BALCONES CANYONLANDS PRESERVE

LAND MANAGEMENT PLAN

TIER II-A

CHAPTER IX

KARST SPECIES MANAGEMENT

May 2014

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

Common Name	Scientific Name
Tooth Cave pseudoscorpion	*Tartarocreagris texana*
Tooth Cave spider	*Neoleptoneta myopica*
Tooth Cave ground beetle	*Rhadine persephone*
Kretschmarr Cave mold beetle	*Texamaurops reddelli*
Bee Creek Cave harvestman	*Texella reddelli*
Bone Cave harvestman	*Texella reyesi*

Table 2. Karst Species of Concern Covered by the BCCP

Common Name	Scientific Name
Flatworm	*Sphalloplana mohri*
Ostracod	*Candona* sp. nr. s*tagnalis*
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	*Neoleptoneta concinna*
Spider	*Neoleptoneta devia*
Spider	*Eidmannella reclusa*
Pseudoscorpion	*Aphrastochthonius* N. S.
Pseudoscorpion	*Tartarocreagris comanche*
Pseudoscorpion	*Tartarocreagris reddelli*
Pseudoscorpion	*Tartarocreagris intermedia*
Pseudoscorpion	*Tartarocreagris* N. S. 3
Harvestman	*Texella spinoperca*
New Comanche Cave Harvestman	*Texella comanche*
Millipede	*Speodesmus* N. S
Ground Beetle	*Rhadine s. subterranea*
Ground Beetle	*Rhadine s. mitchelli*
Ground Beetle	*Rhadine austinica*

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 (**Figure 1: BCCP cave locations**). 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 2: Karst 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-eight of the 62 karst features (62 = 60 caves, one spring, and one mine) covered by this Karst Management Plan are privately owned (**T**). 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 1996). 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.

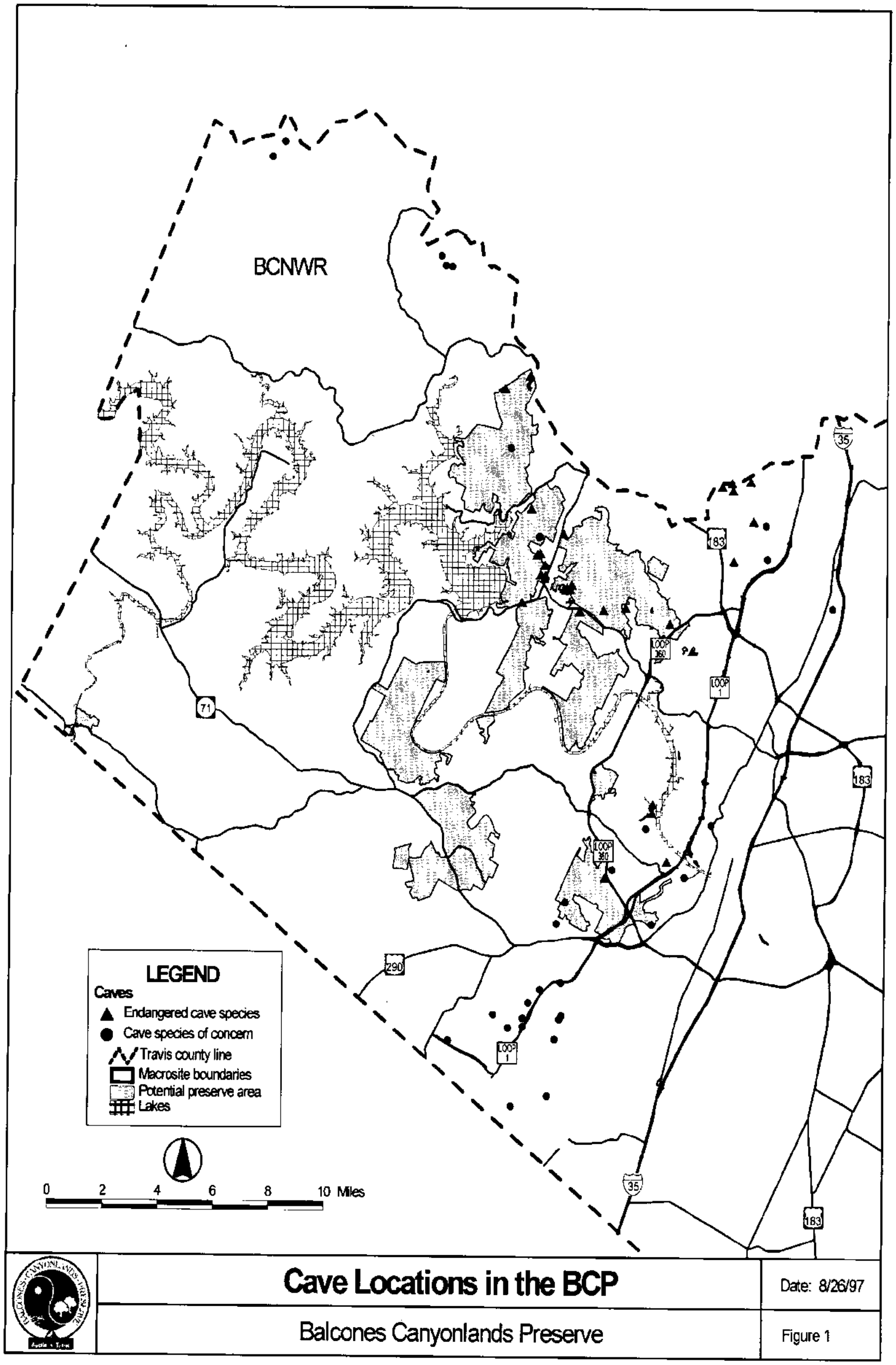

Figure 1. BCCP Cave Locations

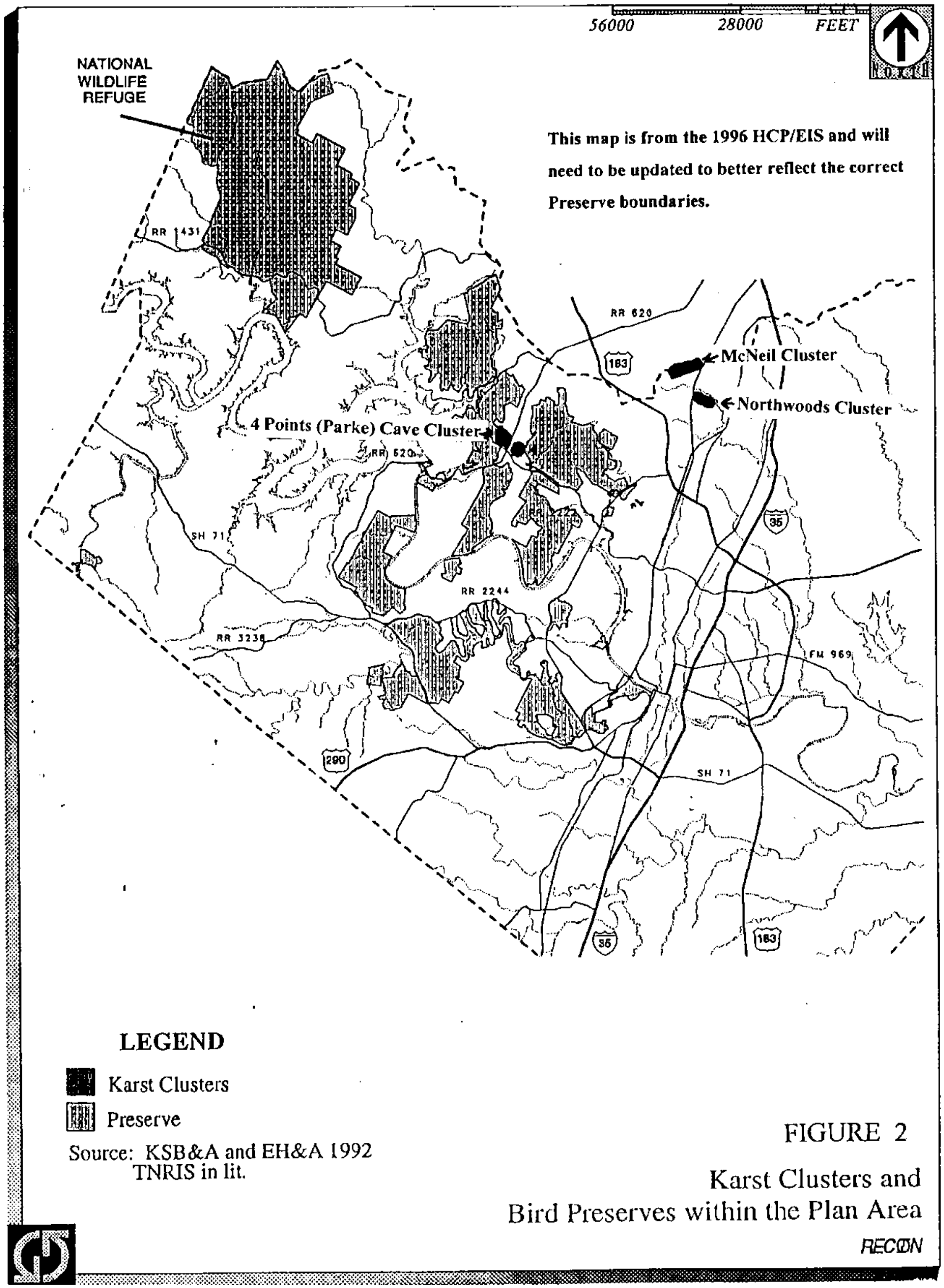

Figure 2. Karst Clusters

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	Private	
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	

<u>Key and Footnotes</u>

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 *Neoleptoneta 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	
Beard Ranch Cave	BCP Ivanhoe COA	Jollyville Plateau						X 1996
Bee Creek Cave	Private	Rolling-wood					X 1996	
Beer Bottle Cave	Not required to be protected under BCCP	McNeil Round Rock						X 1996
Broken Arrow Cave	BCP Lime Creek Preserve COA	Cedar Park			X 1996			
Cave Y	BCP Barton Creek Greenbelt COA	Rolling-wood					P 1996 delete P 2004 (Reddell)	

Cave Name	Current Preserve Status	Karst Fauna Region	Tooth Cave Pseudoscorpion *Tartarocreagris texana*	Tooth Cave Spider *Neoleptoneta myopica*	Tooth Cave Ground Beetle *Rhadine persephone*	Kretschmarr Cave Mold Beetle *Texamaurops reddelli*	Bee Creek Cave Harvestman *Texella reddelli*	Bone Cave Harvestman *Texella reyesi*
Cold Cave	Private	McNeil Round Rock						X 1996
Cotterell Cave	BCP Spicewood Springs Park/COA	Central Austin						X 1996
Dis-believers 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
Fossil Garden Cave	Private	McNeil Round Rock						X 1996
Gallifer Cave	BCP Jollyville/TC	Jollyville Plateau		P 1996 X 2010 (Ledford)	P 1996 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 X 2005		
Jest John Cave	BCP Forest Ridge/COA	Jollyville Plateau					X 1996	

Cave Name	Current Preserve Status	Karst Fauna Region	Tooth Cave Pseudoscorpion *Tartarocreagris texana*	Tooth Cave Spider *Neoleptoneta myopica*	Tooth Cave Ground Beetle *Rhadine persephone*	Kretschmarr Cave Mold Beetle *Texamaurops reddelli*	Bee Creek Cave Harvestman *Texella reddelli*	Bone Cave Harvestman *Texella reyesi*
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
Kretsch-marr Cave	BCP Jollyville/TC	Jollyville Plateau			X 1996	X 1996		
Kretsch-marr Double Pit	BCP Jollyville/TC	Jollyville Plateau	P 1996 X 2005		P 1996 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
McNeil Bat Cave	Private	McNeil Round Rock		X 2010 (Ledford)				X 1996
Millipede Cave	Not Protected under BCCP	McNeil Round Rock						X 1996
M.W.A. Cave	BCP Private 10(a)	Jollyville	P 1996 X 2005		X 1996	P 1996 X 2005		X 1996

Cave Name	Current Preserve Status	Karst Fauna Region	Tooth Cave Pseudoscorpion *Tartarocreagris texana*	Tooth Cave Spider *Neoleptoneta myopica*	Tooth Cave Ground Beetle *Rhadine persephone*	Kretschmarr Cave Mold Beetle *Texamaurops reddelli*	Bee Creek Cave Harvestman *Texella reddelli*	Bone Cave Harvestman *Texella reyesi*
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			
Puzzle Pits Cave	Not required to be protected under BCCP	Jollyville			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)	P 1996 delete P 2004 (Reddell)
Stark's North Mine Cave	BCP Stark's/TC						X 2009 (USFWS)	

Cave Name	Current Preserve Status	Karst Fauna Region	Tooth Cave Pseudoscorpion *Tartarocreagris texana*	Tooth Cave Spider *Neoleptoneta myopica*	Tooth Cave Ground Beetle *Rhadine persephone*	Kretschmarr Cave Mold Beetle *Texamaurops reddelli*	Bee Creek Cave Harvestman *Texella reddelli*	Bone Cave Harvestman *Texella reyesi*
Stovepipe Cave	BCP Canyon Creek/ COA	Jollyville Plateau	P 1996 delete P 2005 (Reddell) *	P 1996 delete P 2010 (Ledford)	X 1996	X 1996		P 1996 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
Weldon Cave	Private	McNeil Round Rock						X 1996
West Rim Cave	Not Protected under BCCP	Central Austin						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 2005 = was listed as confirmed in the HNTB summary of James Reddell's data, 2005 report for USFWS

Tentative 2005 = was listed as tentative in the HNTB summary of Reddell's data, 2005 report for USFWS

Delete P 2004 (Reddell) = this species is no longer thought to occur in this cave (personal communication Reddell 2004)

* Reddell (pers com 2005) reported that *Tartarocreagris texana* does NOT occur in Stovepipe Cave. The species there is *Tartarocreagris attenuata,* known only from that cave.

X 2008 = Cokendolpher (pers com 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 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 com 2010)

Delete P 2010 (Ledford) = *Neoleptoneta* for stovepipe was confirmed as *N devia* (personal communication J. Ledford 2010)

X 2010 (Reddell) = confirmed by J. Reddell (pers com 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 *Neoleptoneta 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
Merkin Hole	COA	Jollyville Plateau					X 2010	
Pond Party Pit	COA	Jollyville Plateau						X 2010
RI-1	TC	Jollyville Plateau					X 2010	
Tight Pit Cave	TC	Jollyville Plateau		X 2010				

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

Sources: USFWS 2008, 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

Key and footnotes follow table

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina ellioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*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										

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina elliotti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*Tartarocreagris N.S. 3*	*Texella spinoperca*	*Trichoniscinae N.S.*
Broken Arrow Cave							X																	
Buda Boulder Spring		X																						
Cave X		X	X	X							X			X			X							
Cave Y				X										X										
Ceiling Slot Cave									X															
Cold Cave									X															
Cotterell Cave					X	X									X						X			
Dis-believers Cave									X															
District Park Cave				X										X										
Eluvial Cave																								
Flint Ridge Cave				X										X										

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina elioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*Tartarocreagris N.S. 3*	*Texella spinoperca*	*Trichoniscinae N.S.*
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															
Japygid Cave																								
Jest John Cave									X															
Jester Estates Cave									X															

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina ellioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*Tartarocreagris N.S. 3*	*Texella spinoperca*	*Trichoniscinae N.S.*
Jollyville Plateau Cave																								
Kretsch-marr Cave							X									X								
Kretsch-marr 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										

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina ellioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*Tartarocreagris N.S. 3*	*Texella spinoperca*	*Trichoniscinae N.S.*
McDonald Cave							X						X								X			
McNeil Bat Cave									X						X									
Midnight Cave				X										X										
Moss Pit																								
New Comanche Trail Cave									X	X									X					
No Rent Cave									X						X									
North Root Cave									X															
Pennie's Cave														X			X							
Pickle Pit								X																
Pipeline Cave																	X							
Rolling Rock Cave									X								X							
Root Cave							X																	

Cave Name	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina ellioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*Tartarocreagris N.S. 3*	*Texella spinoperca*	*Trichoniscinae N.S.*
Slaughter Creek Cave				X																				
Spanish Wells Cave		X																X						
Spider Cave							X			X														
Stark's North Mine												X												
Stove-pipe Cave	X								X	X														
Talus Springs Cave																								
Tardus Hole																								
Tooth Cave							X			X						X								
Weldon Cave	X						X								X									
Whirlpool Cave				X										X										

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

Key and Footnotes

X = confirmed location based on collected specimen.

[1] 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).

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

[3] *Tartarocreagris reddelli* listed as a SOC in the regional permit has now been synonymized with *Tartarocreagris infernalis* (Muchmore 2001).

Table 7. Non-BCCP Caves/Karst Features with Karst SOC Protected on BCP

Key and footnotes follow table

Cave Name	BCP Owner	*Aphrastochthonius N.S.*	*Caecidotea reddelli*	*Candona sp. nr. stagnalis*	*Cicurina bandida* [1]	*Cicurina ellioti*	*Cicurina reddelli*	*Cicurina travisae*	*Cicurina wartoni*	*Cicurina sp.* [2]	*Eidmannella reclusa*	*Miktoniscus N.S.*	*Neoleptoneta concinna*	*Neoleptoneta devia*	*Rhadine austinica*	*Rhadine s. subterranea*	*Rhadine s. mitchelli*	*Speodesmus N.S.*	*Sphalloplana mohri*	*Tartarocreagris comanche*	*Tartarocreagris intermedia*	*Tartarocreagris infernalis* [3]	*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														
LU-29	TC									X															
Pond Party Pit	COA									X												X			
RI-1	TC									X															
RI-3	TC									X															
Siebert Sink	COA				X								X											X	
Two Trunks Cave	TC									X															

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

Key and Footnotes

X = confirmed location based on collected specimen.

[1] 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).

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

[3] *Tartarocreagris reddelli* listed as a SOC in the regional permit has now been synonymized with *Tartarocreagris infernalis* (Muchmore 2001).

3.0 NEW KARST INFORMATION RELATED TO THE BCCP

For 17 years, "*The Caves of the Balcones Conyonlands 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 has yet to adopt this change; therefore, BCP managers will continue to use the genus *Neoleptoneta* until this change is adopted by USFWS.

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 basin (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 1996).

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 com 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 1996).

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 com 2013; Bayless pers com 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 16, 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 com 2013; Bayless pers com 2013).

Mammals bring in tremendous amounts of organic material into caves via their scat. Though 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 com 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 tricolored bat (*Perimyotis subflavus*), has been shown to be susceptible to WNS (USFWS 2011d). Another common bat in the region, cave myotis (*Myotis velifer*), tested positive in 2010 for the presence of *Geomyces destructans*, the fungus associated with WNS, as far west as Oklahoma (USFWS 2011d). In the 2013-2014 monitoring season (winter), WNS was detected and confirmed in Arkansas (USFWS 2014). These occurrences demonstrate 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 1996).

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 whenever 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/treat methods only; no foliar spray treatments will be used within the 105 m cave cricket foraging area of ES/SOC caves.

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 a fence 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 com). 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. Alteration of surface drainage patterns on BCP preserves without approval of USFWS will not be allowed.

6.2.5 Access Guidelines

Access to publicly-owned BCCP caves with endangered species 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).

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 1996). 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.

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.

Human visitation may disrupt cave ecosystems through compaction of cave sediment, 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). The impacts can be especially detrimental to low-energy caves (Gillieson 2011). 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. Excessive or uncontrolled visitation may also endanger inexperienced people entering the caves that are unguided, and/or lack proper safety devices and training. Uncontrolled visitation may also endanger sensitive features within the cave. If unabated, these problems can contribute to poor landowner relations and poor public opinion about caves, and can adversely affect the efforts of the BCCP.

If no listed endangered species are found or known to exist in a karst feature, public access may be allowed. However, USFWS (2011a) also 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. Trained volunteer cave monitors within Austin caving organizations will likely play a vital part in the effort to protect these BCP caves and other caves in the Austin area. These cavers can be a significant resource in cave management and will be allowed access to caves to assist with cave protection. Public education programs about cave biology and cave protection will also likely require the continuation of some access into non-endangered species caves. However, this access to publicly-owned caves will 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 (See Table 1 for ownership status).

Prior to any regular visitation other than necessary research or maintenance, baseline populations of invertebrates will be assessed for BCCP caves that may be considered for "test public access caves" (see section 4.0 for monitoring guidelines). Baseline biological surveys should be conducted once every quarter for the first year at a cave to establish background levels. Where baseline surveys are conducted under extended unrepresentative climatic conditions, such as under an extended drought, the surveys should be extended into more average conditions.

Following baseline surveys, at least two surveys a year should be conducted. Results from surveys should be reviewed annually to better assess the impacts of visitors on cave invertebrates, and limits on visitation should be considered if surveys demonstrate detrimental effects to caves or their inhabitants.

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.

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 Permit Conditions S2 and T2, Permit Holders may substitute some of the privately owned caves listed on the BCCP permit that are unable to be located or protected. COA and TC will continue evaluating the adequacy of protection for all of the 62 BCCP caves, as well as other BCP caves/karst features with endangered species. TC and COA will devise appropriate cave/karst evaluation related to a set of proposed substitution protocols. If protection is not possible for one or more BCCP caves, USFWS will be consulted to evaluate the substitution protocols and whether any currently protected, non-BCCP caves could be suitable as ecological replacement.

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 1996).

7.0 MONITORING / RESEARCH

Monitoring Objectives will include:

- 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).
- All BCP cave locations will be verified 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 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 BCP caves with endangered species will be surveyed annually. 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 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 the 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 *Cicurina* spiders, *Eidmannella* spiders, *Speodesmus* millipedes, *Rhadine* beetles, and Trichoniscidae isopods.

- Karst species field guide. This field guide could include photos, life history and habitat information of all karst species to assist with karst species identification in the field.
- 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.

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