Recovery Outline for the Georgetown Salamander, Jollyville Plateau Salamander, and Salado Salamander

Georgetown (top), Salado (center), and Jollyville Plateau (bottom) salamanders. Images courtesy of Nathan Bendik.

Species: Georgetown salamander *(Eurycea naufragia),* Jollyville Plateau salamander *(Eurycea tonkawae),* and Salado salamander *(Eurycea chisholmensis)*

ESA Listing Status: Threatened; Georgetown and Salado salamander final listing rule (79 FR 10236), February 24, 2014; and Jollyville Plateau salamander final listing rule (78 FR 51278), August 20, 2013

Lead Region: Southwest (Region 2)

Lead Office: Austin Ecological Services Field Office, Austin, Texas

Lead Contact: Michael Warriner, Austin Ecological Services Field Office, Austin, Texas

Species Range: Bell, Travis, and Williamson counties, Texas

PURPOSE AND DISCLAIMER

The recovery outline is a succinct document that presents a preliminary recovery strategy and actions to direct the recovery efforts of a species listed under the Endangered Species Act (ESA) until a recovery plan is completed. Recommendations in the recovery outline are non-binding and are intended to guide (not require) ESA section 7 consultations and section 10 permitting and conservation actions to be implemented by the U.S. Fish and Wildlife Service (USFWS) and our external partners.

This document lays out a preliminary course of action for the survival and recovery of the Georgetown salamander, Salado salamander, and Jollyville Plateau salamander, also referred to herein as the Northern Edwards Aquifer Salamanders. Formal public participation for recovery planning will be invited upon the release of the draft recovery plan. However, we will consider any new information or comments that members of the public offer during the recovery planning process. For more information on Federal recovery efforts for the Georgetown salamander, Salado salamander, and Jollyville Plateau salamander, or to provide additional comments, interested parties may contact the lead field office for these species at esaustininfo@fws.gov or 512-937-7371.

1. BACKGROUND

The following sections include a summary of the biology, life history, and ecology of the species. A complete discussion of the species' morphology, taxonomy, distribution, phenology, reproduction, life span, demographic trends, and habitat needs can be found in listing rules for the Georgetown salamander, Salado salamander, and Jollyville Plateau salamander. An electronic copy of the listing rules are available on the ECOS species webpage for the Georgetown salamander, Salado salamander, and Jollyville Plateau salamander.

Brief Life History

These species are endemic to central Texas, are neotenic (retaining juvenile characteristics at maturity), occur in the northern segment of the Edwards Aquifer, and rely on free-flowing groundwater of adequate quantity and quality from the aquifer as a primary supply of water for

their aquatic habitats (Cole 1995, p. 33). Adult salamanders of these species are about 5 centimeters (cm) (2 inches [in]) long and can vary morphologically between surface-dwelling populations (e.g., developed eyes and pigmentation) and cave (e.g., reduced or absent eyes and reduced pigmentation) forms (Chippindale et al. 2000, pp. 32-42).

Jollyville Plateau and Salado salamanders have been documented to feed on aquatic invertebrates that commonly occur in spring and other groundwater-dependent environments (reviewed in City of Austin 2001, pp. 5-6; Diaz and Bronson-Warren 2018, pp. 8, 14). The diet of the Georgetown salamanders is presumed to be similar. Little is known about the reproductive habits of these species in the wild. Most data available on reproduction comes from studies of the Jollyville Plateau salamander. Based on variation in juvenile abundance, reproduction occurs year-round, with more reproduction occurring in winter and early spring compared to other seasons (Bowles et al. 2006, p. 116; Bendik 2017, p. 5009). Eggs of central Texas *Eurycea* species are rarely found by researchers (Bowles et al. 2006, p. 114; Pierce et al. 2010, pp. 294) and are thought to be deposited in subterranean voids and/or interstitial spaces (e.g., empty voids between rocks) (Bendik 2017, p. 5,010). The few eggs that have been observed in natural settings have been discovered near spring openings on the underside of rocks (i.e., Jollyville Plateau and Texas salamanders) or in loose gravel (i.e., Barton Springs salamander) (O'Donnell et al. 2005, p. 16; Moon et al. 2021, pp. 1-2; City of Austin 2022, pp. 1-2).

At the surface, *Eurycea* salamanders use interstitial spaces for foraging habitat and cover from predators (Cole 1995, p. 24; Pierce and Wall 2011, pp. 16-17). Their surface habitat needs include areas with low amounts of sediment, as filling these spaces with sediment eliminates resting places and reduces aquatic invertebrate abundance (O'Donnell et al. 2006, p. 34). While salamander abundance is typically highest close to spring outlets (Pierce et al. 2010, p. 294; Pierce et al. 2014, pp. 139-140, 141-142; Bendik et al. 2016, p. 9; Gutierrez et al. 2018, pp. 386-388), studies have demonstrated that Jollyville Plateau salamanders can move tens to hundreds of meters from a spring opening if suitable stream habitat is present (Bendik et al. 2016, p. 9). These salamanders can also occur in streams that are not perennial (Bendik et al. 2016, p. 1; Bendik et al. 2017, p. 5013). With drying of surface aquatic habitat, salamanders retreat to interstitial spaces and/or deeper subterranean cavities in search of aquatic refugia (Bendik and Gluesenkamp 2013, pp. 2-5; Bendik and Dries 2018, pp. 5918-5919; Diaz and Bronson-Warren 2018, pp. 8-10). Little is known about their life history in subterranean habitat.

Important Information Gaps and Treatment of Uncertainties

- A Species Status Assessment (SSA) is currently being completed for these species. Therefore, in this document, we use the best available data from other sources.

- When information is not available that is specific to these species, the best available information from closely related species is used.

- The subsurface habitat and populations of these species cannot be accessed to thoroughly assess the status of the species and full subsurface distribution. We assume that surface populations likely have subsurface connectivity.

- Little information is available on reproduction. As discussed in the Brief Life History section, we assume eggs are laid primarily underground.

- Many springs and caves within the species' ranges are not yet surveyed. We expect that these species may exist in more locations than are currently known.

- Population estimates, demographic data, and long-term water quality monitoring are not available for most localities.

- Information on the effects of most contaminants is unavailable for these species. It is also not practical to test the effects of all contaminants on these species, and thus general information on effects of contaminants to other species is used as a proxy.

- Information on flow paths of groundwater to springs is often unavailable, resulting in some uncertainty regarding where urban, suburban, and exurban development activities affect groundwater. We assume that development within the same watershed as a spring is more likely to affect a spring than development in other areas.

Limiting Ecological Traits

As discussed in the Brief Life History section above, the Northern Edwards Aquifer Salamanders require free-flowing groundwater and spring water of adequate water quantity and quality from the northern segment of the Edwards Aquifer. Their water quality requirements limit their distribution to areas where suitable water conditions are present, either underground or near springs. Surface localities need connectivity with the subsurface for reproduction and to retreat during droughts. These salamanders also require interstitial spaces in surface habitat that are relatively free of sediment and provides an adequate supply of aquatic macroinvertebrates as a prey base.

Threats

Threats to these salamanders are discussed in their respective listing decisions (78 FR 51278 and 79 FR 10236). Habitat modification, in the form of degraded water quality and quantity and disturbance of spring sites, is the primary threat to these species. Water quality degradation in salamander habitat has been cited as the significant concern in several studies due to the species' dependence on groundwater for their entire lifecycle (Chippindale et al. 2000, pp. 36, 40, 43; Hillis et al. 2001, p. 267; Bowles et al. 2006, pp. 118–119; O'Donnell et al. 2006, pp. 45–50). Water quality degradation is linked to increases in impervious cover due to urbanization (Bendik et al. 2014, entire; Bowles et al. 2006, p. 119). Urban development leads to various stressors on spring systems, including increased frequency and magnitude of high flows in streams, increased sedimentation, increased contamination and toxicity, and changes in stream morphology and water chemistry (Coles et al. 2012, pp. 1–3, 24, 38, 50–51). Urbanization can also affect aquatic species by negatively affecting their invertebrate prey base (Coles et al. 2012, p. 4). Urbanization is expected to increase in the ranges of these species, as the human population is projected to increase from 2020 to 2060 by 26%-38% in Bell County, 36%-75% in Travis County, and 68%-76% in Williamson County (Texas Demographic Center 2022, unpaginated). Hazardous material spills also risk contaminating the groundwater that the salamanders require. Climate change

affects these species by increasing the frequency of extreme droughts (Rupp et al. 2012, p. 1,054; Nielsen-Gammon et al. 2020, entire), which causes streams to go dry for longer periods of time, and lowering groundwater levels, during which surface habitat and some subsurface habitat is unusable to neotenic salamanders. Extreme droughts that increase reliance on subsurface habitat during dry conditions on the surface may increase negative effects to the salamanders' food availability and individual and population growth, further exacerbating the risk of extirpation in the face of other threats occurring at the site.

Current Biological Status

Overview

The Georgetown, Salado, and Jollyville Plateau salamanders are endemic to the northern segment of the Edwards Aquifer in Bell, Travis, and Williamson counties, Texas (Figures 1 and 2 below; Devitt et al. 2019, p. 2629). Genetic research conducted since the species listing assessed population structure, phylogeny, and distribution of multiple *Eurycea* species across central to west-central Texas (Devitt et al. 2019, entire). The results of that work had substantial taxonomic and distributional implications for several of the region's *Eurycea* species, including the Georgetown and Salado salamanders. Salamanders from the Berry Creek watershed, formerly assigned to the Georgetown salamander, were noted to be genetically similar to the Salado salamander and assigned to the latter species (Devitt et al. 2019, p. 2629). This reassignment of populations expanded the range of the Salado salamander to the south into Williamson County and reduced the range of the Georgetown salamander to sites south and east of Lake Georgetown in the watersheds of the North and Middle Forks of the San Gabriel River (Devitt et al. 2019, p. 2629). A single salamander collected from San Gabriel Springs, long considered the Georgetown salamander, was found to be more genetically similar to the Jollyville Plateau salamander and assigned to that *Eurycea* species (Devitt et al. 2019, p. 2629).

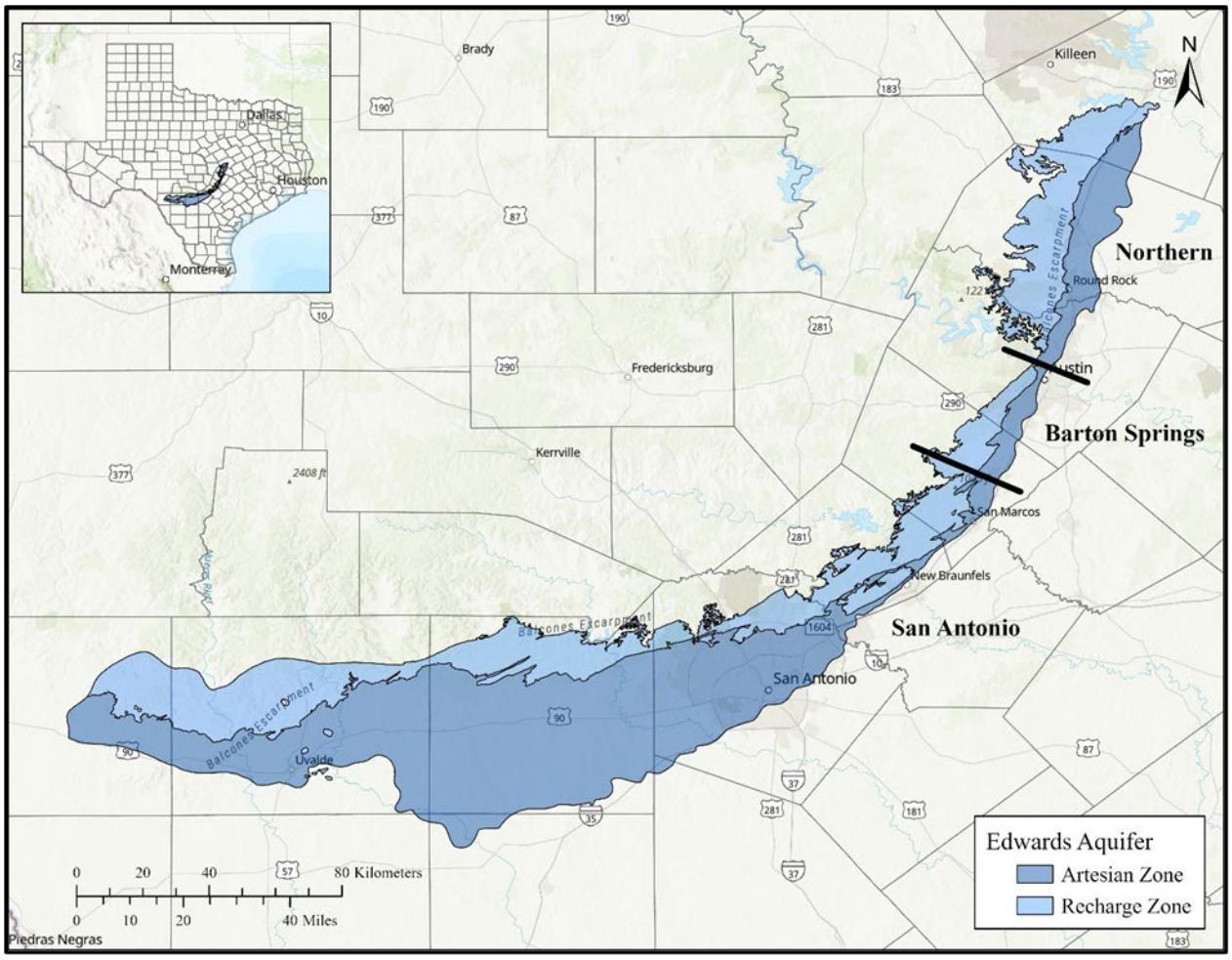

Figure 1. Edwards Aquifer of central Texas. Approximate locations of groundwater divides are represented by black bars. (Texas Water Development Board 2022, unpaginated).

Since these species were described, they have been documented at multiple new localities. This increase in known populations is likely due to an increase in surveyed locations over time that resulted in the discovery of previously unknown populations and is unlikely to represent newly established populations of these species. According to the USFWS database of known locations, the Jollyville Plateau salamander occurs in approximately 130 springs and caves in Travis and Williamson counties. The Salado salamander is currently known from 15 springs/spring complexes and two caves in Williamson and Bell Counties, and the Georgetown salamander is known from 14 springs and one cave in Williamson County (Figure 2).

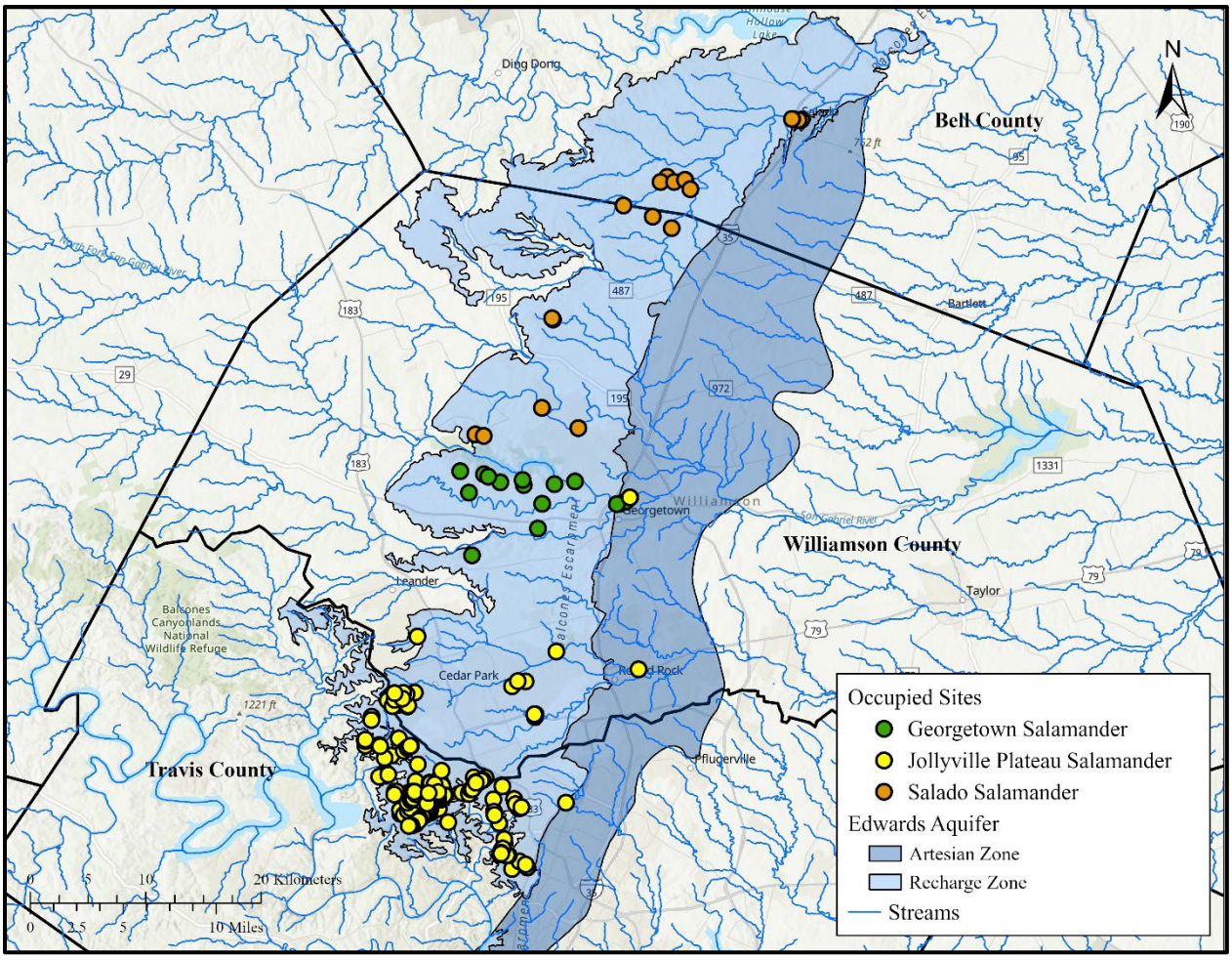

Figure 2. Distribution of the Georgetown, Jollyville Plateau, and Salado salamanders in the northern segment of the Edwards Aquifer.

The USFWS will complete SSA(s) for these species, which will describe the species' viability in terms of its resiliency, redundancy, and representation (collectively, the 3Rs).

> **Resiliency** is the ability to sustain populations through the natural range of favorable and unfavorable conditions.
>
> **Redundancy** is the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events.
>
> **Representation** is the breadth of genetic, phenotypic, and ecological diversity found within a species, its ability to disperse, and its ability to maintain adaptive capacity.

Conservation Actions to Date

This list of conservation actions is not meant to be exhaustive. It is intended to capture the major actions that have likely benefited the conservation of the Georgetown salamander since listing:

- City of Georgetown Edwards Aquifer Recharge Zone Water Quality Ordinance has potentially contributed to water quality protection in the City of Georgetown. Water quality monitoring of caves and springs within the city will help to fully assess the effectiveness of this ordinance.

- The Williamson County Conservation Fund (WCCF) has funded several research and monitoring efforts since 2010, resulting in additional population and water quality data.

- WCCF created Bat Well Cave Preserve, an 18.8 hectare (ha) (46.5 acre [ac]) preserve which protects Bat Well Cave and may partially protect the watershed.

- Garey Ranch Spring is located within Garey Park in the City of Georgetown and likely protects the salamander habitat here (the park is not managed specifically for this species).

- The Texas Commission on Environmental Quality (TCEQ) established Edwards Aquifer rules that increase regulation of surface water quality and may reduce water quality degradation. Expanding the rules to the full contributing zone could boost water quality protection and aid recovery of the salamander.

This list of conservation actions is not meant to be exhaustive. It is intended to capture the major actions that have likely benefited the conservation of the Jollyville Plateau salamander since listing:

- Twelve critical habitat units of the Jollyville Plateau salamander have habitat protection as part of the Balcones Canyonlands Preserve for the City of Austin and Travis County. While these protections are incidental to other species protected on these preserves, and management is not specifically required for the Jollyville Plateau salamander, measures have been taken at spring sites to improve and protect habitat. For example, habitat management has protected some springs from feral hog damage and removed impoundments to improve surface habitat. Additional improvement of some sites via protection from disturbances upstream and on adjacent tracts would aid in the recovery of the salamander.

- The City of Austin and Travis County regularly monitor populations and water quality for the Jollyville Plateau salamander in Travis County and have contributed reports and publications improving species knowledge.

- The Buttercup Habitat Conservation Plan (HCP) resulted in the permanent protection of 10 Jollyville Plateau salamander caves in the form of preserves. The preserves include surface drainage basins, subsurface extent of all caves, and connectivity between nearby caves and features.

- The WCCF has funded several research and monitoring efforts since 2010, resulting in additional population and water quality data.

- The TCEQ's Edwards Aquifer rules (30 Texas Administrative Code § 213) increase regulation of surface water quality and may reduce water quality degradation in portions of the range of these salamanders in Travis and Williamson Counties. Expanding the rules to

cover the entire recharge zone in Travis County and the contributing zone to the west could boost water quality protection and aid recovery of the salamander.

This list of conservation actions is not meant to be exhaustive. It is intended to capture the major actions that have likely benefited the conservation of the Salado salamander since listing:

- A conservation easement on Solana Ranch Preserve, held by The Nature Conservancy, protects Cistern, Hog Hollow, and Solana springs. Habitat management has protected some springs from feral hog and cattle damage. Additional improvement of some sites via protection from disturbances upstream and on adjacent tracts would aid in the recovery of the salamander.

- WCCF has created preserves at Twin Springs and Cobbs Springs that partially protect the surface watersheds. There is uncertainty about where subsurface flows originate from at both sites and whether contributing groundwater areas are protected.

- The WCCF has funded several research and monitoring efforts since 2010, resulting in additional population and water quality data.

- The Clearwater Underground Water Conservation District (CUWCD) has supported monitoring of Salado salamander populations at several springs in the Bell County by the USFWS Texas Fish and Wildlife Conservation Office since 2015.

- The CUWCD monitors spring discharge and recommends voluntary water reductions based on drought severity that may increase water conservation.

- The TCEQ's Edwards Aquifer rules increase regulation of surface water quality and may reduce water quality degradation in portions of the range in Williamson County. Expanding the rules to cover the recharge zone in Bell County and the contributing zone to the west could boost water quality protection and aid recovery of the salamander.

2. PRELIMINARY RECOVERY PROGRAM

Recovery Priority Number

The first step to recovering a listed species is to prevent extinction. To balance the risk of extinction and available resources, the USFWS assigns a Recovery Priority Number (RPN) to listed species that ranges from 1 (high priority) to 12 (lower priority) per our 1983 policy (48 FR 43098, September 21, 1983, as corrected in 48 FR 51985, November 15, 1983). Three criteria are used to evaluate the risk of extinction: the degree of threat, potential for recovery, and the taxonomic uniqueness of the listed species. All three species were assigned a recovery priority number of 2C, indicating a high degree of threat, a high recovery potential, and the potential for conflict with development or other economic activity. The area is rapidly developing due to human population growth, which may be in conflict with the recovery of these species.

Preliminary Recovery Strategy

This interim strategy for the Northern Edwards Aquifer Salamanders recovery program initiates conservation and recovery actions that will be carried forward under an approved recovery plan. The recovery strategy addresses the principal threats of habitat modification, in the form of degraded water quality and quantity and disturbance of spring sites. In addition, the strategy includes public outreach to promote conservation and recovery on private lands and scientific investigations on the species' life history, subsurface distribution, threats abatement, population estimates, demographic data, and long-term water quality monitoring.

The interim recovery strategy for the Northern Edwards Aquifer Salamanders is to have all currently documented sites remain extant and persistent in each of the species' occupied management units to sustain redundancy and representation. Data analyses should indicate that populations of these salamanders are stable or increasing and expected to be viable for the foreseeable future. Species persistence at occupied sites is evidenced by surface and subsurface populations of adequate size to support ongoing natural recruitment and multiple age classes (eggs, juveniles, and adults). For a population to be healthy and resilient, it would have sufficient recruitment to maintain a self-sustaining population. A healthy population also would have an adequate number and distribution of occupied sites to allow the population to be resilient to stochastic and catastrophic events, to maintain genetic diversity, and to provide for natural reestablishment if an occupied site is extirpated.

Initial recovery efforts should focus on attempting to find additional occupied sites, while continuing to stabilize known populations by managing for water quantity and quality and habitat disturbance within the species' ranges. Long-term recovery efforts should focus on improving water quality, reducing impacts from water withdrawal, and addressing any other threats found to contribute to declines. Impacts to avoid are those that could 1) result in mortality or injury to Northern Edwards Aquifer Salamanders, 2) reduce reproduction or recruitment of young into populations, 3) increase threats to individuals in the wild, or 4) alter habitat such that survival or reproduction is reduced.

Preliminary Recovery Actions

Table 1. Preliminary Recovery Actions – prioritized in order of need for the species' recovery.

Preliminary Recovery Action	**Threat(s) Addressed**
1. Ensure the long-term protection of salamander habitat, caves, springs, and their supporting surface and subsurface (e.g., springshed or ground watershed) drainage basins. Habitat and supporting land for water quality and quantity should be protected for multiple documented sites within each watershed to ensure adequate redundancy and representation, using conservation mechanisms such as preserves or conservation easements and include USFWS approved site-specific habitat management plans. Contact the Austin Ecological Services Field Office for more	Water quality, water quantity, and disturbance of spring sites

Preliminary Recovery Action	Threat(s) Addressed
information on which watersheds to protect to ensure adequate redundancy and representation.	
2. Enhance water quality and quantity through groundwater management plans that incorporate projected future climate, development regulations, water quality regulations, and other regulatory mechanisms, conservation easements, hazardous spill prevention and spill response plans, and water quality and recharge improvement projects.	Water quality and quantity
3. Enhance understanding by collaborating and supporting conservation partners, landowners, municipalities, and researchers across the range.	Water quality, water quantity, and disturbance of spring sites
4. Complete research that promotes the conservation and recovery of these species, specifically: 1) identify additional localities, both surface and subsurface (e.g., through use of techniques such as eDNA), to aid understanding of species distribution and to support protection of populations; and 2) map the recharge and contributing zones of water that flows to salamander localities at springs and caves to better understand effects to water quality and quantity.	Water quality, water quantity, and disturbance of spring sites
5. Implement a long-term monitoring program that includes the assessment of population data (e.g., age structure, recruitment, population size), and habitat and water data (e.g., extent and quality of typical habitat at surface using direct observations, subsurface via monitoring wells, and assessing the range of water quality, flows, and groundwater depth). Monitoring data should help inform the status of salamander populations, determine adequate water quantity and quality for salamanders, and detect changes to threats.	Water quality, water quantity, and disturbance of spring sites

3. RECOVERY PRE-PLANNING CONSIDERATIONS

The Biological Scope of the Recovery Plan

The USFWS will prepare a recovery plan for the Northern Edwards Aquifer Salamanders using the scientific information compiled and evaluated in the listing rule and SSA, which is currently being developed for these species. The recovery plan will be a multi-species plan and will include objective and measurable recovery criteria for delisting which when met, may indicate that recovery has been achieved. Leveraging the scientific analysis from the SSA report(s), we

will develop the recovery plan following the 3-part recovery planning framework. This streamlined recovery plan will focus primarily on the elements under section 4(f)(1)(B) of the ESA:

i. A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
ii. Objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and
iii. Estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In cooperation with our partners, we will also prepare a recovery implementation strategy (RIS) for the Northern Edwards Aquifer Salamanders, which will serve as an operational plan for stepping down the higher-level recovery actions in the recovery plan into specific tasks, or activities. The RIS will be a separate document from the recovery plan and can be modified, as needed, when specific activities are accomplished or if monitoring reveals that expected results are not being achieved, thereby maximizing flexibility of recovery information. To summarize, there will be three documents under the USFWS 3-part framework for the Northern Edwards Aquifer Salamanders: (1) the SSA(s) that is currently being developed, which provides the foundational scientific information to guide recovery planning; (2) the recovery plan, which provides the recovery strategy, objective and measurable recovery criteria, site-specific management actions, and estimates of time and cost; and (3) the RIS, which is the operational plan of detailed activities needed for recovery.

Who Will Develop the Recovery Plan

The USFWS will draft a multi-species plan for the Georgetown, Salado, and Jollyville salamanders, with the recovery planning effort led by the Austin Ecological Services Field Office in collaboration with the national Recovery Planning Team. We will also review and incorporate substantive comments received during peer review and the public comment period before finalizing the recovery plan.

Plan for Stakeholder Involvement in Recovery Planning

Stakeholders may be invited by the USFWS to participate in developing the recovery plan and RIS. Stakeholders may also be asked to provide technical and scientific expertise regarding the species. Stakeholders may be composed of representatives from State and Federal agencies, Tribes, research universities, and conservation organizations with relevant scientific expertise or who may be currently cooperating in ongoing conservation planning and other working groups associated with the Northern Edwards Aquifer Salamanders. All stakeholders will also have opportunity to review and comment on the draft recovery plan during the public comment period.

Signed: ANGELA ANDERS Digitally signed by ANGELA ANDERS Date: 2024.10.08 11:57:00 -06'00'

Assistant Regional Director, Ecological Services
U.S. Fish and Wildlife Service, Southwest Region

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