United States Fish and Wildlife Service
Section 10(a)(1)(A) Scientific Permit Requirements
For Conducting Georgetown, Jollyville Plateau, and Salado Salamander Surveys

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Introduction

This document outlines the U.S. Fish and Wildlife Service's (Service) requirements for conducting surveys for the federally listed threatened Georgetown (*Eurycea naufragia*), Jollyville Plateau (*Eurycea tonkawae*), and Salado (*Eurycea chisholmensis*) salamanders as conditions of holding a section 10(a)(1)(A) permit. These salamanders are referred to collectively as "Northern Edwards salamanders" in this document. Section 10(a)(1)(A) permits, also referred to as recovery, scientific, or enhancement of survival permits, allow for "take" of listed species that may or will occur while conducting research or other activities to enhance the survival of the species (see *When a Section 10(a)(1)(A) Scientific Permit is Needed* below). This document outlines methods to be used and information to be included in annual reports for a section 10(a)(1)(A) permit.

The objective of this document is to identify survey methods (including surface counts, capture-mark-recapture, occupancy, and other presence/absence surveys) that will produce sound scientific information upon which to base decisions and actions for the conservation of the Northern Edwards salamanders. Using consistent survey methodology will also allow for greater comparison and analysis of results, and thereby increase our understanding of these species and their habitat requirements. Please note this document supersedes any previous guidance from the Service on conducting surveys for the Northern Edwards salamanders. Information that relates to the effectiveness of these survey guidelines in conserving the Georgetown, Jollyville Plateau, or Salado salamanders is welcome. We will consider modifications of, or alternatives to, these methods as new information becomes available.

For work requiring a section 10(a)(1)(A) permit other than conducting field demographic surveys (for example, research, management, or captive propagation activities), applicants should include a detailed description of their proposed methodology and how the work is expected to benefit the species. Such applications will be approved on a case-by-case basis with consideration given to (1) the amount of "take" anticipated by the proposed action(s), (2) the qualifications and credentials of individuals that will conduct the proposed action(s), (3) the likelihood that the proposed action(s) will contribute to recovery of the Northern Edwards salamanders, and (4) any other factors we deem appropriate to consider at the time of our review.

This document also provides guidance on when you might be at risk of "taking" a Northern Edwards salamander while conducting field surveys and when it is advisable to have a Section 10(a)(1)(A) permit issued by the Service under the Endangered Species Act of 1973, as amended (Act), to be covered for "take." (See *When a Section 10(a)(1)(A) Scientific Permit is Needed* below for the definition of "take").

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

The purpose of a section 10(a)(1)(A) permit is to authorize specific individuals under the Act to conduct activities that may result in take of a listed species, but ultimately enhance its survival or contribute to its recovery. For example, collecting an endangered species is a form of "take" and therefore, is prohibited under section 9 of the Act, unless the collection (or "take") is covered under a section 10(a)(1)(A) scientific permit. "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" in the process of conducting Georgetown, Jollyville Plateau, or Salado salamanders surveys include

- collecting individuals;
- crushing individuals inadvertently;
- compacting habitat;
- disturbing cover objects;
- excavating caves, which could result in removal or alteration of habitat;
- harming or harassing individuals by introducing noise, light, chemicals, or biological substances (such as microbes) into their environment; and
- possibly other actions that would cause individuals to flee, seek shelter, or alter or cease normal feeding, breeding, and sheltering behavior.

The potential for "take" exists with entry into a water body or other feature where Northern Edwards salamanders may occur. Therefore, the Service recommends that all activity that is being conducted to benefit the species and that involves excavating, entering, or collecting in a spring, cave, or other aquatic areas that may contain suitable habitat for these species be covered under a valid 10(a)(1)(A) permit for the Northern Edwards salamander species in the area being surveyed or be under the direct supervision of a 10(a)(1)(A) permittee.

For information on how to apply for a 10(a)(1)(A) permit, contact the Region 2 Permits Office at (505) 248-6663 or access the application form directly at http://www.fws.gov/forms/3-200-55.pdf.

Requirements for Conducting Salamander Surveys

These requirements cover a variety of survey types for a variety of purposes that may be covered in a 10(a)(1)(A) permit. Permittees must refer to their permit for the types of activities or surveys they are allowed to conduct. Permittees must then refer to the appropriate sections below that correspond to the type of activities for which they are permitted.

General Data Collection Diligence and Thoroughness for All Survey Methods

- All field gear (including footwear) that comes into contact with animals, water, or soils must be cleaned and disinfected between survey sites to prevent inadvertent movement of disease or

parasitic organisms among sites. Disinfection is accomplished by putting four ounces of bleach in one gallon of clean water and using the solution to rinse off all field gear prior to going to another site. The bleach solution must be allowed to evaporate from the gear and equipment, or rinsed off after a minimum of 15 minutes of contact. Other disinfectants, such as ethanol or those containing quaternary ammonium compounds, may also be used instead of bleach according to national protocols developed by the Declining Amphibian Task Force (p. 1) or the White Nose Syndrome Decontamination Team (2012, p. 1). Disinfection must occur away from salamander habitat. Disinfection between sites is not required if the sampling sites are along the same tributary.

- Efforts must be made to avoid stepping within the habitat before it is searched. If stepping into the habitat is required, stepping on cover objects greater than 25 mm (.98 in) must be avoided.

- All structure objects must be returned to the stream after they are moved or removed during the survey.

- Effort must be made to characterize the salamander habitat at each surveyed site. This characterization must include all three elements described in the section Characterizing Salamander Habitat below.

- Measurements of habitat should occur the day of the salamander survey, but before the salamander survey disrupts the substrate.

- Surveying for salamanders in caves must also follow the requirements listed above, as appropriate for cave environments.

- If the goal is to monitor salamander population dynamics over time, sampling designs must incorporate a method for estimating detection probability at each sampling site, such as the use of capture-mark-recapture or occupancy methods (Mazerolle *et al*. 2007, pp. 674-677; Collier and Fenolio 2009, pp. 229-230). Estimating detection probabilities allows robust assessments of population sizes and trends over time, and allows data from different sites to be compared reliably (Dodd and Dorazio 2004, p. 469; Mazerolle *et al*. 2007, p. 673). We have described acceptable sampling designs for monitoring salamander population dynamics in the sections below.

- **All survey programs conducted at known salamander locations must be approved in writing by the Austin ESFO before their initiation.** This will help us monitor which locations are being studied and prevent possible over-disturbance due to multiple concurrent studies.

- The type of survey method employed by a researcher will depend upon the specific research question and available resources. The sections below describe accepted demographic survey methods for known salamander locations (capture-mark-recapture, surface counts, and occupancy) and procedures for inferring absence of salamanders at undocumented locations. See conditions for these specific methodologies below.

- Also see Reporting Requirements below for information that will need to be included in your annual report.

Capture-Mark-Recapture (CMR) Surveys

- **To estimate salamander abundance, survival, and recruitment at salamander sites, permit holders must use an open population model design in their CMR survey** (Pollock *et al*. 1990, pp. 18-30). A robust design that combines open and closed models (Pollock 1982, entire; Kendall *et al*. 1997, pp. 564-570) may also be used in lieu of an open model to estimate migration, as implemented by Bailey *et al*. (2004, pp. 3-7) and O'Donnell *et al*. (2008, pp. 11-16).

- Researchers should follow the methods presented in Bendik *et al*. 2013 (pp. 2-5) to "mark" captured individuals using digital photographs of the pigment patterns. Visible implant elastomer marking must not be used unless prior written approval is given to the permit holder by the Austin ESFO.

- Salamanders may be captured using either nets or any of the methods described in the section Trapping below. All trapping must follow the requirements listed under the section Trapping below. Efforts must be made to minimize the handling time.

- The length of individual salamanders from snout to vent must be estimated or measured to determine the relative proportion of juveniles and adults.

- Captured salamanders must be released as close to where they were captured as possible.

- Captured salamanders must be kept in fresh spring water with stable temperatures at all times.

- Data on habitat (see methods on obtaining habitat characteristics in the section Characterizing Salamander Habitat below) must also be collected during CMR surveys.

- CMR surveys must also follow the requirements under the section General Data Collection Diligence and Thoroughness for All Survey Methods above.

Surface Count Surveys

- **Researchers should implement surface count surveys to estimate salamander abundance only when time and resources do not allow for more intensive CMR surveys**. Salamander abundance can be estimated from simple surface counts using N-mixture models that incorporate detection probability. Count surveys must be designed in a way that allows analysis by N-mixture modeling (Royle 2004, entire; Price *et al*. 2012, pp. 196-197; Zipkin *et al*. 2014, entire).

- Count surveys must vc only be implemented if the survey design includes repeated counts at a specific site over a short period of time (Nichols 2013, pers. comm., Salvidio 2013, pers. comm.). This must be a period of time where the population is considered closed (that is, no births, deaths, immigration, or emigration is occurring) (Royle 2004, p. 109; Zipkin *et al*. 2014, pp. 24, 28). We require that this period lasts no longer than seven days. Large rainfall events should not occur between repeated counts because flooding can temporarily remove all salamanders from the surface.

- Count surveys should use an area-constrained survey technique, such as the drive method, to avoid double counting salamanders. In the drive method, a consistent search area is established by marking the ends of a stream segment of any length. Observers start at the downstream end of the segment and systematically remove cover objects to create an open area stretching across the width of the stream, bank-to-bank. This open area is continuously backfilled with upstream cover objects as more area is searched with the observer moving upstream toward the end of the segment. Only salamanders that move downstream to the observer and cross the open area of substrate created are counted. All moveable cover objects within the search area must be searched by the end of the survey.

- The length of individual salamanders from snout to vent must be estimated or measured to determine the relative proportion of juveniles and adults.

- Data on habitat (see methods on obtaining habitat characteristics in the section Characterizing Salamander Habitat below) must also be collected during surface count surveys.

- Surface count surveys must also follow the requirements under the section General Data Collection Diligence and Thoroughness for All Survey Methods above.

Occupancy Surveys

- **Researchers wishing to study how the Northern Edwards salamanders are distributed across a large cave or stream system should use occupancy modeling** as described in MacKenzie *et al.* 2006 (entire). Occupancy sampling designs can also be used to monitor species persistence over time and space in a cost-effective manner.

- Methods must be comparable to those used by Bailey *et al*. 2004 (pp. 694-695) and Bendik 2013 (pp. 12-14).

- In addition to documenting the presence and absence of salamanders, data on habitat (see methods on obtaining habitat characteristics in the section Characterizing Salamander Habitat below) must also be collected during the surveys. These data should be incorporated into the occupancy model as covariates.

- Occupancy surveys must follow the requirements under the section General Data Collection

Diligence and Thoroughness for All Survey Methods above.

Surveys to Infer Absence of Salamanders from an Undocumented Site

This section describes methodology for conducting surveys to infer absence of salamanders from previously undocumented sites. A site is certainly "occupied" if the species is detected at that site, but failure to detect a species during all sampling occasions does not necessarily imply the species is absent (Mazerolle *et al*. 2007, p. 679). No study has been completed on Georgetown, Jollyville Plateau, or Salado salamanders that estimates how many visual surveys are necessary to infer with a high degree of confidence that the species is absent from a site. This information is important for determining the status of sites that have the potential but have not been surveyed for salamanders. Several sites within the ranges of the Georgetown, Jollyville Plateau, and Salado salamanders have either never been surveyed for the presence of salamanders or only searched a few times. The sections below describe our approach for determining the minimum number of surveys needed to be 95 percent confident that a surface or subsurface site is unoccupied. (**NOTE**: To determine if a site is occupied by salamanders, a thorough search of the surface habitat alone is not adequate because salamanders may also occupy subsurface habitat at the site. Procedures under both surface and subsurface habitat below must be conducted for spring and stream sites.)

Surface Habitat

To estimate the number of surveys needed to infer absence at a surface site, we used existing data for the Jollyville Plateau salamander. Bendik (2013, p. 16) reports baseline estimates of detection probability and occupancy for four tributaries (Bull Creek mainsteam/Tributary 8, Bull Creek Tributary 7, Bull Creek Tributary 4, and Barrow Hollow). There has not been an occupancy study conducted for the Georgetown or Salado salamanders.

Because Georgetown and Salado salamanders are generally less abundant than Jollyville Plateau salamanders and are therefore harder to detect, we decided to use the lowest estimate of detection probability for the Jollyville Plateau salamander and conservatively apply it to the other two species. The lowest detection probability that Bendik (2013, p. 16) reports is 0.37 with a standard error of 0.19 for Tributary 7. We took the lower bound of this estimate (0.37 – 0.19 = 0.18) and used it to represent the expected detection probability (p') to be applied to all Georgetown, Jollyville Plateau, and Salado salamander locations.

To calculate the number of sequential non-detections required to infer absence, one must consider the expected rate of occupancy (Wintle *et al*. 2012, p. 418). Because surveys to determine absence of salamanders will likely be conducted in areas that have not had occupancy studies conducted in the past, we decided to use 0.5 to represent the expected rate of occupancy (Ψ'). This means that, due to a lack of data, we are assuming all undocumented sites have a 50 percent chance of being occupied by a Northern Edwards salamander.

Using the two values of expected occupancy and detection probability discussed above, we calculated the minimum number of sequential surveys necessary to be 95 percent certain that a

salamander species was absent from a site (N_{min}) using the equation provided by Wintle *et al*. (2012, p. 419). For the posterior probability of occupancy (Ψ), we used 0.05. This means that we want the proportion of occupied sites in which we failed to detect the species to be limited to 5 percent (that is, 100 percent – 95 percent confidence).

$$N_{min} = \frac{\log\left(\frac{\psi}{1-\psi}\right) - \log\left(\frac{\psi'}{1-\psi'}\right)}{\log(1-p')}$$

$$= \frac{\log\left(\frac{0.05}{1-0.05}\right) - \log\left(\frac{0.5}{1-0.5}\right)}{\log(1-0.18)}$$

$$= \frac{\log(0.0526) - \log(1)}{\log(0.82)} = \frac{-1.2790}{-0.0862} = 14.8$$

- Therefore, to determine if surface habitat is occupied by salamanders, **we require there to be at least 15 sequential visual surveys performed using methodology described below**. If a salamander is detected, surveys can cease.

- All cover objects within the survey area must be searched in each survey. The survey effort must be at least ten person minutes (for example, at least two observers searching for five minutes each).

- There are no limits on the size of the survey area; however, the inference of absence will only apply to the specific area surveyed. For example, if the absence of salamanders in a 100 m (328 ft) stream stretch needs to be confirmed, all 100 m (328 ft) needs to be searched in each of the 15 surveys. The extent of the survey area cannot change between consecutive surveys.

- Consecutive surveys must be conducted at least 24 hours apart.

- Surveys must follow the requirements under the section General Data Collection Diligence and Thoroughness for All Survey Methods above.

- Surveys must be conducted under the conditions listed in the *Suitable Sampling Conditions for Surveys to Infer Absence* section below.

Assumptions of our minimum number of surveys estimate are as follows:

- *The expected detection probability (p') used in the equation above applies to all Georgetown, Jollyville Plateau, and Salado salamander sites*. We recognize that this detection probability is from a single tributary with a rural watershed (less than 1 percent impervious cover) and relatively high salamander abundances. Capture probabilities from sites within urbanized watersheds or lower salamander abundances may have lower detection probabilities. However, we are not aware of studies that have calculated detection probabilities for Georgetown, Jollyville Plateau, or Salado salamander sites other than the four we have reported here. As these data are collected by permit holders in the future, we may revise our estimated minimum number of surveys needed to infer absence of the species. This number may also vary by species.

- *The expected detection probability (p') used in the equation above applies to all seasons*. The capture probabilities from Bendik (2013, p. 12) were generated from data collected between March and May of 2012 and thus may not represent capture probabilities in winter months. In addition, detection probability may vary year to year. As more data are collected in the future, we will revise our estimated minimum number of surveys needed to infer absence of the species.

- *The occupancy of an unsurveyed site is 0.5*. We used an uninformative rate of occupancy in the equation above to represent uncertainty about the occupancy of a given site. Wintle *et al*. (2012, p. 422) noted that using an uninformative rate of occupancy is an option if data are missing, but it may greatly overestimate the number of surveys required. Using habitat data from Bendik (2013) to adjust the expected occupancy of a site may result in a more site-appropriate occupancy rate. For example, Bendik (2013, p. 16) found that water depth significantly influenced the occupancy of a site. Sites with deeper water are less likely to be occupied, and would consequently require less surveys to infer absence. Additional data and future analyses may allow us to create a gradient of N_{min} that is dependent on habitat metrics.

- *The surveys are independent*.

- *The "Suitable Sampling Conditions for Surveys to Infer Absence" listed below are met*.

Subsurface Habitat

- To determine if a site is occupied by salamanders, a thorough search of the surface habitat is not adequate. Trapping must also be used to test whether salamanders are occupying the subsurface environment of the spring or stream segment. Depending on the physical structure of the site, trapping may be accomplished by either drift nets or bottle traps.

- We are not aware of published methods that describe how long to sample subterranean salamanders using drift nets. However, the San Marcos Aquatic Resource Center regularly

samples for Texas blind salamanders (*Eurycea rathbuni*) using drift nets for two-week periods at several sites, checking the nets twice a week (SMARC 2014, p. 1). Therefore, **we require that the drift net be placed over the orifice of the spring for a period no shorter than two weeks**. **The drift net must be checked at least twice a week while it is deployed. If the site is located in a public area without restricted access, the net must be checked every 24 hours to prevent possible vandalism.**

- At stream or spring sites where placing a drift net is not physically possible, bottle traps may be used to increase the chances of capturing a salamander that emerged from the subsurface habitat. **Bottle traps Bottle traps must be deployed for a period of no less than seven days at spring or stream sites (Willson and Dorcas 2003, p. 128), with the traps being checked at least every 24 hours**. **For cave and borehole locations, traps must be deployed for at least two weeks and checked at least twice a week**. Traps require more frequent checks on the surface compared to subsurface site due to the relatively greater potential for disturbance by humans and wildlife (for example, raccoons and birds). In addition, cave-adapted salamanders have been shown to have much lower metabolic rates than surface-dwelling salamanders in order to withstand long periods of starvation in their low-energy environment (Hervant *et al*. 2000, pp. 1428-1429; Hervant *et al*. 2001, pp. 271-272).

- We encourage permittees to deploy traps during every visual search survey. However, if no salamanders are detected by the eleventh survey then traps **must** be used in addition to surveying.

- **When bottle traps are deployed, at least one bottle trap per square meter (10.8 ft^2) of wetted habitat must be used**. After checking, each trap should be moved within the habitat to ensure thorough trapping of all possible microhabitats within the area (Willson and Dorcas 2003, p. 128).

- If human exploration is possible within subsurface locations (such as caves or wells), at least 15 visual successive surveys (according to the methodology described above) must also be performed at these sites, in addition to the methods described above.

- **All trapping must follow the requirements listed under the section <u>Trapping</u> below**.

- Passive traps such as leaf litter bags or mop heads cannot be used to infer absence because salamanders can freely move in and out of these traps.

Suitable Sampling Conditions for Surveys to Infer Absence

- Surveys may be conducted any time of year as long as the conditions below are met; however, at least half of the 15 surveys (8) should be conducted during the spring or summer (April 1 through September 1) when detection probability is highest. Juvenile and total abundance of Jollyville Plateau and Georgetown salamanders typically increases in

spring and summer compared to fall and winter (Bowles *et al*. 2006, p. 118; Pierce 2012, pp. 10–11, 18, 20). In the absence of contradictory evidence, we assume that Salado salamander abundance follows the same seasonal pattern.

- The site must not be dry; some flow (base flow for visual surveys and base or storm flow for drift net/bottle trap surveys) or cave pools must be present. The spring's discharge during the survey period should be at least high enough to provide useable habitat for a salamander, as evaluated by the researcher's best judgment. If a site is dry, surveys cannot be performed and absence cannot be assessed.

- There must be an absence of recent, extensive, local flooding that may have temporarily removed salamanders or cover objects from the site.

<u>Specimen collection and preservation</u>

- Permittees are authorized to collect no more than three adult voucher specimens (for positive identification) per site from previously **undocumented** locations.

- No more than one voucher specimen per year may also be collected from known locations if the individual salamander appears to be significantly different than other salamanders normally observed at that site.

- Voucher specimens must be delivered with precise locality and observer information within 30 days of collection to either the Texas Natural History Collections at University of Texas-Austin, the Amphibian and Reptile Diversity Research Center at University of Texas-Arlington, Dr. Andrew Gluesenkamp (Texas Parks and Wildlife Department, at (512) 389-8722), or another public facility approved by the Austin ESFO in writing.

- Salamanders collected as voucher specimens should be maintained or preserved as follows (in order of preference):

  - maintained alive in aquaria with spring ambient conditions for the short-term (one or two weeks unless otherwise approved by the Austin ESFO in writing) until disposition of tissue samples (i.e., liver, muscle, or both) and the voucher specimen can be arranged, or

  - fixated in 95 to 100 percent ethanol (not denatured), or

  - (i) have the liver tissue (or other mitochondrial DNA-rich tissue such as muscle) excised and preserved in 95 to 100 percent ethanol or ultra cold conditions [-49°F to -121°F (-45°C to -85°C)], (ii) the rest of the specimen be fixed in 10 percent buffered formalin solution for 1 day, (iii) rinsed in water at least three times (rinse an additional two times after the formalin smell is completely gone), and (iv) be preserved in 95 to 100 percent ethanol (Cannatella and LaDuc, University of Texas-Austin, 2014, pers. comm.)

- Prior to preservation, all voucher salamanders must be humanely euthanized using any of the non-physical methods approved by the American Veterinary Medical Association (2013, pp. 76-78).

- Although laboratory and mesocosm experiments have shown no adverse impacts of tail clipping to the growth or survival of some salamander species (Vaglia *et al*. 1997, p. 27; Polich *et al*. 2013, p. 1424), we are not aware of any similar studies or field observations that have been conducted on central Texas *Eurycea* salamanders. Therefore, we allow tail-clipping by permittees for the purpose of obtaining genetic information **only after a study plan describing how many individuals from each site will be tail-clipped has been approved in writing by the Austin ESFO**. No more than 20 percent or 5 mm (0.2 in) of the tail (whichever is less) may be clipped (Gluesenkamp 2014, TPWD, pers. comm.).

Trapping

- Drift nets may be placed over spring outlets to capture salamanders from subsurface habitat.

- If an obvious spring outlet is not present or it is too difficult to use a drift net (for example, in boreholes or low flowing alluvial springs), plastic bottle traps should be constructed and used according to the methods presented in Willson and Dorcas 2003 (p. 128). Minnow traps or an Ortmann funnel trap can also be used, as described in Dreschsler *et al*. 2010 (pp. 14-15). All traps must have several small holes to allow water to flow through.

- All traps must be secured in a way that allows them to be retrievable at the end of the survey. Strings and knots used to deploy traps should be inspected for loosening or 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. Traps should be removed before periods of heavy rainfall and high flow events.

- All animals must be removed from nets and bottle traps at each visit.

- Bait may be used in the bottle traps to facilitate capture. Potato peels, pistachios, and brine shrimp have been used successfully in the past for other *Eurycea* species.

- Passive traps, such as leaf litter bags or mop heads, may also be used to capture salamanders, but not for inferring absence. These traps must be anchored to prevent loss during normal flow. Traps should be removed before periods of heavy rainfall and high flow events.

- Permittees may follow procedures detailed by Jung and Pauley (2003, entire) or Waldron *et al*. (2003, pp. 25-26) to construct and deploy leaf litter bags. However, gravel may not be used in leaf litter bags without first being approved by the Austin ESFO in writing on a case-by-case basis, as rocks may harm salamanders when the bags are checked.

Characterizing Salamander Habitat

- Data on salamander habitat must include the following three elements:

    1. **Description of the substrate for each site**. This involves estimating the amount of embeddedness and the composition of substrate within at least three randomly assigned sample points within the surveyed area.
        - Embeddedness measurements must follow the EPA EMAP method described in Sennatt *et al*. 2006 (p. 1674). At each sampling point, all particles larger than sand in a 10 cm diameter circle surrounding the point are visually examined. The fraction of each particles's upper surface surrounded by fine sediment (< 2 mm) is recorded. Sand and finer substrates are considered 100 percent embedded.
        - Within each circular sample point, surveyors should also estimate the percentage of particles that fall within each category of a modified Wentworth scale; see Appendix I).

    2. **Basic water chemistry measurements**. This includes dissolved oxygen, specific conductance, pH, and temperature.

    3. **Some measure of water quantity.** This may include such measures as spring discharge, stream/pool depth, stream/pool width, and/or flow rate. We prefer that spring discharge and flow rate are reported, but we understand the physical limitations of certain sites and equipment will not allow for the measurement of these metrics.

Reporting Requirements

Annual reports are **required** from all section 10(a)(1)(A) permittees. Survey reports must include the following information:

Personnel

- Names of all persons involved in the salamander surveys and their duties
- The section 10(a)(1)(A) scientific permit number under which work was conducted
- Person(s) directly responsible for writing the report

Location

- Locations of all sites surveyed (regardless of whether salamanders were found or not) on either a U.S. Geological Survey quad map (7.5 minute or larger scale) or, if possible, in a GIS (Geographic Information System) layer with georeferenced survey location data (using global positioning system (GPS)), including references, such as road names and political boundaries
- GPS point of each spring outlet, cave opening, and other potential habitat features (also include these on the map above)
- Survey area of each site should be described or mapped in relation to the spring outlet (if present) or cave opening

- If the permittee is trained in local geology, please provide a general description of the geology of each area surveyed
- General description of the land use immediately surrounding each area surveyed. This includes signs of vandalism or possible sources of water quality contamination (sewer lines, drainage pipes, etc.).

Methods

- Survey methodology descriptions using standards consistent with methods described above
- Dates and times of each survey conducted
- Report weather conditions (including amount of rainfall and temperature) on the survey day and previous week
- Report total time spent searching for salamanders (in person-hours) at each site

Survey Results

- The number and length of all observed salamanders, sorted by site and survey date
- Any analyzed data and descriptions of how the values were calculated
    - For occupancy and surface count surveys, estimates of detection probability for each site and survey period must be included
    - For CMR surveys, estimates of abundance, recruitment, and survival for each site must be included
- Both **positive and negative survey results** for each survey conducted in each survey area
- Notable observations on salamander behavior or body condition when surveyed (including gravid females)
- Observations of marked (with visible implant elastomer) salamanders
- Results of any species identification performed by a taxonomist and the method used to delineate that individual to species with the report from the taxonomist
- Location and accession numbers of all specimens collected as vouchers
- Any lost or irretrievable traps

Habitat Characteristics (see Characterizing Salamander Habitat *above for more details)*

- We prefer that all habitat data be reported in raw form. However, it may also be presented as averages per site with standard deviations, the number of observations, and minimum and maximum values.
- Variables reported must include:
    - Embeddedness
    - Composition of substrate
    - Dissolved oxygen
    - Specific conductance
    - pH
    - Water temperature
    - Some measure of water quantity (for example, discharge, flow rate, or water depth)

Caves and Karst Features

- Describe each cave or feature surveyed and include a detailed, scaled cave map with plan and

profile views.

- Description or map must include:
  - The approximate passable length of the cave or feature.
  - The approximate heights and widths of passages
  - Locations of any standing or flowing water and direction of any water movement.
- Describe the interior of each cave or feature surveyed including:
  - Principle formations and whether they are active.
  - Approximate area for any water and approximate width, length, depth, and flow rate.
  - Water temperature, air temperature, [to the nearest 0.1°F (0.2 °C)] and relative humidity (to the nearest 1 percent). Indicate the brand and model of the equipment used and the equipment's degree of accuracy. Air 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.
  - Report any indications of "bad air," (for example, high CO_2 levels or any noxious gas) and reference to labe led locations on the cave map.

Literature Cited

American Veterinary Medical Association. 2013. AVMA Guidelines for the Euthanasia of Animals: 2013 Edition. 102 pp.

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Appendix I

MODIFIED WENTWORTH SCALE
SUBSTRATE CLASSIFICATION

CODE	CLASSIFICATION	SIZE (MM)
0	ORGANICS	MISC ORGANIC DEBRIS
1*	CLAY	<0.004
2	SILT	0.004 < 0.062
3	SAND	0.062 – 1
4	COARSE SAND	1 – 2
5	GRANULE	2 – 4
6	SMALL GRAVEL	4 – 8
7	MEDIUM GRAVEL	8 – 16
8	LARGE GRAVEL	16 – 32
9	RUBBLE	32 – 64
10	SMALL COBBLE	64 – 128
11	LARGE COBBLE	128 – 256
12	SMALL BOULDER	256 – 512
13	MEDIUM BOULDER	512 – 1024
14	LARGE BOULDER	>1024
15	BEDROCK	SOLID SUBSTRATE

* — CLAY WILL FORM INTO A THIN SHEET WHEN ROLLED BETWEEN FINGERS.