



United States Fish and Wildlife Service, Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys and Habitat Assessments for Listed Karst Invertebrates in Central Texas

U.S. Fish and Wildlife Service, Austin Ecological Services Field Office,
1505 Ferguson Lane, Austin, Texas
(512) 937-7371 or esaustininfo@fws.gov

Date: August 12, 2024

Table of Contents

Introduction.....	1
When a Section 10(a)(1)(A) Scientific Permit is Needed.....	2
How to Determine if Karst Invertebrates May be Present	4
Step 1. Identify areas that may contain suitable habitat for listed karst invertebrates in Bell, Bexar, Comal, Medina, Travis, and Williamson Counties.....	5
Step 2. Conduct an initial karst feature survey	6
Step 3. Assess karst features for suitable listed karst invertebrate habitat.....	7
Step 4. Excavating features.....	9
Step 5. Conduct a Karst Invertebrate Survey.....	11
Literature Cited	16
Appendix I: Geologic Assessments	18
Appendix II: Surveyor Qualifications.....	20
Appendix III: Reporting Requirements	21
Appendix IV: Recovery Project Proposals	30
Appendix V: Protocol Revisions (2014).....	32
Appendix VI: Protocol Revisions (2024)	33

Introduction

This document outlines the United States Fish and Wildlife Service's (Service) survey requirements under a section 10(a)(1)(A) permit for conducting presence/absence surveys for federally listed terrestrial karst invertebrate species (herein referred to as "karst invertebrates") originally described from Travis, Williamson, and Bexar Counties, Texas (Table 1). Section 10(a)(1)(A) permits, also referred to as recovery, enhancement of survival, or scientific permits, allow for "take" of listed species that may or will occur while conducting activities to further the recovery of a listed species (see *When a Section 10(a)(1)(A) Scientific Permit is Needed*) below. In addition to describing survey requirements, this document includes:

- information to be included in final reports, which includes positive and negative karst invertebrate survey results;
- information to be included in recovery project proposals (such as monitoring plans for locations known to be occupied by these species), which must be approved in writing by the Austin Ecological Services Office; and
- minimum qualifications for personnel conducting presence/absence surveys for listed karst invertebrates under a section 10(a)(1)(A) permit.

This document supersedes any previous guidance from the Austin Ecological Services Field Office (Austin ESFO) on conducting habitat assessments and presence/absence surveys for these species. Information that relates to the effectiveness of these survey guidelines in conserving listed karst invertebrates is welcome. Such information can be sent through direct correspondence to the Karst Invertebrate Species Lead (Nicholas.Gladstone@fws.gov) or through supplementary discussion within annual reports. As additional information becomes available regarding survey techniques and effectiveness, these guidelines may be updated.

A karst invertebrate habitat assessment, when conducted according to these requirements, is an attempt to determine presence or probable absence of potentially suitable habitat for listed karst invertebrates. A karst invertebrate survey is an attempt to determine presence or probable absence of these species in locations where the species have not been previously located. It does not provide sufficient data to determine population size or structure nor does it determine absence from locations where listed species have been previously found. Following these requirements will standardize survey procedures. It will help maximize the potential for detection of karst invertebrates at previously undocumented sites at a minimum acceptable level of certainty. Although the detection of karst invertebrates confirms their presence, failure to detect them does not absolutely confirm their absence. For example, during cave monitoring from 2002 to 2013 at one karst invertebrate preserve, *Rhadine exilis* was observed in 2007 only (SWCA 2014). Also, cave monitoring at another preserve from 2002 to 2013 found that *Rhadine infernalis* was observed from 2002 through 2005 and then not again until 2012 (SWCA 2014). This exemplifies how even multiple years of sampling without observing a species does not mean the species is extirpated.

When a Section 10(a)(1)(A) Scientific Permit is Needed

Activities may result in prohibited "take" of a species, as defined in section 9 of the Endangered Species Act of 1973, as amended, even if the activity is intended to benefit the listed species or is survey work to determine whether the listed species occurs in the area. In these instances, the entity conducting the activity may seek a section 10(a)(1)(A) scientific permit for "take" coverage. "Take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Activities that could result in take and that could occur while conducting karst invertebrate surveys include:

- collecting individuals;
- crushing individuals inadvertently;
- compacting or disturbing habitat, cover objects, and oviposition sites;
- destroying webs;
- excavating caves, which could result in inadvertent removal of individuals or removal or alteration of habitat;
- harming or harassing individuals by introducing noise, light, chemicals, or biological substances (such as microbes) that are normally found on the surface or in other caves; and
- possibly other actions that would cause individuals to flee, seek shelter, or alter or cease normal feeding, breeding, and sheltering behavior.

Identification and subsequent habitat assessment of karst features are the first steps in determining the need for presence/absence surveys of listed karst invertebrates. Since no "take" of listed karst invertebrates is anticipated while conducting initial surface walking for karst feature identification, and the need to conduct such a survey that identifies karst features is not always related to karst invertebrates (e.g., Geologic Assessments (GAs)), this activity does not necessitate a section 10(a)(1)(A) permit. However, the potential for "take" exists when formally assessing karst invertebrate habitat potential or when directly entering into a karst feature or cave where listed karst invertebrates may occur. Therefore, the Service requires that all activity that is being conducted involving habitat assessment or excavating, entering, or collecting in a void or cave that may contain karst invertebrates be covered under a valid 10(a)(1)(A) permit for the listed karst invertebrates in the county being surveyed.

If a karst invertebrate habitat assessment is conducted on any property or any area of a property that meets the criteria of potential karst invertebrate habitat (see Step 3 described on page 5), then a report on that area or property must be submitted to the Austin ESFO for review (see Appendix III for Reporting Requirements). For example, if karst features on a property were considered not suitable karst invertebrate habitat, this decision should be confirmed by the Karst Invertebrate Species Lead prior to grading or degradation of these features to lessen the risk of unauthorized take under the Endangered Species Act. These reports must be provided to the Karst Invertebrate Species Lead for review as soon as it is decided that the habitat is not suitable for karst invertebrates (we recommend within 5 business days) or as far in advance of planned impact to features as possible. We will do our best to respond in writing within 10 business days if we do not concur with a non-habitat determination. If you are notified that we do not concur, clients (or other persons requesting the assessment) must be notified within 10 business days of our non-concurrence. If personnel are conducting an excavation for reasons other than habitat assessment, they can receive coverage by being supervised by a 10(a)(1)(A) permit holder, and the permittee should also be onsite to collect specimens discovered during excavation.

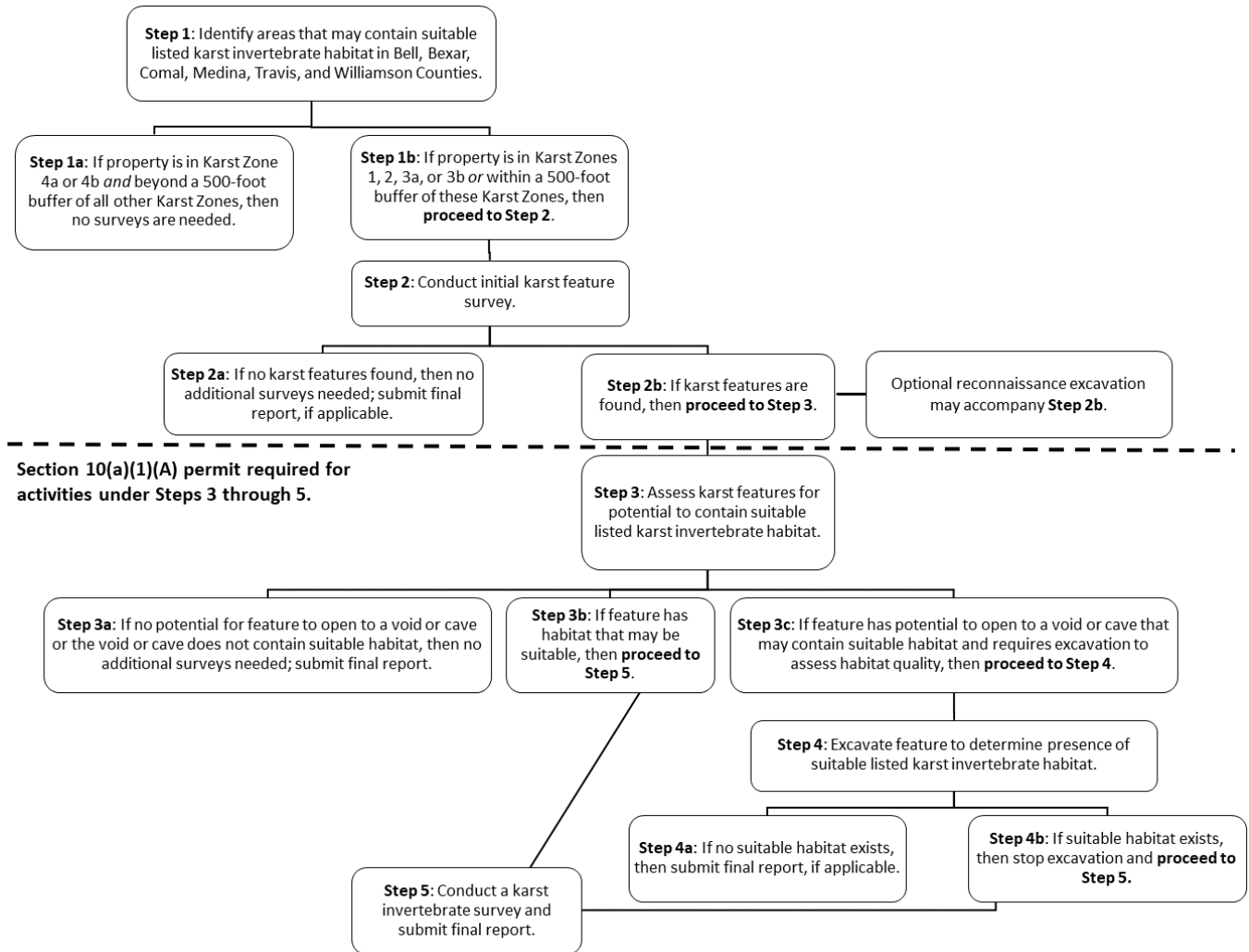
Table 1. Federally listed terrestrial karst invertebrates from central Texas (Final Rule for Travis and Williamson Counties - 53 FR 36029-36033; Bexar County - 65 FR 81419-81433; technical corrections - 58 FR 43818-43820; 87 FR 51925-51928).

Common Name	Species	Known County of Occurrence
Madla Cave meshweaver	<i>Cicurina madla</i>	Bexar
Robber Baron Cave meshweaver	<i>Cicurina baronia</i>	Bexar
Government Canyon Bat Cave meshweaver	<i>Cicurina vespera</i>	Bexar
Government Canyon Bat Cave spider	<i>Tayshaneta microps</i>	Bexar
Cokendolpher cave harvestmen	<i>Texella cokendolpheri</i>	Bexar
Ground Beetle (no common name)	<i>Rhadine exilis</i>	Bexar
Ground Beetle (no common name)	<i>Rhadine infernalis</i>	Bexar
Helotes mold beetle	<i>Batrisodes venyivi</i>	Bexar
Bee Creek Cave harvestmen	<i>Texella reddelli</i>	Travis
Kretschmarr Cave mold beetle	<i>Texamaurops reddelli</i>	Travis
Tooth Cave pseudoscorpion	<i>Tartarocreagris texana</i>	Travis
Tooth Cave spider	<i>Tayshaneta myopica</i>	Travis and Williamson
Tooth Cave ground beetle	<i>Rhadine persephone</i>	Travis and Williamson
Bone Cave harvestmen	<i>Texella reyesi</i>	Travis and Williamson
Coffin Cave mold beetle	<i>Batrisodes texanus</i>	Williamson

How to Determine if Karst Invertebrates May be Present

Figure 1 outlines a five-step approach for identifying karst features, conducting karst invertebrate habitat assessments, and conducting presence/absence of listed karst invertebrates in central Texas. This should be used in conjunction with the text following this figure for a more complete description of each step.

Figure 1. Five-step approach for identifying karst features, conducting karst invertebrate habitat assessments, and conducting presence/absence of listed karst invertebrates in central Texas.



Step 1. Identify areas that may contain suitable habitat for listed karst invertebrates in Bell, Bexar, Comal, Medina, Travis, and Williamson Counties

The original karst zones were delineated as four zones in the Austin area (Travis and Williamson Counties) and five zones in the San Antonio area (Bexar County), respectively (Veni 1992; Veni 1994). The karst zones in both the Austin and San Antonio areas were most recently updated and revised in Veni and Jones (2021) and Veni, Cooper, and Dickerson (2024), further delineating Zone 3 and Zone 4 into two subzones. Portions of Karst Zones 1, 2, 3a, and 3b have been extended into Bell, Comal, and Medina Counties, and recent studies of several taxonomic groups that contain listed karst invertebrate species suggest the potential for listed species presence in these counties (see Derkarabetian et al. 2022; Ledford 2023; Azevedo et al. 2024). Evaluating karst zones are a useful first step in determining if karst features containing listed invertebrates are likely to occur on a property. The karst zone maps are available online at <https://www.fws.gov/library/collections/terrestrial-karst-invertebrates> or upon request from the Austin Ecological Service Field Office.

Table 2. Definitions of Karst Zones (Veni and Jones 2021; Veni, Cooper, and Dickerson 2024)

Zone	Definitions (both Austin and San Antonio areas)
1	Areas known to contain listed karst invertebrate species
2	Areas having a high probability of containing suitable habitat for listed karst invertebrate species.
3a	Areas suitable for troglobite species but which have a low probability of containing listed karst species because the habitat is occupied by other troglobite species.
3b	Areas which have a low probability of containing listed karst species because they are poorly suited for troglobite species.
4a	Areas suitable for troglobite species but which do not contain listed karst species because the habitat is occupied by other troglobite species.
4b	Areas which do not contain troglobite species.

Steps 1a. If any portion of a subject property or study area is in zone 4a or zone 4b and beyond a 500-foot (ft) buffer (152.4 meters (m)) of all other karst zones, then it lies within an area, either cavernous or non-cavernous, that does not contain the listed karst invertebrates, and no karst feature surveys are needed.

Step 1b. If any portion of a subject property or study area is within karst zones 1, 2, 3a, or 3b or within

500 feet of the boundaries of these karst zones, **proceed to Step 2**. Step 2 procedures are only applicable to those portions of a subject property or study area that are either within karst zones 1, 2, 3a, and 3b, or within the 500-ft (152.4-m) buffer. The 500-ft (152.4-m) buffer is added owing to the scale at which mapping efforts are based, resulting in a geographic margin of error for karst zone boundaries. As stated above, if a karst feature survey is associated with a habitat assessment for karst invertebrates (see Step 3), the results of the karst feature survey must be reported.

Note: karst zones could be revised in the future based on survey data and site-specific mapping.

Step 2. Conduct an initial karst feature survey

To proceed with the initial karst feature survey, the Service recommends that this survey be conducted by a qualified karst geologist or karst biologist with demonstrated experience identifying karst features.

Techniques to assess the presence of karst features and potential listed species habitat: To conduct karst feature surveys, follow methods outlined in section II-A of *Procedure for Conducting a Geologic Assessment* in Texas Commission on Environmental Quality's (TCEQ) *Instructions to Geologists for Geologic Assessments (GA)*, as revised October 1, 2004. Applicable portions of those procedures are included here in Appendix I. We intend for you to use the GA procedure to locate features only and not to assess whether a feature has the potential to contain karst invertebrate habitat. Guidance on assessing a feature's potential to contain suitable karst invertebrate habitat is discussed in Step 3 below. If you have questions regarding the GA you may contact the TCEQ Austin Regional Office (512-339-2929), the San Antonio Regional Office (210-490-3096), or via the internet at <https://www.tceq.texas.gov/>.

If a GA has previously been conducted on the subject site following TCEQ's guidelines and is unexpired (i.e., GAs expire ten years after the GA's original certification date), then it may serve as an initial karst feature survey. If a GA is not required on the subject site by TCEQ (for example, the site is not located on the Edwards Aquifer recharge or transition zones) then we recommend that the initial karst feature survey be conducted following the methods outlined in those portions of section II-A of *Procedure for Conducting a Geologic Assessment* in TCEQ's GA (October 1, 2004) that are contained in Appendix I herein. All surveys should be conducted such that the likelihood of overlooking any karst feature is minimal. Similar to the GA expiration period, the Service recommends that karst feature surveys be conducted on a subject property if no such survey has been conducted in the last 10 years.

In addition to the methods in the TCEQ GA, remote sensing techniques, such as Lidar, video cameras, or geophysical techniques such as electrical resistivity, microgravity, ground penetrating radar, or natural potential may be helpful in assessing the presence of a void or the extent of a known feature that may contain suitable habitat. However, the use of such techniques cannot determine the presence of potential karst invertebrate habitat nor the absence of listed karst invertebrates. If using these techniques detects inaccessible voids that have potential to lead to a cave, boreholes should be drilled at no greater than 4 inches (in) (10 centimeters (cm)) in diameter in and near the voids to allow for baiting (see Baiting under Step 5 below). No more than 3 borings should be made when determining the potential presence of any one detected inaccessible void. No minimum depth is recommended, given that depth to cavernous bedrock is site-dependent. Further, TCEQ may require reporting and boring-specific plugging procedures if a subject property is located on the Edwards Aquifer recharge or transition zones, and as such TCEQ should be notified in these cases. Note: drilling boreholes has the potential to result in take, and therefore, we recommend this activity be covered by a 10(a)(1)(A) permit if it is being

implemented as part of these protocols.

Step 2a. If no karst features are found during the initial karst feature survey, no permit report is required. Because surface surveys for karst features are not expected to cause take and can be conducted by someone without a 10(a)(1)(A) permit, this work is not required in a 10(a)(1)(A) annual report. However, we would appreciate receiving karst feature reports not accompanied by habitat assessments because this information will increase our understanding of karst feature distribution and will assist in making decisions on management and conservation and in evaluating and refining scientific survey procedures for determining presence/absence. Also, the results may be needed or useful to document that environmental protection compliance requirements have been met (e.g., documenting that development would not result in incidental take of listed species).

Step 2b. If karst features are found during the initial survey, personnel may conduct an optional reconnaissance excavation can be conducted (see below) **or proceed directly to Step 3.**

Reconnaissance Excavation: If a feature is filled, or partly filled, by leaf litter, loose soils, or loose cobble, it can be subject to a reconnaissance excavation to inform the sensitivity of the feature per TCEQ guidelines or to provide further support for the need for subsequent habitat assessment (See Step 3). If reconnaissance excavations are conducted as described below they are not expected to result in “take”, and as they can be conducted by personnel without a section 10(a)(1)(A) permit.

Reconnaissance excavation involves hand removal of loose soil, rocks, and leaf litter not exceeding 1 ft (30 cm) in depth and 1 ft (30 cm) in diameter prior to its evaluation for potential to lead to a cave. A rod at least 1 ft (30 cm) long should be used to probe into the soils of a feature in search of shallow voids to further estimate the feature’s origin and permeability.

Step 3. Assess karst features for suitable listed karst invertebrate habitat

The potential for each identified karst feature to contain suitable habitat for listed karst invertebrates should be assessed by a valid 10(a)(1)(A) permit holder for karst invertebrates or by a qualified geologist or karst biologist that has written approval from the Karst Invertebrate Species Lead. All karst feature surveys that are accompanied by habitat assessments must be reported to the Austin ESFO (see page 2 and Appendix III).

Cultural Resources Note: When/if a project requires compliance with provisions of the Antiquities Code of Texas and/or Section 106 of the National Historic Preservation Act, coordination with the Texas Historical Commission, lead federal agency, or both may be required to determine if cultural resources investigations are warranted prior to karst feature assessment or excavation.

Potential Karst Invertebrate Habitat

The following karst feature attributes are based on Veni and Reddell (2002) and are considered primary indicators of potential habitat suitability for karst invertebrates. Features that meet at least one of these criteria and do not require further excavation should **proceed to Step 5** (see Step 3b). Features that meet at least one of these criteria but require excavation should **proceed to Step 4** (see Step 3c) if it meets at least of these criteria:

- Presence of leaf litter or other surface nutrients beyond 3.3 ft (1 m) from the surface;
- Presence of air flow;
- Channelized recharge of water;
- Loose soil or rock fill of at least 12 in (30 cm);
- Collapse-formed or related to collapse;
- Clean washed rock at base; or
- Abundant presence of cave crickets (*Ceuthophilus secretus*, *C. cunicularis*), variable meshweaver (*Cicurina varians*), or harvestman (*Leiobunum townsendii*) (20+ individuals) within or in immediate proximity (10 ft) of the karst feature surface expression

If none of the above primary indicators are present, then any combination of at least two of the following secondary indicators should be considered justification for further excavation (Step 4) or survey of a feature for karst invertebrates (Step 5) (Veni and Reddell 2002):

- The feature is developed along or near a fracture.
- The feature extends at least 3.3 ft (1 m) beyond the original surface expression.
- The feature morphology is similar to the pre-excavation appearance of a nearby known cave in the same geologic setting.
- The feature contains a visible humanly or potentially humanly enterable void.

Other indicators that should be considered justification for further excavation (Step 4) or survey of a feature for karst invertebrates (Step 5) (Veni and Reddell 2002) are listed below. These indicators should be thoroughly assessed and may be used to justify proceeding to excavation of a feature at the professional discretion of a valid 10(a)(1)(A) permit holder for karst invertebrates or by a qualified geologist or karst biologist that has written approval from the Karst Invertebrate Species Lead.

- The feature is within 1,000 ft (305 m) to caves known to contain listed species.
- The feature is in karst zone 1 or 2.
- The feature has physical characteristics (for example, size, appearance, catchment basin, conduits, air flow, and mammal etchings) that suggest the presence of a cave.
- The feature contains fill that does not match surrounding area, which may indicate the presence of artificial material in the feature.
- The feature contains roots and/or black soil.
- The feature is located near structural features that may promote cave and karst features to develop, such as a fault, photolineament (possible bedrock feature indicated by aerial photographs), or an area of relatively high fracture density.
- The vegetation near the feature includes trees (for example, cedar elm trees) that may grow in cave entrances and other karst features.

Unlikely Karst Invertebrate Habitat

The following is based on Veni and Reddell (2002) and is provided as guidance for determining when karst features are not likely to contain habitat for listed karst invertebrates. Each factor below indicates conditions unfavorable to karst invertebrates, but individually, none of these factors rule out their occurrence. A conclusion that no surveys are needed requires that all of these factors occur together, making habitat for the listed karst invertebrates unlikely.

- Features that have all, or nearly all, floors, walls, and ceilings covered with calcite speleothems (secondary geologic deposit in caves) are unlikely to provide habitat for karst invertebrates. The calcite speleothems may block the species and nutrients for the species from entering the feature.
- The absence of non-listed troglobites or troglophiles suggests conditions are unsuitable for the listed troglobites. Troglobites are species that are restricted to the subterranean environment that typically exhibits morphological adaptations to that environment, such as elongated appendages and loss or reduction of eyes and pigment (Veni 2002). Troglophiles are species that may complete their life cycle in the subterranean environment but may also be found on the surface (Veni 2002). To determine if this characteristic is met, the evaluation must be conducted or directly supervised by someone with experience recognizing these species.
- The feature lacks evidence of water-formed features that may indicate episodic moisture, such as recently formed scallops and pitting of sediments and bedrock, sediment depositional patterns exhibiting flow or ponding, or recent speleothem growth.
- There is an absence of discernible airflow, which suggests the feature may not connect to a cave or significant void. Although, the presence of airflow usually indicates the existence of such voids, its absence does not indicate the opposite. Several factors may prevent airflow when voids are present.
- The feature is not collapse-formed or related to a collapse. If a feature is part of a collapsed area of bedrock, it is part of a deeper, more extensive cave or series of voids that produced the collapse and are more likely to contain suitable habitat for the listed karst invertebrates.

Based on the assessment of the karst feature to provide suitable habitat, follow the appropriate step below (either 3a, 3b, or 3c):

Step 3a. If, after a thorough assessment, you determine there is no potential for the feature to open to a suitable habitat for karst invertebrates, then no additional surveys are needed.

Step 3b. If the karst feature is a cave or has habitat that may be suitable for listed karst invertebrates, then **proceed to Step 5.**

Step 3c. If the karst feature has potential to open to a void or cave that may contain suitable habitat for listed karst invertebrates and requires excavation to assess habitat potential, then **proceed to Step 4.**

Step 4. Excavating features

Considering that excavation of features could result in “take,” we require that surveyors conducting excavations beyond the scope of a reconnaissance excavation hold a valid 10(a)(1)(A) permit. If personnel are conducting an excavation for reasons other than habitat assessment, they can receive coverage by being supervised by a 10(a)(1)(A) permit holder, and the permittee should also be onsite to

collect specimens discovered during excavation. The permittee should determine if the feature leads to a cave or void and will require removal of fine sediments, collapsed rocks, calcite deposits, and/or bedrock. Excavation with hand tools should be used whenever possible to minimize disturbance of a feature's environment. Explosives may be needed to excavate collapsed rocks, calcite deposits, and/or bedrock but should be used strategically under the supervision of experienced personnel and in small amounts to selectively remove obstructions. Backhoes or related heavy machinery may be needed where large rocks or volumes of sediments are impractical and/or unsafe for removal by hand.¹ The size of excavations should be kept as small as possible while allowing space for efficient excavation efforts and creating an area safe for entry. Multiple entrances dry out caves; therefore, only one entrance should be excavated. Additional entrances should be sealed with natural fill equivalent in permeability to what was excavated (also see *Restoring Excavated Features* below). To minimize promotion of red-imported fire ant (*Solenopsis invicta*) activity, excavated material from all features should be evenly distributed downslope of and sufficiently far away from the feature. This decision is site-specific and should be made with the professional guidance of the section 10(a)(1)(A) permittee. Sediments should minimally be distributed in thicknesses of no more than 1-2 cm (0.39-0.78 inches) to allow rapid integration into the existing soils and stabilization by vegetation. Additional considerations for spoils deposition include drainage area to a feature, proximity to the 100-year floodplain, and proximity to streams or other aquatic resources.

Excavation should cease upon encountering: (1) a cave (caves may require further excavation during biological surveys, see Step 5), (2) solid bedrock with no conduits, (3) packed clay with no airflow present (the passage should be checked several times under different surface temperature conditions [for example, cool mornings, warm evenings] before determining there is no airflow), (4) potential archaeological or paleontological materials, or (5) where continued excavation would be dangerous (for example, due to a large, overhanging rock or high levels of CO₂). If the CO₂ level is high, consider excavating (or surveying) during more favorable weather conditions (such as during the winter months, especially after strong cold fronts, which push O₂ deeper into the cave displacing CO₂).

If a void or cave that may contain suitable habitat for listed karst invertebrates is encountered during excavation, excavation should stop and a qualified individual (see Appendix II) holding a valid section 10(a)(1)(A) scientific permit should survey for listed karst invertebrates and, if needed, conduct or supervise further excavations within the cave. However, we recommend immediate collection of any karst invertebrates observed within the entrance area during the initial excavation by an individual holding a valid section 10(a)(1)(A) permit (see Appendix II). Also, while active excavation is ongoing, features and boreholes should be immediately covered with a tarp to prevent the feature from drying, which may cause species to retreat into mesocavernous voids. The tarp should be secured as tight as possible to prevent air from entering or exiting the feature. Therefore, the tarp should be held down by using a combination of large stones, sandbags, light-colored blankets (which are less likely to absorb sunlight and heat), or other means that would not impact the habitat. Non-toxic materials should be used to accomplish this task, and metal plates should not be used because they dry out the habitat by

¹ **NOTE:** Excavation or any other activity that alters or disturbs the topographic, geologic, or existing recharge characteristics of a site, is regulated under the TCEQ's Edwards Aquifer Program and may require a Water Pollution Abatement Plan (WPAP). TCEQ's regional office should be consulted prior to either blasting or using a backhoe to excavate any feature occurring in the Edwards Aquifer recharge and transition zones. For more information, contact TCEQ at 512-239-1000 or access the Internet at <https://www.tceq.texas.gov/>.

conducting heat into the feature.

Restoring Excavated Features

After all necessary biological surveys have been conducted, features, caves, or boreholes should not necessarily be refilled but should remain in, or be returned to, a state most beneficial for the karst ecosystem, which may include but is not limited to: (1) returning the entrance to its pre-excavated condition (to reduce air flow if the original entrance was small) or (2) installing a cave gate to prevent trespassing or large mammal access (for example, feral hogs).

Features that are excavated into caves should usually be left open enough that human access for biological surveys is possible. However, openings larger than 3.3 ft (1 m) to relatively small caves may be detrimental to the karst ecosystem by increasing drying and temperature fluctuation. Therefore, we recommend that those features with smaller openings be covered with a boulder or other natural materials equivalent in permeability to what was excavated.

After excavating to determine if suitable habitat exists, follow the appropriate step below (either 4a or 4b):

Step 4a. If no suitable habitat for listed karst invertebrates exists, then no further excavation is necessary. A final karst feature survey report should be provided to the Service's Austin ESFO if excavation is conducted under a 10(a)(1)(A) permit (see Appendix III for reporting requirements).

Step 4b. If suitable habitat for listed karst invertebrates exists, then stop excavation and **proceed to Step 5.**

Step 5. Conduct a Karst Invertebrate Survey

Since collection of the listed species constitutes "take" and is a violation of section 9 of the Act without a permit, species surveys should be conducted by persons holding a valid 10(a)(1)(A) permit. The following section outlines the required survey methodology for conducting presence/absence surveys for listed karst invertebrates in central Texas under a section 10(a)(1)(A) permit. Once the survey(s) are complete, a comprehensive report must be submitted whether listed karst invertebrates were encountered or not (See Appendix III for reporting requirements).

NOTE: Any work in a cave is potentially dangerous. The presence of pits and ledges; large, unstable, overhanging rocks; and high levels of CO₂ present danger to researchers. Surveyors should use their best judgment to determine when conditions are safe to proceed with surveys. If invertebrate surveys are limited or discontinued due to safety concerns, this should be made clear in the report. Baiting (see Baiting below) may be recommended as an alternative under these conditions if it can be done safely by the permittee.

Number and Timing of Surveys

To assess the presence/absence of listed karst invertebrates with a high level of confidence, survey all karst features at least 14 times. This requirement applies to both enterable and non-enterable features. The number of surveys to conduct is based on detection of the endangered *Rhadine exilis* (Krejca and Weckerly 2007). For a more thorough explanation for why we are requiring 14 surveys see Appendix V.

All 14 surveys should be conducted even if a listed karst invertebrate is found before the 14th survey because you may detect a different species of a listed karst invertebrate.

Each survey should occur on non-consecutive days but no further than 72-hours apart during suitable surveying conditions (see Suitable Surveying Conditions below). For humanly enterable features, we encourage permittees to bait during every survey unless red-imported fire ants are being observed. However, if no listed species are detected by the eleventh survey, then baits **must** be used within enterable karst features in addition to surveying (see Baiting below). In cases of severe red-imported fire ant invasions, correspondence with the Karst Invertebrate Species Lead should occur to determine site-dependent baiting approaches or removal of baits altogether. Non-enterable features may only be subject to reduced visual survey in proximity to a feature surface expression and baiting (see Baiting below). Each non-enterable feature survey should employ both approaches to the fullest extent practicable over the same survey period (14 surveys, non-consecutive days, no further than 72-hours apart).

Prior to beginning of surveys and throughout the full duration of the survey period, data loggers must be installed in caves and features (as far back into the cave or feature as possible). For enterable karst features, we encourage that at least three surveys be conducted at night and at least three during daylight hours to account for possible daily variation in behavior.

Recommended Surface Sampling

In addition to *in situ* survey of karst features, the Service recommends that surveys of the surface environment within a 32.8-ft (10-m) radius of a karst feature surface expression should also be conducted during at least three of the 14 survey events. Recent studies (e.g., Ledford et al. 2011; Derkarabetian et al. 2022; Ledford 2023) have determined that some listed karst invertebrates (*Tayshaneta*, *Texella*) may not exclusively inhabit subterranean habitats. Instead, they may be associated with other surface microhabitats in proximity to the natural surface expression of karst features, including leaf litter, rotting logs, and rocky breakdown such as scree and talus slopes. Surface surveys should also occur on non-consecutive days but no further than one week apart. Surface surveys should only employ exploratory visual or hand-sift search approaches. Baiting approaches should only be used within a karst feature (see Baiting below for methods). Given the lack of currently available guidance for systematic sampling of the surface environment, level of effort should adhere to the general recommendations for surveying karst features (see Surveying Diligence and Thoroughness below).

Special Instructions For Features Hit During Construction

If the feature is humanly enterable, then conduct presence/absence surveys within the feature. However, although a feature may be humanly enterable within a construction area, some features may pose additional safety limitations (e.g., feature discovered in an unstable trench). In situations where entrance is not feasible due to such safety limitations, surveyors should adhere to the following protocol for inaccessible features.

If you are surveying an inaccessible feature encountered during construction, baiting must be conducted for a minimum of 14 days beginning when the baits are set and ending when the baits are removed. Baits must be checked at least six times during this period on non-consecutive days but no further than 72-hours apart (see Baiting below). Data loggers must be installed during the entire two-week baiting

period.

Suitable Surveying Conditions

Entrance into karst features should only occur during periods without excessive rainfall or other harsh weather conditions to reduce safety issues. The entire karst feature should be searched when conditions in the feature are appropriate for finding the listed karst invertebrates, generally avoiding temperature extremes and low humidity. Surveys may be conducted any time of year as long as the weather conditions below are met (see suitable weather conditions). Ideally at least one survey should be conducted in the fall and one in the spring to observe species that may be more active or visible in one season or the other. For example, *Rhadine* beetles appear to be more abundant in the spring, indicating that fall surveys may not be as useful for these species (James Reddell, Texas Memorial Museum, pers. comm. 2002). Also, a study by Weckerly (2010) assessed surveys conducted by the Balcones Canyonlands Preserve staff and found that *Texella* species were not detected in the fall and winter (however, there was not a statistically significant trend in seasonality of detection).

Surveying Diligence and Thoroughness

Since karst invertebrates are small, have low population sizes, and may have behaviors that make them difficult to find, such as retreating under rocks or into mesocavernous passages too small for humans, it is necessary to ensure that sufficient time and effort have been spent surveying. The following procedures should be incorporated for each survey of an enterable karst feature:

- Search the void/cave thoroughly.
- Search times should be proportional to the size of the karst feature/cave
- Use a system of transects to ensure the entire cave or feature is thoroughly searched.
- Search under all loose and easily moveable rocks. Rocks should be moved with care to ensure species are not injured and should be returned to their original position immediately after examination.
- Search under clumps of dried, cracked sediment, which should also be moved with care and returned to their original position after examination.
- Search in crevices, on ceilings, and walls.
- Hand-sift samples of loose sediment and look on, and in, scat and dead animals.
- Search all habitat types, not only those that are believed to be the preferred habitat of the listed karst invertebrates. Since habitat profiles are incomplete, this will provide information on habitat selection by these species.
- Record species abundance for listed and non-listed species and the microhabitat that they were found on/in. See Appendix III for information to collect during each survey that should be included in annual reports.

Specimen Collection and Preservation

Since the listed karst invertebrates may not be possible to distinguish in the field from closely related species, specimens should be collected for identification by a qualified taxonomist.

- Over the duration of the 14 presence/absence surveys or during a one year period, three specimens of each genus *or* morphotype group (applicable only to *Cicurina* and *Rhadine*, as

defined below) of a listed species may be collected per cave or per surrounding surface search radius. All collected specimens must be sent to a taxonomist within one month of collection for identification. They should be curated no longer than two months after collection. **NOTE:** Entry and collection in caves known to contain listed karst invertebrates is not authorized, even under a section 10(a)(1)(A) permit, unless a monitoring or research plan (see Appendix IV for more information on this) has been submitted by a permittee and approved by Austin Ecological Services Field Office.

- These collections should be identified as specifically as possible and sent to the Texas Memorial Museum, in Austin, Texas or other appropriate museum or university listed in our Karst Invertebrate Taxonomy document found at: <https://www.fws.gov/library/collections/terrestrial-karst-invertebrates> for taxonomic determination and curation.
- All specimens should be preserved in 90 percent or higher non-denatured ethanol because they may be used in future genetic studies.
- Specimens collected should be immediately placed in a cooler and kept there until transferred to a freezer. Before transfer to a freezer, the preservative should be discarded and replaced with new ethanol. All preserved specimens should be stored in a freezer at (-20°C (-4°F)) (Vink et al. 2005).
- All specimens should be stored in separate vials to prevent misidentification in the event that appendages become separated from the body.
- Immature specimens collected alive with the intent of rearing them to adulthood for positive identification (e.g., blind *Cicurina* and *Texella* species) should be sent to a taxonomist immediately. To promote specimen viability, surveyors should coordinate shipments with taxonomists so they will know when to expect them and can prepare accordingly.

Morphotype Groups: species belonging to the genera *Cicurina* or *Rhadine* have readily observable characteristics that allow for preliminary field diagnosis. *Rhadine* ground beetles have two formal morphotype groups: slender body and robust body (see Gómez et al. 2016 for detailed images). *Cicurina* meshweavers are typically large enough to determine the presence of eyes, and as such we informally define *Cicurina* morphotype groups as: eyed and eyeless. Three cumulative specimens from each morphotype group can be collected per cave for *Rhadine* and *Cicurina*. For example, from a single cave, three slender *Rhadine* and three robust *Rhadine* can be collected, despite being within the same genus.

Baiting

Baits may attract red-imported fire ants into the cave; therefore, they should be used with caution as an invertebrate survey technique. No baiting approaches should be employed within the surface search radius. Baits should be used in leads that are inaccessible for visual examination. When baiting is used, follow these conditions:

- Baits should consist of both sticky traps and bottle traps, as feasible. The reason we are recommending two types of traps is because specimens can be damaged in sticky traps. However, capture probability may be higher in them than in bottle traps. This requirement may be revised if future data indicate that one trap is more desirable than the other.
- Bottle traps should be constructed by cutting the top off a plastic bottle, then inverting and inserting the lid back into the bottle. Prior to reinserting the lid, place cheese or another pungent bait inside the bottle and a funnel inside the lid. The funnel should not touch the bottom of the

trap and should allow easy entry and difficult exit. You should also cut small holes in the bottle to allow for air flow; these holes should be as small as possible to prevent individuals from exiting the trap.

- Baits should be placed as far back in a void/cave as possible to reduce the chance of attracting surface species, but the baits must be retrievable.
- Baits can be deployed further into inaccessible features by tying a **strong** string to the bait and feeding the string through a 0.5-inch polyvinyl chloride (pvc) pipe. The string should be long enough to extend a few feet outside of the pipe pushing the bait into the feature with a pole. While deploying the trap, hold the end of the string tightly, once the bait is in place, let go of the string and pull the pipe out of the feature leaving the string for future retrieval. Strings should be inspected for deterioration during each visit to ensure that the trap will be retrievable and not lost in an inaccessible area and thus serving as a constant source of mortality after baiting is completed.
- Baits must be checked on non-consecutive days but no further than 72-hours apart; the surface area above the baits must also be checked to ensure that red-imported fire ant mounds are not present. Any red-imported fire ant mounds found prior to, or during, baiting should be immediately treated with boiling water.
- Data loggers must be installed in features prior to the beginning of baiting and remain in place until all baiting is completed (see above for *Special instructions for features hit during construction.*)

Please note that some karst invertebrate species, such as *Texella* species, are less likely to be captured by baiting (George Veni, George Veni & Associates, in litt. 2003). However, we still recommend this technique, in addition to presence/absence surveys. Also, finding only non-listed invertebrates in bait traps does not necessarily imply there are no listed species present.

Reporting: Reports documenting activities under a section 10(a)(1)(A) scientific permit are to be provided to the Service annually. Reporting requirements are outlined in Appendix III.

Literature Cited

- Azevedo, G.H., J. Blair, and M. Hedin. 2024. Evaluating possible anthropogenic impacts on gene flow and loss of genetic diversity in endangered Madla Cave Meshweaver spiders (Hahniidae, *Cicurina madla*). *Conservation Genetics* 25(1), 149-164.
- Derkarabetian, S., P. Paquin P, J. Reddell, and M. Hedin. 2022. Conservation genomics of federally endangered *Texella* harvester species (Arachnida, Opiliones, Phalangodidae) from cave and karst habitats of central Texas. *Conservation Genetics* 23(2), 401-416.
- Gómez, R.A., J. Reddell, K. Will, and W. Moore. 2016. Up high and down low: Molecular systematics and insight into the diversification of the ground beetle genus *Rhadine* LeConte. *Molecular Phylogenetics and Evolution* 98, 161-175.
- Krejca, J. and F.W. Weckerley. 2007. Detection probabilities of karst invertebrates. *Proceedings of the Eighteenth National Cave and Karst Management Symposium*. pp. 283-289.
- Ledford, J. 2023. Species limits in the endangered Tooth Cave spider, *Tayshaneta myopica* (Gertsch, 1974). Prepared for the Texas Department of Transportation. 37 pp.
- Ledford, J., P. Paquin, J. Cokendolpher, J. Campbell, and C. Griswold. 2011. Systematics of the spider genus *Neoleptoneta* Brignoli 1972 (Araneae: Leptonetidae) with a discussion of the morphology and relationships of the North American Leptonetidae. *Invertebrate Systematics* 25, 334-388.
- SWCA. 2014. 2013. Annual report of management and monitoring activities on the seven La Cantera Karst Preserves, January 2013 – December 2013.
- Texas Speleological Survey. 2006. Definition of a cave. <http://www.txspeleologicalsurvey.org>.
- U.S. Fish and Wildlife Service (Service). 1994. Recovery plan for endangered karst invertebrates in Travis and Williamson counties, Texas. 25 August 1994. USFWS Region 2 Office, Albuquerque, NM. 154 pp.
- Veni, G. 1992. Geological controls on cave development and the distribution of cave fauna in the Austin, Texas, region. Report prepared for U.S. Fish and Wildlife Service, Austin, Texas. George Veni and Associates, San Antonio, Texas. 77 pp.
- Veni, G. 1994. Geological controls on cave development and the distribution of endemic cave fauna in the San Antonio, Texas, region. Report prepared for Texas Parks and Wildlife Department, Austin, Texas, and U.S. Fish and Wildlife Service, Austin, Texas. George Veni and Associates, San Antonio, Texas. 99 pp.
- Veni, G. 2002. Delineation of hydrogeologic areas and zones for the management and recovery of endangered karst invertebrate species in Bexar County, Texas. Report prepared for the U.S. Fish and Wildlife Service, Austin, Texas. George Veni and Associates, San Antonio Texas. 75 pp.
- Veni, G. 2003. Comments on the 12-16-03 draft Karst Survey Guidelines. December 28, email to U.S.

Fish and Wildlife Service, Austin, Texas.

- Veni, G. and J.R. Reddell. 2002. Protocols for assessing karst features for endangered invertebrate species. Report by George Veni and Associates, San Antonio, Texas. 7 pp.
- Veni, G. and M. Jones. 2021. Statistical Analysis and Revision of Endangered Karst Species Distribution, Austin Area, Texas. National Cave and Karst Research Institute Report of Investigation 10, Carlsbad, New Mexico. 58 pp.
- Veni, G., Cooper, J., and W Dickerson. 2024. Statistical analysis and revision of endangered karst invertebrate species distribution, San Antonio area, Texas. Prepared for the Texas Department of Transportation: Voluntary Conservation Measure for US 281 from Loop 1604 to the Comal County Line, Bexar County, Texas. 74 pp.
- Vink, C.J., S.M. Thomas, P. Paquin, C.Y. Hayashi, and M. Hedin. 2005. The effects of preservatives and temperatures on arachnid DNA. *Invertebrate Systematics*, 19, 1–6.
- Weckerley, F.W. 2010. Karst invertebrate species survey protocols and trend analysis at Balcones Canyonlands Preserve. 21 pp.

Appendix I: Geologic Assessments

Section II-A of the TCEQ Procedure for Conducting a Geologic Assessment TNRCC-0585-Instructions (Rev. 10-1-04) to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones

[Note: We have appended applicable portions of Section II-A that we recommend using to locate karst features. In some places, the text here may be modified slightly from that in the TCEQ document. For TCEQ purposes, please see their original and most current document.]

A. Procedure for Conducting a Geologic Assessment

The general procedure for conducting a geologic assessment is to: research information, perform a field survey, evaluate data, return to the site, if necessary, make conclusions, and make a report with your feature assessments and recommendations. A geologic map, notes, photographs and/or sketches should be made while in the field. These data may be used and included in your final report.

Research Information

Published reports and maps of area geology should be studied prior to performing the field survey. A literature or database search should be conducted for the presence of documented caves or other karst features on the property or in proximity to the property boundary. Information may be found about known caves, such as mapped extent, depth or elevation or orientation, on the subject property or on adjacent tracts. Some commonly used data sources for geologic maps and cave location and interpretation are included in the “Citations for Sources of Further information” in these Instructions [see TCEQ, GA for these citations].

Evaluate former land use practices and modifications. Interview persons knowledgeable about historical activities such as well drilling, irrigation or water control ditches or trenches, pit or structure construction, episodes of brush clearing and tree pulling, and cave filling or excavation. In ranches that have been occupied for a long time, manmade features can be degraded and overgrown and be confused with natural features. Human activities also may obscure indicators of natural processes that otherwise could be used to determine the sensitivity of a feature. Aerial photos may be examined for the presence of structural features that should be field checked and plotted on the map.

Perform a Field Survey

The entire subject site must be walked to survey the ground surface for the presence of geologic and manmade features. It is recommended that the site be walked systematically in spaced transects 15.2 meters (50 feet) apart or smaller, paying close attention to streambeds and structural features observed on aerial photographs. The transect pattern should be adapted to ensure that the geologist is able to see features and will vary with topography and vegetation on the site. Streambeds, including dry drainages, are significant because runoff is focused to them. Not only are features in streambeds likely to receive large volumes of recharge, but they are likely to be part of hydrologically integrated flowpaths because past flow has preferentially enlarged and maintained conduits. Features in streambeds are likely to be obscured by transported soil or gravel (swallets or swallow hole). Structural features such as faults and fracture zones have influenced karst processes in the Edwards recharge zone, and awareness of these

structures may be helpful in completing a high-quality assessment. The assessment must include the path of any proposed sewer line that extends outside of the water pollution abatement plan (WPAP) assessed area plus 50 ft (15.2 m) on either side. Any features identified should be marked where possible with flagging or stakes, accurately located, preferably using a GPS, and assigned a unique number with the location accurately plotted on the geologic map.

[Note: After all karst features are located and mapped, please return to Step 3 of the “United States Fish and Wildlife Service, Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Listed Karst Invertebrates in Central Texas” to determine if potential karst invertebrate habitat may be present.]

Appendix II: Surveyor Qualifications

United States Fish and Wildlife Service, Section 10(a)(1)(A) Listed Karst Invertebrate Surveys: Surveyor Qualifications

The following levels of expertise are required for issuance of a section 10(a)(1)(A) scientific permit to conduct habitat assessments and presence/absence surveys for listed karst invertebrates in central Texas. The Service will consider on a case-by-case basis granting a section 10(a)(1)(A) scientific permit to individuals who do not meet these qualifications but who have demonstrated adequate/appropriate experience to conduct this work.

To be considered qualified by the Service to conduct unsupervised habitat assessments and presence/absence surveys for listed karst invertebrates and to supervise others in the field, the conditions below should be met:

- The person has extensive experience identifying karst features and evaluating them for karst invertebrate habitat potential.
- The person has extensive experience identifying both listed and non-listed karst invertebrates in Texas with at least one year of experience collecting (under the on-site supervision of a biologist permitted to survey for karst invertebrates) and accurately identifying, at least to genus, the listed karst invertebrates in the county being surveyed.
- Also, the person can provide letters of recommendation from two individuals that hold a valid 10(a)(1)(A) permit to independently survey for karst invertebrates or a taxonomist that has received their collections. Individuals that write these letters should attest to the applicant's ability to properly collect and identify karst invertebrates to the genus level. Equivalent experience in caves outside of Texas may be acceptable. The Service will review these on a case-by-case basis.

NOTE: Other individuals may be permitted to accompany permittees into caves to gain experience or for the reasons of caving safety but must remain under the direct on-site supervision of the Permittee at all times. Also, a section 10(a)(1)(A) permit may be issued to a qualified geologist with demonstrated experience in karst geology covering "take" of listed karst invertebrates that may occur during a habitat assessment and/or excavation and for the collection of listed karst invertebrates encountered while conducting these activities. Note, these individuals may not conduct presence/absence surveys unless they are permitted for that activity.

Appendix III: Reporting Requirements

United States Fish and Wildlife Service, Section 10(a)(1)(A) Karst Feature and Listed Karst Invertebrate Surveys: Report Requirements

An annual permit report is required for 10(a)(1)(A) permit holders. For information that should be included in these reports and separate data submittals, see the Karst Invertebrate Survey Report section below.

A section 10(a)(1)(A) scientific permit is not required to conduct surface walking surveys to identify the presence of karst features or to conduct reconnaissance excavations, as no “take” of listed species is likely to occur. However, we would appreciate receiving karst feature survey reports. These data are important, even if findings are negative, for the conservation and recovery of the species. See the Karst Feature Survey Report section below for information that we would find helpful in these reports.

KARST INVERTEBRATE SURVEY REPORT: This report is **required** by 10(a)(1)(A) permittees and should include, but is not limited to, the information below. This information will benefit the conservation of these species by furthering our knowledge of the biology and ecology. Failure to submit the listed information within a report will be considered an incomplete annual report submission.

Personnel

- List the names of all persons involved in the surveys (including baiting) and their duties.
- List each person’s section 10(a)(1)(A) scientific permit number, if applicable.
- Provide a brief summary of experience, education, and certification for each person **NOT** holding a valid section 10(a)(1)(A) scientific permit.
- Identify the person(s) directly responsible for writing the report.

Note: It is required that at least one section 10(a)(1)(A) permit holder for karst invertebrates be physically present for presence/absence surveys. Personnel information will be verified by review of all annual reporting materials and subsequent correspondence with individual permittees as necessary.

Location

- Provide the location of caves and features surveyed and the property boundaries on a United States Geological Survey (USGS) topographic map (7.5 minute or larger scale).
- Provide GPS coordinates for each cave or feature surveyed. Also, report the GPS unit model, its accuracy, and if any real time correction or post processing was done.
- Provide georeferenced data in lat-long (decimal degrees) in the North American Horizontal Datum 1983 (NAD 83) geographic coordinate system.

Methods

- Describe survey methodology using standards consistent with a scientific, peer-reviewed publication.
- Report whether the entire cave was surveyed or if surveys were conducted along transects or following another statistical sampling method and describe that methodology.
- Report whether the surface survey radius was surveyed and if so describe the methodology.
- Report the use of baiting. Include a description of the methodology used including the type(s) of

bait used, the type and location of traps, and the amount of time traps were left out. Also, report the capture results by trap and date checked.

- Report total time spent searching (in person-hours) specifically for karst invertebrates.
- Report date and time of day each required subsurface and optional surface survey was conducted.
- Report temperature and humidity on the surface and at locations inside the feature as indicated below in the section titled “Caves and Karst Features.” Indicate the brand and model of the equipment used and the equipment’s accuracy (degree of accuracy).
- Report weather conditions on the survey day and previous week.
- Report temperature and humidity results of data loggers as well as the type of data logger and the location in the cave or feature where the data logger was installed.

Caves and Karst Features

- Describe each cave or feature surveyed and include a detailed, scaled cave map with plan and profile views, including:
 - The approximate passable length of the cave or feature.
 - Possible leads or breakdown areas that could contain mesocavernous invertebrate habitat that is not humanly passable.
 - The approximate heights and widths of passages.
 - Locations of any standing or flowing water.
- Describe the interior of each cave or feature surveyed including:
 - Principal formations and whether they are active.
 - Make-up of the cave floor in each section (for example, mud, breakdown with approximate sizes, powder).
 - Approximate area and depth for standing water and approximate width, length, depth, and flow rate.
 - Temperature (to the nearest 0.1 degree Fahrenheit (°F)) and relative humidity (to the nearest 1 percent). Indicate the brand and model of the equipment used and the equipment’s degree of accuracy. Temperature and relative humidity should be taken at a minimum just inside the entrance and at the farthest humanly accessible part of the cave or feature. Several locations are preferred, particularly for large caves or those with multiple rooms, and should be referenced to labeled locations on the cave map. The standard interval for data collection is at minimum 30 minutes.
 - Report any indications of “bad air,” (for example, high CO₂ levels or any noxious gas) and reference to labeled locations on the cave map.
 - Report the result of any excavation, including reasons for discontinuing excavation.
 - Describe the methodology used for restoring excavated features, if applicable.

Species and Biotic Karst Community

Report the presence of all species, listed and non-listed, observed or collected during required subsurface surveys and optional surface surveys or any other activity such as the initial karst feature survey following the TCEQ GA protocol, including:

- Identify species (vertebrate and invertebrate) as specifically as possible, preferably to species level, including:
 - Troglonites - a species of animal that is restricted to the subterranean environment and

- typically exhibits morphological adaptations to that environment, such as elongated appendages and loss or reduction of eyes and pigment (Veni 2002).
- Troglaphiles - a species of animal that may complete its life cycle in the subterranean environment but may also be found on the surface (Veni 2002).
 - Troglaxenes - a species of animal that inhabits caves but must return to the surface for food and other necessities (Veni 2002).
 - Accidentals - species that may wander into caves but cannot survive there.
 - For optional surface surveys, a comprehensive list of species encountered is not required. Instead, please provide only information pertaining to listed species encountered, members of the same genus as a listed species, or other observations related to species that may have previously been determined to be troglobitic or troglaphilic.
 - Report listed species behavior when observed (for example, feeding, sedentary, moving, etc.).
 - Report the presence of dead specimens (vertebrate and invertebrate) and identify them to the lowest taxonomic level possible.
 - Report numbers of each species (listed and non-listed) encountered on each survey date. For highly abundant species, approximations are acceptable.
 - Describe the microhabitat where species (listed and non-listed) were found, including:
 - Type of substrate the specimen was found on (for example, leaf litter, large breakdown; dry, fine silt; under a fist-sized rock; on the ceiling).
 - Type of rock/soil the specimen was found on.
 - An approximation of how much organic material was found in the cave (for example, scat, bat or cricket guano, dead animals, plant material, fungus) with a reference on the cave map to where the organic material was found.
 - Proximity to water.
 - For listed species, indicate location(s) found on the cave map.
 - Report any previous collections in the cave, regardless of the listing status of those species.
 - Provide a description and sketch of the area immediately around the cave entrance (approximately 32.8 ft (10 m)), including approximate percent cover by bedrock versus soil, approximate percent cover by trees or shrubs versus herbaceous plants, and approximate percent cover by deciduous versus coniferous trees.
 - Also, report locations where caves/features were searched but no listed species were found and any additional information above that is available.

NOTE: Reporting for all Species and Karst Biota Community sections should be prepared in a separate Excel spreadsheet or Geodatabase and not only included in the body of the report.

Species Identification

If specimens are tentatively identified as listed species in the field, they should still be sent to a taxonomist for verification. A list of taxonomists is in our Karst Invertebrate Taxonomy document at: <https://www.fws.gov/library/collections/terrestrial-karst-invertebrates>. The final report should include the results of the taxonomist's identification including accession numbers for each specimen. If taxonomic results are not back at the time your report is due, identify where the specimens were sent, the date they were sent, and how many specimens were included. The report should include a list of species collected (listed and non-listed species to the genus level) and/or encountered during collections, name of collector(s), date of collection, and method of preservation/storage. Once the taxonomist's results are

received, they should be reported to the Service within two weeks.

Specimen Deposition

All specimens should be deposited with an appropriate curated museum collection as approved in writing by the Austin Ecological Services Office if different from our list in the Karst Invertebrate Taxonomy document referenced above.

KARST INVERTEBRATE DATA INSTRUCTIONS: Karst invertebrate survey data must be submitted either in an Excel spreadsheet or a GIS feature class/shapefile (point data). Feature footprint data must be submitted in a GIS feature class/shapefile (polygon data) if the feature was subject to mapping. Moreover, feature footprints need only be provided if the karst feature meets the definition of a cave. Data must be submitted in accordance with the instructions below. All survey data for a given survey year should be submitted as one file per permit (e.g., all surveyors, all locations, and all data within and among locations must be included in a single file). Failure to submit data in accordance with these instructions will be considered an incomplete annual report submission.

Karst Invertebrate Survey Data Format

If submitting data in an Excel spreadsheet: (1) also submit a map within the report clearly illustrating the exact location of the karst features surveyed for karst invertebrates within the context of the surrounding landscape so we can relocate them on a USGS topo, aerial photo, or street map, and (2) clearly define a naming convention for each feature (if no previous name for that feature exists) and label them within the submitted maps.

The spreadsheet / attribute table format should adhere to structure below. Entries should be made for each of the 14 survey events at each feature (in a single file).

1. **Prop_Name** (Excel format = General; GIS Type = Text, Length = 50): Name of property or portion of property surveyed.
2. **Karst_Area** (Excel format = General; GIS Type = Text, Length = 50): Karst Area where survey occurs. Entries should be limited to “SanAntonio” or “Austin”, corresponding with the two sets of Karst Zones and Karst Fauna Regions.
3. **Karst_Zone** (Excel format = General; GIS Type = Text, Length = 2): Karst Zone where survey occurs. Entries should be limited to single numbers, with the exception of the Austin Area Karst Zones “3a”, “3b”, “4a”, and “4b”.
4. **KFR** (Excel format = General; GIS Type = Text, Length = 100): Karst Fauna Region where survey occurs. Entries should not include spaces. E.g., “CulebraAnticline”, “JollyvillePlateau”.
5. **Personnel** (Excel format = General; GIS Type = Text, Length = 100): Name of all persons involved in the surveys. Entries should be first initial and full last name, with surveys separated by a comma (e.g., “JSmith,JDoe”).
6. **Perm_ID** (Excel format = General; GIS Type = Text, Length = 50): Supervising permit holder’s section 10(a)(1)(A) scientific permit number.
7. **Survey_Comp** (Excel format = General; GIS Type = Text, Length = 50): Name of company/organization or individual responsible for conducting surveys.

8. **Date** (Excel format = Number; GIS Type = Double): Date feature was surveyed. Entries should be formatted as YYYYMMDD.
9. **Time_In** (Excel format = Number; GIS Type = Double): Report the time the karst invertebrate survey began using military time. Excel drops leading zeros (e.g., 0800), but please format cells as Numbers in Excel (not text).
10. **Time_Out** (Excel format = Number; GIS Type = Double): Report the time the karst invertebrate survey ended using military time.
11. **Temp_Start** (Excel format = Number; GIS Type = Double): Report the surface temperature at the time the survey began in degrees Fahrenheit (to the nearest 0.1°F)
12. **Hum_Start** (Excel format = Number; GIS Type = Double): Report the surface relative humidity at the time the survey began (to the nearest 1 percent).
13. **Feat_ID** (Excel format = General; GIS Type = Text, Length = 50): Name of feature surveyed (if not a formally named feature, develop a clear naming convention for feature IDs. E.g., “PropName_Feature##_Date”).
14. **Feat_Lat** (Excel format = Number; GIS Type = Double): Latitude of feature location in decimal degrees (NAD 83) with at least five decimal places.
15. **Feat_Lon** (Excel format = Number; GIS Type = Double): Longitude of feature location in decimal degrees (NAD 83) with at least five decimal places.
16. **Species** (Excel format = General; GIS Type = Text, Length = 50): Listed karst invertebrate species observed. Do not include non-listed species. If multiple listed species are observed, entries should be comma delimited without spaces (e.g., Rhaexi,Rhainf). Entries should be formatted as follows:
 - a *Batrisodes texanus* = Battex
 - a *Batrisodes venyivi* = Batven
 - b *Cicurina baronia* = Cicbar
 - c *Cicurina madla* = Cicmad
 - d *Cicurina vespera* = Cicves
 - e *Rhadine exilis* = Rhaexi
 - f *Rhadine infernalis* = Rhainf
 - g *Rhadine persephone* = Rhaper
 - h *Tartarocreagris texana* = Tartex
 - i *Tayshaneta microps* = Taymic
 - j *Tayshaneta myopica* = Taymyo
 - k *Texamaurops reddelli* = Opsred
 - l *Texella cokendolpheri* = Texcok
 - m *Texella reddelli* = Texred
 - n *Texella reyesi* = Texrey

Figure 2. GIS fields needed for karst invertebrate survey data (same format for table in Excel).

KarstInvertSurvey									
<input checked="" type="checkbox"/> Read Only	Field Name	Alias	Data Type	<input checked="" type="checkbox"/> Allow NULL	<input type="checkbox"/> Highlight	Number Format	Domain	Default	Length
<input type="checkbox"/>	Karst_Zone	Karst_Zone	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2
<input type="checkbox"/>	KFR	KFR	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				100
<input type="checkbox"/>	Personnel	Personnel	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				100
<input type="checkbox"/>	Perm_ID	Perm_ID	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Survey_Comp	Survey_Comp	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Date	Date	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Time_In	Time_In	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Time_Out	Time_Out	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Temp_Start	Temp_Start	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Hum_Start	Hum_Start	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Feat_ID	Feat_ID	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Feat_Lat	Feat_Lat	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Feat_Lon	Feat_Lon	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Species	Species	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50

Feature Footprint Data Format

In addition to a description and drawn map within the report, cave passages should be geospatially interpreted to better understand the full ‘footprint’, provided that the cave was mapped. All navigable portions of a cave subject to karst invertebrate surveys should be included within the footprint, as well as any further extents inferred by additional survey methods (described within the report).

Temperature and Humidity Logger Data

In addition to reporting graphical interpretations of temperature and humidity throughout the duration of a karst invertebrate survey included in the report, all raw logger data should be submitted separately as a portion of the total annual report. As described in the Caves and Karst Features subsection of this Appendix, the standard interval for data collection is at minimum 30 minutes.

KARST FEATURE HABITAT ASSESSMENT REPORT: This report is **required** by 10(a)(1)(A) permittees and should include, but is not limited to, the information below. For karst feature surveys that do not include a habitat assessment, while not required, we would appreciate if you prepared and submitted a comprehensive written report following the completion of karst feature surveys. This information will increase our understanding of these species and will assist in making decisions on management and conservation and in evaluating and refining scientific survey procedures for determining presence/absence.

Personnel

- Names of all persons involved in the surveys and their duties in the karst feature survey report.
- Each person's section 10(a)(1)(A) scientific permit number, if applicable.
- Person(s) directly responsible for writing the report.

Feature Survey Methodology and Location

Describe survey methodology and karst feature locations using standards consistent with a scientific, peer-reviewed publication. Please include in the report:

- Total time spent searching for karst features and spacing and direction of all transects.
- A map of the survey location with transects and features identified.
- Provide the location of caves and features surveyed and assessed and the property boundaries on a USGS topographic map (7.5 minute or larger scale)
- Provide GPS coordinates for each cave or feature assessed. Also, report the GPS unit model, its accuracy, and if any real time correction or post processing was done.
- Provide georeferenced data in lat-long (decimal degrees) in the North American Horizontal Datum (NAD 83) geographic coordinate system
- Results of excavations and methodology used for restoring excavated features, if applicable.

Habitat Assessment

Describe the habitat assessment of each identified feature using the indicators outlined in Step 3 of the survey documentation. Please include in the report:

- Habitat determinations for each feature identified and associated indicators justifying each determination.
- Photos of each feature identified as habitat or non-habitat.

Supporting information

- Citations for all references used or consulted in the final report.
- Definitions of any terminology that would not be common knowledge to persons with general scientific, non-geology specific backgrounds including terminology specifically used by or for agencies other than the Service, for example, the TCEQ.
- Results of any additional studies related to the karst investigations, for example, biological observations, remote sensing for subsurface voids, hydrological studies, etc.

Karst Feature Survey Data Format

We would appreciate if you prepared and submitted karst feature survey data either in a GIS polygon shapefile (preferred) or an Excel spreadsheet.

The spreadsheet / attribute table format should adhere to structure below.

1. **Prop_Name** (Excel format = General; GIS Type = Text, Length = 50): Name of property or portion of property surveyed.
2. **Karst_Area** (Excel format = General; GIS Type = Text, Length = 50): Karst Area where survey occurs. Entries should be limited to “SanAntonio” or “Austin”, corresponding with the two sets of Karst Zones and Karst Fauna Regions.
3. **Karst_Zone** (Excel format = General; GIS Type = Text, Length = 2): Karst Zone where survey occurs. Entries should be limited to single numbers, with the exception of the Austin Area Karst Zones “3a”, “3b”, “4a”, and “4b”.
4. **KFR** (Excel format = General; GIS Type = Text, Length = 100): Karst Fauna Region where survey occurs. Entries should not include spaces. E.g., “CulebraAnticline”, “JollyvillePlateau”.
5. **Personnel** (Excel format = General; GIS Type = Text, Length = 100): Name of all persons involved in the surveys. Entries should be first initial and full last name, with surveys separated by a comma (e.g., “JSmith,JDoe”)
6. **Perm_ID** (Excel format = General; GIS Type = Text, Length = 50): Supervising permit holder’s section 10(a)(1)(A) scientific permit number, if applicable.
7. **Survey_Comp** (Excel format = General; GIS Type = Text, Length = 50): Name of company/organization or individual responsible for conducting surveys.
8. **Date** (Excel format = Number; GIS Type = Double): Date feature was observed. Entries should be formatted as YYYYMMDD.
9. **Feat_ID** (Excel format = General; GIS Type = Text, Length = 50): Name of feature surveyed (if not a formally named feature, develop a clear naming convention for feature IDs. E.g., “PropName_Feature##_Date”).
10. **Feat_Type** (Excel format = General; GIS Type = Text, Length = 100): Type of feature identified. Entries should be formatted as follows:
 - a. Cave
 - b. Sinkhole
 - c. Solution Cavity
 - d. Solution Enlarged Fracture
 - e. Fault
 - f. Spring
 - g. Swallet
 - h. Well
 - i. Closed Depression

- j. Bedding Plane
- k. Solution Enlarged Bedding Plane
- l. Karst Feature Zone

- 11. **Feat_Lat** (Excel format = Number; GIS Type = Double): Latitude of feature location in decimal degrees (NAD 83) with at least five decimal places.
- 12. **Feat_Long** (Excel format = Number; GIS Type = Double): Longitude of feature location in decimal degrees (NAD 83) with at least five decimal places.
- 13. **X_Dim** (Excel format = Number; GIS Type = Double): Width of encountered feature in meters.
- 14. **Y_Dim** (Excel format = Number; GIS Type = Double): Height of encountered feature in meters.
- 15. **Z_Dim** (Excel format = Number; GIS Type = Double): Depth of encountered feature in meters (prior to excavation).
- 16. **Recon** (Excel format = General; GIS Type = Text, Length = 50): Indicate with “Y” or “N” if reconnaissance excavation was conducted.

Figure 3. GIS fields requested for karst invertebrate survey data (same format for table in Excel).

KarstSurvey									
<input checked="" type="checkbox"/> Read Only	Field Name	Alias	Data Type	<input checked="" type="checkbox"/> Allow NULL	<input type="checkbox"/> Highlight	Number Format	Domain	Default	Length
<input type="checkbox"/>	Karst_Zone	Karst_Zone	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2
<input type="checkbox"/>	KFR	KFR	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				100
<input type="checkbox"/>	Personnel	Personnel	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				100
<input type="checkbox"/>	Perm_ID	Perm_ID	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Survey_Comp	Survey_Comp	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Date	Date	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Feat_ID	Feat_ID	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				50
<input type="checkbox"/>	Feat_Type	Feat_Type	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				100
<input type="checkbox"/>	Feat_Lat	Feat_Lat	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Feat_Long	Feat_Long	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	X_Dim	X_Dim	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Y_Dim	Y_Dim	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Z_Dim	Z_Dim	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input type="checkbox"/>	Recon	Recon	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				1

Appendix IV: Recovery Project Proposals

United States Fish and Wildlife Service, Section 10(a)(1)(A) Listed Karst Invertebrate Recovery Project Proposal Requirements

Permittees are prohibited from entering, excavating, or collecting from locations known to contain listed karst invertebrates until they submit a detailed recovery project proposal (previously referred to as monitoring plans) and receive written approval of that proposal from the Austin Ecological Services Office (Recovery and Candidate Conservation Branch). We approve recovery project proposals only if the proposed activities and any associated “take” will provide a conservation benefit to the species. Recovery project proposals should be submitted with the following sections and information below. These projects may include research, monitoring, or other conservation-related activities. Recovery project proposals that do not include this information will be returned to the permittees for revision.

Purpose

Thoroughly explain the purpose or hypothesis of the proposed project and how it will benefit the conservation of the listed karst invertebrates. Include any pertinent background information that supports the need for the proposed project. Explain feasibility of the research/project.

Location

- Location of caves and features to be entered and the property boundaries on either a USGS topographic map (7.5 minute or larger scale) or, if possible, in a GIS (Geographic Information System) layer with georeferenced location data (using global positioning system (GPS)), including references such as roads and political boundaries.
- Include GPS location information for each cave or feature to be entered. Also, report the GPS unit model and its accuracy, and if any real time correction or post processing will be done.
- Georeferenced data should be collected in lat-long (decimal degrees) in the North American Horizontal Datum 1983 (NAD 83) geographic coordinate system.

Personnel

- Names of all persons that will be involved in the recovery project and their precise duties.
- Each person’s section 10(a)(1)(A) scientific permit number, if applicable.
- A brief summary of experience, education, and certification for each person **NOT** holding a section 10(a)(1)(A) scientific permit who will be involved in the research.

Methods

- Describe any proposed research methodology using standards consistent with a scientific, peer-reviewed publication.
- Describe the statistical analysis that will be used to assess results such as species abundance, diversity, or other parameters.
- Describe if the entire cave will be involved in the recovery project or if transects or another sampling method will be used and how many times the cave will be entered.
- Discuss if bait traps will be used and why they are necessary for the recovery project. Include a description of the proposed baiting methodology including the type(s) of bait used, bait trap locations, the amount of time baits will be left out, and intervals when they will be checked.

Final Recovery Project Reports

Final projects should include all information from Appendix III and thorough results and discussion sections consistent with a peer-reviewed scientific publication. These reports must be included in each permittee's annual report; however, if the report is available sooner than the due date for annual reports, we request that permittees submit them sooner. If the recovery project is a multi-year project, then a progress report should be included in each permittee's annual report.

Appendix V: Protocol Revisions (2014)

United States Fish and Wildlife Service, Section 10(a)(1)(A) Listed Karst Invertebrate Survey Protocol Revisions (2014)

As part of our May 8, 2014, revision, we changed the number of surveys required to determine presence/absence of listed karst invertebrates in central Texas from 3 to 14. We based the revised number of required surveys on a study by Krejca and Weckerly (2007). This study used the program PRESENCE (Mackenzie et al. 2006) to assess detection probabilities of three troglobitic species including *Chinquipellobunus madlae*, *Batrisodes unicornis*, and the endangered *Rhadine exilis*. They concluded that 10 to 12, 22, and 14 surveys, respectively, are needed to have a 95 percent confidence interval that those species were detected if present at a given site.

Prior to our survey protocol revision, we conducted an independent peer review of Krejca and Weckerly (2007). Peer review comments support that more than three surveys (and possibly more than 14) are needed to detect the fifteen listed karst invertebrates in central Texas; however, they indicated that the number of surveys needed to detect each species may vary. Species that are relatively more abundant and conspicuous may be easier to detect and require fewer surveys than species that are relatively more cryptic, which may require many more surveys.

Although peer reviewers identified some issues with the Krejca and Weckerly (2007) report, they all indicated that more than three surveys are needed to conclude presence/absence with a high degree of confidence. Therefore, absent additional information and analysis, we are requiring 14 surveys to conclude presence/absence of the listed karst invertebrates. In addition, we are seeking advice from biostatisticians on how to analyze survey data in the future to further evaluate and potentially revise this requirement. We plan to adapt the number of required surveys, as needed, based on future analyses.

One exception to the requirement to conduct 14 surveys was included in the May 8, 2014, revisions. This exception allowed presence/absence surveys being conducted for individuals who planned to participate in the Williamson County Regional Habitat Conservation Plan (RHCP) to end when either *Texella reyesi* or *Batrisodes texanus* were detected in the North Williamson County or Georgetown Karst Fauna Regions. This was because the amount of mitigation when participating in the RHCP is the same if one or both species are found and because no other listed karst invertebrates are known from these two regions. In our April 27, 2022, revision, we removed this exception as we believe genera such as *Batrisodes* are being underrepresented in surveys because they are more difficult to detect. Although the mitigation amount for applicants is the same regardless of species, the purpose of section 10(a)(1)(A) permits, also referred to as recovery, enhancement of survival, or scientific permits is to produce information upon which to base decisions and actions for the conservation of the listed species. The knowledge gained during these surveys is important to help us better understand the range of these species and their habitat requirements as well as to facilitate recovery.

Appendix VI: Protocol Revisions (2024)

United States Fish and Wildlife Service, Section 10(a)(1)(A) Listed Karst Invertebrate Survey Protocol Revisions (2024)

As part of our August 12, 2024, revision, the following provides a brief overview of major changes made to the Karst Invertebrate Survey Protocol.

Removal of *Cicurina venii*

Cicurina venii was synonymized with *Cicurina madla* and was subsequently delisted as of 2022. As such, the updated Survey Protocol has now removed mention of *Cicurina venii* (87 FR 51925-51928).

Five-Step Approach for Determining Suitable Habitat and Presence/Absence of Listed Species

The karst zones in both the Austin and San Antonio areas have been updated in Veni and Jones (2021) and Veni, Cooper, and Dickerson (2024), respectively. This has resulted in the development of unified karst zone definitions between each area-specific data set. Moreover, to lessen the risk of unauthorized take under the Endangered Species Act, habitat assessments are now required to be conducted by a valid karst invertebrate Section 10(a)(1)(A) permit holder. The Five-Step Approach (Figure 1) has changed to reflect the requirements for habitat assessments and to reflect the karst zone revisions and the extension of the karst zones 1, 2, 3a, and 3b into Bell, Comal, and Medina Counties. The Service now recommends that evaluation of suitable karst invertebrate habitat include Bell, Bexar, Comal, Medina, Travis, and Williamson Counties, and that karst feature surveys be conducted within a subject property if it is within zones 1, 2, 3a, or 3b, or within 500 feet of the boundaries of these zones.

Addition of Recommended Surface Sampling

In addition to *in situ* survey of karst features, surveys of the surface environment within a 32.8-ft (10-m) radius of a natural karst feature surface expression are recommended during at least three of the 14 survey events. Recent studies (e.g., Ledford et al. 2011; Derkarabetian et al. 2022; Ledford 2023) have determined that some listed karst invertebrates (*Tayshaneta*, *Texella*) may not exclusively inhabit subterranean habitats. Instead, they may be associated with other surface microhabitats in proximity to the natural surface expressions of karst features, including leaf litter, rotting logs, and rocky breakdown such as scree and talus slopes. Surface surveys should only employ exploratory visual or hand-sift search approaches.

Report Requirements

Both karst feature surveys with accompanying habitat assessments and karst invertebrate presence/absence surveys are now required for all karst invertebrate Section 10(a)(1)(A) permit holders.

Karst Invertebrate Survey Data Submittals

The Service now requires that karst invertebrate habitat assessments and presence/absence survey data be submitted in either an Excel spreadsheet or a GIS feature class/shapefile (point data). Feature footprint must be submitted in a GIS feature class/shapefile (polygon data) when feature mapping is

associated with a habitat assessment or presence/absence survey. All survey data for a given survey year should be submitted as one file per permit (e.g., all surveyors, all locations, and all data within and among locations must be included in a single file). Failure to submit data in accordance with the instructions provided in the updated Survey Protocol will be considered an incomplete annual report submission.