# BALCONES CANYONLANDS PRESERVE

# LAND MANAGEMENT PLAN

## TIER II-A

## CHAPTER IX

## KARST SPECIES MANAGEMENT



October 2015

Balcones Canyonlands Conservation Plan (**BCCP**) and the

Balcones Canyonlands Preserve (**BCP**)

The **Balcones Canyonlands Conservation Plan** (**BCCP)** is a federal Endangered Species Act (ESA) incidental "take" permit for 30 years issued to Travis County and the City of Austin on May 2, 1996 by the US Fish and Wildlife Service (USFWS). Incidental take is the loss of federally listed species or their habitats in the course of (or "incidental to") otherwise legal actions, like development. Such permitting is authorized under ESA Section 10(A)(1)(b), so sometimes the BCCP is called a "10A Permit."

A collection of documents guides BCCP implementation: our Endangered Species Act Permit No. TE 788841-2, the BCCP Final Environmental Impact Statement and Habitat Conservation Plan, the Travis County – City of Austin Interlocal Agreement – Shared Vision, Permit Area and Fee Zone Maps and **tiered Land Management Plans**.

These documents together provide the permit conditions, mitigation requirements, land acquisition areas (also known as the **Balcones Canyonlands Preserve** or **BCP**), management guidelines, and mechanisms by which the City and County can cover the impact of endangered species habitat loss in western Travis County and expedite development projects within the Permit Area.

The Land Management Plans are tiered:

| | |
|---|---|
| Tier I | Overview of the Preserve and Partner Responsibilities |
| Tier II A | BCP Land Management Guidelines (Specific Best Practices) |
| Tier II B | BCCP Administration |
| Tier II C | BCP Macrosite Requirements |
| Tier III | BCP individual tract plans |

This plan outlines best practices for **Karst Management, Tier II A-9.**

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## 1.0 PURPOSE

This document outlines the policies and strategies for BCP cave and karst management; individual feature management specifics are outlined in the Tier III Land Management chapter for each BCP Unit or tract.

## 2.0 BACKGROUND

The regional ESA Section 10(a)(l)(B) permit (TE 788841-2), also known as the Balcones Canyonlands Conservation Plan (BCCP), requires the creation of the Balcones Canyonlands Preserve (BCP), protection of 62 karst features, and a high standard of protection, stewardship and adaptive management to secure habitat in perpetuity and protect populations of eight endangered species (ES) and 27 species of concern (SOC). The City of Austin and Travis County (Permit Holders), Lower Colorado River Authority (LCRA) and the City of Sunset Valley (Managing Partners), and other cooperating entities (e.g. private landowners, Travis Audubon, the City of Lakeway, Texas Cave Management Association, The Nature Conservancy of Texas) own and manage BCP species, habitats, and ecosystems.

### 2.1 COVERED SPECIES

Six endangered karst invertebrate species (**Table 1**) and 25 karst SOC are covered by the BCCP (**Table 2**). If these 25 SOC become federally listed as threatened or endangered, no additional mitigation by the Permit Holders would be required if all of the karst protection outlined in the BCCP is fully implemented.

**Table 1. Federally Listed Karst Species Covered by the BCCP**

*Footnotes follow table*

| Common Name | Scientific Name |
|---|---|
| Tooth Cave pseudoscorpion | *Tartarocreagris texana* |
| Tooth Cave spider | *Tayshaneta myopica*[1] |
| Tooth Cave ground beetle | *Rhadine persephone* |
| Kretschmarr Cave mold beetle | *Texamaurops reddelli* |
| Bee Creek Cave harvestman | *Texella reddelli* |
| Bone Cave harvestman | *Texella reyesi* |

[1] *Tayshaneta myopica* is listed in the regional permit as *Neoleptoneta myopica*, but a 2012 study revised the genus *Neoleptoneta,* thus identifying this species in the genus *Tayshaneta* (Campbell et al. 2012).

## Table 2. Karst Species of Concern Covered by the BCCP

*Footnotes follow table*

| Common Name | Scientific Name |
|---|---|
| Flatworm | *Sphalloplana mohri* |
| Ostracod | *Candona* sp. nr. *stagnalis* |
| Isopod | *Caecidotea reddelli* |
| Isopod | *Trichoniscinae N. S.* |
| Isopod | *Miktoniscus N. S*. |
| Spider | *Cicurina bandida* |
| Spider | *Cicurina cueva* |
| Spider | *Cicurina ellioti* |
| Spider | *Cicurina reddelli* |
| Spider | *Cicurina reyesi* |
| Spider | *Cicurina travisae* |
| Spider | *Cicurina wartoni* |
| Spider | *Tayshaneta concinna*[1] |
| Spider | *Tayshaneta devia*[1] |
| Spider | *Eidmannella reclusa* |
| Pseudoscorpion | *Aphrastochthonius* N. S. |
| Pseudoscorpion | *Tartarocreagris comanche*[2] |
| Pseudoscorpion | *Tartarocreagris reddelli* |
| Pseudoscorpion | *Tartarocreagris intermedia* |
| Pseudoscorpion | *Tartarocreagris* N. S. 3 |
| Harvestman | *Texella spinoperca* |
| Millipede | *Speodesmus* N. S |
| Ground Beetle | *Rhadine s. subterranea* |
| Ground Beetle | *Rhadine s. mitchelli* |
| Ground Beetle | *Rhadine austinica* |

[1] *Tayshaneta concinna* and *Tayshaneta devia* are listed in the regional permit with the genus *Neoleptoneta*, but a 2012 study revised the genus *Neoleptoneta,* thus identifying these species in the genus *Tayshaneta* (Campbell et al. 2012).
[2] *Tartarocreagris comanche* is improperly listed in the regional permit as the New Comanche Trail Cave harvestman.

Species descriptions for endangered karst species known to occur in Travis County can be found in the Biological Advisory Team (BAT) report (1990), Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (USFWS 1994), and USFWS 5-year reviews (USFWS 2008, 2009a, 2009b, 2009c).

## 2.2 FEATURES AND RELATIONSHIP TO BCCP SPECIES

Western Travis County is characterized as a strongly dissected limestone outcrop tableland, bordered abruptly on the east by the Balcones fault zone or Balcones Escarpment (Amos and Gehlbach 1988). In addition to surface habitat, the underlying karstic limestone, highly fractured and full of solution cavities, provides diverse subterranean habitats for specially adapted invertebrate and vertebrate species. The cave environment of central Texas, including that within the permit area, has been recognized to support one of the most important cave faunas in the world (Elliott and Reddell 1989).

The regional permit seeks to prevent the loss of caves known to contain federally endangered species covered by the Permit and includes protection for significant features, karst clusters, and preserves. The regional permit, when fully implemented, will protect 35 of the 39 endangered species caves in Travis County that were known when the permit was issued in 1996. In addition, under the permit, 27 caves are proposed to be protected that support SOC for a total of 62 karst features to be protected under the BCCP. These SOC caves are recommended for protection because they support rare invertebrate species and are also important recharge features. These karst features provide water to be recharged to the Edwards Aquifer and help to protect the water quality of the Austin area. **Table 3** depicts **62 BCCP Karst Features - Current Ownership**.

Three cave clusters (**Figure 1: BCCP Cave Clusters**) have been identified within the BCCP permit area and also immediately outside the permit area to the northeast: the Four Points Cluster (includes the area northwest and northeast of the FM 2222/RM 620 intersection), the McNeil Cluster, and the Northwood Cluster. The Northwood and McNeil clusters occur in close proximity to each

other in the vicinity of Walnut Creek near Howard Lane and McNeil Drive in North Austin. Twenty-seven of the 62 karst features (62 = 60 caves, one spring, and one mine) covered by this Karst Management Plan are privately owned (**Table 3**). BCP Partners work with willing non-profit groups, private landowners and other interested parties to protect these privately owned listed karst features.

**Known species distribution in the BCCP-listed caves and caves not listed on the Permit, but protected in the BCP, are depicted in Table 4 through Table 7.**

The environmental integrity of all 62 karst features is proposed to be protected through acquisition and management, or implementation of a management/conservation agreement with entities that influence the hydrogeological area needed to protect the feature (USFWS 1996a). Management in karst preserves includes maintenance of native vegetation, red-imported fire ant (RIFA) control, control of disturbance by humans, and protection of water quality and nutrient input.

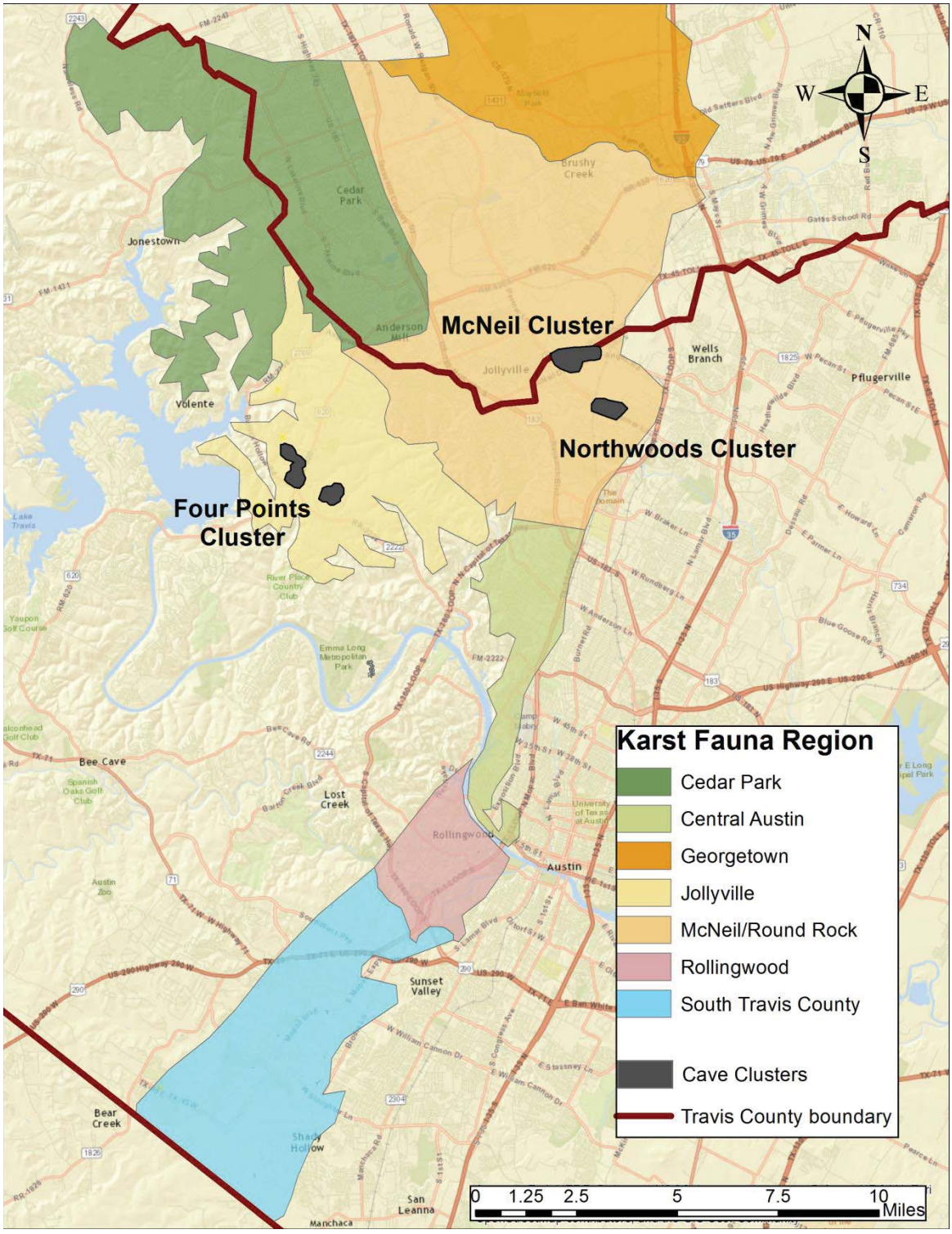


**Figure 1. BCCP Cave Clusters**

## Table 3. 62 BCCP Karst Features: Current Ownership Status

*Key and footnotes follow table*

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| Adobe Springs Cave | SOC | BCP Lehmann/TNC | |
| Airman's Cave | SOC | BCP Barton Creek/COA | |
| Amber Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Armadillo Ranch Sink | SOC | Private | |
| Arrow Cave | SOC | BCP Slaughter Creek Park./COA | |
| Bandit Cave | ES | Private | |
| Beard Ranch Cave (Featherman's Cave) | ES | BCP Ivanhoe/COA | |
| Bee Creek Cave | ES | Private | |
| Blowing Sink Cave | SOC | BCP COA | |
| Broken Arrow Cave | ES | BCP Lime Creek Preserve/COA | |
| Buda Boulder Spring | SOC | BCP Shoal Creek Greenbelt/COA | |
| Cave X | SOC | Private/COA Protection Agreement | |
| Cave Y[1] | SOC | BCP Barton Creek Greenbelt/COA | |
| Ceiling Slot Cave | SOC | Private | |
| Cold Cave | ES | Private | Northwood |
| Cotterell Cave | ES | BCP Stillhouse Hollow Preserve/COA | |
| Disbelievers Cave | ES | BCP Private 10(a) | Four Points (East) |
| District Park Cave | SOC | BCP Dick Nickols Park/COA | |
| Eluvial Cave | ES | BCP Private 10(a) | Four Points (East) |
| Flint Ridge Cave | SOC | Prop 2 Tabor Tract /COA | |
| Fossil Cave | ES | BCP Schroeter Park/COA | |
| Fossil Garden Cave | ES | Private | McNeil |
| Gallifer Cave | ES | BCP Jollyville/TC | Four Points (West) |

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| Get Down Cave | SOC | Private/COA Protection Agreement | |
| Goat Cave | SOC | BCP Goat Cave Karst Preserve/COA | |
| Hole-in-the-Road Cave | ES | Private | Northwood |
| Ireland's Cave | SOC | BCP Ireland's/ TC | |
| Jack's Joint | SOC | Private | |
| Japygid Cave | ES | BCP Private 10(a) | Four Points (East) |
| Jest John Cave | ES | BCP Forest Ridge/COA | |
| Jester Estates Cave | ES | BCP Forest Ridge/COA | |
| Jollyville Plateau Cave | ES | BCP Private 10(a) | Four Points (East) |
| Kretschmarr Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Kretschmarr Double Pit | ES | BCP Jollyville/TC | Four Points (West) |
| Lamm Cave | ES | BCP Private Section 7 | |
| Little Bee Creek Cave | ES | BCP Ullrich WTP/COA | |
| Lost Gold Cave | SOC | Private | |
| Lost Oasis Cave | SOC | Private TCMA | |
| M.W.A. Cave | ES | BCP Private 10(a) | Four Points (East) |
| Maple Run Cave | SOC | BCP Goat Cave Karst Preserve/COA | |
| McDonald Cave | ES | BCP Jollyville/TC | |
| McNeil Bat Cave | ES | Private | McNeil |
| Midnight Cave | SOC | BCP Slaughter Creek Park/COA | |
| Moss Pit | SOC | Private | |
| New Comanche Trail Cave | ES | BCP Lake Travis/TC | |
| No Rent Cave | ES | Private | McNeil |
| North Root Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Pennie's Cave | SOC | Private | |

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| Pickle Pit | SOC | BCP Private Section 7 | |
| Pipeline Cave | SOC | Private | |
| Rolling Rock Cave | ES | BCP Lime Creek Preserve/COA | |
| Root Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Slaughter Creek Cave | SOC | BCP Slaughter Creek Park/COA | |
| Spanish Wells Cave | SOC | BCP Kotrla/TC | |
| Spider Cave | ES | BCP Park West/COA | |
| Stark's North Mine[2] | ES | BCP Stark's/ TC | |
| Stovepipe Cave | ES | BCP Canyon Creek/ COA | |
| Talus Springs Cave[3] | N/A | Private/ 10(a) permit | |
| Tardus Hole | ES | BCP Jollyville/TC | Four Points (West) |
| Tooth Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Weldon Cave | ES | Private | McNeil |
| Whirlpool Cave | SOC | Private TCMA | |

*Key and Footnotes*

ES = Endangered (federally listed) Species

SOC = Species of Concern

[1]Cave Y was considered an ES cave *(Texella reddelli*) in the 1996 BCCP Permit, but has since been determined not to contain *Texella reddelli* (Reddell 2004).

[2]Stark's North Mine was listed as a SOC cave in the 1996 BCCP Permit, but has since been determined to contain *Texella reddelli* (USFWS 2009c).

[3] Talus Springs Cave has never been known to contain ES or SOC (Elliot 1997).

**Table 4. Endangered Karst Invertebrate Locations within BCCP caves of Travis County, Texas**

This table, originally in the BCCP 1996 documents, has been revised to show new species' location information.
*Key and footnotes follow table*

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Amber Cave | BCP Jollyville TC | Jollyville Plateau | X 1996 | | X 2010 (Reddell) | X 1996 | | |
| Bandit Cave | Private | Rolling-wood | | | | | P 1996<br>X 2009 | |
| Beard Ranch Cave | BCP Ivanhoe COA | Jollyville Plateau | | | | | | X 1996 |
| Bee Creek Cave | Private | Rolling-wood | | | | | X 1996 | |
| Broken Arrow Cave | BCP Lime Creek Preserve COA | Cedar Park | | | X 1996 | | | |
| Cold Cave | Private | McNeil Round Rock | | | | | | X 1996 |
| Cotterell Cave | BCP Spicewood Springs Park/COA | Central Austin | | | | | | X 1996 |
| Disbelievers Cave | BCP Private 10(a) | Jollyville | | | X 1996 | | | |
| Eluvial Cave | BCP Private 10(a) | Jollyville | | | | | | X 1996 |
| Fossil Cave | BCP Schroeter Park/COA | McNeil Round Rock | | | | | | X 1996 |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Fossil Garden Cave | Private | McNeil Round Rock | | | | | | X 1996 |
| Gallifer Cave | BCP Jollyville/TC | Jollyville Plateau | | P 1996<br>X 2010 (Ledford) | P 1996<br>X 2005 | X 2009 (Chandler) | | X 1996 |
| Hole-in-the-Road Cave | Private | McNeil Round Rock | | | | | | X 1996 |
| Japygid Cave | BCP Private 10(a) | Jollyville | | | X 1996 | P 1996<br>X 2005 | | |
| Jest John Cave | BCP Forest Ridge/COA | Jollyville Plateau | | | | | X 1996 | |
| Jester Estates Cave | BCP Forest Ridge/COA | Jollyville Plateau | X 2008 (Cokendolpher) | X 2010 (Ledford) | | | X 1996 | |
| Jollyville Plateau Cave | BCP Private 10(a) | Jollyville | | | X 1996 | | | X 1996 |
| Kretschmarr Cave | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | X 1996 | | |
| Kretschmarr Double Pit | BCP Jollyville/TC | Jollyville Plateau | P 1996<br>X 2005 | | P 1996<br>X 2005 | | P 1996 | |
| Lamm Cave | Private Section 7 | Jollyville Plateau | | | X 1996 | | | |
| Little Bee Creek Cave | BCP Ullrich WTP/COA | Rolling-wood | | | | | X 1996 | |
| McDonald Cave | BCP Jollyville/TC | Jollyville Plateau | | | | | | X 1996 |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| McNeil Bat Cave | Private | McNeil Round Rock | | X 2010 (Ledford) | | | | X 1996 |
| M.W.A. Cave | BCP Private 10(a) | Jollyville | P 1996<br>X 2005 | | X 1996 | P 1996<br>X 2005 | | X 1996 |
| New Comanche Trail Cave | BCP Lake Travis/TC | Jollyville Plateau | | X 1996 | | | | X 1996 |
| No Rent Cave | Private | McNeil Round Rock | | | | | | X 1996 |
| North Root Cave | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | | | |
| Rolling Rock Cave | BCP Lime Creek Preserve COA, Sec.10(a) | Cedar Park | | | X 1996 | | | |
| Root Cave | BCP Jollyville/TC | Jollyville Plateau | | X 2010 (Ledford) | X 1996 | | | X 1996 |
| Spider Cave | BCP Park West/COA | Jollyville Plateau | | | X 2004 (Reddell) | | X 2004 (Reddell) | |
| Stark's North Mine Cave | BCP Stark's/TC | Not within a KFR | | | | | X 2009 (USFWS) | |
| Stovepipe Cave | BCP Canyon Creek/ COA | Jollyville Plateau | | | X 1996 | X 1996 | | P 1996<br>X 2009 (USFWS) |
| Tardus Hole | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | X 2009 (Chandler) | | |
| Tooth Cave | BCP Jollyville/TC | Jollyville Plateau | X 1996 | X 1996 | X 1996 | X 1996 | | X 1996 |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Weldon Cave | Private | McNeil Round Rock | | | | | | X 1996 |

**Sources**: BCCP Permit 1996, Elliott 1992, USFWS 1994, Reddell 2004, 2005, 2010, HNTB 2005, USFWS 2009a, 2009b, 2009c, Ledford 2010.

*Key and Footnotes*

X 1996 = confirmed occurrence based on collected specimen, the designation in the 1996 BCCP permit

P 1996 = probable occurrence based on observation but not confirmed with collected specimen, the designation in 1996 BCCP permit

X 2004 (Reddell) = confirmed by J. Reddell (pers. comm. 2004)

X 2005 = was listed as confirmed in the HNTB summary of James Reddell's data, 2005 report for USFWS

X 2008 = Cokendolpher (pers. comm. 2008) confirmed that Jester Estates Cave is a new site for *Tartarocreagris texana*

X 2009 = USFWS - according to the 2009 5 year review on *Texella reyesi* the report lists *T. reyesi* as confirmed for Stovepipe Cave; *Texella reddelli* 5-year review confirms *T. reddelli* for Bandit Cave and Stark's North Mine (USFWS 2009c).

X 2009 (Chandler) = confirmed by D. Chandler, as reported in USFWS 5-year review (2009b).

X 2010 (Ledford) = confirmed by J. Ledford (pers. comm. 2010)

X 2010 (Reddell) = confirmed by J. Reddell (pers. comm. 2010)

## Table 5. Non-BCCP listed Caves/Karst Features with Listed Invertebrates Protected on BCP

*Key follows table*

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Cortana Cave | COA | Jollyville Plateau | | X 2010 | | | | X 2008 |
| Down Dip Sink | COA | Jollyville Plateau | | | X 2007a | | | |
| Garden Hoe Cave | COA | Jollyville Plateau | | | X 2007b | | | |
| Geode Cave | TC | Jollyville Plateau | | X 2008 | X 2008 | | | X 2008 |
| LU-11 | TC | Jollyville Plateau | | X 2008 | | | | |
| LU-12 | TC | Jollyville Plateau | | | | | | X 2008 |
| IV-3 | COA | Jollyville Plateau | | | | | | X 2010 |
| Little Black Hole | COA | Rollingwood | | | | | X 2009c | |
| Merkin Hole | COA | Jollyville Plateau | | | | | X 2010 | |
| Pond Party Pit | COA | Jollyville Plateau | | | | | | X 2010 |
| RI-1 | TC | Jollyville Plateau | | | | | X 2010 | |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Tight Pit Cave | TC | Jollyville Plateau | | X 2010 | | | | |
| Two Trunks Cave | TC | Jollyville Plateau | | | X 2008 (USFWS) | | | |

**Sources**: USFWS 2008, 2009c, Zara Environmental 2007a, 2007b, 2008, and 2010.

*Key*

X = confirmed occurrence based on collected specimen.

## Table 6. Karst Invertebrate SOC within BCCP Caves, Travis County, Texas[1,2]

*Key and footnotes follow table*

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adobe Springs Cave | | | | | | | | | | | | | | | | | | | | |
| Airmen's Cave | | | | X | | | | | | | X | | | | | | X | | X | |
| Amber Cave | | | | | X | | | | | | | | X | | | | | | | |
| Armadillo Ranch Sink | | X | | | | | | | | | | | | | | | | | | |
| Arrow Cave | | | | X | | | | | | | X | | | | | | | | | |
| Bandit Cave | | | | X | | | | | | | X | | | | | | | | | X |
| Beard Ranch Cave | | | | | X | | | | | | | | | | | | | | | |
| Bee Creek Cave | | | | X | | | | | | | X | | | | | | | | | |
| Blowing Sink Cave | | | | X | | | | | | | X | | | | | | | | | |
| Broken Arrow Cave | | | | | | | | | | | | | | | | | | | | |
| Buda Boulder Spring | | X | | | | | | | | | | | | | | | | | | |
| Cave X | | X | X | X | | | | X | | | X | | | X | | | | | | |
| Cave Y | | | | X | | | | | | | X | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ceiling Slot Cave | | | | | | X | | | | | | | | | | | | | | |
| Cold Cave | | | | | | X | | | | | | | | | | | | | | |
| Cotterell Cave | | | | | X | | | | | | | X | | | | | | | | |
| Disbelievers Cave | | | | | | X | | | | | | | | | | | | | | |
| District Park Cave | | | | X | | | | | | | X | | | | | | | | | |
| Eluvial Cave | | | | | | | | | | | | | | | | | | | | |
| Flint Ridge Cave | | | | X | | | | | | | X | | | | | | | | | |
| Fossil Cave | | | | | | | | | | | | X | | | | | | | | |
| Fossil Garden Cave | | | | | | X | | | | | | X | | | | | | | | |
| Gallifer Cave | | | | | X | | | | | | | | | | | | | | | |
| Get Down Cave | | | | X | | | | | | | X | | | | | | | | | |
| Goat Cave | | | | X | | | | | | | | | | X | | | | | | |
| Hole-in-the-Road Cave | | | | | | X | | | | | | | | | | | | | | |
| Ireland's Cave | | | | X | | | | | | | X | | | | | | | | | |
| Jack's Joint | | X | | | | X | | | | | | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Japygid Cave | | | | | | | | | | | | | | | | | | | | |
| Jest John Cave | | | | | X | | | | | | | | | | | | | | | |
| Jester Estates Cave | | | | | X | | | | | | | | | | | | | | | |
| Jollyville Plateau Cave | | | | | | | | | | | | | | | | | | | | |
| Kretschmarr Cave | | | | | X | | | | | | | | X | | | | | | | |
| Kretschmarr Double Pit | | | | | X | | | | | | | | | | | | | | | |
| Lamm Cave | | | | | | | | | | | | | | | | | | | | |
| Little Bee Creek Cave | | | | X | | | | | | | X | | | | | | | | | |
| Lost Gold Cave | | | | X | | | | | X | | X | | | | | | | | | |
| Lost Oasis Cave | | | | X | | | | | | | X | | | | | | | | | |
| M.W.A. Cave | | | | | | | | | | | | | | | | | | X | | |
| Maple Run Cave | | | | X | | | | | | | X | | | | | | | | | |
| McDonald Cave | | | | | X | | | | | X | | | | | | | | | | |
| McNeil Bat Cave | | | | | | | | | | | | X | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Midnight Cave | | | | X | | | | | | | X | | | | | | | | | |
| Moss Pit | | | | | | | | | | | | | | | | | | | | |
| New Comanche Trail Cave | | | | | | X | X | | | | | | | | | X | | | | |
| No Rent Cave | | | | | | | | | | | | X | | | | | | | | |
| North Root Cave | | | | | X | | | | | | | | | | | | | | | |
| Pennie's Cave | | | | | | | | | | | X | | | X | | | | | | |
| Pickle Pit | | | | | X | | | | | | | | | | | | | | | |
| Pipeline Cave | | | | | | | | | | | | | | X | | | | | | |
| Rolling Rock Cave | | | | | | X | | | | | | | | X | | | | | | |
| Root Cave | | | | | X | | | | | | | | | | | | | | | |
| Slaughter Creek Cave | | | | X | | | | | | | | | | | | | | | | |
| Spanish Wells Cave | | X | | | | | | | | | | | | | X | | | | | |
| Spider Cave | | | | | X | | X | | | | | | | | | | | | | |
| Stark's North Mine | | | | | | | | | X | | | | | | | | | | | |
| Stovepipe Cave | X | | | | X | | X | | | | | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talus Springs Cave | | | | | | | | | | | | | | | | | | | | |
| Tardus Hole | | | | | | | | | | | | | | | | | | | | |
| Tooth Cave | | | | | X | | X | | | | | | X | | | | | | | |
| Weldon Cave | X | | | | | | | | | | | X | | | | | | | | |
| Whirlpool Cave | | | | X | | | | | | | X | | | | | | | | | |

**Sources**: Elliot 1997, Paquin and Hedin 2005, Paquin et al. 2008, TMM 2007, Zara Environmental 2008, 2010, Hedin 2015.

*Key and Footnotes*

X = confirmed location based on collected specimen.

[1] *Cicurina ellioti* listed as an SOC in the regional permit is not included in this table because this species has now been synonymized with Cicurina buwata, a non-SOC (Cokendolpher 2004).

[2] *Tartarocreagris reddelli* listed as a SOC in the regional permit is not included in this table because this species has now been synonymized with *Tartarocreagris infernalis*, a non-SOC (Muchmore 2001).

[3] Occurrences of *Cicurina bandida* include localities formerly listed as *Cicurina cueva* and *Cicurina reyesi*, which have been formally grouped together into the single species *C. bandida* (Paquin et al. 2008).

[4] Occurrences of *Cicurina travisae* include localities formerly listed as *Cicurina reddelli* and *Cicurina wartoni*, which have been formally grouped together into the single species *C. travisae* (Hedin 2015).

[5] Localities of possible SOCs; blind *Cicurina* specimens not yet confirmed to species level.

## Table 7. Non-BCCP Caves/Karst Features with Karst SOC Protected on BCP[1,2]

*Key and footnotes follow table*

| Cave Name | BCP Owner | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida* [3] | *Cicurina travisae* [4] | *Cicurina sp.* [5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brewpot Cave | TC | | | | | | | | | | X | | | | | | | | | | |
| Cortana Cave | COA | | | | | | X | | | | | | | | | | | | | | |
| Down Dip Cave | COA | | | | | | X | | | | | | | | | | | | | | |
| Geode Cave | TC | | | | | X | | X | | | | | | | | | | | | | |
| IV-3 | COA | | | | | X | | | | | | | | | | | | | | | |
| LU-29 | TC | | | | | | X | | | | | | | | | | | | | | |
| Pond Party Pit | COA | | | | | | X | | | | | | | | | | | | | | |
| RI-1 | TC | | | | | | X | | | | | | | | | | | | | | |
| RI-3 | TC | | | | | | X | | | | | | | | | | | | | | |
| Siebert Sink | COA | | | | X | | | | | X | | | | | | | | | | X | |
| Two Trunks Cave | TC | | | | | X | | | | | | | | | | | | | | | |

**Sources**: Bayless pers. comm. 2013, Paquin and Hedin 2005, Sanders pers. comm. 2013, TMM 2007, Zara Environmental 2008, 2010, Hedin 2015.

*Key and Footnotes*

X = confirmed location based on collected specimen.

[1] *Cicurina ellioti* listed as an SOC in the regional permit is not included in this table because this species has now been synonymized with Cicurina buwata, a non-SOC (Cokendolpher 2004).

[2] *Tartarocreagris reddelli* listed as a SOC in the regional permit is not included in this table because this species has now been synonymized with *Tartarocreagris infernalis*, a non-SOC (Muchmore 2001).

[3] Occurrences of *Cicurina bandida* include localities formerly listed as *Cicurina cueva* and *Cicurina reyesi*, which have been formally grouped together into the single species *C. bandida* (Paquin et al. 2008).

[4] Occurrences of *Cicurina travisae* include localities formerly listed as *Cicurina reddelli* and *Cicurina wartoni*, which have been formally grouped together into the single species *C. travisae* (Hedin 2015).

[5] Localities of possible SOCs; blind *Cicurina* specimens not yet confirmed to species level.

## 3.0 NEW KARST INFORMATION RELATED TO THE BCCP

For 18 years, "*The Caves of the Balcones Canyonlands Conservation Plan, Travis County, Texas*" (Elliot 1997) has been the primary reference guide for endangered species and SOC location information. Recently, however, the USFWS released 5-year reviews for the six endangered karst species listed on the BCCP permit (USFWS 2008, 2009a, 2009b), which included documentation of new localities for these species. More recent survey work by Zara Environmental, Inc. (2007a, 2007b, 2008, 2010) has also added new location information for four of the endangered karst species and several SOCs listed on the BCCP permit. A complete list of known endangered karst invertebrate locations for the BCCP-listed karst features is summarized in Table 2; known SOC localities within BCCP-listed karst features are summarized in Table 4. Location information for endangered karst species and SOCs found in BCP caves that were not listed in the BCCP are summarized in Table 3 (ES localities) and Table 5 (SOC localities). Though not listed on the permit, these caves and any other BCP caves containing ES or SOC found in the future will be protected in the same manner as those listed on the permit.

Joel Ledford (University of California, Berkeley) conducted a revision of the Family Leptonetidae with particular emphasis on the taxonomy and relationships within the subfamily Archoleptonetinae. This study found new locations for the endangered *Neoleptoneta myopica* and newly described species within the Austin area. Ledford also proposed to change the genus *Neoleptoneta* to *Tayshaneta* (Campbell et al. 2012). USFWS adopted this change in 2015 (Watson pers. comm. 2015).

Marshal Hedin (San Diego State University) conducted a study for USFWS using DNA sequence data to rigorously test the species status of *Cicurina wartoni*, a BCCP-listed SOC known only from Pickle Pit Cave. Hedin's study used specimens collected by BCP staff from multiple caves in northern Travis and southern Williamson counties to determine if *Cicurina* specimens from Pickle Pit were genetically distinguishable from other nearby sites containing *Cicurina*

spiders previously identified as *C. buwata* (formerly known as *C. ellioti*), *C. reddelli*, and *C. travisae*. Results of genetic analyses indicate that there are only two distinct species complexes in the study area: *C. buwata* in the northern range and *C. travisae* in the southern range. Based on these findings, *C. reddelli*, *C. wartoni,* and *C. travisae* should now be treated as a single species: *C. travisae*. Thus, confirmed localities previously identified as *C. reddelli* and *C. wartoni* are now considered as localities for *C. travisae* (Hedin 2015). Following the completion of Hedin's study, USFWS completed a status review of *Cicurina wartoni* and concluded that this species does not warrant protection under the Endangered Species Act (ESA) (USFWS 2014a).

## 4.0 ADDITIONAL VALUES FOR CAVE AND KARST ECOSYSTEMS

Beyond protecting the entrances of caves that are localities for endangered karst invertebrates and SOCs, USFWS Karst Preserve Design Recommendations (2012) also describe the importance of protecting the surface environment surrounding caves. One component of this protection involves preserving adequate habitat for trogloxenes such as cave crickets, bats, and mammals (USFWS 2012). Cave crickets are considered a keystone species for cave ecosystems, providing vital nutrients into an otherwise nutrient poor environment (Taylor et al. 2005). Bats and mammals such as raccoons are also important biotic components of karst ecosystems, supplying nutrient input in the forms of guano and scat which benefits resident karst invertebrates (USFWS 2011e). Providing adequate protection of surface plant and animal communities in cave preserves benefits these trogloxenes, and also protects other sources of nutrient input in the form of roots, leaf-litter, and woody debris, thereby creating a higher probability of long-term survival for protected karst invertebrates (USFWS 2012).

Another component of protecting the surface environment around caves involves maintaining high quality and adequate quantity of water to the cave ecosystem, achieved through protection of a cave's surface and sub-surface drainage basins (USFWS 2012). Well protected drainage basins provide necessary moisture and

stable temperatures in cave habitats, and ensure these ecosystems are free from contaminants (USFWS 2012).

## 5.0 THREATS

One of the main threats to the listed karst species is loss of habitat due to urban development activities. These species occur in an area that is undergoing continued urban expansion at a rapid rate and few caves are protected. Most of the species' localities occur adjacent to or near developed areas, or in areas that are proposed for development (USFWS 1996a).

The most significant effects of urban development on karst habitat are:

- filling of cave entrances or greatly reduced infiltration due to impervious cover. This blockage decreases the total energy entering the cave through the entrance (Russell pers. comm. 1998) and reduces the moisture input necessary to maintain high humidity in the cave.
- inadequate setbacks for cave cricket foraging areas. Vital nutrient input provided by cave crickets could be lost if efforts are not made to protect their entire foraging range (105 meter radius around the cave footprint) (Taylor et al. 2005).
- pollutants from urban run-off, such as pesticides, which can contaminate caves and possibly harm or kill karst species or species that provide organic matter. Urban run-off can also alter the natural flow of nutrients through the cave system by replacing water flow and animal energy inputs with potentially contaminated seepage from yards and parking lots. If the surface and sub-surface drainage basins are not adequately protected, contamination of this nature can be expected.

Other threats to caves related to urban development include alteration of surface plant and animal communities, increased human visitation, vandalism, dumping, habitat fragmentation, and poorly designed cave gates (USFWS 2011a, 2011b). Land use changes can also affect the abundance and spatial arrangement of other organisms in the surface and sub-surface biotic community known to be beneficial to karst invertebrates (USFWS 2011a). Neglect of caves is also a

threat since caves that are not visited or monitored may deteriorate due to inattention to new developments in cave areas; also, cave locations may be lost. Activities at several limestone quarries in northwestern Travis County may also threaten to destroy surrounding karst habitat. (BAT 1990, USFWS 1994).

Twenty percent of the known caves in Travis County have been covered or destroyed in the 20 years prior to the establishment of the BCP as a result of land use practices and development. This rate of loss is expected to continue (USFWS 1996a).

Recent scientific evidence of climate change demonstrates increases in average air temperatures in the last 50 years, coupled with an increase in heat waves and heavy precipitation events (IPCC 2007). These trends are projected to continue and increase in the next century with the southwestern U.S. being the most impacted of the continental U.S. (IPCC 2007). Karst invertebrates may be affected by the effects of climate change, due to their dependence on stable temperatures and humidity (USFWS 2011a). Climate change may impact karst species directly from increased in-cave temperatures and indirectly through changes in the vegetation and surface environment, which could affect food resource availability (USFWS 2011a). The caves of the Jollyville Plateau may be especially vulnerable to global warming due to the fact that they are shallow (generally 20 to 30 feet in depth). Rainfall regime changes and more extreme rain events may also impact the cave environments by flooding, filling in with debris, or adversely affecting nutrient inputs (USFWS 2011a).

Red imported fire ants (*Solenopsis invicta*) (RIFA) threaten the karst community directly by preying on karst invertebrates, but could also indirectly threaten them by reducing the amount of organic nutrients brought in by trogloxene species (species that live in the cave during the day and venture out at night foraging for food). Most notable trogloxenes are cave crickets and mammals such as raccoons. If the cave is overrun by RIFA, trogloxenes may disappear. RIFA will eat cave cricket eggs, nymphs and adults as well as forcing out mammals, greatly reducing the availability of organic material entering the cave. RIFA are

most abundant in disturbed areas (USFWS 2011b). Current estimates indicate that most of the 62 caves have at least some RIFA activity (Sanders pers. comm. 2013; Bayless pers. comm. 2013). See Tier II-A, Chapter X for additional information on RIFA.

Tawny crazy ants (*Nylanderia fulva*) are the latest invasive non-native species to threaten karst invertebrates. These newly arrived, non-native ants are a poorly understood species in the Austin area, making it difficult to project what long term impacts this species may have on karst ecosystems. In the Houston area this species has proven to be a major pest, and in areas of heavy infestation they have displaced RIFA (Meyers 2008). This species will likely have adverse effects on ant diversity as well as abundance and diversity of other arthropods in infestation areas (Meyers 2008). Since tawny crazy ants prefer wetter, more humid environments (Meyers 2008), areas around caves may be even more susceptible to invading colonies by providing preferred habitat characteristics. As of July , 2013 tawny crazy ants were confirmed at the entrance of Whirlpool Cave, and documented foraging as far as 100 ft inside the cave itself (Sanders pers. comm. 2013; Bayless pers. comm. 2013). TCAs were also documented infesting No Rent Cave in November 2014 (Sanders pers. comm. 2015; Bayless pers. comm. 2015).

Mammals bring in tremendous amounts of organic material into caves via their scat. Although the endangered karst fauna are very much dependent on these species to provide this material, the effects of large amounts of scat can also be detrimental when they attract non-cave adapted species (i.e. roaches) (Reddell pers. comm. 2004).

White nose syndrome (WNS) is a newly observed disease responsible for unprecedented mortality of hibernating bats in the northeastern U.S., and since its discovery in 2007 has spread rapidly westward, posing a serious threat to hibernating bats throughout North America (USFWS 2011d). One species that commonly occurs in Travis County, the tri-colored bat (*Perimyotis subflavus*), has been shown to be susceptible to WNS (USFWS 2011d). In the 2013-2014

monitoring season (winter), WNS was detected and confirmed in Arkansas (USFWS 2014b). This occurrence demonstrates the potential for WNS to spread into the western U.S. in the near future (USFWS 2011d). Therefore, the threat of WNS to these important trogloxenes requires special attention of researchers accessing caves to be aware of potential transmission of this disease as well as appropriate decontamination procedures if WNS finds its way into central Texas caves (USFWS 2011d).

## 6.0 MANAGEMENT PROGRAM

### 6.1 KARST MANAGEMENT GOALS

The Recovery Plan for Endangered Karst Invertebrates in Travis County, Texas (USFWS 1994) outlines four major recovery actions: (1) research and information needs, (2) long-term protection for karst fauna areas, (3) monitoring, and (4) education. The BCCP's Habitat Conservation Plan/Environmental Impact Statement states that the BCCP should effectively implement these goals in order to assure that the implementation of the BCCP has no negative impact on the population viability of the endangered karst invertebrates (USFWS 1996a). Karst preserve design is the most important aspect for guarantying the long term survival of the species. Preserves that have adequate setbacks to ensure that the entire surface and subsurface drainage basins as well as the native plant and animal communities are protected will greatly enhance the long term success of the program (UFSWS 2012). The ultimate goal is wherever possible to have quality preserves that are self-sustaining, thus greatly reducing the need for intensive onsite management. A secondary management goal includes the protection of the BCP karst features to protect local water quality.

Currently protected karst habitat will be maintained and enhanced, and permit holders will attempt to protect or acquire additional BCCP caves for karst preserves. BCP partners will attempt to enter into formal management agreement(s) with the landowner(s) for all caves that are recommended for protection but have yet to be acquired or kept in private ownership as cave

preserves. The management agreement(s) will detail the area to be managed for cave protection, what such management will entail, and who is responsible for the management. Efforts are needed to increase public awareness and sensitivity to the karst invertebrates and other endangered species.

## 6.2 CONSERVATION ACTIONS

The following is a summary of more detailed management information available from current literature, TC Natural Resources and Environmental Quality Division, COA - Austin Water Utility, and the USFWS. The following activities will be undertaken for caves owned or managed by BCP partner agencies for the 62 BCCP caves, as well as other BCP caves with ES or SOC.

If monitoring data shows that management methods are ineffective or can be improved, permit holders should practice “adaptive management”; in these cases the management plan will be revised and/or additional activities will be added. Such additions may include: fencing of additional areas around caves to control access, more intensive RIFA control, removal of non-native plant/animal species found to be detrimental to the karst ecosystem, or removal of additional species found to directly harm the species either directly (e.g. predators) or indirectly (e.g. species that prey on food base or increase the nutrient level (e.g. large amounts of raccoon scat attracting more aggressive surface species into the cave).

### *6.2.1 Vegetation Management*

Ashe juniper-oak woodlands and other native vegetation will be protected within the preserve areas. Thick vegetation will be left to help protect caves by camouflaging their entrances. The size of the surface area needed to protect individual caves will be determined based on karst preserve design recommendations (USFWS 2012). Non-native vegetation in the critical area around a cave will be controlled to protect the cave ecosystem, preferably by mechanical control methods (USFWS 2011b). If chemical control methods to eliminate non-native plants around caves are absolutely necessary, herbicide treatments will be limited to cut-stump methods only (applying herbicide individually to freshly cut stumps or stems, which eliminates potential of drift and

run-off); no foliar spray treatments will be used within the 105 m cave cricket foraging area of ES/SOC caves, or within the surface or subsurface drainage basin if run-off is potentially an issue.

When possible, the permit holders will work with nearby developers and landowners in the cave vicinity to encourage xeriscaped landscaping using native plants, which promotes less watering, fertilizers or pesticides, thereby minimizing groundwater contamination. Permit holders will also discourage the presence of non-native fauna such as feral hogs, which may damage native vegetation on cave surfaces.

### *6.2.2 Animal Management*

RIFA should be controlled using USFWS approved methods (USFWS 2011b; see also Tier II-A, Chapter X). Surveys for RIFA mounds should be conducted at least twice per year. RIFA do not maintain their mounds during the summer, making them more difficult to see, but begin rebuilding them as soon as rains and cooler temperatures return (Vinson and Sorensen 1986). Because of this, at least one monitoring survey should be conducted in both spring and fall. These surveys should be conducted over the minimum cave cricket foraging area (within 80 m (262 ft) of cave entrances) and should be sufficient to yield actual RIFA mound densities, not merely indices of RIFA density. In addition, every routine maintenance inspection should include a search for RIFA mounds within 10 m (33 ft) of the cave entrance (USFWS 2011b). To avoid impacting the native ant population, the site must be surveyed for the presence of native ants prior to any RIFA treatment.

Control of RIFA should also be conducted at least twice per year if monitoring indicates their presence. RIFA may remain relatively inactive and deep within their mounds during long periods of drought or cold (Vinson and Sorensen 1986), making them more difficult to eradicate. Because of this, RIFA control should be conducted at least once in the spring and at least once in the fall. This control should be done shortly after the scheduled monitoring and not before so as not to artificially reduce the apparent RIFA density. An increase in the frequency of

RIFA control may be necessary based on (1) declines in cave cricket abundance or (2) an increase in the number of RIFA mounds within 80 m of the cave entrance (USFWS 2011b). Additionally, if RIFA mounds are observed within 10 m (33 ft) of any protected cave during fire ant surveys, routine maintenance, or any other management or monitoring activity or if biological investigations find any RIFA within any cave that has endangered invertebrates, all mounds within 10 m (33 ft) of that cave entrance should be treated within one week (USFWS 2011b). Staff conducting RIFA surveys as well as those conducting routine maintenance and other biological surveys on a Karst Feature Area should be trained to distinguish RIFA and their mounds from native ants and their mounds (USFWS 2011b).

Within 105 m of the entrance of any karst features that support listed invertebrates and/or SOCs, RIFA control must be restricted to the use of boiling water, which ensures protection from pesticides of the entire cave cricket foraging area (Taylor et al. 2005). In addition, RIFA bait treatments are not recommended outside of the cave cricket foraging area due to the fact that the baits can harm native ant species. For boiling water treatments, boiling or near-boiling water should be poured directly onto the mounds. Sufficient boiling water should be used that the mound collapses in on itself. This should typically be 1-4 gallons. These treatments should be conducted when the brood is high in the mound (typically on cool, cloudy days) to ensure that the queen(s) and larvae are likely to be near the top of the mound. During long periods of drought or cold, the queen(s) and larvae will most likely be deep within the mound, making them more difficult to eradicate (Vinson and Sorensen 1986). Mounds should not be disturbed before treatment as this will cause the ants to move the queen(s) and larvae to deeper locations within the mound or to a remote location (USFWS 2011b). Small amounts (1-2 teaspoons) of detergent may be added to the boiling water, which helps the water penetrate the soil.

Passive management strategies should be implemented in conjunction with active management (boiling water treatments to mounds). Passive management strategies include: allowing woody vegetation to flourish and avoiding clearing of

native vegetation with the cave cricket foraging area to create a closed canopy which deters RIFA (RIFA's habitat preference is open/ disturbed habitat); controlling deer densities and feral hog populations, which can greatly increase woody growth and decrease soil disturbance; and not allowing public trails or picnic tables within the cave cricket foraging area.

Inspections will be made at cave sites during field visits for the presence of tawny crazy ant infestation. Managers will use current collection and reporting procedures of suspect infestations to confirm presence of new tawny crazy ant colonies, and if found, will work with the USFWS on control options.

Larger mammals, in particular raccoons, using cave features for shelter especially in and around urban areas can produce large amounts of scat inside the caves. The scat alters the nutrient content, especially nitrogen levels, within the cave ecosystem and can be detrimental to karst invertebrates (USFWS 2011e). Evidence of raccoon populations within caves should be monitored and populations controlled as needed.

### *6.2.3 Cave Gating and Fencing in BCP Caves and Bat Management*

The need for a cave gate or protective fencing will be determined by each cave managing organization based on the following general criteria:

1. In cases where caves are isolated (not near any neighborhoods), and/or with camouflaged entrances that do not appear to be a cave, no gates are warranted.
2. In situations where the cave has either a history of public access or is in near proximity to neighborhoods with a very obvious entrance, gating or fencing is recommended.
3. A gate or fence may also be necessary for liability reasons especially if the cave is vertical, unstable, or is a known "bad air" cave (USFWS 2011b).

Cave gates, where necessary, should be designed to permit normal airflow, water flow, and nutrient input, and should allow bat and small mammal (raccoon, opossum, fox, rodents, etc.) access (USFWS 2011b). Fences are an alternative to gating that may pose less interference with the nutrient regime and other

environmental factors (air and water movement). If the cave contains bats, then a fence may be more appropriate. The fence should be designed to be very difficult or close to impossible to climb over, and placed away from the cave entrance as far as possible (Sanders 1997 pers. comm.). However, neither gates nor fences can prevent people from throwing toxic or other materials into a cave. Cave gates and fences may also serve to attract attention to an otherwise unknown cave which may encourage vandalism. Therefore, decisions about the need and desirability of gating or fencing BCP caves should be made on a case-by-case basis.

Bat gates should be installed on caves with suitable bat habitat. Prior to the construction of a cave gate, the cave should be evaluated for suitability as historic or current bat habitat. The criteria include historic bat use, numbers of bats currently using the cave, size of the entrance, size and arrangement of the interior rooms, surrounding habitat use, unavoidable disturbances from surrounding land use, and compatibility with other cave uses. Specialized gates will also be necessary for caves that receive large amounts of recharge. The design of bat gates should allow for access by the bats, by property managers, and by raccoons and small mammals, and should be as visually natural looking as possible. Information on bat gate design should be obtained from Bat Conservation International (www.bci.org) and/or the American Cave Conservation Association (www.cavern.org) to ensure there are no inadvertent impacts on karst invertebrates, bats or other species (USFWS 2011b).

Bat populations in caves should be monitored for potential effects of WNS on their numbers, and observations of multiple live or dead bats that exhibit signs of WNS should be reported immediately to the USFWS Austin Ecological Field Office. No bats are to be handled unless authorized to do so by the appropriate governmental agency (WNS Decontamination Team 2012). If WNS is discovered in the region in the future, BCP staff will follow appropriate decontamination procedures as outlined by the most recent National White-nose Syndrome Decontamination Protocol (WNS Decontamination Team 2012). Visitors from outside of central Texas or who have caved in Europe or any state

where WNS has been suspected or confirmed, or researchers that request access to BCP caves must agree to adhere to the current WNS decontamination protocol prior to access or scientific research permit approval.

### *6.2.4 Physical Management*

Cave areas should be protected from spills or contamination. The cave area is defined as the protection area designated by a hydrogeological investigation, or in the absence of a study, the area within 1/4-mile radius of the cave entrance. Coordination with USFWS is required if there are any possible contamination issues. Pesticides and fertilizers are prohibited from use within the area designated as needed for protection.

Electric power lines with transformers should be prohibited from critical cave areas because they could leak onto the ground or explode and adversely affect the cave fauna.

“Emergency Response Plans” (where needed) will be written in coordination with the Texas Commission on Environmental Quality (TCEQ), the COA Watershed Protection Department (WPD), and the Barton Springs/ Edwards Aquifer Conservation District (BS/EACD) for any cave near a pipeline or road where a major spill can occur. Most of the responsibilities for response will fall on these above agencies; however, creating such a plan before a spill may be critical to having the BCCP’s interests represented and considered in a timely manner for protection of karst species.

No subsurface utility lines, roads or any other construction should enter or cross the cave area due to possible cave collapse, leakage from pipe corrosion, or related stresses. Altering and severing interstitial spaces negatively impacts and alters sensitive karst areas. Alteration of surface drainage patterns on BCP preserves without approval of USFWS will not be allowed.

BCP Partners will prevent dumping and vandalism at caves, and will remove trash from caves when encountered. When removing trash, BCP land managers will work to remove karst invertebrates from collected trash and return them to the cave.

### *6.2.5 Access Guidelines*

In general, access to publicly-owned BCCP caves should be limited to necessary monitoring, management and research efforts that either directly benefit the endangered species or SOC or provide necessary maintenance (including RIFA control, gate maintenance, and insuring the security of the cave preserve). However, some publicly-owned BCCP caves have allowed public visitation since before the signing of the BCCP; this public access is considered to be grandfathered based on these prior allowances. Publicly owned BCCP caves with grandfathered status are: Airmen's Cave, District Park Cave, Goat Cave, Maple Run Cave, and Midnight Cave.

The Permit states that "all access to caves must be restricted to permits issued by the appropriate land management agency, based on an appropriate program in the land management plan for the preservation of the caves' ecosystem" (USFWS 1996a). BCP Partners will determine the type and amount of access at publicly-owned caves for the purposes of research, monitoring, or education, with priority focusing on adequate protection of karst species (See Tier II-A, Chapter XII). USFWS requires that anyone entering an endangered species cave without a 10(a)1(A) permit should be accompanied by someone who does have this permit.

USFWS (2011a) urges land managers to minimize access into caves due to impacts caused by visitation such as: increasing soil compaction, trash, and vandalism; scaring away trogloxenes; and direct mortality of cave organisms crushed by human disturbance. Human visitation may also disrupt cave ecosystems through introduction of non-native microorganisms, introduction of lint from clothing, increases in carbon dioxide, temperature, and nutrients, decreased humidity, and damage to speleothems (Hunter et al. 2004, Ilkner et al. 2007, Jablonsky et al. 1995, Lavoie and Northup 2005, Legatzki et al. 2011, Pulido-Bosch et al. 1997, U.S. Geological Survey 2013). Visitation impacts can be especially detrimental to low-energy caves (Gillieson 2011). Excessive or uncontrolled visitation may also endanger inexperienced people entering the

caves that are unguided, and/or lack proper safety devices and training, which could contribute to poor public opinion about caves, and can adversely affect the efforts of the BCCP. Because of these concerns, any BCCP caves that are open to the public through controlled, guided access should be accompanied by regular biological surveys of karst invertebrates as well as human visitation counts to assess impacts. Cave visitor impact monitoring may also be implemented to detect damage and guide visitor management. Trained volunteer cave monitors within Austin caving organizations could also play a vital part in the effort to protect BCP caves. These cavers can be a significant resource in cave management and will be allowed access to caves to assist with cave protection and education programs.

COA WPD staff is currently in the process of identifying new non-BCCP caves that will have the potential to reduce current levels of public access to BCCP caves while still providing valuable educational opportunities to the public.

If managing BCCP caves on private land, permission of the property owner or appropriate representative must always be obtained prior to entering. Good relationships with property owners of caves are valuable for promoting the goals of the BCCP, which includes securing the survival of rare and endangered karst species.

### *6.2.6 Public Education and Outreach*

Education both for land management professionals and the general public should be implemented in order to raise awareness of cave conservation issues and encourage protection of caves and karst ecosystems. Education for BCP preserve managers, consultants, other professionals, and private landowners with BCP caves should be the immediate focus, which should include relaying up-to-date management strategies and monitoring efforts for determining and responding to the threats to karst ecosystems addressed above. Education for the general public should be a primary focus in the long term, to better inform citizens on the importance of protecting karst areas and how that protection also benefits them.

For the purposes of this document, public education includes literature, curriculum, web media, interpretive kiosks, and guided surface and subsurface tours that can be made available for the general public, agencies, and individuals interested in learning more about karst areas and their inhabitants. Also included is educational media for cave managers and supporting staff, as well as the agencies involved with invertebrate species protection. A higher public awareness is an important step towards the recovery of the endangered cave invertebrates and continued preservation of karst species of concern.

## 6.3 MANAGEMENT COORDINATION

BCP partners will continue efforts to standardize management strategies and research/monitoring methods for all BCP caves based on best management practices.

BCP partners will attempt to work with and/or obtain landowner agreements with the following groups which are now protecting BCP caves (**Table 3**):

- TNC (one cave),
- TCMA (two caves),
- the Four Points cluster 10(a) agreement holder (five caves), and
- Canyon Creek as Section 7 agreement holder (one cave).

BCP partners will attempt to protect the remaining privately owned caves through acquisition, easements, or cave management agreements with the landowner. The precise location of some of these privately owned caves is currently unknown; therefore, the COA and TC should attempt to locate these caves in order to make a meaningful assessment.

Per BCCP Permit Conditions S2 and T2, if new karst features “are discovered with a significant diversity of troglobitic fauna, those karst features may be submitted to the Service for consideration for exchange with karst features identified for protection by the BCCP” (USFWS 1996b). In order to allow the Permit holders to implement these Permit conditions, COA and TC created a Cave Substitution Policy that provides a process that allows caves listed in the

BCCP permit to be substituted with other suitable caves in a manner that is transparent, science based, and consistent with the vision and intent established for BCCP. This policy includes a definition of "significant diversity of troglobitic fauna" as it applies to eligibility of a cave for substitution, and determines parameters that quantify preservation of environmental integrity for BCCP-listed caves and candidate substitution caves as it applies to management of caves. These defined criteria will be used in determining both the need to substitute a feature listed on the Permit as well as whether the substitution cave will adequately replace the previously identified BCCP cave or caves. The BCCP Cave Substitution Policy was adopted by the BCCP Coordinating Committee in August 2015, and is attached to this Land Management Plan as Appendix A.

The COA and TC will continue to monitor proposals for infrastructure projects that may impact BCP caves (see Management Handbook: Infrastructure).

BCP partners will continue to submit annual reports to the USFWS for all 62 caves detailing implementation of site specific management plans, cave acquisitions and agreements, research/monitoring results, and management actions and issues (USFWS 1996a).

## 7.0 MONITORING / RESEARCH

Monitoring Objectives include the following:

- Routine site inspections for signs of vandalism, unauthorized entry, trash dumping, presence of RIFA/tawny crazy ants, and damage to vegetation due to deer, feral hogs, or visitor off-trail use (USFWS 2011b).
- Verification of all BCP cave locations using established, systematic protocols. All BCP caves should also have interiors mapped using the most up-to-date survey methods available. When verifying cave locations, each site should be given a unique ID number using a tree tag and photos taken of each entrance.
- Baseline monitoring of cave species (listed and unlisted), cave crickets, vegetation, environmental conditions (in-cave and on the surface), RIFA, and mammals (USFWS 2011b).

- Monitoring of vegetation around karst features and within the features themselves for presence of feral hogs, deer, raccoons, etc. Monitoring will follow USFWS approved guidelines (USFWS 2011b).

Caves containing endangered and rare karst invertebrates on BCP properties will be monitored to determine long term trends in populations of cave organisms and overall cave conditions. All COA and TC owned BCCP caves will be surveyed annually. Other BCP caves with ES/SOC will also be surveyed annually dependent on staff availability. In addition, COA and TC identified 25 caves within Travis County managed by BCP partners that provide a more evenly distributed data set across cave clusters and karst faunal regions (KFRs). This new monitoring plan began in FY2011, with the number and frequency of karst faunal surveys and cricket counts synchronized among managing partners to better accommodate comparisons and determine trends. The goal of these changes to the cave monitoring program is to provide a clearer understanding of the species distribution and health of karst ecosystems across the BCP. Biomonitoring of the caves should follow methodology supported by USFWS to provide results that can be compared between caves throughout the region for better study and analysis.

All research, whether by BCP partners or outside researchers should not result in the "take" of an endangered species or in any way degrade endangered species habitat. All researchers must obtain approval from the land managers of BCP tracts being used for the research. If the proposed research involves endangered species the researchers must obtain a 10(a)1(A) permit from USFWS (USFWS 2011c). Land managers should also have potential researchers sign a standard form stating that they will abide by the rules of the BCP management plans or preserve rules.

The protocol for research and monitoring of cave fauna involves the use of 1-5 (depending on size of cave and logistics) pre-designated, permanent transects or zones per cave in which all living organisms encountered are identified and enumerated. Survey areas should be approximately 5 meters in length and span the width of the cave, or when possible, survey areas should occur in discreet

units of the cave such as a small room or an easily discernible section. Most importantly, the size and location of the survey area should remain constant during the course of the study. A non-toxic method of marking the transect boundaries (i.e. plastic flagging) may be necessary.

Ideally, each survey should be conducted by at least two people according to the cave's safety protocol. For each survey area, start and end time and the presence of trash or new vandalism will be recorded. Relative humidity and temperature will be recorded both outside the cave and at each transect or zone. Preferably, in order to standardize counts, the same observers will conduct all surveys. Typically observers start at opposite ends of the survey area and move toward each other while searching the cave floor, walls, ceilings, and beneath rocks for invertebrates. Any rocks that are lifted during the search will be replaced to their original position. Observers will be able to identify cave organisms to the nearest possible taxa (often genus or species), and will use a checklist of known invertebrates from the cave being surveyed. All data collected during cave surveys will be entered into the BCP Karst Database.

Any unknown invertebrates will be collected and identified by a karst invertebrate specialist. In caves containing endangered species, collecting should only occur in these caves with a special collecting permit obtained by USFWS. Observers should be extremely careful to not harm cave organisms while conducting surveys. All collected specimens should be deposited within the Texas Memorial Museum, or other reputable facility (USFWS 2011c). The date of deposition and collection number should also be recorded (USFWS 2011c). Additional procedures should continue to be developed to further define acceptable survey methods.

For caves that have controlled access, managers will keep records of every visit including information on: date, time, number of visitors, observations, temperature, humidity, etc.

Land managers will also monitor the entrances of caves containing endangered species at least twice yearly for anything that might harm the rare invertebrates

including presence of toxic substances, unauthorized use by recreational cavers, and surface disturbances which might have erosive potential or cause changes in surface drainage patterns. In addition, the interior of caves containing endangered species or SOC will be surveyed annually during dry, hot periods to check for RIFA infestation.

The overall health of caves can also be monitored by using semi-annual cave cricket exit counts. Cricket counts are done as they emerge from caves during good weather nights (i.e. not raining, warm etc.). The duration of the counts should remain constant (timed for two hours starting just after sunset). Additional information should be researched and incorporated into the methodology for conducting these cricket counts, as well as insight on how to relate survey data to cave health.

Groundwater and drip water samples should be collected to determine the impact of development on groundwater quality. Baseline sampling should be done in critical caves and springs. Tests should be done for geochemical mineral parameters as well as tests for heavy metals, organic chemicals and other likely pollutants. These tests should be done during development and for several years after development to determine if the groundwater and cave fauna are being adversely impacted by the changes in land use (Veni and Associates 1988). A list of parameters will be developed to standardize monitoring objectives. These should be listed in order of priority, should include sampling protocols, and should include a table of estimated and current year costs to assist landowners in budgeting management costs.

## 7.1 NEWLY DISCOVERED KARST FEATURES IN THE PERMIT AREA

If BCP Partners become aware of new cave and karst features (i.e. in projects submitted to these agencies during the development process), these features should be reported to the appropriate organizations such as USFWS, TCEQ, etc. Newly discovered karst features on BCP properties should be documented and species inventories done by BCP partners to provide information on potential new endangered species or SOC localities. When considering excavation of

newly discovered karst features for monitoring access, BCP land managers should consult cave excavation guidelines provided by USFWS (2011c).

## 7.2 RESEARCH NEEDS

There is currently insufficient information about some of the aspects of karst species and management of their habitat. In addition to the basic information listed above, BCP Partners should try to obtain information about the following topics and encourage research proposals and projects in these areas. This is not an exhaustive list, and research needs should be reviewed periodically. Research topics include:

- Cave Environments (humidity, temperature, airflow, and $CO_2$ concentrations). Increased airflow can cause the desiccation of cave passages. Also, the fluctuations of these abiotic conditions are not well documented in local caves and should be monitored to better understand potential impacts to karst invertebrates.
- Effects of opening or enlarging cave entrances. Excavating cave openings probably allows organic matter and nutrients to enter, and may enhance invertebrate diversity. For example, in Electromag Cave of Sun City, cave crickets became numerous after opening the entrance. However, it is possible that excavating these cave openings would enhance airflow and sunlight that may lead to drying of the cave. The general effect of opening caves probably results in returning the cave environment to pre-Colonial period conditions. This is because over grazing, agriculture, and other land-disturbance activities appear to have caused widespread filling of sinkhole depressions and cave entrances over the last few hundred years. The possible effect of opening or enlarging cave entrances requires further study. Criteria for determining the need for excavating karst features should be developed for the BCP, following cave excavation guidelines provided by USFWS (2011c).
- Delineating surface and sub-surface drainage basins to all BCP caves. Observations of flow inside caves and groundwater tracing should be used to better understand the water source for caves. Hauwert and Cowan (2013) provide methodology to adequately delineate the source area of cave drips and streams for achieving these goals.

- Life history studies. Information on the life history of karst invertebrate species on the BCCP permit is lacking and should he conducted. Life history studies that occur inside caves are best. Research of this type could potentially also be conducted at simulated cave environments, such as in the Austin Nature Center or in the Barton Springs Splash exhibit. Additionally there is a need to study habitat requirements of key trogloxene species such as cave crickets.
- Invasive species. RIFA, pill bugs, roaches, hothouse millipedes, and fleas can compete with or prey on other invertebrates. The degree of impact of these invasive species could be better understood. Attempts should be made to collect RIFA carrying prey to determine which species are most impacted. Understanding the effects of tawny crazy ants on karst ecosystems is also necessary. Finally, quantifying the effects of large amounts of scat in caves could be useful in understanding how this could attract non-cave adapted species such as roaches.
- Chemical impacts. Sampling and water-quality analysis of cave drips should be performed in urban areas, especially for pesticides, fertilizers, and metals. COA WPD tests groundwater for water-quality constituents from selected caves throughout the BCP. Local groundwater studies have found occurrences of lead, arsenic, petroleum hydrocarbons, and pesticides like bromacil and 4-nitrophenol in the groundwater under urban areas. Levels of hydrocarbon fumes have been documented in and near caves containing SOC (Get Down and Midnight caves), following a petroleum pipeline spill in 1986. The constituents of air in Travis County caves should be monitored periodically or in association with biological surveys.
- Aquatic life within the aquifer. Very little is known about life inside the aquifer in Travis County. Abundant diversity has been found in the Edwards Aquifer of the San Marcos to San Antonio area after investigation. Possible research could include: down-hole cameras and baited traps utilized in open bore wells; fine nets used to catch body parts in large capacity pumping wells; and surveys conducted in caves extending down to the water table. Efforts should be made to discover cave routes that extend to the water table, as these present tremendous opportunities to examine aquatic life.

- Cave cricket abundance as an indicator of cave ecosystem health. Cave cricket exit count data should be analyzed to determine trends. Studies on cave cricket foraging and surface habitat preferences should be conducted. Cave cricket survey methodology should be examined for improvements based on future scientific studies.
- Species identification. Efforts should be made to identify to species level yet undetermined troglobites in BCP caves, with special emphasis on species that may be identified as endangered or SOC as listed on the regional permit. Such examples include blind *Eidmannella* spiders, *Speodesmus* millipedes, *Rhadine* beetles, and Trichoniscidae isopods.
- Long-term trends in populations of cave organisms and overall cave conditions.
- Impacts on the species by recreational uses of caves (in caves with allowed access).
- Impacts of surface disturbances on karst species. Such disturbances may include reduced habitat area around the cave, erosion, changes in surface drainage patterns, and habitat restoration projects (mechanical clearing of vegetation and prescribed burns).
- Impacts from changes in surrounding land use. There is a need to better understand how development around cave areas may adversely impact groundwater, nutrient input, or the cave fauna themselves.

## 8.0 LITERATURE CITED

Amos, B.B., and F.R. Gehlbach, 1988. Edwards Plateau Vegetation: Plant Ecological Studies in Central Texas. Baylor University Press, Waco, TX.

Bayless, Todd, Travis County, Natural Resources and Environmental Quality, personal communication, 2013, 2015.

Biological Advisory Team (BAT). 1990. Comprehensive report of the biological advisory Team. Austin, Texas.

Campbell, J., Cokendolpher, J., Griswold, C., Ledford, J., Paquin, P. 2012. Systematics, conservation and morphology of the spider genus Tayshaneta (Araneae, Leptonetidae) in Central Texas Caves. Zookeys: (167): 1-102.

Cokendolpher, James C., 2004. *Cicurina* spiders from caves in Bexar County, Texas (Araneae: Dictynidae). Texas Memorial Museum, Speleological Monographs, 6:13-58.

Cokendolpher, James, Natural Science Research Laboratory, Museum of Texas Tech University, personal communication, 2008.

Elliot, William R. 1992. Endangered and Rare Karst Species in Travis County, Texas: Options for the Balcones Canyonlands Conservation Plan.

Elliott, William R. 1997. The Caves of the Balcones Canyonlands Conservation Plan, Travis County Texas, Travis County Natural Resources program.

Elliott, William R. and J. R. Reddell. 1989. The status and range of five endangered arthropods from caves in the Austin, Texas, region. Appendix A in comprehensive report of the Biological Advisory Team, 1990.

Gillieson, David S. 2011. Management of Caves. Chapter 6 in Karst Management, Phillip E. van Beynen (Ed.), p. 141-158.

Hauwert, N., and Cowan, B. 2013, Delineating Source Areas To Cave Drips And Cave Streams In Austin Texas, USA: 13th Sinkhole Conference, Carlsbad, NM.

Hedin, Marshall. 2015. High-stakes species delimitation in eyeless cave spiders (*Cicurina*, Dictynidae, Araneae) from central Texas. Molecular Ecology 24(2): 346-361.

HNTB. 2005. Summary of Information for Assessing the Status of the Tooth Cave ground beetle (*Rhadine persephone,*), a report for USFWS by Casey Berkhouse.

Hunter, A., D. Northup, C. Dahm, and P. Boston. 2004. Persistent coliform contamination in Lechuguilla Cave pools. Journal of Cave and Karst Studies 66(3):102-110.

Ikner, L., R. Toomey, G. Nolan, J. Neilson, B. Pryor, and R. Maier. 2007. Cultural microbial diversity and the impact of tourism in Kartchner Caverns, Arizona. Microbial Ecol. 53:30-42.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate change 2007: synthesis report, summary for policymakers. Intergovernmental Panel on Climate Change, Fourth Assessment Report. Released on 17 November 2007. 23 pp. Available from: http://www.ipcc.ch/pdf/assessment report/ar4/syr/ar4_syr_spm.pdf.

Jablonsky, P., S. Kraemer, and B. Yett. 1995. Lint in caves. Proceedings of the 1993 Cave Management Symposium. Carlsbad Caverns, New Mexico. p. 73-86.

Lavoie, K. and D. Northup. 2005. Bacteria as indicators of human impact in caves. Proceedings of the 2005 National Cave and Karst Management Symposium. Albany, New York. p. 40-47.

Legatzki, Antje, et al. "Bacterial and archaeal community structure of two adjacent calcite speleothems in Kartchner Caverns, Arizona, USA." Geomicrobiology Journal 28.2 (2011): 99-117.

Ledford, Joel, Department of Entomology, California Academy of Sciences, personal communication, 2010.

Meyers, Jason M. 2008. Identification, Distribution, and Control of an Invasive Pest Ant, *Paratrechina* sp. (Hymenoptera:Formicidae), in Texas. PhD. Dissertation. Texas A and M University.

Muchmore, William B. 2001. Review of the genus *Tartarocreagris*, with descriptions of new species (Pseudoscorpionida: Neobisiidae). Texas Memorial Museum, Speleological Monographs, 5:57-72.

Paquin, P. and M. Hedin. 2005. Genetic and morphological analysis of species limits in *Cicurina* spiders (Araneae, Dictynidae) from southern Travis and northern Hays counties (TX), with emphasis on *Cicurina cueva* Gertsch and relatives. Special report for the Department of Interior United States Fish & Wildlife Service Contract No. 201814G959. Revised version10 May 2005.

Paquin P., Dupérré, N., Cokendolpher J., White, K.and M. Hedin. 2008. The fundamental importance of taxonomy in conservation biology: the case of the eyeless *Cicurina bandida* (Araneae:Dictynidae) of central Texas, including new synonyms and the description of the male of the species. Invertebrate Systematics 22: 139–149.

Pulido-Bosch, A., W. Martin-Rosales, M. Lopez-Chicano, C. Rodriguez-Navarro, and A. Vallejos. 1997. Human impacts in a touristic karstic cave (Aracena, Spain). Environmental Geology 31:142-149.

Reddell, James, Texas System of Natural Laboratories (TSNL), Texas Cave Management Association (TCMA), personal communication, 1998, 2004, 2005.

Reddell, James, Texas Memorial Museum, University of Texas, personal communication, 2010.

Sanders, Mark, City of Austin, Austin Water Utility, BCP Program, personal communication, 1997, 2013, 2015.

Taylor, S.J., J.K. Krejca, and M.L. Denight. 2005. Foraging range and habitat use *of Ceuthophilus secretus* (Orthoptera: Rhaphidophoridae), a key

trogloxene in central Texas cave communities. American Midland Naturalist 154: 97-114.

Texas Memorial Museum (TMM). 2007. TEXBIO database, The University of Texas at Austin.

U.S. Fish and Wildlife Service. 1994. Endangered Karst Invertebrates (Travis and Williamson Counties): Recovery Plan.

U. S. Fish and Wildlife Service, 1996a. Final Environmental Impact Statement/Habitat Conservation Plan for Proposed Issuance of a Permit to Allow Incidental Take of the Golden-cheeked Warbler, Black-capped Vireo, and Six Karst Invertebrates in Travis County, Texas. U. S. Fish and Wildlife Service, Albuquerque, N. M.

U. S. Fish and Wildlife Service. 1996b. Federal Fish and Wildlife Permit No. TE-788841-2.

U.S. Fish and Wildlife Service. 2008. Tooth Cave Ground Beetle (*Rhadine Persephone*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2009a. Bone Cave Harvestman (*Texella reyesi*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2009b. Tooth Cave Spider (*Neoleptoneta myopica*), Kretschmarr Cave Mold Beetle (*Texamaurops reddelli*), and Tooth Cave Pseudoscorpion (*Tartarocreagris texana*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2009c. Bee Creek Cave Harvestman (*Texella reddelli*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2011a. Bexar County Karst Invertebrates Recovery Plan. USFWS Southwest Region, Albuquerque, NM.

U.S. Fish and Wildlife Service. 2011b. Karst Preserve Management and Monitoring Recommendations. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2011c. Section 10(a)(1)(A) Karst Invertebrate Survey Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrates in Central Texas. Fish and Wildlife Service, 10711 Burnet Road, Suite 200, Austin, Texas 78758. September 8, 2011. 21 pp.

U.S. Fish and Wildlife Service. 2011d. A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats. US Fish & Wildlife Service, 300 Westgate Center Drive, Hadley, MA.

U.S. Fish and Wildlife Service. 2011e. Karst Invertebrate Habitat Requirements. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2012. Karst Preserve Design Recommendations. Austin Ecological Services Field Office, Austin, TX.

U.S. Fish and Wildlife Service. 2014a. Service Determines that the Warton's Cave Meshweaver does not Warrant Protection Under the Endangered Species Act. U.S Fish and Wildlife Service Southwest Region News Release, August 13, 2014.

U.S. Fish and Wildlife Service. 2014b. White Nose Syndrome Map – Suspected and Confirmed Occurrences. WNS Coordination Node (online resource). http://www.whitenosesyndrome.org/resource/white-nose-syndrome-infographic-updated-april-11-2014 (accessed 22 April 2014).

U.S. Geological Survey. 2013. Threats to cave ecosystems. Retrieved July 2013 from http://sbsc.wr.usgs.gov/cprs/research/projects/caves/threats.asp.

Veni and Associates. 1988. Hydrologic investigation of the Jollyville Plateau karst, Travis County, Texas. U.S. Fish and Wildlife Service.

Vinson, S.B. and A.A. Sorensen. 1986. Imported fire ants: Life history and impact. Texas Dept. of Agriculture, Austin, TX. 28p.

Watson, Cyndee, U.S. Fish and Wildlife Service, Austin Ecological Services Field Office, personal communication, 2015.

WNS Decontamination Team. 2012. National White-Nose Syndrome Decontamination Protocol - Version 06.25.2012. http://whitenosesyndrome.org/sites/default/files/resource/national_wns_revise_final_6.25.12.pdf

Zara Environmental, LLC. 2007a. Report of Excavation and Biology of Down Dip Sink, Water Treatment Plant 4 Bull Creek Site, Travis County, Texas. Report for Carollo Engineers, Austin TX.

Zara Environmental, LLC. 2007b. Report of Excavation and Biology of Garden Hoe Cave and Canopy Joint Sink, Water Treatment Plant 4 Bull Creek Site, Travis County, Texas. Report for Carollo Engineers, Austin TX.

Zara Environmental, LLC. 2008. Excavation and Biology of Caves and Karst Features on the Lucas Tract, Travis County, Texas. Report for Carollo Engineers, Austin TX.

Zara Environmental, LLC. 2010. Population Status of Karst Invertebrates in the Balcones Canyonlands Preserve. Report for Weston Solutions, Inc., Austin TX.

# APPENDIX A

# BCCP CAVE SUBSTITUTION POLICY

Balcones Canyonlands Conservation Plan Coordinating Committee
Cave Substitution Policy

Adopted: 8/21/15

Precinct 3 County Commissioner Gerald Daugherty

District 7 City Council Member Leslie Pool

Acknowledged: William A. Conrad, Coordinating Committee Secretary

**Purpose**

Provide a process that that will allow the Balcones Canyonlands Conservation Plan (BCCP) Coordinating Committee to implement conditions in the BCCP Endangered Species Permit (ES 788841-2 and future revisions, amended permits, or subsequent permits) that allow caves listed in the permit to be substituted with other suitable caves in a manner that is transparent, science based, and consistent with the vision and intent established for BCCP

**BCCP Permit Conditions**

**BCCP Permit (TE 788841-2) Condition S2 [related to Endangered Species covered by the permit]:** If during investigations for development of a tract, karst features are discovered with a significant diversity of troglobitic fauna, those karst features may be submitted to the Service for consideration for exchange with karst features identified for protection by the BCCP. The determination of "significant diversity" will be made by the permit applicants and the Service, in association with karst experts. The inclusion of such a karst feature would not increase the number of caves to be protected by the BCCP, but would result in the new feature replacing a previously identified cave or caves.

**BCCP Permit (TE 788841-2) Condition T2 [related to Species of Concern covered by the permit]:** If during investigations for development of a tract, karst features are discovered with a significant diversity of troglobitic fauna, those karst features may be submitted to the Service for consideration for exchange with karst features identified for protection by the BCCP. The determination of "significant diversity" will be made by the permit applicants and the Service, in association with karst experts. The inclusion of such a karst feature would not increase the number of caves to be protected by the BCCP, but would result in the new feature replacing a previously identified cave or caves.

## Roles and Responsibilities

**BCCP Coordinating Committee -** was created to implement the BCCP - Shared Vison. The BCCP Interlocal Cooperation Agreement requires that the Coordinating Committee carry out the BCCP Shared Vision as Authorized by the BCCP federal permit. It may adopt policies recommended by its Secretary. They are responsible for adopting this policy, providing public involvement with respect to its implementation, and for making decisions and taking action as provided by this policy including initial approval that would trigger actions to initiate a minor permit amendment.

**Permit Covered Governing Bodies** - as provided in the BCCP Interlocal Cooperation Agreement include Austin City Council and Travis County Commissioners Court. They are responsible for providing additional opportunities for public involvement and reviewing the Coordinating Committee's decisions to substitute caves for those covered in the permit and for taking action as they deem appropriate as provided for in the BCCP Interlocal Cooperation Agreement for permit amendments.

**U.S. Fish and Wildlife Service (Service)** - is the federal agency authorized by the Endangered Species Act to issue, suspend, and revoke incidental take permits in accordance with Section 10(a)(1)(B) of the Endangered Species Act and its implementing regulations, policy and guidance. They issued permit TE-788841-2 based on the March 1996 Habitat Conservation Plan and Final Environmental Impact Statement. Under their authorities, they are responsible for reviewing and approving any requests to amend this permit. The Service's role is to advise the BCCP on matters related to permit compliance and Fish and Wildlife Service processes and procedures at the earliest possible opportunity.

**Third Parties** - many caves identified for protection in BCCP are on property owned by third parties not bound to BCCP. They are not required to coordinate with or seek approval from BCCP before taking action that may affect a BCCP listed cave. Third parties may offer cave protection to BCCP for permit covered caves or for caves that might be considered for substitution by BCCP.

## Cave Substitution Process

### Background

The regional Endangered Species Act Section 10(a)(l)(B) permit (TE 788841-2), also known as the Balcones Canyonlands Conservation Plan (BCCP), requires the Permit holders (City of Austin and Travis County) to acquire, protect, and ensure management that preserves the environmental integrity of 62 listed caves protecting populations of six endangered karst invertebrates and 25 karst species of concern (SOC). This Permit "is subject to compliance with, and implementation of, the terms and conditions of the Environmental Impact Statement and Habitat Conservation Plan" (EIS/HCP) as well as all specific conditions contained in the Permit itself (USFWS 1996a).

One such condition described in the Permit states that "if during investigations for development of a tract, karst features are discovered with a significant diversity of troglobitic fauna, those karst features may be submitted to the Service for consideration for exchange with caves identified for protection by the BCCP. The determination of 'significant diversity' will be made by the permit applicants and the Service, in association with karst experts. The inclusion of such a karst feature would not increase the number of caves to be protected by the BCCP, but would result in the new feature replacing a previously identified cave or caves" (USFWS 1996a).

In order to meet the terms and conditions of the U.S. Fish and Wildlife Service (USFWS) Permit, Permit holders determined a need to define "significant diversity of troglobitic fauna" as it applies to eligibility of a cave for substitution, and determine parameters that quantify preservation of "environmental integrity" for BCCP-listed caves and candidate substitution caves as it applies to management of caves. These defined criteria will be used in determining both the need to substitute a feature listed on the Permit as well as whether the substitution cave will adequately replace the previously identified BCCP cave or caves. These criteria are not intended to evaluate whether a BCCP-listed caves has met Permit compliance, but rather only to evaluate caves for substitution. Following Permit conditions, a group of karst experts, USFWS staff, and Permit holder staff collaborated on these criteria as members of the BCCP Scientific Advisory Committee Karst Sub-committee (chair: Dr. Nico Hauwert).

**Significant Troglobitic Diversity as Applied to Conservation of Karst Species**

Due to the predicted loss of the vast majority of potential karst habitat allowed by the BCCP, the EIS/HCP states that "the adequacy of the plan is contingent upon full implementation of the acquisition and management strategies detailed in the BCCP", which includes caves named as specific localities for the six endangered karst invertebrates and 25 BCCP-listed karst SOCs (USFWS 1996b). The EIS/HCP also stresses that given the fact that several BCCP karst SOCs were known from only a few caves when the plan was written, the loss of even one BCCP-listed cave could result in a major reduction to the species' population (USFWS 1996b).

However, the EIS/HCP acknowledges that although the BCCP was designed to protect most known localities of endangered karst invertebrates and karst SOCs at the time of permit issuance, "the possibility remains that features may be found that provide habitat for listed species or other equally rare karst invertebrates", and there is a "high probability that other new rare species will be described from Travis County in the future" (USFWS 1996b). The Permit provides for these types of new discoveries to be considered substitutions for BCCP-listed caves if such karst features provide a "significant diversity of troglobitic fauna" (USFWS 1996a).

In order to adhere to the protection strategy in the EIS/HCP and Permit for listed karst invertebrates, as well as ensuring Permit holders receive the "No Surprises" guarantee for protecting the 25 karst SOCs, a karst feature considered for exchange with a BCCP-listed cave must consider those species for which the BCCP cave was designated to protect. However, the EIS/HCP also guides Permit holders to attempt to protect newly discovered karst features that provide habitat for other equally rare karst invertebrates (USFWS 1996b).

The USFWS Biological Opinion also states that the BCCP "identifies an option that establishes a process that allows any newly discovered cave to be protected in the place of a less biologically significant cave currently identified for protection" (USFWS 1996c).

Incorporating this guidance from the EIS/HCP and Biological Opinion, the determination of a replacement cave's significant biological diversity will consider several factors that include species composition, diversity, and abundance, as well as the cave's location and ecological benefits. See Methodology for Assessing Significant Diversity and Environmental Integrity of BCCP Caves and Potential Substitution Caves for specifics on these factors and methodology used for determining significant troglobitic diversity of karst features.

**Environmental Integrity as Applied to Karst and Caves**

The EIS/HCP states that for a karst fauna area to be considered protected, it must "contain a large enough expanse of continuous karst and surface area to maintain the integrity of the karst ecosystem on which each species depends." The EIS/HCP also provides protection criteria to meet this goal, stating that "the size and configuration of each karst fauna area must be adequate to maintain moist, humid conditions, air flow, and stable temperatures in the air-filled voids; maintain an adequate nutrient supply; prevent contamination of surface and groundwater entering the ecosystem; prevent or control the invasion of exotic species, such as fire ants; and allow for movement of the karst fauna and nutrients through the interstitium between karst features" (USFWS 1996b).

The EIS/HCP states that, "in most instances, this will entail protecting the entire surface and sub-surface drainage area of each cave and enough of the surface vegetation community to support small animals and buffer against fire ant infestations" (USFWS 1996b).

Although the 1996 EIS/HCP does not provide a quantifiable area for protection of the surface vegetation community, it does address the need for this information by stating that the delineation of appropriate boundaries for individual cave preserves will require additional studies to determine the surface area necessary to maintain the biological resources important to the cave (USFWS 1996b).

Research and information needs such as this were also outlined in the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (1994) as one of four major recovery actions; the EIS/HCP reiterates that the effective enactment of this and other recovery actions are necessary "to assure that the implementation of the BCCP has no negative impact on the population viability of the endangered karst invertebrates" (USFWS 1996b).

This recovery action was met with the completion of USFWS Karst Preserve Design Recommendations in 2012, which quantifies the protection criteria quoted above from the BCCP EIS/HCP, and provides specific preserve components for configuring karst preserves that maintain environmental integrity of the karst invertebrate locations and ecosystems they are designed to protect.

According to USFWS' Karst Preserve Design Recommendations, in addition to protecting the entire surface and sub-surface drainage areas, preserve components which maintain the cave's environmental integrity should include: the cave cricket foraging area; a preserve configuration of at least 40 acres that protects the surface plant and animal communities and ensures that the cave footprint is over 105 meters from the nearest hard edge; and is free of incompatible forms of land use and sources of contamination (USFWS 2012).

These recommendations (USFWS 2012) also reiterate the need for karst preserves to be protected and management assured through acquisition or formal management agreements, which is also a requirement of the Permit and EIS/HCP (USFWS 1996a, USFWS 1996b).

Additional preserve components meeting these objectives and methods for quantifying and evaluating these factors are described in Methodology for Assessing Significant Diversity and Environmental Integrity of BCCP Caves and Potential Substitution Caves.

Caves submitted as substitution caves for BCCP-listed caves will be assessed for their environmental integrity using these factors, and measured against the environmental integrity assessment of the cave or caves suggested for replacement.

Only replacement caves with sufficient environmental integrity and significant diversity of troglobitic diversity, and equivalent to or superior to the BCCP cave it has been submitted to replace will be used as an adequate substitution. See Methodology for Assessing Significant Diversity and Environmental Integrity of BCCP Caves and Potential Substitution Caves for methodology on factors for determining environmental integrity of karst features.

**Literature Cited**

U. S. Fish and Wildlife Service. 1994. Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas. Albuquerque, New Mexico.

U. S. Fish and Wildlife Service. 1996a. Federal Fish and Wildlife Permit No. TE-788841-2.

U. S. Fish and Wildlife Service. 1996b. Final Environmental Impact Statement /Habitat Conservation Plan for Proposed Issuance of a Permit to Allow Incidental Take of the Golden-cheeked Warbler, Black-capped Vireo, and Six Karst Invertebrates in Travis County, Texas.

U. S. Fish and Wildlife Service. 1996c. Biological Opinion for the Issuance of a Section 10(a)(l)(B) Permit for the Balcones Canyonlands Conservation Plan. Albuquerque, New Mexico.

U. S. Fish and Wildlife Service. 2012. Karst Preserve Design Recommendations. Austin Ecological Services Field Office. Austin, Texas.

**Methodology for Assessing Significant Diversity and Environmental Integrity of BCCP Caves and Potential Substitution Caves**

The following methodology describes criteria that will: 1) define significant diversity of troglobitic fauna in caves considered for replacement of BCCP-listed caves and 2) determine protection measures that quantify preservation of environmental integrity for BCCP-listed caves and candidate substitution caves.

These criteria will be used in determining both the need to substitute a feature listed on the Permit, such as when a cave ecosystem has been significantly damaged or destroyed or if Permit holders have been unable to secure adequate protections for a cave, as well as whether the substitution cave will adequately replace the previously identified cave or caves.

Caves submitted as substitution for BCCP-listed caves will be assessed for equal or superior significant diversity of troglobitic fauna and environmental integrity using the factors below, and measured against the assessment of the cave or caves suggested for replacement.

**Evaluation to Determine Substitution Need and Suitability of Replacement Caves**

Caves submitted as substitution caves for BCCP-listed caves will be assessed for whether they meet objectives for significant diversity of troglobitic fauna and environmental integrity using the

factors detailed below, and measured against equal assessments of the cave or caves suggested for replacement.

Only replacement caves meeting significant diversity requirements and with sufficient environmental integrity equal or superior to the BCCP cave it has been submitted to replace will be used as an adequate substitution.

Essential to this evaluation is that the replacement cave(s) be a confirmed locality for the same federally listed karst invertebrate(s) and/or karst species of concern (SOC) as the BCCP-listed cave designated for substitution.

Evaluations for BCCP-listed caves and candidate replacement cave(s) will be made using the most up-to-date research and karst preserve design recommendations available at the time of the assessment. If additional research valuable to this evaluation process becomes available in the future, the BCCP Scientific Advisory Committee's karst sub-committee will review the new information and incorporate or revise assessment factors below if deemed appropriate.

This document is not intended to be a precise rating system or contain a complete scoring rubric, but rather serves as a comprehensive list of the data that would be ideal to have in hand to evaluate cave substitution.

Caves are not easily comparable in terms of biology, ecosystem health, and value to preserve strategies. Each situation is different, and it is impossible to anticipate the variety of issues that may arise when comparing two caves.

The purpose of this document is to provide the evaluation team with a list of all reasonably measured factors relevant to the decision for approving a cave for substitution.

This document is strictly designed for the cave substitution process and not intended to be used to evaluate whether a BCCP-listed cave's protections are compliant with the Permit.

Evaluations for proposed substitutions will occur on a case by case basis, which includes determining if sufficient data are available to evaluate both BCCP-listed caves proposed for substitution and their candidate replacement cave(s).

If there are too many unknowns or assumptions about either cave, evaluators are allowed to reject the substitution proposal until the proposer fills in more of the dataset, up to the discretion of the evaluation team.

Proposers allowing cave access to evaluators may provide one option for obtaining missing evaluation data.

**Factors for Determining Significant Diversity of Troglobitic Fauna for a Candidate Substitution Cave**

Candidate replacement caves will be compared with BCCP caves designated for substitution and will only be accepted as replacements if the following conditions are met:

1. Replacement cave has similar or greater species composition in relation to target species (federally listed taxa or karst SOCs), as determined by the following factors:
    a. The replacement cave must be a confirmed locality for the same federally listed karst invertebrate(s) as the BCCP cave it will be replace.

b. For BCCP caves containing one of the 25 karst SOC, the replacement cave must contain the same SOC(s) as the BCCP cave it will replace.
    i. Exception: If the BCCP cave does not contain any of the 25 karst SOC (Talus Spring Cave), then the replacement cave must contain either: 1) one or more karst SOC listed on the Permit or 2) one or more troglobitic species of similar taxa to the SOCs listed on the Permit considered to be at least as rare as the BCCP-listed SOCs.
    Rare karst invertebrates not listed as SOCs on the Permit will be evaluated using information from the BCP Karst Database, Texas Memorial Museum's TexBio Database, Texas Park and Wildlife Department's Species of Greatest Conservation Need (SGCN) list rankings (TPWD 2011), and NatureServe's Conservation Status Assessments (Master et al. 2012) to quantify significance of the species in terms of rarity and need for protection.

2. Replacement cave has similar or greater overall troglobitic karst invertebrate species diversity, as determined by the following factors:
    a. Demonstrate through repeated biological surveys that the replacement cave has greater or equal diversity; for example, by graphing the number of troglobitic taxa seen on each visit and noting those previously seen vs. new occurrences. Karst invertebrate surveys should follow survey methodology described in USFWS 2014b, which explains that in order to assess presence/absence of endangered karst invertebrates with a high level of confidence, caves should be surveyed at least 14 times.
    b. Evaluate whether the caves in consideration have been thoroughly measured in terms of diversity. Since many karst species are rare and poorly studied, problems with detection and taxonomy hamper creating a complete list. Evaluate and explain the status of the diversity list for the cave(s).
    c. Evaluate the numbers of troglobitic taxa vs. other taxa (troglophiles, trogloxenes, or accidentals). In some cases the cave entrance has great diversity, but the deep cave community structure is limited.
    d. Additional rare karst invertebrates not listed as SOCs on the Permit will be evaluated using information from the BCP Karst Database, Texas Memorial Museum's TexBio Database, Texas Park and Wildlife Department's SGCN list rankings (TPWD 2011), and NatureServe's Conservation Status Assessments (Master et al. 2012) to quantify significance of the species in terms of rarity and need for protection.
    e. Consider non-troglobitic karst species, which rank high on TPWD's SGCN list and NatureServe's Conservation Status Assessments list that could be affected/protected by the substitution (ex: bats, salamanders), as contribution to the overall biological diversity of the cave being considered for substitution.
3. Replacement cave has similar or greater Permit-listed species abundance, as determined by the following factors:
    a. Demonstrate through repeated biological surveys the relative abundance of taxa on the cave's species list. With well-delineated in-cave survey methodology, it should be clear where the rare species are found within the cave, and how many are typically seen in a visit. If collection methods are not performed in a uniform fashion, results may not be comparable among sites or within a site on different survey days; this should be explained or accounted for in the evaluation. Karst invertebrate surveys should follow survey methodology described in USFWS 2014b.

b. If the entire cave isn't inventoried during each visit, then an estimate of the non-surveyed area would help determine the total potential of the cave to support a healthy population. This estimate will account for the fact that, on average, larger caves have more habitat available and a greater diversity of habitat, thus having a greater diversity and abundance of fauna (Schneider and Culver 2004).

4. Replacement cave's location is within the same karst fauna region as defined by Veni (1992) or future USFWS-approved revisions of the KFRs.
5. Replacement cave's location is within the same BCCP-protected cave cluster (Northwood, McNeil, or Four Points). Note: only applicable if BCCP cave to be substituted is within one of these cave clusters. This requirement ensures that the replacement cave is contributing to a Karst Fauna Area that helps meet the recovery criteria for the federally listed karst invertebrates in the BCCP cave to be substituted.

**Factors for Determining Environmental Integrity of BCCP Listed Caves and Potential Replacement Caves**

The following protection criteria, largely based on USFWS Karst Preserve Design Recommendations (2012), will be used to quantify the environmental integrity of BCCP caves and candidate substitution caves for determining both the need for substitution of a BCCP cave and adequate replacement by a candidate substitution cave.

Ideally preferred protection goals are also described for each factor to guide evaluation assessments.

A. Karst feature surface area protection measures:
   1. Percent of cave footprint within protected area:
      a. Determined by GIS spatial analysis and use of footprint digitized from cave map to quantify percent protected.
      b. Protected area – lands owned or acquired by the Permit holders (City of Austin and Travis County) or BCP managing partners that are managed for protection of the cave or caves, or lands that have formal management agreements with the Permit holders as described in S-4 and T-4 of the Permit (USFWS 1996a).
      c. Ideally preferred protection goal: 100 percent of cave footprint is within protected area (USFWS 2012).

   2. Distance of cave footprint to nearest preserve edge:
      a. Determined by GIS spatial analysis by calculating the distance of edge of the digitized cave footprint to nearest preserve boundary.
      b. Edge: defined as the cave preserve's property boundary and/or where impervious cover dissects the natural area surrounding the karst feature, such as paved roads or urban development areas detrimental to surface protection efforts.
      c. Ideally preferred protection goal: footprint is as near to the center of the protected area as possible, and at least 105 m from the preserve edge (USFWS 2012).

   3. Percent of surface drainage within protected area:
      a. Determined by GIS spatial analysis by quantifying percent of delineated surface drainage basin that is within protected area(s).

b. Surface drainage basins will be conservatively over-estimated with high confidence by licensed geologists performing hydrogeologic studies of caves using methods described in Veni 2003, Hauwert et al. 2005, Hauwert 2009, or other methods approved by the BCCP Scientific Advisory Committee's karst sub-committee.
c. Where surface drainage basin delineations are unable to be performed due to denied access, this analysis will be performed based on the area draining to the cave entrance using available topographic and cave map data.
d. Ideally preferred protection goal: the entire surface drainage basin is within the protected area (USFWS 2012).

4. Percent of subsurface drainage basin within protected area:
    a. Determined by GIS spatial analysis by quantifying percent of delineated subsurface drainage basin that is within protected area(s).
    b. Subsurface drainage basins will be conservatively over-estimated with high confidence by licensed geologists performing hydrogeologic studies of caves using methods described in Hauwert and Cowan 2013, Veni 2003, or other methods accepted by the SAC karst sub-committee.
    c. Where subsurface drainage basin delineations are unable to be performed due to denied access, this analysis will be performed using a delineation made by the contour level at the bottom of the cave, as required by S-3 and T-3 of the Permit (USFWS 1996a).
    d. Ideally preferred protection goal: the entire subsurface drainage basin is within the protected area (USFWS 2012).

5. Percent of cave cricket foraging area (105 meters from cave footprint) within protected area:
    a. Determined by GIS spatial analysis by creating a 105m buffer area around the cave's footprint digitized from its cave map, and quantifying percent of this buffer area that is within protected area(s).
    b. Ideally preferred protection goal: 100 percent of cave cricket foraging area is within the protected area (USFWS 2012).
    c. As an alternative to assuming a 105m buffer, site-specific cave cricket surveys could be performed in order to determine the foraging area around a specific cave. Methods should include an adequate survey area and effort during appropriate season and over enough nights to capture the large diversity of exit and foraging patterns known for *Ceuthophilus* spp. Taylor et al. (2005) and Zara Environmental (2013, 2014) give examples of methods used for site specific cave cricket foraging studies in Texas.

6. Preserve tract size:
    a. Determined by GIS spatial analysis. In cases where BCP or other preserve tracts are adjoining each other, all connected interior preserve tract boundaries will be dissolved to account for connectivity to all preserve areas. Cave preserve tract delineations also cease at hard edges such as paved roads or impervious cover detrimental to surface protection efforts.
    b. NOTE: This environmental factor is extremely important when determining environmental integrity of a candidate replacement cave. A large, intact tract has ecological stability and natural buffers that are difficult if not impossible to create artificially or manage successfully. Large preserves protect the quality of native

surface plant, arthropod, and animal communities necessary for adequate nutrient input (USFWS 2012). Large preserves are also more resilient and typically support caves that need less active management (USFWS 2012). Large preserves with contiguous karst areas have abundant mesocavernous zones which are likely to support immeasurable populations of rare troglobites. Having naturally resilient preserves also makes them less sensitive to problems associated with loss of funding and staffing resources that may happen over time.

c. USFWS has chosen preserve size as a critical indicator in determining quality of a karst preserve (USFWS 2012). Ideally preferred protection goals include a preserve size of at least 100 acres to be considered a high quality preserve, or at least 40 acres to be considered a medium quality preserve (USFWS 2012).

7. Net gain in protected land for BCP:
   a. Determined by subtracting acreage of BCCP cave's protected area from the replacement cave's preserve tract size.
   b. Ideally preferred protection goal: Cave preserves with larger protected areas will be favored due to benefits described above in item 6, preserve tract size.

8. Shape of protected area:
   a. Subjective determination using map that shows cave's location within delineated preserve area boundaries.
   b. Ideally preferred protection goal: USFWS 2012 defines preserves that are circular in shape and/or are connected to other preserves as an ideally preferred protection measure, along with the cave or caves being as near to the center of the preserve area as possible to reduce edge effects.

9. Landscape mosaic of protected area (% woodland/grassland):
   a. Determined by GIS spatial analysis using NAIP aerial imagery and/or LIDAR data to classify landscape components in the protected areas within 100 acres of cave.
   b. Proper landscape mosaic helps to ensure the quality of the native surface plant, arthropod, and animal communities, beneficial to the cave's nutrient input (USFWS 2012).
   c. Ideally preferred protection goal: according to USFWS (2012), cave preserve areas should include ≥80% woodland to 10% grassland mosaic.

10. Number of adjacent karst features within protected area:
    a. Quantified by performing karst feature surveys in protected area within a 100 acre radius of cave which includes the surface and subsurface drainage basins, following recommendations in USFWS 2014b.
    b. Ideally preferred protection goal: cave preserves should be designed to protect as many caves or karst features as possible to support nutrient input from cave crickets (USFWS 2012).

11. Incompatible land use/fragmentation:
    a. Subjective determination using aerial map that demonstrates the cave's location and incompatible forms of land use within delineated preserve area boundaries.
    b. Incompatible forms of land use within the delineated karst preserve itself such as paved roads, impervious cover, livestock, water retention ponds, or hiking and

biking trails should also be documented for consideration of this factor (USFWS 2012). Also describe adjacent land use outside of the preserve including developments, roads, impervious cover, etc.

c. Ideally preferred protection goals: There should be no paved roads, development, impervious cover or other structures that result in permanent habitat loss within the cave's protected area (USFWS 2012). Protected areas should also not include trails or picnic tables inside the cave cricket foraging area, the surface or subsurface drainage basin or within 105m of the cave footprint (USFWS 2012).

12. Proximity to infrastructure/ utilities:
    a. Subjective determination using aerial map that illustrates the cave's location and infrastructure within and adjacent to delineated preserve area boundaries.
    b. Ideally preferred protection goal: cave preserve is free of underground pipelines, storage tanks, water retention ponds, or other structures/facilities that could cause contamination (USFWS 2012).

B. Hydrogeologic quality of troglobitic habitat measures:
1. Contribution to water quality/quantity within the karst ecosystem. Quantified by:
    a. Surface Catchment Area size
    b. Maximum Potential Subsurface Catchment Area based on data collected
    c. Average combined drip rate per cave following methodology described in Hauwert and Cowan (2013).
    d. Lack of subsurface pipelines or retention basins (USFWS 2012).
    e. Ideally preferred protection goals: larger catchment areas are preferred due to their more significant contribution to water quantity within the karst ecosystem.

2. Total accessed length, depth, and volume of cave:
    a. Determined by cave maps. Also, if applicable, describe potential of undiscovered cave passages with supporting evidence.
    b. Volume of cave determined by methods described in Krejca and Weckerly (2007).
    c. Ideally preferred protection goal: USFWS (2012) states that larger, deeper caves may help protect against impacts to protected species from climate change by better maintaining in-cave stable temperatures and high humidity.

3. Presence of permanent water bodies within cave:
    a. Determined by in-cave surveys and/or documentation on cave maps and data from access to phreatic zone habitat where aquatic life such as aquatic salamanders may potentially be found.
    b. Ideally preferred protection goal: caves with permanent bodies of water (pools, cave streams) are preferred for their contribution of habitat for aquatic life, potentially increasing biological diversity.

C. Ecological health measures:
These parameters may not be a critical factor on their own, but are important for the evaluation team to help understand the current ecological status and potential future management needs of the cave.

1. Healthy/stable cave cricket population:
    a. Use existing cave cricket exit count survey results to assess population trends at caves.
    b. If cave cricket data are absent or lacking, perform cave cricket monitoring following recommendations in USFWS 2014a.
    c. Ideally preferred protection goal: results at caves will demonstrate a healthy and stable cave cricket population as demonstrated by repeated surveys.

2. Density of red-imported fire ants (RIFA), tawny crazy ants, and/or other invasive species that could impact the cave ecosystem:
    a. Perform surveys using a scientifically accepted protocol for tawny crazy ants (*Nylanderia fulva*) to confirm absence at sites: caves suggested as candidates for replacement caves should not have infestations of tawny crazy ants.
    b. Quantify RIFA densities using survey methods detailed in USFWS 2014a to ensure that RIFA threshold levels have not been reached at replacement caves.

**Evaluation Documentation Requirements**

The following documents and information should be included for conducting the evaluation to determine substitution need of a BCCP-listed cave and suitability of its replacement cave(s) (see above for details/definitions of specific factors):

1. Maps of each cave preserve area demonstrating the following:
    a. Cave location and footprint.
    b. Cave protection area.
    c. Surface and subsurface drainage basin delineations.
    d. Cave cricket 105 meter foraging area delineation.
    e. Adjacent karst feature locations.
    f. Landscape mosaic of karst preserve.
    g. Incompatible forms of land use within the delineated karst preserve.
    h. Infrastructure within and adjacent to delineated preserve area boundaries.
    i. Surrounding land use.

2. Cave map for each cave demonstrating length, depth, and permanent bodies of water.

3. Documentation confirming presence of federally-listed karst invertebrates and/or BCCP karst SOC's.

4. Species lists for each cave.

5. In-cave faunal survey results demonstrating species abundance and methodology for conducting surveys.
6. Hydrogeologic study reports demonstrating methodology to assess drainage basin delineations and average combined drip rate results.

7. Cave cricket exit count survey results at caves and methodology for conducting surveys.

8. RIFA survey data for caves demonstrating mound densities.

See the Cave Comparison Worksheet below (Table 1) for a summary of cave substitution evaluation criteria.

## Table 1 Cave Comparison Worksheet

| | Cave Substitution Evaluation Criteria Worksheet | BCCP Cave | Substitution Cave | Comments |
|---|---|---|---|---|
| | **Significant Diversity Criteria** | | | |
| 1a. | Confirmed endangered species locality? | | | |
| 1a. | List of endangered species (ES) present | | | |
| 1b. | BCCP Species of Concern (SOC) locality? | | | |
| 1b. | List of BCCP SOC present | | | |
| 2a - 2c. | Replacement cave has similar or greater overall species diversity | | | |
| 2d. | List of additional troglobitic species | | | |
| 2d. | SGCN list ranking of additional troglobitic species | | | |
| 2d. | Natureserve rarity rank of additional troglobitic species | | | |
| 2e. | List of rare non-troglobitic species | | | |
| 3. | Replacement cave has similar or greater overall species abundance | | | |
| 4. | Karst Fauna Region | | | |
| 5. | Replacement cave is within same BCCP cave cluster (if applicable) | | | |
| | | | | |
| | **Environmental Protection Criteria** | | | |
| **A.** | **Karst feature surface area protection measures:** | | | |
| 1. | Percent of cave footprint within protected area | | | |
| 2. | Distance of cave footprint to nearest preserve edge | | | |
| 3. | Percent of surface drainage within protected area | | | |
| 4. | Percent of subsurface drainage within protected area | | | |
| 5. | Percent of cave cricket foraging area within protected area | | | |
| 6. | Preserve tract size | | | |
| 7. | Net gain in protected land for BCP | | | |
| 8. | Shape of protected area | | | |
| 9. | Landscape mosaic of protected area (% woodland/grassland) | | | |
| 10. | Number of adjacent karst features within protection area | | | |
| 11. | Incompatible land use/fragmentation | | | |
| 12. | Proximity to infrastructure/pipelines/utilities | | | |
| | | | | |
| **B.** | **Hydrogeologic quality of troglobitic habitat measures:** | | | |
| 1a. | Surface catchment area size | | | |
| 1b. | Maximum potential subsurface catchment area | | | |
| 1c. | Average combined drip rate | | | |
| 2. | Total accessed length of cave | | | |
| 2. | Total accessed depth of cave | | | |
| 2. | Total accessed volume of cave | | | |
| 3. | Presence of permanent water bodies in cave | | | |
| | | | | |
| **C.** | **Ecological health measures:** | | | |
| 1. | Cave cricket population: in-cave survey and exit count results | | | |
| 2. | Red-imported fire ant density at site | | | |
| 2. | Tawny crazy ants present at site? | | | |

**Literature Cited**

Krejca, J.K. and F.W. Weckerly. 2007. Detection probabilities of karst invertebrates. Report prepared for Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service.

Hauwert, NM, ME Litvak, and JM Sharp. 2005. Characterization and Water Balance of Internal Drainage Sinkholes: In Beck, B. ed., Geotechnical Special Publication No. 144, Sinkholes and the Engineering and Environmental Impacts of Karst, Proceedings of the Ninth Multidisciplinary Conference, p. 188-200.
http://www.austintexas.gov/watershed_protection/publications/document.cfm?id=186248

Hauwert, Nico M. 2009. Groundwater Flow and Recharge within the Barton Springs Segment of the Edwards Aquifer, Southern Travis County and Northern Hays County, Texas: Ph.D. Diss., University of Texas at Austin, Texas. 328 p.
http://repositories.lib.utexas.edu/handle/2152/14107

Hauwert, N., and Cowan, B. 2013. Delineating Source Areas to Cave Drips and Cave Streams in Austin Texas, USA: 13th Sinkhole Conference, Carlsbad, NM.
**http://www.karstportal.org/node/11735?destination=node/11735**

Master, L.L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Extinction Risk. NatureServe, Arlington, VA.

Schneider, K. and D. C. Culver. 2004. Estimating subterranean species richness using intensive sampling and rarefaction curves in a high density cave region in West Virginia. Journal of Cave and Karst Studies 66(2): 39-45.

Taylor, S.J., J. Krejca, and M.L. Denight. 2005. Foraging range and habitat use of *Ceuthophilus secretus* (Orthoptera: Rhaphidophoridae), a key trogloxene in central Texas cave communities. American Midland Naturalist 154: 97-114.

Texas Memorial Museum (TMM). 2009. *TEXBIO* database, The University of Texas at Austin.

Texas Parks and Wildlife Department. 2011. Texas Conservation Action Plan: Species of Greatest Conservation Need. Austin, Texas.
https://tpwd.texas.gov/landwater/land/tcap/sgcn.phtml

U. S. Fish and Wildlife Service. 1996a. Federal Fish and Wildlife Permit No. TE-788841-2.
U. S. Fish and Wildlife Service. 2012. Karst Preserve Design Recommendations. Austin Ecological Services Field Office. Austin, Texas.

U.S. Fish and Wildlife Service. 2014a. Karst Preserve Management and Monitoring Recommendations. Austin Ecological Services Field Office. Austin, Texas.

U.S. Fish and Wildlife Service. 2014b. Section 10(a)(1)(A) Karst Invertebrate Survey Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrates in Central Texas. Fish and Wildlife Service, 10711 Burnet Road, Suite 200, Austin, Texas 78758. May 8, 2014.

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. 2003. Delineation of hydrogeologic areas and zones for the management and recovery of endangered karst invertebrate species in Bexar County, Texas. Report for U.S. Fish and Wildlife Service, Austin, Texas, prepared by George Veni and Associates, San Antonio, Texas. Dated 23 December 2002 with minor revisions submitted 12 April 2003.

Zara Environmental LLC (Zara). 2013. Study Design: Cave cricket foraging study from Stark's North mine to (proposed) North Walnut Creek trail, Austin, Travis County, Texas. Report prepared for: RPS, 4801 Southwest Parkway, Austin, Texas 78735. 8 pp.

Zara Environmental LLC (Zara). 2014. Cave cricket foraging study from Stark's North Mine to proposed North Walnut Creek trail, Austin, Travis County, Texas. Report prepared for: RPS, 4801 Southwest Parkway, Austin, Texas 78735. 27 pp.

**How is a Cave Substitution Made?**

a. A BCCP Coordinating Committee Member makes a proposal to substitute for a cave listed in condition S1 or T1 in the BCCP Federal Permit
b. BCP staff(s) assembles information required, as described in the Evaluation Documentation Requirements
c. Refer the proposal to the BCCP Scientific Advisory Committee – Karst Subcommittee for review, assessment, and recommendation to the Coordinating Committee for action.
d. When the Coordinating Committee takes action to accept a cave substitution proposal, the coordinating committee will initiate the BCCP amendment process for a minor amendment to the BCCP federal permit (Article 7, section 7.2, Interlocal Cooperation Agreement Between Travis County and City of Austin Implementing the Balcones Canyonlands Conservation Plan – Shared Vision)
e. Proposals for cave substitution will be completed within one year from the date of submission by a Coordinating Committee member. This allows for any needed information gathering, additional field investigations, data analysis, and limited Coordinating Committee meeting schedules. This timeline will allow BCCP to appropriately address issues of non-compliance in a manner that would not result in an immediate permit violation while allowing third party actions to proceed in a reasonable manner.

**Karst Preserve Protection and Management Measures**

These management measures must be able to be enacted at BCCP caves or candidate replacement caves. If for some reason the candidate replacement cave's site can not adhere to these measures, then it may not be considered as a substitution.

1. No public access allowed in cave:
    a. Ideally preferred protection goal: USFWS 2012 states that no public access should be allowed at caves: "to protect the subsurface habitat, several things should be carefully controlled including ensuring that the cave is entered for monitoring purposes only".
    b. Candidate replacement caves should not allow public access.

c. If recreational use is allowed in the cave's protected area, it should not interfere with karst management objectives as described in 11. c. (Incompatible land use) above and as defined in the most recently approved BCP Land Management Plan (Chapter IX, Karst Species Management).

2. Cave is (or will be) gated and/or fenced:
    a. Ideally preferred protection goal: perimeter fencing around cave preserves is preferred for protection of the karst ecosystem from dumping, vandalism, and trespass (USFWS 2014a). Properly designed and installed cave gates are also preferred where there is a history of trespass and vandalism, and where human health or safety may be at risk (USFWS 2014a).

3. Cave is (or will be) monitored/managed per most recent USFWS Karst Preserve Management and Monitoring Recommendations (2014a). Ideally preferred protection goals for this factor:
    a. Biological monitoring is being conducted.
    b. Vegetation management supports health of karst habitat.
    c. Red-imported fire ant management is performed.