LEE COUNTY CAVE ISOPOD
(LIRCEUS USDAGALUN)

RECOVERY PLAN

U.S. FISH AND WILDLIFE SERVICE
HADLEY, MASSACHUSETTS

September 1997

LEE COUNTY CAVE ISOPOD (*Lirceus usdagalun*)

RECOVERY PLAN

Prepared by:

Dr. Steve Roble and Terri Brown
Virginia Department of Conservation and Recreation
Division of Natural Heritage
Richmond, Virginia

and

Leroy M. Koch
U.S. Fish and Wildlife Service
Southwest Virginia Field Office
Abingdon, Virginia

for:

U.S. Fish and Wildlife Service
Hadley, Massachusetts

Approved: _____ ACTING
Regional Director, Northeast Region

Date: SEP 30 1997

EXECUTIVE SUMMARY

Lee County Cave Isopod Recovery Plan

CURRENT STATUS: The Lee County cave isopod, *Lirceus usdagalun*, is a subterranean freshwater crustacean found only in Lee County, Virginia. This rare isopod was federally listed as endangered in November 1992; at the time, one of the two known populations was believed extirpated, leaving a single population. The present known distribution of the Lee County cave isopod is in the Surgener-Gallohan Cave system and in two springs at Flanary Bridge and Sims Creek in the Powell River Valley. This species appears to have an extremely limited range, increasing its susceptibility to a single incident of groundwater pollution, which could pose serious threats to long-term viability.

LIMITING FACTORS AND HABITAT REQUIREMENTS: Unlike most other species in this genus, the Lee County cave isopod is an aquatic troglobite, an obligate cave-dwelling organism. It is usually found on the surfaces of small, submerged rocks and gravels in cave streams or similar habitat at spring resurgences. The isopod is considered extirpated from the Thompson Cedar Cave system due to groundwater pollution originating from a sawmill operation. As with many other aquatic species, it is considered susceptible to various types of groundwater pollution.

RECOVERY OBJECTIVE: To achieve long-term population viability of the Lee County cave isopod within a significant portion of its range and remove this species from the Federal list of endangered and threatened species.

RECOVERY CRITERIA: ***Delisting*** may be considered when all the following criteria are met:

A. The present and historic distribution for this species is thoroughly delineated.
B. The surface and subterranean hydrology within the known range of isopod is understood sufficiently to monitor and manage the species.
C. Populations of the Lee County cave isopod in at least four subterranean systems are shown to be stable over a ten-year (minimal) monitoring period.
D. A groundwater monitoring program is established for cave systems known to contain the isopod, with ten-year results demonstrating that groundwater quality and quantity are sufficient to ensure the survival of this species.
E. Measures have been secured for the permanent protection from significant groundwater contamination of all four cave systems supporting the Lee County cave isopod.

Reclassification to threatened may be considered when A and B above are completed, when C and D have been underway for at least five years with positive results, and when E is accomplished for at least two sites.

ACTIONS NEEDED:

1. Conduct surveys to determine the location and extent of all areas supporting the Lee County cave isopod.
2. Monitor populations of the Lee County cave isopod.
3. Conduct life history and other research to determine what constitutes a viable and stable population of the isopod.
4. Develop an understand the surface and subterranean drainage systems where the isopod occurs.
5. Monitor water quality and quantity and isopod habitat at selected sites, and eliminate or minimize environmental impacts on the species.
6. Implement habitat protection and, as needed, restoration measures for all populations of the isopod.
7. Conduct educational programs for the Lee County region that focus on protection of cave-karst resources.
8. If feasible and as needed, restore populations of the isopod to habitat within its historic range.
9. Implement a program to monitor recovery progress.

PROJECTED COSTS ($000):

	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Need 9	Total
FY1	11.5	1	20	30	82	105	28			279.5
FY2	3.5	5	20	20	79	105	13		.5	246.0
FY3	3.5	5	20	15	68	105	13	tbd*	.5	230.0

Fiscal year costs for all tasks beyond these three years will be determined as needed.
* to be determined

TIME FRAME: If recovery tasks are implemented on schedule, delisting the Lee County cave isopod will be considered in the year2010.

ACKNOWLEDGMENTS

The Lee County cave isopod recovery plan has benefitted from the contributions of several individuals, including Caren Caljouw, Melissa Donoff, Chris Hobson, Larry Smith, and Tom Smith. Their help is greatly appreciated.

* * *

The following recovery plan delineates a practical course of action for protecting and recovering the endangered Lee County cave isopod *(Lirceus usdagalun)*. Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This recovery plan has been prepared through the joint efforts of the Virginia Department of Conservation and Recreation, Division of Natural Heritage, and the U.S. Fish and Wildlife Service. The plan does not, however, necessarily represent the views of any individuals or the official position of any agencies other than the U.S. Fish and Wildlife Service. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1997. Lee County Cave Isopod *(Lirceus usdagalun)* Recovery Plan. Hadley, Massachusetts. 40 pp.

Additional copies of this draft plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
Telephone: 301/492-6403 or 800/582-3421

For questions about the plan, please contact:

U.S. Fish and Wildlife Service
Southwestern Virginia Field Office
P.O. Box 2345
988 West Main Street
Abingdon, Virginia 24210
Telephone: 540/623-1233

TABLE OF CONTENTS

LIST OF FIGURES

PART I: INTRODUCTION

The Lee County cave isopod, *Lirceus usdagalun*, is a subterranean freshwater crustacean belonging to the family Asellidae. The family is represented in North America by several genera, including *Caecidotea* and *Lirceus*. While *Caecidotea* is known to occur in both surface water and underground habitats, *Lirceus* is almost always found in surface water habitats, such as springs, seeps, and small streams (Williams 1972, Holsinger and Bowman 1973). Unlike most other species in this genus, *Lirceus usdagalun* is a troglobite, an obligate cave-dwelling organism. This isopod is endemic to southwestern Virginia, where it has been documented from only two cave systems and two springs (both presumably associated with undiscovered cave systems) in Lee County.

The Lee County cave isopod was federally listed as endangered in November of 1992 (U.S. Fish and Wildlife Service 1992). This status was determined because one of the two populations known prior to listing was extirpated, leaving a single population. In addition, the Lee County cave isopod has an extremely limited range, increasing its susceptibility to a single incident of groundwater pollution, which could pose serious threats to the survival of the species.

DESCRIPTION AND DISTRIBUTION

The Lee County cave isopod, discovered by Dr. John R. Holsinger and William Mauck in August 1961, was the first troglobitic species known within its genus (Holsinger and Bowman 1973). Since this discovery, only one other troglobite, *Lirceus culveri,* has been described in this genus (Estes and Holsinger 1976, Holsinger and Culver 1988). Like all isopods, the Lee County cave isopod lacks a carapace, is dorsoventrally flattened, and possesses seven pairs of leglike cephalothoracic appendages. This isopod reaches a length of only 7.0 mm to 7.5 mm, and it lacks eyes and pigmentation (Figure 1). The Lee County cave isopod is distinguished from other species in its genus by a deep, narrow, lateral incision of the head, relatively wide spaces between the anterior pereonites, the absence of median and distal processes on the palm of the gnathopodal propod, the presence of a slender spur on the endopod of the male second pleopod, and a proportionately short uropod (Holsinger and Bowman 1973).

This species is endemic to the extreme southwestern corner of Virginia in the Central Lee County Karst region, part of which is known locally as The Cedars (Holsinger 1985). The isopod has been documented from only two cave systems and two springs in the Powell River Valley of Lee County, Virginia (Figure 2). The extent of the subterranean waterways that feed these two springs, and therefore the extent and abundance of the isopod in those systems, is unknown. Traveling in a northeast to southwest direction, the historic distribution of the Lee County cave isopod in these two cave systems and two springs includes six known site occurrences: (1) Thompson Cedar Cave, (2) a spring near Flanary Bridge, (3) a spring along

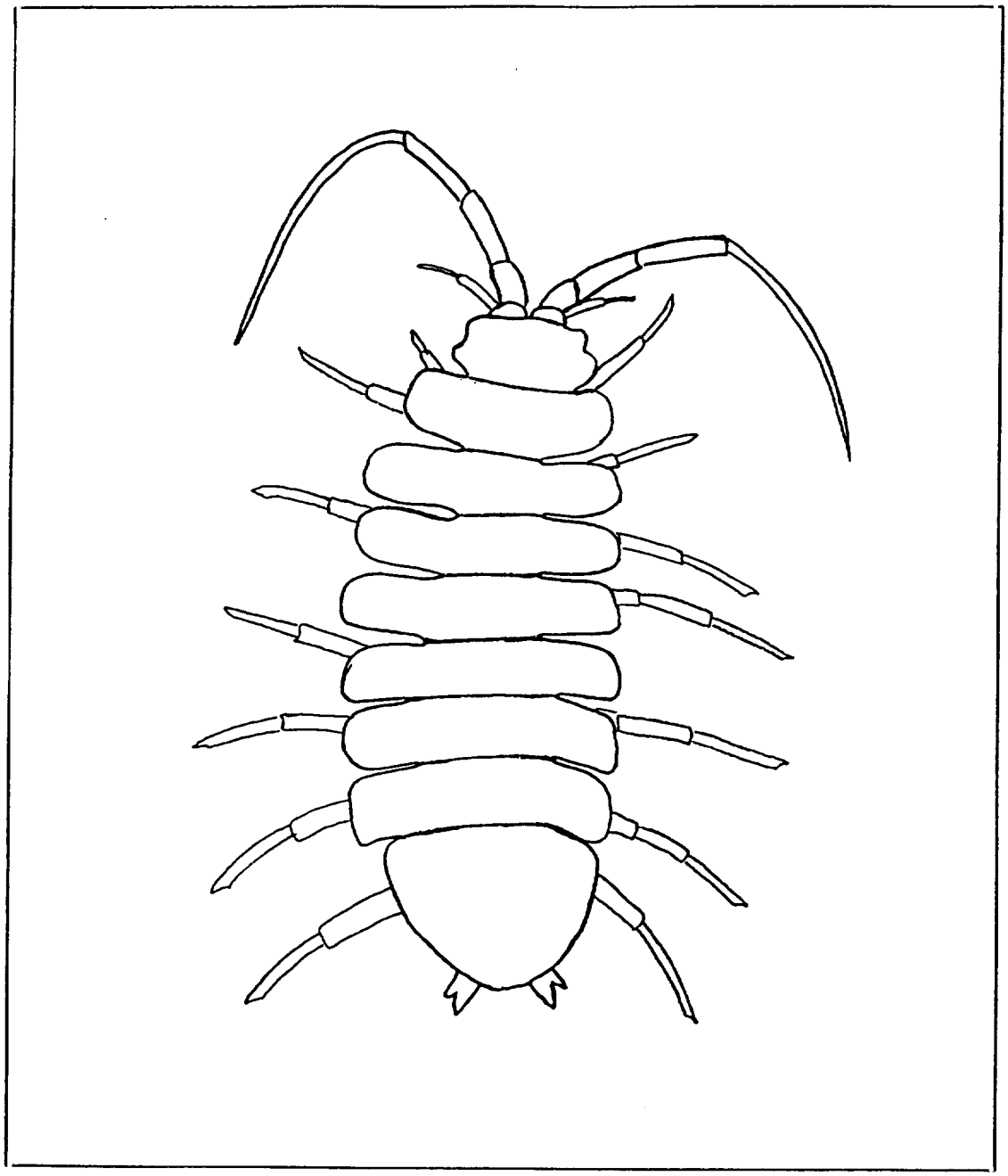

Figure 1. Lee County Cave Isopod, *Lirceus usdagalun* (adult length approx. 7.5 mm)

Drawing by Leroy Koch

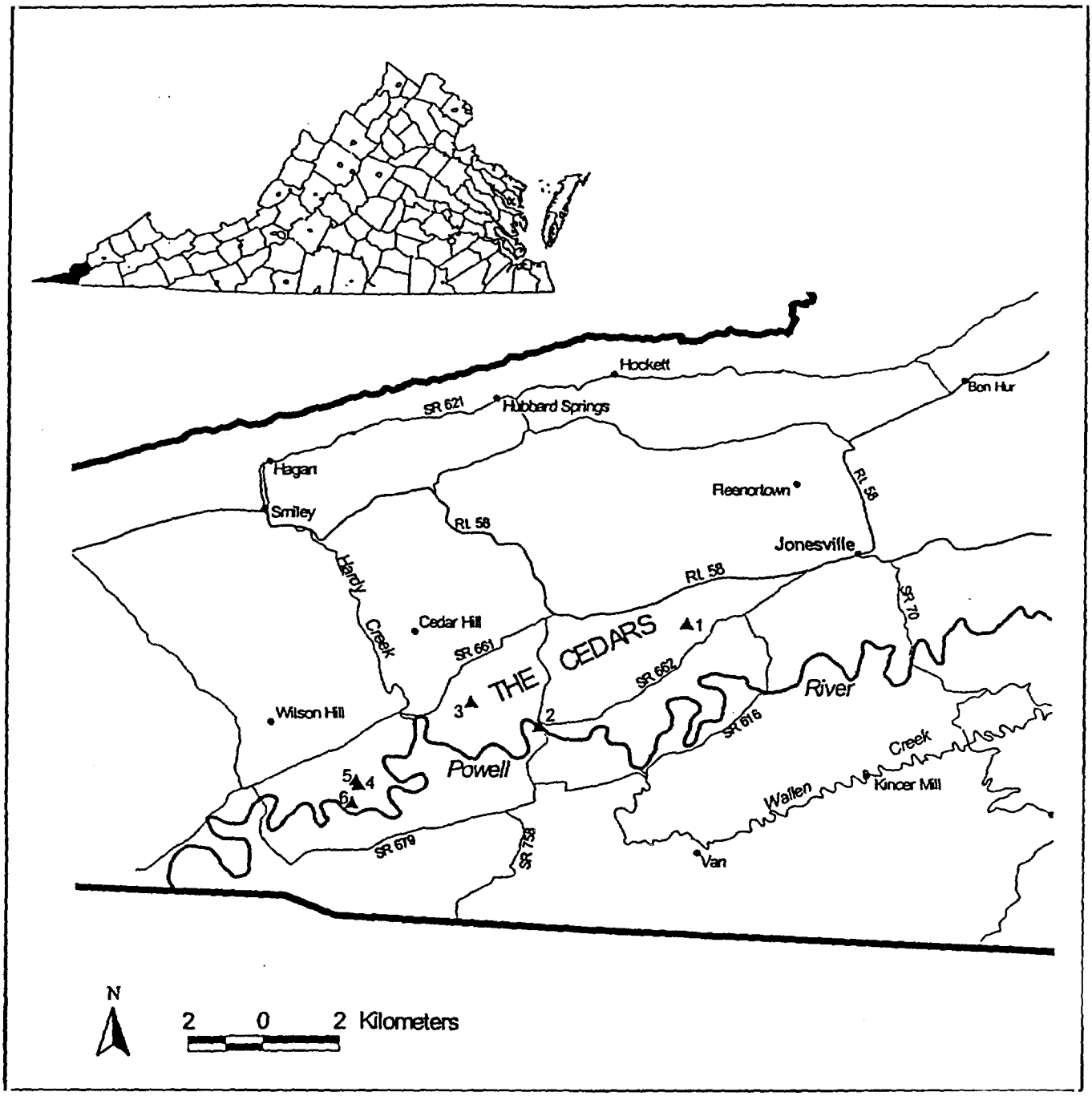

Figure 2. Distribution of *Lirceus usdagalun* in Lee County, Virginia. Sites from east to west are: (1)Thompson Cedar Cave, (2) spring near Flanary Bridge, (3) spring along Sims Creek, (4) Gallohan Cave No. 1, (5) Gallohan Cave No. 2, and (6) Surgener Cave.

Map by Virginia Department of Conservation and Recreation, Division of Natural Heritage

Sims Creek, (4) Gallohan Cave No. 1, (5) Gallohan Cave No. 2, and (6) Surgener Cave. The northernmost cave system (i.e., Thompson Cedar Cave) includes only one known occurrence of this species, currently considered to be extirpated (J.R. Holsinger, Old Dominion University, pers. comm. 1997). The isopod was formerly very abundant in Thompson Cedar Cave (Holsinger and Bowman 1973); the cave stream supported densities of 100 individuals per square meter (Culver *et al.* 1992). Heavy sawdust pollution, first documented in 1987 from a local sawmill operation, then resulted in severe degradation of the groundwater quality. The fauna of the cave stream was extirpated by this pollution and had shown little sign of recovery as of May 1990 (Culver *et al.* 1992). More recent surveys have confirmed some recolonization of the cave stream by the troglobitic isopod *Caecidotea recurvata* and the troglobitic amphipod *Crangonyx attenatus*, but have failed to reconfirm the presence of the Lee County cave isopod (J.R. Holsinger pers. comm. 1997).

The present distribution of the Lee County cave isopod includes the Surgener-Gallohan Cave system, as well as the karst systems that feed the two springs at Flanary Bridge and Sims Creek. Three occurrences of the Lee County cave isopod (i.e., Gallohan Caves No.1 and No. 2 and Surgener Cave) are considered subunits of one population because they are within the same cave system (Holsinger 1975). This hydrological link between streams and springs within these caves is known as the Surgener-Gallohan Cave System (Holsinger and Bowman 1973). Both of the spring sites where the Lee County cave isopod has been documented are fed by subterranean streams of unknown location and extent.

HABITAT AND ASSOCIATED AQUATIC FAUNA

The Lee County cave isopod is usually found on the surfaces of small, submerged rocks and gravels in cave streams, and has also been collected from similar substrates at the Flanary Bridge spring. Collections at Sims Spring were by drift net during a flooding event; however, the isopod likely exists in this subterranean system in a similar habitat. Other aquatic troglobites associated with the Lee County cave isopod include the isopod *Caecidotea recurvata*, the amphipod *Crangonyx antennatus*, snails of the genus *Fontigens,* and planarians of the genus *Sphalloplana* (Holsinger and Bowman 1973).

THE KARST ECOSYSTEM

The aquatic habitat of the Lee County cave isopod is a component of a karst ecosystem. The term *karst* typically refers to land forms produced by the dissolution of carbonate rocks (limestone and dolomite). Features such as closed depressions or sinkholes, blind valleys, sinking streams, springs, and caverns reflect the development of subsurface drainage systems with direct connections to the surface. In contrast to non-karst regions, where rainwater filters very slowly through soil and bedrock before reaching groundwater, the sinkholes, fissures, and crevices that are characteristic of karst regions offer accelerated routes for surface water to enter groundwater systems with either no filtering or minimal filtering by soils (Smith 1991).

In 1985, the Virginia Cave Board designated the Central Lee County Karst region, including the local area known as The Cedars (see Figure 2), as a *Significant Karst Area* for its unique geological, hydrological, and biological values. The geochemistry, juxtaposition, hydrology, and climate of The Cedars are elemental to the limited habitats of 33 rare plant and animal species, including the Lee County cave isopod.

The Cedars extends southwestward from the Town of Jonesville along a gently rolling valley, approximately 1 to 3 miles (1.5 to 4.8 kilometers) wide and 10 miles (16 kilometers) long, toward the Tennessee-Virginia border (Culver *et al.* 1992, Holsinger 1985). The topography is characterized by extensive bare limestone ledges solutionally etched and sculpted (karren), numerous sinkholes, blind valleys, sinking streams, subterranean drainages, and caves (Holsinger and Culver 1990). The Cedars is a mature karst terrane developed on soluble limestone of middle Ordovician age. Approximately 300 million years ago during mountain-building activity, these rocks were structurally deformed and thrust for miles along the Pine Mountain Overthrust Fault. As a result, the structural profile is that of a slightly synclinal (down-warped) basin imprinted by distinct bedrock fractures and joints. Bedrock is nearly horizontal along the trough of The Cedars syncline and strikes 60° to 70° northeast. The fracture porosity superimposed on the soluble bedrock apparently facilitated the development and integration of subterranean conduits in the Hurricane Bridge and underlying Martins Creek carbonate units (Miller and Brosge 1954).

Qualitative tracer tests conducted to date indicate that groundwater in The Cedars area generally moves southwest and south along geologic strike and fracture zones to four major spring systems (Batie Springs, Flanary Springs, Sims Spring, and the Surgener-Gallohan Cave

resurgence). At least seven smaller springs draining portions of The Cedars emerge along the north bank of the Powell River, including Rock Wall Spring and Blue Hole Spring. During normal low-flow conditions, groundwater gradients between U. S. Route 58 and the Powell River range from approximately 7 meters per kilometer (36 ft/mi) to 16 m/km (83 ft/mi), with the vadose water table (i.e., the level where spaces in rock, soil, or sediments are filled with water) generally being less than 20 m (66 ft) below ground level. In 1996, Jones (1990) and Terri Brown (Virginia Department of Conservation and Recreation, pers. comm. 1997) conducted tracer tests from the Fleenortown Creek sinkhole and Thompson Cedar Cave to the Batie Springs. These tests indicated average groundwater flow rates of 40 meters per hour during normal low-flow conditions.

Groundwater velocities in the Sims Spring basin were estimated at 40 m/hr (130 ft/hr) to 60 m/hr (197 ft/hr) in tracer studies conducted by Ewers (1995) and Neely (1996). Semi-quantitative tracer tests for estimating the rate of groundwater movement in the Surgener-Gallohan basin are in progress as of 1997. Seasonal variations in groundwater velocity and the relationships between adjacent groundwater basins have been observed in The Cedars but cannot be quantified without additional quantitative tracer testing and discharge monitoring.

An evaluation of U.S. Geological Survey water budget studies in mature karst terranes suggests that at least 75% of the average precipitation falling in The Cedars reaches the Powell River as groundwater. Thus, it is apparent that in this type of ecosystem, any single contamination of land, surface streams, or underground caverns could rapidly contaminate springs and cave streams.

Karst " windows" are created where sections of the cave roof have collapsed, dissolved, and weathered away, exposing groundwater streams to view. Several flat-bottomed sinkholes along U.S. Route 58 are relatively dry under normal conditions but temporarily discharge and/or store large volumes of stormwater when the water-bearing capacity of the conduit system is exceeded.

Accessible caves in The Cedars provide a glimpse of the solution-enlarged, underdrain system that captures and conveys water from sink points near U.S. Route 58 to the Powell River. Thompson Cedar Cave, Molly Wagle Cave, Wynn Cave, Gibson-Frazier Cave, Surgener-Gallohan Cave, and others have formed close to the surface and can be directly affected by surface activities producing sediment, increased runoff, and chemical/bacterial pollutants. Undiscovered cave passages most likely underlie several portions of The Cedars.

LIFE HISTORY AND POPULATION DYNAMICS

Little is known about the life history of the Lee County cave isopod, and additional research should be conducted. Population data for the known occurrences of the Lee County cave isopod are also limited. Of 89 specimens collected between 1961 and 1971 by Dr. J.R. Holsinger and several colleagues, 73 were females and 16 were males, suggesting a female-biased sex ratio (Holsinger and Bowman 1973). Only five of the females were either ovigerous (egg-bearing) or larviparous (bearing newly hatched young); these individuals were collected in

July and August. The average number of eggs per female was estimated to be 27.5; however, this calculation was based on only three females (Holsinger and Bowman 1973).

Estes and Holsinger (1982) compared characteristics of the populations in Gallohan Cave No. 1 and Thompson Cedar Cave based on samples collected over a one-year (1974-75) period. They found that isopods of both sexes were significantly larger in Gallohan Cave No. 1 and that this population also exhibited less seasonal variation in body size. A smaller percentage of males was found in the Thompson Cedar Cave population, but a greater proportion of the females was ovigerous. The authors attributed these various differences to greater environmental heterogeneity of the stream in Gallohan Cave No. 1 and to the effects of different levels of competition among the isopods in the two caves.

THREATS TO THE SPECIES

General Degradation of Groundwater Quality

Degradation of groundwater quality resulting from surrounding land uses represents a potentially serious threat to the long-term viability of the Lee County cave isopod. In karst areas, the quality and integrity of the underground environment is completely dependent on the management of the surface environment and the activities that occur there (Smith 1991). In order to effectively protect this ecosystem from water quality degradation, it is crucial to identify and understand the sources, inputs, and resurgences of water in the cave systems relative to surface areas (Culver *et*

al. 1994). Past hydrologic studies in The Cedars have identified important patterns of this hydrological system (Jones 1990), and future studies should increase our knowledge of the subterranean drainage patterns.

Since 1994, The Nature Conservancy, the Virginia Department of Environmental Quality, and the Virginia Department of Conservation and Recreation have periodically monitored springs in The Cedars in an effort to characterize the types of contamination affecting the groundwater system there. Collectively, springs draining The Cedars have been tested for fecal and total coliform bacteria, pesticides/herbicides, petroleum derivatives, metals, nutrients, semi-volatile organics, tannins/lignins, and physical parameters such as pH, dissolved oxygen, temperature, conductivity, suspended solids, biological oxygen demand, etc. Limited sediment and sawmill leachate sampling has also been conducted. The Virginia Water Resources Research Center is currently compiling a review of this data.

Concentrations of tannins, lignins, fecal coliform, and turbidity appear to be having the most pronounced adverse effects on the Lee County cave isopod's habitat, as well as other surface and subsurface aquatic habitats. To date, the majority of monitoring activity has been directed at the Batie Springs and Sims Springs sub-basins, where the effects of pollution are the most evident. Further information is needed about flow rates, especially in areas receiving drainage from construction and commercial sites, and the presence of pollutants in seasonal and stormwater pulses. A number of small springs in The Cedars remain to be sampled for the isopod.

All known occurrences of the Lee County cave isopod are on private land and are currently unprotected. Many landowners in this region are unaware of the critical link between surface water and groundwater, as is evident by the use of sinkholes as disposal areas for household, industrial, and agricultural waste products. Grazing, farming, logging, and sawmill operations are prominent uses of the lands surrounding the cave systems in Lee County. Such operations represent a potentially significant threat to karst ecosystems. Poor farming practices may also contribute excessive sediments to the groundwater system, and leachate from organic decomposition of sawdust and other woodwaste material may contaminate groundwater.

Other potential threats to habitats supporting the Lee County cave isopod include nonpoint source pollution, sedimentation from other activities, inadequate or failing septic systems, toxic spills along roadways, leaking gasoline tanks, cave vandalism, and residential and commercial development in the area with inadequate erosion and stormwater control systems.

Site-Specific Degradation of Groundwater Quality

Thompson Cedar Cave: In early 1987, a lumber company expanded its sawmill operation on property just west of Thompson Cedar Cave. The company piled massive ridges of sawdust and wood shavings in the drainage basin where surface water enters the underground stream that flows through the cave (Holsinger and Culver 1990). By the spring of 1987, the sinkhole entrance to the cave was filled with sawdust and other wastewood debris, some of which entered the cave stream. The direct result of this action was massive organic pollution of the cave stream ecosystem and the extirpation of its cavernicolous fauna (Culver *et al.* 1992). Indirectly, surface

runoff containing leachate entered the groundwater through sinkholes and fissures surrounding and beneath both current sawmill site and a nearby, currently inactive, sawmill site.

Surgener-Gallohan Cave System: Due to the hydrological connection of the three known isopod occurrences within the Surgener-Gallohan Cave System, this population is extremely vulnerable to a single incident of groundwater pollution. Construction of a new airport and associated roads is proposed within three to four miles of the Surgener-Gallohan Cave System; however, these activities do not currently represent serious threats. More immediate concerns include the presence of inadequate or failing septic systems in the drainage basin, the presence of livestock in surface streams or other insurgence sources, and storm water runoff contaminated with chemicals utilized in agricultural practices.

Flanary Bridge spring: This site is believed to be the resurgence for an undiscovered subterranean drainage system. Potential threats to the water quality of the associated subterranean stream include increased future residential and commercial development in the area and storm water runoff from an existing golf course. Turf maintenance activities of the golf course could introduce nutrients, herbicides, pesticides, and other chemicals into the groundwater.

Sims Creek spring: Construction of a new airport is proposed within 0.5 miles of this site. In addition, there are proposals for road construction activities in the area. The impacts from these activities are unknown at this time. Future planning of such projects should be coordinated with biologists and hydrologists so as to avoid possible degradation of groundwater quality. In this

context, it is very desirable to determine the exact location of the undiscovered subterranean stream(s) in this area of The Cedars.

CONSERVATION AND RECOVERY

Limited conservation has been achieved for this species. Several landowners have expressed both concern about pollution in the region and support for protection of the cave systems and the endangered isopod. Some of these landowners have agreed to voluntarily protect their resources through The Nature Conservancy Cave Registry Program. Initial landowner contacts have created a greater awareness among owners regarding the importance of maintaining water quality, but additional efforts of this nature are needed. For instance, the owner of the lumber company adjacent to Thompson Cedar Cave signed an agreement with the Virginia Cave Board in 1990, cleaned the sinkhole cave entrance, and constructed a soil berm around the entrance. In addition, this landowner is now recycling sawdust and is considering the implementation of a wood-energy conversion process (T. Brown pers. comm. 1997). These measures have improved the situation to some degree, although the sawmill operation continues to affect this cave system.

Recovery of the Lee County cave isopod will require further widespread protection efforts by county officials, conservation agencies and organizations, and private landowners. Protection strategies should include the following initiatives:

- Localities should employ best management practices to protect surface and groundwater quality.
- County officials should: (1) apply strategic planning to the protection of significant karst resources through zoning or other local means, and (2) implement and enforce strict erosion and sedimentation controls.
- Conservation agencies and organizations should work toward permanent protection of essential habitat for the Lee County cave isopod habitat through acquisition and Natural Area dedication.
- Landowners should be encouraged to sign agreements, such as conservation easements and management plans, as a means of protecting the water quality of the cave systems.

As an integral part of the recovery program, more effort should be given to creating a greater awareness among landowners and residents regarding stewardship of groundwater and karst habitat. Finally, in addition to protection efforts, it is critical to continue hydrological studies, monitor isopod populations on a routine basis, and to continue searching for additional populations.

PART II: RECOVERY

RECOVERY GOAL

The goal of this recovery program is to maintain and restore viable populations of the Lee County cave isopod, *Lirceus usdagalun,* over a significant portion of its range, thereby enabling the withdrawal of this species from the federal list of endangered and threatened species.

RECOVERY OBJECTIVES

Delisting may be considered when the following criteria are met:

A. Inventory work leads to a thorough delineation of the present and historic distribution for this species.

B. The surface and subterranean hydrology within the known range of the isopod are understood sufficiently to monitor and manage the species.

C. Populations of the Lee County cave isopod, in at least four subterranean systems, are shown to be stable and persistent over a ten-year (minimal) monitoring period. For the

three known extant populations, this monitoring period would begin when the following actions are completed: (1) baseline data correlating habitat conditions with population status are gathered for the Surgener-Gallohan cave system, (2) sampling techniques are finalized for the two springs at Flanary Bridge and Sims Creek, and (3) a monitoring protocol is established that provides for consistency among populations and allows inferences, if necessary, about the isopod's population status in the springs based upon comparative analysis of habitat conditions among the various cave systems. For the fourth population, the ten-year (minimal) monitoring period would begin when criteria A and B are met and either a new population is found or habitat restoration/return of a Thompson Cedar Cave population is achieved.

D. A groundwater monitoring program is established in systems known to contain the Lee County cave isopod, with ten-year results demonstrating that groundwater quality and quantity are sufficient to ensure the survival of this species. For each system, groundwater monitoring would be conducted concurrently with the population monitoring period.

E. Measures have been secured for the permanent protection from significant groundwater contamination of all four cave systems for the Lee County cave isopod (see criterion C).

Reclassification to threatened may be considered when A and B above are completed, when the monitoring programs in C and D have been underway for all four cave systems for at least five years with positive results, and when E is accomplished for at least two sites.

RECOVERY TASKS

1. ***Conduct surveys to determine the location and extent of all areas supporting this isopod.*** The current distribution of this species needs to be better defined. Cave systems that either currently contain populations, or recently were known to contain populations, need to be surveyed to determine the distribution of the species within each system.

   1.1 Survey the Thompson Cedar cave system at least annually at locations where this species was previously recorded.

   1.2 Inventory potential sampling sites in the drainage basin of the Thompson Cedar Cave system and in the other systems where this species is now known to occur.

   1.3 Search for additional cave systems containing the Lee County cave isopod. Starting at the perimeter of the known historic range and using appropriate sampling techniques and strategy, sample a sufficient number of sites to determine if the species occurs outside its present known distribution. If the species is found in a new system, use appropriate sampling techniques to determine the distribution of the species throughout each system to the extent possible. Although extensive surveys have been conducted for additional populations throughout The Cedars (J.R. Holsinger pers. comm. 1997), these efforts should be continued. Many caves in this ecosystem are very small, hindering or preventing scientists from entering the system in order to sample

suitable habitat. Alternative sampling methods (e.g., drift nets, pumping) should be explored and implemented if applicable.

2. ***Monitor populations of the Lee County cave isopod.***

2.1 Select appropriate sites for population monitoring within each cave system, based on task 1.2, and determine the appropriate monitoring technique and strategy for each system.

2.2 Implement monitoring of Lee County cave isopod populations using the methods determined in task 2.1 on a regular basis (at least once annually) for ten years.

3. ***Conduct life history and other research required to determine what constitutes a viable and stable population of the Lee County cave isopod.***

3.1 Conduct research on sex ratios, fecundity, survival rate, mortality rate, longevity, food supply, habitat requirements, viable population size, and threats to the species.

3.2 Using research results from task 3.1, determine when a *Lirceus usdagalun* population may be considered viable and stable.

4. ***Develop a more comprehenisve understanding of the surface and subterranean drainage systems in which the Lee County cave isopod occurs.*** Several karst hydrologists have conducted qualitative tracer testing to partially delineate groundwater basin boundaries in The Cedars. Dr. Ralph Ewers (Ewers Groundwater Consultants, Inc., Eastern Kentucky University) estimates that four discrete groundwater sub-basins and several smaller discontinuous basins have developed in The Cedars. Although additional tracer tests are needed, a preliminary map of the conceptual groundwater basin boundaries of The Cedars has been prepared based on initial tracer tests by Jones (1990), Ewers (1995), and Terri Brown (unpubl. data).

4.1 Map drainage systems and indicate sites where pollution is entering or is likely to enter the system. Develop a GIS database that includes a piezometric surface map and active/sensitive karst features.

4.2 Use appropriate techniques to better delineate drainages and determine the temporal relationship between them.

5. ***Monitor water quality and quantity and isopod habitat at selected sites, and eliminate or minimize environmental impacts on the species.***

5.1 Determine the effects of water pollution on this species. The potential impact of various pollutants needs to be evaluated by conducting bioassays with surrogate species. Examples of potential pollution sources include septic systems,

sawmills, livestock in streams, siltation, development, roads, golf courses, spills, dumping in sinkholes, the use of pesticides, and others.

5.2 Locate appropriate sites for monitoring pollution.

5.3 Establish permanent monitoring stations if needed.

5.4 Implement regular monitoring as required to track impacts of pollution and changes in natural water levels.

5.5 Work with landowners, agencies, and other entities to prevent, eliminate, or minimize negative impacts to the water quality and quantity of the isopod's habitat. This will require the efforts of various agencies, local groups, and individuals dedicated to finding ways to improve water quality, maintain water quantity, and improve habitat for this species. Pollution prevention and remediation efforts will vary depending upon the particular threat to the species. The development of storm water management plans is crucial to reducing impacts to habitats supporting the Lee County cave isopod because nonpoint source pollution is largely unregulated.

6. ***Implement habitat protection and, as needed, restoration measures for all populations of the Lee County cave isopod.*** Land within the watersheds of known isopod populations and habitats should be protected to ensure the long-term integrity of the water quality that is so important to this species' survival. Development and

implementation of habitat restoration and protection strategies for karst systems that support the Lee County cave isopod should be required contingent on the level of threat. Actions to protect this species could include protecting recharge areas and surface watersheds, limiting access to caves or springs, gating caves and enclosing springs, preventing sinkhole dumping, informing landowners about tax incentives for certain conservation activities, and other protection measures.

6.1 Where feasible, develop protection and restoration plans for groundwater recharge areas for all sites that historically supported or currently support the isopod. Restore and/or maintain natural drainage patterns, and establish effective buffer areas around recharge zones such as sinkholes and discharge points such as springs and seeps. To avoid possible degradation of groundwater quality, project planning should be coordinated with hydrologists.

6.2 Protect and restore Lee County cave isopod habitat, especially at sites where pollution may enter the groundwater system and at all sites known to have historically supported or which currently support this species. Encourage these efforts through acquisition, easements, and management agreements with willing landowners.

6.3 Enforce existing laws and regulations (e.g., section 7 of the federal Endangered Species Act, the Clean Water Act, State and local laws concerning groundwater, surface water, and sedimentation and erosion control) to protect the Lee County cave isopod and its aquatic habitat.

7. ***Conduct educational programs for the Lee County region that focus on protection of cave-karst resources, including the Lee County cave isopod.*** Encourage cooperation among landowners, government agencies, and nongovernmental organizations in achieving long-term protection of the Lee County cave isopod. The public needs to be aware of land management problems unique to karst landscapes, and understand that development in karst areas must be well planned to maintain water quality and quantity.

7.1 Meet with landowners to discuss the species and its habitat needs, and to enlist their assistance in protecting Lee County cave isopod habitat.

7.2 Produce informational materials and conduct public education programs. The aim of these efforts will be to: (1) improve landowner and public awareness of the Lee County cave isopod's status as an endangered species as well as its habitat requirements and recovery needs, and (2) develop public appreciation of karst terrains, water quality and quantity, unique karst ecosystems and their biota, and perturbation effects. This will involve activities such as tours, programs, fact sheets, and popular articles. The support of individuals or groups should be enlisted to foster improved stewardship of land and water in order to minimize negative impacts to the isopod and its habitat. The most effective way to foster interest in the protection of cave fauna and its habitat may be through developing a general appreciation of karst systems.

8. ***If feasible and as needed, restore populations of the Lee County cave isopod within its historic range.*** It may become necessary to reintroduce populations of this species to locations (such as Thompson Cedar Cave) within its presumed historic range.

8.1 Determine the feasibility of transplanting individuals of the species. Determine what actions would be required to reestablish a population and identify appropriate reintroduction locations.

8.2 Take appropriate actions to establish a population or populations at selected locations, if feasible and if the water quality and habitat are improved and protected so that successful establishment could be expected.

8.3 Monitor the newly established population at least annually for ten years to evaluate its status, and determine if additional monitoring is required.

9. ***Implement a program to monitor recovery progress.*** Monitoring recovery progress will be done by maintaining a running list of individuals (see Appendix A) with knowledge of the status of the Lee County cave isopod and/or knowledge of the karst region (and its status) where this species occurs. As needed, various experts will be consulted on particular questions or issues in order to obtain their individual opinions regarding recovery progress and direction.

LITERATURE CITED

Culver, D.C., J.R. Holsinger, W.K. Jones, and C.M. Wicks. 1994. Cave fauna management and protection workshop: Karst hydrology and integrated karst drainage basins. Karst Waters Institute, Charles Town, West Virginia.

Culver, D.C., W.K. Jones, and J.R. Holsinger. 1992. Biological and hydrological investigation of The Cedars, Lee County, Virginia, an ecologically significant and threatened karst area. *In*: Stanford, J. A. and J. J. Simons. Proceedings of the First International Conference on Ground Water Ecology, pp. 281-290. U.S. Environmental Protection Agency and American Water Resources Association.

Estes, J.A. and J.R. Holsinger. 1976. A second troglobitic species of the genus *Lirceus* (Isopoda, Asellidae) from southwestern Virginia. Proceedings of the Biological Society of Washington 89: 481-490.

Estes, J.A. and J.R. Holsinger. 1982. A comparison of the structure of two populations of the troglobitic isopod crustacean *Lirceus usdagalun* (Asellidae). Polskie Archiwum Hydrobiologii 29: 453-461.

Ewers, R.O., P.J. Idstein, J. Jacobs, and W. Keith. 1995. A hydrogeological investigation of "The Cedars," Lee County, Virginia. Unpublished report prepared for the Virginia Chapter of The Nature Conservancy. 25 pp.

Holsinger, J.R. 1975. Descriptions of Virginia caves. Virginia Department of Mines, Minerals, and Energy, Division of Mineral Resources, Bulletin 81, Charlottesville, Virginia.

Holsinger, J.R. 1985. Annotated list of significant caves and karst areas in Virginia. Unpublished report of the Virginia Cave Board. 251 pp.

Holsinger, J.R. and D.C. Culver. 1988. The invertebrate cave fauna of Virginia and a part of eastern Tennessee: Zoogeography and ecology. Brimleyana 14: 1-162.

Holsinger, J.R. and D.C. Culver. 1990. Report on the subterranean biological resources of the Cedars Karst in Lee County, Virginia. Unpublished report prepared for the Virginia Department of Conservation and Recreation. 10 pp.

Holsinger, J.R. and T.E. Bowman. 1973. A new troglobitic isopod of the genus *Lirceus* (Asellidae) from southwestern Virginia, with notes on its ecology and additional cave records for the genus in the Appalachians. International Journal of Speleology 5: 261-271.

Jones, W.K. 1990. Preliminary hydrological investigation of "The Cedars," Lee County, Virginia. Environmental Data Systems, Inc., Charleston, West Virginia. Unpublished report. 8 pp.

Neely, R.A. 1996. Hydrogeological investigation of the proposed Lee County regional airport site, Lee County, Virginia. Report prepared by Mill Creek Environmental Consultants, Ltd. Hampton, Virginia, for Delta Airport Consultants, Inc. 7 pp.

Miller, R.L. and W.P. Brosge. 1954. Geology and oil resources of the Jonesville District, Lee County, Virginia. U.S. Geological Survey Bulletin No. 990. 210 pp.

Smith, L. 1991. An overview of the natural heritage resources of The Cedars, Lee County, Virginia. Unpublished report of the Division of Natural Heritage, Department of Conservation and Recreation. 8 pp.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants: Determination of endangered status for the Lee County cave isopod (*Lirceus usdagalun*). Federal Register 57 (225): 54722-54726.

Williams, W.D. 1972. Freshwater isopods (Asellidae) of North America. Water Pollution Control Research Series Publication 18050 ELD05/72, U.S. Environmental Protection Agency. 45 pp.

PART III: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the Lee County cave isopod recovery program over three years. It is a guide for meeting the recovery objectives discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. The schedule will be updated as recovery tasks are accomplished.

Key to Implementation Schedule Priorities (column 1)

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Responsible Agencies (column 5)

USFWS:	U.S. Fish and Wildlife Service
R5:	USFWS Region 5 (Northeast Region)
ES:	Ecological Services (includes the Endangered Species program)
USGS:	U.S. Geological Survey
BRD:	Biological Resources Division, USGS

EPA:	Environmental Protection Agency
FAA:	Federal Aviation Administration
FBOP:	Federal Bureau of Prisons, U.S. Department of Justice
NRCS:	Natural Resources Conservation Service
Corps:	U.S. Army Corps of Engineers
VDNH:	Division of Natural Heritage, VA Department of Conservation and Recreation
VDGIF:	VA Department of Game and Inland Fisheries
VDEQ:	VA Department of Environmental Quality
VDOT:	VA Department of Transportation
VCB:	VA Cave Board
VWRRC:	VA Water Resources Research Center
Lee County:	Lee County agencies and officials, and other local governmental groups
TNC:	The Nature Conservancy and other conservation ogranizations

Lee County Cave Isopod Recovery Implementation Schedule (page two), September 1997

Priority	Task Description	Task Number	Duration	Responsible Agency		Estimated Costs ($1000)			Comments
				USFWS	Other	FY1	FY2	FY3	
2	Establish permanent monitoring stations if needed.	5.3	2 years	R5 ES	EPA USGS VDEQ VDNH contract	10	10		Costs pertain to initial establishment; ongoing maintenance needs covered by task 5.2
2	Implement regular monitoring as required to track impacts of pollution and changes in natural water levels.	5.4	ongoing	R5 ES	BRD/USGS EPA VDEQ contract	15	15	15	Future funding contingent on results of initial monitoring
2	Work with appropriate landowners, agencies, and other entities to prevent, eliminate, or minimize negative impacts to the water quality and quantity of the isopod's habitat.	5.5	ongoing	R5 ES	EPA Corps VDNH VDGIF VDEQ Lee County	5	3	3	+2K/yr through FY10
2	Where feasible, develop protection and restoration plans for groundwater recharge areas for all sites that historically supported or currently support the isopod.	6.1	ongoing	R5 ES	NRCS VDNH VDGIF VCB Lee County TNC	5	5	5	Future funding contingent on results of initial efforts
2	Enforce existing laws and regulations to protect the Lee County cave isopod and its aquatic habitat.	6.3	ongoing	R5 ES	FAA FBOP Corps EPA VDEQ VDOT VDGIF Lee County				Costs associated with regular staff duties
3	Survey the Thompson Cedar cave system at least annually at locations where this species was previously recorded.	1.1	ongoing	R5 ES	VDNH TNC contract	0.5	0.5	0.5	Funding continued as needed

IMPLEMENTATION SCHEDULE

Lee County Cave Isopod Recovery Plan

eptember 1997

Priority	Task Description	Task Number	Task Duration	Responsible Agency		Estimated Costs ($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
1	Protect and restore Lee County cave isopod habitat, especially at sites where pollution may enter the groundwater system and at all sites known to have historically supported or which currently support this species.	6.2	ongoing	R5 ES	EPA NRCS VCB VDEQ VDNH Lee County TNC	100	100	100	Funding to continue through recovery period, as needed
2	Inventory potential sampling sites in the Thompson Cedar cave system and in the other systems where this species is currently known to occur.	1.2	1 year	R5 ES	VDNH contract	8			Initial comprehensive survey followed by task 2.1
2	Select appropriate sites for population monitoring within each cave system and determine the appropriate monitoring technique and strategy for each system.	2.1	ongoing	R5 ES	VDNH	1			
2	Implement monitoring of Lee County cave isopod populations on a regular basis (at least once annually) for ten years.	2.2	10 years	R5 ES	VDNH contract		5	5	+ 5K annually through FY10
2	Map drainage systems and indicate sites where pollution is entering or is likely to enter the system.	4.1	3 years	R5 ES	BRD/USGS VDEQ VDNH contract	20	10	10	
2	Determine the effects of water pollution on this species.	5.1	ongoing	R5 ES	BRD/USGS EPA VDEQ contract	50	50	50	Future funding contingent on results of initial laboratory studies
2	Locate appropriate sites for monitoring pollution.	5.2	2 years	R5 ES	USGS VDEQ VDNH contract	2	1		

Lee County Cave Isopod Recovery Implementation Schedule (page three), September 1997

Priority	Task Description	Task Number	Duration	Responsible Agency		Estimated Costs ($1000)			Comments
				USFWS	Other	FY1	FY2	FY3	
3	Search for additional cave systems containing the Lee County cave isopod.	1.3	3	R5 ES	VDNH contract	3	3	3	Evaluate after 3 years to determine if task is completed; may require additional time and funds
3	Conduct research on sex ratios, fecundity, survival rate, mortality rate, longevity, food supply, habitat requirements, viable population size, and threats to the species.	3.1	5 years	R5 ES	contract	20	20	20	Future funding contingent upon successful completion of first 3 years
3	Using research results from task 3.1, determine when a *Lirceus usdagalun* population may be considered viable and stable.	3.2	1 year	R5 ES	contract			2	
3	Use appropriate techniques to better delineate drainages and determine the temporal relationship between them.	4.2	2-3 years	R5 ES	VDNH contract	10	10	5	
3	Meet with landowners to discuss the species and its habitat needs, and to enlist their assistance in protecting Lee County cave isopod habitat.	7.1	ongoing	R5 ES	VDNH TNC contract	3	3	3	Future funding as needed
3	Produce informational materials and conduct public education programs to: (1) improve public awareness of the Lee County cave isopod's endangered status and recovery needs, and (2) develop public appreciation of karst terrains, water quality and quantity, unique karst ecosystems and their biota, and perturbation effects.	7.2	ongoing	RE ES	EPA VDEQ VDNH VCB TNC contract	25	10	10	
3	If feasible and as needed, restore populations of *Lirceus usdagalun* to habitat within its historical range.	8	tbd	tbd	tbd	tbd	tbd	tbd	Feasibility and cost to be determined based on the results of tasks 3.1 and 3.2
3	Implement a program to monitor recovery progress.	9	ongoing	R5 ES			0.5	0.5	Annual meetings to continue until full recovery is achieved

APPENDIX A:
RECOVERY CONTACTS

The following list includes those individuals who are likely to be involved in coordinating and monitoring the Lee County Cave Isopod recovery program. This list is not exclusive, and it will be amended or added to as appropriate during the course of recovery. It is presented as a source of contacts for information regarding specific recovery activities and progress toward meeting recovery objectives. The primary U.S. Fish and Wildlife Service coordinator for recovery of this species is:

Leroy Koch, Southwestern Virginia Field Office
U.S. Fish and Wildlife Service
P.O. Box 2345
988 W. Main Street
Abingdon, VA 24210
540/623-1233

Other contact persons are:

Terri Brown
VA Department of Conservation and Recreation
Division of Natural Heritage
c/o Soil and Water Field Office
P.O. Box 1506
Dublin, VA 24084
540/674-5541

Dr. David Culver
Department of Biology
American University
4400 Massachusetts Avenue, NW
Washington, D.C. 20016
202/885-2194

Caren Caljouw
VA Department of Conservation and Recreation
Division of Natural Heritage
Main Street Station
1500 E. Main Street, Suite 312
Richmond, VA 23219
804/786-7951

Ralph Ewers
Ewers Water Consultants, Inc.
160 Redwood Drive
Richmond, KY 40475
606/623-8464

E. Sue Cantrell
Lee County Health Director
Lee County Health Department
P.O. Box 763
Jonesville, VA 24263

Dr. John R. Holsinger
Department of Biological Sciences
Old Dominion University
Norfolk, VA 23529
757/683-3606

David Hubbard
VA Department of Mines, Minerals, and Energy
Division of Mineral Resources
Fontaine Research Park
900 Natural Resources Drive
P.O. Box 3667
Charlottesville, VA 22903
804/293-5121

Andy Moser
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
1825 Virginia Street
Annapolis, MD 21401
410/573-4537

Bill Jones
Karst Hydrologist
Box 490
Charlestown, WV 25414
304/725-2872

Rick Reynolds
VA Department of Game and Inland Fisheries
4725 Lee Highway
P.O. Box 996
Verona, VA 24482
703/248-9386

Bill Keith
Natural Resources Conservation Service
Route 2, Box 35
Jonesville, VA 24263

Dr. Steve Roble
VA Department of Conservation and Recreation
Division of Natural Heritage
Main Street Station
1500 E. Main Street, Suite 312
Richmond, VA 23219
804/786-7951

Bill Kittrell
The Nature Conservancy
Clinch Valley Bioreserve
151 W. Main Street
Abingdon, VA 24210
540/676-2209

Larry Smith
VA Department of Conservation and Recreation
Division of Natural Heritage
Main Street Station, Suite 312
Richmond, VA 23219
804/786-7951

APPENDIX B:
LIST OF REVIEWERS

A number individuals submitted comments on the technical/agency draft Lee County cave isopod plan. All comments were considered during final plan preparation and incorporated into this document as warranted. Letters of comment are retained on file in the Southwestern Virginia Field Office of the U.S. Fish and Wildlife Service. An asterisk (*) denotes those individuals who were asked to contribute independent scientific review of the plan.

Substantive comments generally covered time frame and criteria for reclassifying and delisting *Lirceus usdagalun*. Other comments were primarily editorial in nature or covered specific points in the text. These comments were incorporated into the text as appropriate.

The overall time frame for monitoring isopod populations to measure recovery progress, and when this monitoring period should be initiated, was a concern of four of the peer reviewers. Their primary concern was that this period adequately detect fluctuations in the populations monitored and/or changes in the hydrology of the cave system being monitored. Different time frames were suggested, varying from five to twenty years, although reviewers did not specify when monitoring should begin or how monitoring in the four cave systems might vary due to physical constraints. These concerns and suggestions have been addressed in the final recovery plan.

The Service wishes to thank those who took time to review and comment on the draft recovery plan. Effective recovery of the Lee County cave isopod ultimately depends on the combined expertise and involvement of professionals and concerned parties.

Kurt Buhlmann *
University of Georgia
Savannah River Ecology Laboratory
Aiken, SC 29802

Terri Brown
VA Department of Conservation and Recreation
Division of Natural Heritage
c/o Soil and Water Field Office
P.O. Box 1506
Dublin, VA 24084

Dr. David C. Culver *
American University
Department of Biology
4400 Massachusetts Avenue N.W.
Washington, D.C. 20016

Theresa Frazier
VA Department of Environmental Quality
P.O. Box 1688
Abingdon, VA 24212

Dr. John R. Holsinger *
Department of Biological Sciences
Old Dominion University
Norfolk, VA 23529

David Hubbard *
Virginia Cave Board
P.O. Box 3667
Charlottesville, VA 22903

Larry Smith
VA Department of Conservation and Recreation
Division of Natural Heritage
Main Street Station, Suite 312
Richmond, VA 23219