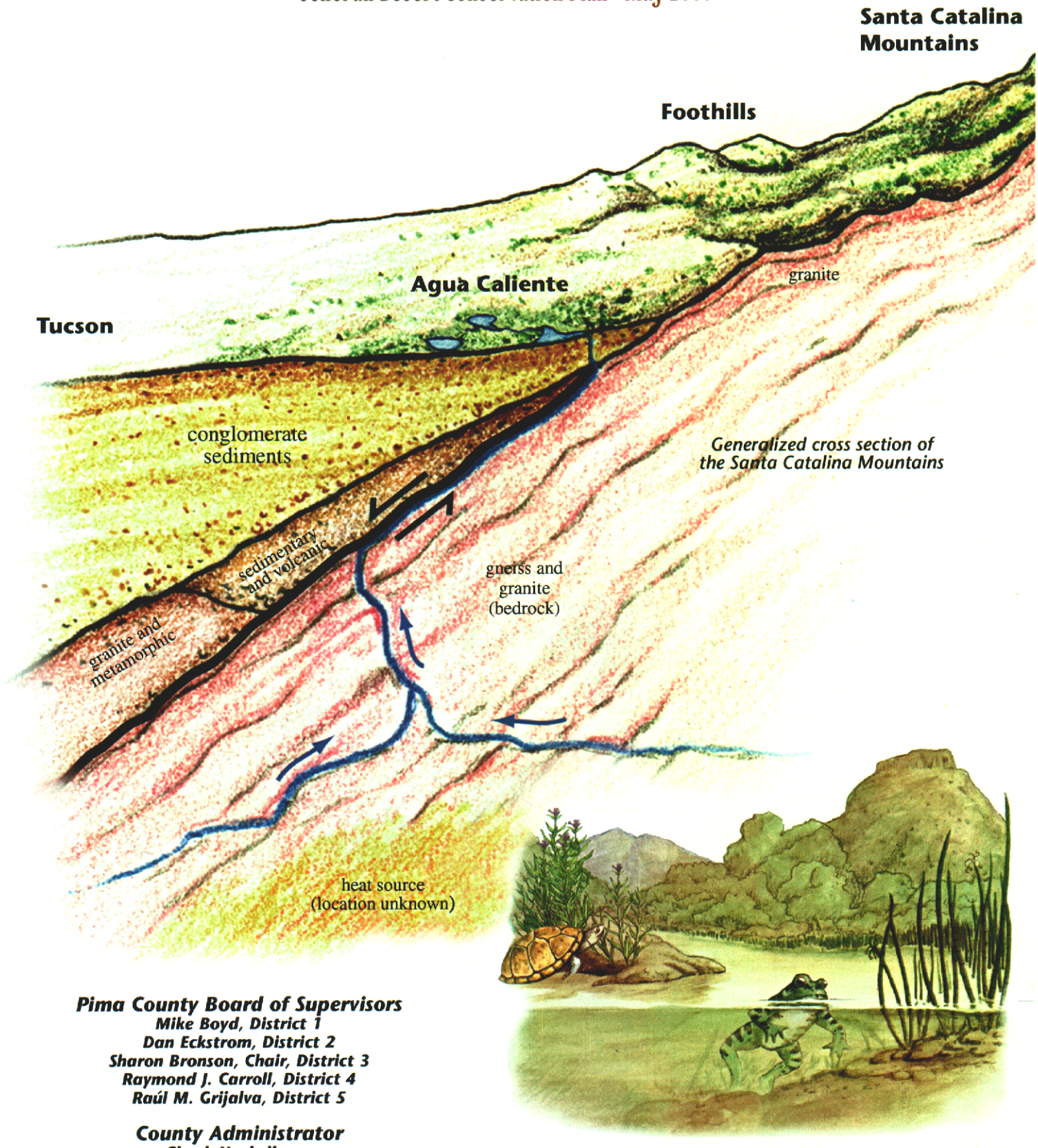
Springs in Pima County

DRAFT

Sonoran Desert Conservation Plan May 2000



Generalized cross section of the Santa Catalina Mountains

MEMORANDUM

Date: May 23, 2000

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Springs in Pima County**

Background

During the past months a number of reports have been produced to contribute to the Riparian Protection Element of the Sonoran Desert Conservation Plan, including:

- *Water Resources and the Sonoran Desert Conservation Plan*
- *Perennial and Intermittent Streams, and Areas of Shallow Groundwater*
- *Overview of Watersheds and Watercourses*
- *Prioritization of Streams for Conservation in Pima County*
- *Cocio Wash and the Gila Topminnow*
- *Riparian Habitat and Riparian Vegetation Mapping Efforts*
- *Riparian Vegetation Mapping Pilot Study*

The attached report entitled *Springs in Pima County* continues this line of investigation and follows up on a recommendation in the March 2000 *Land Cover Data Assessment* by defining, discussing, and documenting the current information about springs in Pima County.

Defining Springs

As the name suggests, a spring is a place where water rises to the surface. Figure 1 on page 2 of the attached report shows various causes for spring formation: a bedrock outcrop may force water to the surface, or an alignment of water-bearing and less porous rock in a fault zone may create the circumstances that promote spring formation. Springs, sensitive to groundwater depletion, occur rarely in the southwestern United States but can support a disproportionate amount of the region's species.

In Pima County, springs provide the habitat for vulnerable species such as the Quitobaquito Pupfish and a rare grass known as Box Canyon Muhly. Springs also serve as the remaining refugia for some species that were widespread at one time, such as the Chiricahua and Lowland Leopard Frogs.

Table 1, found on page 3 of the report and reproduced here, lists some of the vulnerable species in Pima County that are associated with springs.

Vulnerable species associated with springs in Pima County, Arizona.

SCIENTIFIC NAME	COMMON NAME
Sorex arizonae	Arizona Shrew
Choeronycteris mexicana	Mexican Long-tongued Bat@
Lasiuris borealis	Western Red Bat@
Pipilo aberti	Abert's Towhee@
Vireo bellii	Bell's Vireo@
Melospiza melodia	Song Sparrow@
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo@
Trogon elegans	Elegant Trogon@
Rana yavapaiensis	Lowland Leopard Frog
Rana chiricahuensis	Chiricahua Leopard Frog
Thamnophis eques megalops	Mexican Garter Snake
Elaphe triaspis intermedia	Western Green Rat Snake@
Kinosternon sonoriense longifemorale	Sonoyta Mud Turtle
Cnemidophorus burti stictogrammus	Giant Spotted Whiptail@
Poeciliopsis occidentalis occidentalis	Gila Topminnow
Gila intermedia	Gila Chub
Cyprinodon macularius macularius	Desert Pupfish
Cyprinodon macularius	Quitobaquito Pupfish
Agosia chrysogaster	Longfin Dace
Rhinichthys osculus	Speckled Dace
Argia sabino	Sabino Canyon Damselfly
Zaitzevia parvula	Santa Rita Water Beetle
Tryonia protea	Desert Tryonia
Tryonia quitobaquitae	Quitobaquito Tryonia
Anodonta californensis	California Floater*
Speyeria nokomis caerulescens	Blue Silverspot Butterfly*
Lilaeopsis schaffneriana var. recurva	Huachuca Water Umbel
Salvia amissa	Arivaipa Sage
Eryngium sparganophyllum	Ribbonleaf Button Snakeroot
Carex ultra	Arizona Giant Sedge

Table 2, found on pages 5 through 10 of the report, lists the location and ownership of known springs. Springs have been identified on federal land within the jurisdiction of the United States Forest Service, the National Parks Service, the Bureau of Land Management, and the United States Fish and Wildlife Service. Springs are also known to exist within the Tohono O'odham Nation, state land, private land, and on land owned by Pima County. In the absence of a standard classification of springs, the attached report identifies known springs with these characteristics for conservation purposes:

- springs thought to have perennial flow
- springs known to have native fish, or suitable habitat for native fish
- thermal springs

Springs thought to have perennial flow

Agua Caliente Spring	Nogales Spring
Aguajita Spring	Papago Spring
Bingham Cienega Spring	Pidgeon Spring
Box Spring	Quitobaquito Springs
Busch Spring	Scholefield Spring
Cold Spring	Silver Spring
Flicker Spring	Simpson Spring
Green Spring	Unnamed spring
Huntsman Spring	Unnamed spring
Kingler Spring	Unnamed spring
La Cebadilla Spring	Wakefield Spring
Little Nogales Spring	Wild Cow Spring (Whetstones)
Lower Wakefield Spring	Wild Cow Spring (Santa Catalinas)
Mountain Spring	

Springs known to have native fish, or suitable habitat for native fish

Agua Caliente Spring
Little Nogales Spring
Mountain Spring
Nogales Spring
Quitobaquito Springs
Unnamed Spring in Davidson Canyon
Wakefield Spring

Thermal Springs in Pima County, Arizona

Agua Caliente Spring
Mercer Spring
La Cebadilla Spring
Nogales Spring
Quitobaquito Spring

The value of perennial flow and suitable habitat for native fish justifies conservation of existing springs with such characteristics. Thermal springs provide a home to rare species, and are even more valuable for preservation purposes.

Springs within Pima County

Pages 14 through 27 of the attached report describe a number of springs in Pima County. A few are found on county-owned land, such as the Agua Caliente Spring, which is described in detail. A few highlights are reproduced below:

- "Agua Caliente Park is a 101 acre park, centered around a perennial spring and three ponds."
- "As a desert oasis, the area surrounding the spring was first occupied as early as 3500 B.C., by Archaic Period hunters and gatherers who moved throughout their range in a pattern following ripening plant foods. Near the end of the Archaic Period, Hohokam Indians established a village in the vicinity of the spring that has been named the Whiptail Site."
- "After this time, little is known about the happenings in the Agua Caliente region until the late 1800's. Agua Caliente was used as an encampment by soldiers before and after the Gadsen Purchase (1853), and up until the time of the ranching days of the early 1870's."
- "Between 1873 and 1984, the land was used as a ranch, resort, and small farms."
- In 1984, Pima County purchased the property, and the park was opened to the public in 1989.
- "The spring flows year-round, though discharge varies with rainfall. The flow rate varies from a low of 40 to 50 gallons per minute, to a high of 150 gallons per minute."

- "At one time, there were two different springs: a hot one with temperatures up to 100 degrees Fahrenheit, and a cool spring. The two springs were combined through the use of dynamite to provide a more consistent source of water, resulting in a combined temp averaging 87 degrees."

- "Agua Caliente is a source of perennial water. This feature, along with riparian plant communities, attracts many vertebrate species."

- "Wildlife found on the park include mule deer, javelina, bobcat, raccoon, ring-tail cat, skunk, and reptiles."

- "Many species of birds are found in the park including raptors and migratory species."

- "Fish are found in all three ponds. The fish species include grass carp, bluegill, tilapia, large-mouth bass, mosquito fish, koi, and goldfish. "

- "Vegetation near the spring consists of large palm trees lining the spring from source to Pond 1. Bermuda grass is also present."

- "The ponds and streams have existing habitat for several species of rare and endangered native fish and amphibians. The removal of existing non-native species of fish and amphibians is needed, as well as some minor habitat modifications."

Descriptions are also provided for the Bingham Cienega Spring, Mountain Spring (located in Posta Quemada Creek within Colossal Cave Mountain Park), Davidson Spring, La Cebadilla Spring (which flows from a spring located adjacent to Tanque Verde Creek), and the Quitobaquito Springs, probably the most well known of the Sonoran Desert springs.

Identification of Conservation Needs

Beginning on page 27, the report identifies a number of conservation actions that could be taken to protect springs, including the most obvious measure of ceasing spring water depletion where that is occurring. Management of non-native species is identified as a conservation need, as well as the simple need to inventory and monitor springs. The following conservation activities are taking place with springs owned by Pima County.

Conservation activities at spring habitats owned by Pima County

Conservation Activity	Bingham	Agua Caliente	Mountain	La Cebadilla
Vegetation Mapping	X	X		X
Plant Species Survey	X			
Hydrologic Investigations	X	X	X	
Vertebrate Survey				
Macroinvertebrates Survey		X		
Exotic Species Management	X			
Water Quality	X	X	X	
Flow Conditions	X			
Groundwater	X			
Surface Water Appropriation	X			
Recreation Management	X	X	X	

Recommendations

The report makes four recommendations.

- Improve and expand the springs database and GIS cover by reviewing existing surface water rights appropriations to determine the location and legal status of springs, incorporating U.S. Forest Service information, and compiling more complete information about regarding location, use, and biological or hydrological significance of springs.

- Obtain relevant scientific and legal information needed to protect County-owned springs from diversion or depletion.

- Obtain biological inventories of plants, and aquatic invertebrates and vertebrates associated with County-owned springs.

- Evaluate the protection offered to springs by the Sonoran Desert Conservation Plan, with particular emphasis on conserving springs which might protect native fish and frogs, and those which support such as travertine deposits, thermal conditions or cienega wetlands.

Conclusion

I have directed County staff to draft program proposals that will improve the conservation activities by Pima County for county-owned spring habitats. Conservation staff have also started to work with wildlife biologists and regulatory specialists to open up the Pima County owned springs to the reintroduction of native fish and frogs, where appropriate. Progress reports will be issued this summer as part of the Preliminary Sonoran Desert Conservation Plan.

SPRINGS OF PIMA COUNTY, ARIZONA

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SPRINGS IN PIMA COUNTY, ARIZONA

Draft of May 2000

by Julia Fonseca, David Scalero, and Neva Connolly
Pima County Flood Control District

A previous report entitled, *Land Cover Data Assessment in Pima County* (March 2000) recommended adding "mapping of springs, cienegas, marshlands, ponds and lakes" to existing land cover data. The purpose of this report is to document the preparation of a geographic information system cover that represents springs in Pima County, to discuss characteristics of certain springs in Pima County, and to identify actions needed to improve the conservation of springs and spring habitats. This report places special emphasis on springs owned by Pima County.

Definition

Springs are places where water that is traveling in rocks or soil naturally rises to the surface. The flow of springs is naturally replenished by a water table, so flow may cease when the water table is depleted by either drought, diversion of recharging surface water, or groundwater pumping.

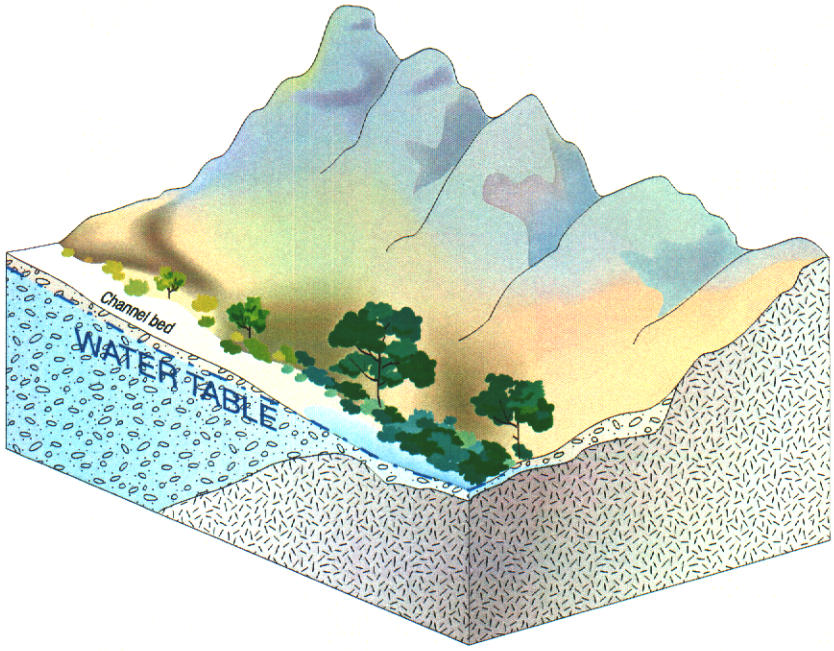
Some springs occur in the bottom of stream beds where a bedrock outcrop or other slowly permeable layers force water traveling in channel sediments to the surface (Figure 1a). Others may occur where fault zones juxtapose a porous water-bearing rock type against a less porous rock (Figure 1c).

Significance

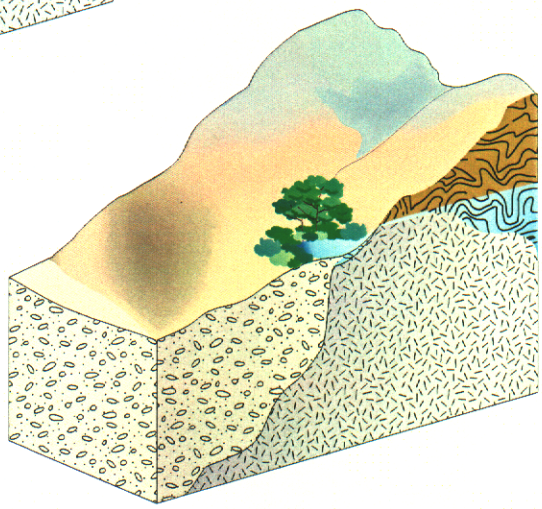
Springs are biologically important because they can serve as a source of water for wildlife, they are productive of algae and aquatic insects that form the base of the food chain, they may create rare habitats that increase the diversity of life, and they may provide thermal refuge in a harsh environment.

Because adequate inventories of our local spring biota are lacking, studies in other areas serve to illustrate the importance of springs to biologic diversity. Southwestern springs serve as unique low-elevation paleofugia (Stevens, 2000). In the area around the Grand Canyon, springs, seeps, and wet meadows make less than 0.01% of the overall landscape, but support more than 11% of the regional flora, including several endemic species. Eighty-three percent of the landsnail species in the Grand Canyon are associated only with springs, and 10% of the Hemiptera (true bugs) are endemic to springs of the area.

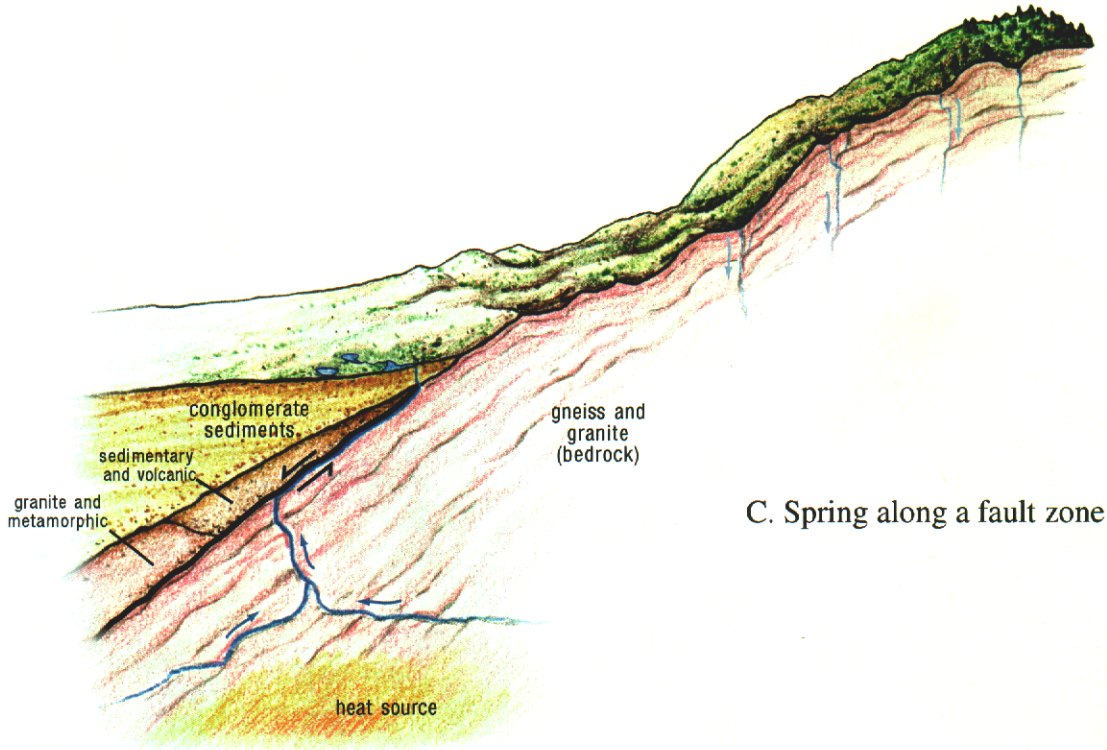
Several of Pima County's vulnerable species are known to rely upon springs. For instance, the Quitobaquito Pupfish is found principally in Quitobaquito Spring. The Box Canyon Muhly is a rare grass known from only six locations in the world, certain springs among them. Springs are important refugia for formerly widespread species such as Chiricahua and Lowland Leopard Frogs. Table 1 lists vulnerable species associated with springs.



A. Spring in channel bed.



B. Spring at contact of rock types.



C. Spring along a fault zone.

Figure 1.
Geological origin of springs.

Table 1. Vulnerable species associated with springs in Pima County, Arizona.

SCIENTIFIC NAME	COMMON NAME
Sorex arizonae	Arizona Shrew
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Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo@
Trogon elegans	Elegant Trogon@
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Thamnophis eques megalops	Mexican Garter Snake
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Rhinichthys osculus	Speckled Dace
Argia sabino	Sabino Canyon Damselfly
Zaitzevia parvula	Santa Rita Water Beetle
Tryonia protea	Desert Tryonia
Tryonia quitobaquitae	Quitobaquito Tryonia
Anodonta californensis	California Floater*
Speyeria nokomis caerulescens	Blue Silverspot Butterfly*
Lilaeopsis schaffneriana var. recurva	Huachuca Water Umbel
Salvia amissa	Arivaipa Sage
Eryngium sparganophyllum	Ribbonleaf Button Snakeroot
Carex ultra	Arizona Giant Sedge

Springs are also culturally significant. Some springs may be considered sacred by some indigenous peoples. Springs also provide medicinal plants, such as yerba mansa; in addition to materials for basket-making. Springs were the basis of early European enterprises: mining, ranching, and agricultural settlements all required a dependable source of water.

Distribution of Springs

Various sources of information were used by Pima County Technical Services to complete an ArcInfo cover of springs. The primary source of information was the spring cover compiled by the State of Arizona from the U.S. Geological Survey's Geonames database and digital line graphs. The second source of information was the literature search and expert input compiled by Pima Association of Governments (2000) for the GIS cover of perennial and intermittent streams. A third source of information was personal knowledge of the senior author. Staff also reviewed County files and reports for information about springs, and visited selected springs.

There are over 250 springs known to exist in Pima County (Table 2, Figure 2). This cannot be considered to be a complete inventory. Efforts such as those of Pima Association of Governments and others in the southwest have shown that topographic maps alone cannot be relied upon for inventory of springs. Instead, field-based efforts would be needed.

Figure 2 illustrates that the vast majority of springs in Pima County are located in the higher elevation National Forest lands, where precipitation is generally greater. The Santa Catalina, Rincon, and Santa Rita Mountains host many springs, while lower elevation mountains such as the Whetstone and Atascosa Mountains have relatively few springs.

According to Forest Service hydrologist Bob LeFevre, most springs within the Coronado National Forest have been developed at one time or another to concentrate spring flows into pipelines, troughs, and tanks. Spring box development does not necessarily deprive the associated riparian areas of water, as many of these developments leak water (LeFevre, pers. comm., 2000).

Developed springs provide water for livestock and wildlife (LeFevre, pers. comm., 2000). Springs are an important source of water to the community of Summerhaven in the Santa Catalina Mountains, and they supply campgrounds, ranger stations, and toilets in the National Forest. The City of Tucson has water rights to nine million gallons per year from springs in the Santa Catalina Mountains; the USFS has rights to 10 million gallons per years (RECON, 2000). Currently, annual use averages five million gallons per year, as documented in the Biological Stress Assessment (RECON, 2000). An acre-foot is 325,850 gallons. This amount of water, less than 37 acre-feet per year, is very small; however, most springs in the forest produce very little water (LeFevre, pers. comm., 2000).

Table 2. Locations and ownership of springs in Pima County, Arizona.

Sub-area	Map #	Name	Location (TRS)	Owner(s)
1	1	Upper Stratton Spring	11-16-09	USFS
1	3	Juanito Spring	11-16-10	USFS
1	4	Doctor Spring	11-16-10	USFS
1	9	Juan Spring	11-16-13	STATE
1	7	Geesaman Spring	11-16-16	USFS
1	8	Hartman Spring	11-16-17	USFS
1	13	Stratton Camp Spring	11-16-20	USFS
1	14	Orchard Spring	11-16-20	USFS
1	16	Alder Box Spring	11-16-22	USFS
1	11	Big Alder Spring	11-16-23	USFS
1	15	Eagle Spring	11-16-24	USFS
1	18	Coyote Spring	11-16-26	USFS
1	19	Green Spring	11-16-30	USFS
1	30	Crystal Spring	11-16-32	USFS
1	40	Morus Spring	11-16-36	USFS
1	29	Araster Spring	11-16-36	USFS
1	17	Davis Spring	11-17-30	USFS
1	38	Iron Spring	11-17-31	USFS
1	41	Unnamed spring	11-17-31	USFS
1	42	Cottonwood Cove Spring	11-17-32	USFS
1	5	Peck Spring	11-18-18	PRIVATE
1	244	Bingham Cienega Spring	11-18-23	USFS
1	45	Novio Spring	12-16-04	USFS
1	53	Unnamed spring	12-16-05	USFS
1	47	Bear Wallow Spring	12-16-05	USFS
1	44	Bill Williams Spring	12-16-05	USFS
1	57	Boy Scout Spring	12-16-08	USFS
1	65	Maverick Spring	12-16-12	USFS
1	46	Pipeline Spring	12-17-04	USFS
1	54	Cedar Spring	12-17-04	USFS
1	50	Chimney Spring	12-17-05	USFS
1	48	Unnamed spring	12-17-05	USFS
1	51	Pinto Spring	12-17-06	USFS
1	52	Trampa Spring	12-17-06	USFS
1	55	Finley Spring	12-17-08	USFS
1	56	Mesquite Flat Spring	12-17-08	USFS
1	60	Pearsons Spring	12-17-09	USFS
1	58	Georges Spring	12-17-09	USFS
1	66	Agua Nueva Spring	12-17-18	USFS
1	71	Alamo Spring	12-17-21	USFS

Sub-area	Map #	Name	Location (TRS)	Owner(s)
1	73	Iron Spring	12-17-26	USFS
1	74	Unnamed spring	12-17-26	USFS
1	75	Bellota Spring	12-17-27	USFS
1	76	Bullock Corrals Spring	12-17-34	USFS
1	78	Bull Spring	12-17-36	USFS
1	49	Unnamed spring	12-18-06	PRIVATE
1	94	Flagtail Spring	13-18-34	USFS
1	92	Pelon Spring	13-18-36	USFS
1	99	Steel Trough Spring	14-18-02	USFS
1	98	Sycamore Spring	14-18-02	USFS
1	97	Upper West Fork Spring	14-18-02	USFS
1	95	Willow Spring	14-18-02	USFS
1	96	West Fork Aliso Spring	14-18-04	USFS
1	100	Bear Spring	14-18-11	USFS
1	104	Sycamore Spring	14-18-15	USFS
1	107	Canon la Carne Spring	14-18-15	USFS
1	105	Turtle Spring	14-18-16	NPS
1	113	Deer Head Spring	14-18-19	NPS
1	111	Spud Rock Spring	14-18-20	NPS
1	112	Unnamed spring	14-18-20	NPS
1	110	Upper Spring	14-18-22	USFS
1	109	Lower Spring	14-18-23	USFS
1	115	Fresno Spring	14-18-24	USFS
1	118	Upper Mesquite Canyon	14-18-27	USFS
1	116	Turkey Creek Spring	14-18-28	NPS
1	120	Lower Turkey Creek Spring	14-18-34	USFS
1	119	Mesquite Canyon Spring	14-18-35	USFS
1	131	Alboyd Spring	15-18-26	USFS
1	129	Bear Spring	15-18-27	USFS
1	132	San Juan Spring	15-18-35	USFS
2	122	Fresno Spring	14-16-35	NPS
2	117	Grass Shack Spring	14-17-22	NPS
2	121	Wasp Spring	14-17-32	NPS
2	114	Unnamed spring	14-18-19	NPS
2	123	Head Trails Springs	15-17-04	NPS
2	127	CCC Spring	15-17-14	NPS
2	126	CCC Spring	15-17-14	NPS
2	136	Papago Spring	15-17-35	USFS
2	139	Van Trap Spring	15-17-36	USFS
2	134	Lion Spring	15-17-36	USFS
2	124	Cow Head Trail Spring	15-18-06	NPS
2	128	Bear Wallow Spring	15-18-20	NPS
2	137	Chimney Spring	15-18-31	USFS

Sub-area	Map #	Name	Location (TRS)	Owner(s)
2	135	Cumaro Spring	15-18-34	USFS
2	140	Hidden Spring	16-17-01	USFS
2	246	Mountain Spring	16-17-08	PC
2	142	Coyote Spring	16-17-13	STATE
2	145	Unnamed spring	16-17-30	PC
2	138	Grapevine Spring	16-18-05	USFS
2	141	Distillery Canyon Spring	16-18-08	USFS
2	148	Unnamed spring	17-17-06	PRIVATE
2	156	Davidson Spring	17-17-19	PRIVATE
2	151	Mescal Spring	17-17-21	PRIVATE
2	155	Bobo Spring	17-17-21	PRIVATE
2	159	Unnamed spring	17-17-28	PRIVATE
2	158	Wakefield Spring	17-18-27	STATE
2	161	Smitty Spring	17-18-28	STATE
2	165	Bootlegger Spring	17-18-31	STATE
2	255	Unnamed spring	17-18-33/18-18-4	PRIVATE
2	188	Barrel Spring	18-16-14	STATE
2	178	Unnamed spring	18-16-16	USFS
2	189	Scholefield Spring	18-16-16	USFS
2	190	Unnamed spring	18-16-16	USFS
2	182	Unnamed spring	18-16-17	USFS
2	199	Questa Spring	18-16-27	USFS
2	201	Rosemont Springs	18-16-34	USFS
2	174	Nogales Spring	18-18-11	BLM
2	173	Unnamed spring	18-18-11	BLM
2	172	Little Nogales Spring	18-18-11	BLM
2	176	Lower Wakefield Spring	18-18-12	USFS
2	171	Silver Spring	18-18-12	USFS
2	187	Lower Wakefield Spring	18-18-13	USFS
2	193	Bootlegger Spring	18-18-24	USFS
2	197	Apache Spring	18-18-27	BLM
2	200	Willow Spring	18-18-36	USFS
2	205	Deering Spring	19-15-01	USFS
2	213	Bowman Spring	19-15-13	USFS
2	217	Paja Verde Spring	19-15-23	USFS
2	227	Aliso Spring	19-15-34	USFS
2	211	Blacktail Spring	19-18-10	PRIVATE
2	209	Wild Cow Spring (Whetstones)	19-18-12	USFS
2	214	Bear Spring	19-18-13	USFS
2	212	Simpson Spring	19-18-13	USFS
2	221	Goat Spring	19-18-25	PRIVATE
2	219	Mud Spring	19-18-28	BLM

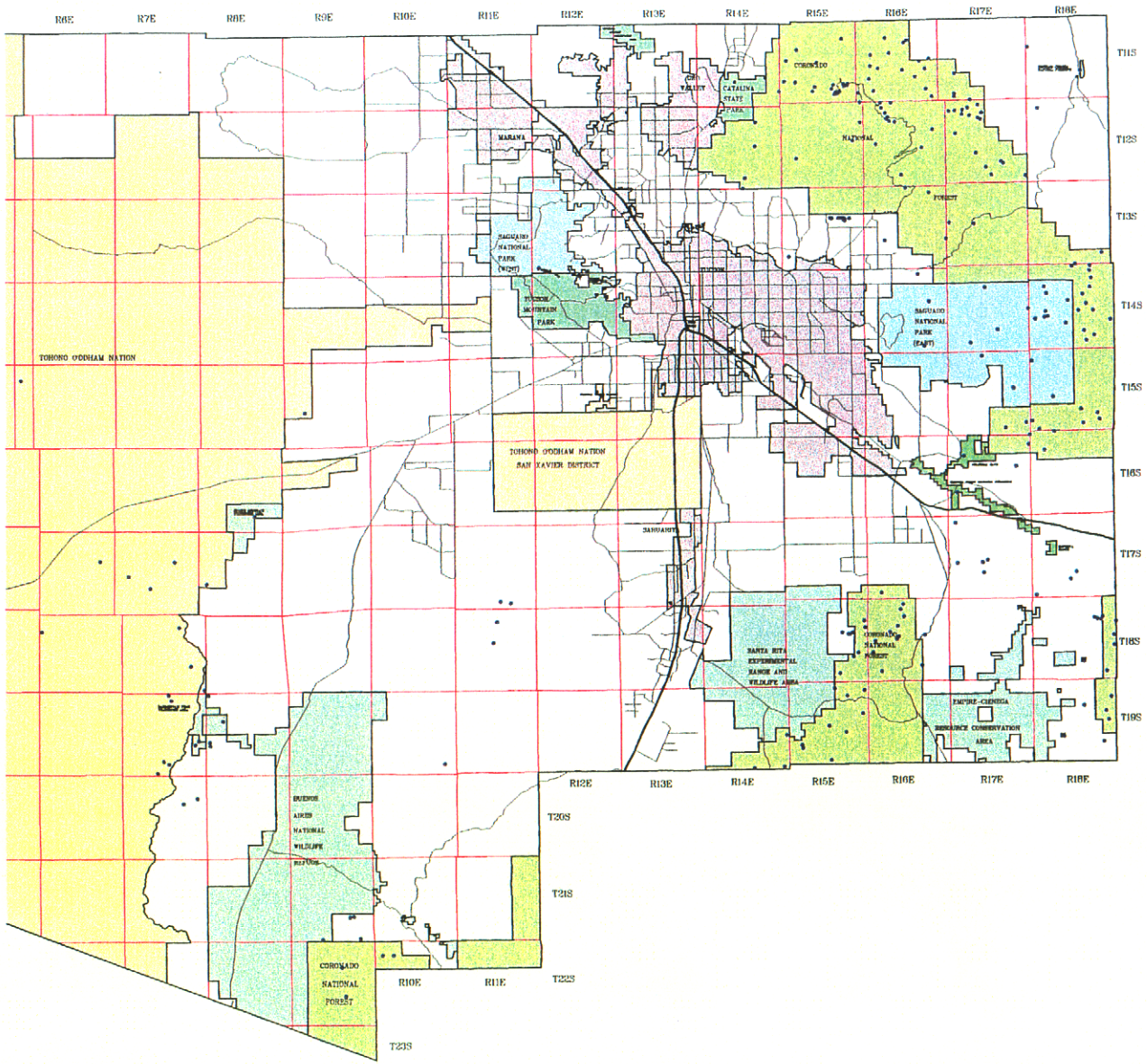
Sub-area	Map #	Name	Location (TRS)	Owner(s)
3	166	Grays Spring	17-11-34	PRIVATE
3	167	Sid Simpson Spring	17-11-35	STATE
3	164	Tunnel Spring	17-16-32	USFS
3	177	Bills Spring	18-11-10	BLM
3	192	Unnamed spring	18-11-16	STATE
3	175	Sycamore Spring	18-15-12	USFS
3	180	Casita Spring	18-15-13	USFS
3	183	Zackendorf Spring	18-15-14	USFS
3	186	Chavez Spring	18-15-14	BLM
3	184	Shamrod Spring	18-15-14	BLM
3	185	Helvetia Spring	18-15-14	BLM
3	195	Unnamed spring	18-15-24	USFS
3	196	Ruelas Spring Number Two	18-15-26	USFS
3	202	Ruelas Spring	18-15-34	USFS
3	168	Ojo Blanco Spring	18-16-04	USFS
3	170	Mulberry Spring	18-16-09	USFS
3	191	Fig Tree Spring	18-16-19	USFS
3	194	Unnamed spring	18-16-19	USFS
3	218	Faber Spring	19-14-24	USFS
3	232	Unnamed spring	19-14-34	USFS
3	231	Dutch John Spring	19-14-36	USFS
3	203	Proctor Spring	19-15-03	USFS
3	208	Basin Spring	19-15-11	USFS
3	216	Willow Spring	19-15-22	USFS
3	224	Robinson Spring	19-15-29	USFS
4	22	Cold Spring	11-15-25	USFS
4	25	Pidgeon Spring	11-15-25	USFS
4	23	Kingler Spring	11-15-25	USFS
4	26	Flicker Spring	11-15-25	USFS
4	39	Quartzite Spring	11-15-35	USFS
4	32	Annabel Spring	11-15-35	USFS
4	34	Cascade Spring	11-15-35	USFS
4	36	Dead Pine Spring	11-15-35	USFS
4	37	Brinkley Spring	11-15-35	USFS
4	35	Busch Spring	11-16-31	USFS
4	81	Unnamed spring	12-14-34	USFS
4	79	Finger Rock Spring	12-14-34	USFS
4	43	Huntsman Spring	12-15-01	USFS
4	63	Box Spring	12-15-12	USFS
4	67	Apache Spring	12-15-13	USFS
4	61	Girl Scout Spring	12-16-08	USFS
4	59	Palisade Spring	12-16-08	USFS
4	62	Unnamed spring	12-16-09	USFS

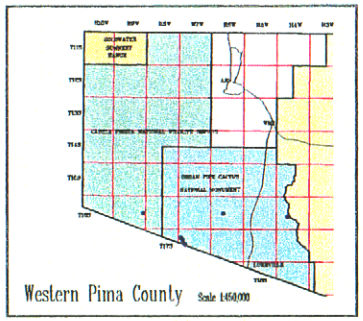
Sub-area	Map #	Name	Location (TRS)	Owner(s)
4	68	Mud Spring	12-16-18	USFS
4	70	Horse Camp Spring	12-16-23	USFS
4	77	Bug Spring	12-16-33	USFS
4	253	Unnamed spring	13-15-14	PRIVATE
4	252	Unnamed spring	13-15-14	PRIVATE
4	251	Unnamed spring	13-15-14	PRIVATE
4	85	Barrel Spring	13-15-14	PRIVATE
4	86	Gibbon Springs	13-15-14	PRIVATE
4	250	Unnamed spring	13-15-14	PRIVATE
4	249	Unnamed spring	13-15-14	PRIVATE
4	248	Unnamed spring	13-15-14	PRIVATE
4	254	Unnamed spring	13-15-14	PRIVATE
4	83	Unnamed spring	13-15-15	PRIVATE
4	84	Unnamed spring	13-15-15	PRIVATE
4	87	Unnamed spring	13-15-15	PRIVATE
4	93	Unnamed spring	13-15-30	PRIVATE
4	82	West Spring	13-16-02	USFS
4	80	Mercer Spring	13-16-03	USFS
4	91	Agua Caliente Spring	13-16-20	PC
4	90	Echo Spring	13-16-24	USFS
4	89	Precopia Spring	13-17-16	USFS
4	88	Rinconada Spring	13-17-18	USFS
4	245	La Cebadilla Spring	14-16-03	TNC
4	106	Rock Spring	14-16-14	NPS
4	102	Douglas Camp Spring	14-17-09	NPS
4	108	Unnamed spring	14-17-13	NPS
4	101	Italian Spring	14-18-07	NPS
4	103	Arts Spring	14-18-08	NPS
5	33	Cargodera Spring	11-14-25	USFS
5	2	Wild Cow Spring (Catalinas)	11-15-11	USFS
5	6	Iron Spring	11-15-17	USFS
5	10	Unnamed spring	11-15-18	USFS
5	12	Walnut Spring	11-15-22	USFS
5	24	Lemmon Spring	11-15-26	USFS
5	27	Shovel Spring	11-15-28	USFS
5	21	Samaniego Spring	11-15-29	USFS
5	20	Wooden Trough Spring	11-15-30	USFS
5	31	Unnamed spring	11-15-33	USFS
5	28	Bill Williams Spring	11-15-35	USFS
5	64	Buster Spring	12-14-11	USFS
5	69	Pima Spring	12-14-14	USFS
5	72	Mormon Spring	12-15-20	USFS
6A	147	Unnamed spring	16-08-26	BLM

Sub-area	Map #	Name	Location (TRS)	Owner(s)
6A	153	Unnamed spring	17-07-14	TON
6A	162	Unnamed spring	17-08-19	TON
6A	204	Unnamed spring	18-07-36	BLM
6A	220	Broken Trough Spring	19-07-24	USFWS
6A	223	Max Seep	19-07-24	USFWS
6A	207	Unnamed spring	19-08-06	STATE
6A	215	Unnamed spring	19-08-17	USFWS
6A	225	Tinaja Spring	19-08-19	STATE
6A	222	Unnamed spring	19-08-19	STATE
6A	229	Saucito Spring	19-10-36	STATE
6A	234	Corodope Spring	20-07-12	STATE
6A	235	Escondido Spring	20-07-14	STATE
6A	236	Cienegita Spring	21-09-26	STATE
6A	239	Agua Blanca Spring	21-09-33	STATE
6A	238	Unnamed spring	21-09-36	STATE
6A	169	Unnamed spring	21-10-27	PRIVATE
6A	242	Coches Spring	22-09-10	USFS
6A	243	Lesna Spring	22-09-22	USFS
6A	241	Watergate Spring	22-10-07	USFS
6A	240	Fraguita Spring	22-10-08	USFWS
6A	226	Unnamed spring	22-10-08	USFS
6B	247	King's Canyon Spring	13-12-31	NPS
7	125	Unnamed spring	15-05-12	TON
7	130	Unnamed spring	15-09-20	TON
7	152	Unnamed spring	17-06-14	TON
7	160	Unnamed spring	17-07-20	TON
7	163	Unnamed spring	17-07-27	TON
7	181	Unnamed spring	18-06-07	TON
7	179	Unnamed spring	18-07-11	TON
7	198	Unnamed spring	18-07-26	TON
7	206	Unnamed spring	19-07-03	TON
7	210	Unnamed spring	19-07-03	TON
7	228	Unnamed spring	19-07-28	TON
7	233	Unnamed spring	19-07-33	TON
7	230	Unnamed spring	19-07-34	TON
8	146	Bull Pasture Spring	16-4w-21	NPS
8	144	Dripping Springs	16-6w-16	NPS
8	143	Agua Dulce Spring	16-9w-13	USFWS
8	150	Burro Spring	17-7w-07	NPS
8	149	Williams Spring	17-7w-07	NPS
8	154	Quitobaquito Springs	17-7w-20	NPS
8	157	Aguajita Spring	17-7w-21	NPS

Eastern & Western Pima County Springs

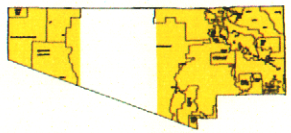
Figure 2





- Springs
- Major Roads
- Administrative Boundaries
- Township Range Lines

Pima County Index Map



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Scale 1: 150,000

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/pygmyowl2/sonora/gmis/springs_small.aml Plotted: 5/11/00

Classification of Springs

No standardized classification exists for springs. Springs may be classified in terms of their geologic origin, water chemistry, elevation, biotic affinities or discharge rates. We chose several characteristics to classify springs in eastern Pima County: flow characteristics, suitability for fish, thermal properties, and presence of travertine deposition.

Perennial springs are potentially significant from a biologic standpoint because they can provide habitat for species which depend on year-round water. Personal knowledge and the inventory by Pima Association of Governments (2000) are the only sources of information available to us regarding flow at this time.

Table 3. Springs thought to have perennial flow.

Agua Caliente Spring	Nogales Spring
Aguajita Spring	Papago Spring
Bingham Cienega Spring	Pidgeon Spring
Box Spring	Quitobaquito Springs
Busch Spring	Scholefield Spring
Cold Spring	Silver Spring
Flicker Spring	Simpson Spring
Green Spring	Unnamed spring
Huntsman Spring	Unnamed spring
Kingler Spring	Unnamed spring
La Cebadilla Spring	Wakefield Spring
Little Nogales Spring	Wild Cow Spring (Whetstones)
Lower Wakefield Spring	Wild Cow Spring (Santa Catalinas)
Mountain Spring	

Pima County's native fish fauna has been decimated by diversions, groundwater pumping and introduction of non-native fish. Re-introductions of fish like Gila topminnow have been hampered by periodic desiccation of water sources and other habitat factors.

Springs which are known to contain fish should be a priority for conservation because their water quality and flow can be considered suitable. Some springs which contain fish are known to contain non-native species which exclude the presence of native fish. At these sites, it would be necessary to remove the non-native fish to allow native fish to survive.

Table 4. Springs known to have fish.

Agua Caliente Spring
Little Nogales Spring
Mountain Spring
Nogales Spring
Quitobaquito Springs
Unnamed Spring in Davidson Canyon
Wakefield Spring

Thermal springs are those which have a water temperature which is elevated above the annual mean temperature for that elevation. Thermal waters generally indicate waters which have circulated to greater depths than normal. There are few thermal springs in Pima County. Thermal springs may be harbor rare species, or species which are normally found in other regions, so they may be important for conserving the full range of plants and animals in Pima County.

Table 5. Thermal Springs in Pima County, Arizona

Agua Caliente Spring
Mercer Spring
La Cebadilla Spring
Quitobaquito Spring
Nogales Spring

Travertine springs deposit calcium carbonate. Travertine ledges and pools can create niches for exploration by fish and other animals. Carbonate-charged waters at the springhead may be toxic to some organisms, but others can become uniquely adapted to these conditions. There are very few travertine springs known to occur in Pima County (Table 6).

Table 6. Known travertine springs in Pima County, Arizona.

Nogales Spring

Descriptions of Selected Springs

Quitobaquito Springs (#154)

The Quitobaquito Springs form the largest oasis found in the central portion of the Sonoran Desert (Johnson et al., 1983). The springs are located in Organ Pipe Cactus National Monument, less than 200 feet north of the international boundary between Mexico and the United States.

Quitobaquito Springs were first noted by Father Kino in 1698. At that time, Hia-Ced O'odam were residing near the springs. In the 1800's, the springs were an important water source for people traveling along the Camino del Diablo, a route running from Caborca, Mexico to Yuma, Arizona. In 1860, Aldoph Dorsey dammed the springs to form a pond. Between 1860 to the 1950's a variety of people lived near the springs and pond, using the water to irrigate crops growing nearby. Organ Pipe Cactus National Monument was established in 1937, when Quitobaquito was still inhabited and farmed by O'odam people. In 1957, the National Park Service bought Quitobaquito from a Hia-Ced O'odam named Jim Orosco. Quitobaquito Springs is considered sacred site by the O'odam, who continue to visit the site to collect sacred water from the Springs and to gather medicinal plants (NPS, 1997).

The Quitobaquito Springs were highly disturbed by the time the National Park Service acquired the area (Johnson et al. 1983). Photographs show the pond as shallow and broad, surrounded by open space with little vegetation. The open space and lack of vegetation was probably caused by years of woodcutting for shelter and firewood, grazing of livestock, clearing of adjacent areas for agriculture, construction of dwellings, and the introduction of exotic plants for orchards and shade. When the NPS acquired the land, the open water was drained, bulldozed, and diked into a discrete pond (Johnson et al., 1983). NPS management reduced most disturbances, resulting in the development of dense riparian vegetation around the pond (Brown 1983a). In a survey done in 1983, the woody vegetation found around Quitobaquito was even-aged stands of mesquite with a shrubby understory. Large, isolated cottonwood trees provide structural diversity (Brown, 1983a).

The Quitobaquito Springs are an oasis that is utilized by many wildlife species. The Springs attract a large and diverse group of migratory birds, as well as water-dependent local birds and rare, vagrant wading and shore birds. Quitobaquito is recognized by the NPS as the premier location for recreational bird watching in the Organ Pipe Cactus National Monument (Johnson et al.,1983). The Quitobaquito Desert Pupfish (*Cyprinodon macularius eremus*) is an endangered fish endemic to the springs and pond of Quitobaquito. Another endemic to the spring complex is the Quitobaquito snail. Other animals found to use Quitobaquito are the Underwood's mastiff bat, Sonoran mud turtle, and cactus ferruginous pygmy owl (NPS 1997). The site possesses potential habitat for the Southwestern willow flycatcher, and may be used by the endangered Sonoran pronghorn.

Quitobaquito Springs consists of one large and one small perennial spring and several intermittent springs. The source of the spring is assumed to be groundwater rising along a fault or fissure to the surface (Brown, 1983b). The land around the springs have been diked to form a pond. In 1917, the rate of flow was measured at 43 gallons per minute (gpm) and the average temperature was 26.8 degrees Celsius (Kynard 1976). Since that time, flow rate has decreased to an average of 30 to 35 gpm in 1985 (Fisher 1989). Water from the spring has a pH of almost neutral, while the pond has a basic pH of 9.0 (Kynard, 1976).

A primary threat to the flow of the springs is excessive groundwater pumping occurring in Mexico. While the Mexican government is aware of the increasing demands on the ground water table and has imposed a moratorium on new wells, established wells are used for irrigation purposes (Brown, 1991). Intrusion of agricultural chemicals from Mexico by air and insects are another threat to the water quality of the springs and pond. Increased visitor access to the springs increases chances that exotic fish and plant species may be introduced. NPS proposes to deal with this potential problem by increased public education and a clearly marked visitor trail (NPS, 1997).

Agua Caliente Spring (#91)

Agua Caliente Park is a 101 acre park, centered around a perennial spring and three ponds (Figures 3 and 4). The spring and surrounding 101 acre park are owned by Pima County and managed by the Parks and Recreation Department. The Agua Caliente Spring is the focus of a public park. Activities at the park include picnicking, walking, bird watching, and other forms of passive recreation. The park is located northeast of Tucson city limits and south of the Coronado National Forest. The park has a diverse mix of plants, wildlife, hydrologic, archaeologic, and historic features.

As a desert oasis, the area surrounding the spring was first occupied as early as 3500 B.C., by Archaic Period hunters and gatherers who moved throughout their range in a pattern following ripening plant foods. Near the end of the Archaic Period, Hohokam Indians established a village in the vicinity of the spring that has been named the Whiptail Site. After this time, little is known about the happenings in the Agua Caliente region until the late 1800's. Agua Caliente was used as an encampment by soldiers before and after the Gadsen Purchase (1853), and up until the time of the ranching days of the early 1870's. Between 1873 and 1984, the land was used as a ranch, resort, and small farms. Twice, in the 1920's and 1959, the property was planned for large-scale development. In both instances, the plans were not materialized. In 1984, Pima County purchased the property, and the park was opened to the public in 1989.

The spring flows year-round, though discharge varies with rainfall. The flow rate varies from a low of 40 to 50 gallons per minute, to a high of 150 gallons per minute. At one time, there were two different springs: a hot one with temperatures up to 100 degrees Fahrenheit, and a cool spring. The two springs

Photo: Jan McDonald, Pima County Illustration Section, 1996

Figure 3.
Springhead at Agua Caliente Park

Photo: Jan McDonald, Pima County Illustration Section, 1996

Figure 4.
Pond at Agua Caliente Park

were combined through the use of dynamite to provide a more consistent source of water, resulting in a combined temp averaging 87 degrees. At the spring source, low levels of oxygen and high levels of dissolved minerals are found (Davis, 1967). The spring gains oxygen after reaching the surface. Studies done by Davis (1967) support the explanation that the spring originates where the ground water table intersects the ground surface.

The water from the spring creates a stream which flows into Pond 1. Overflow from Pond 1 flows into Pond 2. Overflow from Pond 2 flows in the third pond. At full capacity, usually after the rainy seasons, Pond 3 discharges into Agua Caliente Wash.

Water quality in the spring was tested in 1983 and 1988. Aquatic plants, macroinvertebrates, and plankton were also surveyed in 1988 (Lloyd, 1989).

As in many areas of Tucson, growth near Agua Caliente Spring has been increasing. In the mid-1990's, bedrock for new homes was dynamited. Park personnel noticed a decrease in spring flow, apparently due to the dynamiting happening nearby. Spring flow returned to normal when this practice ceased (Frazier, 2000).

Agua Caliente is a source of perennial water. This feature, along with riparian plant communities, attracts many vertebrate species. Wildlife found on the park include mule deer, javelina, bobcat, raccoon, ring-tail cat, skunk, and reptiles. Many species of birds are found in the park including raptors and migratory species. Fish are found in all three ponds. The fish species include grass carp, bluegill, tilapia, large-mouth bass, mosquito fish, koi, and goldfish.

Vegetation near the spring consists of large palm trees lining the spring from source to Pond 1. Bermuda grass is also present.

The ponds and streams have existing habitat for several species of rare and endangered native fish and amphibians. The removal of existing non-native species of fish and amphibians is needed, as well as some minor habitat modifications. The Arizona Game and Fish Department would have to fully support and direct the introductions of native fish.

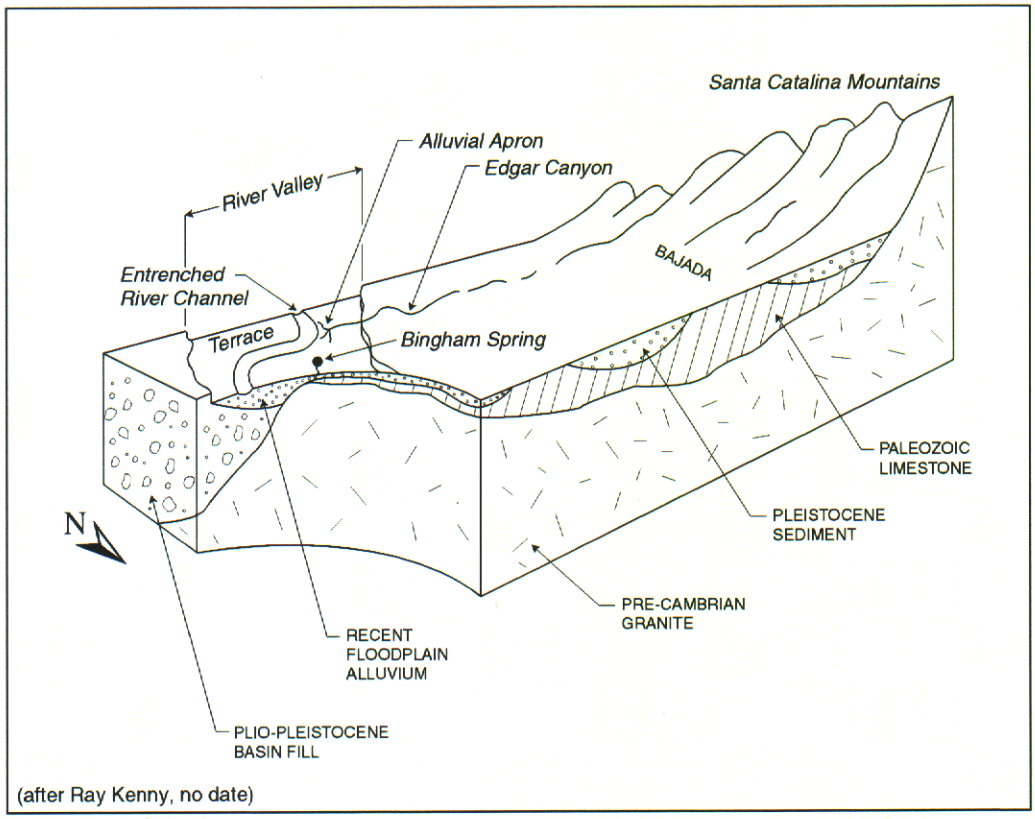
Bingham Cienega Spring (#244)

A spring-fed wetland known as Bingham Cienega occurs within the San Pedro River valley near Redington (Figures 5 and 6). The head of the spring is densely wooded with ash (*Fraxinus velutina*). Spring flows support a cienega dominated by approximately 23 acres of cattail (*Typha sp.*) and bulrush (*Scirpus sp.*). The spring is known to support mosquitofish (Gambusia affinis), lowland leopard frog (Rana yavapaiensis), a rich assemblage of reptiles and mammals, and hundreds of species of birds (D. Gori, per. comm., 2000). A single pair of Southwestern willow flycatchers (Empidonax extimus traillii), a federally-listed, endangered species, nested on the preserve in 1991, however, a survey conducted in 1995 failed to

Photo: L. Woods, April 2000

Figure 5.
Left:Bingham Cienega Spring originates in a grove of ash trees, and flows into a marsh of cattail and bulrush (dark green areas).

Figure 6.
Right: Geological Diagram San Pedro River Valley near Bingham Cienega



Pima County Illustration Section 12/98 ep

locate any birds (D. Gori, per. comm., 2000). Still the habitat appears suitable for the species.

Anglo agriculture and grazing in Bingham Cienega was underway as early as 1879 (Fonseca, 1999). Corn pollen in sediments indicates that the cienega was likely used for farming by prehistoric peoples as well (Davis, 1994). Today, farming and ranching continues on private land adjacent to the Bingham Cienega.

The spring water is dominated by calcium and sulfate ions. Total dissolved solids concentration is 250 mg/l. Water temperature at the spring head was 18°C in November 1993. Tritium values suggest a recent origin for the water. Pima Association of Governments and University of Arizona are analyzing isotopes to determine more about the source waters for the spring.

The management plan for this area was adopted by the Pima County Board of Supervisors on November 17, 1992. The management plan calls for favoring natural, rare plant communities.

In 1994, the District reviewed original 1879 land surveys of the Preserve and its vicinity to improve our understanding of potential vegetation communities. That study indicated that sacaton grasslands studded with mesquite and walnut once characterized the area outside the cienega. Analyses of pollen and sediment by Dr. Owen Davis (1994) indicate increases in cattail, cottonwood and willow pollen during historic times.

Researchers at University of Arizona completed a study of the hydrology and vegetation of marsh, relating the occurrence of plants to hydrologic conditions. This Heritage-funded report provides the underpinnings of ongoing efforts to restore the adjacent farm fields. Monitoring of vegetation and depths-to-water continues (Ronanye and Maddock, 1996).

Davidson Spring (#148)
Davidson Spring is located on Davidson Canyon on state and private land. It is located on U.S. geological Survey topographic maps.

This spring (Figure 7) is of particular significance because it contains native longfindace fish. No published information is available concerning this spring. At the time last visited by J. Fonseca , this spring was being grazed. Off-road recreational use was apparent.

La Cebadilla Spring (#245)
This spring is not found on U.S. Geological Survey topographic maps. Flows from a spring located adjacent to Tanque Verde Creek are diverted via a pipeline to maintain lake levels for the La Cebadilla Homeowner's Association. The spring is owned and maintained by the La Cebadilla Homeowners's Association.

Flows which are not diverted from the spring create an open pond and cienega marshland that extend onto adjacent property owned by Pima County Flood Control District (Figure 8). Flow appears to be perennial and thermally elevated, although no written information exists.

Uses in the vicinity of the spring are limited to equestrian and human trails. A May 4, 2000, field investigation of District property determined that a homeowner is using District property for disposal of horse dung. Exotic species noted on district property included extensive bermuda grass, yellow clover, and a few tamarisk.

Pima Association of Governments has collected one surface water quantity sample for this spring in the past. Little or no additional information is available at this time on the biology, water resources, or management needs at this location.

Sabino Springs (#85, 86, and 248-254)

Nine springs are located in the vicinity of The Raven golf course, at the base of the Santa Catalina Mountains along a fault zone. The land is privately-owned. Eight of the nine springs are located on U.S. Geological Survey topographic maps. Numerous additional seeps occur in the vicinity, reportedly due to "the shallowness of the groundwater table in the vicinity of the Catalina Fault Line" (Planning Center, 1990).

Natural vegetation around the springs and seeps include a few Goodding willow trees and a single cottonwood around the major spring and pond in Tres Hombres Wash (Planning Center, 1990). Non-native bermuda and rabbit foot grass occurred in wet, sandy areas. One spring supported cattails and duck weed.

Uses in 1990 included livestock grazing, recreation, and wildcat dumping (Planning Center, 1990). After golf course development, livestock use and diversion of one spring for potable uses ceased, resulting in more extensive flow of water (David Janders, pers. comm., 2000). Downstream residents complained about the flows of water in the Tres Hombres Wash, so the builder diverted the flows into a constructed channel system that goes into a detention basin (D. Janders, pers. comm., 2000).

Wakefield Spring (#158)

Wakefield Spring is located on Wakefield Canyon on state and private land. It is located on U.S. geological Survey topographic maps. The spring occurs at the contact between granite and basin fill alluvium.

This spring is of particular significance because it contains fish. No fish biologist has determined what species is present. Cottonwood, ash, and seepwillow plants were present along the channel.

No published information is available concerning this spring.

At the time last visited by J. Fonseca (1994), this spring was being grazed.

Photo: N. Connolly, May 2000

Figure 8.
La Cebadilla Spring

Recreational use was not apparent.

Nogales Spring (#174)
Nogales Springs is one of several springs located along a fault zone at the western base of the Whetstone Mountains. The land is owned by U.S. Bureau of Land Management. The spring is located on U.S. Geological Survey topographic maps.

This spring is of particular importance for a number of reasons. It is one of Pima County's few thermal springs, and it is the only one that forms natural dams of travertine. Nogales Spring is a potential Gila topminnow reintroduction site, and it provides habitat for the lowland leopard frog.

Vegetation around the site includes mesquite, oak, juniper, hackberry, walnut, poison ivy, and acacia. Vegetation types also include chaparral species such as sugarbush and buckthorn. The site was not grazed at the time last visited by J. Fonseca; grazing and recreational use was limited by poor access.

The water from this spring contains carbonate minerals obtained from Paleozoic limestones (Grahn, 1995). The spring emerges from the ground into a gravel-lined pool which bubbles with carbon dioxide, but does not visibly precipitate minerals. Once the spring waters reach the second pool, located about 1/8 of a mile downstream, the calcium carbonate rapidly precipitates out, forming travertine ledges along the stream.

Mountain Spring (#246)
Mountain Spring is located in Posta Quemada Creek within Colossal Cave Mountain Park. It does not appear on the U.S. Geological Survey topographic map. This spring was the basis for establishment of La Posta Quemada Ranch. The spring was an important stopping point for historic travel between the Tucson and San Pedro watersheds, prior to the advent of railroads and highways.

Mountain Spring could be classified as intermittent. The spring was dry in June 1989 (Acton, 1989). Field investigations in March and May 2000 showed that flow was restricted to seepage along the banks of the wash; however, at times the spring flow supports longfin dace for extended periods of time (Pima County Parks, 1998). The water table maintains an extensive gallery forest of cottonwood, Goodding willow, walnut, and mesquite woodland. Downstream of the spring, a perennial or nearly perennial pond occurs (Figure 9). The pond is surrounded by Goodding willow, seep willow, cattail, bulrush and buttonbush. The pond capacity is maintained by occasional scouring floods, which sweep away sediment and vegetation accumulating upstream of a bedrock outcrop (Bill Peachey, pers. comm. 2000).

Exotic species noted at the site on May 7, 2000, include oleander and bermuda grass. Signage and a fence at El Bosquecito Picnic Ground are in place to curb excessive trampling of the site. No livestock grazing occurs in the vicinity of the spring.

Photo: J. Fonseca, May 2000

Figure 9.
Mountain Spring and intermittent surface flows create this cattail marsh
in Posta Quemada Wash, within Colossal Cave Mountain Park.

A previous hydrogeologic investigation indicates that groundwater reserves in the vicinity are very limited and highly dependent upon annual precipitation in the upper drainage basin of Posta Quemada Wash (Cella Barr Associates, 1981). The primary water-bearing units are the Bolsa quartzite, a diabase and recent alluvium (Cell Barr Associates, 1981). The highly fractured Paleozoic limestone outcrops in the area transmit water rapidly to the aquifer; the limestone itself constitutes an aquifer where it overlies the Rincon Valley granodiorite.

Conservation Needs

The most crucial biologic conservation need for springs is protection from wholesale diversion or depletion. Many springs are already diverted for human or livestock use in a way that diminishes their biologic functions. Some have been lost to groundwater depletion.

Most springs are considered to be groundwater, unless a surface water appropriation is recognized by the State of Arizona (Nancy Nelson, 2000). Because of state law treats rights to surface water and groundwater under separate systems of law, surface water appropriations may not necessarily protect flows from aquifer depletion.

Federal reserved rights were created to protect spring flows of national forests, parks, refuges, monuments and reservations, but these do not encompass lands managed by the Bureau of Land Management in Pima County. This means that the water resources associated with the BLM's Empire-Cienega Ranch are not protected. Furthermore, even with federal reservations, springs may be developed and diverted, unless contrary to the intent for which the reservation was made.

The Endangered Species Act can protect springs from depletion or diversion, if a federally listed species would be jeopardized. Quitobaquito Spring in Pima County is known to contain a federally listed animal fish species, which depends on a spring for its existence.

Protection from and management of non-native species is another important conservation need. Many spring flows, such as those at Agua Caliente Spring, have been taken over by non-native fish, bullfrogs, or other organisms which act to exclude native species. Non-native plants, such as tamarisk, oleander, fountain grass, and others are already present at springs.

Inventory and monitoring is a third pressing conservation need. Our efforts and those at other locations, such as the Grand Canyon, have shown that the USGS spring database cannot be relied upon to provide a complete knowledge of the distribution of springs. Of the known springs, relatively few have received biologic inventories. Quitobaquito Spring is a notable exception. Even Bingham Cienega Spring still lacks a complete inventory of its vertebrate species and an inventory of macroinvertebrates has not been undertaken (Table 7).

Most springs lack vegetation surveys to determine what plants depend on the spring flows. Water quality and basic flow condition surveys are also lacking.

Management of human activities, such as livestock grazing, recreation, and roadway construction is also important. Excessive use by livestock and people can trample vegetation and degrade water quality. Roadway construction can divert flows and clear vegetation.

There are relatively few regional assessments of springs undertaken for conservation purposes. World Wildlife Fund's Chihuahuan Desert ecoregional assessment specifically reviewed the representation of freshwater ecosystems in their proposed reserve network. The classification system that they used divided springs by thermal and chemical characteristics (Table 8).

Table 7. Conservation activities at spring habitats owned by Pima County

Conservation Activity	Bingham	Agua Caliente	Mountain	La Cebadilla
Vegetation Mapping	X	X		X
Plant Species Survey	X			
Hydrologic Investigations	X	X	X	
Vertebrate Survey				
Macroinvertebrates Survey		X		
Exotic Species Management	X			
Water Quality	X	X	X	
Flow Conditions	X			
Groundwater	X			
Surface Water Appropriation	X			
Recreation Management	X	X	X	

Table 8. Freshwater habitat types in the Chihuahuan Desert used in the representation analysis by World Wildlife Fund (1999).

1. Warm springs
    A. high salinity
    B. low salinity

2. Cool springs
    A. high salinity
    B. low salinity

3. Ephemeral streams
    A. high gradient
    B. medium gradient
    C. low gradient

4. Perennial streams
    A. high gradient
    B. medium gradient
    C. low gradient

5. Lagunas
    A. permanent terminal
    B. temporary

6. Large rivers and floodplain

7. Ciénegas

8. Subterranean habitats

Recommendations

1. Improve and expand the springs database and GIS cover by:

    a. reviewing existing surface water rights appropriations to determine the location and legal status of springs.
    b. incorporating U.S. Forest Service information about location and development of springs, when it is available.
    c. securing the input of knowledgeable persons regarding location, use, and biological or hydrological significance of springs.

2. Obtain relevant scientific data and prepare legal documents needed to protect County-owned springs from diversion or depletion.
3. Obtain biological inventories of plants, and aquatic invertebrates (especially snails) and vertebrates associated with County-owned springs.
4. Evaluate the protection offered to springs by the Sonoran Desert conservation Plan, with particular emphasis on conserving springs which might conserve native fish and frogs, and those which support such as travertine deposits, thermal conditions or cienega wetlands.

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