

DEC 05 1989

CONF-891098--2

DE90 003196

**ECOLOGICAL ASSESSMENTS AT DOE HAZARDOUS WASTE SITES:
CURRENT PROCEDURES AND PROBLEMS**

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ABSTRACT

Major actions at U.S. Department of Energy (DOE) hazardous waste sites require CERCLA compliance that meets NEPA considerations. Although NEPA compliance includes ecological considerations, neither the Council on Environmental Quality (CEQ) nor the DOE provide detailed guidance for conducting ecological assessments under NEPA. However, the identification of the form and magnitude of potential ecological impacts associated with a proposed action is directly dependent on the quality of the baseline data available for a particular site. Using the Surplus Facilities Management Program Weldon Spring site as an example, we discuss the collection of baseline ecological data for the site. This site is surrounded by approximately 17,000 acres of wildlife area. Available wildlife data consisted of qualitative, county-level species lists, and vegetation data was in the form of a regional qualitative narrative. Detailed site-specific occurrence data for listed species and high quality natural communities was provided by the Missouri Department of Conservation Heritage data base.

INTRODUCTION

The U.S. Department of Energy (DOE) currently maintains responsibility for a number of hazardous waste sites throughout the United States, including several sites that are on or proposed for inclusion on the National Priorities List (NPL). The remedial actions carried out at these sites are subject to U.S. Environmental Protection Agency (EPA) oversight under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. Current regulatory compliance

guidelines under CERCLA emphasize remediation for human health impacts and development and selection of cleanup technologies.

The DOE is also responsible for meeting the requirements of the National Environmental Policy Act (NEPA) of 1969, which requires federal agencies to consider environmental consequences of a proposed action as part of the decision-making process. Although NEPA considerations include ecological assessments, neither the Council on Environmental Quality (CEQ) regulations nor the DOE NEPA Compliance Guide (USDOE 1988) provide detailed guidance for conducting ecological investigations, and ecological assessments at DOE sites are often afforded secondary considerations relative to human health and remediation technology development. Detailed guidance for conducting ecological assessments under CERCLA at these sites has only recently been provided (USEPA 1987; USEPA 1989).

The combination of a relative lack of ecological assessment guidance and a primary emphasis on human health and site cleanup, along with budgetary and time constraints, often preclude quantitative investigations that can forecast potential impacts to ecological systems at these sites. Using the Surplus Facilities Management Program (SFMP) Weldon Spring site in Missouri as an example, we discuss the sources and methods used for the collection of baseline ecological data for this site. We chose the Weldon Spring site because it is surrounded by approximately 17,000 acres of actively managed wildlife area and is thus ecologically very diverse. The identification of potential impacts associated with a proposed action, and the estimation of the magnitude of these impacts on ecological resources, is directly dependent on the quality of the baseline data available for a particular site.

SITE DESCRIPTION

The Weldon Spring site is located in St. Charles County, Missouri, approximately 48 km west of the city of St. Louis. The site consists of two noncontiguous areas: (1) a

raffinate pits and chemical plant area and (2) a quarry (Fig. 1). The raffinate pits and chemical plant area occupies approximately 217 acres, and the quarry covers approximately 9 acres. The chemical plant was originally used by the U.S. Army for production of trinitrotoluene (TNT) and dinitrotoluene (DNT) and subsequently by the Atomic Energy Commission (AEC) for processing of uranium and thorium ores. The plant has been unused and in caretaker status since 1969. The quarry area had been used by the U.S. Army for the disposal of chemically contaminated explosive material from the early 1940's through the mid-1950's. Between 1957 to 1966, the quarry was used by the AEC for the disposal of uranium and thorium residues and radioactively contaminated building rubble and process equipment. Waste disposal in the quarry ended in 1969.

The chemical plant area is bordered to the north by the August A. Busch Memorial Wildlife Area, by the Weldon Spring Wildlife Area to the south and east, and the U.S. Army and National Guard Training Area to the west. The quarry was excavated into a limestone bluff that overlooks a portion of the Missouri River alluvial floodplain, and is surrounded by the Weldon Spring Wildlife Area.

AUGUST A. BUSCH MEMORIAL WILDLIFE AREA

The August A. Busch Memorial Wildlife Area (Fig. 1) encompasses approximately 7,000 acres, including 35 lakes totaling 500 acres, and is under the jurisdiction of the Missouri Department of Conservation (MDOC). The area is used as a demonstration for wildlife management, integrating the development and use of forestry, water, agricultural and wildlife resources. A variety of habitats occur within the wildlife area, including open fields and pasture, forests, and cultivated cropland.

In addition to the hunting and fishing provided by the management programs, the wildlife area also supports and provides for a variety of research, education, and nature study programs. The Busch Wildlife Area receives approximately 800,000

visitors each year from the St. Louis and surrounding areas.

WELDON SPRING WILDLIFE AREA

The Weldon Spring Wildlife Area (Fig. 1) is a 7,230-acre Special Management Area managed for wildlife by the MDOC. The area is extensively wooded with some areas of old field, grassland, and agriculture. The wildlife management program includes a share cropping program with local farmers that provides area wildlife with high energy cereal grains and winter green browse.

The southern boundary of the wildlife area is delineated by the Missouri River (Fig. 1), and includes portions of the 100-yr floodplain for the Missouri River and also Little Femme Osage Creek. Some of the floodplain area is used for crop production. Aquatic habitats include numerous small, unnamed creeks, drainages, springs, and ponds located throughout the Weldon Spring Wildlife Area. The estimated 250,000 yearly visitors use the wildlife area for a variety of recreational activities, including hunting, fishing, hiking, and boating (in the Missouri River).

HOWELL ISLAND WILDLIFE AREA

The Howell Island Wildlife Area is located in the Missouri River across from the Weldon Spring Wildlife Area (Fig. 1). This 2,575-acre wildlife area is within 2.5 km of both the chemical plant and quarry areas, and contains a known night roost for bald eagles overwintering in the area (Gaines 1988).

CONSTRAINTS

The goal of the ecological assessment is to provide sufficient information and analyses on the ecosystems of an area so that an evaluation of potential impacts from the proposed and alternative actions can be performed. Biological resources for which baseline data was deemed necessary included terrestrial and aquatic ecosystems, listed

species, unique or high quality natural areas and communities, and wetlands. At the Weldon Spring site, these data were collected to support a feasibility study (FS) under CERCLA. Although not a NEPA document, the FS was to include a NEPA environmental assessment (EA) level of analysis to support a remedial action at the site.

Several problems were encountered during the collection of baseline ecological data for the SFMP Weldon Spring site and surrounding areas. Little site-specific ecological information was available for the Weldon Spring site. Previous site-specific investigations discussed the ecological resources at and in the vicinity of the site only in very general, qualitative terms (USDOE 1987), or consisted primarily of radiological and chemical uptake and bioaccumulation studies on selected biota (RETA 1978; MK-Ferguson and Jacobs Engineering Group 1988).

The collection of baseline ecological data for the Weldon Spring site was further complicated for a variety of reasons. The completion of the EA-level analysis and documentation for the site was scheduled at approximately seven months, thus limiting the amount of time available for the collection and analysis of baseline data for the area. The CEQ (1981) suggests that the NEPA process for an EA should take no more than three months. In addition, the presence of the extensive wildlife areas, along with the time constraints, precluded the field-collection of ecological data for the site. The Weldon Spring area includes several actively managed wildlife areas totalling approximately 17,000 acres and containing a large number of habitats.

METHODS

The MDOC Heritage data base was the primary source of information on the wildlife of the area. The Heritage data base provided species lists of wildlife known to occur in St. Charles County and included information on the status (i.e., rare, transient, common, winter resident only) of the bird and mammal species known to occur in the county. Discussions with naturalists at the Busch and Weldon Spring Wildlife areas

provided additional information on the ecological resources in the immediate area of the site.

Life history and additional distribution information on the biota of the Weldon Spring site area was obtained from a variety of regional literature sources, such as *The Fishes of Missouri* (Pflieger 1975) and *Amphibians and Reptiles of Missouri* (Johnson 1987). Quantitative information on the flora of the area was obtained from Bailey's (1976) *Ecoregions of the United States*, the Missouri Botanical Garden (1975), and MDOC information pamphlets for the Busch (MDOC 1978) and Weldon Spring (MDOC 1985) wildlife areas. Additional information on the topography, wildlife habitats, and vegetation of the Weldon Spring SFMP site and surrounding wildlife areas was obtained during a visit to the area. The site visit consisted of a walking inspection of the chemical plant and quarry areas, and also included driving and walking through portions of the Busch and Weldon Spring wildlife areas.

The Heritage data base provided detailed information on state and federally listed rare and endangered species, and on high quality natural communities, occurring in St. Charles County, adjacent St. Louis County, and in the Howell Island, Busch, and Weldon Spring Wildlife areas. Information on the status of federally listed threatened or endangered species was obtained through consultation with the U.S. Fish and Wildlife Service (USFWS) under Section 7(c) of the Endangered Species Act. The USFWS was also contacted for National Wetlands Inventory maps of St. Charles County. However, no base maps were available at the time for this portion of Missouri.

RESULTS

TERRESTRIAL ECOLOGY

The Weldon Spring SFMP site is located along the boundary between two physiographic provinces (Johnson 1987; Thom and Wilson 1980), and both portions of the site occur in areas that are biologically rich and contain significant ecological resources.

The quarry area is situated in the northern portion of the Ozark Border physiographic province. This region occurs in a band along the lower Missouri River and the eastern edge of the State of Missouri along the Mississippi River, and is characterized by hills and bluffs, deciduous forests, and wide river valleys. The quarry is surrounded by the Weldon Spring Wildlife Area.

The chemical plant area occurs within the southern portion of the Glaciated Plains physiographic province. This area is characterized by rolling hills and broad flat valleys, and limestone bluffs and steep hills occur at the eastern edge of the province along the Missouri River (Johnson 1987).

Vegetation

The Quarry Area. Although extensively affected by past human activities, little human disturbance currently occurs in this area and vegetation has become reestablished. The quarry floor is old-field habitat with a variety of grasses, herbs, and shrubs. The rim and upper portions of the quarry consist primarily of slope and upland forest; tree species present include cottonwood, sycamore, and oak (personal observation). No list of plant species occurring at the quarry was available.

The Chemical Plant Area. The chemical plant area is essentially grassland/old-field habitat with numerous buildings, roads, parking areas, and other plant facilities. The area has a gently-rolling topography, and receives active mowing. Little undisturbed vegetation exists at the site, and vegetation is limited to a variety of grasses with

scattered small shrubs (personal observation). No list of plant species occurring at the chemical plant area was available.

The Wildlife Areas. Habitats identified during the site visit included open fields and pastures; slope, upland, and bottomland forests; and cultivated farmlands. Plant species common to the open fields and pastures of the area include a variety of grasses, annuals, perennials, and shrubs (USDOE 1987; MDOC 1978; 1985; Missouri Botanical Garden 1975). Forested habitats in the area contain a variety of tree species, such as shagbark hickory, pawpaw, black walnut, eastern cottonwood, and a variety of oaks.

The area south of the quarry is within the 100-year floodplain of Little Femme Osage Creek and the Missouri River. Vegetation in this area consists primarily of crops or grasses and herbaceous species (personal observation). Trees, when present, are restricted to numerous levees throughout the area and to the banks of Little Femme Osage Creek and Femme Osage Slough; these are primarily willow and cottonwood. No listing of plant species occurring in the wildlife areas was found, and none was provided by the MDOC.

Wildlife

Little site specific information on the wildlife of the chemical plant and quarry areas was found. The MDOC Heritage data base identified 25 species of amphibians, 47 species of reptiles, and 29 species of mammals as occurring in St. Charles County. Many of these species could occur in the wildlife areas near the site. Although no list of species occurring at the quarry was available, the natural condition of the quarry and the proximity of the Weldon Spring Wildlife Area suggest that a number of the species listed for St. Charles Co. may inhabit or utilize habitats at the quarry. In contrast, the chemical plant area probably contains relatively depauperate amphibian, reptile, and mammal communities characterized by species commonly associated with developed urban and residential areas.

Few reptile species would be expected to occur at the chemical plant because of the relative absence of suitable habitat. Similarly, amphibian species if present would be restricted to the few aquatic habitats present at the plant, and none of the more terrestrial forms such as the eastern tiger salamander would be expected to occur at the plant. Some amphibians and reptiles, such as the bullfrog and snapping turtle, have been reported from the aquatic habitats at the raffinate pit and chemical plant area (MK-Ferguson Company and Jacobs Engineering Group 1988).

The SFMP Weldon Spring site is situated along the Mississippi Flyway, one of the major north-south routes for migratory North American birds. As a consequence, the Weldon Spring area possesses a very diverse avifauna. More than 295 avian species have been reported from St. Charles County and could occur at the Weldon Spring site. More than 100 species are known to breed in the habitats present at the wildlife areas, and many are common year-round residents. The many ponds and small lakes in the area, and also Little Femme Osage Creek and the Missouri River, provide important habitat for nesting and migratory waterfowl and shorebirds.

AQUATIC ECOLOGY

Aquatic habitats at the quarry are limited to a 0.5-acre pond located on the quarry floor. No data are available on the presence or absence of vertebrates in this pond, or on use of this pond by terrestrial species. However, collection of fish from the quarry pond for radiological and chemical uptake studies was unsuccessful (MK-Ferguson Company and Jacobs Engineering Group 1988). Aquatic habitats at the chemical plant include the raffinate pits, two small ponds, and several small intermittent streams and drainages. Collection of fishes at the raffinate pits has been unsuccessful, and only an unidentified species of sunfish (Lepomis sp.) has been collected from one of the ponds at the plant (MK-Ferguson Company and Jacobs Engineering Group 1988).

Principal aquatic habitats in the Weldon Spring Wildlife Area are the Missouri River (approximately 1.6 km southeast of the quarry), Little Femme Osage Creek (150 m west of the quarry), Femme Osage Creek (610 m south-southwest of the quarry), and Femme Osage Slough (150 m south of the quarry). Other aquatic habitats in the area include numerous small, unnamed creeks, drainages, springs, and ponds. Several intermittent and perennial streams also occur at the Busch Wildlife Area. In addition, this wildlife area contains 35 ponds and lakes ranging in size from approximately 1 acre to 182 acres.

The MDOC reports 105 species of fish from St. Charles County, including the Missouri River, and some of these species could occur in the aquatic habitats of the wildlife areas. However, little information was found with regards to the species known to occur in these areas. Many of the aquatic habitats in the area, and especially at the Busch Wildlife Area, are actively managed for recreational fishing activities, and some of the ponds and lakes are stocked with channel catfish, bass, crappie, and other species.

THREATENED AND ENDANGERED SPECIES AND HIGH QUALITY COMMUNITIES

Consultation with the USFWS indicated that the only federally listed threatened or endangered species known to occur in the Weldon Spring area is the bald eagle, Haliaeetus leucocephalus. A night roost for overwintering bald eagles occurs on the Howell Island Wildlife Area. However, no critical habitat for this species exists at either the quarry or the chemical plant. The range of the federally endangered peregrine falcon, Falco peregrinus includes the Weldon Spring area. Although this species was not identified by the USFWS as occurring in the area, the MDOC Heritage data base includes this species as a migrating transient in the area.

The MDOC Heritage data base included records of the sturgeon chub Hyloopsis gelida and the sicklefin chub Hybopsis meeki from the Missouri River at the Howell Island and Weldon Spring Wildlife areas. These chubs are classified as Category 2 (C2) species, candidates for federal listing as threatened or endangered species. These species, however, are restricted to open channels of large turbid rivers such as the Missouri River, and do not enter tributary stream (Pflieger 1975). Thus, with the exception of the Missouri River proper, these species will not be found in the aquatic habitats of the Weldon Spring area.

An additional three C2 species (Table 1) have been reported from St. Charles County and thus could possibly occur in the Weldon Spring vicinity. One of these species, the pallid sturgeon Scaphirhynchus albus, has recently been proposed for Endangered status under the Endangered Species Act. This species inhabits the Missouri River. Two Category 3 (former C2 candidate species) have also been reported from St. Charles County (Table 1) and could potentially be found in the Weldon Spring area. None of these species, however, are known to occur in the immediate vicinity of the Weldon Spring SFMP site.

The MDOC Heritage data base contains detailed information on state listed rare, threatened and endangered species, and on high quality natural areas, and includes detailed location and status information. The MDOC has identified 17 state endangered and 17 state rare species from St. Charles County; eight additional species that are considered by the state to be of special concern are also reported from the county (Table 1). However, except for the bald eagle and the sicklefin and sturgeon chubs, only two state-listed rare or endangered species and one state species of concern are known to occur in the immediate vicinity of the Weldon Spring site.

The Cooper's hawk Accipiter cooperii, a state endangered species, is reported to nest in the Weldon Spring Wildlife Area. This species nests in large trees greater than 7 m in height (Bent 1937, Bull 1974), and trees of this size are found in the quarry area.

The wood frog Rana sylvatica is classified by the state as rare, and is known to occur and breed at the Weldon Spring Wildlife Area (Saladin 1989). In Missouri, this species is generally associated with wooded hillsides, and breeds in small fishless woodland ponds and pools (Johnson 1987). The quarry pond may provide suitable breeding habitat for this species.

The sedge wren Cistothorus platensis, a species on the state's watch list, has been reported at the Weldon Spring Wildlife Area from old-field habitat in the vicinity of the chemical plant. No legal status is associated with this listing; watch list status is given to species of possible concern for which the MDOC is seeking further information.

A search of the MDOC Heritage data base identified several high-quality natural communities in the area of the Weldon Spring site. A mesic forest/dry-mesic chert forest of approximately 125 acres and containing very good old growth occurs in the Weldon Spring Wildlife Area southeast of the chemical plant. Approximately 81 acres of this forest community lies within the Weldon Spring Natural Area, which is a very old-growth mesic forest. In addition, very high quality dry chert forest and chert savannah are located in the Weldon Spring Wildlife Area northwest of the quarry area. These communities contain old-growth vegetation, and the dominant trees (primarily oak) often exceed 50-cm diameter breast height. The chert savannah community, which contains very old-growth black and post oak and some unusual plants, is essentially undisturbed and has been classified as rare by the MDOC.

DISCUSSION

Actions and activities undertaken by federal agencies, including remedial activities at hazardous waste sites, can result in a wide range of environmental effects, and CERCLA, NEPA, and the CEQ regulations require considerations of potential impacts that could result from the implementation of a specific action. To estimate the type and magnitude of (ecological) impact that could result from the implementation of a proposed or alternative action, sufficient baseline data of good quality must be available for the impact analyses.

With the exception of listed species and unique natural areas, available information on "typical" species, communities and ecosystems is generally lacking. However, these are the ecological resources that could be most affected by the implementation of a proposed action, and it is in this regard that the adequacy of the available site-specific baseline ecological data used in many ecological assessments fall short. It should be noted that these shortcomings are not unique to DOE hazardous waste sites, and are evident in many NEPA documents and particularly in those for proposed actions sited in or near relatively natural areas.

In the present study, relatively detailed data was available for threatened, endangered and rare species, and on high quality natural communities in the vicinity of the quarry and chemical plant areas. These data were provided by the USFWS and the MDOC Heritage data base. We were fortunate that the quality of the MDOC Heritage data base was so high; comparable data bases for other portions of the country may be lacking. The Heritage data base has only recently been completed, and if the assessment at the Weldon Spring site had been conducted two years earlier, much of the information on listed species and high quality natural areas would have been unavailable.

The MDOC Heritage data base was particularly detailed, providing specific location data for the listed species and high quality communities in the area. Life

history information for many of these species, obtained from literature sources such as Pflieger (1975) and Johnson (1987), provided additional material useful in determining the potential for some of these species, such as the sicklefin and sturgeon chubs, to occur in the project area. Because these species and communities are uncommon and have been provided some degree of protective status, numerical abundance information is not as critical for estimating potential impacts to these resources as are presence/absence and distribution data. If these resources were found to occur in the immediate area of the site and potential impacts to these resources identified, then additional, detailed quantitative ecological data would be collected and analyzed.

No National Wetlands Inventory maps for the area were available from the USFWS, and no wetlands were identified from the Weldon Spring location by the MDOC Heritage data base. Given the level of detail that exists within the Heritage data base for high quality natural areas, important wetlands if present in the area probably would have been identified by the MDOC. The absence of wetlands information from this data base thus suggests that no major wetlands occur in the area of the Weldon Spring site.

In contrast to the information on listed species and high quality natural areas, very little quantitative data were available for the non-endangered species and non-unique ecosystems at the Weldon Spring SFMP site. Available data for these resources consisted almost exclusively of qualitative presence/absence species lists for a very broad geographical area, St. Charles County. Little or no data on habitation or use of the quarry and chemical plant areas by individual species were available, and basic measures of ecosystem condition or quality are lacking for the site.

CONCLUSIONS

The collection of ecological data should be afforded the same level of importance and effort as occurs with the collection of baseline data on groundwater and surface

water resources, air quality, noise, and chemical and radiological contaminants. However, several factors have acted to limit the quality of ecological assessments at hazardous waste sites. The primary concerns at these sites, driven by CERCLA, are for human health, i.e., potential exposure to contaminants through inhalation, ingestion, or other direct contact. As a consequence, ecological concerns are often assigned secondary importance. Recent guidance by EPA (USEPA 1989a) indicates that ecological assessments at Superfund sites under CERCLA will be expected to include specific, detailed, quantitative data. This information would then be available for use during the preparation of NEPA documentation.

A variety of sources exist which describe techniques and methods for the collection and analysis of baseline ecological data. Among the more commonly used metrics for estimating the condition of populations and ecosystems are measures of species diversity (Margelaf 1958; Wilhm and Dorris 1968; Wilson and Bossert 1971; Krebs 1978), measures of faunal similarity (Pinkham and Pearson 1976; Matthews 1986), and measures of community structure and persistence (Simpson 1949; Krebs 1978; Winner et al., 1980; Matthews 1986). In addition, the ecological literature contains a variety of metrics that have been developed for estimating the relative condition of ecological communities with respect to anticipated, observed, or perceived environmental impacts. Examples of these measures include the index of biotic integrity (Karr 1981; Karr et al., 1986), the Hilsenhoff biotic index (Hilsenhoff 1987), and the community degradation index developed by Ramm (1988). Several ecological assessment guidance documents have recently been published by the EPA (USEPA 1987, 1989a, 1989b) and the Bureau of Land Management (USDOI 1986). A more quantitative approach to ecological assessments incorporating some of these ecological metrics and assessment protocols will aid in the characterization of site-specific biotic components and in the identification of the form and severity of potential impacts, and thus strengthen the environmental documentation and decision-making under CERCLA and NEPA.

ACKNOWLEDGEMENTS

Work supported by the U.S. Department of Energy, Assistant Secretary for Nuclear Energy, under Contract W-31-109-Eng-38.

Table 1. Threatened, endangered, or special concern species reported from St. Charles County, Missouri, and potentially occurring in the SFMP Weldon Spring site area.

Species	Status	
	Federal ^a	State ^b
<u>Plants</u>		
Starwort (variety)	C2	Endangered
Forbes saxifrage	C3	Watch List
Rose turtlehead	C3	Endangered
Arrow arum	-	Rare
Star Duckweed	-	Rare
<u>Fish</u>		
Pallid sturgeon	C2	Endangered
Pugnose minnow	-	Endangered
Sturgeon chub	C2	Rare
Sicklefin chub	C2	Rare
Alligator gar	-	Rare
Brown bullhead	-	Rare
Alabama shad	-	Rare
Starhead topminnow	-	Watch list
Western sand darter	-	Watch list
<u>Reptiles and Amphibians</u>		
Western fox snake	-	Endangered
Eastern massasauga rattlesnake	-	Endangered
Western smooth green snake	-	Endangered
Wood frog	-	Rare
Northern crawfish frog	-	Watch list
<u>Birds</u>		
Bald eagle	Endangered	Endangered
Perigrine falcon	Endangered	Endangered
Least tern	C2	Endangered
Cooper's hawk	-	Endangered
Northern harrier	-	Endangered
Sharp-shinned hawk	-	Endangered
Osprey	-	Endangered
Barn owl	-	Endangered
Double-crested cormorant	-	Endangered

Table 1 (Continued)

Species	Status	
	Federal ^a	State ^b
<u>Birds (continued)</u>		
Snowy egret	-	Endangered
Bachman's sparrow	-	Endangered
American bittern	-	Rare
Yellow-headed blackbird	-	Rare
Red-shouldered hawk	-	Rare
Black-crowned night heron	-	Rare
Little blue heron	-	Rare
Mississippi kite	-	Rare
Upland sandpiper	-	Rare
Henslow's sparrow	-	Rare
Sedge wren	-	Watch list
<u>Mammals</u>		
Long-tailed weasel	-	Rare

a C2 = federal candidate for listing as a threatened or endangered species.

C3 = former federal candidate species.

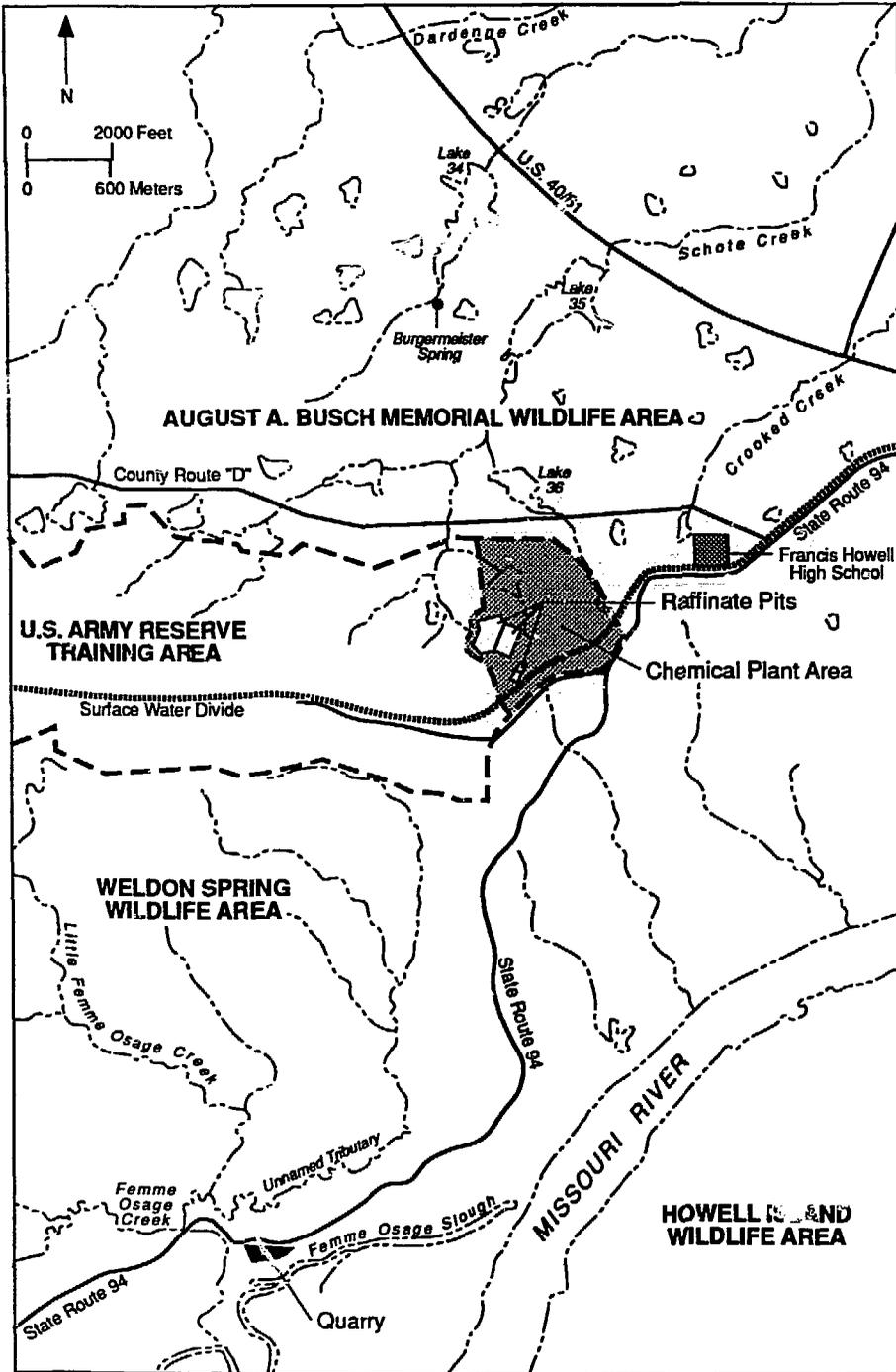
b Special concern species include those classified by the state as rare or on the watch list.

Watch list = species of possible concern for which the MDOC is seeking further information; this listing does not imply that these species are imperiled.

Undetermined = possibly rare or endangered but insufficient information is available to determine the proper status.

Sources: Dickneite 1988; Gaines 1988

Figure 1. Location of the SFMP Weldon Spring site and the Weldon Spring, August A. Busch Memorial, and Howell Island wildlife areas, St. Charles County, MO.



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