles (e.g., snow, hail, sleet) to the land surface; (2) formation of a solid from dissolved or suspended matter.
Pump or pumping test – one of a series of techniques to evaluate the hydraulic properties of an aquifer by observing how water levels change with space and time when water is pumped from the aquifer.
Recharge – process by which water enters the groundwater system or, more precisely, the phreatic zone.
Recharge zone – area of the aquifer in which water infiltrates the surface and enters permeable rock layers (Barton Springs/Edwards Aquifer Conservation District, 2003).
Root mean square (RMS) – statistical measure of the magnitude of a set of numbers.
Safe yield- volume of water that can be annually withdrawn from an aquifer (or groundwater basin or system) without (1) exceeding average annual recharge, (2) violating water rights, (3) creating uneconomic conditions for water use, or (4) creating undesirable side effects, such as subsidence or saline water intrusion.
Saturation – state that occurs when all pores are filled with water.
Sinkhole – closed depression in a karstic landscape.
Specific capacity – discharge of a well divided by drawdown in the well. Note that specific capacity can depend on the pumping rate.
Specific storage (Ss) – volume of water released per unit volume of aquifer for a unit decrease in hydraulic head.
Specific yield (Sy) – volume of water that a saturated porous medium can yield by gravity drainage divided by volume of the porous medium.
Spring – point(s) of natural discharge from an aquifer (Barton Springs/Edwards Aquifer Conservation District, 2003).
Storage – water contained within an aquifer or within a surface-water reservoir.
Storativity (S) – volume of water released per unit area of aquifer for a unit decline in head. In a confined aquifer, S is the specific storage (Ss) times aquifer thickness; in an unconfined aquifer, S is equal to the specific yield (Sy) or the effective porosity.
Tracer – usually a solute, suspended matter, or heat that is artificially or naturally induced to evaluate rate and direction of groundwater flow.
Transient – condition in which properties of a system vary with time.

Transmissivity (T) – discharge through a unit width of the entire saturated thickness of an aquifer for a unit hydraulic gradient normal to the unit width, sometimes termed the coefficient of transmissibility [L^2 t^{-1}, gpd/ft].
Transport – movement of solute, suspended matter, or heat in a porous medium, in a surface stream, or through the atmosphere.
Trinity Group aquifer – includes the Upper Member of the Glen Rose Formation, known as the Upper Trinity; the Lower Member of the Glen Rose Formation, and the Hensell Sand and Cow Creek Limestone Members of the Travis Peak Formation, known as the Middle Trinity; and the Sligo and Hosston Members of the Travis Peak Formation, known as the Lower Trinity (Barton Springs/Edwards Aquifer Conservation District, 2003).
Unconfined – refers to an aquifer that has a water table and implies direct contact from the water table to the atmosphere (through the vadose zone).
Unsaturated – condition when porosity is not completely filled with water.
Water table – a surface at or near the top of the phreatic zone (zone of saturation) where the fluid pressure is equal to atmospheric pressure. In the field this is defined by the level of water in wells that barely penetrate the phreatic (saturated) zone.
Well – any artificial excavation or borehole constructed for the purposes of exploring for or producing groundwater or for injection, monitoring, or dewatering purposes (Barton Springs/Edwards Aquifer Conservation District, 2003).
Well log – accurately kept record, made during the process of drilling, on forms prescribed by the Water Well Drillers Team, showing the depth of the well bore, thickness of the formations, and character of casing installed, together with any other data or information required by the Water Well Drillers Team; or any other special-purpose well log that may be available for a given well, such as a gamma-ray log, a temperature log, an electric log, or a caliper log (Barton Springs/Edwards Aquifer Conservation District, 2003).
Well yield – discharge of well at (nearly) steady flow [L^3t^{-1}].
Yield – generically, the amount of water pumped from a well (or bore). In Australia, there is a narrower definition—maximum sustainable pumping rate such that the drawdown in a well after 24 hours does not exceed a specified percentage (typically ~2%) of the column of water above the base of the aquifer. It assumes that the well is fully penetrating and screened over all permeable intervals of the aquifer. Units of yield are volume per time [L^3 t^{-1}].

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TABLES

Table 3-1. Comparison of measured and simulated water-level values and residuals from the 2001 GAM and recalibrated model.

State well number	Lowest measured elevation*	Measure date	2001 GAM simulation*	Water-level residual (ft)	Recalibrated model simulation*	Water-level residual (ft)
5842911	428	Aug-56	441.7	-13.7	435	-7
5850301	459	Aug-56	443	16	453	6
5850801	521	Jul-56	445	76	519	2
5858101	561	Aug-56	473	88	583	-22
5857903	563	Aug-56	486	77	597	-34
5850502	487	Aug-56	452	35	482	5
5850702	626	Aug-56	476	150	590	36
5850412	650	Aug-78	585	65	653	-3
5857301	595	Aug-56	492	103	598	-3
5857204	643	Dec-50	513	130	624	19

*Elevation in ft above mean sea level

Table 3-2. Comparison of hydraulic conductivity (K) for the 2001 GAM and recalibrated GAM.

Original K (ft/day) 2001 GAM	Revised K (ft/day) recalibrated GAM	% Change
3	0.3	-90%
4.5	0.8	-82%
3.5	1.7	-51%
1	0.5	-50%
93	40	-57%
93	25	-73%
100	75	-25%
39	80	+105%
320	60	-81%
320	192	-40%
1236	740	-40%
39	12	-69%

Table 4-1. Composite potentiometric data.

SWN	Measurement date	Latitude	Longitude	WL elevation (feet above msl)
58-42-607	1/1/1951	30.30139	-97.77194	434.40
58-42-809	2/16/1949	30.26583	-97.80972	421.10
58-42-901	3/7/1955	30.27583	-97.77917	421.20
58-42-903	3/15/1957	30.2633	-97.77124	424.51
58-42-910	2/1/1955	30.27695	-97.78972	428.00
58-42-924	8/1/1949	30.28667	-97.76972	443.40
58-49-802	1/26/1981	30.12825	-97.92657	802.56
58-49-904	4/10/1980	30.13611	-97.88084	594.00
58-50-101	3/19/1952	30.22583	-97.86916	670.74
58-50-104	6/25/1940	30.23611	-97.84444	527.87
58-50-105	10/4/1939	30.23417	-97.85056	581.20
58-50-201	3/9/1956	30.21958	-97.79373	432.29
58-50-205	9/5/1939	30.23111	-97.80556	430.88
58-50-208	3/1/1955	30.21861	-97.82083	458.00
58-50-218	8/1/1978	30.2425	-97.79723	441.00
58-50-301	8/31/1956	30.21035	-97.78159	459.46
58-50-406	8/11/1978	30.19674	-97.84316	532.56
58-50-411	8/18/1978	30.1867	-97.85	554.95
58-50-416*	7/9/2001	30.1766	-97.86723	539.60
58-50-502	8/31/1956	30.18694	-97.81416	486.72
58-50-511	6/30/1956	30.17159	-97.82578	478.59
58-50-701	11/29/1949	30.13722	-97.84778	515.45
58-50-702	8/31/1956	30.14778	-97.87334	626.09
58-50-704	8/14/1978	30.13694	-97.85555	524.67
58-50-7DT*	7/9/2001	30.15528	-97.86182	535.55
58-50-801	8/29/1956	30.14281	-97.81076	531.14
58-50-804	2/10/1949	30.16159	-97.82873	493.86
58-50-808	6/27/1939	30.12556	-97.79972	559.49
58-50-814	3/21/1955	30.14056	-97.79694	552.60
58-50-817	1/1/1956	30.14	-97.83222	500.00
58-50-839	8/14/1978	30.12972	-97.82166	547.64
58-50-902	11/1/1954	30.14139	-97.75777	480.00
58-57-201	12/28/1982	30.10278	-97.93694	748.40
58-57-204	12/5/1950	30.08361	-97.91805	636.60
58-57-301	8/28/1956	30.09389	-97.89139	594.80
58-57-3DB	9/15/1999	30.11445	-97.91221	666.51
58-57-502	5/24/1978	30.06635	-97.94447	675.52
58-57-5JM	3/31/1952	30.04722	-97.95139	710.07
58-57-902	8/29/1956	30.00833	-97.895	567.37
58-57-903	8/28/1956	30.0385	-97.88617	560.14
58-57-905	1/3/1951	30.02667	-97.90361	559.70
58-57-9LN	3/27/1952	30.02583	-97.87833	557.10
58-58-101	8/28/1956	30.08358	-97.84264	562.03
58-58-104	10/24/1950	30.10417	-97.84861	549.10

Table 4-1 continued				
SWN	Measurement date	Latitude	Longitude	WL elevation (feet above msl)
58-58-301	8/29/1956	30.09194	-97.78917	554.39
58-58-4JH	3/27/1952	30.06694	-97.85861	570.98
58-58-4PR	11/8/1950	30.04972	-97.86777	566.33
58-58-502	1/9/1951	30.05083	-97.80722	554.40
58-58-7LN	2/26/1952	30.02972	-97.85472	551.87
67-01-3CC	3/26/1952	29.97111	-97.89222	574.50
67-01-3OG	3/26/1952	29.98228	-97.89149	574.30
67-01-3WL	8/31/1954	29.98917	-97.89139	574.00
67-01-6EN	3/26/1952	29.93083	-97.90444	570.91
67-01-807	2/2/1940	29.90083	-97.91917	570.89
67-01-809	11/14/1950	29.91195	-97.92861	574.60
67-02-101	3/26/1952	29.98139	-97.865	568.30

**Water level adjusted 34 ft from well 5850702*

Table 4-2. Simulated drawdown in wells under 1950's drought conditions and various pumping scenarios.

SWN	Water-level drawdown (ft)			
	5 cfs	10 cfs	15 cfs	19 cfs
5842914	1	2	3	16
5842915	2	5	7	21
5849802	5	11	16	20
5849935	26	29	31	30
5850211	5	12	17	26
5850212	6	13	19	34
5850215	6	13	19	33
5850216	4	9	14	28
5850222	7	17	25	40
5850301	7	15	22	38
5850406	14	31	44	56
5850408	13	27	37	45
5850412	11	23	31	38
5850413	14	28	38	46
5850501	21	47	70	96
5850502	16	35	52	74
5850511	21	47	70	95
5850520	8	18	27	43
5850701	32	75	112	151
5850702	32	55	74	87
5850704	33	76	114	151
5850801	29	67	101	135
5857201	11	23	30	35
5857204	38	84	113	128
5857301	42	97	145	187
5857502	25	43	47	49
5857602	38	82	107	114
5857903	48	115	183	246
5858101	48	113	178	241
5858102	43	101	156	211
5858104	43	100	155	209
5858123	41	96	148	200
5858406	48	115	182	246
5858704	49	115	184	245
58501NF	9	20	29	31
58502B2	4	10	15	29
58572R2	36	77	104	119
58573BW	19	41	54	64
58573JD	41	95	141	179
58573SW	16	33	44	52

Table 4-3. Saturated aquifer thickness analysis under 1950's drought conditions and various rates of pumping.

Pumping rate (cfs)	0.66*	5	10	15	19
Total number wells west of the 100-ft saturated-thickness contour	230	267	291	330	408
Number of wells with high probability of insufficient yield**	30	35	38	43	53

**1950's drought pumping;*
***Based on 13% of wells with low specific capacity (Sc=0.17; Q=15.9 gpm)*

Table 4-4. Saturated borehole analysis under 1950's drought conditions and various rates of pumping.

Pumping rate	0.66*	5	10	15	19
Number of wells with high probability of insufficient yield**	43	74	151	216	347

**1950's drought pumping;*
***Based on wells with <25 ft saturated thickness*

Table 4-5. Total impact to wells under 1950's drought and various rates of pumping.

Pumping rate	0.66*	5	10	15	19
Total number of Impacted wells	73	109	189	259	400
Percentage of total wells (n=971)	7	11	19	27	41

**1950's drought pumping*

FIGURES

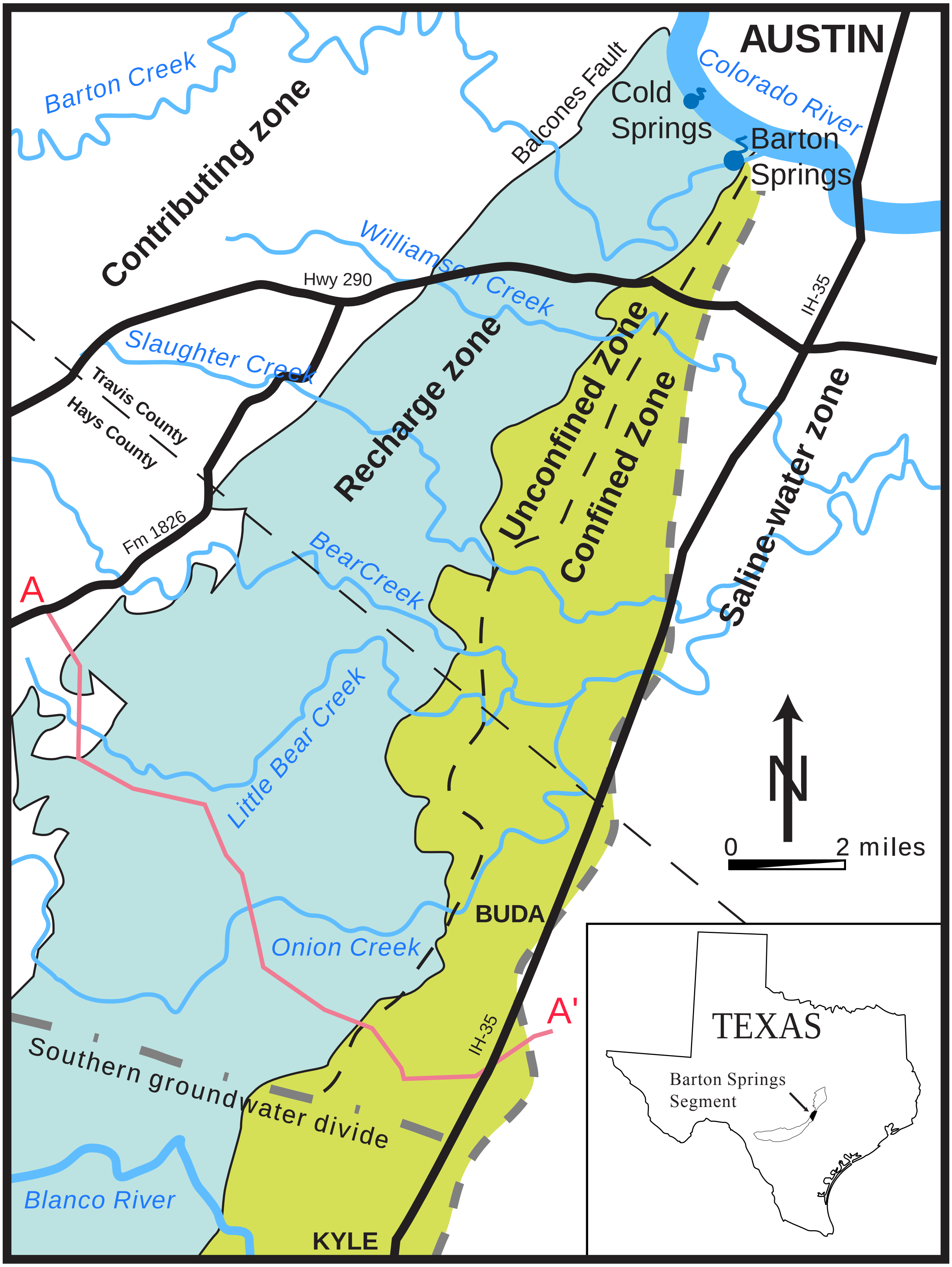

Figure 2-1. Location map of the study area. Note: shaded area is the Edwards Aquifer.

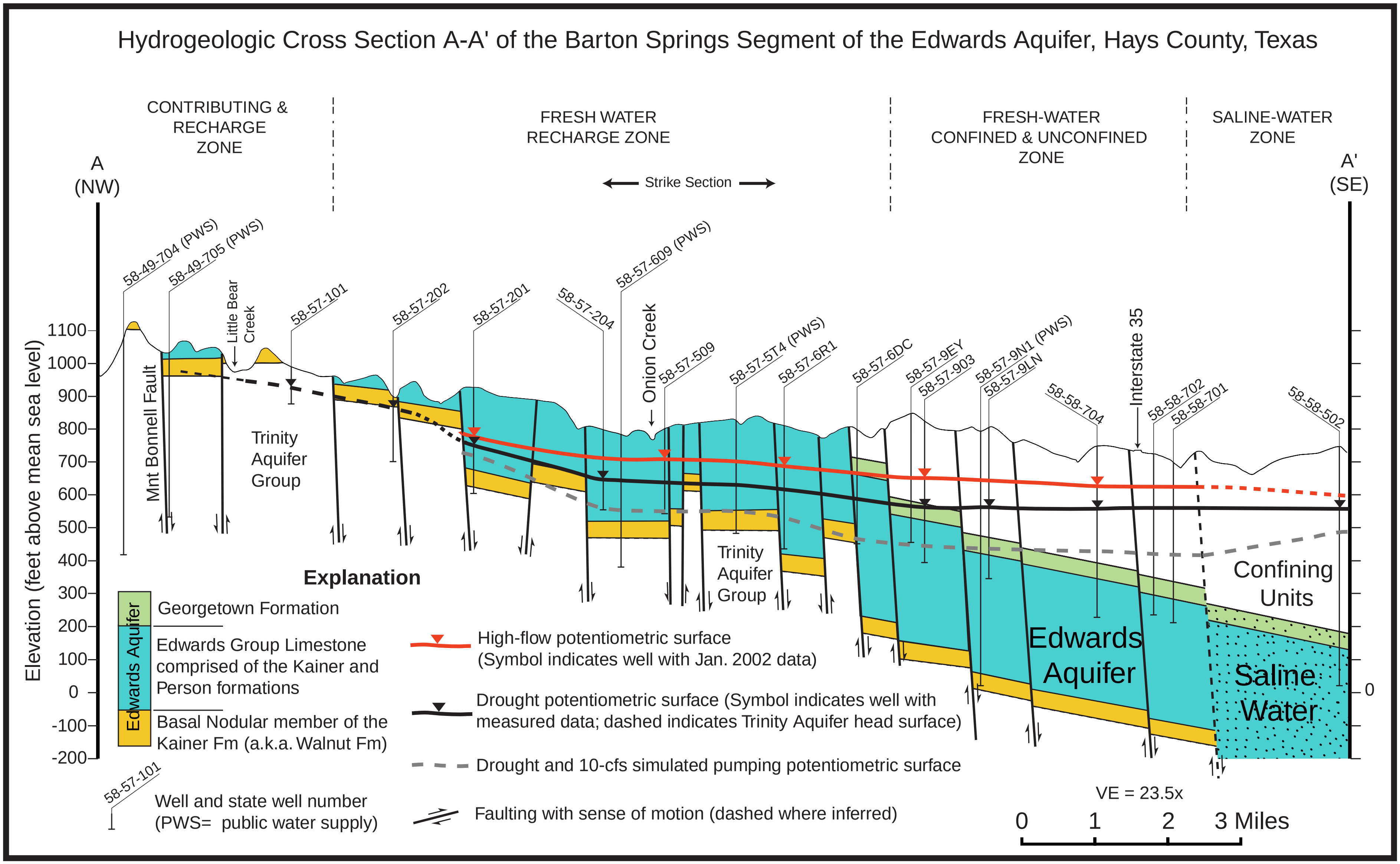

Figure 2-2. Cross section of the Barton Springs and Trinity Aquifers in Hays County (see Figure 2-1).

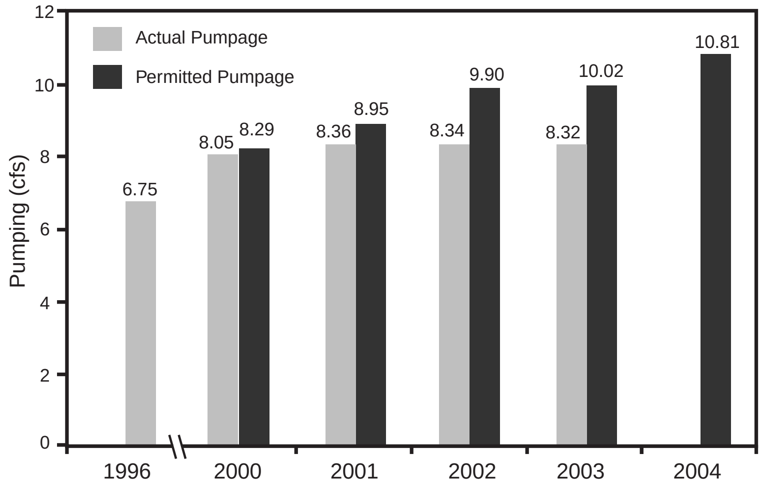

Figure 2-3. Histogram of permitted and actual pumping from the Barton Springs aquifer.

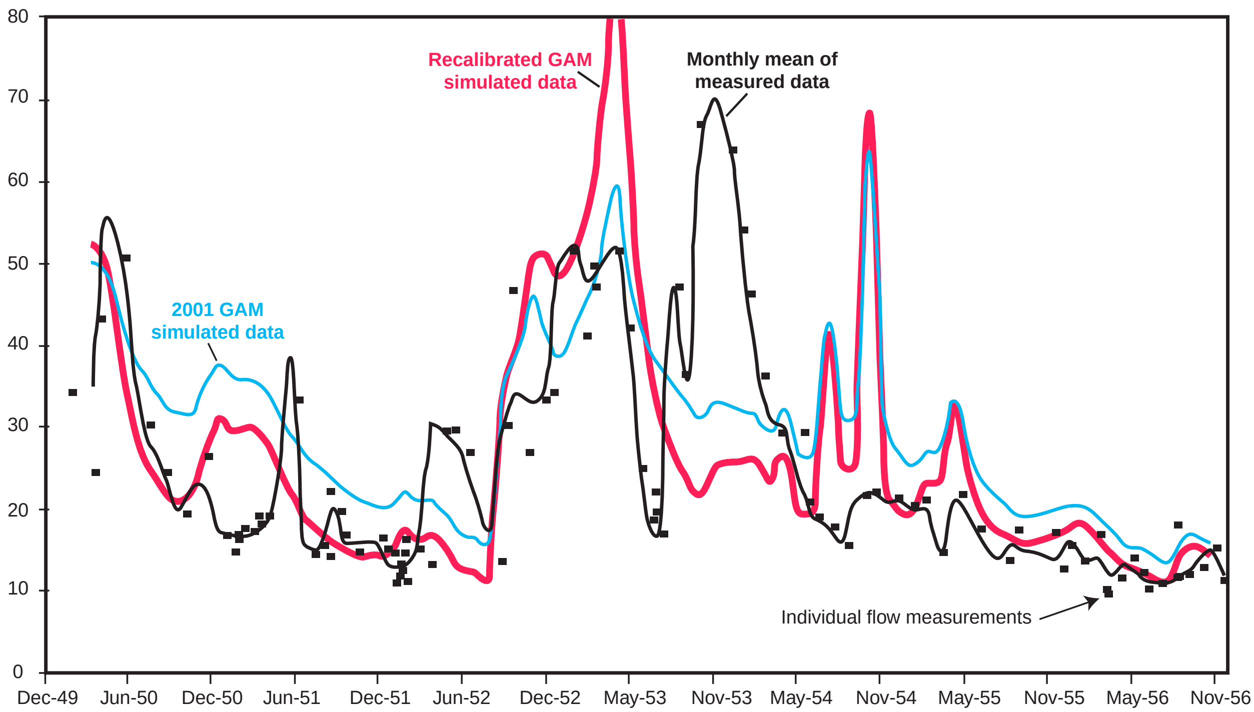

Figure 3-1. Hydrograph of simulated and measured spring flow dishcarge from 1950's drought. Note: lowest individual measured value (arrow) 9.6 cfs. Both simulations were run with 0.66 cfs pumping.

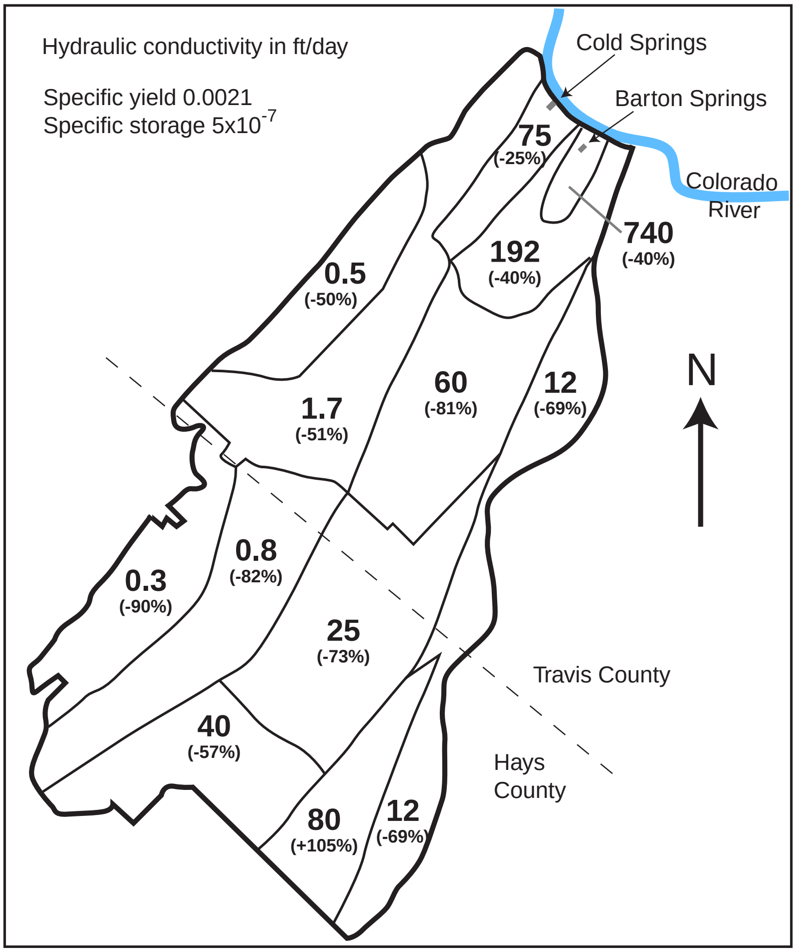

Figure 3-2. Map of zonal distribuion of hydraulic conductivity (ft/day) in the recalibrated GAM model. Note: percent change from 2001 GAM values shown in parentheses (see Table 3-2).

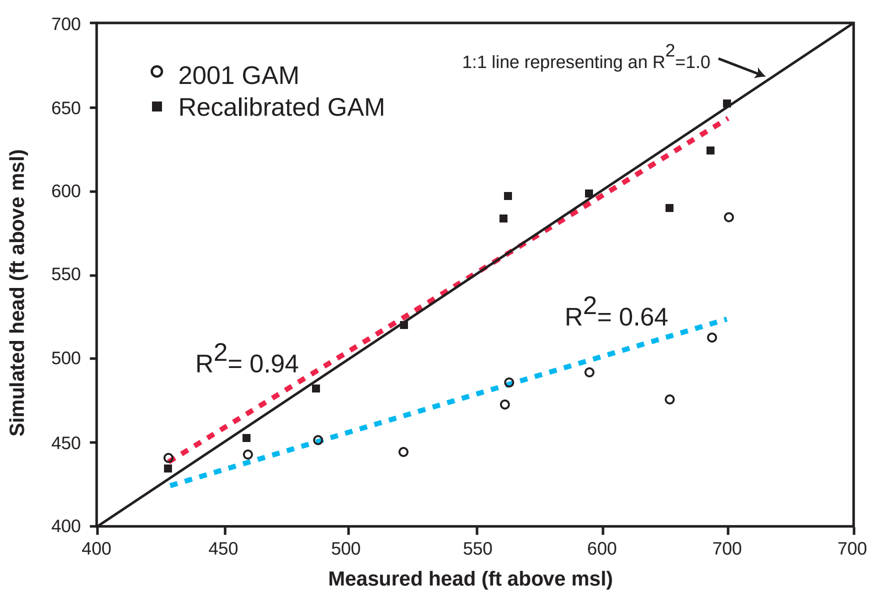

Figure 3-3. Scatter plot of the simulated results from the 2001 GAM and recalibrated GAM plotted against measured low-flow 1950's water levels. See Table 3-1.

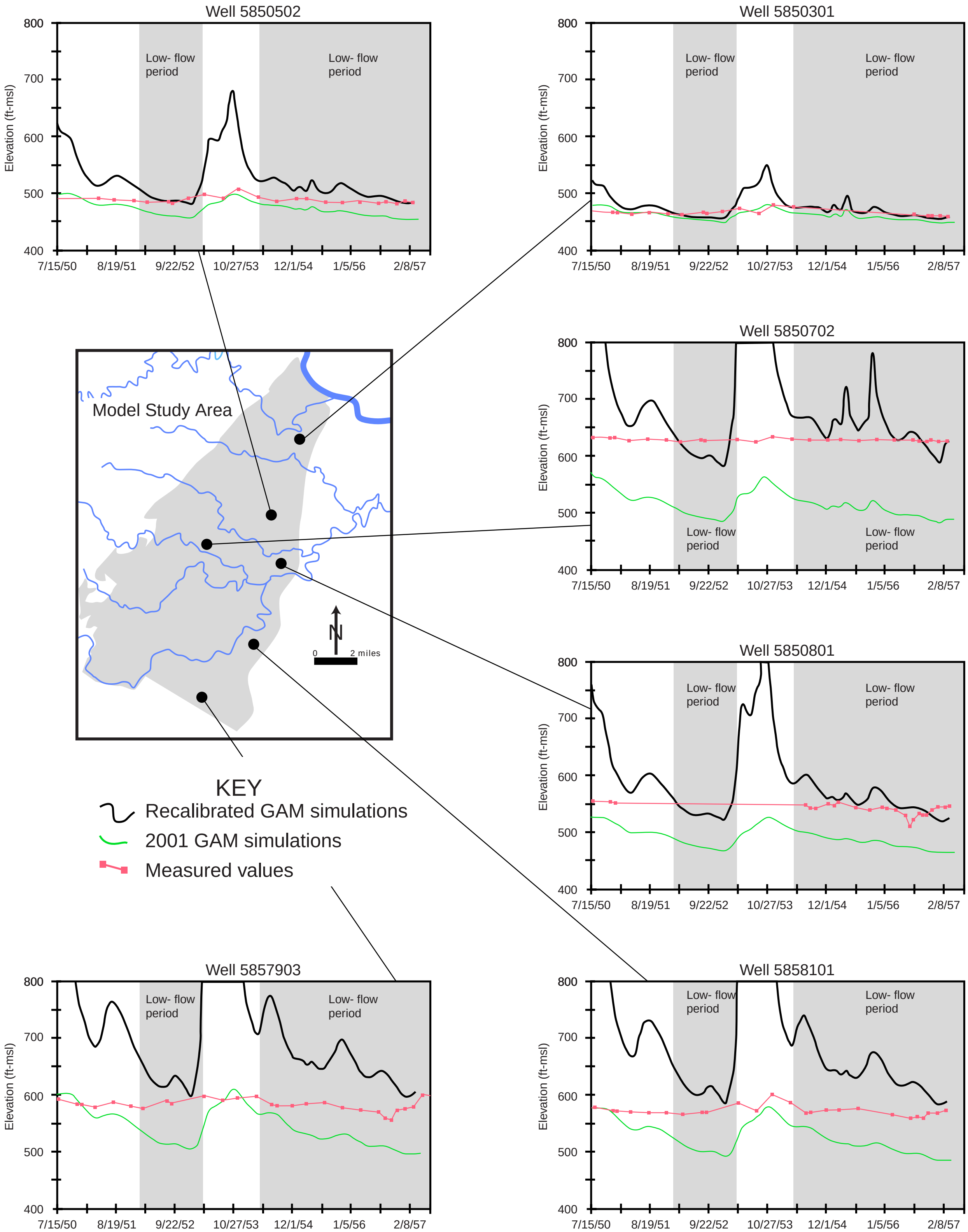

Figure 3-4. Comparison of simulated and measured water-level elevation hydrographs from the study area. Recalibration of the GAM was to the low-flow periods (shaded area) of the 1950's drought.

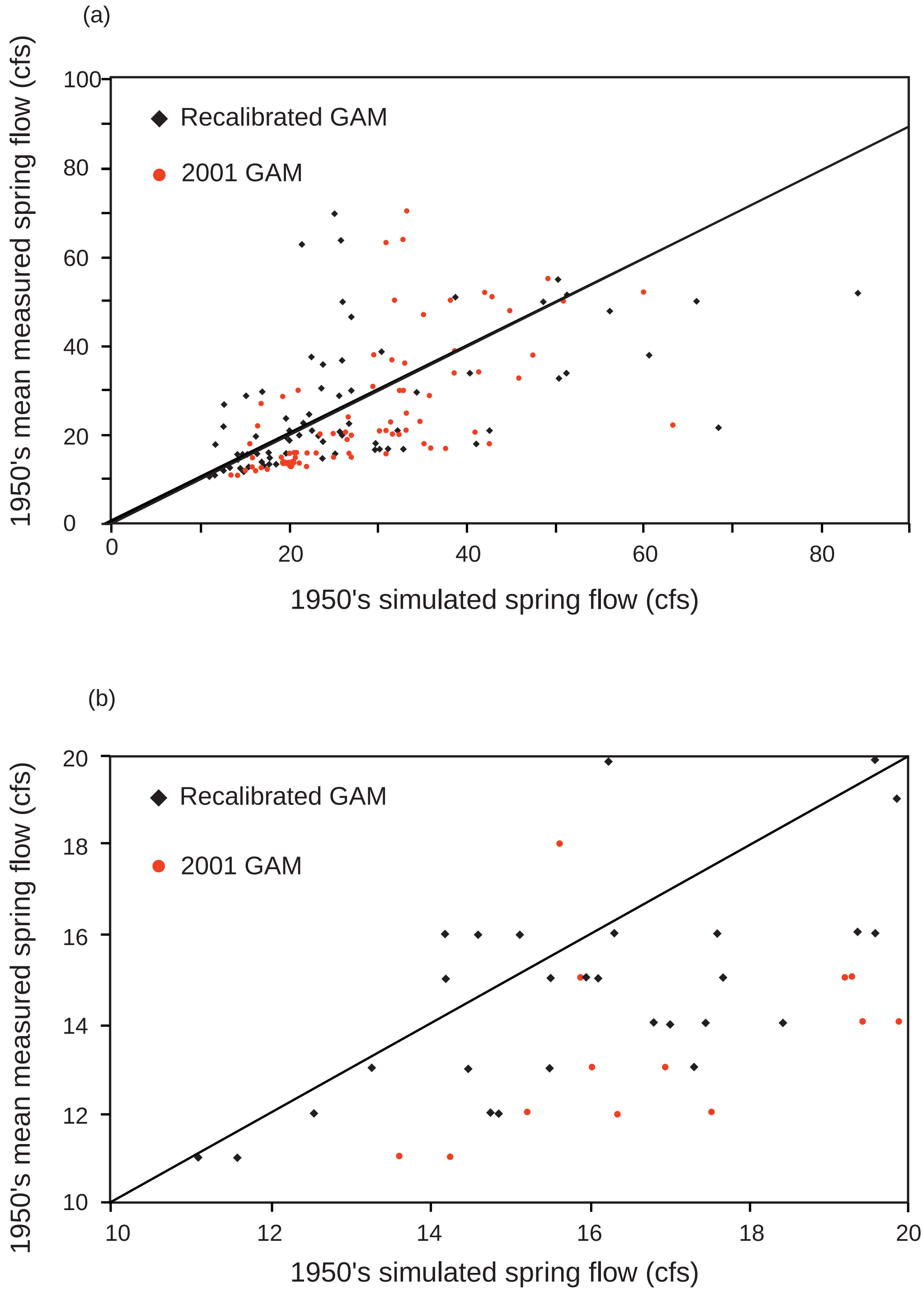

Figure 3-5. Scatter plot of spring-flow simulations from the 2001 and the recalibrated GAMs and mean of measured spring-flow values for (a) all flow conditions and (b) low-flow conditions.

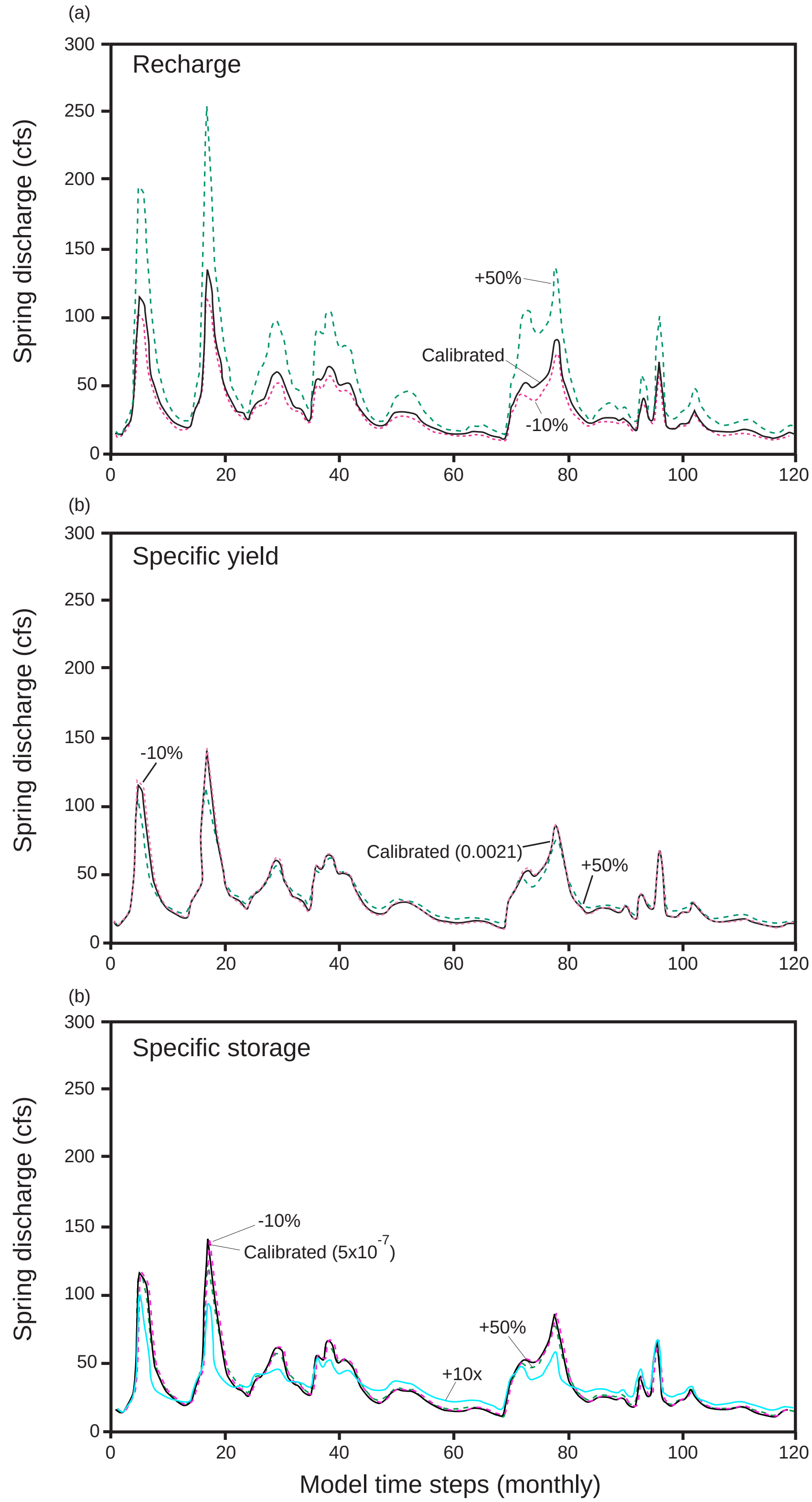

Figure 3-6. Sensitivity of transient simulated spring discharge to (a) recharge, (b) specific yield, and (c) specific storage.

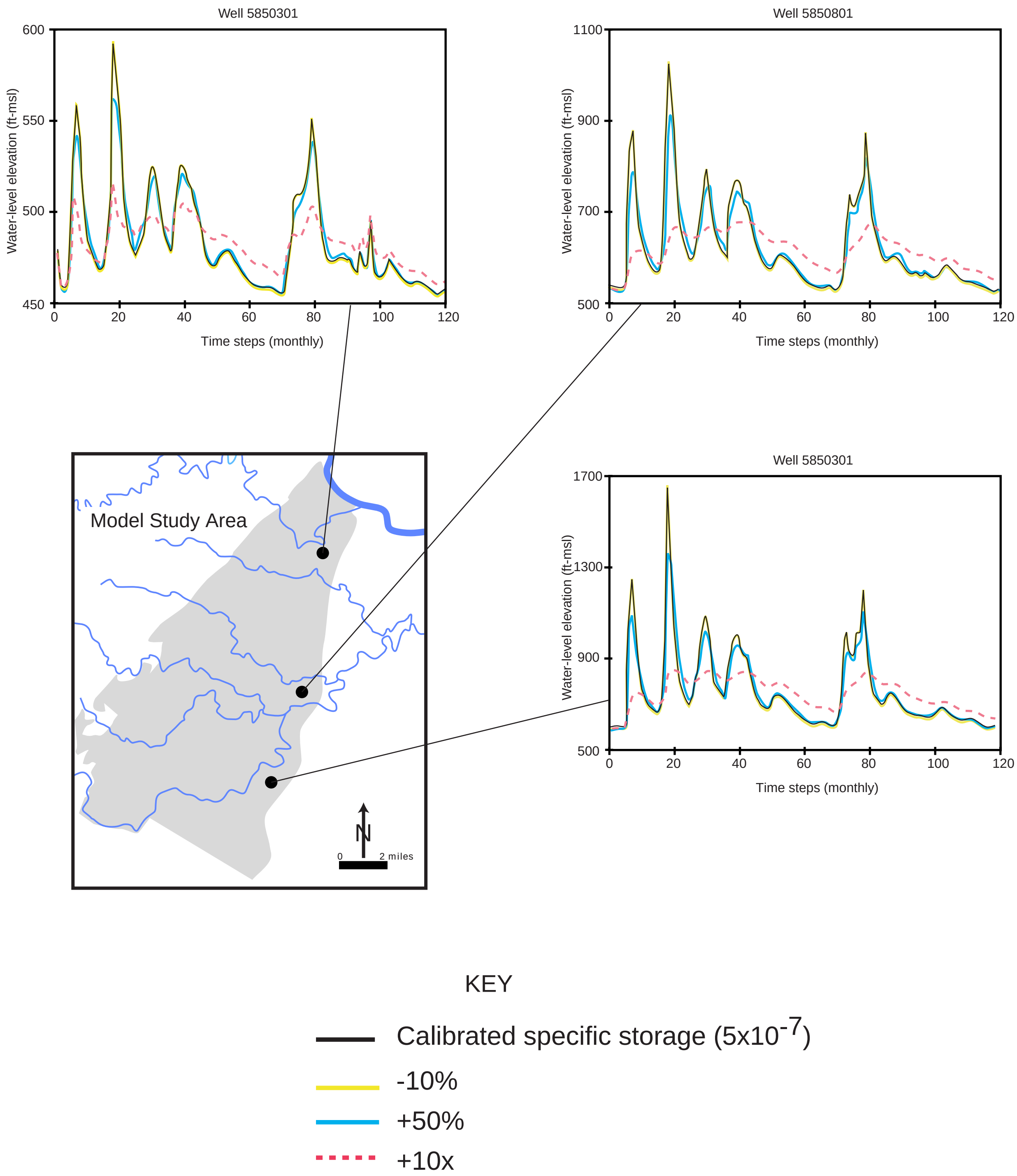

Figure 3-7. Sensitivity of transient calibration water levels to specific storage.

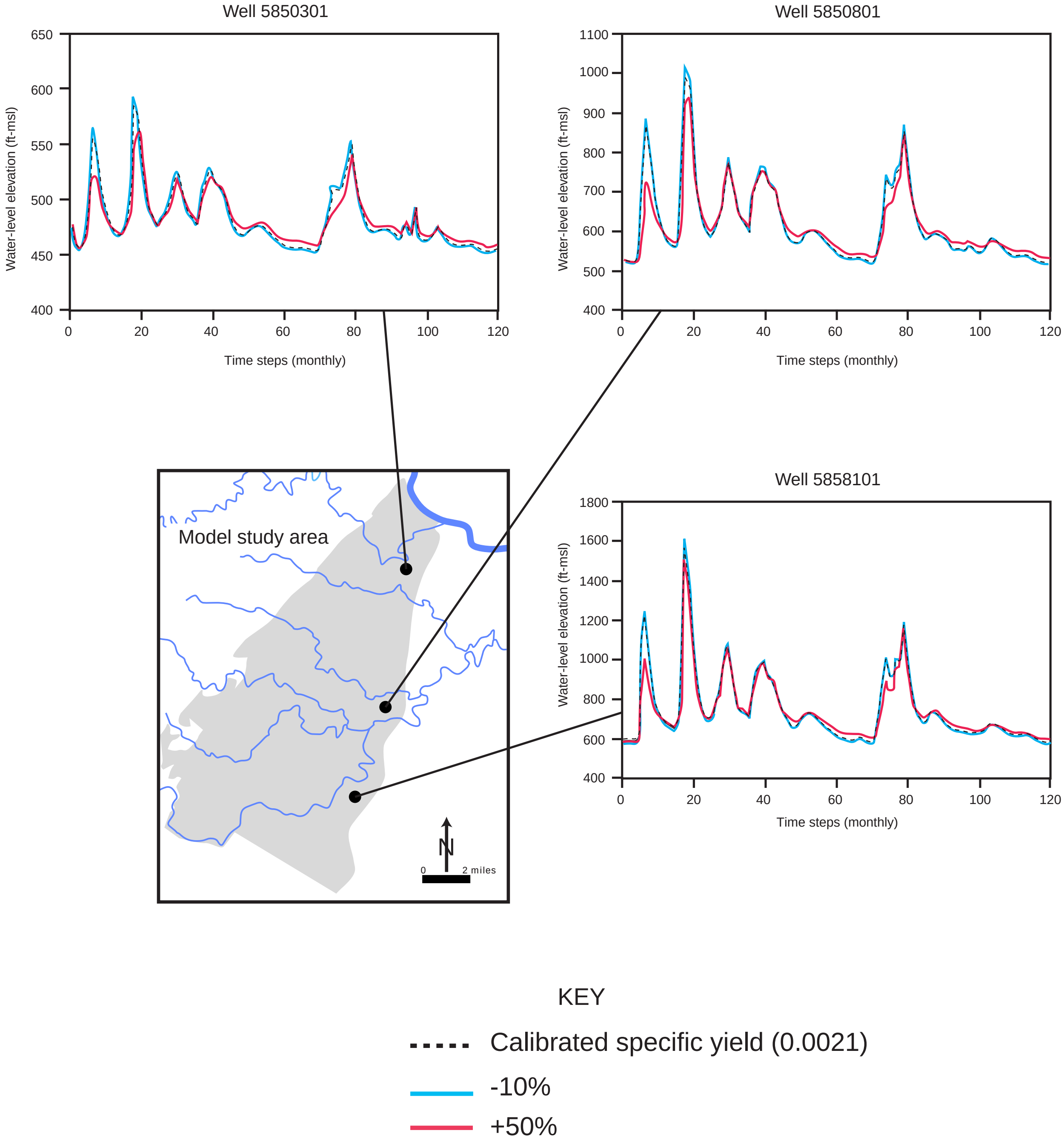

Figure 3-8. Sensitivity of transient calibration water levels to specific yield.

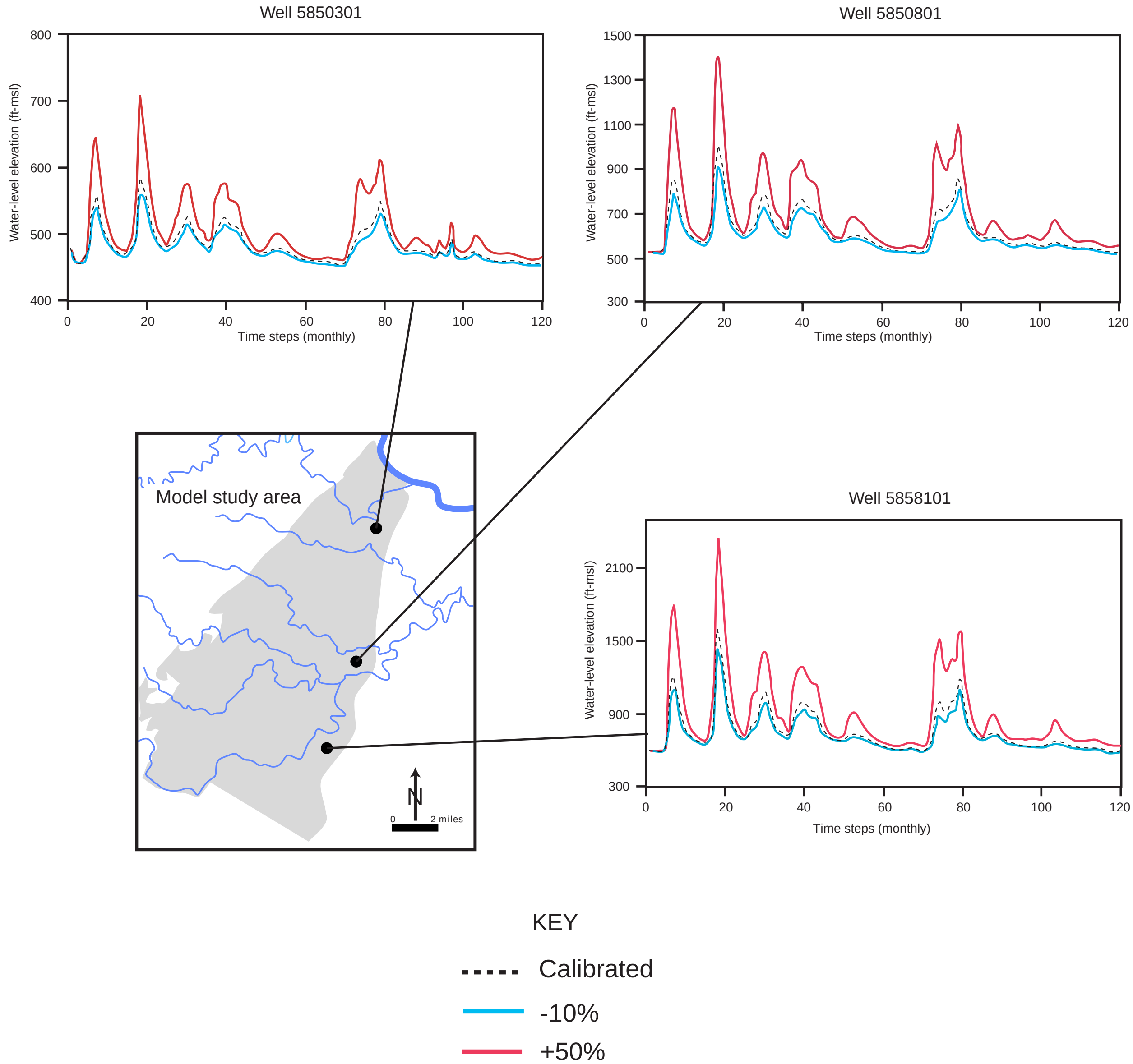

Figure 3-9. Sensitivity of transient calibration water levels to recharge.

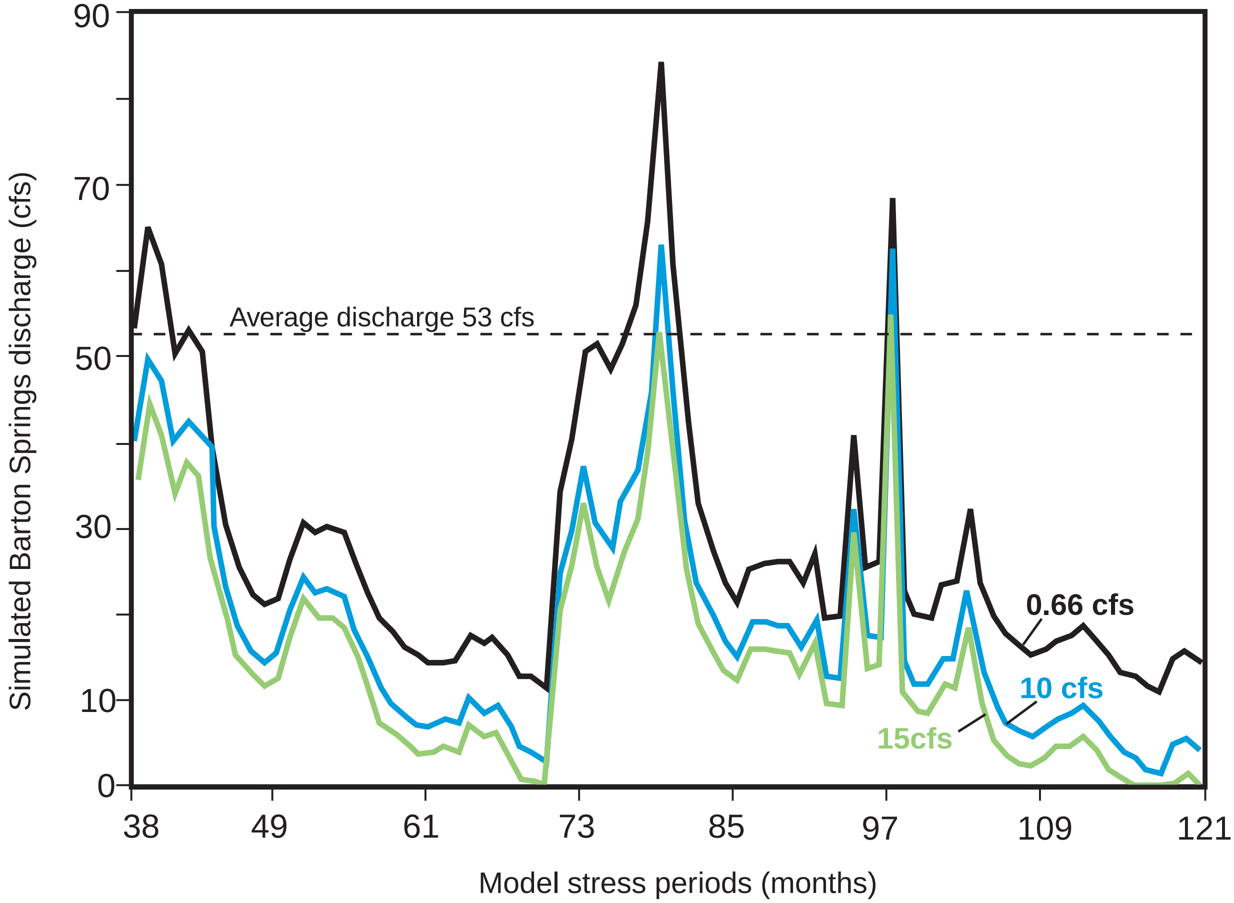

Figure 3-10. Hydrograph of simulated spring flow under 1950's drought conditions and 0.66, 10, and 15 cfs pumping rates.

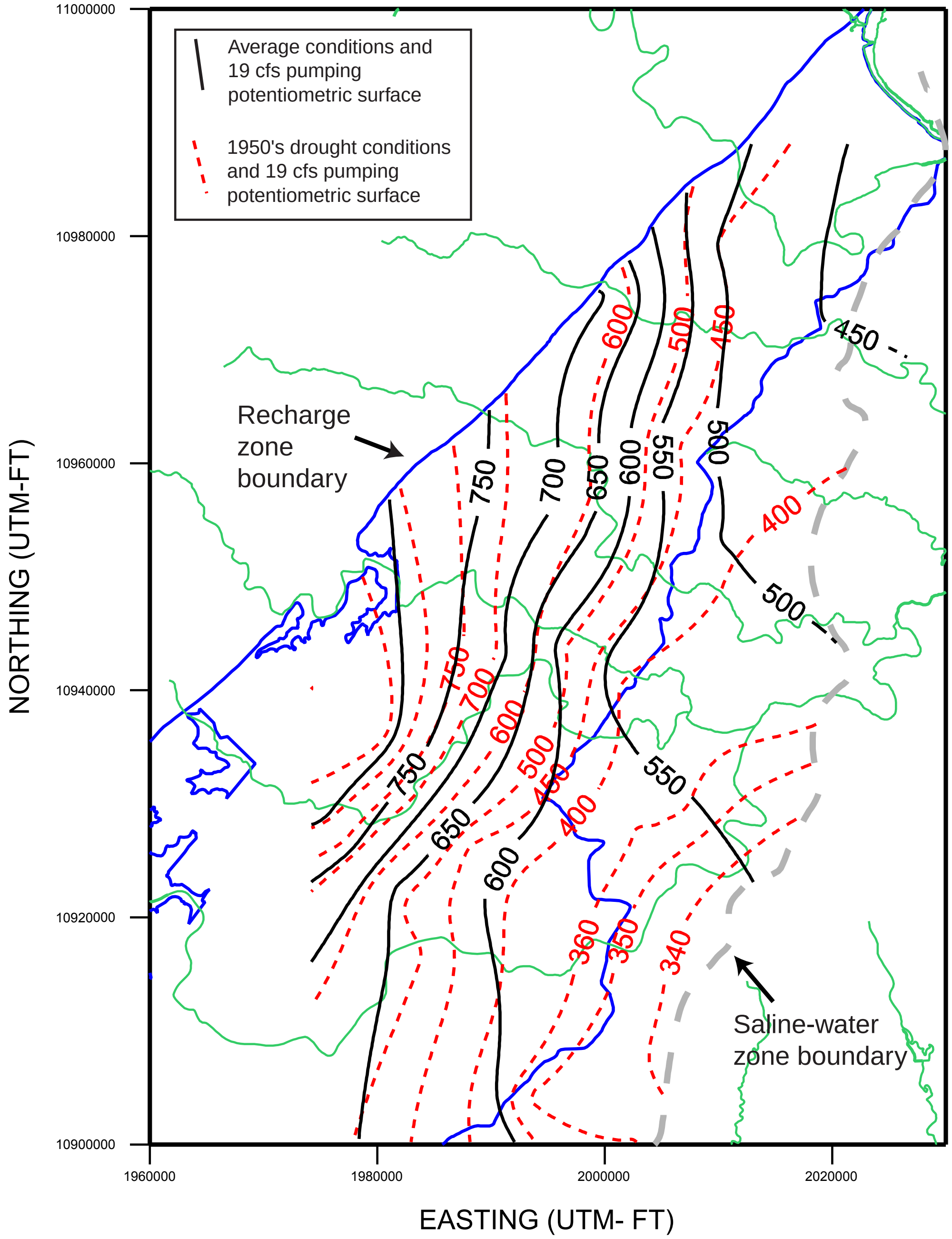

Figure. 3-11. Simulated potentiometric surface contour map under average conditions and 19 cfs of pumping (solid lines) and 1950's drought conditions with 19 cfs pumping (dashed lines). Springflow is 36 cfs and 0 cfs, respectively, at the end of simulations for each scenario .

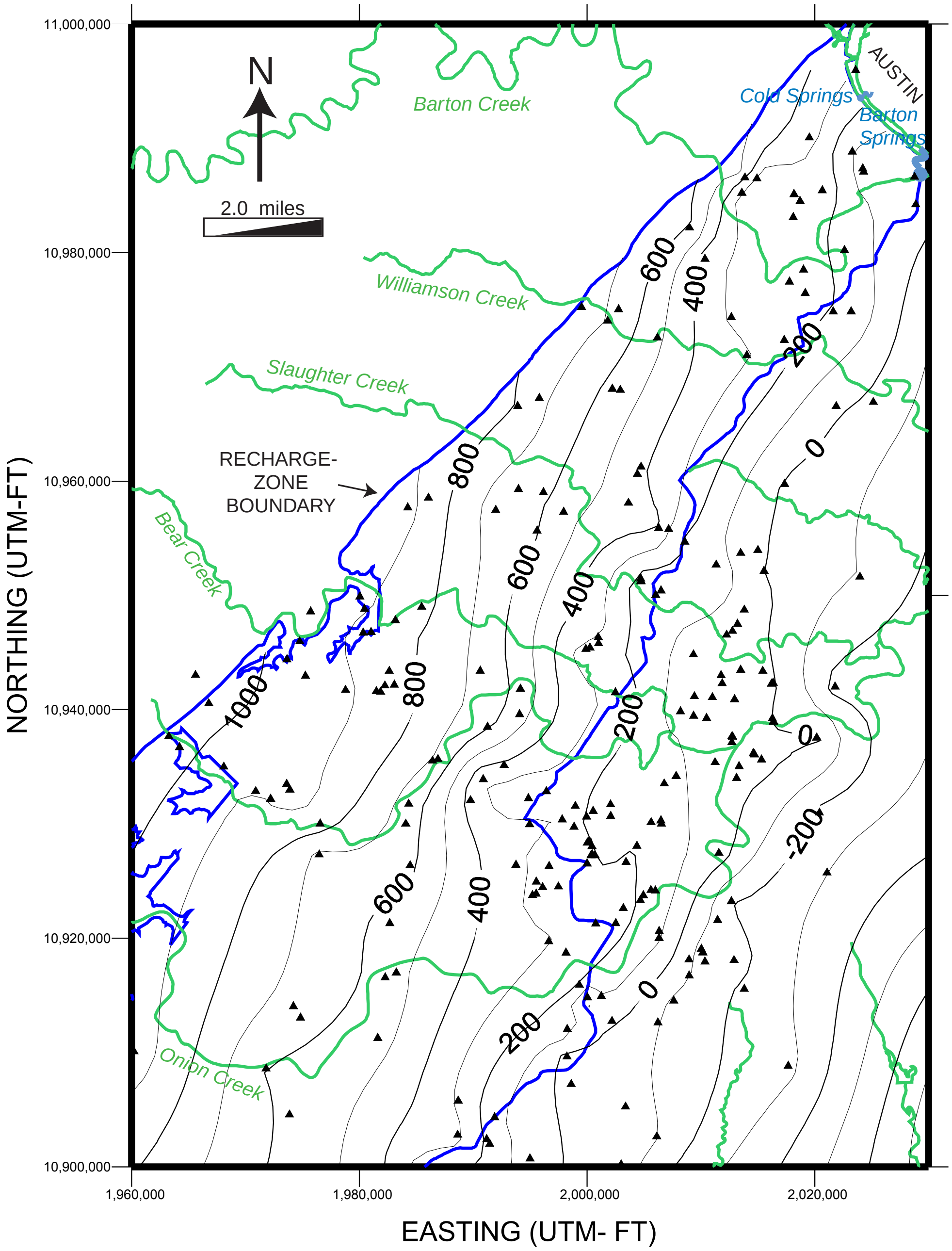

Figure 4-1. Structure contour of the elevation (ft-msl) of the bottom of the Edwards Aquifer. Note: control points shown as triangles.

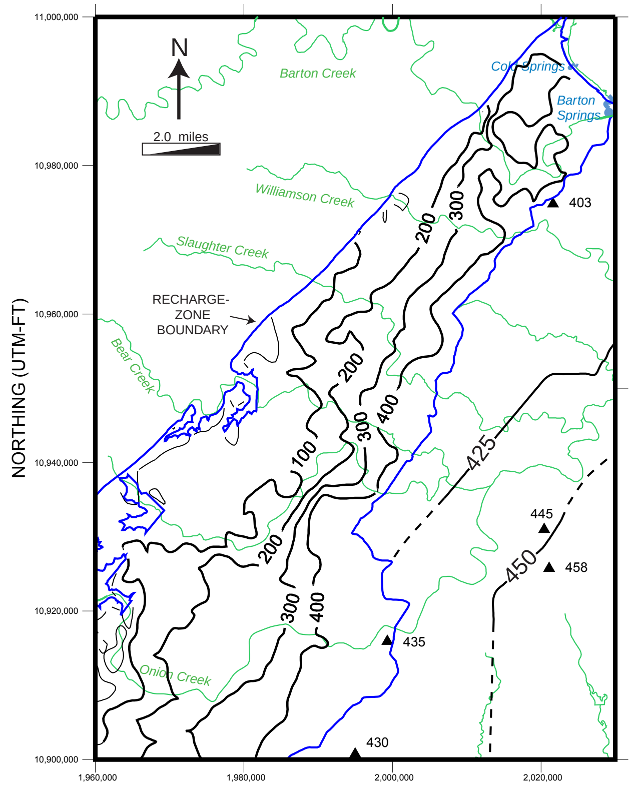

Figure 4-2. Isopach (thickness) map of the Edwards Aquifer. Note: triangles are fully-penetrating wells. Thickness contours are in ft.

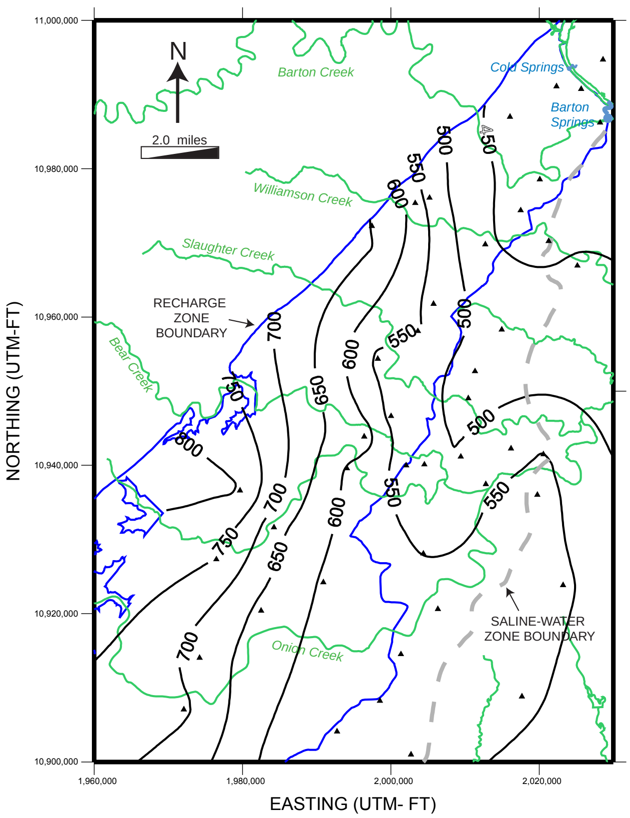

Figure 4-3. Potentiometric map of the Edwards Aquifer under 1950's drought conditions. Note: triangles indicate data locations. Contours are in ft above msl.

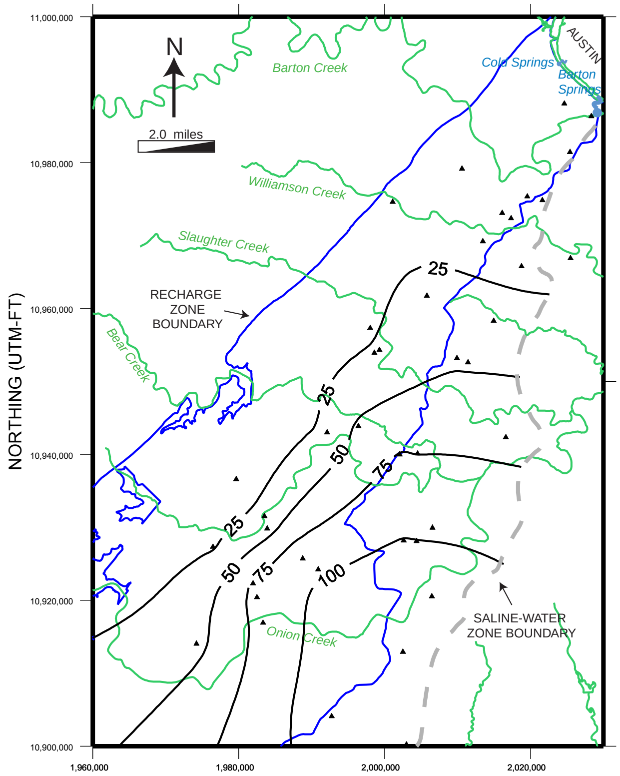

Figure 4-4. Simulated drawdown from pumping 10 cfs at the end of the 10-yr simulation. Note: contours are in ft of drawdown.

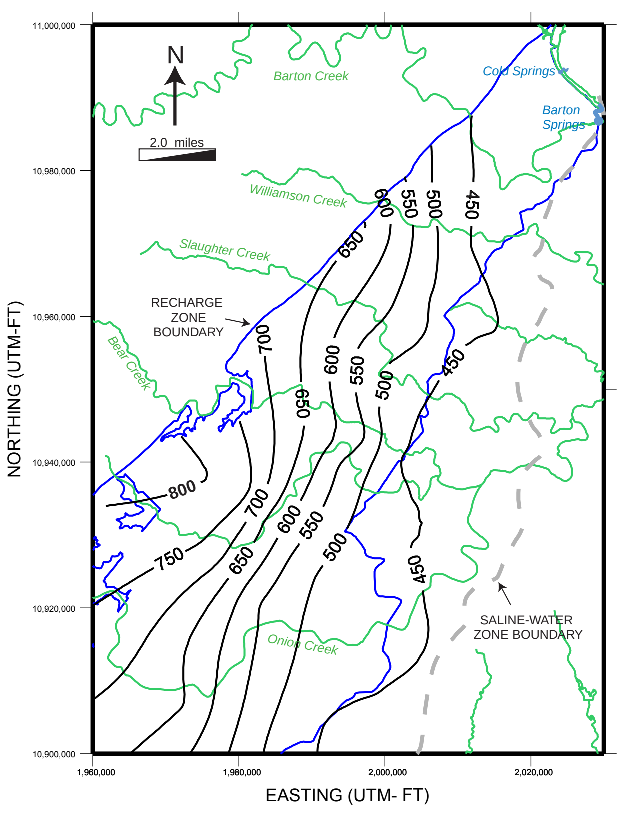

Figure 4-5. Potentiometric map of 1950's drought conditions and 10 cfs pumping. Note: contours are in ft above msl.

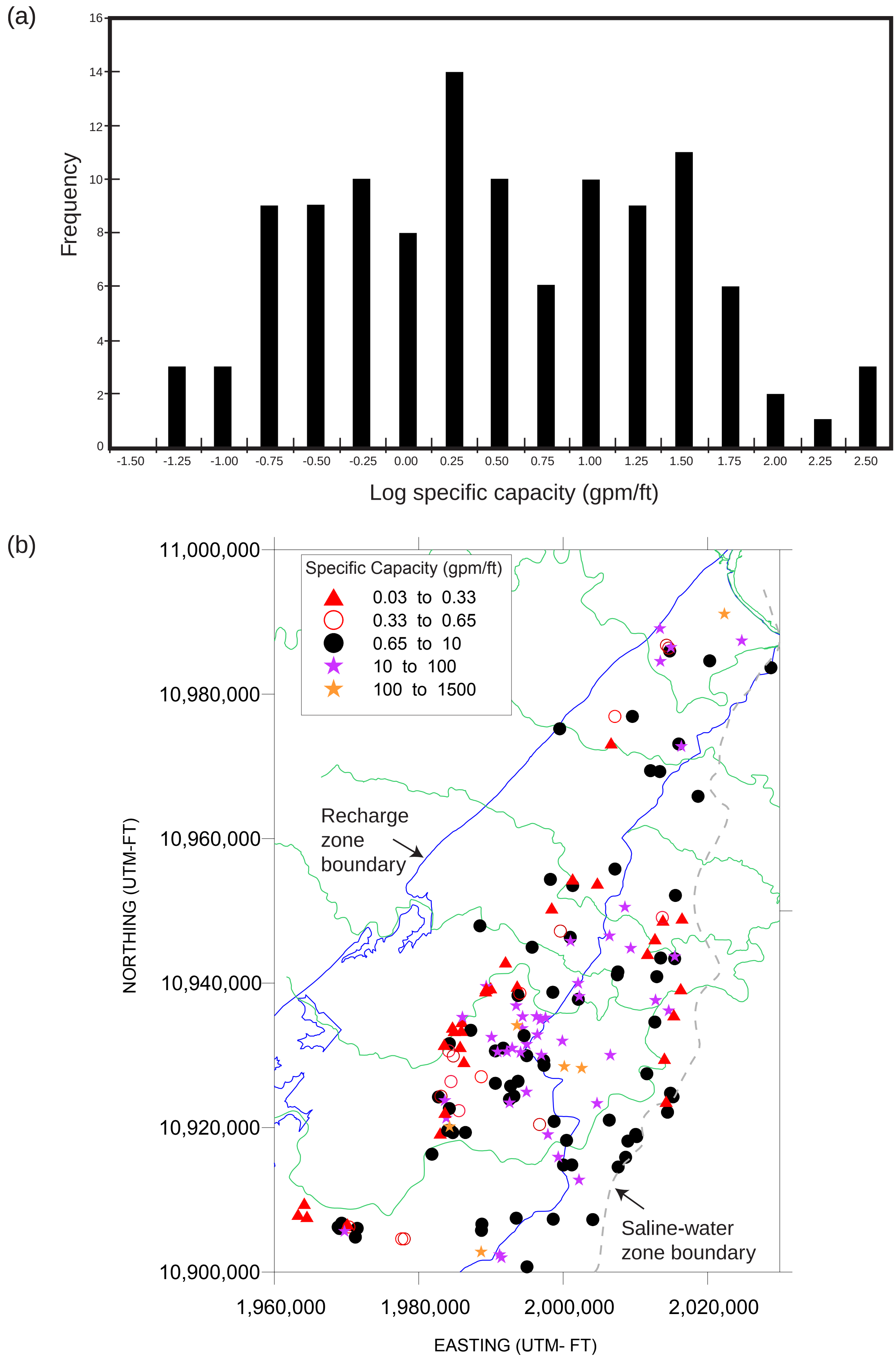

Figure 4-6. (a) Histogram of specific-capacity values from the unconfined portion of the Barton Springs aquifer (n=113). (b) Distribution and classed values of all specific capacity data (n=170).

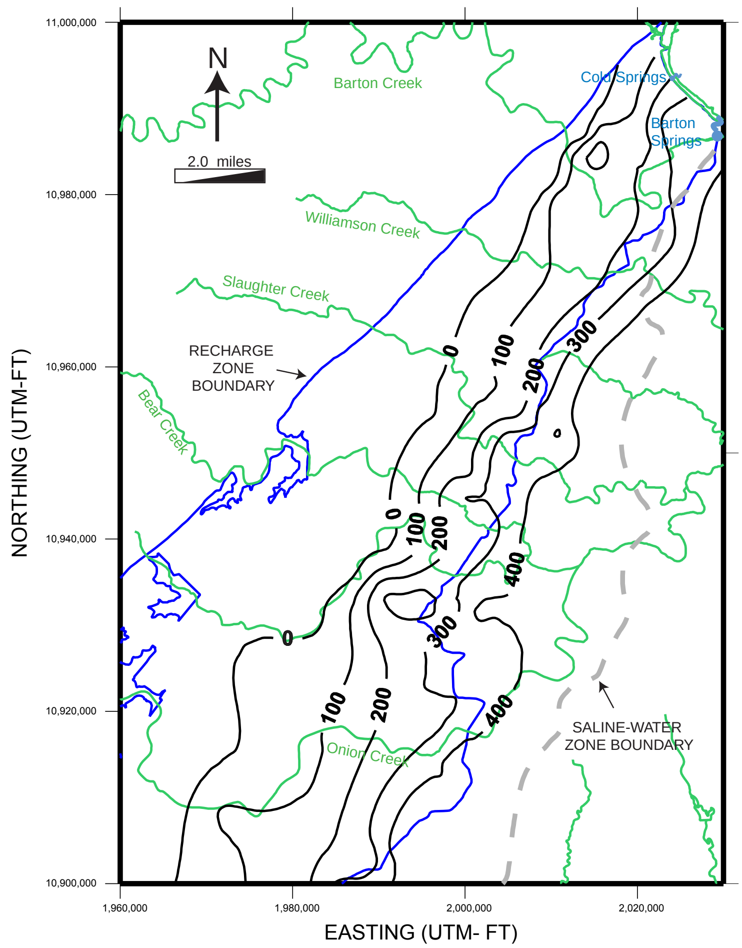

Figure 4-7. Saturated-thickness contour map of the Edwards Aquifer under 1950's drought conditions with minimal (0.66) pumping. Note: contours are in ft.

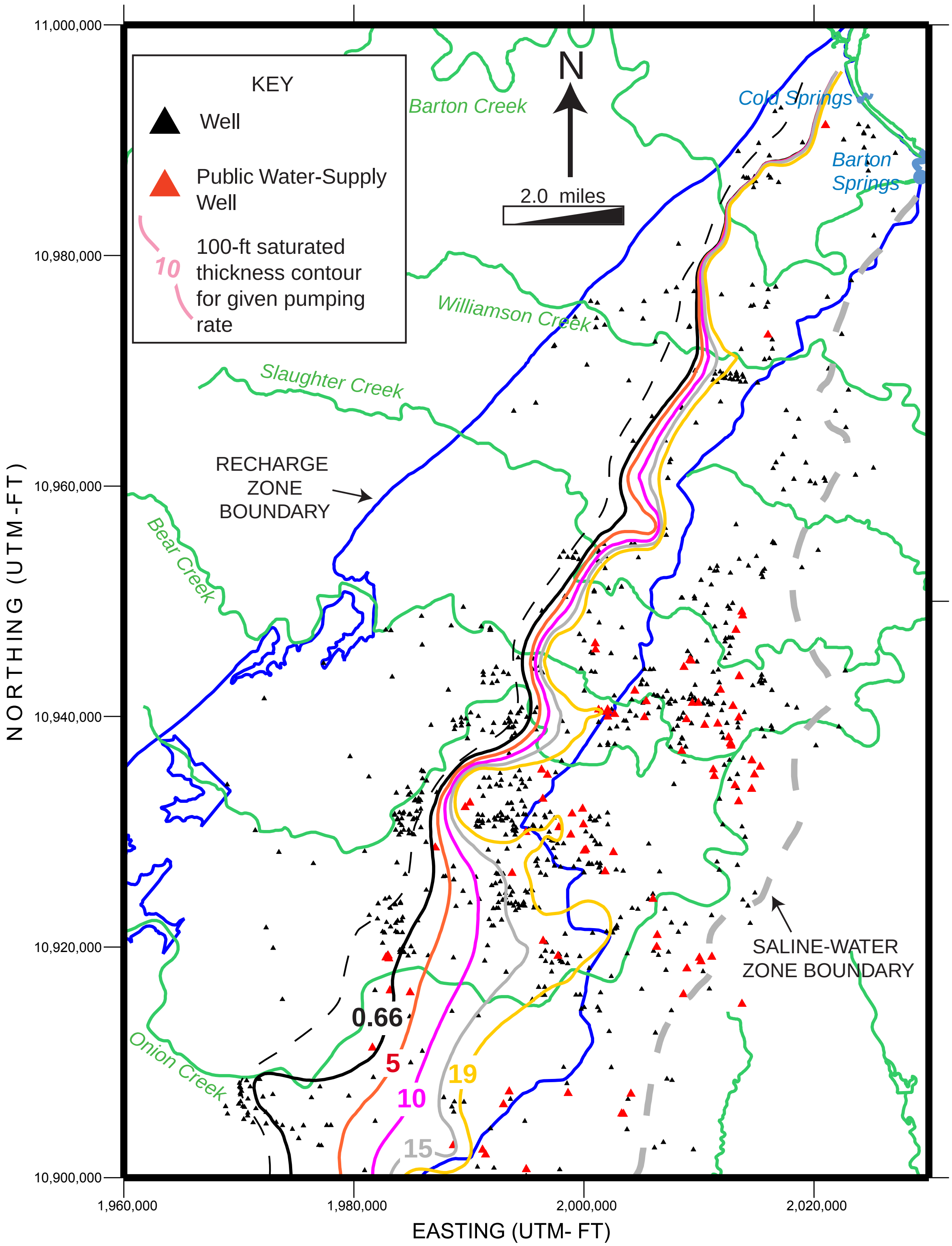

Figure 4-8. Composite of 100-ft saturated aquifer thickness contour lines under 1950's drought conditions with 0.66, 5, 10, 15, and 19 cfs of pumping. Dashed line is 100-ft saturated aquifer thickness contour under high-flow conditions.

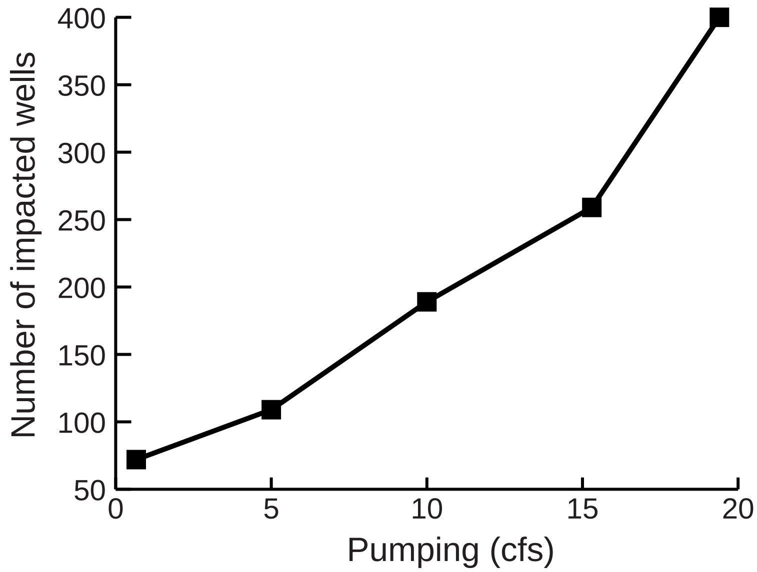

Figure 4-9. Chart summarizing number of wells impacted under 1950's drought conditions and various pumping rates.

APPENDIX A

Report:

Scanlon, B., Mace, R., Smith, B., Hovorka, S., Dutton, A., and Reedy, R., 2001, Groundwater Availability of the Barton Springs Segment of the Edwards Aquifer, Texas—Numerical Simulations through 2050: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the Lower Colorado River Authority, under contract no. UTA99-0, 36 p. + figs., tables, attachment.

APPENDIX M

Rules and Bylaws of the Barton Springs/Edwards Aquifer Conservation District

RULES AND BYLAWS

OF THE

BARTON SPRINGS / EDWARDS AQUIFER

CONSERVATION DISTRICT

Adopted as Revised
on
April 12, 2007

Effective Date

April 12, 2007

RULES AND BYLAWS

OF THE

BARTON SPRINGS / EDWARDS AQUIFER

CONSERVATION DISTRICT

Board of Directors

Robert D. Larsen - President
Precinct 3

Jack Goodman - Vice President
Precinct 4

Craig Smith - Secretary
Precinct 5

Gary Franklin – Director
Precinct 2

Chuck Murphy - Director
Precinct 1

General Manager

W. F. (Kirk) Holland

TABLE OF CONTENTS

Note: Page Numbering in this Markup's Table of Contents is only approximately correct

1. INTRODUCTION.

In August of 1986, a petition was filed by the Cities of Buda, Hays, San Leanna, Sunset Valley, and Austin to form a groundwater conservation district. As a result, the Barton Springs/Edwards Aquifer Conservation District was created in 1986 by the Texas Water Commission, now the Texas Commission on Environmental Quality (TCEQ), validated in 1987 by the 70th Legislature of the State of Texas (Senate Bill 988), and confirmed by approximately 80% of those voting in an election on August 8, 1987.

The Groundwater Conservation District serves southern Travis County, northern Hays County, and portions of southwestern Bastrop and northwestern Caldwell Counties. The District incorporates approximately 155 square miles including both urban and rural areas. In June 1988, the Environmental Protection Agency (EPA) federally designated a portion of the District as a Sole Source Aquifer. Water from the Barton Springs segment of the Edwards Aquifer serves as a water supply for residential, industrial, and commercial purposes, is a major source of high quality base flow to the Colorado River, and provides water for a popular recreational resource in Austin - Barton Springs and Barton Springs Pool.

The District office is open Monday through Friday, 8:00 a.m. to 5:00 p.m. The Board of Directors holds regular semi-monthly meetings. The public is invited to attend all Board of Directors meetings and meetings of the advisory committees.

The Rules and Bylaws of the Barton Springs/Edwards Aquifer Conservation District are used to guide, define, and achieve the District goals of water conservation and pollution prevention in an effort to preserve, protect, and enhance the groundwater within the District's jurisdictional boundaries. The Rules, Bylaws, and accompanying definitions are complementary and inseparable.

The District's Rules, Bylaws, and Standards are promulgated under the District's statutory authority (primarily Senate Bill 988 and Texas Water Code Chapter 36) to achieve the following objectives: to provide for conserving, preserving, protecting, and recharging of the groundwater or of a groundwater reservoir or its subdivisions in order to control subsidence, or prevent waste of groundwater. The District's Orders, Rules, regulations, requirements, resolutions, policies, guidelines, or similar measures have been implemented to fulfill these objectives.

2. DEFINITIONS, PURPOSE, AND CONCEPTS OF THE RULES AND BYLAWS.

2-1. DEFINITIONS OF TERMS.

Unless the context hereof indicates a contrary meaning, the words hereinafter defined shall have the following meanings in these Rules and Bylaws and all other documents promulgated by the District.

"**Abandoned Well**" - a well that has not been used for a beneficial purpose for at least six consecutive months and/or a well not registered with the District. A well is considered to be in use in the following cases:

1. A non-deteriorated well which contains the casing, pump and pump column in good condition; or
2. A non-deteriorated well which has been capped; or
3. the well is used in the normal course and scope and with the intensity and frequency of other similar users in the general community; or
4. the owner is participating in the Conservation Reserve Program authorized by Sections 1231-1236, Food Security Act of 1985 (16 U.S.C. Sections 3831-3836), or a similar governmental program.

"**Act**" - the District's enabling legislation, S.B. No 988 of the 70th Texas Legislature in conjunction with Chapter 36, Texas Water Code.

"**Actual and Necessary Expenses**" - expenses incurred while performing duties associated with District business or representing the District for purposes of the District.

"**Aggregate Wells**" - a well system comprised of two or more wells that are owned and operated by the same permittee and serve the same subdivision, facility, or area served by a Certificate of Convenience and Necessity (CCN) issued by the Texas Commission on Environmental Quality (TCEQ).

"**Aggregate Withdrawal**" - the amount of water withdrawn from two or more registered wells in a water system that is permitted under a single permit for a total pumpage volume of all wells in the aggregate system.

"**Agricultural Irrigation Use**" - the use associated with providing water for application to plants or land in connection with cultivating the soil to produce crops for human food, animal feed, or planting seed or for the production of fibers; the practice of floriculture, viticulture, silviculture, and horticulture including the cultivation of plants in containers or non-soil media by a nursery grower; or planting cover crops, including cover crops cultivated for transplantation, or leaving land idle for the purpose of participating in any governmental program or normal crop or livestock rotation procedure.

"**Agricultural Well**" - a well providing groundwater for agricultural livestock use or agricultural irrigation use. (A non-exempt well.)

“Agricultural Livestock Use” – the use associated with the watering, raising, feeding, or keeping of livestock for breeding purposes or for the production of food or fiber, leather, pelts or other tangible products having a commercial value; wildlife management; and raising or keeping equine animals.

“**Alarm Stage Drought**” – the first of two drought severity stages that the District may declare when aquifer conditions reach drought stage levels. At least 20% reduction in monthly water use required for all permittees.

“Alternative (Water) Supply” - A supply of water from some other source than the groundwater authorized for withdrawal under a District permit and that is not groundwater from the freshwater part of the Edwards Aquifer.

“**Annular Space**” - the space between two concentric cylindrical objects, one of which surrounds the other, such as the space between the walls of a drilled hole and the installed casing.

“**Aquifer**” - a geologic formation that will yield water to a well in sufficient quantities to make the production of water from this formation feasible for beneficial use.

“**Aquifer Emergency Warning**” - a groundwater condition that may be declared by the District when water quality or water quantity becomes detrimental to public health or the beneficial use of water from the aquifer.

“**Artesian Zone**” - a zone where water is confined in an aquifer under pressure so that the water will rise in the well casing or drilled hole above the bottom of the confining bed overlying the aquifer.

“**AWWA**” - American Water Works Association.

“**Bad Water Line**” - the eastern boundary of Edwards Aquifer water in the Barton Springs segment of the Edwards Aquifer characterized by having more than 1,000 milligrams per liter (mg/l) of total dissolved solids.

“**Baseline Pumpage**” - the average monthly representative water use for the user for the corresponding months during the years 1988, 1989, and 1990, or a representative three year period approved by the District. Retail water utilities may set these goals on a per capita basis or a per connection basis system-wide, calculating usage from either the actual number of residents, the number of active connections multiplied by a mutually agreeable per capita standard, or the total number of connections served by the system. If permitted pumpage for any permittee is within 10% of a three-year average annual usage, a permittee may calculate the individual monthly target pumpage volume based on the permitted pumpage. Baseline pumpage may be adjusted for current conditions within the system and approved administratively by the District.

“**Beneficial Use**” - the use of water at all times for domestic, municipal, stock raising, agricultural, industrial, commercial, mining, irrigation, gardening, or pleasure /

recreational purposes, and for exploring for, producing, handling, or treating oil, gas, sulphur, or other minerals.

"**Barton Springs Segment**" - that segment of the Edwards Aquifer which is hydrologically connected to Barton Springs and is the term used to distinguish this segment from the San Antonio segment of the Edwards Aquifer and from the northern Edwards Aquifer.

"**Board**" - the Board of Directors of the Barton Springs/Edwards Aquifer Conservation District.

"**Capping**" - equipping a well with a securely affixed, removable device that will prevent the entrance of surface pollutants into the well.

"**Casing**" - a tubular structure installed in the excavated or drilled borehole to maintain the well opening.

"**Cement Grout**" - a mixture of water and cement, which may also include a bentonite clay component.

"**Cement Report**" - a portion of the Water Well Drillers Log which indicates the type and ratio of mixture, the volume of cement, the method used for placement, the depths grouted and other appropriate documentation of the procedures used in cementing the well.

"**Certificate of Convenience and Necessity**" **(CCN)** – a permit issued by TCEQ which authorizes and obligates a retail public utility to furnish, to make available, to render or extend continuous and adequate retail water or sewer utility service to a specified geography area.

"**Cessation**" – a temporary discontinuance of groundwater production from water wells authorized under a conditional production permit during Critical Stage Drought conditions.

"**Cistern**" - an in-ground storage facility for water. Abandoned or deteriorated facilities will be treated as hand dug wells for sealing, capping, or plugging purposes.

"**Closed Loop Well**" - a well constructed for circulating water through a continuous length of tubing, generally for earth coupled-heat exchange purposes. See also Earth Coupled Heat Exchange-Closed Loop System. (An exempt well).

"Commercial Use" – the use associated with supplying water to properties or establishments, which are in business to build, supply, or sell products, or provide goods, services or repairs and which use water in those processes or used primarily for employee and customer conveniences (i.e. flushing of toilets, sanitary purposes, and limited landscape watering). This includes use in other business enterprises for which monetary consideration is given or received, which will typically increase water demand compared to typical domestic use.

"**Commercial Well**" - a well providing groundwater for commercial use. (A non-exempt well).

“**Conditional Production Permit**” - an authorization issued by the District allowing the withdrawal of a specific amount of groundwater from a nonexempt well for a period of time not exceeding one (1) year, generally in the form of a specific number of gallons per District fiscal year, which is subject to complete cessation, temporary curtailment, or reduction of the amount of groundwater that may be withdrawn during District declared Alarm and Critical Stage Drought conditions.

“**Confining Bed**” - a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

“**Conservation**” - water saving practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses.

“**Consolidated Formation**” - naturally occurring geologic formations that have been lithified (turned to stone). The term is sometimes used interchangeably with the word "bedrock". Commonly, these formations will stand at the edges of a borehole without caving.

“Continuing Arrangement” – an ongoing relationship between a water provider and any individual customer, subdivision, or other water user, whereby the water provider has water delivery infrastructure in place and operational, and water is available for direct, on-site use by the customer, subdivision, or water user upon demand. The continuing arrangement dates from the day the water was first made available for actual on-site delivery to the customer, subdivision, or water user. A continuing arrangement does not include contractual obligations to provide water at some future date, nor does it include providing water to any subdivision of property by any water user currently served by the provider.

“**Critical Environmental Feature**” - a feature such as a sinkhole, fault, or fracture that is a point recharge source for an aquifer.

“**Critical Stage Drought**” - the second of two drought severity stages that the District may declare when aquifer conditions reach drought stage levels. At least 30% reduction in monthly water use required for all permittees.

“**Cubic Feet Per Second” (cfs)** - the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second of time. This rate is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute.

“**Demand Reduction Measure**” - a specific action to be taken by defined categories of users to reduce the pumpage demand on the aquifer(s), typically defined by a User Drought Contingency Plan (UDCP).

"Deteriorated Well" - a well that, because of its condition, will cause or is likely to cause pollution of any water in this state, including groundwater.

“Dewatering Well” – a well that is constructed on a temporary basis for the purpose of producing groundwater to lower the water table or potentiometric surface to allow for construction or use of underground space.

“**Director**” - an elected or appointed member of the Board of Directors of the BS/EACD.

“**Discharge**” – means the amount of water that leaves an aquifer by natural or artificial means.

“**District**” - the Barton Springs/Edwards Aquifer Conservation District (BS/EACD).

“District Management Plan” – the plan promulgated and adopted by the District on October 30, 2003, as amended and revised by the Board from time to time, that defines the conditions in the District and the groundwater management goals and objectives to achieve the District’s legislative mandate.

“**District Office**” - the main office of the District at such location as may be established by the Board.

“**Domestic Use**”- water 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. Ancillary use may include watering of domestic animals.

“**Domestic Well**” - a well providing groundwater for domestic use.

“**Drill**” - drilling, equipping, completing wells, or modifying the size of wells or well pumps/motors (resulting in an increase in pumpage volume) whereby a drilling or service rig must be on location to perform the activity.

“**Drilling Authorization**” - an authorization issued by the District for the drilling or modification of a well. (See Well Development/Registration Application).

“**Drought**” - a shortfall in Edwards Aquifer recharge, generally brought about by below-normal rainfall for an extended period of time that is accompanied by high rates of pumping from the Aquifer, that has the potential for substantial negative impacts to water-supply wells and to endangered species at Barton Springs.

“Drought Indicator Well” - a well designated as such by the District Board or staff that is used for specific District needs including the determination of drought conditions. (An exempt well).

“**Drought of Record**” – the historical period when natural hydrological conditions provided the least amount of water. For the Barton Springs segment of the Edwards Aquifer the drought of record occurred from 1950 through 1956.

“**Drought Contingency Plan**” **(DCP)** - a plan by the District that is designed to reduce demand on the available water supply through a process that becomes more restrictive as drought conditions worsen.

"**Drought Stage**" - either "no drought" or one of two designated drought conditions that the District may declare.

"**Earth Coupled Heat Exchange**" or "**Closed Loop System**" - a well system drilled and equipped for the purpose of utilizing the subsurface as a source of energy for heat exchange in heating and cooling systems. These are sealed systems; no water is to be produced or injected. (An exempt well).

"**Edwards Aquifer**" - the water-bearing zone comprised of the Edwards and associated limestone formations.

"**Edwards Outcrop**" - the Edwards and associated limestone formations found at the surface. This area is generally referred to as the Edwards Aquifer Recharge Zone.

"**Evidence of Historic or Existing Use**" – evidence that is material and relevant to a determination of the amount of groundwater beneficially used without waste by a permit applicant during the relevant time period set by District rule that regulates groundwater based on historic use. Evidence in the form of oral or written testimony shall be subject to cross-examination. The Texas Rules of Evidence govern the admissibility and introduction of evidence of historic or existing use, except that evidence not admissible under the Texas Rules of Evidence may be admitted if it is of the type commonly relied upon by reasonably prudent persons in the conduct of their affairs.

"Emergency Response Period" – a declared period of Extreme Drought, deep within the most severe Critical Stage Drought, in which the Board may declare additional curtailment of water use by conditional permittees and other users. See also "Extreme Drought"

"**Exempt Well**" - a well may be exempt if it is:

A. A well that is used solely to supply the domestic use needs of 5 or fewer households and a person who is a member of each household is either the owner of the well, a person related to the owner or a member of the owner's household within the second degree by consanguinity, or an employee of the owner that is either drilled, completed or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day, and is on a tract of land larger than 10 acres or;

B. A well that is used for providing water for livestock or poultry that is either drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day and is on a tract of land larger than 10 acres.

"**Existing Well**" - any well in the District that was drilled on or before August 13, 1987.

"Export of Groundwater" – see "Transport of Groundwater".

"Extreme Drought" -- a severe drought period, deep within a Critical Stage Drought, that is characterized by the sustained flow at Barton Springs being at or below 14 cubic feet per second (cfs) on a 10-day running average basis; this may trigger the declaration by the Board of an Emergency Response Period for additional emergency management action.

“Extreme Drought Withdrawal Limitation” – a drought-time aquifer cap that defines the maximum amount of groundwater that may be pumped from designated aquifer(s) by all groundwater users in the District during Extreme Drought, to be achieved by imposition of more stringent regulatory restrictions on non-exempt users.

“**Fault**” - a fracture or fracture zone in a rock or body of rock, along which there has been movement of the geologic formation on one side of the fault plane relative to the other side, parallel to the fracture.

“**Federal Conservation Program**” – means the Conservation Reserve Program of the United States Department of Agriculture, or any successor program.

“**Fees**” - charges imposed by the District pursuant to Rule, Order, or the Act.

“**Fiscal Year**” - the business year of the District begins on September 1 of each year and ends on August 31 of the following year.

“**Fracture**” - a plane along which there is a break in the geologic formation, but along which there has been no obvious movement. This is sometimes called a "joint".

“**Groundwater or Underground Water**” - water located beneath the earth's surface but does not include water produced with oil and gas production.

“**Groundwater Reservoir**” - a specific subsurface water-bearing reservoir having ascertainable boundaries and containing groundwater.

“**Hand-Dug Well**” - wells with a diameter greater than thirty-six (36) inches and less than 100 feet in depth installed by hand digging or by auger drilling are considered to be hand-dug wells.

“**Hand-Held Hose**” - a garden hose less than 1" in diameter attended by one person, possibly fitted with a manual or automatic shutoff nozzle.

“**Hazardous Conditions**” - any groundwater quality condition that may be detrimental to public health or affect the beneficial use of water from the aquifer.

“**Historic Low Water Level Elevation**” - the lowest measured or observed water level elevation in a well as determined by the District.

“Historic Use Status” - a status applied to registered existing, non-exempt wells with authorized production permits approved by the District prior to September 9, 2004.

“**Hydrogeological Report**” - a report that identifies the availability of groundwater in a particular area and formation, and which also addresses the issues of quantity and quality of that water and the impacts of pumping that water on the surrounding environment including impacts to nearby or adjacent wells.

"**Impervious Cover or Surface Area**" - any structure or any street, driveway, sidewalk, patio, or other surface area covered with concrete, brick, paving, tile, or other non-permeable material.

"Incidental Use" - a beneficial use of water which is of a minor nature. Transport of water outside the District by a permittee which totals 5% or less, but in no case more than 5,000,000 gallons of that permittee's FY 1998 annual permitted pumpage volume, or the initial permitted pumpage volume for permittees permitted after FY 1998, is considered incidental use.

"Industrial Use" – the use of water in the building, production, manufacturing, or alteration of a product or good. This includes the use associated with washing, cleansing, cooling, or heating such goods or products.

"**Industrial Well**" - a well providing groundwater for industrial use. (A non-exempt well.)

"**Inflows**" – means the amount of water that flows into an aquifer from another formation.

"**Injection Well**" - a well used to inject water or other material into a subsurface formation or into pipe or tubing placed in the formation for the purpose of storage or disposal of the fluid. (An exempt well.) "Injection well" includes:

(1) an air-conditioning return flow well used to return water that has been used for heating or cooling in a heat pump to the aquifer that supplied the water;

(2) a cooling water return flow well used to inject water that has been used for cooling;

(3) a drainage well used to drain surface fluid into a subsurface formation;

(4) a recharge well used to replenish water in an aquifer;

(5) a saltwater intrusion barrier well used to inject water into a freshwater aquifer to prevent the intrusion of salt water into fresh water;

(6) a sand backfill well used to inject a mixture of water and sand, mill tailings, or other solids into subsurface mines; and

(7) a subsidence control well used to inject fluids into a non-oil-producing or non-gas-producing zone to reduce or eliminate subsidence associated with the overdraft of fresh water.

"**Irrigation Use**" - the application of water, not associated with agricultural irrigation use, to plants or land in order to promote growth of plants, turf, or trees. Irrigation use includes but is not limited to athletic fields, parks, golf courses, and landscape irrigation not tied to domestic use.

"**Irrigation Well**" - a well providing groundwater for irrigation use. (A non-exempt well.)

"**Karst**" - a terrain and topography usually associated with limestone, dolomite, and gypsum formations, characterized by distinctive landforms above and below the surface such as sinkholes, caves, and underground drainages which have developed due to a combination of high rock solubility, well-developed secondary porosity (such as fractures, solution cavities, and caves), the physical structure of the rock, and the presence of an aggressive sub-surface hydrology.

"**Landscape Irrigation**" - the use of water to irrigate lawns, yards, and/or outdoor plants.

"**Late Payment**" - a payment received more than ten (10) days after the due date.

"**Licensed Water Well Driller**" - any person who holds a license issued by the State of Texas pursuant to the provisions of the Texas Water Well Drillers Act and the substantive rules of TDLR's Well Drillers and Pump Installers Program.

"**Licensed Water Well Pump Installer**" - any person who holds a license issued by the State of Texas pursuant to the provisions of HB 1648, 72nd Texas Legislative Session and the substantive rules of the TDLR's Water Well Drillers and Pump Installers Program.

"**Line Loss**" - see shrinkage.

"**Livestock**" - domesticated horses, cattle, goats, sheep, swine, poultry, ostriches, emus, rheas, deer and antelope, and other similar animals involved in farming or ranching operations on land, recorded and taxed in the County as an agricultural land use. Dogs, cats, birds, fish, reptiles, small mammals, potbellied pigs, and other animals typically kept as pets are not considered livestock. Livestock-type animals kept as pets or in a pet-like environment are not considered livestock.

"**Lower Quartile**" - the value below which 25 percent of data observations can be found and above which 75 percent of the data are observed.

"**Managed Available Groundwater**" – means the amount of water that may be permitted by the District for beneficial use in accordance with the desired future condition of the aquifer as determined under Section 36.108, Texas Water Code.

"**Median**" - the positional middle of an ordered array of data, with one-half of the observations (data) preceding the middle value and one-half of the observations following the middle value.

"**Meter**" - a water flow measurement device which meets AWWA standards for the line size, pressures, and flows, and which is properly installed according to the manufacturer's specifications; or other measuring device approved by the District capable of measuring the actual volume of water pumped and maintaining a cumulative record of measured flows.

“**Meter Reading**” - a monthly written report of the reading taken from the water flow measurement device installed on a permitted well. Permitted users are required to submit these reports to the District on a monthly basis.

“**Modify**” - to alter the physical or mechanical characteristics of a well, its equipment, or production capabilities. This does not include repair of equipment, well houses or enclosures, or replacement with comparable equipment.

“Monitor Well” - An artificial excavation, generally by drilling, that is constructed by non-governmental entities to measure or monitor the quality, quantity, or movement of substances, elements, chemicals, or fluids beneath the surface of the ground. Included within this definition are environmental soil borings, piezometer wells, observation wells, and recovery wells. (Non-exempt wells). The term shall not include any well that is used in conjunction with the production of oil, gas, coal, lignite, or other minerals.

“**MSL**” - Mean Sea Level. An average sea level reference datum determined by the National Oceanic and Atmospheric Administration used as a reference in the measurement of elevations.

“**New Well**” - any well that is not an existing well or any existing well that has been modified to increase water production after August 13, 1987.

“**No-Drought Status**” - this stage is in effect when discharge at Barton Springs is above a certain flow rate or when the depth to water in the District's Lovelady monitor well is below a certain level, and/or the District determines that no conditions exist which constitute drought conditions.

“**Non-Exempt Well**” - a well required to obtain a permit for the production of groundwater from within the District and required to report groundwater use.

"Nursery Grower" – a person who grows more than 50 percent of the products that the person either sells or leases, regardless of the variety sold, leased, or grown. For the purpose of this definition, "grow" means the actual cultivation or propagation of the product beyond the mere holding or maintaining of the item prior to sale or lease and typically includes activities associated with the production or multiplying of stock such as the development of new plants from cuttings, grafts, plugs, or seedlings.

“**Open or Uncovered Well**” - an artificial excavation at least 10 feet deep and not more than six feet in diameter, that is dug or drilled for the purpose of producing the groundwater, or for injection, monitoring, or dewatering purposes, and is not capped or covered as required by the District.

“**Operate or Operations**” - to produce or cause to produce water from a well or to use a well for injection or closed-loop heat exchange purposes.

“**Overpumpage**” - to produce water from a well in excess of the amount authorized to be withdrawn in accordance with the permitted pumpage volume issued by the District.

“**Per Capita**” - one individual or person, a unit of population; may be phrased as a standard value such as: one active residential account or meter equals 3.0 per capita.

“**Permit Amendment**” - a minor or major change in the production permit.

“**Permittee**” - a person who is required to obtain a permit from the District.

“Permit” – term used collectively for authorizations issued by the District for well drilling, well modification, groundwater production, or transfers of produced groundwater out of the District.

“**Person**” - includes a corporation, individual, organization, cooperative, government or governmental subdivision or agency, business trust, estate, trust, partnership, association, or any other legal entity.

“**Plugging**” - the permanent closure of a well in accordance with approved District standards.

“**Plugging Authorization**” - an authorization issued by the District which defines the methods for the permanent closure of a well.

“**Pollution**” – means the alteration, thermal, chemical, or biological quality of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

“**Potentiometric Surface**” - the surface defined by the elevation to which water from a specific aquifer will rise in a well (water level) at all geographic locations of that aquifer.

“**Proportional Adjustment**” – a management practice meaning that a temporary curtailment or cessation of groundwater production from a conditional production permitted water well is proportional when the adjustment is maintained at a constant ratio in relation to the adjustment to all other conditional production permitted water wells.

“Public Water Supply Use” – water used primarily for residential use, but may include commercial, industrial, or other use, and which is sold or distributed to the users by a retail water utility (may include non-profit public corporations or municipalities).

“**Public Water Supply Well**” - a well providing groundwater for public water supply use. (A non-exempt well.)

“**Pumpage, or Groundwater Production**” - all water withdrawn from the ground, measured at the wellhead.

“Production Permit” - an authorization issued by the District allowing the withdrawal of a specific amount of groundwater from a nonexempt well for a designated period of time, generally in the form of a specific number of gallons per District fiscal year. Under normal or non-drought conditions, this volume of water may be pumped at any time during the course of the fiscal year at the convenience of and based on the needs of the permittee. However, during times of District-declared drought, monthly pumpage target reduction goals for specific drought stages are designated in the permittee's UDCP. Achieving these target reduction goals may result in a permittee's pumping less than the permittee's annual permitted pumpage volume.

"**Recharge**" – means the amount of water that infiltrates to the water table of an aquifer.

"**Recharge Zone**" - the area of the aquifer in which water infiltrates the surface and enters permeable rock layers.

"**Red Tag**" - an official seal, tag, or label placed on a well or its equipment, or the act of placing the tag or label, to indicate that further pumping of groundwater, or operation of the well, or continuing with other District regulated activities is not permitted by the District, will be in violation of District Rules, and may subject the well owner and operator to civil suit and/or penalties.

"**Reduction Goal**" - the amount of reduction in pumpage volume, expressed in a percentage from baseline pumpage volume for each drought stage.

"Register" –a visual display that is built-in to water meters and that allows direct reading at the meter of the aggregate amount of water that has passed through the meter from the time it was installed.

"**Remediation Well**" - a well used to pump contaminated water or fluids or vent contaminated air from the ground. (An exempt well.)

"Repair" - the procedures employed in the restoration or replacement of damaged or deteriorated equipment and materials used to obtain water from an existing well or the construction involved in establishing seals and safeguards as necessary to protect the groundwater from contamination provided that the repairs do not alter the original state of the well and do not increase the original production capacity of the well.

"**Rules**" - standards and regulations promulgated by the District.

"Scientific Monitor Well" – a well used primarily for scientific monitoring of an aquifer, specifically for water-quality sampling and /or taking water-level measurements, by local, state, and federal government entities. (An exempt well.)

"**Seal**" - the impermeable material, such as cement grout, bentonite, or puddling clay, placed in the annular space between the borehole wall and the casing to prevent the downhole movement of surface water or the vertical mixing of groundwater.

"**Shrinkage**" - the loss of water between the producing well(s) meter and the customers meter in a water system. [Note: when the amount of shrinkage becomes excessive (greater than 15% of pumpage volume) the loss of water may become waste.] (See also "line loss").

“**Sinkhole**” - a naturally occurring solution or collapse depression characterized by subterranean drainage.

“**Special Provisions**” - conditions or requirements added to a permit, which may be more or less restrictive than the Rules as a result of circumstances unique to a particular situation.

“**Spring**” - a point(s) of natural discharge from an aquifer.

“**Stratum**” - a layer of rock having a similar composition throughout.

“Subsidence” – the lowering in elevation of the land surface caused by withdrawal of groundwater.

“**Surface Completion**” - sealing off access of undesirable water, surface material, or other potential sources of contamination to the wellbore by proper casing and/or cementing procedures.

“Sustainable Yield” – the amount of water that can be pumped for beneficial use from the Barton Springs segment of the Edwards Aquifer under a reoccurrence of the drought of record conditions after considering adequate water levels in water wells and degradation of water quality that could result from low water levels and low spring discharge.

“**Target Pumpage**” - the reduced level of monthly pumpage required by the permittee's UDCP by drought stage.

“**TCEQ**” – Texas Commission on Environmental Quality.

“**TDLR**” – Texas Department of Licensing and Regulation.

“**Temporary Curtailment**” – a temporary reduction in the permitted volume of groundwater allowed to be produced by a water well authorized under a conditional production permit during Alarm and Critical Stage Drought conditions.

“**Total Aquifer Storage**” – means the total calculated volume of groundwater that an aquifer is capable of producing.

“**Total Dissolved Solids” (TDS)** - a measurement of the quantity of minerals, chemical compounds, elements, or other matter contained in a state of solution by water.

“**Transfer of Groundwater**” – see "Transport of Groundwater".

“Transport of Groundwater” - pumping, transferring or exporting groundwater out of the District. The terms "transfer" or "export" of groundwater are used interchangeably within Chapter 36 and these Rules.

“**Transport Permit**” - an authorization issued by the District allowing the transfer or transporting of a specific amount of groundwater out of the District for a designated period of time. All applicable permit rules also apply to transport permits.

“**Trigger**” -specific conditions of aquifer water-level elevations, spring discharges, and water quality that the District will monitor and use as indicators of drought conditions for purposes of declaring the various drought severity stages.

“**Tremie Method**” - the pumping of cement grout through a pipe inserted in the borehole annulus.

“**Trinity Group Aquifer**” - includes: the Upper Member of the Glen Rose Formation, known as the Upper Trinity; the Lower Member of the Glen Rose Formation, and the Hensel Sand and Cow Creek Limestone Members of the Travis Peak Formation, known as the Middle Trinity; and the Sligo and Hosston Members of the Travis Peak Formation, known as the Lower Trinity.

“**Unconsolidated Formations**” - naturally occurring earth formations that are not lithified. Alluvium, soil, gravel, clay, and overburden are some of the terms used to describe this type of formation.

“**User**” - a person who produces, distributes, or uses water from the aquifer(s).

“**User Conservation Plan” (UCP)** - a conservation plan submitted to the District by a permitted user, which is approved by the District Board and in accordance with the District Water Conservation Plan.

“**User Drought Contingency Plan” (UDCP)** -a drought contingency plan submitted to the District by a permitted user, which is approved by the District Board and in accordance with the District Drought Contingency Plan.

“**Variance**” - an authorized exception to requirements or provisions of the Rules, granted by the District's Board of Directors.

“**Void**” - a general term for pore space or other opening in rock. The openings can be very small to cave size, and are filled with water below the water table.

“**Waste**” - as used herein shall have the following meaning:

(1) The withdrawal of groundwater from a groundwater reservoir at such rate and in such an amount that causes or threatens to cause the intrusion therein of water not suitable for agricultural, municipal, domestic, or stock raising purposes.

(2) The flowing or producing of wells from a groundwater reservoir when the water produced therefrom is not used for a beneficial purpose, or is not used for such purposes with a reasonable degree of efficiency. Includes line losses in excess of those determined to be unavoidable.

(3) The escape of groundwater from one groundwater reservoir to any other reservoir or geologic strata that does not contain groundwater.

(4) The pollution or harmful alteration of the character of the groundwater by means of salt water or other deleterious matter admitted from another stratum or from the surface of the ground.

(5) Willfully or negligently causing, suffering, or allowing groundwater to escape into any river, creek, natural watercourse, depression, lake, reservoir, drain, sewer, street, highway, road, road ditch, or onto any land other than that of the owner of the well other than the natural flow of natural springs, unless such discharge is authorized by permit, rule, or order issued by the TCEQ under Texas Water Code Chapter 26 *"Water Quality Control"*.

(6) The loss of groundwater in the distribution system and/or storage facilities of the water supply system, which should not exceed 15% of total pumpage. This loss is also termed "shrinkage".

(7) To willfully cause or knowingly permit the water from an artesian well to run off the owner's land or to percolate through the stratum above which the water is found, unless the water is used for a purpose and in a manner in which it may be lawfully used on the owner's land.

(8) Groundwater pumped for irrigation that escapes as irrigation tailwater onto land other than that of the owner of the well unless permission has been granted by the occupant of the land receiving the discharge.

"Water Audit Worksheet" – a District approved worksheet used to calculate shrinkage and/or accounted for and unaccounted for system losses for a given period.

"**Water Level Elevation**" - the measure or estimate of a water surface in a well or aquifer as measured in feet above mean sea level.

"**Water Meter Seal**" - a physical seal that is installed in or on the water meter to prevent tampering with meter readings.

"**Water Pollution Abatement Plan**" (WPAP) - a project impact assessment and pollution prevention proposal.

"**Water-Quality Report**" - a report prepared by the Texas Department of Health, the U.S.G.S. or any other governmentally or District approved laboratory that is the product of testing the water for bacteria, solids, elements, chemicals, or contaminants.

"**Water Table**" - the upper boundary of the saturated zone in an unconfined aquifer.

"**Water Tight Seal**" - a seal that prohibits the entrance of liquids or solutions, including water, which may enter through the wellhead and potentially, contaminate the well.

"**Water Table Zone**" - that part of the aquifer confined only by atmospheric pressure (water levels will not rise in the well above the water table).

“**Water Use Fee**” - a fee based upon total authorized annual pumpage imposed by the District on each well or aggregate system for which a permit is issued. The terms "user fee" and "pumpage fee" are synonymous and used interchangeably with "water use fee".

“Water Utility” - means any person, corporation, public utility, water supply or sewer service corporation, municipality, political subdivision or agency operating, maintaining, or controlling in this state, facilities (such as a public water supply well) for providing potable water service for compensation. A Water Utility under these District Rules may be either a “retail water utility” or a “wholesale water utility” as defined under TCEQ rules.

“**Water Well**” - any drilled or excavated facility, device, or method used to withdraw groundwater from the groundwater supply.

“**Well**” - any artificial excavation or borehole constructed for the purposes of exploring for or producing groundwater, or for injection, monitoring, or dewatering purposes.

“**Well Abandonment**” - leaving a well unused, unattended, and improperly protected from contamination and/or sources of pollution. Abandoned wells must be capped, permanently closed, or plugged in accordance with approved District standards.

“**Well Development Authorization**” - authorization issued to the owner of the property to construct, drill, or modify a well within the District in compliance with approved District standards.

“**Well Development/Registration Application**” - an application made to the District for the purpose of registering a well with the District and/or for the purposes of authorizing or allowing the construction, drilling, plugging, or modifying a well within the District. An approved application is commonly referred to as a "drilling authorization".

“**Well Elevation**” - the ground surface elevation of the wellbore.

“**Well Pumps and Equipment**” - equipment and materials used to obtain water from a well, including the seals and safeguards necessary to protect the water from contamination.

“**Well Registration**” - the creation of a record of the well by use and a well identification number for purposes of registering the well as to its geographic location and for notification to the well owner in cases of spills or accidents, data collection, record keeping and for future planning purposes. (See Rule 3-1.1).

“**Well Report (Log)**” - an accurately kept record, made during the process of drilling, on forms prescribed by the TDLR’s Water Well Drillers and Pump Installers Program, showing the depth of the wellbore, thickness of the formations, character of casing installed, together with any other data or information required by the Water Well Drillers and Pump Installers Program; or any other special purpose well log that may be available for a given well such as a gamma ray log, a temperature log, an electric log, or a caliper log.

"Wildlife Management" – the watering and/or feeding of free-ranging, non-caged, wild animals under a management plan approved by Texas Parks and Wildlife, US Fish and Wildlife Service, or other governmental agency with authority to approve and regulate wildlife management plans.

"**Withdraw or Withdrawal**" - the act of extracting groundwater by pumping or any other method other than the discharge of natural springs.

"**Xeriscape**" - a landscape practice combining the use of low water use plants, design, conservation, and other landscaping principles to conserve water and energy.

2-2. PURPOSE OF RULES.

The Districts Rules, Bylaws, and Standards are promulgated under the District's statutory authority to achieve the following objectives: to provide for conserving, preserving, protecting and recharging of the groundwater or of a groundwater reservoir or its subdivisions in order to provide for: the efficient use of groundwater, controlling and preventing subsidence, controlling and preventing waste of groundwater, addressing conjunctive surface water management issues, addressing natural resource issues, addressing drought conditions, and addressing conservation. The District's orders, rules, regulations, requirements, resolutions, policies, guidelines, or similar measures have been implemented to fulfill these objectives. Groundwater conservation districts are the State's preferred method of groundwater management through rules developed, adopted, and promulgated in accordance with the provisions of Chapter 36.

2-3. USE AND EFFECT OF RULES.

The District uses these Rules and Bylaws as guides in the exercise of the powers conferred by law and in the accomplishment of the purposes of the Act. They shall not be construed as a limitation or restriction on the exercise of any discretion where it exists, nor shall they be construed to deprive the District or Board of the exercise of any powers, duties or jurisdiction conferred by law, nor shall they be construed to limit or restrict the amount and character of data or information that may be required to be collected for the proper administration of the Act.

2-4. RULES OF PROCEDURE FOR RULEMAKING.

2-4.1 SPECIFIC RULES OF PROCEDURE FOR RULEMAKING HEARING.

A. The Board may, following notice and hearing, amend these Rules and Bylaws or adopt new Rules and Bylaws from time to time.

B. Not later than the 20^{th} day before the date of a rulemaking hearing, the General Manager or Board shall:

(1) post notice in a place readily accessible to the public at the District office;

(2) provide notice to the county clerk of each county in the District;

(3) publish notice in one or more newspapers of general circulation in the county or counties in which the District is located;

(4) provide notice by mail, facsimile, or electronic mail to any person who has requested notice under Subsection G; and

(5) make available a copy of all proposed rules at a place accessible to the public during normal business hours and, if the District has a website, post an electronic copy on a generally accessible Internet site.

C. The notice provided under Subsection B must include:

(1) The time, date, and location of the rulemaking hearing;

(2) A brief explanation of the subject of the rulemaking hearing; and

(3) A location or Internet site at which a copy of the proposed rules may be reviewed or copied.

D. The President of the Board or presiding officer shall conduct a rulemaking hearing in the manner the presiding officer determines to be most appropriate to obtain information and comments relating to the proposed rule as conveniently and expeditiously as possible. Comments may be submitted orally at the hearing or in writing. The presiding officer may hold the record open for a specified period after the conclusion of the hearing to receive additional written comments.

E. The District shall require each person who participates in a rulemaking hearing to submit a hearing registration form stating:

(1) the person's name;

(2) the person's address; and

(3) whom the person represents, if the person is not at the hearing in the person's individual capacity.

F. The President of the Board or presiding officer shall prepare and keep a record of each rulemaking hearing in the form of an audio or video recording or a court reporter transcription.

G. A person may submit to the District a written request for notice of a rulemaking hearing. A request is effective for the remainder of the calendar year in which the request is received by the District. To receive notice of a rulemaking hearing in a later year, a person must submit a new request. An affidavit of an officer or employee of the District establishing attempted service by first class mail, facsimile, or e-mail to the person in accordance with the information provided by the person is proof that notice was provided by the District.

H. The District may use an informal conference or consultation to obtain the opinions and advice of interested persons about contemplated rules and may appoint advisory committees of experts, interested person, or public representatives to advise the District about contemplated rules.

I. Failure to provide notice under Subsection B(4) does not invalidate an action taken by the District at a rulemaking hearing.

2-4.2 EMERGENCY RULES.

A. The Board may adopt an emergency rule without prior notice or hearing, or with an abbreviated notice and hearing, if the Board:

(1) finds that a substantial likelihood of imminent peril to the public health, safety, or welfare, or a requirement of state or federal law, requires adoption of a rule on less than 20 days' notice; and

(2) prepares a written statement of the reasons for its finding under Subdivision (1).

B. Except as provided by Subsection C, a rule adopted under this section may not be effective for longer than 90 days.

C. If notice of a hearing on the final rule is given not later than the 90th day after the date the rule is adopted, the rule is effective for an additional 90 days.

D. A rule adopted under this section must be adopted at a meeting held as provided by Chapter 551, Government Code.

2-5. HEADINGS AND CAPTIONS.

The section and other headings and captions contained in these Rules and Bylaws are for reference purposes only and shall not affect in any way the meaning or interpretation of these Rules and Bylaws.

2-6. GENDER.

Use of masculine pronouns for convenience purposes in these Rules and Bylaws shall include references to persons of feminine gender where applicable. Words of any gender used in these Rules and Bylaws shall be held and construed to include any other gender, and words in singular number shall be held to include the plural and vice versa, unless context requires otherwise.

2-7. SEVERABILITY.

In case any one or more of the provisions contained in these Rules and Bylaws shall for any reason be held to be invalid, illegal, or unenforceable in any respect, such invalidity, illegality, or unenforceability shall not affect any other Rules, Bylaws, or provisions hereof, and these Rules and Bylaws shall be construed as if such invalid, illegal, or unenforceable rule or provision had never been contained herein.

2-8. SAVINGS CLAUSE.

If any section, sentence, paragraph, clause, or part of these Rules or Bylaws should be held or declared invalid for any reason by a final judgment of the courts of this state or of the United States, such decision or holding shall not affect the validity of the remaining portions of these Rules or Bylaws, and the Board does hereby declare that it would have adopted and promulgated such remaining portions irrespective of the fact that any other sentence, section, paragraph, clause, or part thereof may be declared invalid.

2-9. REGULATORY COMPLIANCE.

All wells shall comply with all applicable Rules and regulations of other governmental entities. Where District rules and regulations are more stringent than those of other governmental entities, the District rules and regulations shall control.

2-10. COMPUTING TIME.

In computing any period of time prescribed or allowed by these Rules and Bylaws, by order of the Board, or by any applicable statute, the day of the act, event, or default from which the designated period of time begins to run, is not to be included, but the last day of the period so computed is to be included, unless it be a Sunday or legal holiday, in which event the period runs until the end of the next day which is neither a Sunday nor a legal holiday.

2-11. TIME LIMITS.

Applications, requests, or other papers or documents required or permitted to be filed under these Rules, Bylaws, or by law must be received for filing at the District within the time limit, if any, for such filing. The date of receipt and not the date of posting are determinative.

2-12. VERB USAGE.

The verbs may, can, might, should, or could are used when an action is optional or may not apply in every case.

The verbs will, shall, or must are used when an action is required.

The verb cannot is used when an action is not allowed or is unachievable.

3. RULES.

RULE 3-1. REGISTRATION, AUTHORIZATION, AND PERMITS.

3-1.1. REGISTRATION.

All wells within the District are required to be registered with the District on forms approved by the General Manager. Information on the form shall include the owner's name, mailing address, well location, well size, use, and any other information the General Manager may determine to be of need. All wells registered with the District shall be classified by the District, according to use. Use classifications include: domestic, commercial, industrial, public water supply, agricultural, irrigation, injection, closed loop, remediation, scientific monitor wells, and District Drought Indicator wells. Exempt wells, abandoned wells, and wells used for incidental purposes are also required to be registered with the District. A well registration identification number will be issued to each well.

3-1.2. AUTHORIZATION.

No person shall construct, drill, modify, complete, change type of use, perform dye-tracing operations, plug, abandon, or alter the size of a well in the District without District authorization.

Prior to conducting any of the above activities on any well in the District, the owner or owner's representative must complete and submit to the District a Well Development/Registration Authorization Application form. Upon approval of the application, the General Manager or the General Manager's designated representative shall advise the applicant of the well use classification and whether a permit is necessary. If the well does not have an existing state well number, a temporary well number will be issued along with any authorization to drill, plug or modify.

Prior to performing any type of dye-tracing or other form of groundwater tracing operations within the District's jurisdictional boundary where materials are introduced into surface water or groundwater, the person proposing such operations must submit an operations plan for the proposed tracer study to the District for approval at least 30 days before the proposed starting date of the study. This plan must describe the entire proposal including: the responsible party; type of tracer and any visual, taste, chemical, or health considerations; rationale or need for the proposed study; injection and recovery points; methods to be employed; expected flow paths; expected project term; method of notification of affected well, spring, and property owners; any contingency plans; and any other information involving the proposed study. These studies must not conflict with any part of Rule 3-3 concerning pollution. District approval of any tracing plan may be denied if the District determines that the proposed plan is in conflict with other ongoing tracing studies.

3-1.3. PERMITS AND EXEMPTIONS.

Permits may be issued subject to the rules promulgated by the District, and subject to terms and provisions with reference to the drilling, equipping, completion, or alteration of wells or pumps that may be necessary to prevent waste and achieve conservation, minimize the drawdown of the water table or the reduction of artesian pressure, to control subsidence, to prevent interference between wells, to prevent degradation of water quality, or to prevent waste.

A. No person shall drill, pump, or operate a well without first submitting and obtaining approval of a well development/registration authorization application, production permit, or transport permit from the District. A violation occurs on the first day the drilling, alteration, or operation begins, and continues each day thereafter until the appropriate authorization or permits are approved.

B. The following wells are exempt from having to obtain a production or transport permit from the District:

(1) A well drilled after August 14, 2003, is exempt if it is:

(a) A well that is used solely to supply the domestic needs of 5 or fewer households and a person who is a member of each household is either the owner of the well, a person related to the owner or a member of the owner's household within the second degree by consanguinity, or an employee of the owner, that is either drilled, completed or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day, and is on a tract of land larger than 10 acres or;

(b) A well that is used for providing water for livestock or poultry that is either drilled, completed, or equipped so that it is incapable of producing more than 10,000 gallons of groundwater a day, and is on a tract of land larger than 10 acres.

(2) A well drilled before August 14, 2003 is exempt if it is:

(a) a well not capable of producing more than 10,000 gallons per day;

(b) a well used to satisfy the needs of five or fewer households and a person who is a member of each household is either the owner of the well, a person related to the owner or a member of the owner's household within the second degree by consanguinity, or an employee of the owner;

(c) a well used for the watering, raising, feeding, or keeping of livestock for breeding purposes or for the production of food or fiber, leather, pelts or other tangible products having a commercial value. Boarding of horses, veterinarian facilities, sale barn or auction facilities, animal slaughtering operations, equestrian or rodeo arenas and facilities, and similar businesses are not considered agricultural livestock operations;

(d) a well used solely to supply water for a rig that is actively engaged in drilling or exploration operations for an oil or gas well permitted by the Railroad Commission of Texas provided that the person holding the permit is responsible for drilling and operating the water well and the well is located on the same lease or field associated with the drilling rig and within the boundaries of the field in which the drilling rig is located;

(e) a well authorized under a permit issued by the Railroad Commission of Texas under Chapter 134, Natural Resources Code, or for production from such a well to the extent the withdrawals are required for mining activities regardless of any subsequent use of the water or;

(f) a well that was otherwise treated as exempt by the District.

(3) A District Drought Indicator Well;

(4) A Scientific Monitor Well;

(5) A Remediation Well;

(6) An Injection Well;

(7) A Closed Loop Well;

(8) A Dewatering Well;

(9) The drilling of a water well used solely to supply water for a rig that is actively engaged in drilling or exploration operations for an oil or gas well permitted by the Railroad Commission of Texas provided that the person holding the permit is responsible for drilling and operating the water well and the well is located on the same lease or field associated with the drilling rig and within the boundaries of the field in which the drilling rig is located; or

(10) The drilling of a water well authorized under a permit issued by the Railroad Commission of Texas under Chapter 134, Natural Resources Code, or for production from such a well to the extent the withdrawals are required for mining activities regardless of any subsequent use of the water.

C. The District may not restrict the production of any well that is exempt from permitting under Paragraph (B) of this section, provided any such production doesn't change the type of well or otherwise re-define it such that it is no longer exempt.

D. An entity holding a permit issued by the Railroad Commission of Texas under Chapter 134, Natural Resources Code that authorizes the drilling of water well shall report monthly to the District:

(1) The total amount of water withdrawn during the month; and,

(2) The quantity of water necessary for mining activities; and,

(3) The quantity of water withdrawn for other purposes.

E. Notwithstanding Subsection (D), the District may not require a well exempted under Subsection (B)(9) to comply with the spacing requirements of the District.

F. The District may not deny an application for a permit to drill and produce water for hydrocarbon production activities if the application meets all applicable rules as promulgated by the District.

G. A water well exempted under Subsection (B) shall:

(1) Be registered in accordance with Rules promulgated by the District; and

(2) Be equipped and maintained so as to conform to the District Rules and well construction standards requiring installation of casing, pipe, and fittings to prevent the escape of groundwater from a groundwater reservoir to any reservoir not containing groundwater and to prevent the pollution or harmful alteration of the character of the water in any groundwater reservoir.

H. The driller of a well exempted under Subsection (B) shall file the State of Texas Well Report and any other available drilling log with the District.

I. A well to supply water for a subdivision of land, for which a plat approval is required by Chapter 232, Local Government Code, is not exempted under Subsection (B).

J. Groundwater withdrawn from a well exempt from permitting or regulation under Subsection (B) and subsequently transported outside the boundaries of the District is subject to any applicable District production and export fees.

K. This section applies to water wells, including water wells used to supply water for activities related to the exploration or production of hydrocarbons or minerals. This section does not apply to production or injection wells drilled for oil, gas, sulphur, uranium, or brine, or for core tests, or for injection of gas, saltwater, or other fluids, under permits issued by the Railroad Commission of Texas.

3-1.3.1. TRANSFER OF GROUNDWATER OUT OF THE DISTRICT.

A. Transport Permit Required**.** Before any person transports any water out of the District from a well that is located within the District, the person must obtain a transport permit from the District. If a person transports water under any of the exceptions set forth in Paragraph (B) below, the person need not obtain a transport permit unless the person exceeds the amount of water authorized to be transported without a transport permit under (B) below. If the person exceeds the amount of water transported under (B) below, the person must immediately make application for a transport permit under the process described herein and provide the District with records of pumpage for all water transported from the District.

If an application for a permit or an amendment to a permit under this Section proposes the transfer of groundwater outside of the District's boundaries, the District may also consider the provisions of this Section in determining whether to grant or deny the permit or permit amendment.

B. Exceptions. A transport permit is not required for transporting of groundwater from the District in the following cases:

(1) Transporting of groundwater from the District pursuant to a continuing arrangement (see definition) that was in effect on or before March 2, 1997, to the extent that the amount of water to be transported does not exceed by more than 5 million gallons annually the maximum amount previously transported prior to March 2, 1997 under the terms of the continuing arrangement.

(2) Transporting of groundwater from the District for Incidental Use (see definition) or that takes place only sporadically.

(3) Persons transporting or intending to transport water under any of these exceptions are responsible for notifying the District that transport is occurring under these exceptions and for metering and maintaining records of transport of water outside the District. Upon request, any such metering and records must be provided to the District for review.

C. Except as provided in this Section, the District may not impose more restrictive permit conditions on transporters than the District imposes on existing in-District users.

D. The District may impose a reasonable fee for processing an application under this Section. The fee may not exceed fees that the District imposes for processing nonexempt applications. An application filed to comply with this Section shall be considered and processed under the same procedures as other applications for permits and shall be combined with applications filed to obtain a permit for in-District water use from the same applicant.

E. In addition to the fees imposed by the District under Rule 3-1.16, the District may continue to collect export fees pursuant to Chapter 36.122(p) for groundwater transported, transferred, or exported outside the District boundaries.

F. In reviewing a proposed transfer of groundwater out of the District, the District shall consider:

(1) The availability of water in the District and in the proposed receiving area during the period for which the water supply is requested;

(2) The projected effect of the proposed transfer on aquifer conditions, depletion, subsidence, or effects on existing permit holders or other groundwater users within the District; and

(3) The approved regional water plan and certified District Management Plan.

G. The District may not deny a transport permit based on the fact that the applicant seeks to transfer groundwater outside of the District but may limit a transport permit issued under this Section if conditions in Subsection (F) warrant the limitation, subject to Subsection (C).

H. In addition to conditions provided by this Section, the transport permit shall specify:

(1) The amount of water that may be transferred out of the District; and,

(2) The period for which the water may be transferred.

I. The period specified by Subsection (H)(2) shall be:

(1) At least three years if construction of a conveyance system has not been initiated prior to the issuance of the transport permit; or

(2) At least 30 years if construction of a conveyance system has been initiated prior to the issuance of the transport permit.

J. A term under Subsection (I)(1) shall automatically be extended to the terms agreed to under Subsection (I)(2) if construction of a conveyance system is begun before the expiration of the initial term.

K. Notwithstanding the period specified in Subsections (I) and (J) during which water may be transferred under a transport permit, the District may periodically review the amount of water that may be transferred under the transport permit and may limit the amount if additional factors considered in Subsection (F) warrant the limitation, subject to Subsection (C). The review described by this Subsection may take place not more frequently than the period provided for the review or renewal of regular permits issued by the District. In its determination of whether to renew a transport permit issued under this Section, the District shall consider relevant and current data for the conservation of groundwater resources and shall consider the transport permit in the same manner it would consider any other permit in the District.

L. The District is prohibited from using revenues obtained under Subsection (E) to prohibit the transfer of groundwater outside of the District. The District is not prohibited from using revenues obtained under Subsection (E) for paying expenses related to enforcement of this Section or District Rules.

M. The District may not prohibit the export of groundwater if the purchase was in effect on or before June 1, 1997.

N. This Section applies only to a transfer of water that is permitted after September 1, 1997.

3-1.4. APPLICATION FOR REGISTRATION, PRODUCTION PERMITS, TRANSPORT PERMITS, WELL PLUGGING, WELL DEVELOPMENT, WELL DRILLING, OR WELL MODIFICATION AUTHORIZATION.

A. Administrative Completeness of Application. Applications for well registration, production permits, conditional production permits, transport permits, well plugging, well development, well drilling, or well modification authorization shall be made in the name of the well owner or property owner on a form or forms provided by the District. The sworn, original application must be submitted and signed by the owner or an authorized agent of the owner, who may be required to provide the District with a notarized authorization from the owner. This agent may be the well driller, lessee or renter of the property or well, power of attorney, or other appropriate agent. District staff will determine if an application is administratively complete.

An administratively complete application shall consist of the submission to the District of an original, completed, signed, and notarized application, payment of all applicable application fees, inspection fees, water use fees, and other District-imposed fees, submission of any required maps, documents, or supplementary information required by the General Manager, or the General Manager's designated representative, the submission of a hydrogeological report if required by Rule 3-1.4(D), and any other documentation required by the District as part of the application. The District will not take action on an application which is not administratively complete or which has preceded in a manner not consistent with District Rules. Applicants submitting incomplete applications will be notified by the District in writing.

Applicants exempted under the District Rules from obtaining a permit to drill must still submit a District-approved application form for District well development/well registration and pay applicable application and inspection fees. Such exempted wells are still subject to District Well Construction Standards.

Application and production permit requirements are the same for groundwater to be used inside the District's jurisdiction or to be transported outside of the District's jurisdiction. All applications for nonexempt wells must contain, in addition to any information determined necessary for the evaluation of the application by the General Manager, or the General Manager's designated representative, the following information in sufficient detail to be acceptable to the District:

(1) A detailed statement of the nature, and purpose of the various proposed uses and the amount of water to be used for each proposed use, and, in the case of a well requiring a production permit, including, but not limited to: a projected quarterly timeline detailing the anticipated pumpage volumes for the first three years of pumpage; a breakdown by types of use (domestic, commercial, irrigation, industrial, etc.); estimated or calculated per capita and/or household consumption; explanation of anticipated demands or system growth and associated pumpage needs; local water use trends; conservation practices in effect or proposed; and any other pertinent information required by the District.

(2) A declaration that the applicant will comply with the District Rules and all groundwater use permits and plans promulgated pursuant to the District Rules.

(3) The location of each well and the estimated rate at which water will be withdrawn from each well.

(4) A water well closure plan or a declaration that the applicant will comply with well plugging and capping guidelines set forth in these Rules and will report well closures as required in Rule 3-5.

(5) For wells for which notice must be provided under Section B below, a location map indicating the locations of: the proposed well or the existing well to be modified; all existing wells within a half (1/2) mile radius of the proposed well or the existing well to be modified; the subject property; and all properties within a half (1/2) mile radius of the proposed well or the existing well to be modified. This provision is subject to technical evaluation by District staff based on site-specific conditions.

(6) For wells for which notice must be provided under Section B below, a tax plat map indicating the location of: the proposed well or the existing well to be modified; the subject property; and all properties within a half (1/2) mile radius of the proposed well or the existing well to be modified and the names, mailing addresses, and physical addresses of the property owners with property located within a half (1/2) mile radius of the proposed well or the existing well to be modified.

(7) Notice of any application to the Texas Commission on Environmental Quality (TCEQ) to obtain or modify a Certificate of Convenience and

Necessity (CCN) to provide water or wastewater service with water obtained pursuant to the requested production permit.

(8) The location of the proposed receiving area for the water to be produced.

(9) A description of the amount and purposes of use in the proposed receiving area for which water is needed.

(10) The availability of feasible and practical alternative supplies available to the applicant.

(11) For new wells or well modifications, a proposed well design schematic with specifications to include: the total depth, borehole diameter, casing diameter and depth, annular seal interval(s), annular sealing method, surface completion specifications, and any other pertinent well construction information.

(12) A hydrogeological report, in accordance with Section D below. A hydrogeological report is not required for a Development / Drilling / Modification Authorization application.

(13) A User Conservation Plan (UCP) and a User Drought Contingency Plan (UDCP). A UCP or UDCP are not required for a Development / Drilling / Modification Authorization application.

(14) If the groundwater is to be resold, leased, or otherwise transferred to others, provide the location to which the groundwater will be delivered, the purpose for which the groundwater will be used, and a copy of the legal documents establishing the right for the groundwater to be sold, leased, or otherwise transferred, including but not limited to any contract for sale, lease, or transfer of groundwater.

(15) Applications for Class B conditional permits under Rule 3-1.24(B)(2) must demonstrate the certain ability and binding commitment to switch from the to-be-permitted volume of groundwater to some Alternate Water Supply source(s) on a 100% basis. This demonstration will include providing, to the Board's satisfaction, adequate documentation of a) the reasonable likelihood that all necessary physical infrastructure and supporting agreements, rates, and tariffs will be in place within the first year of the permit; and b) the commitment to use the Alternative Supply as warranted by District-declared drought conditions.

(16) Other facts and considerations deemed necessary by the General Manager for protection of the public health and welfare and conservation and management of natural resources in the District.

In addition to the information required for all non-exempt permit applications, an application for a transport permit must contain the following information:

(17) Information describing the projected effect of the proposed transporting of water on aquifer conditions, including flow at Barton Springs depletion, subsidence, or effects on existing permit holders or other groundwater users within the District.

(18) Information describing the availability of water in the proposed receiving area during the period for which the water transport is requested.

(19) A description of the indirect costs and economic and social impacts associated with the proposed transporting of water.

(20) Any proposed plan of the applicant to mitigate adverse hydrogeologic, social, or economic impacts of the proposed transporting of water in the District.

(21) A description of how the proposed transport is addressed in any approved regional water plan(s) and the certified District Management Plan.

(22) A technical description of the facilities to be used for transportation of water and a time schedule for any construction thereof.

Fees included with Application. The application must be accompanied by the application processing fee, inspection fee, and other fees as appropriate. The application must be administratively complete and all appropriate fees must be paid to the District before notice is published and mailed, to the extent required by Section B below. Payment of all fees, including water use fees, remain the responsibility of the property owner.

B. Notice.

(1) Applicants must provide public notice for the following types of Permit applications:

(a) all new non-exempt wells not authorized by a District general permit;

(b) modification of existing wells to increase production capacity when the well will be completed with an inside casing diameter greater than six (6) inches or a pump size equal to or greater than one horse power and will be used for public water supply, commercial, industrial, agricultural, irrigation, or injection purposes;

(c) notice of intent to transport any groundwater out of the District; or

(d) all major Permit amendments, as defined in Section 3-1.9 of these Rules.

(2) Such notices shall be published in a newspaper of general circulation within the District in a form approved by the District. Public notice shall include a twenty (20) day public response period effective on the day said notice is published in a newspaper of general circulation within the District. Applicants shall publish notice not later than ten (10) business days after receiving an administratively complete determination from the General Manager or the General Manager's designated representative.

(3) All required Permit applications must provide notice by certified mail, return receipt requested, to all property owners within a half (1/2) mile radius of the well that is the subject of the application. Notification of any property owner served by a retail water utility is not required of any applicant if notice is provided to the retail water utility. Applicants shall provide notice by mail not later than ten (10) business days after receiving an administratively complete determination from the General Manager or the General Manager's designated representative.

(4) Applicants may not publish notice or provide notice by mail until the General Manager, or the General Manager's designated representative, determines that the application for which notice is required is administratively complete.

(5) Under no circumstances will a public hearing be held or action taken on the application by the Board prior to the termination of the twenty (20) day public response period.

(6) All public notices covered by this section must contain at least the following information:

(a) The name and address of the applicant;
(b) The date the application was filed;
(c) The location and a description of the well that is the subject of the application; and
(d) A brief summary of the information in the application.

(7) Upon completion of the published and mailed public notice, the District shall be provided with:

(a) Proof of publication of public notice. The applicant shall submit an <u>original</u> newspaper clipping which shows the date of publication and the name of the newspaper to the District office within ten (<u>10) business days</u> after the date of publication.

(b) Proof of public notice to property owners by certified mail. The applicant shall submit copies of all U.S. Postal Service Certified Mail Receipt (PS Forms 3800, June 2002, or a successor form as issued by the U.S. Postal Service).

C. Decision to Hold Public Hearing. On any application for non-exempt well Permits not authorized by a general permit, the General Manager will schedule a hearing if the General Manager determines that a hearing will be beneficial to the District's consideration of the application, or if the General Manager receives protests to the application or requests for a public hearing from any party at interest, including any party to whom notice is provided in accordance with Paragraph B above. The District will conduct a public hearing for all new well Permits with proposed production of more than 2,000,000 gallons annually. On any application for a transport permit, the General Manager shall schedule a hearing. The General Manager shall make a determination whether to schedule a hearing on an application within sixty (60) days of the date the application is administratively complete. A hearing on an application will be held within thirty-five (35) days of the date the determination to schedule a hearing is made. The District will publish notice of the public hearing in a newspaper of general circulation in the District not later than the 10^{th} day before the date of the hearing. The District's Board shall act on the application within sixty (60) days after the conclusion of the date the final hearing on the application. The failure of the District to comply with these deadlines shall not affect the District's jurisdiction over or the merits of an application. The Board of Directors at a regular or special Board meeting may conduct a hearing on any application. Said hearing shall be conducted pursuant to District Bylaw 4-9.

The District's Board may consolidate any hearings or actions on an application for a transport permit with any hearings or actions on applications for other Permits filed by the same applicant or property owner.

D. Hydrogeological Report. Applicants seeking to transport groundwater out of the District, to permit a nonexempt well with an annual pumpage volume of more than 2,000,000 gallons, or to modify in order to increase production or production capacity of a Public Water Supply, Commercial, Industrial, Agricultural or Irrigation well with an inside casing diameter greater than six (6) inches or with a pump size equal to or greater than 1 horsepower, shall submit to the District a current hydrogeological report addressing the area of influence, draw down, recovery time, and other pertinent information required by the District. The well must be equipped for its ultimate planned use and the hydrogeological report must address the impacts of that use. The report must include hydrogeologic information addressing, and specifically related to, the proposed water pumpage rate intended for the well or for the transporting of water outside the District. The District has developed guidelines for preparation of hydrogeological reports that would address District requirements. The District will provide a copy of the hydrogeological report guidelines to applicants upon request. Applicants may not rely solely on reports previously filed with or prepared by the District. If a hydrogeological report is required by this section, the hydrogeological report is a required component of all administratively complete production permit applications.

E. Sanitary Control Easement. For all new Public Water Supply wells, a 150-feet radius sanitary control easement around the well must be recorded with the county of record and evidence of said easement shall be provided to the District within sixty (60) days upon completion of the well. If the 150-feet radius cannot be contained within the tract of land on which the well is to be located, the well owner must obtain sanitary easements from any affected property owner and submit copies with his/her application.

F. Applications submitted during District-declared drought. Due to potential and unpredictable impacts new wells may have on existing wells and aquifer users during drought conditions, applications to drill any well requiring a production permit which are submitted during a District-declared drought will be referred to the Board for consideration and/or public hearing. Applicants should be aware that, due to the need to minimize the drawdown of the water table or the reduction of artesian pressure, to control subsidence, to prevent interference between wells, to prevent the degradation of water quality, or to prevent waste during times of District-declared drought, the Board may require additional information from the applicant, may place special conditions on the application and/or permit, may authorize the drilling, but modify the production permit, or may delay or deny the application entirely if the Board determines that it does not meet all the requirements of District Rules 3-1.4 and 3-1.6.

G. Applications approved during District-declared drought. Although the District must take action on permit applications in accordance with Rule 3-1.4(C), any permits approved by the Board during a District-declared Alarm or Critical Drought, including amendments of existing permits to increase permitted pumpage, shall contain a special provision delaying the effective date of the permit so long as the District remains in a District-declared Alarm or Critical Drought.

3-1.5. PERMITS FOR EXISTING WELLS.

A. Any well existing on or before August 13, 1987, which has not been permitted and which is not exempted from permitting under Rule 3-1.3, is entitled to obtain a permit from the District in the manner provided by this Rule.

B. Applications for permits for existing nonexempt wells must be filed with the District. Failure of the District to provide mailed notice shall not be grounds for failing to meet the requirements of these Rules and Bylaws. Any owner of an existing nonexempt well who failed to apply by October 13, 1987, may make application for a permit pursuant to this section; provided, however, if the well was in operation during the period from August 13, 1987, until the application was made, in addition to the normal requirements, past water use fees shall be paid for each year of operation. Upon written request of the well owner or permittee, the Board may waive any or all past due fees.

Upon completion of a sworn application providing the completion date, capacity, location, historical use, and such other information as may be required by the

District, and upon payment of the application processing fee, the current annual water use fee, and any required past water use fees, the District will issue a permit to the applicant in accordance with the applicable provisions of these Rules.

3-1.6. ACTION ON PERMITS.

A. Permits. Before approving, modifying, delaying, or denying a Permit, the District shall consider whether:

(1) The application conforms to the requirements of these Rules and is accompanied by the appropriate fees;

(2) The proposed use of water is dedicated to beneficial use at all times including whether there are reasonable assurances of definite, non-speculative plans and intent to use the water for specific beneficial uses during the production permit term;

(3) The proposed use of water would not cause or contribute to waste and the applicant has agreed to avoid waste and achieve water conservation. In assessing the acceptability of the proposed volume of water to be permitted, the District will apply standards based on industry and regional standards for permitted usage;

(4) The proposed use of water would not present the possibility of unreasonable interference with the production of water from exempt, existing, or previously permitted wells or other surface water resources;

(5) The proposed use of water would not be otherwise contrary to the public welfare;

(6) The proposed use of water is consistent with the District's certified Management Plan or an approved regional water supply plan;

(7) The applicant has agreed that reasonable diligence will be used to protect groundwater quality and that the applicant will follow well plugging guidelines at the time of well closure and report closure to the District and all other applicable government agencies;

(8) The water is used within the term of the production permit; and

(9) The approved User Drought Contingency Plan for the well yields a maximum volume of authorized groundwater production that, when added to all other authorized amounts under District permits, as restricted by UDCPs, and to other specified (Exempt) withdrawals, does not exceed the Extreme Drought Withdrawal Limitation specified in Section 3-1.23 of these Rules.

In order to protect the public health and welfare and to conserve and manage the groundwater resources in the District during times of drought, the District may prioritize groundwater use, place special requirements on, modify, delay, or deny a production permit for a new well during a District-declared drought.

The District may impose more restrictive permit conditions on new Permit applications and increased use by historic users if the limitations:

(a) Apply to all subsequent new Permit applications and increased use by historic users, regardless of type or location of use;

(b) Bear a reasonable relationship to the existing District Management Plan; and

(c) Are reasonably necessary to protect existing use.

B. Time for Action. After the application is administratively complete, the District shall promptly consider and act on each administratively complete application (see Rule 3-1.4(C)). If a hearing is called to consider any of the foregoing applications, the District will conduct the hearing within thirty-five (35) days after the General Manager determines that a hearing is necessary, and the District's Board will act to approve, modify, delay, or deny the application within sixty (60) days after the date the final hearing on the application is concluded. The failure of the District to act within this time period shall not affect the District's jurisdiction over or the merits of an application. An administratively complete application requires submission of all information set forth within these Rules.

If any applications for nonexempt wells are administratively incomplete 90 days after receipt of the application by the District, the District, by certified mail, return receipt requested, will notify the applicant of the missing documentation and the need to complete the application. Applications that remain administratively incomplete will expire 90 days following the above-mentioned notice to the applicant.

C. Action by General Manager. The District's General Manager or the General Manager’s designated representative may act for the District in approving any application for well registration, new in-District production permits for 2,000,000 gallons or less, minor amendments of 2,000,000 gallons or less, and well drilling, plugging, well modification, or other well development applications so long as the District does not receive any protests to the application nor any requests for a public hearing from any party at interest, including any party to whom notice is provided in accordance with Rule 3-1.4(B), above. The General Manager will schedule a public hearing for all transport permit applications and well production permit applications for more than 2,000,000 gallons and refer the applications to the Board for action. The General Manager will refer all new nonexempt well development applications, all production permit applications, and all major pumpage amendments received by the District during periods of District-declared Alarm or Critical Stage Drought to the Board for action.

3-1.7. TERM OF PERMITS.

A. All permits are effective for the Fiscal Year of issuance, unless otherwise stated on the permit. (Example: a permit issued on September 14, 1977, would be valid as of September 14, 1977 and expire on August 31, 1978.) The Board may issue a permit with an option to extend for a specified term upon payment of the then current annual water use fee (the annual water use fee in effect for the extension period) or for a term longer than one (1) year, but not to exceed five (5) years, except as provided for in Section (C) below and District Rule 3-1.24(E), when to do so aids the District in the performance of its duties and accomplishing the goals of the Act.

B. A transport permit shall specify the period for which water may be transferred.

C. The period specified by the transport permit shall be:

(1) At least three years if construction of a conveyance system has not been initiated prior to the issuance of the permit; or

(2) At least 30 years if construction of a conveyance system has been initiated prior to the issuance of the permit.

D. Notwithstanding the period specified in Subsection (c) during which water may be transferred under a transport permit, a district may periodically review the amount of water that may be transferred under the permit and may limit the amount if additional factors considered in Subsection (f) warrant the limitation, subject to Subsection (c). The review described by this subsection may take place not more frequently than the period provided for the review or renewal of regular production permits issued by the district. In its determination of whether to renew a permit issued under this section, the district shall consider relevant and current data for the conservation of groundwater resources and shall consider the permit in the same manner it would consider any other permit in the district.

3-1.8. PERMIT RENEWAL.

The General Manager without hearing will normally renew a permit for wells a) if the terms and conditions of the permit (including maximum authorized withdrawal) are not changed, b) if the permittee is in compliance or has a compliance agreement with all terms of the permit, and c) if the permittee has resolved all enforcement actions, if any, for the permit.

3-1.9. PERMIT AMENDMENTS.

A. Minor amendments include:

(1) Transfers of ownership without any change in use;

(2) Reductions in use or changing use of a well from nonexempt to exempt;

(3) Increases in use of 10% or less of permitted pumpage for users permitted for more than 12,000,000 gallons annually;

(4) Increases of up to 2,000,000 gallons annually for users permitted for 12,000,000 gallons or less; and

(5) Converting two or more wells individually permitted by the same permittee into an aggregate system under one permit.

All other amendments, including all amendments pertaining to transport permits, are major amendments.

B. Major amendments shall be subject to all the requirements and procedures applicable to issuance of a production permit for a new well or, if applicable, a transport permit.

C. The General Manager or the General Manager's designated representative may grant minor amendments without public notice and hearing. If two or more minor amendments are requested during any fiscal year for an increase in pumpage, and the combined increase in volume requested in the amendments exceeds the limits described in Rule 3-1.9(A), then the amendment which results in a pumpage increase in excess of the limits specified in Rule 3-1.9(A) will be considered a major amendment subject to Rule 3-1.9(B).

D. Minor amendment applications must include a detailed justification for the increase including, but not limited to: analysis of average daily, weekly, and/or monthly water usage and pumpage records; a breakdown by types of use (domestic, commercial, irrigation, industrial, etc.); estimated or calculated per capita and/or household consumption; explanation of increased demands or system growth; anticipated pumpage needs; local water use trends; conservation practices in effect; a revised UCP and UDCP, information about current procedures to locate and repair leaks and the system's current percentage of line loss, and any other pertinent information required by the District.

E. Permittees with annual permitted pumpage volumes greater than 12,000,000 gallons requesting multiple minor amendment pumpage increases that total more than 20% of the permitted pumpage volume of the fiscal year three years prior to the most recent amendment may be required to submit a current hydrogeological report to the District office. (Example: Permittee A is permitted for 50,000,000 gallons in FY 96. The permittee files three minor amendments between 1997 and 1999, one for 5,000,000 gallons, another for 3,000,000 gallons, and another for 4,000,000 gallons, a total of 12,000,000 gallons increase since 1996. The District may require a hydrogeological test as a condition of the most recent amendment application for 4,000,000 gallons.) A current hydrogeological report is one that has been completed within the three years preceding the date of the applications. The hydrogeological report shall be in accordance with Rule 3-1.4(D).

F. Permittees requesting a minor amendment may be required to submit a hydrogeological report at the General Manager's discretion based on aquifer condition, type of modification, status of adjacent wells, local water use trends, and other aquifer management considerations.

G. Application for a permit amendment shall be made upon forms supplied by the District and must be accompanied by an application processing fee established by the Board. No application-processing fee will be required from permittees requesting a decrease in permitted pumpage or changing use of a well from nonexempt to exempt.

H. Permittees requesting an increase in pumpage volume must have a Board approved User Conservation Plan and a Board approved User Drought Contingency Plan on file at the District office, and must be in compliance with Rule 3-6.1 regarding conservation-oriented rate structures. Permittees will be required to update their UCP and UDCP to reflect their new permitted pumpage amount and/or new ownership.

I. Recognizing that any District-declared drought condition may have serious water conservation implications and in order to protect the public health and welfare and to conserve and manage the groundwater resources in the District during times of drought, applications for either minor or major amendments to increase annual permitted pumpage volumes submitted during any District-declared drought shall be referred to the Board for consideration and/or public hearing. A failure to achieve drought-mandated targeted monthly pumpage reduction goals does not in itself justify a pumpage increase.

3-1.10. PERMITS: ISSUANCE AND FORMAT.

A. Permits. The permit shall include the following information in a format approved by the General Manager: the name and address of the person to whom the permit is issued; the state well number or District-assigned temporary well number of the well(s); the date the permit is to expire; the maximum withdrawal authorized; and any other terms and conditions necessary to accomplish the purposes of the Act.

B. Transport Permits. A transport permit may be issued as a consolidated permit, including consolidation with an aggregate permit under Rule 3-1.14 that authorizes drilling, production, and transporting of water from the District. In addition to all other matters required for permits, a transport permit shall include the amount of water that may be transported out of the District and any limitations or conditions placed on the transport permit based on the factors set forth in Rule 3-1.6(B) and Section 36.122(d) of the Act. The District will not deny the issuance of a transport permit if the water to be transported was purchased pursuant to an agreement that was in effect on or before June 1, 1997.

3-1.11. PERMIT CONDITIONS AND REQUIREMENTS.

All Permits are granted subject to the Rules, regulations, orders, special provisions, and other requirements of the Board, and the laws of the State of Texas. In addition, each permit issued shall be subject to the following conditions and requirements:

A. The permit is granted in accordance with the provisions of S.B. 988 of the 70th Texas Legislature in conjunction with Chapter 36, Texas Water Code, and the Rules, regulations and orders of the District as may be in effect from time to time, and acceptance of the permit constitutes an acknowledgment and agreement that the permittee will comply with all the terms, provisions, conditions, requirements, limitations, and restrictions embodied in the permit and with the Rules, regulations, and orders of the District.

B. The permit confers no vested rights in the holder and the permit is non-transferable. Written notice must be given to the District by the permittee prior to any sale or lease of the well covered by the permit. The permit may be revoked or suspended for failure to comply with its terms, which may be modified or amended pursuant to the requirements of the Act and any applicable Rules, regulations and orders of the District.

C. A permit shall be subject to amendment by the District of the amount of water authorized for pumpage based upon a review of the District's sustainable yield model and a determination by the District that an amendment is necessary 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.

D. The drilling and operation of the well for the authorized use shall be conducted in such a manner as to avoid waste, pollution, or harm to the aquifer.

E. The permittee shall keep accurate records and meter readings, on a monthly basis, of the amount of groundwater withdrawn, the purpose of the withdrawal, and, for any transporting of water outside the District, the amount of water transported and the identity and location of the recipients, and such records shall be submitted to the District office on a monthly basis, and shall also be available for inspection at the permittee's principal place of business by District representatives. **Immediate written notice shall be given to the District in the event a withdrawal or transporting of water exceeds the quantity authorized by the permit or rules**. Unless the permittee can present evidence that the pumpage or transport which exceeded the permitted amount is due to an isolated incident that is not likely to be repeated and/or would not result in continued higher demands, the permittee must immediately submit an application to increase the permitted pumpage or transport volume based on the amount of pumpage or transport which exceeded the permitted amount projected for the remainder of the fiscal year.

F. The well site or transport facilities shall be accessible to District representatives for inspection during normal business hours and during emergencies. The permittee agrees to cooperate fully in any reasonable inspection of the well site or transport facilities and related monitoring or sampling by District representatives. The well owner shall provide a twenty-four (24) hour emergency contact to the District.

G. The application pursuant to which a permit has been issued is incorporated therein, and the permit is granted on the basis of and contingent upon the accuracy of the information supplied in that application and in any amendments thereof. A finding that false information has been supplied shall be grounds for immediate revocation of a permit. In the event of conflict between the provisions of the permit and the contents of the application, the provisions of the permit shall prevail.

H. Driller's logs must be submitted within sixty (60) days of the drilling of a well. Monitoring of groundwater pumpage is to be accomplished in the manner specified in the District's metering policy and any modifications thereto.

I. Violation of the permit's terms, conditions, requirements, or special provisions, including pumping amounts in excess of authorized withdrawal or transporting amounts outside of the District in excess of the amount authorized for transport, shall be punishable by civil penalties as provided by the Act and these Rules.

J. If special provisions are inconsistent with other provisions or regulations of the District, the Special Provisions shall prevail.

K. A transport permit may contain any term, condition, or limitation determined to be warranted by the District's Board based on the factors set forth in Rule 3-1.6(B), and Section 36.122(d) of the Act.

L. Permittees will notify the District upon filing an application with the TCEQ to obtain or modify CCN to provide water or wastewater service in a service area that lies wholly or partly within the District or for which water shall be supplied from a well located inside the District.

M. Upon request of the District, permittees that are water utilities and that are not in compliance with their permit conditions concerning water use are required to furnish the District the names, addresses, and monthly water usage of all end-user customers that exceed the presumptive excessive-use criteria set forth in Section 3-3.7(C)(2) of these Rules.

N. Permittees holding Class B conditional permits under Rule 3-1.24(B)(2) must maintain at all times the certain ability and binding commitment to switch from the to-be-permitted volume of groundwater to some alternate water supply source(s) on a 100% basis, including a) all necessary physical infrastructure and supporting agreements, rates, and tariffs required for such substitution, and b) the commitment to use the alternative supply as warranted by District-declared drought conditions.

3-1.12. REGULATION OF SPACING AND PRODUCTION.

A. In order to minimize the drawdown of the water table or the reduction of artesian pressure, to prevent interference between wells, to prevent degradation of water quality, or to prevent waste, provided that agricultural, municipal, and natural resources are protected, the District may regulate:

(1) The spacing of water wells by:

(a) Requiring all water wells to be spaced a certain distance from property lines or adjoining wells;

(b) Requiring wells with a certain production capacity, pump size, or other characteristic related to the construction or operation of and production from a well to be spaced a certain distance from property lines or adjoining wells; or

(c) Imposing spacing requirements adopted by the Board; and,

(2) The production of groundwater by:

(a) Setting production limits on wells;

(b) Limiting the amount of water produced based on acreage or tract size;

(c) Limiting the amount of water that may be produced from a defined number of acres assigned to an authorized well site;

(d) Limiting the maximum amount of water that may be produced on the basis of acre-feet per acre or gallons per minute per well site per acre; or,

(e) Any combination of the methods listed above in paragraphs (a) through (d).

B. The District may preserve historic use before the effective date of this Rule, September 9, 2004, to the maximum extent practicable consistent with the District's Management Plan.

C. In regulating the production of groundwater based on tract size or acreage, the District may consider the service needs of a retail water utility as defined in these Rules.

3-1.13. REVOCATION, TERMINATION, CANCELLATION, OR MODIFICATION OF PERMITS.

A. A permit is not a vested right of the holder. After notice and an opportunity for hearing, a Permit may be revoked, suspended, terminated, canceled, modified, or amended in whole or in part for cause, including, but not limited to:

(1) Violation of any terms or conditions of the Permit,

(2) Obtaining the Permit by misrepresentation or failure to disclose relevant facts, or

(3) Failure to comply with any applicable Rules, regulations, Fee Schedule, special provisions, requirements, or orders of the District.

The permittee shall furnish to the District upon request, and within a reasonable time, any information to determine whether cause exists for revoking, suspending, terminating, canceling, modifying, or amending a Permit.

3-1.14. AGGREGATION.

Multiple wells that are part of an aggregate system that are owned and operated by the same permittee and serve the same subdivision, facility, or area served by a TCEQ issued CCN may be authorized under a single permit. Separate applications and registrations may be authorized under a single permit. Separate applications shall be submitted for each well and the District will maintain separate records of each well's location and characteristics. Geographic location of wells and integrated distribution systems will be considered in determining whether or not to allow aggregation.

For the purpose of categorizing wells by the amount of groundwater production, when wells are permitted with an aggregate withdrawal, the aggregate value shall be assigned to the group, rather than allocating to each well its prorated share or estimated production.

3-1.15. REPORTS.

A. Production and Transport Reports. Permittees shall submit monthly records of meter readings and information on transporting groundwater outside the District, including all information recorded as required by Rule 3-1.11(E), to the District on forms approved by the District. Meter readings must be read within one or two days of the end of the reporting month, and submitted to the District on or before the 5th day of the following month, even if there is zero pumpage or transport for the time period. Permittees may mail, e-mail, or fax (but shall not call in over the telephone) the required information to the District to meet this deadline. (See also Rules 2-10 and 2-11.)

B. Water Quality Reports.

(1) All permittees required by statute or regulation to conduct water quality analyses (including water utilities) shall, at the time of obtaining results of the analyses, submit a duplicate copy to the District.

(2) If a water utility is required by the TCEQ to notify its customers that water fails to meet TCEQ standards, the permittee shall immediately notify the District and submit a copy of the TCEQ's notice to the District.

3-1.16. FEES AND PAYMENT OF FEES.

A. Water Use Fees. The water use fee rate shall be established by Board resolution annually thirty (30) days prior to the end of the fiscal year. The rate shall be applied to the total authorized annual pumpage for each permit (and amendments if appropriate) issued during the fiscal year the rate is in effect. The District will review the account of any permittee changing the use of a well from nonexempt to exempt to determine if additional water use fees are due or if a reimbursement of water use fees is warranted. Reimbursements exceeding $250 must receive Board approval.

B. Application, Registration, and other Fees. The Board, by resolution, shall establish a schedule of fees. The District will set fees for administrative acts of the District (including services performed outside the boundaries of the District) and such fees may not unreasonably exceed the cost to the District of performing the administrative function for which the fee is charged. The General Manager may exempt any well from fees, or reduce fees, if the well is used only for scientific or water quality monitoring purposes and all data collected from said well are made available to the District upon request.

C. Payment of Fees. All fees are due at the time of application, registration, or permitting. The annual water use fee for a permit shall be paid in annual, quarterly or monthly installments, at the election of the permittee. Permittees whose annual water use fee is $50.00 or less are required to pay annually. New permittees electing to pay by installments shall make the first installment at the time of permit issuance with subsequent payments due as described below.

(1) Annual water use fees shall be paid at the time of permit issuance or are due on the fifth day of September of each year upon permit renewal.

(2) Quarterly water use fee payments of four (4) equal installments shall be due on or before the fifth day of the months of September, December, March, and June.

(3) Monthly water use fee payments of twelve (12) equal installments shall be due on or before the fifth day of each month.

(4) Permit renewal fees are due on the fifth day of September of each year.

(5) Payments received within the ten (10) days following the due date will not be subject to a late payment fee. Thereafter, the late payment fees set forth in Rule 3-8.6 shall be imposed. (See also Rules 2-10 and 2-11).

(6) All fees other than water use fees are due at the time of assessment and are late after ten (10) days. (See also Rules 2-10 and 2-11).

D. Alternate Water Use Fees. The Board may, by resolution, establish water use fee rates for pumpage of water from aquifers other than the Edwards at rates lower than the rate charged for pumpage from the Edwards Aquifer in order to provide an incentive to make greater use of other aquifers and conserve the Edwards Aquifer.

E. Minimum Water Use Fees. The Board may, by resolution, establish a minimum water use fee.

F. Inspection and Plan Review Fees. The Board may, by resolution, establish fees for: the inspection of wells, meters, or other inspection activities; review of Water Pollution Abatement Plans, development plans, or other plan reviews; special inspection services requested by other entities; or other similar services that require significant involvement of District personnel or its agents. Fees may be based on the amount of the District's time and involvement, number of wells, well production, well bore casing size, size of transporting facilities, or amounts of water transported.

G. Special Fees. Wells drilled in aggregate, such as closed loop heat exchange wells, may qualify for reduced fees for review, registration, and inspection. The fee rate will be based on review and inspection time on a case-by-case basis.

H. Exceptions. If a regulated water utility is unable to pass through pumpage fees due to delays in obtaining regulatory approval, or in other unusual instances of hardship, the Board may grant exceptions and establish a payment schedule.

I. Excess Pumpage Fees. The Board may, by resolution, establish additional water use fees for any pumpage exceeding the permitted pumpage volume by more than 500,000 gallons.

J. Returned Check Fee. The Board may, by resolution, establish a fee for checks returned to the District for insufficient funds, account closed, signature missing, or any other problem causing a check to be returned by the District's depository.

K. Accounting Fee. The Board may, by resolution, establish a fee for permittee-requested accounting of pumpage reports, water use fee payments, or other accounting matters pertaining to the permittee's account which the District does not routinely maintain in its accounting of a permittee's records. Should a District error be discovered, the accounting fee, if any, will be fully refunded. Permittees may request one review of their account per Fiscal Year without charge.

L. Processing Fee. The application must be accompanied by the application processing fee, inspection fee, or other fees as appropriate. Such fees must be paid before notice is published and mailed, to the extent required by Section B below. Payments of all fees including water use fees remain the responsibility of the property owner.

3-1.17. CONSERVATION CREDITS.

The District supports and encourages a permittee's efforts to conserve water and to reduce their annual pumpage as a result of conservation efforts. As a conservation incentive, the District may credit a permittee for a portion of their unused permitted amount, which can be attributed to the implementation of conservation measures. The District will undertake an annual audit of each permittee's account to determine the status or late payment of water use fees or other fees, and the number of late or missing meter readings for each fiscal year. This accounting will be done during the first quarter of the fiscal year to determine a credit for the immediately preceding fiscal year.

When approving a production permit, the District must consider whether the proposed use of water is dedicated to a beneficial use at all times and therefore discourages speculation in permitting. The District seeks to have production permits tied tightly to actual use and need that will occur within the year. Therefore, in calculating a conservation credit, the maximum reported pumpage on an annual basis for the last three fiscal years (as long as none of the last three fiscal years annual reported pumpage totals represent an overpumpage of the fiscal year permit), will be used instead of the permitted pumpage as the basis of the credit. This will allow for a more meaningful conservation credit audit and will not allow for permitted pumpage, that may be in excess of actual use, to skew the calculated credit.

If the audit indicates that a permittee's reported pumpage volume is less than the maximum amount pumped on an annual basis in the last three fiscal years, and the water use fees paid by the permittee exceed the amount due for the reported pumpage, the permittee may receive, as a water conservation incentive, a calculated credit to the permittee's account as provided below for the ensuing fiscal year. No cash refunds will be made except when authorized by the Board.

A. Ineligibility.

(1) If the audit indicates that a permittee's reported pumpage volume has exceeded the permitted pumpage volume, the permittee will be ineligible for a conservation credit. The permittee will be billed for the excess gallons pumped using the fee schedule in effect during that fiscal year plus any other fees or late payment fees that may be imposed or required by the Board.

(2) A permittee will be ineligible for a conservation credit if there has been falsification of a meter reading.

(3) Permittees are required to submit timely meter readings and payment(s). Upon the occurrence of a second violation of either a late or missed meter reading or payment, the permittee will be ineligible for a conservation credit.

(4) A permittee with a calculated credit of less than or equal to $100.00 will be ineligible for a conservation credit.

B. Calculation of Conservation Credit. The District will use the variables below to calculate the Conservation Credit. To ensure that the credit is based on conservation efforts and not on permitted pumpage that may be speculative in nature, the maximum reported pumpage on an annual basis for the last three fiscal years will be the basis of the credit. Following is the method by which the conservation credit will be calculated.

M = The maximum reported pumpage on an annual basis for the last three fiscal years, as long as none of the last three fiscal years annual reported pumpage total does not represent an overpumpage of the fiscal year permit. If any of the last three fiscal year annual reported pumpage totals represent an overpumpage of that fiscal year permit, then it will be removed from the calculation.

A = The actual annual reported pumpage of the fiscal year immediately preceding the conservation credit audit.

P = The permitted annual pumpage for the current fiscal year under audit.

M – A = Calculated Credit (in gallons)

$$\frac{\text{Calculated Credit (in gallons)}}{1000} \times \$0.17/1000 \text{ gals} = \text{Calculated Credit (in dollars)}$$

BUT

If M = A, and P ≤ A + (.15 x A), then M = P

If the maximum reported pumpage on an annual basis for the last three fiscal years (not including overpumpage years) is equal to the actual reported pumpage for the year under audit and the permitted pumpage amount is less than or equal to the actual reported pumpage for the year under audit plus a reasonable allowance for growth or other unpredictable needs, then the permitted pumpage amount will be used for M in the calculation.

If M = A, and P > A + (.15 x A), then M = A + (.15 x A)

If the maximum reported pumpage on an annual basis for the last three fiscal years (not including overpumpage years) is equal to the actual reported pumpage for the year under audit and the permitted pumpage amount is greater than the actual reported pumpage for the year under audit plus a reasonable allowance for growth or other unpredictable needs, then the actual reported pumpage for the year under audit plus a reasonable allowance for growth or other unpredictable needs will be used for M in the calculation.

If M = A, and P = A, then M = P

If the maximum reported pumpage on an annual basis for the last three fiscal years (not including overpumpage years) is equal to the actual reported pumpage for the year under audit and the permitted pumpage amount is equal to the actual reported pumpage for the year under audit, then the permitted pumpage amount will be used for M in the calculation.

C. Administration Fee. The District will retain 10% of the calculated Conservation Credit.

D. Criteria for Minimum Conservation Credit. Following are the minimum criteria required for an eligible permittee to receive 50% of their calculated Conservation Credit:

(1) The permittee must be in compliance with District Rules and production permit.

(2) Annual shrinkage or gross unaccounted for water must be less than or equal to 15%.

E. Criteria for Additional Conservation Credit. Additional credit up to 40% of the calculated Conservation credit will be available if the permittee implements and shows documentation for additional conservation measures as established by the District's Conservation Credit Policy.

The fact that a permittee may be eligible for a conservation credit does not relieve the permittee of the responsibility of making timely installment payments for the regular installment amount. Reduced payments or a payment(s) covered by the credit amount will be authorized by the District only after the District completes an audit and determines that a credit is due. Permittees who disagree with the audit may request additional accounting by the District.

3-1.18. EMERGENCY APPROVALS.

A. Emergency Transfer of a Permit to another well. Upon application to the District, the General Manager shall authorize a permit, including a permit associated or consolidated with a transport permit, to be transferred to another well, or a replacement well, in the immediate vicinity of the permitted well upon a satisfactory demonstration by the applicant that:

(1) The action is necessary in order to alleviate an immediate and serious threat to human life or health, or to prevent extensive or severe property damage to economic loss to the person proposing or requesting to make the transfer, and

(2) The replacement or transfer well will not endanger human life or health, and will not cause what would, under the particular circumstance, be unreasonable property damages or economic loss to others.

The General Manager may issue a temporary order authorizing the withdrawal of water without notice and hearing, or with such notice and hearing as the General Manager, in his/her judgment, deems practical under the circumstances.

B. Emergency Withdrawals. Upon application to the District, the General Manager shall authorize withdrawal of water not covered by a permit upon a satisfactory demonstration by the applicant that:

(1) An emergency exists due to acts of God or nature or other disaster, not including drought conditions,

(2) The withdrawal of water is necessary in order to alleviate an immediate and serious threat to human life or health or to prevent extensive and severe property damage or economic loss to the person requesting the withdrawals, and

(3) The withdrawal will not endanger human life or health and will not cause what would under the particular circumstances be unreasonable property damage or economic loss to others.

The General Manager may issue a temporary order authorizing the withdrawal of water without notice and hearing, or with such notice and hearing as the General Manager, in his/her judgment, deems practical under the circumstances.

C. Procedural Requirements. A copy of every order entered by the General Manager under this Rule shall be sent by certified mail to the person or persons to whom it is directed. However, when the time factor is critical, the order may be delivered in person, transmitted by telephone or telegram, or delivered by any other satisfactory method; but it shall be promptly followed by the written order sent by certified mail. If the order authorizes a new, transfer, or replacement well, the person to whom the order is issued may not cause or undertake drilling of the well under the order except in strict compliance with its terms and conditions.

Any such emergency ruling by the General Manager shall be approved or disapproved by the Board at its next meeting. Pending the Board's action, the General Manager's order shall be given full effect.

Any applicant receiving a temporary order under this Rule shall make timely application for permit or permit amendment and pay all applicable fees. The application shall be processed in the manner provided in these Rules.

3-1.19. CITY OF AUSTIN WATER USE FEE.

In order to establish the water use fee authorized by S.B. 988 of the 70th Texas Legislature, H.B. 2294 of the 74th Texas Legislature, and Chapter 36, Texas Water Code, the Board shall, by resolution, establish an annual water use fee for the City of Austin at the time that it adopts the water use fee schedule. Payment of the City's water use fee may be made on a quarterly basis, with one quarter of the City's annual payment due on or before each of the following dates: September 5, December 5, March 5, and June 5. Payments received after the 15 day of the month will be considered late and subject to late payment fees set forth in Rule 3-8.6. (See also Rules 2-10 and 2-11) If the City of Austin is compliant with all District Rules applicable to each of the wells for which the City holds or should hold a permit from the District, then after the end of a District's fiscal year, the District will grant the City a credit against the amount of water use fee that the District has assessed the City as a non-permit holder for the then current fiscal year by an amount equal to sixty percent (60%) of the dollar amount of Conservation Program Credits that the District issued to all permit holders for the District's prior fiscal year.

3-1.20. GENERAL PERMIT AUTHORIZING CERTAIN NON-EXEMPT DOMESTIC USE WELLS.

A. The purpose of this provision is to permit by rule the drilling and completion of non-exempt domestic use wells and the production of groundwater from non-exempt domestic use wells. Unless otherwise prohibited by the District and subject to the eligibility requirements listed in Paragraph (E) below, non-exempt domestic use wells are authorized to operate pursuant to this provision without an individual Permit from the District upon satisfaction of all the following requirements:

(1) A Well Development/Registration Application, as required under Rule 3-1.2, has been completed

(2) The well is registered under Rule 3-1.1;

(3) The well is equipped with a meter under Rule 3-2.1;

(4) The well permittee shall keep accurate records and meter readings, on a monthly basis of the amount of groundwater withdrawn, the purpose of the withdrawal, and such records shall be submitted to the District Office on a monthly basis;

(5). The well permittee prepares, adopts, and implements a User Conservation Plan consistent with Rule 3-6;

(6) The well permittee prepares, adopts, and implements a User Drought Contingency Plan consistent with Rule 3-7;

(7) The well permittee has obtained district authorization to pump a specified volume of groundwater; and

(8) Any other conditions that the District may require.

B. This rule authorizing a general permit for certain non-exempt domestic use wells is granted subject to the Rules, regulations, orders, special provisions, and other requirements of the Board and laws of the State of Texas. In particular, this general permit by rule is subject to the Permit Conditions and Requirements of Rule 3-1.11 and the provisions of Rule 3-4.

C. This general permit is applicable to a non-exempt domestic use well drilled and completed on or after August 14, 2003.

D. A well permitted pursuant to this Rule is not subject to Water Use Fees.

E. To be eligible for authorization under this general permit, non-exempt domestic use wells must:

(1) Not be located in an area in which a water supplier has a valid Certificate of Convenience and Necessity and is able to supply water to the applicant;

(2) Have a requested annual pumpage that does not exceed 500,000 gallons per household;

(3) Have an annual pumpage request that does not exceed the District-calculated allocation based on planned use and accepted AWWA water usage standards; and

(4) Not have pumpage amounts in which landscape irrigation comprises more than 60% of the requested annual volume.

In lieu of a general permit, the Board may require a non-exempt domestic use well applicant that does not meet all these eligibility criteria to obtain an individual Permit before any groundwater production may take place.

F. All non-exempt domestic use wells registered after September 9, 2004, shall be subject to compliance with drought rules and protocols pursuant to Section 3-1.24.

3-1.21. GENERAL PERMIT AUTHORIZING CERTAIN NON-EXEMPT MONITOR WELLS.

The purpose of this provision is to permit by rule the drilling and completion of non-exempt monitor wells and the production of restricted amounts of groundwater from non-exempt monitor wells. Unless otherwise prohibited by the District and subject to conditions, requirements, and other provisions of this section, non-exempt monitor wells are authorized to operate pursuant to this provision without an individual Permit.

A. Conditions and Requirements. Each authorization under this general permit shall be subject to the following conditions and requirements:

(1) A Well Development / Registration Application, as required under Rule 3-1.2, has been completed, and the well is registered under Rule 3-1.1;

(2) The applicant shall submit along with the appropriate fees, an application using forms provided by the District for presenting the following information:

(a) a detailed statement describing the nature and purpose of the proposed monitor well(s);

(b) a map clearly indicating the location of each well;

(c) a sampling and monitoring plan;

(d) A water well closure plan, or a declaration that, 1) the applicant will comply with well plugging and capping guidelines set forth in these Rules and 2) will report well closures as required in Rule 3-5; and

(e) any other information required by the District that is pertinent to the evaluation of the application.

(3) Groundwater produced from the well is not in excess of the volume that is necessary for the sole purpose of conducting sampling and monitoring consistent with the sampling and monitoring plan;

(4) The well is equipped with a meter under Rule 3-2.1. This condition may be waived by the General Manager, provided that the applicant demonstrates that the well is not equipped with a dedicated pump;

(5) The well permittee shall keep accurate records on a monthly basis of the dates of each sampling event, the meter reading or the estimated volume of groundwater withdrawn with each sampling event, the purpose of the withdrawal, and such records shall be submitted to the District Office on a monthly basis;

(6) Authorization under the general permit shall be renewed on an annual basis. With renewal, the permittee shall submit the following:

(a) an annual renewal fee;

(b) an updated monitoring and sampling plan;

(c) an annual report describing the project status; a summary of monthly records maintained pursuant to A(5) of this section; any water level or analytical data associated with each sampling event; and any other pertinent information required by the District; and

(d) any studies or reports generated using data acquired from the monitor well(s).

(7) The District shall be provided access to the monitor well(s) for sampling and data collection upon reasonable prior notice.

(8) The District may require other conditions on the basis of site-specific or use-specific circumstances.

B. This rule authorizing a general permit for certain monitor well(s) is subject to the Rules, regulations, orders, special provisions, and other requirements of the Board and laws of the State of Texas. In particular, this general permit by rule is subject to the Permit Conditions and Requirements of Rule 3-1.11 and the provisions of Rule 3-4.

C. This general permit is applicable to non-exempt monitor well(s) registered on or after January 26, 2006.

D. A well permitted pursuant to this Rule is not subject to Water Use Fees.

E. In lieu of a general permit, the Board at its sole discretion may require a non-exempt monitor well to obtain an individual Permit.

3-1.22. HISTORIC USE STATUS.

A. Purpose. The District seeks to achieve and not exceed the sustainable yield of groundwater resources in the District, protect spring flow, and protect existing water wells, and historic users to the maximum extent practicable.

B. Designation of Historic Use Status. A registered existing, non-exempt well with an authorized production permit issued by the District, or application for a production permit pending before the District, prior to or on September 9, 2004, shall be designated under a historic use status designation and subject to any and all applicable rules, regulations, and requirements as set forth by the District, excluding those rules, regulations, and requirements specific only to conditional production permits.

C. Transfer of Historic Use Status. Historic use status is not a vested right of the permittee. The District may transfer a historic use status designation upon receiving an administratively complete District approved Permit Application Form stating a request for a permit amendment specific to a request in Change of Ownership. Said application shall comply with all appropriate District rules and regulations relating to permit amendments relative to change in ownership status.

D. Aggregation. A permittee having a well or wells, each well having a historic use designation, may be aggregated or combined with additional wells while still retaining a historic use status for the aggregated system if all of the following provisions are satisfied:

(1) the total aggregate withdrawal of groundwater assigned to the aggregated system shall be equal to or less than the combined total of all individual production permits comprising the entire aggregated system; and

(2) all individual production permits have a historic use status designation; and

(3) all individual production permits are in compliance with any and all applicable District rules and regulations.

Permittees seeking to aggregate multiple production permits under the historic use status designation shall apply for a single production permit pursuant to all rules, regulations, and conditions including, but not limited to, those contained in District Rules 3-1.4 and 3-1.11.

If one or more of the wells do not have a historic use status designation, the permitting for the aggregation shall proceed pursuant to District Rule 3-1.24(D).

E. Replacement Wells. A permittee may apply to re-equip, re-drill, or replace a currently permitted or registered well while preserving historic use status designation by filing an application to amend such permit or registration and providing such information as may be required by the General Manager under the following conditions:

(1) the replacement well must be drilled on the same tract of land as the original well as defined by the legal description filed with the county appraisal district of record; and

(2) the re-equipped, re-drilled, or replacement well complies with all applicable District rules and regulations, including issuance of Permits and authorizations and payment of all fees and charges; and

(3) if a replacement well is drilled, the permittee shall cease production from the well being replaced and immediately comply with any and all well closure and abandonment requirements pursuant to District Rule 3-5, "Abandoned, Open, or Uncovered Wells."

3-1.23. THE EXTREME DROUGHT WITHDRAWAL LIMITATION FOR THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER.

On the basis of the Sustainable Yield determined by the District, in order to minimize, to the greatest extent practicable, interference among water wells, wells drying, and the likelihood of cessation of spring flow at the natural aquifer outlets, the total amount of water that will be allowed to be withdrawn from the aggregated Freshwater Edwards Aquifer and the Upper Trinity Aquifer in the District, including both exempt and non-exempt wells in those aquifers, during Extreme Drought shall be limited to 8.5 cfs on an average annual basis. This limit is a drought-period regulatory cap imposed on pumping from these two hydrogeologic units, and shall be designated the Extreme Drought

Withdrawal Limitation (EDWL). The EDWL does not apply to water produced from the Saline Zone Edwards Aquifer or from the Middle and Lower Trinity Aquifers.

3-1.24. CONDITIONAL PRODUCTION PERMITS.

A. Purpose. The purpose of this section is to provide for the effective and sustainable management of the Barton Springs segment of the Edwards Aquifer by regulating the production of groundwater from new permitted wells or existing wells with increased pumpage. The continuing usage and reliance upon such wells, during Alarm and Critical Stage Drought, may exceed the EDWL of the Aquifer, and thereby may pose an unreasonable interference between water wells and potentially cause the cessation of spring flow.

B. Applicability. All applications for new production permits and production permit amendments issued after September 9, 2004, shall be designated as conditional production permits. Two classes of conditional production permit are designated:

(1) Class A Conditional Permits – Conditional production permits that existed in approved and issued form and new conditional production permits whose applications were in processing by the District as of the effective date of these Rules (nominally April 26, 2007), and whose permit-holder has not successfully amended its permit to be re-classified to Class B by agreeing to and complying with all of the requirements of Class B specified in this Rule section 3-1.24, to be included as conditions in the permit.

(2) Class B Conditional Permits -- Conditional production permits for use of water from the Freshwater Edwards and Upper Trinity hydrogeologic units that are not Class A Conditional Permits. Class B conditional permits shall not be reclassified as Class A conditional permits.

C. New Production Permit Applications. Applications for new production permits received after September 9, 2004, shall be considered conditional production permit applications and shall be processed pursuant to District Rule 3-1.4, including as applicable the demonstration required for Class B conditional permit applications to the satisfaction of the District Board.

D. Pumpage Amendment Applications. Applications for pumpage amendments filed with the District after September 9, 2004, shall comply with District Rule 3-1.9 and all other applicable District rules and regulations.

(1) An applicant who has a historic use status designation for an existing and authorized production permit and who is applying for a pumpage amendment, upon receiving said amendment after consideration and if approved by the Board, shall be issued a conditional production permit only for the authorized additional withdrawal amount of groundwater, which shall be separate from but associated with the original production permit for the duration of the original permit, unless terminated by the

permittee or the District pursuant to District rules. (Example: Permittee X has a historic use status production permit for 50 million gallons per year and files and receives a permit amendment of 70 million gallons per year. The District would issue Permittee X a conditional production permit for 70 million gallons per year, giving Permittee X a combined total available authorized pumpage volume of 120 million gallons per year. The 50 million gallon production permit would retain its historic use status.) Under no circumstance, shall the pumpage amendment, as a conditional production permit, be considered for historic use status designation.

(2) Applicants seeking a permit amendment to an existing conditional production permit, upon receiving said amendment after consideration and if approved by the Board, shall have the original conditional production permit amended to reflect the authorized increase in groundwater withdrawal.

E. Term of Conditional Production Permits.

(1) All Class A conditional production permits are effective for the fiscal year of issuance, and unless otherwise stated on the permit, shall not be issued for a term longer than one (1) year, except as provided for in District Rule 3-1.7(C.). Renewal of all Class A conditional production permits are governed by Rule 3-1.8, Permit Renewal.

(2) All Class B conditional production permits are effective for the fiscal year of issuance and, unless otherwise stated on the permit, are automatically renewable annually for an aggregate term up to 40 years, provided a) the infrastructure, contracts, rates, and facilities for 100% water substitution that were demonstrated to the Board as a condition of initial permit approval have been effectively deployed within the first year and effectively remain in place for all subsequent years; and b) all other rules of the District are met, including Rule 3-1.8, Permit Renewal. Failure to comply with both provisions a) and b) of this subsection, in the sole judgment of the Board, shall result in the expiration of the conditional permit, or such other action as the Board may take.

F. Compliance with Drought Stages. All conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, “Drought,” and in addition the requirements and conditions as enumerated below:

(1) No-Drought Status. Permittees with either Class A or Class B conditional production permits, as defined under Rule 3-24(B.), shall comply with all applicable drought rules and protocols required under District Rule 3-7, “Drought”, including Water Conservation Period measures specified in their permit.

(2) Alarm Stage Drought.

i. Permittees with Class A conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and may be subject to temporary curtailment greater than the mandatory 20% drought target reduction requirements, pursuant to District Rule 3-1.24(G).

ii. Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and shall curtail monthly groundwater production by a mandatory 50% drought reduction requirement.

iii. The Board may allow individual Class A and Class B Non-exempt Domestic Use permittees, upon Board order, to use temporary alternate curtailment schedules for good and valid reasons related to compelling water-supply circumstances that might arise from time to time during Alarm Stage Drought.

(3) Critical Stage Drought.

i. Permittees with Class A conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and may be subject to temporary curtailment greater than the mandatory 30% drought target reduction requirements, pursuant to 3-1.24(G) below.

ii. Permittees with Class B conditional production permits shall comply with all applicable drought rules and protocols required under District Rule 3-7, "Drought," and shall curtail monthly groundwater production by a mandatory 75% drought reduction requirement.

iii. The Board may allow individual Class A and Class B Non-exempt Domestic Use permittees, upon Board order, to use temporary alternate curtailment schedules for good and valid reasons related compelling water-supply circumstances that might arise from time to time during Critical Stage Drought.

(4) Emergency Response Period.

i. Upon declaration of an Emergency Response Period (ERP) under Rule 3-7.3(F), the Board shall order an increase in the mandatory curtailments for all Class A conditional permits to 50% for the first three full months, 75% for the next three full months, and 100% (cessation of use) thereafter. If Barton Springs flow exceeds 14 cfs for continuous 90-day increments, the next less severe stage of curtailment will be declared following that increment, until either the 30% curtailment is reached in such stepwise fashion or Critical Stage Drought is no longer declared.

ii. Upon declaring an ERP, the Board shall order all Class B conditional permits to cease all pumping of groundwater, which order shall remain in effect until the ERP is declared by the Board to no longer exist. Once the ERP no longer exists, the curtailment schedule will then follow the Class A conditional permit restrictions for the balance of that Critical Stage drought period.

iii. The Board may allow individual Class A and Class B Non-exempt Domestic Use permittees, upon Board order, to use temporary alternate curtailment schedules for good and valid reasons related to compelling water-supply circumstances that might arise from time to time during a declared Emergency Response Period.

G. Other Temporary Curtailment or Cessation of Production. Both Class A and Class B conditional production permits are subject to temporary curtailment up to and including cessation by order of the Board, based upon a determination that one or more of the following conditions exist:

(1) during Alarm or Critical Stage Drought conditions, the EDWL will be exceeded for a duration of time sufficient to potentially cause severe and detrimental impacts to water wells or spring flow; or

(2) a lowering of the water-table and/or the reduction of artesian pressure to such a degree that it negatively impacts water wells; or

(3) degradation of water quality, subsidence, or other adverse groundwater quantity or quality conditions are occurring or will potentially occur in the immediate future such that said adverse effects will negatively impact water wells.

H. Ordering Curtailment. The Board may issue an order for curtailment under 3-1.24(F) or temporary curtailment or cessation of production under 3-1.24(G) without holding a public hearing, inasmuch as these are agreed conditions as part of both Class A and Class B permits. However, the permittee may request a hearing to appeal the Board order, and the permittee and any other interested party as defined by District Bylaw 4-9.13 may appear before the Board during such an appeal and give testimony pursuant to District procedures as set forth in District Bylaw 4-9. During the appeal, the order shall remain in full force and effect.

I. Proportional Adjustment. To the maximum extent practicable, the Board shall observe the principle of proportional adjustment within conditional permit classes, meaning an order issued by the Board for the temporary curtailment or cessation of production of a conditional production permit of one class is proportional when the adjustment of the maximum available and authorized groundwater withdrawals is maintained at a constant ratio in relation to the adjustment of the maximum available and authorized groundwater withdrawals of all other conditional production permits of the same class.

J. Consideration of alternative provisions for conditional permits. Nothing in this section of these Rules should be construed as preventing an applicant from proposing alternative provisions to these conditional permitting requirements. Any proposed variance from these provisions must demonstrate to the Board that:

(1) Management flexibility arising from unique or unusual resource management circumstances is warranted and where such variances are required;
(2) The proposed alternative approach would not be overly burdensome to implement or administer effectively;
(3) The proposed alternative provides an overall benefit to existing users and the groundwater resources of the District that is equal to or superior to what would be achieved under the prevailing rules; and
(4) The alternative approach will ultimately preserve or tend to reduce the EDWL.

3-1.25 VARIANCE REQUESTS; GENERAL.

A. Application. An applicant may by written petition to the Board request a variance from the requirements of District Rule 3-1, except Sections 3-1.20, 3-1.21, 3-1.22, 3-1.23, and 3-1.24, relating to conditional production permit applications, requirements, or restrictions. A variance request under this Section shall be accompanied with any variance request fee set by the Board pursuant to District Rule 3-1.16. A petition for a variance request shall include the following information:

(1) the specific rule citation for which the variance is sought;

(2) the nature of the variance requested;

(3) a detailed explanation as to why the variance should be granted;

(4) any additional information, materials, maps, or documents required by the General Manager, or the General Manager's designated representative.

B. This Section is not applicable for variance requests relating to drought as addressed under District Rule 3-7.10.

C. Basis for Variance Approval. In evaluating a request, the Board shall act based on the following considerations:

(1) There are special circumstances existing on the property on which the application is made related to size, shape, area, topography, hydrogeology, surrounding conditions and location that do not apply generally to other properties in the vicinity;

(2) A variance is necessary to permit the applicant the same rights in the use of property that are presently enjoyed by other properties in the vicinity,

but which rights are denied to the property on which the application is made;

(3) The granting of the variance on the specific property will not adversely affect any other provision of the District's Rules and Bylaws;

(4) The variance, if granted, will be no material detriment to the public welfare or injury to the use, enjoyment, or value of property in the vicinity for such activities that are under the jurisdictional authority of the District;

(5) Whether the operations proposed are reasonable under the circumstances and conditions prevailing in the vicinity considering the particular location and the character of the improvements located there;

(6) Whether alternative options are available to the applicant such that if pursued a variance would not be required;

(7) Whether the operations proposed are consistent with the health, safety, and welfare of the public when and if conducted in accordance with the authorization or permit conditions to be imposed;

(8) Granting the variance would be in accordance with the intent of the District's Mission Statement, Rules and Bylaws, and certified Management Plan.

(9) The recommendations of the General Manager, or the General Manager's designated representative.

D. District Action. A variance request shall be considered by the Board after public notice and hearing pursuant to the requirements of District Bylaw 4-9 and completion of a twenty (20) day public comment period pursuant to District Rule 3-1.4(B). The applicant requesting the variance shall receive written notification of the District's action.

E. Variance Conditions

(1) The Board may grant a variance for a term and with any conditions the Board deems appropriate, which shall be set out in the order granting the variance request.

(2) The Board may require an applicant granted a variance to file reports with the District containing such information as is relevant to monitoring the continuing appropriateness of the variance and compliance with the terms and conditions of the variance.

F. Rescission of Variance. By order, the Board may rescind an order granting a variance at any time due to changed circumstances, new information, or failure of the holder of the variance to abide by the terms and conditions of the variance or any order of the Board.

RULE 3-2. METERING.

3-2.1. WATER METERS.

A functioning water meter with Register, meeting AWWA standards for the line size, pressures, and flows, that is properly installed according to the manufacturer's specifications, or other measuring device approved by the District, is required on all non-exempt wells and/or non-exempt Aggregate Wells, at the point each permitted pumpage amount applies. Meters are not required to be installed on exempt wells, but exempt well owners are strongly encouraged to install meters for their own use and benefit.

3-2.2. METERING AGGREGATE WITHDRAWAL.

Where wells are permitted in the aggregate, one water meter may be used for the aggregate well system, if the water meter is installed so as to measure the groundwater production from all wells covered by the aggregate and approval of aggregate metering is obtained from the District.

3-2.3. WATER METER VERIFICATION.

The General Manager may require the well owner or primary operator to test and calibrate, at the well owner's or primary operator's expense, the water meter on each permitted well and provide the District with a certification in affidavit form of the test results and accuracy calibrations on a form provided by, or in a format approved by, the General Manager, but not more often than once every three (3) years. At the District's expense and at any time, the District, may also undertake random investigations for the purposes of verifying water meter readings, acquiring data for alternate calculations of groundwater withdrawal, estimating the capability of a well, determining water levels, and acquiring such other information helpful to the District in carrying out goals under the Act. If the District's verification reveals that a water meter is not within an accuracy of five percent (±5%), the permittee must reimburse the District for its cost of verification and undertake immediate repair, replacement, or correction of the water meter.

3-2.4. VIOLATION OF METERING AND REPORTING REQUIREMENTS.

False reporting or logging of meter readings, intentionally tampering with or disabling a meter, or similar actions to avoid accurate reporting of groundwater use and pumpage shall constitute a violation of these Rules and shall subject the person performing the action, as well as the well owner, and/or the primary operator who authorizes or allows that action, to such penalties as provided in the Act and these Rules.

3-2.5. WATER METER SEALS.

If the General Manager finds it necessary, the District may, at its expense, seal by physical means those water meters required to be installed by these Rules and may red tag such water meters to indicate they have been sealed. The well owner or primary operator shall report any alteration, damage, or removal of the water meter seal at once to the District and request repair of the seal. Tampering with, altering, damaging, or removing the water meter seal or red tag, or in any way violating the integrity of the seal or red tag shall constitute a violation of these Rules and shall subject the person performing the action, as well as any well owner and/or primary operator who authorizes or allows that action, to such penalties as provided in the Act and these Rules.

3-2.6. METERING LUBRICATING/COOLING WATER.

Water used for cooling pumps which is re-circulated from the system back into the well or aquifer may be metered and subtracted from monthly pumpage amounts when calculating total water use, provided the return flow is metered at the wellhead return. The water used for lubricating and cooling pumps must be fresh water and must not have been contaminated through the process. Water used for this purpose must be kept away from any sources of contamination through isolation in a watertight jacket. Meters used to measure re-circulated water must meet AWWA standards and must be reported along with actual pumpage volumes. District inspection and approval of the lubricating/re-circulating system is required prior to subtracting re-circulated volumes from system use.

RULE 3-3. WASTE/POLLUTION/PROSCRIBED USE.

3-3.1. WASTEFUL USE.

Groundwater produced from within the District shall not be used in such a manner or under such conditions as to constitute waste.

3-3.2. WASTEFUL PRODUCTION.

Any person producing or using groundwater shall use every possible precaution to stop and prevent waste of such water.

3-3.3. SUBSURFACE POLLUTION.

No person shall pollute or harmfully alter the character of the groundwater reservoir of the District by causing or allowing the introduction of salt water pollutants or other deleterious matter from another stratum, from the surface of the ground, or from the operation of a well.

3-3.4. SURFACE POLLUTION.

No person shall pollute or harmfully alter the character of the groundwater reservoir by activities on the surface of the ground that will cause or allow pollutants to enter the reservoir through recharge features, whether natural or manmade.

3-3.5. GENERAL PROHIBITION.

No person shall intentionally or negligently commit waste.

3-3.6. ORDERS TO PREVENT WASTE/POLLUTION.

After providing notice to affected parties and opportunity for a hearing, the Board may adopt orders to prohibit or prevent waste or pollution. If the factual basis for the order is disputed, the Board shall direct that an evidentiary hearing be conducted prior to entry of the order. If the Board determines that an emergency exists, requiring the immediate entry of an order to prohibit waste or pollution and protect the public health, safety, and welfare, it may enter a temporary order without notice and hearing provided, however, the temporary order shall continue in effect for the lesser of fifteen (15) days or until a hearing can be conducted.

3-3.7. PROSCRIBED WATER USE DURING DECLARED DROUGHTS.

A. Failure to conserve and preserve groundwater through the excessive use of water during District-declared drought conditions constitutes a threat to and harmful alteration of the character of groundwater or the groundwater reservoir and is prohibited.

B. Failure to conserve and preserve groundwater during drought conditions is wasteful use and is therefore waste.

C. Domestic use that meets the following criteria is presumed to be excessive use that harms the groundwater reservoir and aquifer resources and is therefore proscribed use.

(1) Water use in occupied houses in excess of 30,000 gallons per connection per month, or 4000 gallons per capita per month, whichever is greater, during an Alarm Stage Drought, and in excess of 20,000 gallons per connection per month, or 3000 gallons per capita per month, whichever is greater, during a Critical Stage Drought, indicating excessive use for purposes other than protection of human health and welfare

(2) Water use for newly constructed, never occupied housing in excess of 6,000 gallons per house/lot per month during an Alarm Stage Drought, and any substantive use for such purposes during a Critical Stage Drought, which would indicate excessive use for purposes other than protection of human health and welfare

(3) During an Alarm Stage Drought, water use for common areas within a service area in excess of an amount proportional to the total volume represented by the number of service connections multiplied by 6,000 gallons (the allocation specified in C(2) of this Section). This proportion shall be calculated based on the ratio of common area relative to non-common area. All such water use during Critical Stage Drought is proscribed.

D. The presumptions in Section C above may be rebutted by clear and convincing evidence that:

(1) A person without a metered connection has implemented water use reductions including, but not limited to, curtailment of all outdoor water uses that are not essential to protection of human health and welfare, such as lawn irrigation, washing impervious cover, filling or topping off pools and water features, and washing cars, and/or in the alternative has installed a water meter and demonstrated such curtailment.

(2) A person with a metered connection demonstrates water use essential to protection of human health and welfare that exceeds that component of the presumed criterion of Section C(1) above.

(3) A person demonstrates a component of use that is essential, non-domestic use (e.g., agricultural, livestock, commercial truck gardens, etc.).

E. No person who uses groundwater shall make, cause or permit the excessive use of such water by failing to conserve during drought conditions, whether or not the person is a permittee or served by a permittee. Any person using groundwater shall take all actions necessary to conserve groundwater and stop excessive use during drought conditions.

F. To conserve and preserve groundwater, the District prohibits excessive use of groundwater by any person during drought. The board may adopt orders to prohibit excessive water use and require water conservation in the manner prescribed under these rules for adoption of orders to prevent waste/pollution.

RULE 3-4. DRILLING OF WELLS AND INSTALLATION OF WELL PUMPS AND EQUIPMENT.

3-4.1. DRILLING AUTHORIZATION.

A District-approved well development application to construct, drill, or modify a well must be obtained prior to drilling, removing casing, boring, altering the size of the bore, cleaning the bore, re-boring the existing hole, or performing other modification activities. A person who requests authorization to construct, drill, or modify a well that will be used for nonexempt purposes or to transport groundwater out of the District must also obtain a production permit or a transport permit. No drilling or modification activities authorized by the District shall commence until the District has been provided with twenty-four (24) hour advance notification.

3-4.2. DRILLING AUTHORIZATION TERM.

Unless the Board specifies otherwise, an approved well development/registration application is effective for one (1) year from the date of issuance provided no change in ownership or proposed use occurs prior to drilling.

3-4.3. DRILLING RECORDS.

A. Complete records shall be kept and reports thereof made to the District concerning the drilling, equipping, and completion of all wells drilled in the District. Such records shall include an accurate driller's log, depth to water, any electric log that shall have been made, and such additional data concerning the description of the well, its discharge, and its equipment as may be required by the Board. Such records shall be filed with the District within sixty (60) days after drilling and/or completion of the well.

B. No person shall operate any well drilled and equipped within the District, except operations necessary to the drilling and testing of such well and equipment, unless or until the District has been furnished an accurate driller's log, any special purpose log or data which have been generated during well development, and a registration of the well correctly furnishing all available information required on the forms furnished by the District.

3-4.4. DRILLING AND COMPLETION OF WELLS.

Drilling and completion of wells must satisfy applicable requirements of the TCEQ, the TDLR's Water Well Drillers and Pump Installers Program, and the District Well Construction Standards. The Board of Directors shall adopt, and may periodically amend, Well Construction Standards for wells drilled within the District. Approved Well Construction Standards will be made available to the public at the District office.

3-4.5. INSTALLATION OF WELL PUMPS AND EQUIPMENT.

Well pumps and equipment shall only be installed or serviced in wells registered with the District.

3-4.6. SUSPENSION.

The General Manager may suspend an authorization for a Permit or a permit amendment for failure to comply with the requirements of Rules 3-4.1, 3-4.2, 3-4.3, 3-4.4, and 3-4.5.

3-4.7. APPLICABILITY TO EXEMPT WELLS.

The requirements of Rule 3-4 are applicable to all wells drilled in the District, including exempt wells.

RULE 3-5. ABANDONED, DETERIORATED, OPEN, OR UNCOVERED WELLS.

3-5.1. REGISTRATION.

Any landowner or other person who possesses an abandoned, deteriorated, open, or uncovered well must register the well with the District. Any well not registered with the District shall be classified as abandoned.

3-5.2. ABANDONED WELL CAPPING.

At a minimum, nondeteriorated open or uncovered abandoned wells must be completed and capped in accordance with the applicable requirements of the TCEQ; the laws and rules of the TDLR's Water Well Drillers and Pump Installers Program; and the District Rules and Well Construction Standards. The landowner or other person who possesses the well shall keep the well properly capped with a water tight covering capable of sustaining weight of at least 400 pounds and constructed in such a way that the covering cannot be easily removed by hand, except when the well is in actual use. The well must also be completed to prevent entrance of surface pollutants into the well itself, either through the well bore or well casing.

3-5.3. ABANDONED WELL PLUGGING.

Unless granted an exception by the General Manager or Board, all abandoned wells that are not capped in accordance with Rule 3-5.2 and all deteriorated wells must be plugged in accordance with the applicable requirements of the TCEQ, 16 TAC §76.1004 of the TDLR's Water Well Drillers and Pump Installers Program Rules, District Rule 3-5, and other applicable Rules and Well Construction Standards adopted by the Board of Directors. Prior to plugging a well, the District Well Construction Standards require as a minimum, registration of the well with the District, a site inspection by District staff, submission to the District for review and approval a Plug and Abandonment Plan by the owner or the well driller, and payment of the Well Abandonment Fee. The General Manager may require the well owner to take a water sample and have a water quality analysis conducted as part of or prior to the plugging operation at the well owner's expense.

3-5.4. REPORTING.

In accordance with Section 16 TAC §76.700, TDLR's Texas Water Well Drillers and Pump Installers Administrative Rules, within 30 days of completing the plugging of a well located within the District, the person that plugs the well shall deliver or send by first-class mail the District a copy of the State of Texas Plugging Report.

3-5.5. ENFORCEMENT.

Pursuant to Texas Occupations Code, Title 12 - Practices and Trades Related to Water, Health, and Safety (TOC) §1901.256, the District may pursue enforcement against a landowner or other person who possesses an abandoned or deteriorated well for failure to comply with the provisions of TOC §1901 and District Rules. If the owner or lessee fails or refuses to plug or cap the well in compliance with this rule and District standards within thirty-five (35) days after being requested to do so in writing by an officer, agent, or employee of the District, then, upon Board approval, any person, firm or corporation employed by the District may go on the land (pursuant to Texas Water Code Chapter 36.118) and plug or cap the well safely and securely. Should the well remain abandoned 180 days after the date that the landowner or other person who possesses the well learns of its condition, the District may pursue further enforcement in cooperation with the TDLR in accordance with the provisions of Texas Occupations Code §1901.255.

3-5.6. LIEN FOR RECOVERY OF EXPENSES INCURRED BY DISTRICT.

A. Reasonable expenses incurred by the District in plugging or capping a well constitute a lien on the land on which the well is located.

B. The District shall perfect the lien by filing in the deed records of the county where the well is located an affidavit, executed by any person conversant with the facts, stating the following:

(1) The existence of the well;

(2) The legal description of the property on which the well is located;

(3) The approximate location of the well on the property;

(4) The failure or refusal of the owner or lessee, after notification, to close the well within ten (10) days after the notification;

(5) The closing of the well by the District, or by an authorized agent, representative, or employee of the District; and

(6) The expense incurred by the District in closing the well.

3-5.7. PENALTIES.

Rule 3-8 penalties shall be applicable in cases of failure or refusal to plug abandoned wells or cap wells not currently in use.

RULE 3-6. CONSERVATION.

3-6.1. CONSERVATION - ORIENTED RATE STRUCTURE.

All water utilities within the District shall be required to adopt and institute an effective conservation-oriented rate structure in the sales of water to their customers. The conservation-oriented rate structure shall be adopted and put into effect prior to amendment of the permit that would increase the amount of permitted pumpage volume.

Extensions or exceptions for adoption of conservation-oriented rates may be granted by the Board in consideration of postponing implementation of a conservation-oriented rate structure until the next water utility rate change, provided a conservation-oriented rate structure is proposed for that rate hearing. The Board may grant such exceptions when requested by the permittee of a water utility.

3-6.2. CONSERVATION POLICY.

The District may implement conservation policies through incentive fee structures and amendments to its own water use fees (for example, the Conservation Credits program of Section 3-1.17).

3-6.3. USER CONSERVATION PLANS.

Each permittee is required to prepare, adopt, and implement User Conservation Plans (UCP) consistent with these Rules.

A. Contents of UCP. UCPs shall consider, as a minimum, the following:

(1) Implementation of a conservation-oriented rate structure;

(2) Promotion and encouragement of voluntary conservation measures;

(3) Promotion and encouragement, installation, and use of water saving devices;

(4) Promotion and encouragement of water efficient landscape practices;

(5) Financial measures that encourage conservation;

(6) Distribution of conservation information and other educational efforts; and

(7) Provision for ordinances, regulations or contractual requirements necessary for the permittee to enforce the UCP.

B. Compliance. The District shall approve UCPs, if they satisfy the objectives of this Rule. The permittee may revise or amend the UCP, as necessary, with approval by the District. Permittees must have a District approved UCP prior to receiving a permit amendment. UCPs shall be prepared as part of the permit application and presented for District approval.

RULE 3-7. DROUGHT.

3-7.1. PURPOSE.

The purpose of these Rules is to provide guidelines and procedures for the District to implement and administer a Drought Contingency Plan (DCP). Drought, or other uncontrollable circumstances, can disrupt the normal availability of groundwater supplies, causing water availability and water quality emergencies. This Rule establishes procedures intended to preserve the availability and quality of water during such conditions. The implementation of drought severity stages, aquifer warning conditions, and other procedures shall be at the direction of the District.

3-7.2. APPLICABILITY.

These Rules apply to all permittees within the District. In addition, the District shall utilize public education and assistance programs to encourage compliance with this Rule by owners of wells exempt from permitting and all other water users located within the District's jurisdictional area.

These Rules are applicable to water users of the Barton Springs segment of the Edwards Aquifer and to users of groundwater from all other aquifers and water-bearing formations located within its jurisdictional boundaries.

3-7.3. DROUGHT STAGES AND TRIGGERS.

Drought severity stages are triggered by declines in the rate of discharge at Barton Springs and increases in depth to water in the District's Drought Indicator Well. A decision to change the drought status of the aquifer may consider other factors that influence or reflect aquifer conditions (Section 3-7.3 (G)).

There is a "No-Drought" stage and two drought severity stages: Alarm and Critical. A Water Conservation Period will be in place between May 1 and September 30 of each year when not in a declared drought stage, during which voluntary reductions in water use are requested and expected of all groundwater users. The implementation of required demand reduction measures will begin with the requirements of the Alarm stage. More stringent reduction measures will be required in the Critical stage.

A. No-Drought Status. The Barton Springs segment of the Edwards Aquifer will be in a "No-Drought" condition when the rate of discharge at Barton Springs is above the Alarm flow rate of 38.0 cfs, and the -depth to water in the Lovelady Drought Indicator Well (state well number 58-50-301) is above the Alarm level of 180.8 feet below the land surface datum (LSD). During this condition, the District will maintain and conduct a routine aquifer monitoring program. This stage shall be determined and administered at the discretion of the District's General Manager.

B. Water Conservation Period. This period will be in effect between May 1 and September 30 every year when not already in a declared drought period. Permittees within the District will be expected to follow the voluntary measures described in their User Drought Contingency Plans (Section 3-7.5) during the Water Conservation Period, and all other groundwater users will be asked to reduce their water use voluntarily during this period.

C. Alarm Stage. An Alarm Stage Drought commences when a 10-day running average rate of discharge from Barton Springs is equal to or less than 38.0 cfs, <u>or</u> the depth to water in the Lovelady Drought Indicator Well is equal to or greater than 180.8 ft from LSD, <u>and</u> the District's Board of Directors determines that conditions warrant the declaration of this stage.

D. Critical Stage. A Critical Stage Drought commences when a 10-day running average rate of discharge from Barton Springs is equal to or less than 20.0 cfs, <u>or</u> the depth to water in the Lovelady Drought Indicator Well is equal to or greater than 192.1 ft from LSD, <u>and</u> the District's Board of Directors determines that conditions warrant the declaration of this stage.

E. Discontinuance of Drought stages. The Critical drought stage will be discontinued when the rate of discharge from Barton Springs rises above a 10-day running average of 20.0 cfs <u>and</u> the water level elevation in the Lovelady Drought Indicator Well is above a depth to water of 192.1 ft, <u>and</u> when in the judgment of the District's General Manager or Board of Directors a Critical drought situation no longer exists. The Alarm drought stage will be discontinued when the rate of discharge from Barton Springs rises above a 10-day running average of 38.0 cfs and the water level elevation in the Lovelady Drought Indicator Well is above a depth of 180.8 ft, and when in the judgment of the District's General Manager or Board of Directors an Alarm drought situation no longer exists.

F. Emergency Response Period (ERP). The District Board may declare an Emergency Response Period during Extreme Drought conditions, when a 10-day running average rate of discharge from Barton Springs is equal to or less than 14 cfs. (This trigger level may be revised as additional scientific information on the low flow characteristics of Barton Springs is developed.) In addition, the Board may take emergency actions underneath District Rule 2-4.2, and request other governmental agencies to implement structural measures designed to minimize take and prevent jeopardy of endangered species populations (e.g. the Barton Springs Recovery Plan).

G. Drought Factors. In addition to the rate of discharge at Barton Springs and depth to water in the Lovelady well, the District may consider other factors that may have some relevance to the urgency of declaring a drought or that may indicate that a drought is likely to continue regardless of spring discharge or water levels. These factors may be related to hydrogeologic or climatological conditions that have a bearing on aquifer conditions. Some factors that may be considered include:

(1) Water levels in the Buda (58-58-101), Porter (58-58-123), and Negley (58-57-903) monitor wells;

(2) Number of consecutive prior months with below average rainfall, and related climatological outlook;

(3) Rainfall deficit for previous 12-month period;

(4) Palmer Hydrologic Drought Index;

(5) Flow in Blanco River at Wimberley;

(6) Number of months since last creek flow in major contributing creeks;

(7) Recent pumping rates; and

(8) Saturated thickness of the aquifer.

3-7.4. WATER QUALITY.

As aquifer level elevations approach historical lows, the District may monitor the water quality of public water supply wells along or near the bad water line, in the water table zone, in the artesian zone, and in Barton Springs.

3-7.5. USER DROUGHT CONTINGENCY PLANS.

Each permittee is required to prepare, adopt and implement User Drought Contingency Plans (UDCP) consistent with these Rules.

A. Contents of UDCP. UDCPs shall consider, as a minimum, the following:

(1) Establishment of a permittee's historical baseline pumpage volume and target pumpage volume in accordance with reduction goal percentages of the two drought management stages;

(2) Voluntary compliance restrictions to achieve a 10% reduction goal during the Water Conservation Period;

(3) Demand reduction measures, which may include prohibition of water waste, alternative and/or supplemental water supply sources, adjustment to water rates, and use of water saving devices;

(4) Additional demand reduction measures developed by the permittee, which achieve reduction goal percentages associated with and specified by each drought management stage;

(5) Financial measures, which encourage compliance with the UDCP and UCP while maintaining financial stability of the permittee during drought stages;

(6) Provision for ordinances, regulations or contractual requirements necessary for the permittee to enforce the UDCP; and

(7) Provisions for reporting pumpage.

(8) UDCP special provisions for Conditional Production Permits shall include:

(a) For both Class A and Class B Conditional Production permits, demonstration of demand reduction measures for a temporary curtailment of 50% and 75% of total authorized pumpage withdrawals.

(b) For Class A Conditional Production permits, demonstration of demand reduction measures, including identification of alternative sources of water, if available, and operational processes used for causing substitution, should the Board issues an order for the cessation of production of groundwater during a Critical Stage Drought pursuant to District Rule 3-1.24(G).

(c) For Class B Conditional Production permits, demonstration of demand reduction measures, including identification of alternative sources of water and operational processes used for causing substitution, as required under District Rule 3-1.11(N), should the Board issue an order for the cessation of production of groundwater during a Critical Stage Drought pursuant to District Rule 3-1.24(G).

B. Compliance. The District shall approve UDCPs if they satisfy the objectives of this Rule. The permittees may revise or amend the UDCP, as necessary to reflect changes in permitted pumpage or ownership, subject to administrative approval by the General Manager. Any other revisions or amendments must be approved by the Board. After April 1, 1992, permittees must have a District approved UDCP prior to receiving a permit amendment or renewal. For users obtaining permits after the effective date of this Rule, UDCPs shall be prepared and presented for District approval.

C. Update upon Renewal. The UDCP of each permit shall be updated upon permit renewal no less often than every five years. District staff will assist permittees in providing the latest and most appropriate guidance for such updates.

D. Consistency with CCN Drought Contingency Plans. Any permittee that is also a holder of a Certificate of Convenience and Necessity (CCN) issued by TCEQ shall assure that all drought-management provisions in the TCEQ Drought Contingency Plan (DCP) and in the District permit's UDCP are aligned and internally consistent. The CCN holder shall modify its TCEQ DCP to conform to requirements of the District UDCP, if necessary, upon the earlier of twelve (12) months from the effective date of this provision or when the DCP is next amended.

E. Authority to Enforce UDCP. Any District permittee that is a water utility or otherwise a holder of a Certificate of Convenience and Necessity (CCN) issued by TCEQ shall:

a. Include the procedures for the enforcement of mandatory water use restrictions, including specification of water rate surcharges for violation of such restrictions, as authorized under 30 Tex. Admin. Code §288.20(a)(1)(J) and 288.22(a)(10).

b. Inform each of its customers of its authority, its physical ability, and its intent to enforce the mandatory drought restrictions contained within its permit with the District.

3-7.6. RESERVED.

3-7.7. PERMITTEE'S RESPONSIBILITIES.

Upon declaration of each drought management stage, permittees shall reduce water usage, report to the District the monthly water volumes pumped from the aquifer, and implement User Drought Contingency Plans.

A. Reduction Goals. Water use reduction goals are 10% during the Water Conservation Period, and 20%, and 30% for the Alarm and Critical drought management stages, respectively. These reduction goals are based on monthly baseline pumpage established for each permittee and are included as part of the UDCP. Additional reduction conditions are placed on all conditional production permits pursuant to District Rules 3-1.24 and 3-7.5(A)(8).

(1) All permittees not granted a variance from the Drought Rules shall achieve individual monthly (prorated for partial months) target pumpage volumes for each drought management stage by reducing established monthly baseline pumpage by the respective percentage reduction goals associated with each drought stage.

(2) If a permittee cannot develop a baseline pumpage volume, one shall be established by the District by using a monthly average percentage of annual use based on other permittees with similar water use.

(3) The target pumpage volume for a permittee that does not have historical pumpage data available shall be derived from the District generated baseline described in A.(2) above, or it may be based on their current permitted pumpage until a more accurate baseline can be established.

B. Implementation of User Drought Contingency Plans. Upon notification from the District that drought management stages are triggered, permittees not granted a variance from the Drought Rules are required to initiate action according to their UDCP.

(1) For the Alarm stage, mandatory compliance with a 20% reduction in monthly water use is required. Conditional Production Permits may have additional mandatory compliance reduction conditions pursuant to District Rule 3-1.24, including temporary curtailment of production.

(2) For the Critical stage, mandatory compliance with a 30% reduction in monthly water use is required. Conditional Production Permits may have additional mandatory compliance reduction conditions pursuant to District Rule 3-1.24, including temporary curtailment of production or cessation of production.

C. Reporting. During each drought stage all permittees shall report to the District the actual monthly volumes pumped.

3-7.8. DISTRICT ACTION.

During each drought management stage the District will take action to inform the public and to monitor conditions. The District's minimum actions may include:

A. Implementation Mechanism. The District shall declare the commencement or discontinuance of an Alarm or Critical Drought Stage. Upon declaration, the

District shall notify all permittees of the drought condition so that appropriate permittee actions can be undertaken.

B. Public Awareness. Provide press releases to local newspapers and electronic media that may include information on discharge from Barton Springs, water levels in wells, water quality, and groundwater declines whenever the District declares a change in drought status.

C. Aquifer Monitoring. District staff shall monitor aquifer conditions on a regular basis during non-drought periods so that staff will be aware of impending drought conditions. Staff will review USGS-telemetered data made available through the USGS web site to monitor conditions at Barton Springs. Staff will also review District-telemetered data made available through the web to monitor conditions at the Lovelady Drought Indicator Well. Periodic visits to the Lovelady well and Barton Springs may be used to verify conditions. District staff may contact the USGS directly for verification of data on the USGS web site, or District staff may manually measure discharge from Barton Springs. During periods of District-declared drought, District staff will check the telemetered data at least weekly.

D. Forecast of Water Level Elevations. The District may perform forecasts of water level elevations and water quality changes. If drought conditions or changes in stages are projected, the District may notify all permittees. Notification may include a description of pending drought or non-drought conditions (stages) and expected permittee response.

E. New Wells Requiring a Production Permit and Pumpage Amendment Applications. All applications for new wells that require the issuance of a Production Permit or an Amended Production Permit submitted during any District-declared drought will be referred to the Board for consideration and/or public hearing under Rules 3-1.4(A) and 3-1.6(A), and 3-1.9(B). Generally, the District will delay the effective date of such permits until no Drought Stage exists. The District recognizes that some applicants may be required to maintain a state-mandated sufficiency of water service under TCEQ Rules for Public Drinking Water Sections 290.44D and/or 291.93, or other appropriate sections of TAC 30 and will work with these applicants to ensure that both state and District requirements are satisfied.

3-7.9. IMPOSITION OF REGULATORY FEES.

During periods of District-declared drought, including both Alarm Stage and Critical Stage droughts, starting after two full months of a drought period, a drought management fee will be imposed on all individual permittees (excludes all uses under general permits). This regulatory fee will be paid annually in arrears, as a condition of permit renewals at the beginning of each fiscal year. It is designed to promote compliance with permit conditions.

A. Fee schedule:

(1) For production zone casing with outside diameters (or for aggregated multiple-well systems, an average outside diameter of production wells) nominally 5.0 inches or less, the drought management fee will be $100.00 per full month of declared drought, with a credit of $100.00 per month applied for each month that the permittee does not exceed its monthly mandated restriction in the prevailing UDCP.

(2) For production zone casing with outside diameters (or for aggregated multiple-well systems, an average outside diameter of production wells) nominally between 5.0 inches and 10.0 inches, the drought management fee will be $250.00 per full month of declared drought, with a credit of $250.00 per month applied for each month that the permittee does not exceed its monthly mandated restriction in the prevailing UDCP.

(3) For production zone casing with outside diameters (or for aggregated multiple-well systems, an average outside diameter of production wells) nominally greater than 10.0 inches, the drought management fee will be $500.00 per full month of declared drought, with a credit of $500.00 applied for each month that the permittee does not exceed its monthly mandated restriction in the prevailing UDCP.

B. Forfeiture of Conservation Credits. Any permittee that has more than one month of drought management fees without an offsetting compliance-related credit, as described in the Fee Schedule of Rule 3-7.9.A above, during the course of a single fiscal year forfeits the right to participate in the Conservation Credits program of Rule 3-1.17 for that year.

3-7.10. VARIANCE.

A variance to the Rules of this Section may be granted by the Board to prevent severe economic or financial hardship, to prevent health hazards, to alleviate immediate and serious threat to public health and safety, to prevent severe property damage, or to enable construction of public works projects by a political subdivision of the State.

The Board recognizes that some permittees may be using water at some minimal level necessary to maintain basic human domestic needs and minimum human and animal health and safety standards. However, the Board also recognizes the serious nature of drought conditions and the need to reduce pumpage to ensure, to the extent possible, the availability and equitable use of groundwater. Therefore, the Board encourages permittees, who are having difficulty meeting drought pumpage reduction targets needed to comply with their UDCP, to meet with District staff and discuss their situation and the possibility of qualifying for a variance.

The District recognizes that some applicants may be required to maintain a state-mandated sufficiency of water service under TCEQ Rules for Public Drinking Water Sections 290.44D and/or 291.93, or other appropriate sections of TAC 30 and will work with these applicants to ensure that both state and District requirements are satisfied.

A. Application. Applications for a variance from the requirements of this rule shall be filed with the District and accompanied with information and data supporting the request. The permittee will be required to identify the requirement(s) for which the variance is sought, to justify the variance and to identify the demand reduction measures that can be implemented. A variance request must be justified by a unique economic or financial hardship or health hazard, which is not experienced by other similar permittees. The permittee must provide the District with information and data supporting the request.

B. District Action. All variance cases will be presented to the Board for approval. The District shall evaluate each variance request on the merits described in the application. In evaluating a request, the District will consider factors such as the permittee's water use efficiency, demonstrated health and safety concerns, and economic/financial considerations. The District may conduct a public hearing on variance requests, and may approve or disapprove each request in accordance with established procedures. The approval shall specify the period of time that the variance will be in effect. The permittee shall receive written notification of the District's action.

3-7.11. ENFORCEMENT/PENALTIES DURING DROUGHT.

Pursuant to Rule 3-8, the District may initiate enforcement actions and assess penalties for each act of violation of this Section and for each day of violation, as appropriate and warranted. Each day a violation continues may be considered a separate, specific violation. Penalties shall be assessed within the ranges specified in this Section.

A. Penalty Assessment Criteria. In determining the amount of a civil penalty to be assessed within the ranges presented, the District will consider the following factors:

(1) The severity or seriousness of the violation;

(2) Whether the violation was willful, intentional, or could have been reasonably anticipated and avoided;

(3) Whether the violator acted in good faith to avoid or mitigate the violation, or to correct the violation after it became apparent and compensate those affected;

(4) The economic gain obtained by the violator through the violation;

(5) Whether similar violations have been committed in the past;

(6) The amount necessary to deter future violations;

(7) Any other matter that justice may require;

The Board may also choose to assess sanctions, including permit suspension or revocation, based on the consideration of these factors.

B. Penalty Ranges.

(1) For specific violations of this Section and other Drought related provisions of the District Rules during an Alarm Stage Drought, penalties shall be assessed in accordance with the following:

(a) Penalties for violations of 3-1.11(E.), 3-1.15, and/or 3-8.7 for failure to timely report, or failure to report accurate, meter readings shall be assessed at a minimum of $50 to a maximum of $250 per violation per day.

(b) Penalties for violations of 3-2.4 for falsifying or tampering with meter readings, shall be assessed at a minimum of $500 to a maximum of $1000 per violation per day.

(c) Penalties for violations of 3-3, related to water use that constitutes waste/pollution/proscribed use, shall be assessed at a minimum of $500 to a maximum of $1,000 per violation per day.

(d) Penalties for violations of 3-7.5, for failure to implement measures of the user drought contingency plan, shall be assessed at a minimum of $250 to a maximum of $500 per violation per day.

(2) Penalties for the above violations during Critical Stage Drought will be assessed at twice the amount selected from the specified range.

(3) Penalty Ranges for Violations of 3-7.7. Penalties for violations related to failure to reduce pumpage during District declared drought shall be assessed according to the following daily penalty matrices:

	Daily Penalties During Alarm Stage Drought Rule 3-7.7.B(1)		
Permitted Pumpage	**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

	Daily Penalties During Critical Stage Drought Rule 3-7.7.B(2)		
Permitted Pumpage	**Overpumpage Levels**		
	Level A	***Level B***	***Level C***
Tier 1	$100-$200	$200-$400	$400-$800
Tier 2	$400-$800	$800-$1,600	$1,600-$3,200
Tier 3	$1,600-$3,200	$3,200-$6,400	$6,400-$10,000

Where:

Permitted Pumpage (gallons/year):		**% Pumpage over Monthly Target:**	
Tier 1:	< 12,000,000	Level A:	< 25%
Tier 2:	≥ 12,000,000 and < 120,000,000	Level B:	> 25% and < 100%
Tier 3:	≥ 120,000,000	Level C:	> 100%

3-7.12 SPECIAL DROUGHT RESERVE ACCOUNT.

Fees that are collected pursuant to Rule 3-7.9.A and drought-related fines and penalties pursuant to Rule 3-7.11 shall be placed in a special reserve account that will be used solely to respond to drought-related problems and needs, without further restriction and at the discretion of the District Board of Directors or General Manager.

RULE 3-8. ENFORCEMENT.

3-8.1. NOTICE AND ACCESS.

Pursuant to Texas Water Code Section 36.123, any authorized officer, agent, employee, or representative of the District, when carrying out technical and other investigations necessary to the implementation of the Rules or the Act, and after reasonable notice to the owner or operator, may enter upon private property for the purpose of inspecting and investigating conditions relating to the withdrawal, waste, water quality, pollution, or contamination of groundwater or other acts covered by the these Rules or Texas Water Code.

3-8.2. SHOW CAUSE ORDERS AND COMPLAINTS.

The Board, either on its own motion or upon receipt of sufficient written protest or complaint, may at any time, after due notice to all interested parties 10 days prior to the scheduled hearing, cite any person owning or operating a well within the District, or any person in the District violating the Act, these Rules, or an Order of the Board. Under the citation, that person is ordered to appear before the Board in a public hearing and required to show cause why an enforcement action should not be initiated or why the person's operating authority or Permit should not be suspended, cancelled, or otherwise restricted and limited, for failure to abide by the terms and provisions of the Permit, these Rules, or the Act.

3-8.3. CONDUCT OF INVESTIGATION.

When investigations or inspections require entrance upon private property, such investigations and such inspections shall be conducted at reasonable times, and shall be consistent with all applicable rules and regulations concerning safety, internal security, and fire protection. The persons conducting such investigations shall identify themselves and present District identification upon request by the owner, operator, lessee, management in residence, or person in charge.

3-8.4. SEALING OF WELLS.

The District may seal wells that are prohibited by the Act, Rules, or Board orders from withdrawing groundwater within the District when the General Manager, or the General Manager's designated District employees, determines that such action is reasonably necessary to assure that a well is not operated in violation of the Act, Rules, or Board orders. This authorization to seal a well or to take other appropriate action to prohibit the withdrawal of groundwater extends to, but is not limited to, the following circumstances in which: (i) a permit has been granted, but the applicable fees have not been paid within the time period provided for payment; (ii) representations have been made by the well owner or primary operator that no groundwater is to be withdrawn from a well during a particular period; (iii) no application has been made for a permit to withdraw groundwater from an existing well that is not excluded or exempted from the requirement that a permit be obtained in order to lawfully withdraw groundwater; (iv) the Board has denied, cancelled, or revoked a permit; (v) permit conditions have not been met or (vi) a threat of, or potential for, contamination to the Aquifer exists.

The well may be physically sealed and red tagged to indicate that the District has sealed the well. Other appropriate action may be taken as necessary to preclude operation of the well or to identify unauthorized operation of the well.

Tampering with, altering, damaging, or removing the seal or red tag of a sealed or red tagged well, or in any other way violating the integrity of the seal or red tag, or the pumping of groundwater from a well that has been sealed or red tagged shall constitute a violation of these Rules and shall subject the person performing that action, as well as any well owner and/or primary operator who authorizes or allows that action, to such penalties as provided by the Act and these Rules.

3-8.5. REQUEST FOR INJUNCTIVE RELIEF AND ASSESSMENT OF PENALTIES.

If it appears that a person has violated, is violating, or is threatening to violate any provision of the Act or any Rule, regulation, permit, Board order, or other order of the District, the Board may institute and conduct a suit in the name of the District for injunctive relief, for recovery of a civil penalty, or for both injunctive relief and penalty.

3-8.6. LATE PAYMENT FEES FOR FAILURE TO PAY WATER USE FEES.

A. Failure of New Permittees to Make Initial Water Use Fee Payment. Failure of new permittees to make the initial annual water use fee payment or the initial installment payment within 10 (ten) days following issuance of a new permit constitutes grounds for the District to declare the permit void. Unless there are extenuating circumstances, the District may declare the permit void if the initial payment is not made within ten (10) days.

B. Failure to Make Fee Payments. Failure to make complete and timely payments of a fee as required by District Rule 3-1.16 shall automatically result in a late payment fee of 10% of the amount not paid and may result in the loss of any potential credit which may be applicable under Rule 3-1.17. The fee payment plus the late payment fee must be made within thirty (30) days following the date the payment is due, otherwise the permit may be declared void by the Board. (See also Rules 2-10 and 2-11).

C. Loss of Installment Payment Option. The option of making payment of the annual water use fee in installments is made available by the District primarily in order to avoid causing cash flow problems for retail water utilities. Any permittee who, two or more times during the permit term, makes late payment of fee installments, may be required to pay water use fees during the following two (2) years as an annual payment upon permit issuance, without an installment payment option, unless just cause is shown and an exception granted by the Board.

D. After a permit is declared void for failure to make payment of water use fees, all enforcement mechanisms provided by this Rule and the Act shall be available to prevent unauthorized use of the well, and may be initiated by the General Manager without further authorization from the Board.

3-8.7. FAILURE TO REPORT PUMPAGE AND/OR TRANSPORTED VOLUMES.

The accurate reporting and timely submission of pumpage and/or transported volumes is necessary for the proper management of water resources. Failure of the permittee to submit complete, accurate, and timely pumpage, transport and water quality reports as required by District Rule 3-1.15, may result in the loss of any potential credit which may be applicable under Rule 3-1.17, and may result in late payment fees under Rule 3-8.6, forfeiture of the permit, or payment of increased meter reading and inspection fees as a result of District inspections to obtain current and accurate pumpage and/or transported volumes and water quality reports. (See also Rules 2-10 and 2-11).

3-8.8. EMERGENCY ORDERS.

The District will develop Emergency Contingency Plans to deal with water quality or water quantity emergencies. The Board prior to adoption shall conduct public hearings on Emergency Contingency Plans. To implement Emergency Contingency Plans, the Board, or the General Manager if specifically authorized by an Emergency Contingency Plan, may adopt emergency orders of either a mandatory or prohibitory nature, requiring remedial action by a permittee or other party responsible for the emergency condition.

3-8.9. CIVIL PENALTIES.

A. If a person violates any District Rule, the District may assess a civil penalty against that person as provided by this section.

B. Any person who violates any District Rule is subject to a civil penalty of not less than $50.00 or more than $10,000.00 for each act of violation and for each day of violation, as a court may deem proper. Each day a violation continues may be considered a specific violation for purposes of penalty assessment.

C. All civil penalties recovered by the District shall be paid to the Barton Springs/Edwards Aquifer Conservation District.

D. A penalty under this section may be enforced by complaints filed in the appropriate court of jurisdiction in Travis County.

E. A penalty under this section is in addition to penalties provided under Section 2(e)(1)(B), Ch. 429, Acts of the 70th Legislature (S.B. 988).

4. BYLAWS

BYLAW 4-1. BOARD OF DIRECTORS

4-1.1. COMPOSITION AND OFFICERS.

The Board is composed of five directors, elected according to provisions of the Act. Unless otherwise required by law, three directors shall be President, Vice-President, and Secretary. Officers shall be elected annually for terms of one year at the Board's first meeting in June or at such time as is necessary to fill a vacancy.

4-1.2. COMPENSATION OF DIRECTORS.

Unless disqualified, and upon completion and approval of compensation form of record, directors may receive compensation up to the maximum allowed by law for time spent performing duties as a Director pursuant to Texas Water Code Section 36.060 provided the Director claims compensation within three (3) months of the performance of the duty.

4-1.3. INDEMNIFICATION OF DIRECTORS AND EMPLOYEES.

Each Director and employee is indemnified by the District against any liability imposed upon them and for any expense reasonably incurred by them in connection with any claim made against them, or any action, suit or proceeding to which he/she may be a party by reason of his/her being, or having been, a Director or employee, and against such sums as counsel selected by the Board shall deem reasonable payment made in settlement of any such claim, action, suit, or proceeding; provided, however, that no Director or employee shall be indemnified with respect to actual damages arising out of a cause of action for a willful act of omission, an act or omission constituting gross negligence or official misconduct, or with respect to matters for which such indemnification would be unlawful or against public policy. Any right of indemnification granted by this Section is in addition to and not in lieu of any other such right of which any Director or employee of the District may at any time be entitled under the laws of the State of Texas; and if any indemnification that would otherwise be granted by this Section is disallowed by any competent court or administrative body as illegal or against public policy, then any Director or employee with respect to whom such adjudication was made, and any other Director or employee, shall be indemnified to the fullest extent permitted by law and public policy, it being the express intent of the District to indemnify its Directors and employees to the fullest extent possible in conformity with these Bylaws, all applicable laws and public policy. The District may purchase and maintain insurance on behalf of any person who is a Director or employee of the District in any capacity, or arising out of his/her status as such. The indemnification provided herein shall insure to the benefit of the heirs, executors, and administrators of the Directors and employees of the District.

4-1.4. CONFLICT OF INTEREST.

Directors shall, pursuant to the standards of § 171.001, et seq., Local Government Code, the Texas Water Code, and the District Code of Ethics, disclose any conflict of interest with matters pending before the Board and shall refrain from participation in the discussion or decision on such matters.

4-1.5. STANDARDS OF CONDUCT.

A. No Director or employee should accept or solicit any gift, favor, or service that might reasonably tend to influence him/her in the discharge of his/her official duties or that he/she knows or should know is being offered him/her with the intent to influence his/her official conduct.

B. No Director or employee should accept employment or engage in any business or professional activity that he/she might reasonably expect would require or induce him/her to disclose confidential information acquired by reason of his/her official position.

C. No Director or employee should accept other employment or compensation that could reasonably be expected to impair his/her independence of judgment in the performance of his/her official duties.

D. No Director or employee should make personal investments that could reasonably be expected to create a substantial conflict between his/her private interest and the public interest.

E. No Director or employee should intentionally or knowingly solicit, accept, or agree to accept any benefit for having exercised his/her official powers or performed his/her official duties in favor of another.

4-1.6. BOARD MEETINGS.

A. Regular Meetings. The Board shall hold regular bi-monthly meetings. It may hold meetings at other times as required for the business of the District. At the request of the President, or in the President's absence, the presiding officer, or by written request of at least three Directors, the Board may hold special meetings. All such meetings shall be open to the public in accordance with the Texas Open Meetings Act. To the extent necessary for orderly conduct of proceedings, the guidelines of "Parliamentary Procedure at a Glance," New Edition, by O. Garfield Jones, 1971 revised edition may be followed.

B. Work Sessions. From time to time and as may be necessary, the Board may hold work sessions to discuss and evaluate issues in such detail as to require open and free discussion not normally possible in regular Board meetings. During work sessions of the Board, no public comment will be heard, unless specifically requested by a Director and recognized by the Board chair. Public comment may be made at the time the item(s) is up for discussion at a regular Board meeting.

4-1.7. PUBLIC COMMENT.

During Board meetings, other than a work session, the Board may hear public comment. Public comment during a Board meeting will be of two types:

A. Public comments of a general nature may be made under the public comment item on the agenda.

B. Specific comments on any posted agenda item may be made following recognition of the speaker by the Board chair. Such comments may be made after the presentation of the item, or during the Board discussion of the item, if the speaker is called upon.

The Board chair will accept public comments of either type only after the person wishing to speak has completed an information card, which is available at the meeting. The card must contain the speakers name, address, phone number, Director's precinct in which speaker resides, and the number of the agenda item, which will be addressed. A speaker may sign up to speak for any posted item for three (3) minutes or less. Speakers shall address only the item for which they signed up. No speaker will be allowed to pass his/her time to someone else, nor will be permitted to repeat comments made by another, except to concur with those remarks.

4-1.8. CANCELLATION OF POSTED MEETINGS.

All meetings requiring posting in accordance with the Texas Open Meetings Act will be held regardless of weather conditions when a quorum of the Board is present. Should weather conditions prohibit the regular meeting, the meeting will be rescheduled for a later date, not sooner than seventy-two (72) hours after the cancelled meeting unless posted as an emergency in compliance with state law.

BYLAW 4-2. COMMITTEES

4-2.1. COMMITTEES.

The President may establish and designate Directors for advisory committees and shall appoint the committee chairs for formulation of policy recommendations to the Board or for such other purposes as the Chair may designate. All meetings of such committees shall be open to the public.

4-2.2. COMMITTEE MEMBERSHIPS.

Members of the various committees shall be appointed from residents of the District as much as is feasible. Membership may include individuals residing outside the District when it would be in the best interest of the committee's work efforts and the District. Membership is voluntary and without compensation. The appointing Director shall consult the Director of the precinct in which the proposed appointee resides, if applicable, when appointing someone from outside of the Director's precinct.

A. Members of committees will be selected from persons recommended to the Board by Directors, public officials, and citizen request.

B. All members appointed to a committee by the Board or Board President shall have a single vote on any issue before the committee.

C. Written proxy votes may be accepted when the vote is cast by an informed and active committee member as determined by the committee chair.

D. Members of the committees are appointed by the Directors. The Board, based on recommendations from the General Manager, appoints technical representatives.

E. Committee size will be limited to a number, which may reasonably address an issue and will be determined by the Board. Subcommittees appointed by the committee chair may be formed to create a work product for Board and/or full committee review and input.

F. Members of committees who miss three or more consecutive committee meetings may, at the request of the committee chair, be replaced by the appointing Director.

BYLAW 4-3. ADMINISTRATION

4-3.1. GENERAL MANAGER.

The person employed by the Board as General Manager shall be the chief operating officer of the District and shall have full authority to manage and operate the affairs of the District, subject only to Board orders. The General Manager is responsible for employing all persons necessary for the proper handling of the business and operation of the District and for determining their compensation. The General Manager is empowered to obtain official or legal status in matters of concern or interest to the District in public hearing processes, or other proceedings, when the opportunity to obtain such status presents itself and Board action to establish an official Board or District position cannot be obtained in a timely manner. Such matters will be brought to the Board for action at the earliest possible convenience.

4-3.2. DELEGATION OF AUTHORITY.

The General Manager may delegate his/her administrative duties as may be necessary to effectively and expeditiously accomplish his/her duties, provided, however, that no such delegation shall ever relieve him/her of responsibilities which are ultimately his/her under the Act, Rules and Bylaws, or Board orders.

4-3.3. TRAVEL EXPENSES.

A. The General Manager, with the Board's approval, shall provide and periodically revise a written policy concerning the incurring and reimbursement of travel expenses on District business. Directors and employees shall be entitled to reimbursement for actual and necessary expenses incurred in performing District business.

Transportation costs for Directors on days when there are scheduled District meetings will not be paid. These transportation costs are included in the payment for attending meetings. Any Director who declines per diem compensation for his/her duties as a Director may receive transportation expenses for attending meetings.

The General Manager or Board President, or the Board Vice President must approve travel expenditures submitted for reimbursement in the absence of the Board President.

Travel will be reimbursed at the current mileage rate established by the Internal Revenue Service.

B. Normal Reimbursable Expenses

"Actual and necessary expenses" includes:

(1) Mileage - All mileage traveled in behalf of District related matters.

(2) Travel - All actual costs incurred in out-of-town District related business (taxi, bus, air, car, rental, gasoline, etc.).

(3) Parking/Tolls - All, anywhere.

(4) Telephone - All for District business.

(5) Lodging - All costs for lodging and meals on out-of-town trips and other District business.

(6) Conventions/Seminars - The General Manager has the privilege and discretion to attend or approve District staff attendance at conventions and/or seminars where matters pertinent to District business are to be discussed or where there is to be an exchange in regards to information, education, or legislation pertinent to District business. The General Manager will seek approval of the Board to attend out of state conventions and/or seminars of interest and value to the District.

(7) Purchasing - The General Manager is entrusted and has the authority to purchase education, conservation, and/or pollution related materials to be used by the District, while attending meetings with state agencies, political subdivisions, conventions, seminars, or other conferences.

(8) Food/Beverage - The General Manager is entrusted with the privilege and discretion of purchasing food and/or non-alcoholic beverages within budget constraints. The District may provide a per diem allowance to

Directors or staff to cover food and/or beverage expenses incurred while on District business.

Original receipt or proper documentation must be submitted in order to be reimbursed.

BYLAW 4-4. OPERATIONAL PROCEDURES

The Board or the General Manager may establish and approve operational procedures for the District and such other procedures mandated by state law.

BYLAW 4-5. USE OF CONSULTANTS

The District may use a private consultant if a substantial need exists for the consulting services and the District cannot adequately perform the services with its own personnel. In selecting a private consultant, the District shall base its choice on demonstrated competence, knowledge, and qualifications, and on the reasonableness of the proposed fee for the services. Professional services contracts shall conform to Texas Water Code provisions for groundwater conservation districts.

BYLAW 4-6. ANNUAL REPORT

At fiscal year end, the President and/or General Manager shall report to the Board on the status of the District and its programs. The report shall include at least the following: (i) the status of the Aquifer and the District's programs to protect and conserve the Aquifer; (ii) a financial report, including a report from the Board's audit committee, and a report on the performance and security of District investments; (iii) a review and evaluation of professional services rendered to the District during the year; (iv) a report on the status of any capital projects of the District; (v) an evaluation of the District's performance in light of long range plans developed pursuant to Section 36.107, Texas Water Code; and, (vi) a self-evaluation report and environmental audit pursuant to the "Valdez Principles" adopted by the District. The report shall be available to the Board not later than one hundred twenty (120) days beyond fiscal year end for Board approval and submission to the TCEQ not more than one hundred thirty five (135) days after the fiscal year ends.

BYLAW 4-7. DISTRICT

4-7.1. DISTRICT ADDRESS.

The District's mailing address is 1124 Regal Row, Austin, Texas 78748. Such address may be changed by resolution of the Board.

4-7.2. MINUTES AND RECORDS OF THE DISTRICT.

All documents, reports, records, taped recordings, and minutes of the District shall be available for public inspection in accordance with the Texas Public Information Act. Upon application of any person, the District, when appropriate, will furnish copies, certified or otherwise, of any of its proceedings or other official acts of record or of any paper, map, or document files in the District office. Certified copies shall be made under the hand of the office secretary or General Manager, and affixed with the seal of the District. Persons who are furnished any such copies may be assessed a charge for the documents, pursuant to policies established by the General Manager based on the reasonable cost of furnishing such copies.

4-7.3. OFFICE HOURS.

The regular office hours of the District shall be 8:00 a.m. to 5:00 p.m., Monday through Friday, except for District holidays, or as may be set from time to time by the General Manager.

4-7.4. OFFICIAL SEAL.

The Board by resolution may adopt an official seal for the District to be used on Permits and other official documents of the District.

BYLAW 4-8. FINANCIAL

4-8.1. CONTRACTS, INSTRUMENTS, AND DOCUMENTS.

The Board may authorize the President or the General Manager to enter into any contract or to execute and deliver any instrument or document in the name of and on behalf of the District, and such authority may be general or confined to specific instances. All contracts shall be executed by either the President or the General Manager, attested by the Board Secretary, and approved by General Counsel. Any contract not so approved is void, and of no effect to the District.

4-8.2. LOANS.

No loans shall be contracted on behalf of the District, and no evidence of indebtedness shall be issued in its name unless authorized by resolution of the Board, executed by the President, and attested to by the Board Secretary.

4-8.3. BANKING AND INVESTMENTS.

A. Checks, Drafts, etc. All checks, drafts, notes, or other orders for the payment of money issued in the name of the District shall be signed by such officers or employees of the District as shall from time to time be authorized by resolution of the Board.

B. Depositories. All funds of the District, except petty cash, shall be deposited from time to time to the credit of the District in such banks or accounts as the Board may, from time to time, designate, and upon such terms and conditions as shall be fixed by the Board, unless otherwise required by orders or resolutions authorizing the issuance of the District's bonds or notes. The Board may, from time to time, authorize the opening and maintaining of general and special accounts within any such depository as it may designate, and may make such special rules and regulations with respect thereto as it may deem expedient. To the extent that the Federal Deposit Insurance Corporation does not insure funds in the depository bank or banks, they shall be secured as provided by Texas Water Code Section 36.155. The depository shall be located within the counties of the District unless the Board determines that a suitable depository cannot be found within the counties. The Board may also utilize the Texas Treasury Safekeeping Trust Company, commonly referred to as "TexPool" as a depository.

C. Investments. The Board may provide that an authorized representative of the District may invest and reinvest the funds of the District and provide for money to be withdrawn from the appropriate accounts of the District for such investments on terms as the Board considers advisable. Unless expressly authorized by the Board, such investments must be made in direct or indirect obligations of the United States, the State, or any county, city, school district or other political subdivision of the State, or in certificates of deposit of state or national banks, saving and loans associations within the State of Texas, or the Texas Treasury Safekeeping Trust Company (TexPool), provided that such certificates are secured in the manner provided for the security of the funds of counties of the State of Texas.

4-8.4. AUDIT.

The Board, at the end of each fiscal year, shall have prepared an audit of its affairs by an independent certified public accountant or a firm of independent certified public accountants, which audit shall be open to public inspection. Such auditors shall have no personal interest directly or indirectly in the fiscal affairs of the District, and shall be experienced and qualified in the accounting and auditing of public bodies. The audit shall be performed in accordance with generally accepted auditing standards and shall satisfy all requirements imposed by Chapter 36, Texas Water Code. It is provided, however, that the District's auditors may undertake consulting services for the District in addition to their duties in connection with the annual audit.

4-8.5. BUDGET.

Prior to the commencement of the fiscal year, the Board shall adopt an annual budget. The budget shall contain a complete financial statement, including a statement, or estimate, if appropriate, of:

A. The outstanding obligations of the District;

B. The amount of cash on hand to the credit of each fund of the District;

C. The amount of money available to the District from all sources during the ensuing year;

D. The amounts of the balances expected at the end of the year in which the budget is being prepared;

E. The estimated amounts of revenues and balances available to cover the proposed budget; and

F. The estimated water use fee that will be required.

G. Salary adjustments, if any.

Before the Board adopts its annual operating budget, it shall conduct , at a minimum, two (2) public hearings and shall make a proposed budget available to the public at least ten (10) days prior to the first hearing. Any resident of the District shall be allowed to participate in the budget hearing, subject to reasonable time limitations. The District may not make expenditures in excess of the total budgeted expenditures for a fiscal year unless the Board amends the budget.

4-8.6. SETTING FEE SCHEDULE.

A. Each year the Board shall, by resolution, adopt a fee schedule to apply to all applications, registrations, inspections, and permits that are issued, renewed, or amended during the following fiscal year, as well as fees for other services the District performs or fees to cover charges incurred by the District. The schedule shall establish a rate sufficient, when combined with City of Austin water use fees, to produce revenues required by the budget, and may include a reasonable allowance to take into account for the annual variability in pumping and groundwater demands.

B. The Board may amend the fee schedule from time to time following a public hearing.

4-8.7. FISCAL YEAR.

The District's fiscal year shall begin on the first day of September and end on the last day of August.

4-8.8. PURCHASING.

A. Expenditures to acquire goods or services valued at greater than $5,000 require approval by the Board in advance, unless an emergency acquisition requiring an expenditure greater than $5,000 shall be presented to the Board for approval and validation at its next following meeting. Acquisitions valued at less than $5,000 may be made by the General Manager without prior Board approval and if within budget constraints.

B. No expenditures may be made that are not authorized by the budget. This requirement shall not, however, prevent the Board from amending the budget at the same time that it authorizes an expenditure, provided that funds are available in other budget categories or that reserve funds are available.

C. In the case of acquisitions of goods valued at $1,000 or more, competitive quotations shall be obtained from three vendors, if possible, and documented for the District records prior to making the purchase.

D. The Board may solicit proposals for professional services according to the Professional Services Procurement Act, Chapter 2254, Government Code, Subchapter A.

E. The Board authorizes purchasing through the State's cooperative local purchasing program established under Texas Local Government Code § 271.081, et seq.

F. Construction contracts and contracts for the acquisition of materials and machinery requiring the expenditure of $15,000 or more may be competitively bid.

BYLAW 4-9 NOTICE AND HEARING PROCESS

4-9.1 SCHEDULING OF HEARING.

A. The general manager or Board may schedule a hearing, as necessary, on 1) Permit or Permit amendment applications received by the district, as provided by District Rule 3-1.4(C); 2) on matters under Rule 3-8; and 3) on any other matter that the District general manager or Board of Directors deems appropriate.

B. The general manager or Board may schedule more than one application for consideration at a hearing.

C. A hearing must be held at the District office or regular meeting location of the board unless the board provides for hearings to be held at a different location.

4-9.2 NOTICE.

A. If the general manager or Board schedules a hearing on a matter identified in Rule 4-9.1(A) above, the general manager or Board shall give notice of the hearing as provided by this section.

B. The notice must include, as appropriate to the circumstance:

(1) the name of the applicant or subject;

(2) the address or approximate location of the well or proposed well;

(3) a brief explanation of the proposed Permit or Permit amendment, including any requested amount of groundwater, the purpose of the proposed use, and any change in use;

(4) the time, date, and location of the hearing; and

(5) any other information the general manager or Board considers relevant and appropriate.

C. Not later than the 10th day before the date of a hearing, the general manager or board shall:

(1) post notice in a place readily accessible to the public at the District office;

(2) provide notice to the county clerk of each county in the District; and

(3) provide notice by:

(a) regular mail to the applicant;

(b) regular mail, facsimile, or electronic mail to any person who has requested notice under subsection (D) below; and

(c) regular mail to any other person entitled to receive notice under the Rules of the District.

D. A person may request notice from the District of a hearing on a matter identified in Rule 4-9.1(A) above. The request must be in writing and is effective for the remainder of the calendar year in which the request is received by the District. To receive notice of a hearing in a later year, a person must submit a new request. An affidavit of an officer or employee of the District establishing attempted service by first class mail, facsimile, or e-mail to the person in accordance with the information provided by the person is proof that notice was provided by the District.

E. Failure to provide notice under Subsection (C)(3)(b) does not invalidate an action taken by the District at the hearing.

4-9.3 HEARING REGISTRATION.

A. The District shall require each person who participates in a hearing to submit a hearing registration form provided by the District stating:

(1) the person's name;

(2) the person's address; and

(3) whom the person represents, if the person is not there in the person's individual capacity.

4-9.4 HEARING PROCEDURES.

A. A hearing must be conducted by:

(1) a quorum of the Board; or

(2) an individual to whom the Board has delegated in writing the responsibility to preside as a hearings examiner over the hearing or matters related to the hearing.

B. Except as provided by Subsection (C), the Board president or the hearings examiner shall serve as the presiding officer at the hearing.

C. If the hearing is conducted by a quorum of the Board and the Board president is not present, the directors conducting the hearing may select a director to serve as the presiding officer.

D. The presiding officer may:

(1) convene the hearing at the time and place specified in the notice;

(2) set any necessary additional hearing dates;

(3) designate the parties regarding a contested application;

(4) establish the order for presentation of evidence;

(5) administer oaths to all persons presenting testimony;

(6) examine persons presenting testimony;

(7) ensure that information and testimony are introduced as conveniently and expeditiously as possible without prejudicing the rights of any party;

(8) prescribe reasonable time limits for testimony and the presentation of evidence; and

(9) exercise the procedural rules adopted under Section 4-9.13.

E. The District may allow any person, including the general manager or a District employee, to provide comments at a hearing on an uncontested application.

F. The presiding officer may allow testimony to be submitted in writing and may require that written testimony be sworn to. On the motion of a party to the hearing, the presiding officer may exclude written testimony if the person who submits the testimony is not available for cross-examination by phone, a deposition before the hearing, or other reasonable means.

G. If the board has not acted on the matter in the hearing, the presiding officer may allow a person who testifies at the hearing to supplement the testimony given at the hearing by filing additional written materials with the presiding officer not later than the 10^{th} day after the date of the hearing, to any person who provided comments on an uncontested hearing matter or any party to a contested hearing. A person who receives additional written material under this subsection may file a response to the material with the presiding officer not later than the 10^{th} day after the date the material was received.

H. The District by rule adopted under Section 4-9.15 may authorize the presiding officer, at the presiding officer's discretion, to issue an order at any time before Board action under Section 4-9.9 that:

(1) refers parties to a contested hearing to an alternative dispute resolution procedure on any matter at issue in the hearing;

(2) determines how the costs of the procedure shall be apportioned among the parties; and

(3) appoints an impartial third party as provided by Section 2009.053, Government Code, to facilitate that procedure.

4-9.5 EVIDENCE.

A. The presiding office shall admit evidence that is relevant to an issue at the hearing.

B. The presiding officer may exclude evidence that is irrelevant, immaterial, or unduly repetitious.

4-9.6 RECORDING.

A. Except as provided by Subsection (B) below, the presiding officer shall prepare and keep a record of each hearing in the form of an audio or video recording or a court reporter transcription. On the request of a party to a contested hearing, the presiding officer shall have the hearing transcribed by a court reporter. The presiding officer may assess any court reporter transcription costs against the party that requested the transcription or among the parties to the hearing. Except as provided by this subsection, the presiding officer may exclude a party from further participation in a hearing for failure to pay in a timely manner costs assessed against that party under this subsection. The presiding officer may not exclude a party from further participation in a hearing as provided by this subsection if the parties have agreed that the costs assessed against that party will be paid by another party.

B. If a hearing is uncontested, the presiding officer may substitute minutes or the report required under Section 4-9.8 for a method of recording the hearing provided by Subsection (A) above.

4-9.7 CONTINUANCE.

The presiding officer may continue a hearing from time to time and from place to place without providing notice under District Bylaw 4-9.2. If the presiding officer continues a hearing without announcing at the hearing the time, date, and location of the continued hearing, the presiding officer must provide notice of the continued hearing by regular mail to the parties.

4-9.8 REPORT.

A. Except as provided by Subsection (E) below, the presiding officer shall submit a report to the Board not later than the 30th day after the date a hearing is concluded.

B. The report must include:

(1) a summary of the subject matter of the hearing;

(2) a summary of the evidence or public comments received; and

(3) the presiding officer's recommendations for board action on the subject matter of the hearing.

C. The presiding officer or general manager shall provide a copy of the report to:

(1) the applicant; and

(2) each person who provided comments or each designated party.

D. A person who receives a copy of the report under Subsection (C) may submit to the Board written exceptions to the report.

E. If the hearing was conducted by a quorum of the Board and if the presiding officer prepared a record of the hearing as provided by District Bylaw 4-9.6(A), the presiding officer shall determine whether to prepare and submit a report to the Board under this section.

4-9.9 BOARD ACTION.

The Board shall act on a matter identified in Rule 4-9.1(A) above not later than the 60th day after the date the final hearing on the matter is concluded.

4-9.10 REQUEST FOR REHEARING OR FINDINGS AND CONCLUSIONS.

A. An applicant in a contested or uncontested hearing on an application or a party to a contested hearing may administratively appeal a decision of the Board on a Permit or Permit amendment application by requesting written findings and conclusions or a rehearing before the Board not later than the 20th day after the date of the Board's decision.

B. On receipt of a timely written request, the Board shall make written findings and conclusions regarding a decision of the Board on a Permit or Permit amendment application. The Board shall provide certified copies of the findings and conclusions to the person who requested them, and to each person who provided comments or each designated party, not later than the 35th day after the date the Board receives the request. A person who receives a certified copy of the findings and conclusions from the Board may request a rehearing before the Board not later than the 20th day after the date the Board issues the findings and conclusions.

C. A request for rehearing must be filed in the District office and must state the grounds for the request. If the original hearing was a contested hearing, the person requesting a rehearing must provide copies of the request to all parties to the hearing.

D. If the Board grants a request for rehearing, the Board shall schedule the rehearing not later than the 45th day after the date the request is granted.

E. The failure of the Board to grant or deny a request for rehearing before the 91st day after the date the request is submitted is a denial of the request.

4-9.11 DECISION; WHEN FINAL.

A. A decision by the Board on a matter identified in Rule 4-9.1(A) above for which a hearing is held is final:

(1) if a request for rehearing is not filed on time, on the expiration of the period for filing a request for rehearing; or

(2) if a request for rehearing is filed on time, on the date:

(a) the Board denies the request for rehearing; or

(b) the Board renders a written decision after rehearing.

B. Except as provided by Subsection (C) below, an applicant or a party to a contested hearing may file a suit against the district under Section 36.251, Texas Water Code, to appeal a decision on a matter identified in Rule 4-9.1(A) above for which a hearing is held not later than the 60th day after the date on which the decision becomes final.

C. An applicant or a party to a contested hearing may not file suit against the district under Section 36.251, Texas Water Code, if a request for rehearing was not filed on time.

4-9.12 CONSOLIDATED HEARING ON APPLICATIONS.

A. Except as provided by Subsection (B) below, the District shall process applications from a single applicant under consolidated notice and hearing procedures on written request by the applicant if the District requires multiple Permits or Permit amendments for a single well.

B. The district is not required to use consolidated notice and hearing procedures to process separate Permit or Permit amendment applications from a single applicant if the Board cannot adequately evaluate one application until it has acted on another application.

4-9.13 RULES GOVERNING PROTESTS.

A. Notice of Protest. In the event anyone should desire to protest or oppose any pending application or other matter identified in Rule 4-9.1(A) above before the Board or a hearing officer, the person wishing to protest must file with the Board or hearing officer a written notice of protest or opposition, providing the basis for such protest and opposition as described in Paragraph (B) below, and request a hearing on or before the date on which the public comment period expires pursuant to District Rule 3-1.4(B).

B. Protest Requirements. Protests shall be submitted in writing with a duplicate copy to the opposite party or parties and shall comply in substance with the following requirements:

(1) Each protest shall show the name and address of the protestant.

(2) The protestant shall identify any injury that will result from the proposed action or matter to be considered by the Board.

(3) If the protest is based upon claim of interference with some present right of protestant, it shall include a statement of the basis of protestant's claim of right.

(4) Protestant shall call attention to any amendment of the application or adjustment which, if made would result in withdrawal of the protest.

(5) Protestant shall demonstrate a personal justiciable interest related to a legal right, duty, privilege, power, or economic interest not common to members of the public that is within the district’s regulatory authority and affected by a Permit or Permit amendment application.

C. The District shall limit participation in a hearing on a contested application to only persons who 1) have timely requested a hearing in Paragraph (A) above, and 2)have a personal justiciable interest as defined by Paragraph (B)(5) above.

4-9.14 DISCOVERY.

The presiding officer may issue subpoenas, require depositions, or order other discovery consistent with the authority granted to a state agency under Subchapters C, D, and F, Chapter 2001, Texas Government Code.

4-9.15 ALTERNATIVE DISPUTE RESOLUTION.

The presiding officer may refer parities to a contested hearing to an alternative dispute resolution procedure in the manner consistent with the authority granted to a state agency under Chapter 2009, Texas Government Code.

4-9.16 HEARINGS CONDUCTED BY STATE OFFICE OF ADMINISTRATIVE HEARINGS.

The District may contract with the State Office of Administrative Hearings to conduct hearings. Said hearings shall be conducted in such manner as provided by Subchapters C, D, and F, Chapter 2001, Texas Government Code.