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REPORT ON THE STATUS OF THE CAVE SALAMANDER (EURYCEA LUCIFUGA) AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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JEFFREY DAVIS
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REPORT

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REPORT ON THE STATUS OF THE CAVE SALAMANDER (*EURYCEA LUCIFUGA*) AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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Table of Contents

Executive Summary

During August through October 1993, efforts were made to locate potential habitat and populations or individuals of the state endangered cave salamander (*Eurycea lucifuga*) at the Fernald Environmental Management Project (FEMP). Off-property locations were also investigated. The nearest known cave salamander population was found one kilometer (km) north of the FEMP property during a 1988 study and was used as a control for the current study. Following the movements of this species is difficult because the larvae migrate through subsurface water between fissures in limestone. A subsurface geological feature known as the New Haven Trough, where porous silts and clays replace limestone, may inhibit normal larval migration through subsurface water at the FEMP.

In southwest Ohio, adult cave salamanders inhabit limestone areas where groundwater sources open to the surface in the form of intermittent streams, springs, wells, spring houses, and fissures between layers of exposed rock. Two such locations were found at the FEMP. One small, relatively dry ravine near the northern border of the FEMP property was determined to be poor habitat for cave salamanders. The second, a limestone-lined well (Well No. 1124) on a former home site, was more suitable, offering crevices between rocks above the water line in which adults could hide and a deep pool of water for reproduction and larval development. Although no adult or larval cave salamanders were found on FEMP property during this survey, suitable habitat was identified.

Within a radius of seven kilometers of the FEMP, there are known populations of cave salamanders to the north, south, southwest, and east. Well No. 1060, off property but adjacent to the southern border of the FEMP on Willey Road, offers suitable habitat for cave salamanders. An unidentified salamander fitting the description of a postmetamorphic cave salamander was seen in this well and described by a groundwater technician.

Additional survey efforts during periods of optimal cave salamander activity could provide more conclusive evidence about the presence or absence of populations or individuals on FEMP property. If populations or individuals are found on FEMP property in the future, strategies for remediation might include financial support to protect habitat of known populations in the vicinity of the FEMP. This is preferable to relocation of any individuals to other areas.

Introduction

The objectives of this study were to delineate potential habitat for the state endangered cave salamander and to locate cave salamander populations on U.S. Department of Energy (DOE) property at the Fernald Environmental Management Project (FEMP). Field work began on August 27, 1993 and was concluded by October 10, 1993. This was in accordance with Fernald Environmental Restoration Management Corporation (FERMCO) schedule of deliverables (P.O.#942291). Across most of their range, cave salamanders usually inhabit the twilight zones of caves, which are absent in southwest Ohio; here, the species is typically associated with intermittent limestone streams and ravines that have access to subterranean waterways.

Study Location Description

The FEMP property is located in both Hamilton and Butler Counties on 425 hectares. The western edge of the FEMP property is drained by Paddys Run, a third order stream that approximately parallels the FEMP's western border. Drainage of the eastern half of the property is limited since it is situated on the first terrace north of the Great Miami River floodplain creating wet meadows and some wetland habitats. The former Production Area offers no suitable cave salamander habitat, nor do the extreme southern and eastern edges. Along the northern edge of the FEMP, a pine plantation is located adjacent to a disturbed deciduous wood lot. Although this deciduous wood lot (bordered to the north by State Route 126) slopes steeply, there is only one very small ravine which offers potential cave salamander habitat. Exposed limestone on the valley wall offers access to fissures in the bedrock, which is typical southwest Ohio cave salamander habitat. The margins of Paddys Run were investigated in 1988 (Davis 1988) and designated as potential habitat, based on published descriptions of cave salamander habitat across their entire range (Minton 1972; Conant 1975). However, additional life history information (Juterbock 1986) and experience in the field indicates that small limestone ravines provide optimal habitat in southwest Ohio. The current study led to the conclusion that the habitat is not suitable due to a lack of surface limestone. The reason there is no surface limestone present is because of a subsurface geological feature known as the New Haven Trough in which limestone was replaced by silts and clays during the last glaciation. One other location on the FEMP property offers potential cave salamander habitat. Well No. 1124 (Cone House Well) is situated at a former home site in the field east of the east access road. Its walls are lined with 30-45 centimeters of limestone, which could provide suitable cover for adult cave salamanders and has ample water for their reproduction and larval development. Potential habitat for cave salamanders is shown in Figure 1 (Appendix A).

Natural History of the Cave Salamander (*Eurycea lucifuga*)

Description

The cave salamander is bright orange dorsally and marked with small randomly placed, irregularly shaped black spots (Figure 2, Appendix A). Typically, the venter is yellowish and unspotted. The body and head are slightly compressed dorsoventrally to allow it to slip into narrow rocky crevices, and the eyes appear to protrude beyond what might be expected for a salamander of comparable size. Minton (1972) reported 12 to 14 costal grooves for Indiana specimens, and Pfingsten and Downs (1989) reported 14 or 15 for Ohio specimens. The tail is 51 to 60 percent of the total body length and is prehensile, allowing cave salamanders to actively climb about cave walls (Minton 1972). None of the spots on the tail fuse to form chevrons as they do in the closely related longtail salamander (*Eurycea longicauda*) (Figure 3, Appendix A). These species are sufficiently similar that confusion may occur in the identification, but the tail pattern is conclusive. Male cave salamanders from southwest Ohio average approximately 60 mm, snout-vent length, and females average 62 mm. The largest known specimen was 181 mm total length (Conant and Collins 1991). Males are also distinguished by elongated cirri at the base of their nasolabial grooves and a rounded mental gland (Figure 4). Postmetamorphs are typically more olive with black speckling and the characteristic dorsoventrally flattened appearance. Larvae are lemon yellow with liberally pigmented throats and pigmentation on the ventral surface of the hind feet and on the belly beyond the level of limb insertion. The dorsum has paired light spots and a pale middorsal stripe. Like all stream-dwelling salamander larvae, the tail fin ends at the base of the tail. The number of costal grooves is 13 to 16, and the number of gill slits is four (Brandon 1964). Metamorphosis occurs at around 60 mm total length in Indiana (Minton 1972); in Ohio, Juterbock (1986) reports that metamorphosis occurs between 27 and 33 mm snout-vent length.

Reproduction

Because reproduction occurs underground, little is known about the reproductive behavior of cave salamanders. Females do not lay their first clutch of eggs until they are four years old. Eggs are attached individually to the undersides of submerged rocks by a pedicel (Myer 1958). The number of females with large ova found in Hamilton County increased from 20 percent in May to 100 percent of individuals by July (Juterbock 1986). Egg-laying lasts from October to May with probable wide variation among populations (Hutchinson 1956). Hatchlings are seven to ten mm in total length. Developmental rates are probably influenced by the availability of small invertebrates as forage in the subterranean habitat of the larvae. Most larvae metamorphose in six to nine months, although some may not transform for more than one year (Rudolph 1978).

Range

The cave salamander is known from limestone areas from Virginia westward to Missouri, Kansas, and Oklahoma. North to south distribution extends from Georgia and Alabama to Illinois, Indiana, and extreme southwest Ohio (Figure 5, Appendix A) (Conant and Collins 1991). Exceptions to habitation of limestone areas includes cypress swamps in southern Illinois near rocky bluffs (Smith 1961) and crystalline caves in northeastern Georgia (Banta and McAtee 1906).

In Ohio, cave salamanders are known in only three counties (Figure 6, Appendix A). Daniel (1984) reported them from Adams County based on historical data, but found no specimens from the same sites. Two southwest Ohio counties, Hamilton and Butler, have numerous recently documented cave salamander populations (Davis and Miller 1985; Juterbock 1986; Davis 1988; Davis and Krusling 1989a; Pfingsten and Downs 1989; Davis and Krusling 1990; Davis, et al.,1991; Rubin 1992; Davis and Krusling 1993). Populations in southwest Ohio are at the edge of the species' range. They do not inhabit caves; however, they do inhabit narrow recesses and crevices in limestone areas. The Butler County populations are approximately on the same latitude as the northernmost populations reported by Minton (1972) in Indiana. However, Minton does report two individuals from different sites farther north in Indiana. In southwest Ohio, the Mill Creek Valley seems to form a barrier that limits cave salamander distribution to the western halves of both Butler and Hamilton Counties (Figure 7). Consequently, Butler County populations represent the northeastern edge for this species' distribution. Genetic variation for a species increases in populations farther from the center of its range. Therefore, populations located at the periphery of a species' range represent genotypic diversity for the species. It is for this reason that cave salamanders in Ohio are listed as endangered.

Habitat

Most adult cave salamanders are found in the twilight zones of limestone caves and under rocks in springs and spring-fed streams. Although no caves are known in southwest Ohio, the solubility of limestone does create small subterranean waterways and crevices through which cave salamanders move. Being adapted to cave life, cave salamanders find the small limestone seeps common in southwest Ohio adequate to meet their habitat requirements.

Hutchinson (1956) reported finding adult cave salamanders as much as 12 m above cave floors, some in rock crevices, and others hanging only by their prehensile tail. Larvae live in subterranean waterways and are seldom seen in surface waters, although they occasionally show up in spring-fed streams and cave streams where they emerge from below ground. During drought periods, adults move into subterranean recesses. Subterranean movements of larvae may be important to species dispersal and cause adults to surface in unexpected places. They have been found in cellars and under stones on dry hillsides (Minton 1972;

Davis and Krusling 1990). Sink holes and wells may also provide suitable habitat for adult cave salamanders according to Paul M. Daniel (personal communication), as do the rock foundations of spring houses (Davis and Krusling 1989b). Juterbock (1986) suggests that population size may be related to the extent of subterranean water supplies.

Diet

Several studies have analyzed the diet of cave salamanders. Dipterans, mites, ticks, lepidopterans, pseudoscorpions, small annelids, and small mollusks are consumed by adults (Hutchinson 1956; Juterbock 1986). Studies on larval diet have not been conducted. Other salamander larvae of the genus *Eurycea* are known to consume small aquatic arthropods, especially copepods, chironomid larvae, and plecopteran nymphs (Minton 1972; Pfingsten and Downs 1988).

Seasonal Activity

Surface activity for adults peaks during May and June when temperatures are warm in combination with high moisture levels. Adults are more resistant to desiccation than many other adult *Eurycea*, but, during the drier parts of July and August, they are difficult to find at the surface (Juterbock 1986). During this dry season, postmetamorphic individuals come to the surface to feed. Recently transformed individuals are found more commonly than adults from mid-summer through September. Juterbock found adults active at the surface through November. According to Paul J. Krusling (personal communication), adults in wells at Miami Whitewater Forest are active into the late fall. Likewise, in spring houses, where humidity is constantly high and temperatures stable, adults are active from early spring to late fall (Davis and Krusling 1989a).

Methods and Materials

An initial reconnaissance survey was conducted on foot and by car on August 27, 1993. During this survey, habitats with potential for cave salamander populations were noted and assessments were made to determine which habitats would be monitored during subsequent visits to the study site. Between August 27, 1993 and October 10, 1993, seven days in the field, on- and off-property, were spent identifying potential cave salamander habitat, looking for individuals and/or populations of cave salamanders, and looking for signs of cave salamander surface activity. A population located approximately 1 km north of FEMP property near the Christian Road water tower was used as a control (Figure 1, Appendix A). This population was identified in 1988 in a limestone ravine at what was formerly the Ross Trails Girl Scout Camp (Davis 1988). The property has since been sold to a private land owner who granted permission to access the control location for the purpose of this study.

The control population was used to assess the suitability of surface conditions for cave salamander activity. If individuals were found active above ground at the control location but not at the FEMP habitat locations for at least four visits, then it would be assumed that none exist on the property. However, if no individuals were found at the control location and none were found on FEMP property, then it was concluded that conditions were not optimal for cave salamanders, and accurate conclusions could not be drawn. The main survey method used at the control location and the potential habitat in the ravine along the northern woodlot on the FEMP property was the general search-and-seize method described by Karns (1986). This method allows for the development of species lists and identification of the locality of populations, but does not sample for other ecological data.

A search for wells and cisterns with limestone on former home sites on property revealed one such well. Well No. 1124 was examined as potential cave salamander habitat. A hand-dug well that does not reach the aquifer, the well is lined with loosely mortared limestone. The distance from ground level to the water's surface is 8 m. The diameter of the well is approximately 2 m, and the water is 5.5 m deep. The limestone lining continued to the well's floor. An off-property well, Well No. 1060, was also examined (Figure 1, Appendix A). It is limestone-lined with no mortar between the rocks and is about 1.5 m in diameter. The water's surface was about 4 m from ground level, and the water was approximately 30 cm deep. Because cave salamander larvae move great distances through subterranean water systems, their potential presence (or the presence of adults) in Well No. 1060 might suggest that larvae or adults have moved from the southwest where populations exist at Miami Whitewater Forest and the wooded hillsides southwest of the intersection of New Haven Road and Crosby Road (Davis and Krusling 1993). In Fairfield Township, Butler County, Ohio, a population (voucher specimen is accessioned at the Cincinnati Museum of Natural History, CSNH 2900) is known from an abandoned spring house foundation on East Miami River Road. The nearest known suitable habitat is approximately 4 km southwest on the land owned by and south of Procter and Gamble's Miami Valley Laboratories on East Miami River Road in Colerain Township, Hamilton County. No cave salamanders have been located there. The nearest known specimen (CSNH 3028) came from approximately 10 km southwest of the Fairfield population on East Miami River Road, 5 km north of Harrison Avenue.

Well No. 1124 was examined with the aid of an Electronic Eye 4-Inch Down Hole Camera. Observations were recorded on VHS videotape and examined on a 25-inch color monitor. The monitor was divided into four sections, and each section was viewed individually for any signs of adult cave salamanders between rocks and for larvae in the pool of water at the bottom of the well. Well No. 1060 was well illuminated and sufficiently shallow to examine with a flashlight and unaided eye.

A WILDCO 2400 ml Petite Ponar Grab was used to obtain a sample of sediment from the floor of Well No. 1124 on October 12, 1993. The surface and interface zones of the sediment samples were examined for macroinvertebrates that might serve as cave salamander larvae forage. Similarly, a North's Teflon Bailer was used to collect a one liter sample of water from the interface zones of Well No. 1124 on October 4, 1993. Twenty 10 ml samples of this water were observed at 10X for suspended macroinvertebrates, particularly copepods, which might serve as forage for cave salamander larvae. Water temperature, pH, and dissolved oxygen were measured and recorded. The percentage of oxygen in the air above the water was also measured and recorded.

Results

At this time, it is inconclusive to determine whether or not cave salamanders inhabit the FEMP. Only two specimens were found at the control location where a stable population existed as recently as 1988. During the 1988 study in which the control population was located, all field work was completed by July because of severe drought. The summer of 1993 has been the harshest drought year since 1988. As a result of having salamander surveys done during the two driest years in recent history, it is highly recommended that a follow-up survey be performed during May and June 1994. Warm, late spring and early summer rains cause cave salamander surface activity to peak.

Five visits were made to look for cave salamanders in the north woodlot ravine, but no individuals were found. Although the conditions proved too dry each time, there were several crevices between rock layers that appeared to open underground. Visits to the FEMP were timed such that they would follow significant rainfall. Adult cave salamanders are typically active when the substrate is sufficiently wet to keep their venter moist (Juterbock 1986). Considering that insufficient moisture was found in the ravine, even after substantial precipitation, the habitat was considered marginal.

The down-hole camera did not reveal any adult or larval cave salamanders, but showed that Well No. 1124 contains invertebrates that would be suitable forage for cave salamander larvae. Numerous small amphipod-like or isopod-like arthropods were seen moving about the floor of the well and on the pipes that were suspended one to two meters above it. Additionally, small worm-like larvae were found in the mud sample taken from the interface zone of the water and substrate in the well. Although not identified, they appeared to be midge larvae, an important constituent of other *Eurycea* larvae (Pfingsten and Downs 1989). Copepods and related arthropods were not found in the water sample taken from Well No. 1124, but there did appear to be small suspended invertebrates recorded with the down hole camera.

Water and air conditions inside Well No. 1124 were suitable for both adult and larval cave salamanders (Table 1, Appendix A). Although none were seen in the well, additional video footage allowing for a view between the rocks might be more conclusive. The technique used for the current study shined bright lights into the well as the camera was lowered. Cave salamanders shun light, and it may be advantageous to keep lights off until the camera is completely lowered into the well.

During the current study, no individuals were located in Well No. 1060. Further investigation of this well during the season of peak cave salamander activity may substantiate their presence. Cindy Melroy and Leslie Williams (FEMP groundwater technicians) have seen unidentified salamanders species beneath the cover of Well No. 1060 (personal communication). Leslie Williams described a specimen seen in 1992 as 1.5 inches long and olive green in color. She did not recall any black spotting on the specimen.

Discussion

The presence of the state endangered cave salamander in the vicinity of the FEMP property at the former Ross Trails Girl Scout Camp is significant because this location represents the northern edge of the species' distribution. The genotypes from the edges of a species' range are diverse in comparison to those in the main body of the range. Only two cave salamanders were seen during the current study. Both were observed at the control location on September 10, 1993. Visits were made to Miami Whitewater Forest (MWF) and Newberry Wildlife Sanctuary (NWS) where populations are large and individuals are easily found in wells (MWF) and in a spring pool (NWS). None were seen at either locality, suggesting that the drought conditions during the summer of 1993 made conditions inhospitable for cave salamander activity at the surface. Although nonconclusive evidence was found that no cave salamanders inhabit the FEMP property, the suitability of Well No. 1124 for larval development and the report of the unidentified salamander larva in Well No. 1060 support the possibility that they may exist there.

Even though other local salamander species are known to inhabit wells and spring houses, the individual described from Well No. 1060 fits the description of a postmetamorphic cave salamander. Recently transformed longtail salamanders are bright gold, and two-lined salamander postmetamorphs are yellow and gold. Neither appears olive green such as the salamander described by Leslie Williams. At 1.5 inches, cave salamander postmetamorphs are olive green in color. The habitat and description suggest that cave salamanders may inhabit Well No. 1060; however, positive identification is needed for conclusions to be drawn. Two-lined salamanders (*Eurycea cirrigera*) have been observed in well foundations near the Bolton Water Works Plant in Butler County (Davis and Krusling 1989b). Longtail salamanders (*Eurycea longicauda*) are also commonly found in the rock walls of such structures. In such situations, these species are found in wells and spring houses located in wooded areas. Adults probably move into the wells from the surrounding woods. Well No. 1060 is isolated on a home site surrounded by pasture, small industry, and tilled fields. The nearest wooded areas are about 0.5 km away. It is not likely that adult salamanders could move across such terrain to this well. Under most circumstances, a logical explanation would be larval migration through subterranean water systems. However, the presence of porous silts and clays associated with the New Haven Trough, rather than fissured limestone, prevents larval migration from occurring through this area.

The nearest known cave salamander population to Well No. 1124 is the control population at the former Ross Trails Girl Scout Camp. Streams draining the camp flow south and beneath State Route 126 before changing course and flowing to the east. At one point, one of these streams flows within 0.25 km of Well No. 1124. Historically, it is possible that cave salamanders may have migrated from this stream to Well No. 1124. The secretive behavior of cave salamanders makes them difficult to locate. Considering the drought of the latter portion of the summer of 1993, additional field work should be conducted during the spring to try to locate populations in the potential habitat areas examined during this study and all limestone-lined wells in the vicinity of FEMP property.

Identifying populations of threatened and endangered species is a necessary task. Cave salamanders are on the Ohio Endangered Species list because the southwest corner of the state is at the periphery of their range. If a cave salamander population were found on the FEMP property in the future, decisions might need to be made about protecting them. Optimally, under any circumstance, the way to protect a population of any species is to protect its habitat. If the habitat cannot be protected, several other measures might be considered. Entire populations, or significant portions of them, have been repatriated (Dodd and Seigel 1991). Habitats have been created in some repatriation efforts; individuals are simply relocated in others. There is always a risk of disturbing established gene pools when individuals from one population are mixed with another. Populations at carrying capacity should never have individuals from outside sources added; otherwise, a trophic level imbalance will result. Since cave salamanders live in habitats that are usually not disturbed, populations are probably at or close to carrying capacity. Caves and subterranean ecosystems are delicate. Energy flow is supported by the limited supply of organic matter entering from the surface. The added burden of introduced individuals would probably upset balances in this system of limited energy flow much more easily than in systems at the surface. Therefore, if cave salamanders are located at the FEMP property, their habitat on property should be isolated and protected. No attempt should be made to move them to another locality. Creating an artificial habitat is virtually impossible since larval development is directly linked to underground water systems.

Recognizing that habitat preservation on property probably will not be possible, alternative measures to compensate for a population lost at the FEMP should be established. An effective plan might be to financially support the preservation of other known cave salamander habitats. This might be accomplished by establishing wildlife sanctuaries where cave salamanders are known to exist. The Land Management Department of the Hamilton County Park District has been diligent about protecting cave salamander populations. The Metro Parks of Butler County could manage properties purchased or financially supported to protect cave salamanders in Butler County. Cooperative efforts with either park district could establish long-term management plans anywhere in the two counties.

Acknowledgments

I would like to thank Jason Vineyard for his time and talent in preparation of the cave salamander illustrations for this report. Paul M. Daniel of Miami University's Hefner Zoology Museum offered suggestions for protocol in the field and ideas about following subterranean movements of cave salamander larvae. Becky Bixby was invaluable for her assistance in the field, obtaining resources, and coordinating efforts between groundwater crew members and myself. John Homer is also recognized for his assistance in the field. Cindy Melroy and Leslie Williams provided valuable information regarding sightings of salamanders at Well No. 1060. Michelle Barnes of the Miami University Hefner Zoology Museum reviewed the first draft of this manuscript and made editorial suggestions.

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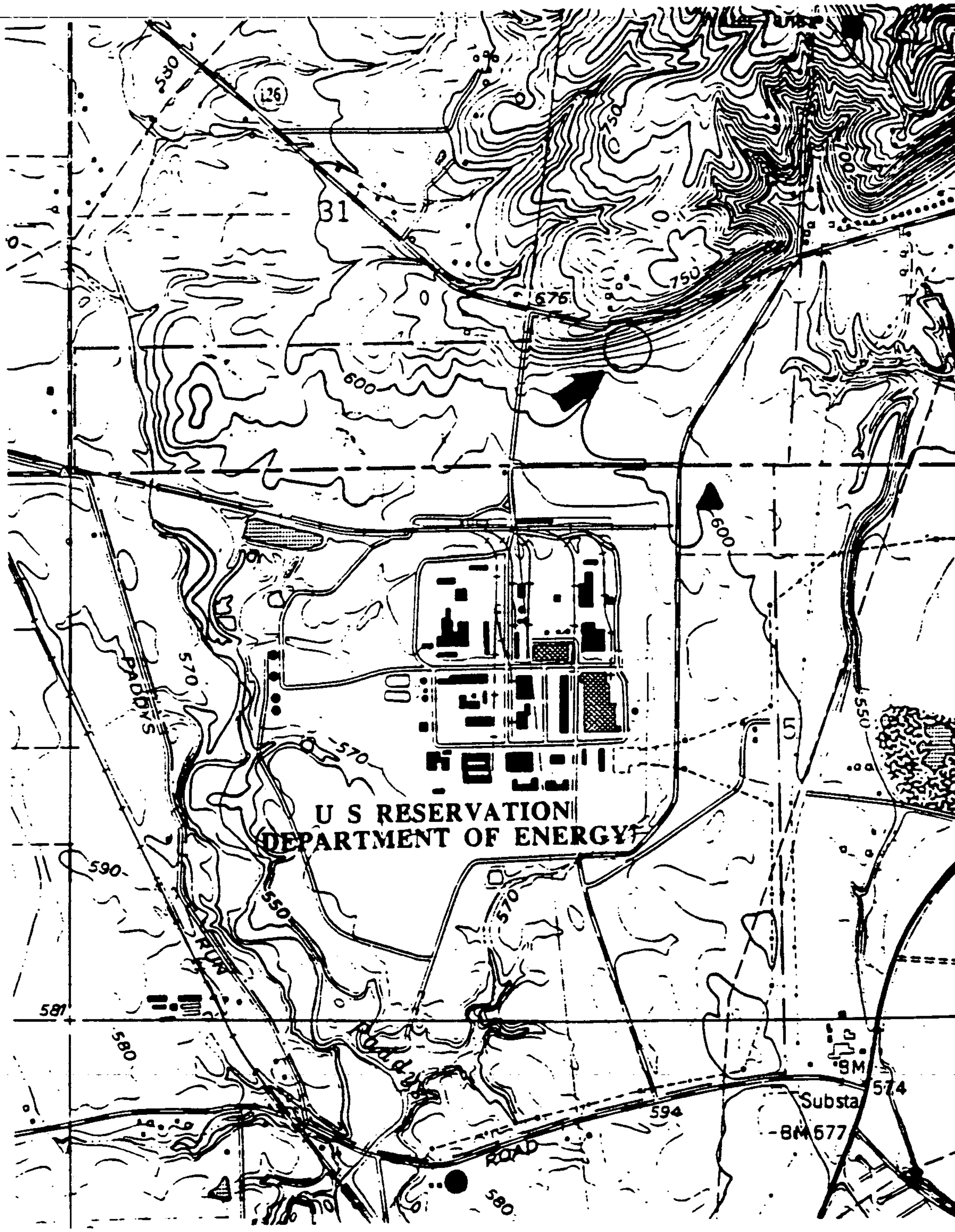
Appendix A
Figures and Table 1

Figure 1. Potential cave salamander habitat on FEMP property at Fernald, Ohio, Well No. 1060 (off-property), and location of control population.



Well 1124
Control Population
Well 1060
Potential Habitat

Figure 2. The cave salamander (*Eurycea lucifuga*) is characterized by randomly placed, irregularly shaped black dots on an orange background. The eyes bulge from the slightly compressed head.

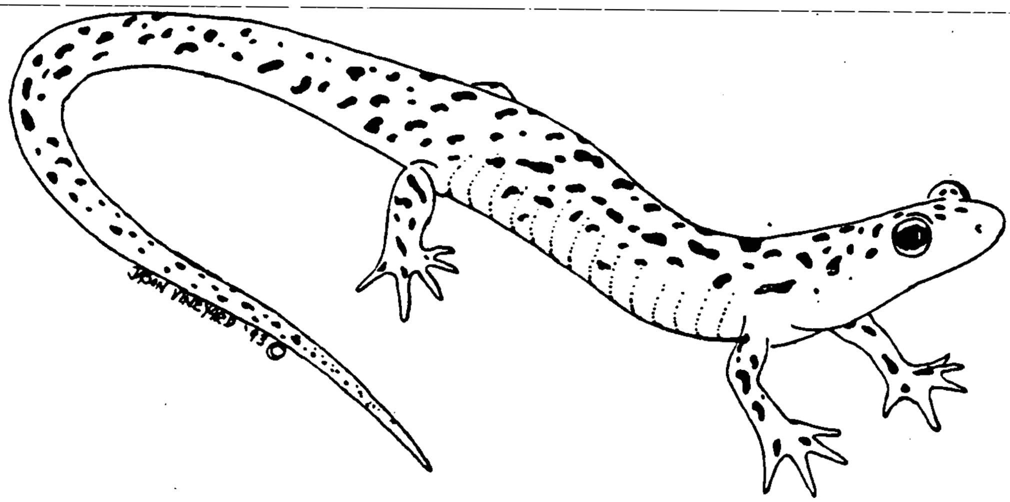


Figure 3. The spots on the cave salamander's tail (a) do not fuse to form chevrons like those of similar longtail salamander (*Eurycea longicauda*)(b).

a b

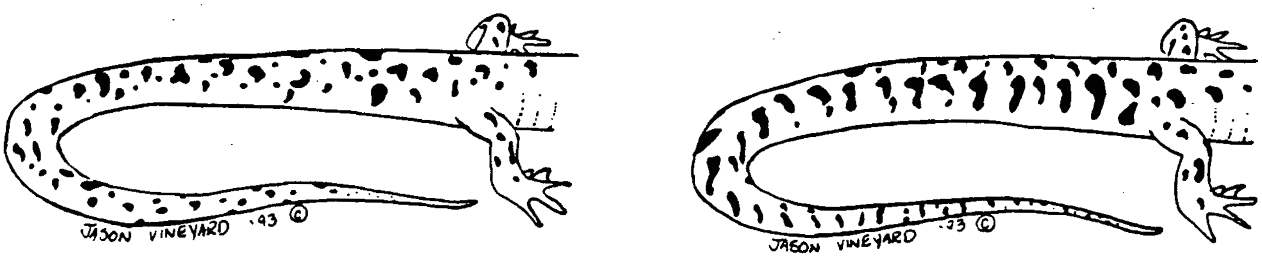
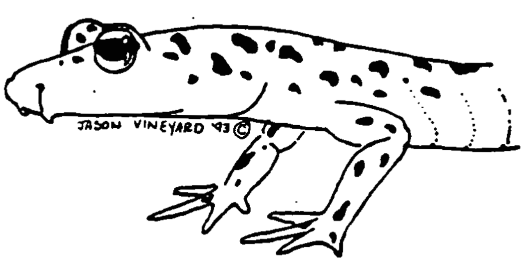


Figure 4. Male cave salamanders have elongated cirri at the base of the nasolabial groove on the upper lip (a) and a rounded mental gland on the chin (b).

a



b

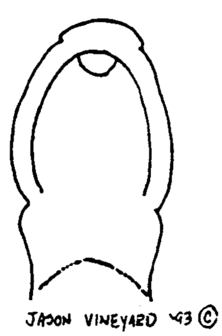


Figure 5. Range of the cave salamander. Southwest Ohio is on the northern limit of the cave salamander's range (modified from Conant and Collins 1991 and Pfingsten and Downs 1989).

Figure 6. Cave salamander populations are known from Butler and Hamilton Counties in southwest Ohio and from Adams County in south-central Ohio.

6858

Figure 7. Townships in Butler and Hamilton Counties, Ohio with known cave salamander populations. All known localities are west of the Mill Creek Valley.

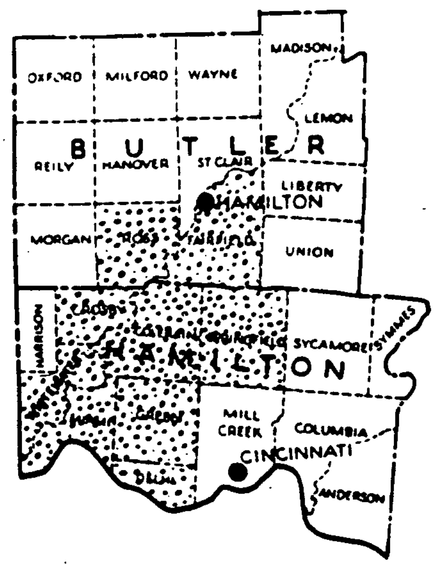


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Table 1. Water and Air Conditions in Well 1124.

Parameter	Value
Dissolved Oxygen (air)	20.3%
Dissolved Oxygen (water)	3.65%
pH	6.77
Temperature	12.8°C
Depth (well)	8 m
Water Depth	5.5 m

Appendix B
Field Notes

August 27, 1993

Reconnaissance survey - Jeff Davis, Becky Bixby, John Homer

>Paddys Run Road 1 km north of Willey Road. Forested hillside on FEMP property falls from 590 feet to 550 feet. One open ravine with limited exposed limestone. Appears too dry to support cave salamanders at the surface. Marginally suitable habitat.
>Deciduous wood lot along northern border of FEMP property. Hillside falls from 700 feet to 650 feet. One small ravine with 10 to 15 m of open limestone. Very dry under rocks, but numerous openings into underground crevices are found beneath rocks. Suitable habitat if more water is available.
>Oak-hickory flatwoods behind Neiman's Nursery was surveyed, but no suitable habitat was found.
>Woodlots east side of Paddys Run were surveyed but no suitable habitat was identified.

September 10, 1993

Control site - Jeff Davis, Becky Bixby - Sunny, 70°F

>Redback salamanders (*Plethodon cinereus*) too numerous to count in ravine under rocks, logs, and other debris. Adults and juveniles, all redback phase.
>Two adult cave salamanders (*Eurycea lucifuga*) at control site. One missing its tail; the other backed into a crevice.
>One subadult green frog (*Rana clamitans*) under stone in ravine at control site.

Deciduous Wood Lot (north woods on site) - Jeff Davis, Becky Bixby

>Very dry, no cave salamanders, no redback salamanders.

Well No. 1124 - Cone House Well

>Ample water for reproduction and larval development.
>Limestone lined with mortar between rocks.
>Approximately 30 feet to water's surface.

September 20, 1993

Control site - Jeff Davis, Becky Bixby - two days after substantial rainfall, 65°F

>Redback salamanders (*Plethodon cinereus*) too numerous to count. Adults and juveniles all redback phase.
>No cave salamanders.
>Still too dry.

September 28, 1993

Well No. 1124 - Jeff Davis, Becky Bixby, John Homer

>Electronic Eye 4-Inch Down Hole Camera was used in conjunction with video cassette recorder to examine the crevices between rocks in well wall for adults and water for larvae and larva food items.

Control Site - Jeff Davis, Becky Bixby, John Homer - Sunny, 65°F

>Two days after rain. Still too dry.
>Saw six redback salamanders (*Plethodon cinereus*) five adults, one juvenile, all redback phase.

Deciduous Woodlot (north woods on property) - Jeff Davis, Becky Bixby, John Homer

>Very dry, no cave salamanders, no redback salamanders.

October 4, 1993

Well No. 1124 - Jeff Davis, Becky Bixby, Paul Daniel

>Examined well walls with aid of a flashlight. No cave salamanders.

Control Site - Jeff Davis, Becky Bixby, Paul Daniel - Sunny, 72°F.

>Saw eleven redback salamanders (*Plethodon cinereus*) all adults, ten redback phase, one leadback phase.
>Two juvenile green frogs (*Rana clamitans*) beneath stones in ravine bed.
>No cave salamanders.

Deciduous Wood Lot (north woods on-site) - Jeff Davis, Becky Bixby, Paul Daniel

>Very dry, no cave salamanders, no redback salamanders.

October 6, 1993

Well No. 1124 - Jeff Davis, Becky Bixby, QA personnel

>Water sample taken by groundwater technician using one liter bailer. Sample to be observed later.
>Well walls observed with the aid of a flashlight. No cave salamanders seen.

Well No. 1060 - Jeff Davis, Becky Bixby, QA personnel

>Well examined with the aid of a flashlight. No cave salamanders were seen. Salamanders have been seen in this well before by FERMCO personnel. Very probable that cave salamanders use this well.

Control Location - Jeff Davis, Becky Bixby, QA personnel

>Four redback salamanders observed.
>No cave salamanders.
>Extremely dry.

Deciduous Wood Lot (north woods on property) - Jeff Davis, Becky Bixby

>Very dry, no cave salamanders, no redback salamanders.

Miami Whitewater Forest Reservoir Wells - Jeff Davis, Becky Bixby - Sunny, 65°F

>Objective was to see if cave salamanders were active at a locality where they are active during most of the year; none found.

October 8, 1993

Newberry Wildlife Sanctuary - Jeff Davis, Becky Bixby - Sunny 68°F

>Objective was to see if cave salamanders were active at a locality where they have been observed through November on a regular basis; none found.

Appendix C
Salamander Diversity in Vicinity of FEMP Property

Salamanders In The Vicinity of FEMP Property

Historically, 17 species of salamanders have been reported from Hamilton and Butler Counties (Pfingsten and Downs 1989). In recent years, a series of herpetological surveys, supported largely by the Hamilton County Park District, have documented active populations of twelve species (Table 1A) (Davis 1988; Krusling et al., 1991a; Krusling et al., 1991b; Davis et al., 1992; Rubin 1992).

Rarely does species richness match that of the region that immediately surrounds the FEMP property. Within one km of FEMP property boundaries, especially to the north and to the west, ten species of salamanders are known (Figure 1A). Included among these are cave salamanders and the only documented Hamilton County population of marbled salamanders (*Ambystoma opacum*) (Davis and McCarty 1993). Only two other regional marbled salamander populations have been documented. One of these populations is approximately 40 km to the east in southwest Warren County, Ohio (King 1935), and the other was recently discovered some 50 km to the southwest in Ohio County, Indiana (Krusling and Ferner 1993).

Four salamander species of the family Ambystomatidae have been documented in Hamilton and Butler Counties during recent surveys. Very rarely do more than two species inhabit the same wood lot and share the same breeding pond. A remnant pin oak-hickory swamp forest adjacent to FEMP property along Paddys Run Road and south of the Hamilton-Butler County border is the only known site in southwest Ohio where all four species of Ambystomatids share a breeding site (Figure 2A) (Davis et al., 1992). Such sites are probably rare anywhere. Salamander species diversity in the immediate vicinity of the FEMP property is unusually high and merits further investigation to establish which environmental factors are so favorable there. In another on-site study, Facemire et al. (1990) reported only two amphibian species, the American toad (*Bufo americanus*) and the spring peeper (*Pseudacris crucifer*). Although no endangered salamanders are known at this location, the rarest Hamilton County species, the marbled salamander, occurs there and no where else within the county's borders. Cave salamanders are abundant at the southwest Ohio sites where they exist. The swamp forest habitat is unique to the region, and the fact that at least four species, in addition to the marbled salamander, inhabit it is noteworthy. Members of the family Ambystomatidae are known as "mole salamanders" because of their burrowing behavior. Some individuals, that breed in the swamp forest ponds during spring and fall may spend the rest of the year burrowed in the soils of FEMP property. These early spring breeding salamanders will move hundreds of meters to their selected breeding site. Spotted salamanders were observed on Paddys Run Road in March 1992.

The site directly north of FEMP property, where longtail salamanders, two-lined salamanders, redback salamanders (*Plethodon cinereus*), and dusky salamanders (*Desmognathus fuscus*) have been found (Figure 1A), is equally important. Together, these two sites illustrate species richness for a small area that is unmatched in any literature and former local surveys.

In recent years, much publicity has been given to the apparent decline in global amphibian populations (Baringa 1990; Phillips 1990). Baseline data must be obtained if amphibian populations are to be monitored in the future. The area immediately around the FEMP property has proven quite valuable in the collection of this important baseline data. Efforts should be made to survey the entire region, including the FEMP property, in the very near future. A Declining Amphibian Populations Task Force has recently been established to look at historical population trends and to monitor known populations. Because amphibians are important bio-indicator species, a sound environmental management plan should consider these species.

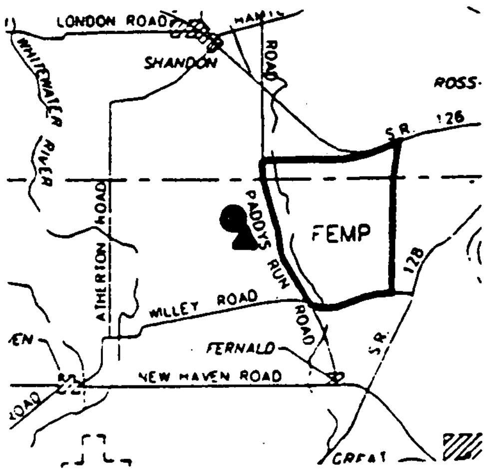
Appendix C
Figures and Table 1A

Table 1A. Historic and recent salamander species of Hamilton and Butler Counties in southwest Ohio.

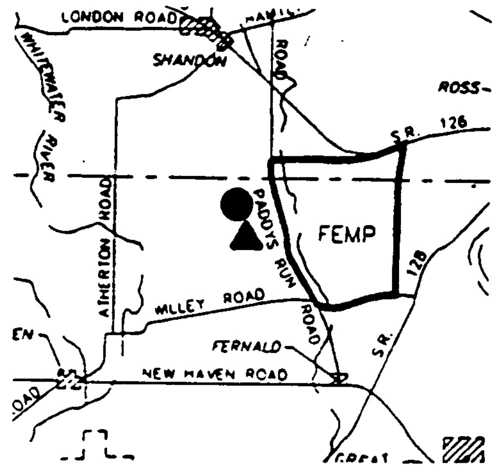
Recent species are in bold print.

Scientific Name	Common Name
Ambystoma barbouri	**Streamside Salamander**
Ambystoma jeffersonianum	**Jefferson Salamander**
Ambystoma maculatum	**Spotted Salamander**
Ambystoma opacum	**Marbled Salamander**
Ambystoma tigrinum	Tiger Salamander
Cryptobranchus alleganiensis	Hellbender
Desmognathus fuscus	**Dusky Salamander**
Eurycea cirrigera	**Two-lined Salamander**
Eurycea longicauda	**Longtail Salamander**
Eurycea lucifuga	**Cave Salamander**
Gyrinophilus porphyriticus	**Spring Salamander**
Necturus maculosus	Mudpuppy
Notophthalmus viridescens	Eastern Red-spotted Newt
Plethodon cinereus	**Redback Salamander**
Plethodon glutinosus	**Slimy Salamander**
Plethodon richmondi	**Ravine Salamander**
Pseudotriton ruber	Red Salamander

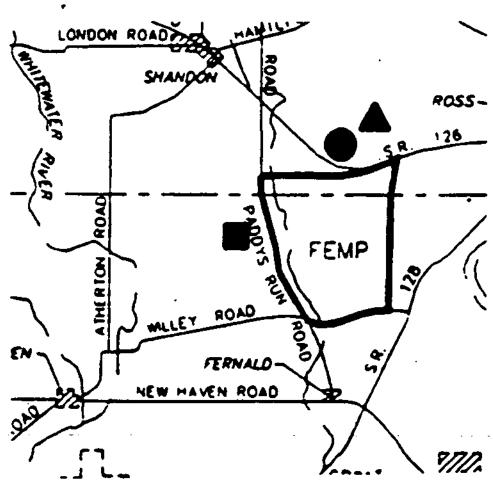
Figure 1A. Localities of ten salamander species' populations known within one km of FEMP property.



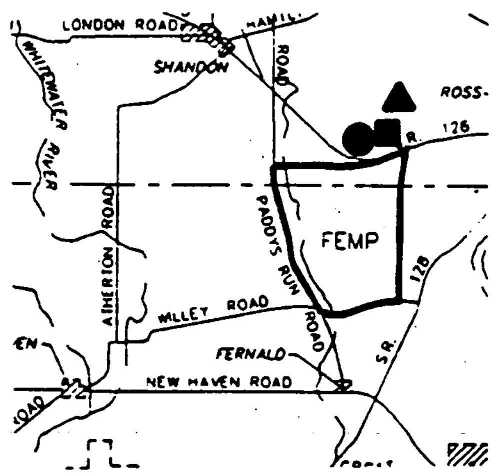
● *Ambystoma barbouri*
▲ *Ambystoma opacum*



● *Ambystoma jeffersonianum*
▲ *Ambystoma maculatum*

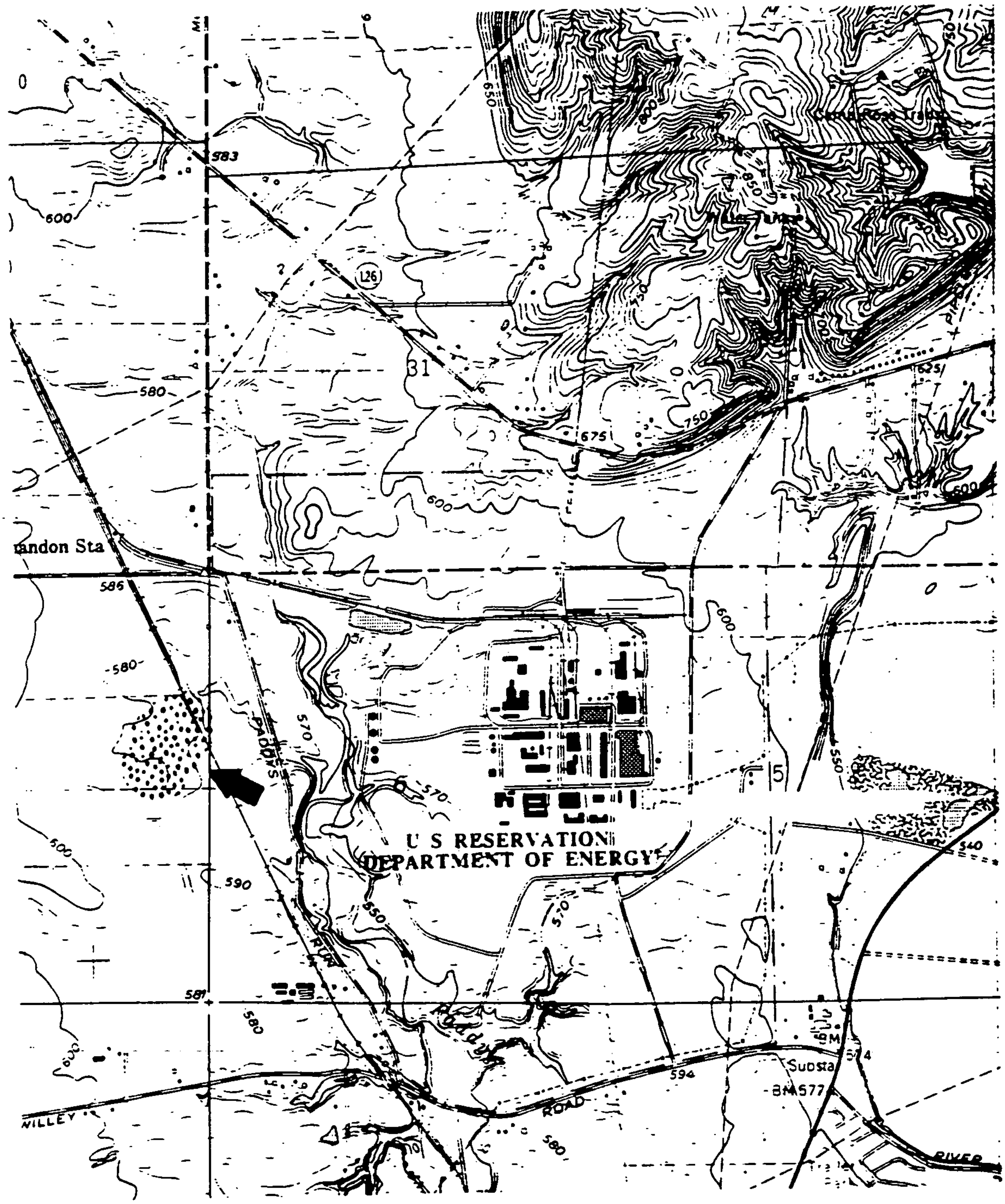


● *Desmognathus fuscus*
■ *Plethodon richmondi*
▲ *Plethodon cinereus*



● *Eurycea cirrigera*
■ *Eurycea longicauda*
▲ *Eurycea lucifuga*

Figure 2A. Location of a pin oak - hickory swamp forest where at least four Ambystomatid salamander species share habitat and breeding sites. This site is adjacent to FEMP property on Paddys Run Road.



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