

City of Austin, Watershed Protection Dept.
2019 Annual Report
U.S. Fish and Wildlife Service Scientific Permit (TE-833851)

Reporting period: 2019

This report documents activities involving Barton Springs, Austin Blind, and Jollyville Plateau salamanders (*Eurycea sosorum*, *E. waterlooensis*, and *E. tonkawae* respectively) as well as karst invertebrate work performed by the City of Austin that are authorized under the above permit for 2019. Tables and figures are numbered by section.

TE-833851, Section S., Permit Condition 6: General Annual Reporting Requirements for Barton Springs and Austin Blind salamanders

1) Precise locations of previously undocumented surveyed areas
None.

2) Dates of surveys conducted
Please see # 4, below.

3) Survey methods
Barton Springs and Austin Blind salamander counts were conducted quarterly throughout the year at Parthenia, Eliza, Old Mill (Sunken Gardens) and Upper Barton springs. For each survey, the date, weather, type of flow (base flow or storm flow) and aquifer discharge are recorded by the U.S. Geological Survey station at Parthenia Spring. Each site was searched using a drive survey method where all non-embedded substrate is searched, except for at Old Mill Spring, where a timed survey is used due to the low abundance of salamanders at that site. Every individual salamander found was identified to species and categorized by total length (0–1", 1–2", >2") or measured from photographs. Photographic capture-recapture surveys were performed at all sites except Parthenia Spring. Salamanders are captured using small handheld dip nets, photographed, and released as soon as possible, usually within 1–4 hours. The total number of salamanders of each species and size class found were recorded, although we only present the totals below.

4) Survey results
Salamander counts from 2019 surveys are presented in Table 1, below.

Table 1. Barton Springs and Austin Blind salamander counts from 2019.

Site	Date	Number <i>E. sosorum</i>	Number <i>E. waterlooensis</i>
Barton Spring	2/14/2019	8	0
Barton Spring	6/6/2019	2	0
Barton Spring	8/22/2019	77	0
Barton Spring	11/7/2019	505	2
Eliza Spring	2/22/2019	54	0
Eliza Spring	2/25/2019	45	0
Eliza Spring	2/28/2019	43	0
Eliza Spring	6/14/2019	79	1
Eliza Spring	6/17/2019	43	0
Eliza Spring	6/20/2019	50	1

Eliza Spring	8/26/2019	208	3
Eliza Spring	8/28/2019	151	0
Eliza Spring	8/30/2019	149	2
Eliza Spring	11/18/2019	556	2
Eliza Spring	11/20/2019	520	1
Eliza Spring	11/21/2019	384	2
Eliza Stream	2/22/2019	2	0
Eliza Stream	2/25/2019	1	0
Eliza Stream	2/28/2019	5	0
Eliza Stream	6/14/2019	13	0
Eliza Stream	6/17/2019	5	0
Eliza Stream	6/20/2019	5	0
Eliza Stream	8/26/2019	57	0
Eliza Stream	8/28/2019	35	0
Eliza Stream	8/30/2019	31	0
Eliza Stream	10/28/2019	1	0
Eliza Stream	10/29/2019	0	0
Eliza Stream	10/30/2019	5	0
Eliza Stream	10/31/2019	0	0
Eliza Stream	11/1/2019	5	0
Eliza Stream	11/18/2019	157	0
Eliza Stream	11/20/2019	235	0
Eliza Stream	11/21/2019	122	0
Old Mill (Sunken Gardens) Spring	3/8/2019	4	0
Old Mill (Sunken Gardens) Spring	5/6/2019	8	0
Old Mill (Sunken Gardens) Spring	8/22/2019	10	1
Old Mill (Sunken Gardens) Spring	11/22/2019	19	1
Old Mill Stream	3/8/2019	2	0
Old Mill Stream	5/6/2019	0	0
Old Mill Stream	8/22/2019	1	0
Old Mill Stream	11/22/2019	0	0
Upper Barton Spring	2/25/2019	2	0
Upper Barton Spring	6/6/2019	1	0
Upper Barton Spring	8/22/2019	1	0
Upper Barton Spring	11/7/2019	1	0

We performed a drift net survey as part of the Eliza Stream daylighting monitoring plan. The Eliza stream terminates at a junction box that connects to the Barton Springs Pool bypass tunnel. Salamanders that enter the junction box are lost from the population. A net was placed approximately 5 feet from the junction box from October 28-November 1, 2019 and checked twice

daily for salamanders that would otherwise go into the bypass tunnel. A total of 12 salamanders were found dead in the bypass net, or an average of 2.4 per day (Table 1). This large number found in the net may be due to the large number of salamanders found during the November surveys at Eliza springs. All salamanders caught in the net were small juveniles. Eight salamanders were Barton Springs salamanders and two were Austin blind salamanders. Two salamanders appeared to be hybrids; DNA analysis will be performed on these specimens. Four dead juveniles, the most of any check, were found the morning of 11/1/2019. This was the first time the net was checked after a partial drawdown ended the previous day. Without additional data, it's not possible to determine whether the drawdown was a contributing factor. It cannot be determined whether salamanders were already dead when they reached the net, or whether they died in the net. However, it is possible that downstream movements or drift is a mechanism that juvenile salamanders use to disperse. No adult salamanders were found in the net. The velocity along the net was measured and was near or below 1 foot per second. Thus, adults may have been able to escape the net if they entered it.

The net was also installed during the Eliza Spring survey on November 21. During this day, two live juvenile Barton Springs salamanders and two dead juvenile Barton Springs salamanders were removed from the net.

5) Number of salamanders collected from the wild

Salamanders collected from the wild (salvaged from surveys, drift nets, or collected alive for captive propagation) are presented in Table 2, below.

Table 2. Salamanders collected from the wild. Salvaged individuals were killed or injured during surveys, or otherwise found dead. Individuals that were collected alive were done in accordance with the City’s captive population management plan.

Species	County	Site	Date	Latitude	Longitude	Deposition	Notes
<i>Eurycea sosorum</i>	Travis	Old Mill Spring	3/8/2019	30.263474	-97.768117	sent to pathologist (Wash. State)	1-2" TL rescue (GBT, hole in skin at throat) during survey, appeared to recover, mortality 10/14/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	6/20/2019	30.263719	-97.770876	preserved	<1" TL rescue, found injured during survey, mortality 6/20/19
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	6/20/2019	30.263719	-97.770876	captive breeding program COA#A89	<1" TL collected for captive breeding during survey
<i>Eurycea sosorum</i>	Travis	Barton Springs Pool	6/27/2019	30.263719	-97.770876	captive breeding program COA#1015	<1" TL found during drawdown, collected for captive breeding
<i>Eurycea sosorum</i>	Travis	Barton Springs Pool	7/11/2019	30.263719	-97.770876	captive breeding program COA#1016	1-2" TL found during drawdown, collected for captive breeding
<i>Eurycea tonkawae</i>	Travis	Upper Ribelin Spring	7/12/2019	30.399207	-97.832562	used during gross necropsy	>2" TL. Found during survey- severe lesions, fungus growing out of severed limb- sent to NW Zoopath
<i>Eurycea sosorum</i>	Travis	Old Mill Spring	8/22/2019	30.263474	-97.768117	captive breeding program COA#1041	<1" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Old Mill Spring	8/22/2019	30.263474	-97.768117	captive breeding program	<1" TL collected during survey for captive breeding
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved for genetics	<1" TL collected during survey for captive breeding, mortality 8/26/19
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved for genetics	<1" TL collected during survey for captive breeding, mortality 8/26/19
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved for genetics	<1" TL collected during survey for captive breeding, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with GBT, injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with GBT, injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with GBT, injuries during survey, mortality 8/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	preserved	<1" TL rescue found with GBT, injuries during survey, mortality 9/29/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey

<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/26/2019	30.263719	-97.770876	no specimen	<1" TL rescue found with GBT, injuries during survey, mortality 9/29/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/28/2019	30.263719	-97.770876	no specimen	<1" TL rescue found with GBT, injuries during survey, mortality 9/29/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/28/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/28/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/28/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/28/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	no specimen	<1" TL collected during survey, possible injury, mortality ~10/5/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	no specimen	<1" TL rescue found with GBT during survey, mortality ~9/26/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	no specimen	<1" TL rescue found with injury during survey, mortality ~9/14/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	8/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling killed during survey
<i>Eurycea sp.</i>	Travis	Eliza Spring	9/18/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sp.</i>	Travis	Eliza Spring	9/18/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/18/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/18/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/18/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/19/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected in drift net with GBT, rescue
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/20/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected in drift net with GBT, rescue
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/20/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected in drift net, added to captive breeding

<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/20/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/20/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/23/2019	30.263719	-97.770876	no specimen	<1" TL collected in drift net, possible injury, mortality ~10/5/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/24/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	preserved	<1" TL rescue collected in drift net with GBT, mortality ~10/16/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/25/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	9/26/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected in drift net, added to captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/26/2019	30.263719	-97.770876	preserved	<1" TL rescue collected in drift net with GBT and injury, mortality 10/10/19
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/26/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/26/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	9/26/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	no specimen	<1" TL rescue collected in drift net with injury, mortality ~11/25/2019

<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/1/2019	30.263719	-97.770876	donated to Schwartz for isotope work	hatchling dead in drift net; salvaged for isotope work
<i>Eurycea waterlooensis</i>	Travis	Old Mill Spring	10/18/2019	30.263719	-97.770876	preserved for genetics	<1" TL collected in drift net, added to captive breeding, mortality ~11/25/2019
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/28/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	10/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sp.</i>	Travis	Eliza Spring	10/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	10/30/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sp.</i>	Travis	Eliza Spring	10/31/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/1/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/1/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/1/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/1/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/1/2019	30.263719	-97.770876	salvaged for genetics/isotopes	hatchling dead in bypass net; salvaged for genetics/isotope work

<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/18/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected for captive breeding during survey
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/18/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected for captive breeding during survey
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/20/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected for captive breeding during survey
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/20/2019	30.263719	-97.770876	if survives, will be added to CB	1-2" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/20/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected during survey for captive breeding
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected during survey for captive breeding
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected during survey for captive breeding
<i>Eurycea waterlooensis</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	1-2" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	1-2" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	if survives, will be added to CB	1-2" TL collected during survey for captive breeding
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	small juvenile killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	small juvenile killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	small juvenile killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	small juvenile killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	small juvenile killed during survey
<i>Eurycea sosorum</i>	Travis	Eliza Spring	11/21/2019	30.263719	-97.770876	donated to Schwartz for isotope work	adult crushed during previous day's survey
<i>Eurycea waterlooensis</i>	Travis	Old Mill Spring	11/22/2019	30.263719	-97.770876	if survives, will be added to CB	<1" TL collected during survey for captive breeding

6) Results of species identifications

See Table 1, above.

7) Number of salamanders handled and marked with elastomers

None

8) Observations of abnormal behavior or condition of salamanders handled/marked

None

9) Results of any mark-recapture work

We conducted capture-recapture surveys at three sites in 2019 using photographic identification methods (Bendik et al. 2013). Not enough recaptures were made at Upper Barton or Old Mill springs, so we are unable to calculate estimates of abundance at those sites.

We conducted robust-design mark-recapture sampling at Eliza Spring in February, June, August, and November. Abundance estimates are provided in Table 4. Data from the November 2019 surveys have yet to be analyzed.

Attached is a draft report of our capture-recaptures studies on the Barton Springs and Austin Blind salamanders, which summarizes information collected through 2018.

Table 4. Estimates of abundance (\hat{N}) and standard deviation (SD) for three of four capture-recapture surveys at Eliza Spring in 2019.

Period	\hat{N}	SD
Feb-18	94	6
June-19	155	12
Aug-19	469	22

10) Results of genetic research conducted as a result of tail-clipping

No tail-tips were collected in 2019 for genetics research.

11) Results of any research or management activities authorized by this permit and approved through the submission of study plans to the CPI Branch of the Austin ESFO

a. City of Austin monitors water quality in the Barton Springs Complex under this permit to meet the requirements of the Habitat Conservation Plan contained in the USFWS 10(a)(1)(B) permit PRT-839031 and the Texas Pollutant Discharge Elimination System permit WQ0004705000 (EPA NPDES TXS000401). Permitted staff collect water samples from each spring in the Barton Springs complex. On an approximately biweekly frequency, tested parameters include total suspended solids, volatile suspended solids, $\text{NO}_3 + \text{NO}_2 - \text{N}$, $\text{NH}_3 - \text{N}$, Ortho-P, temperature, dissolved oxygen, pH, conductivity, and turbidity. Quarterly sampling includes biweekly parameters plus alkalinity, Ca, Na, K, Mg, Cl, SO_4 , F, As, Cu, Fe, Pb, Ni, Zn. TPDES annual sampling includes all of the above plus Hardness, Ag, Cd, Cr, Hg, TOC, oil and grease, total polycyclic aromatic hydrocarbons, bromacil, organophosphate pesticides, chlorinated herbicides, volatiles, and semi-volatiles. Additionally, the City of Austin in cooperation with the United States Geological Survey maintains continuous monitoring for spring discharge and physiochemical parameters at Barton Springs.

b. U.S. Geological Survey deploys and maintains water quality sampling equipment in Parthenia

Spring. Equipment was serviced by USGS dive teams. An fDOM sensor and SUNA sensor were deployed as part of a study funded by the Barton Springs Salamander Conservation Fund to understand carbon and nitrogen fate and transport within the Edwards Aquifer. A copy of the study proposal is attached.

- c. City of Austin staff collect sediment samples at the four Barton springs for testing to meet requirements of the City's TPDES permit. Samples were collected on 4/19/18 at all four spring sites (Eliza, Old Mill, Upper Barton, and Barton Springs Pool), and on 2/1/18, 7/24/18, and 12/6/18 at Barton Springs Pool only.
- d. BSSCF Trophic Ecology Project. Participants: Benjamin Schwartz, Benjamin Hutchins, Weston Nowlin, Victor Castillo, III, Ashley Cottrell (Texas State University). Activity: Drift samples for aquatic invertebrates were collected for 8 days at Eliza Spring from 09/18/2019 to 10/02/2019, and for 5 days at Old Mill Spring from 10/17/2019 to 11/01/2019. Invertebrate sampling: In the samples sorted to-date, many microinvertebrates have been collected. Interesting finds include the first records at Barton Spring of: *Parabogidiella* sp. amphipod (Eliza); Ingolfiellid n. sp. amphipod (Old Mill); *Seborgia* (c.f. *relicta*) amphipod (Eliza and Old Mill), and Microcerberidae n. sp. isopod (Eliza). At least three snail species have been found at Eliza, and three at Old Mill (only one found in Old Mill appears to be the same as at Eliza). In addition, at least five undescribed species of ostracods have been found at the two sites, but at least two of these are found only at one site. Numerous unidentified species of copepods, annelids, and nematodes have also been found at both sites. Previously documented isopods (*Lirceolus* sp.) and amphipods (*Stygobromus* sp.) have been collected at both springs, and a few individuals of *Microcylloepus* sp. Riffle Beetle have been collected. Sample sorting and identification by specialists continues, and additional diversity will certainly be documented. During drift sampling, a number of salamanders (*E. waterlooensis* and *E. sosorum*) were captured in the nets. Live salamanders were released or transferred to the City of Austin refugia. Dead salamanders were retained for stable isotope studies. From Eliza Spring, 17 dead juvenile *E. sosorum* and 2 dead juvenile *E. waterlooensis* were collected. On November 20, 2019, tail clips from 20 adult *E. sosorum* were collected in coordination with City of Austin staff during their salamander survey/count. These will be used for stable isotope studies. No salamanders or tail clips were collected from Old Mill Spring.
- e. The Barton Springs Salamander Conservation Fund funded a request for proposal for a study of the salamander microbiome by scientists from Tarleton State University. Samples were obtained for proof of concept on 11/18/2019. Five salamanders were swabbed at the Austin Salamander Conservation Center and six were swabbed at Eliza Spring. Fecal samples were also obtained from three salamanders at Eliza Spring. Quarterly sampling for the study will begin in 2020 and consist of skin swabs, fecal samples, and environmental samples during the regular salamander surveys at Eliza, Sunken Gardens, Upper Barton, and Parthenia springs, as well as samples from the Austin Salamander Conservation Center and Spillar Ranch.

TE-833851 Permit Condition: Captive Breeding Annual Reporting Requirements

- 1) The number of *Eurycea sosorum*, *E. waterlooensis*, and *E. tonkawae* held at the captive breeding facility (including the number of wild-caught and captive-bred individuals from each spring site collected).

Table 1. Inventory of salamanders in the captive breeding program. WC=wild caught, CB=captive bred.

Species	Spring of Origin	WC	CB>6 mo.
<i>Eurycea sosorum</i>	Parthenia	8	47
	Old Mill	7	130
	Eliza	34	72
	UBS	0	4
	Dallas Aquarium ¹	0	1
Total		49	254
<i>E. waterlooensis</i>	Parthenia	0	NA ²
	Old Mill	7	NA ²
	Eliza	20	NA ²
	UBS	0	NA ²
Total		27	34
<i>E. tonkawae</i>	Bull Creek	3	4
	McDonald Well	0	4
	SAS Canyon	1	0
	Testudo Tube	1	0
	Wheless	1	0
Total		6	8

¹ Founder salamanders for the Dallas Aquarium captive population were collected from more than one spring site (Parthenia and Old Mill) and mixed together. COA has F2's from Dallas F1's that were used for educational purposes at the Splash! Into the Edwards Aquifer exhibit at Barton Springs in Zilker Park.

² *E. waterlooensis* are not separated and bred according to spring site of origin due to the fact that the species is primarily aquifer-dwelling.

- 2) Number of observations of courtship behavior, spermatophores, spermatophore depositions, sperm transfers, and ovipositions.

In 2019, courtship behavior was observed in both wild-caught and captive-bred salamanders at the

captive breeding facility. In general, salamanders are not disturbed by City staff during courtship. Because salamanders can store sperm, observed courtship behavior does not necessarily result in immediate egg-laying. Each oviposition with viable offspring represents at least one sperm transfer, and possibly multiple transfers. Oviposition data are presented in Table 2.

Table 2. Ovipositions in captivity 12/01/18-11/30/19. Tank ID indicates spring site of origin, reproductive group, and wild-caught or captive-bred status. Individuals in reproductive groups are recorded in order to follow actual or potential dams and sires. BSP denotes groups from Parthenia Spring, E, groups from Eliza Spring, OM, groups from Old Mill Spring, UBS, groups from Upper Barton Spring, and F, captive-bred salamanders.

Estimated Oviposition Date	Tank ID	Clutch Size	No. Hatched
<i>Eurycea sosorum</i>			
12/04/18	E (C304)	23	16
01/04/19	OM (C005)	15	4
01/20/19	OMF2 (C184)	8	Did not develop (not fertilized)
01/22/19	OMF2 (C230)	14	Did not develop (not fertilized)
01/25/19	E (C304)	32	24
02/03/19	BSP (C178-2)	29	11
02/04/19	OMF1 (C314)	35	14
03/01/19	BSPF1/2 (C295)	23	Did not develop (not fertilized)
03/15/19	OMF1 (C230)	10	8
03/24/19	E (C304)	19	NA ¹
10/02/19	BSPF2 (C311)	6	NA ¹
~10/18/19	E (C304)	NA	5 hatchlings found in tank on 11/18/19
11/16/19	E (C304)	32	NA ¹
11/26/19	BSPF2 (C311)	26	NA ¹
<i>Eurycea waterlooensis</i>			
11/15/19	F1 (CW15-3)	17	Did not develop (not fertilized)

¹ Eggs preserved to manage the population size and genetic diversity (prevent a disproportionate number of offspring produced from a single reproductive group, or to minimize inbreeding)

3) Information on clutch sizes (range, mean, and standard deviation) and hatching success (range, mean, and standard deviation)

Table 3. Salamander clutch size and hatching success for *E. sosorum* from 12/01/18–11/30/19.

	Range	Mean	Standard Deviation
Clutch Size	6-35 (N=13)	20.9	9.74
No. Hatched	4-24 (N=6)	12.8	6.94
% Hatched	27-75 (N=6)	54.9	22.6

A study to describe courtship behavior was initiated in 2019 but not completed. Pairs of Barton Springs salamanders were videotaped to score the behaviors from June through November. Out of 47 courtship trials that were performed, 22 pairs courted (i.e., they performed a tail-straddle walk). These videos will be scored further to characterize courtship behavior. Gas bubbles were observed in salamanders for 11 of the 25 failed courtship trials. Total dissolved gasses in groundwater have been high this year. Animals were acclimated to the courtship tanks for a minimum of two days and water flow was to reduce the incidence of gas bubble. Of the other 14 failed courtship trials, there was a lack of interest in courtship from one or both animals. It is possible that there are temporal effects on courtship behavior that influenced the success rate of this study, but this investigation is beyond the scope of this study. Courtship trials of Austin blind salamanders will begin in December and finish in 2020.

Night observations occurred at Eliza Spring on 8/10/2019 and 10/2/2019 two hours after sunset with the goal of observing potential courtship behavior at the surface. No courtship was observed from salamanders and no salamanders were observed that were not hiding underneath rocks. While other species of salamanders show peak activity approximately two hours after sunset, this may not be the case with Barton Springs salamanders. It's also possible that light pollution from Barton Springs Pool and its parking lot may affect the circadian rhythms at Eliza Spring, and that other sites such as Upper Barton Spring need to be observed at night.

4) Salamander Mortalities (including age and cause of death, if known)

Table 4. Salamander mortalities from 12/01/18–11/30/19.

Species	Wild-Caught or Captive-Bred	Age (years)	No. Mortalities	Cause of Death (health condition observed)
<i>E. sosorum</i>	WC	11-13 ¹	3	Senescence
	CB	≤ 2	7	Unknown
	CB	6-7	8	1 with gas bubble trauma (GBT), others unknown
	CB	8-9	10	1 with GBT, others unknown
	CB	11	8	Senescence

	CB	12-13	2	Senescence
	CB	15	2	Senescence
<i>E. waterlooensis</i>	CB	3-4	2	Possibly GBT (see health section below)
	CB	7	1	Unknown
	CB	9-10	2	Senescence
<i>E. tonkawae</i>	WC	14-15 ¹	2	Senescence
	CB	8	1	Unknown

¹ Age of wild-caught salamanders is estimated based on size at collection, with a maximum estimated age of 1.5 years for salamanders > 2 inches total length at collection.

5) Information on Obvious Health Conditions or Behavioral Aberrations

In 2019, there were several mortalities thought to be due to gas bubble trauma. Two mortalities occurred during the early stage of the courtship study. To temporarily separate males from females while in the same tank, each male salamander was placed in a small, perforated isolation chamber that, incidentally, did not provide the salamander access to the tank water surface. This may have prevented individuals experiencing gas bubble trauma from being able to off-gas. Gas bubble trauma can cause internal hemorrhaging and ruptures resulting in death. Since these incidences, the isolation chambers were modified so that the salamanders could reach the water surface.

In another case, two salamanders (wild-caught *Eurycea sosorum* large juvenile collected from Old Mill Spring seven months prior with severe gas bubble trauma and a 3-year-old captive-raised *E. waterlooensis*) exhibited internal hemorrhaging and short toes or no feet when, a month prior, the salamanders appeared healthy and had normal feet. Both salamanders were sent to Dr. Allan Pessier, veterinary pathologist at Washington State University. Preliminary information indicates that gas bubble trauma may have resulted in the hemorrhaging and necrosis at the limb tips. In addition, Bd (*Batrachochytrium dendrobatidis*), a fungus known to infect amphibians, was documented on one of the feet of *E. sosorum*. This fungus has been found on *E. sosorum* in the wild with no apparent problems and it is unknown whether it played a role in the health problems of these individuals. The pathology report will be forwarded to the Service when it is received.

In addition, limb reduction was observed in both wild-caught and captive-raised small juveniles. Two *Eurycea sosorum* small juveniles collected from Old Mill Spring were observed with severely reduced limbs and no feet within two months of collection and one month of being observed with normal limbs and feet. The cause of this reduction is not known and the salamanders have since started regenerating. Similarly, all eight members of a single clutch of captive-raised salamanders less than six months in age were observed with reduced limbs and short to no feet within a month of having been photographed with complete and normal limbs and feet. The salamanders regenerated a month later. This latter case may have been due to a change in water chemistry that occurred due to a malfunction in a CO2 system that was being used temporarily to maintain the water chemistry for a

small group of tanks. Typically, the salamanders in captivity are housed in tanks with a constant influx of groundwater in order to maintain the water chemistry of that in the wild. However, on occasion, the water chemistry in the tanks may change on a short-term basis as the pump that supplies the water trips and the water flow stops for a day or two. We suspect that certain water chemistry changes may cause the reduction in limbs, either directly or synergistically with a potential pathogen such as Bd. Given observations of limb reduction in captivity over the years, we will be conducting an experiment in 2020 on the effects on toe length of select water chemistry differences compared to the groundwater in the wild.

6) Special Projects

The captive breeding program provides support and salamanders for the public display tank at the Splash! Into the Edwards Aquifer Educational Exhibit.

TE-833851, Section T, Permit Condition 6: General Annual Reporting Requirements for Jollyville Plateau Salamanders

As part of an ongoing study to understand the distribution of Jollyville Plateau salamanders within spring-fed streams, biologists sampled two tributaries of Bull Creek that travel through the Hanks and Gardens at Bull Creek tracts. This work was done in collaboration with Travis County Transportation and Natural Resources. We mapped 52 sites along Tributaries 5 and 6 of Bull Creek (Fig. 1) starting from the upstream end of the flood detention dam culvert in the Gardens at Bull Creek tract. Sites were delineated and sampled generally following methods described in Bendik et al. (2016), which I will briefly describe. Each site was defined as a 10 m linear creek segment, and we attempted to space them evenly (approximately 70 m apart) along the channel by pacing 90 steps. The goal was to avoid judgement sampling (e.g., preferentially selecting “good” habitat) and to sample approximately 20–25 sites per tributary to achieve acceptable statistical power. We avoided deeper pools (> 0.5 m) to maintain a consistent and efficient sampling technique. Sampling proceeded with two observers, each searching cover objects for 5 minutes. Each site was sampled during three different days between 3/28/2019 and 4/11/2019. The number and approximate size of salamanders observed was recorded, along with the following environmental variables: channel wetted width, water depth, dominant substrate type, percent area of algae and rock cover, an assessment of the amount of calcium carbonate deposition, presence/absence of maidenhair ferns along the bank, fish (number and ID to family/genus), pH, dissolved oxygen, specific conductance, and water temperature. Additionally, we acquired one grab sample to quantify a standard suite of ions and nutrients in the water and from rock scrapings.

We have yet to perform an analysis of these results to estimate site occupancy rates, which are corrected for detection error. All of the raw data are available from [this link](#). Figure 1 shows the location of all survey sites and Table 1 contains the site names and GIS coordinates for all sites where salamanders were observed in 2019.

Table 1. Locations where Jollyville Plateau salamanders were observed during occupancy surveys.

Site Number	Latitude	Longitude
215	30.42209	-97.8114
216	30.42259	-97.8126
219	30.42469	-97.8147
220	30.42547	-97.8147
221	30.42616	-97.8142
225	30.42754	-97.8201
229	30.4283	-97.8231
230	30.42872	-97.8238
244	30.42989	-97.835
247	30.42845	-97.8148
251	30.43068	-97.8159
252	30.4312	-97.8155
253	30.43149	-97.8147
254	30.43231	-97.8142
260	30.43715	-97.8143
261	30.43784	-97.8146
265	30.44038	-97.8171

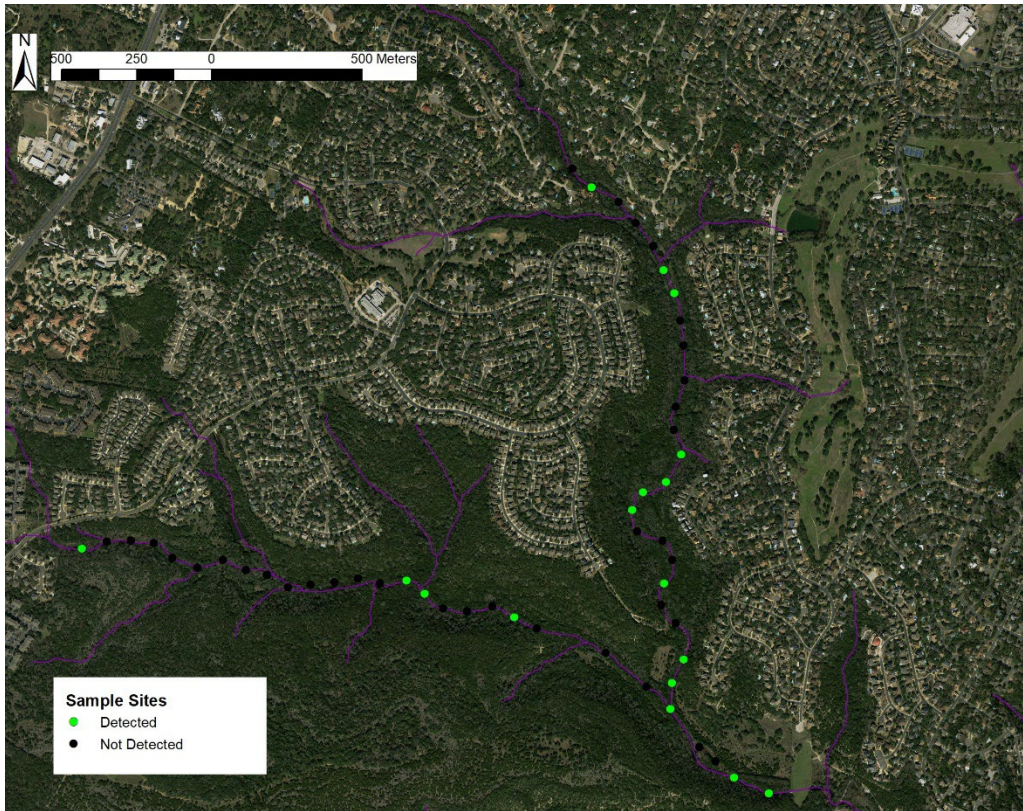


Figure 1. Sample sites and presence/absence results for Jollyville Plateau salamander occupancy study along tributaries 5 and 6 of Bull Creek, Travis Co., Texas.

We also assisted Travis County with population surveys at upper and lower Ribelin springs. We observed an adult salamander with lesions during the survey and collected the individual to test for pathology. It subsequently died shortly after we captured it and we sent it for a gross necropsy. We have included this report as an attachment.

TE-833851, Section U, Permit Condition 6: General Annual Reporting Requirements for San Marcos Salamanders

No research activities were performed on San Marcos salamanders (*Eurycea nana*) or within San Marcos Salamander habitat.

TE-833851, Section V, Permit Condition 6: General Annual Reporting Requirements for Karst Invertebrates

During the course of hydrogeological work, City of Austin permitted staff entered several caves that may harbor protected karst invertebrates. These caves, the dates of entry, City personnel, purpose of visit, and relevant observations are presented in the table below.

<u>Date</u>	<u>Cave or Property</u>	<u>Purpose</u>	<u>Habitat Observations</u>	<u>Karst Zone</u>	<u>Personnel</u>
1/11/2019	7710 N FM 620	Karst survey for impacts to recharge features	Pre-construction activities on property with caves, high potential for endangered species habitat. Adjacent to preserve with endangered species caves.	1	Saj Zappitello
1/17/2019	6002 1/2 McNeil Dr.	Karst survey for recharge features	Two solution cavities and one large sinkhole with high potential to lead to caves, high potential for endangered species habitat.	1	Saj Zappitello, Scott Hiers
1/24/2019	Gaines Creek @ Southwest Pkwy.	Karst survey for recharge features	Inspected sinkholes in creek channel, low potential for endangered species habitat (Karst Zone 3)	2	Saj Zappitello, Scott Hiers, Lindsey Sydow, Radmon Rice, David Johns
2/7/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TxDOT to coordinate with consultant for environmental surveys.	3	David Johns
2/13/2019	4801 La Crosse Ave	Cave and sinkhole education training/refresher	Cave environment as usual. Cave crickets observed, low potential for endangered species due to Karst Zone 3.	3	Saj Zappitello, Radmon Rice
2/20/2019	6002 1/2 McNeil Dr.	Karst survey for recharge features	One large sinkhole cave, high potential for endangered species habitat. Following fence-line off property, so no access for follow-up surveys.	1	Saj Zappitello, Lindsey Sydow, Radmon Rice, Kristy Nguyen
2/23/2019	4801 La Crosse Ave	Cave and sinkhole visits for education during Cave Fest event.	Cave environment as usual. Cave crickets and Slimy salamanders observed, low potential for endangered species due to Karst Zone 3.	3	Saj Zappitello, Radmon Rice
3/5/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TxDOT to coordinate with consultant for environmental surveys.	3	David Johns
3/27/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TxDOT to coordinate with consultant for environmental surveys.	3	David Johns
4/12/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TxDOT to coordinate with consultant for environmental surveys.	3	David Johns
6/18/2019	SE corner of Avery Ranch Blvd and 183A	Verify locations of karst features for development review	Three solution cavities with potential for caves. Karst Zone 1. Adjacent to property with endangered species caves. No cave species observed.	1	Lindsey Sydow

6/13/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TCEQ and City of Austin void closure protocols followed. Low potential for endangered species (Karst Zone 3).	3	David Johns
6/14/2019	Escarpment Blvd - SW Elementary School water quality pond.	Inspection of karst voids/caves encountered during construction	Inspection of karst voids/caves encountered during construction. TCEQ and COA void mitigation methods. Low potential for endangered species (Karst Zone 3).	3	Scott Hiers
8/30/2019	Mopac at La Crosse intersection	Inspection of karst voids/caves encountered during construction	Karst voids/caves encountered during construction. TxDOT to coordinate with consultant for environmental surveys. Low potential for endangered species (Karst Zone 3).	3	David Johns