

AD-784 793

ENVIRONMENTAL EFFECTS OF HARD PAN I
TEST SERIES

Richard Rowland, et al

Air Force Weapons Laboratory

Prepared for:

Defense Nuclear Agency
Space and Missile Systems Organization

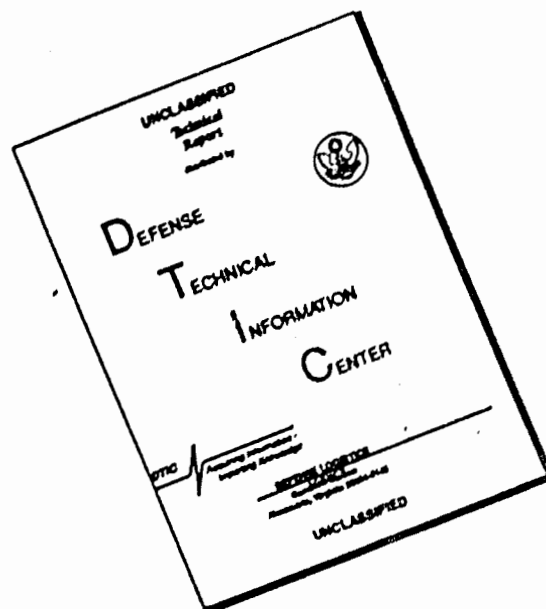
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFWL-TR-74-202	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD 784 793
4. TITLE (and Subtitle) ENVIRONMENTAL EFFECTS OF HARD PAN I TEST SERIES		5. TYPE OF REPORT & PERIOD COVERED Final Report April through June 1974
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) K. E. Gould, R. H. Rowland, Capt R. C. Wooten, Lt J. W. Sigler, and Sgt D. E. Compton		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Weapons Laboratory (DEV) Kirtland Air Force Base, New Mexico 87117		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element 62710H Project 133B
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Nuclear Agency Washington, DC 20305		12. REPORT DATE July 1974
		13. NUMBER OF PAGES 158
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Space and Missile Systems Organization PO Box 92960, WNPC Los Angeles, California 90009		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Environmental effects Explosive field testing Ecological assessment		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study investigates the environmental effects of the proposed administrative action named HARD PAN I, a Department of Defense series of high-explosive field tests (events) to simulate the shock effects of nuclear weapons on scaled Minuteman launch facilities in a specific geology. The proposed test site is a rural area of Linn County in east-central Kansas, approximately 62 miles south of Kansas City. It is planned to begin construction in July 1974 and to execute the three events in September 1974, November 1974, (over)		

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and June 1975. There should be no significant adverse impact on the natural or socioeconomic environment due to the construction, operations, and execution of the proposed tests. There will be the normal dust, noise, traffic, etc., associated with a construction project, but there are few houses in the area. Procedures will be initiated to ensure that construction efforts constitute no hazard to the environment outside the immediate work area. The project should be beneficial to the economy of the area. The project should be beneficial to the economy of the area. The local populace will be well informed of the project and will be invited to witness the three events. Alternatives to the proposed action include conducting the project at a different site, reducing the size of the project, and cancelling the project. None of these is acceptable.

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PREFACE

This report was initiated to investigate the environmental effects of the Space and Missile Systems Organization/Air Force Weapons Laboratory (SAMSO/AFWL) Structure-Medium Interaction Field Test Program. The DASIAC Group, GE-TEMPO, under a Defense Nuclear Agency contract, performed the general environmental study. The Air Force Weapons Laboratory Environics Branch contributed in-depth information on the ecology of the Linn County, Kansas, area. The AFWL effort is included as an appendix to the DASIAC work.

The following individuals prepared the general study by DASIAC: Richard Rowland, James Doran, Kenneth Gould, Evelyn Harner, and Howard Hawthorne. The AFWL ecological reconnaissance was performed by Captain Rutherford Wooten, Lt John Sigler, and Sgt Dennis Compton.

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SECTION 1

PROJECT DESCRIPTION

INTRODUCTION

The proposed program, HARD PAN I, is planned as a series of three high-explosive field tests (events) to evaluate the response of one-quarter and one-half scale Minuteman launch facilities subjected to the simulated nuclear weapon effects of airblast and ground shock induced by a traveling airblast wave. The ground shock in rock propagates faster than ("outruns") the airblast wave. The geology/structure relationship is representative of the majority of the Minuteman launch facilities near Whiteman Air Force Base (AFB), i. e., clay over hard interbedded shale and limestone.

HARD PAN I will be conducted by the Air Force Weapons Laboratory (AFWL) as part of the Structure-Media Interaction (SMI) program, supported by the Space and Missile Systems Organization (SAMSO).

The proposed simulation techniques are known as HEST (airblast simulation) and BLEST (ground shock simulation). The proposed test site is on private property in a rural area of east-central Kansas, in the vicinity of Whiteman AFB.

Construction is planned to begin in July 1974. The first event is scheduled for September 1974, and will be a HEST test on a quarter-scale launch facility. The second event is an environment demonstration test scheduled for November 1974, and will be a combined HEST/BLEST test on a quarter-scale launch facility. The third event is scheduled for July 1975, and will be a combined HEST/BLEST test on a half-scale launch facility. The first two events are in support of the larger third event which will consist of 11.45 tons of penta-erythryte tetranitrate (PETN) explosive in detonating cord for the HEST portion, and 250 tons of ammonium nitrate/fuel oil (AN/FO) or ammonium nitrate gel (AN Gel) explosive for the BLEST portion. The total test bed area for this third event is a 600-foot by 800-foot ellipse.

The project will be described to the public through news releases, public briefings at local and higher levels, and by direct contacts with nearby residents. The public will be invited to view the test events from a safe distance.

BACKGROUND AND NEED FOR THE PROGRAM

SAMSO/Minuteman has the obligation, responsibility, and authority to ensure that it maintains its leadership in nuclear weapon effects technology and that the weapon system maintains its capability as a valid deterrent in the face of any possible future threat. The technology base for weapon system refinement and development is extremely dynamic and occurs at ever increasing levels of sophistication. The purpose of the Structure-Media Interaction (SMI) Program is to determine phenomenology to levels of detail and accuracy not before attainable. To optimally respond to changes in future threats, it is necessary to possess the highest capability and expertise possible in order to provide accurate definitions of Minuteman hardness, when required. Such definitions may ultimately be used in cost-effectiveness studies, modernization designs, or hardness assessments, as directed.

The HARD PAN program is a proposed series of high-explosive field tests on scaled Minuteman launch facilities in soil over rock geologies, designed to evaluate airblast and ground shock induced by the traveling airblast wave with emphasis on the "outrunning" ground shock effects of a simulated close-in nuclear explosion. Most of Minuteman launch and launch-control facilities near Whiteman AFB are constructed in a geology consisting of a relatively thin layer of clay over hard interbedded layers of shale and limestone. HARD PAN I will evaluate the phenomenological effects of nuclear-burst-generated airblast and ground shock on facilities in this type of geology. HARD PAN II is a conceptual future action to evaluate facilities in a different geology which is typical of other Minuteman Wings.

In the HARD PAN I geology, a close-in nuclear explosion would induce a ground shock into the rock strata which would propagate faster than ("outrun") the traveling airblast wave. A Minuteman launch facility in such a geology would be subjected to this "outrunning" ground shock in the lower portion of the launch facility coupled with the airblast wave passing over the ground surface.

Estimating survivability of a launch facility in such a geological and nuclear environment requires extensive theoretical and experimental programs directed toward expanding the level of knowledge in the main areas of uncertainty.

In addition to the system technical objectives of the program, the possibility exists to provide unique information for the Minuteman Wing near Whiteman AFB which may impact the extent to which design modifications are required in that wing in the near future. The possible resulting changes to design modifications may provide cost savings of millions of dollars.

CONSTRUCTION AND OPERATIONS

This subsection describes the construction and operations to prepare the test beds, conduct the tests, and restore the test area. Descriptions of the proposed test site and the surrounding area and the predicted phenomena resulting from the actual explosions are contained in subsequent subsections.

Portions of the HARD PAN I test series are still in the planning stage and some of the details of Event 3 depend upon the results obtained in Events 1 and 2, so complete details are not available and some of the decisions made by the project planners may be subject to change. These potential changes are not believed to represent a major change from the test details described here, however, nor would they represent a departure from the phenomena expected or the conclusions reached. Figure 1 shows a plan view of the test site and proposed configuration.

Schedules and Manpower

Preparation of the test site is scheduled to begin on 1 July 1974. (Preliminary geologic studies which are pertinent to site selection and definition, such as test borings and seismic surveys, have been completed or are in progress.) Preparation of the test bed for the first event, a HEST test, is estimated to require 3 to 4 months, and the event is scheduled for September 1974. Preparation of the test bed for the second event, a HEST/BLEST test, is estimated to require 4 to 5 months and the test bed can be constructed concurrently with the test bed for the first event. The second event is scheduled for November 1974. Preparation of the test bed for the third event, a HEST/BLEST test, is estimated to require 5 to 6 months, and some construction details may depend on the results from the first two events. This third event is scheduled for execution by July 1975, so

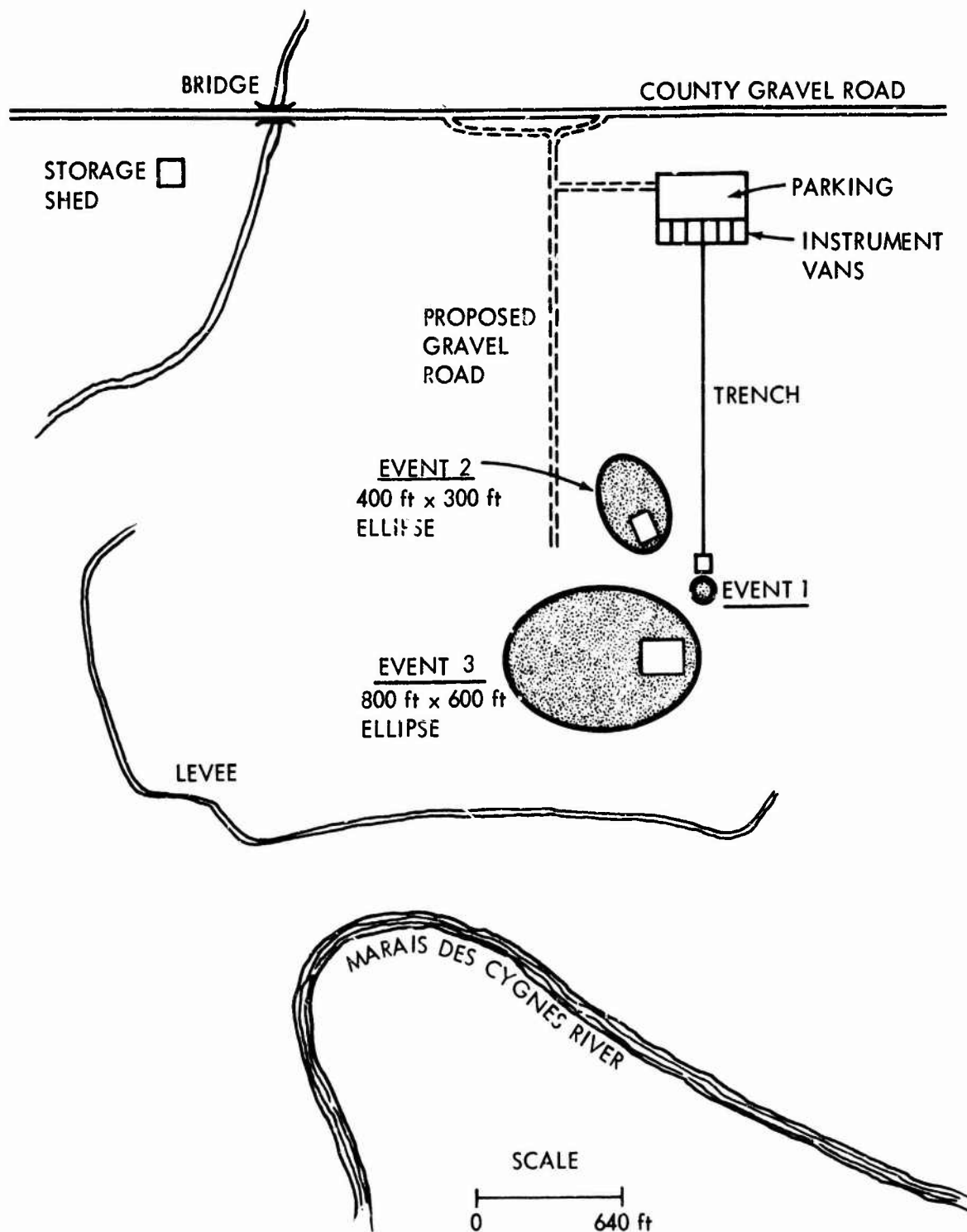


Figure 1. Plan view of test site and proposed construction.

construction must begin about September 1974 to allow for a possible work exclusion period from late November to early April, due to severe weather conditions. These approximate schedules are shown in Figure 2.

Support operations such as providing site access, setting up instrumentation vans and support vans, preparing the explosives, installing instrumentation cables and sensors, and protecting these facilities from the explosions will have to be largely completed in time for the first event.

Manpower schedules are not yet available but, based on previous field test experience, approximately twenty-five construction workers furnished by a local contractor and perhaps fifteen AFWL personnel will be required (on the average) throughout the project.

Test Bed Construction

The test bed for Event 1 will be a 100-foot diameter circle (hence its name DISC HEST). The test beds for Events 2 and 3 will be rectangular HEST beds surrounded by elliptical BLEST beds. The floor of all the HEST beds may be up to 3 feet below existing ground level. All three HEST cavities will be 3 feet high and will be covered with 4 feet of earth (surcharge). An earthen berm will surround the surcharge, sloping from the top of the surcharge to the natural grade at a 1:2 slope. Plan and section views of the test beds are shown in Figures 3, 4, and 5.

Construction of each test bed will entail the following operations (the magnitude of the construction is indicated in Table 1):

1. Remove the top ten inches (average) of topsoil from the HEST areas and stockpile for restoration of the area following execution of the events.
2. Level each HEST bed by excavating to three feet (or less) below original ground level, and stockpile this soil for use as surcharge.
3. Excavate in the bottom of the HEST beds and construct the scaled Minuteman launch facility.
4. Dig trenches in the floor of the HEST bed, and install and cover instrumentation and cables.
5. Level and compact the floor of the HEST cavity.

1974					1975							
July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
					Possible							
					Work							
					Exclusion							
		*			Period							
					due to							
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Figure 2. Approximate schedule for conducting HARD PAN I Test Series.

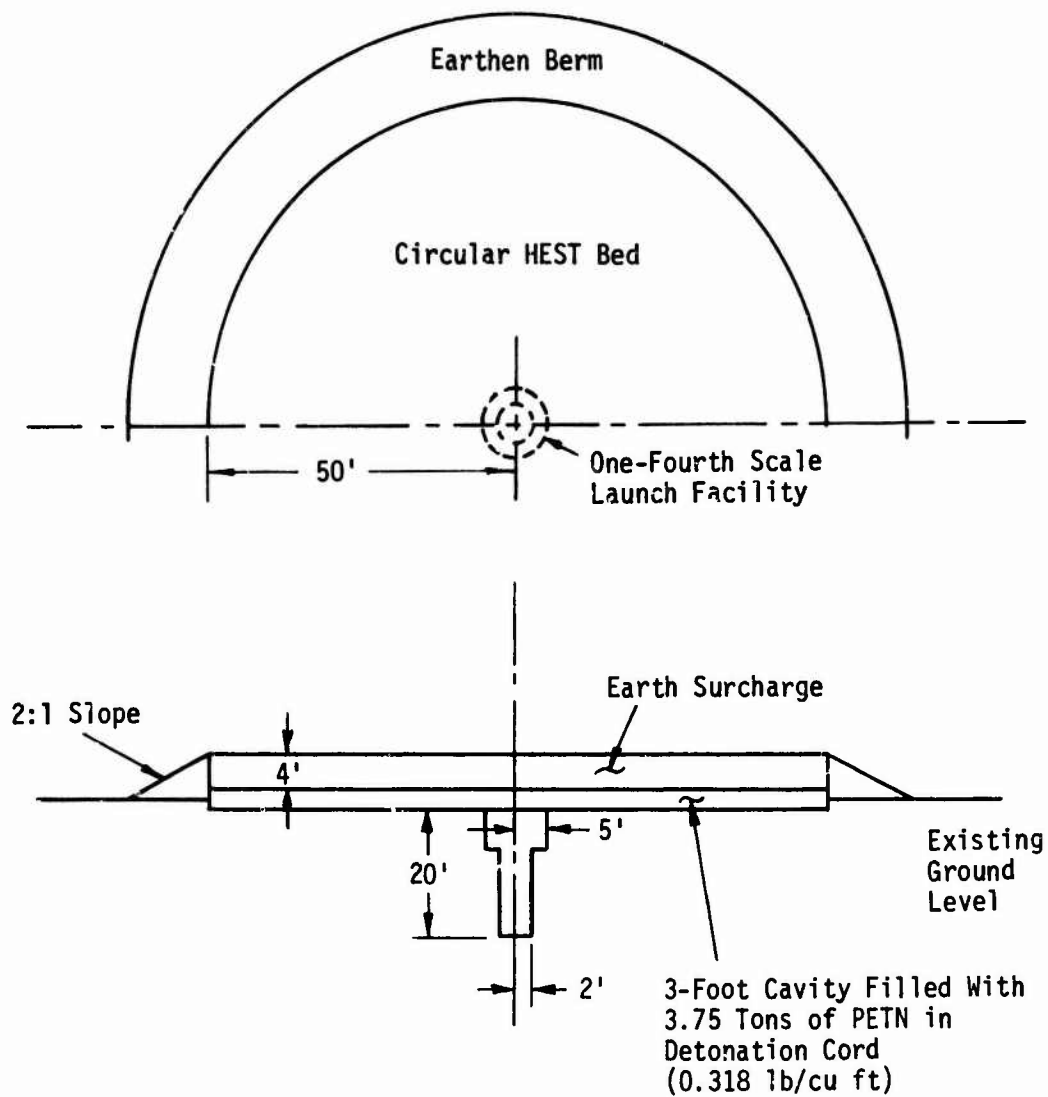


Figure 3. Plan and section view of Event 1 (DISC HEST)

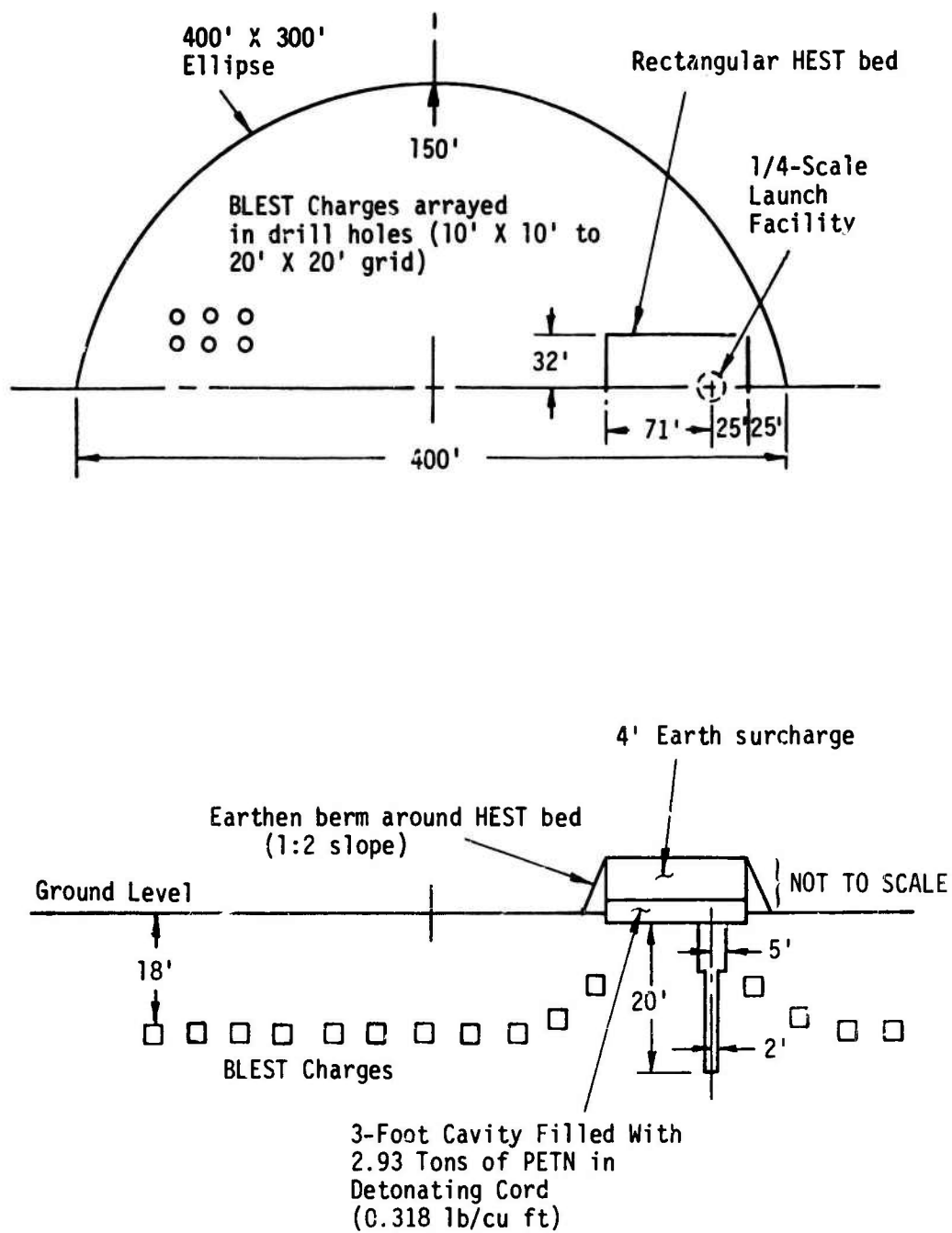


Figure 4. Plan and section view of Event 2 (HEST/BLEST)

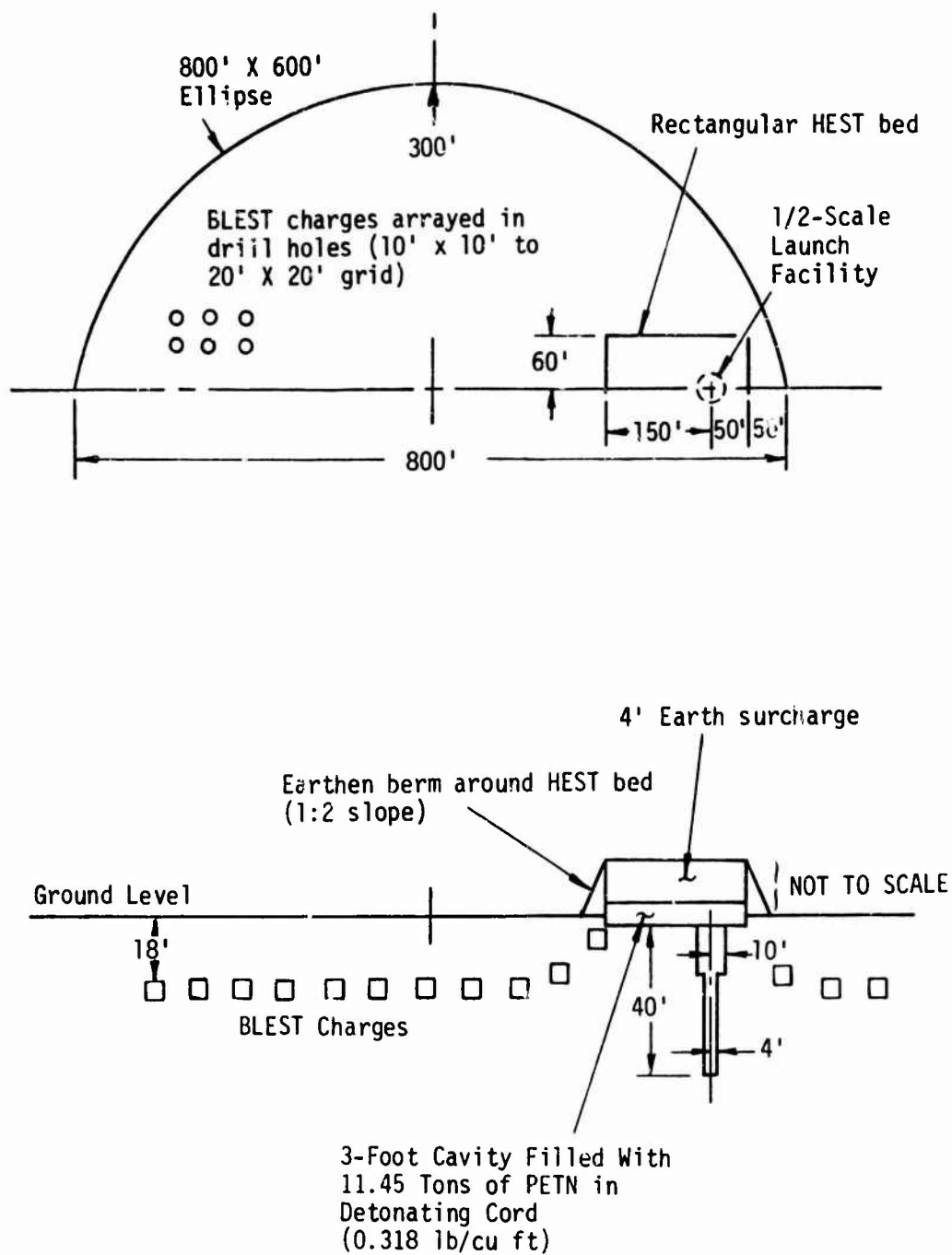


Figure 5. Plan and section view of Event 3 (HEST/BLEST)

Table 1. Magnitude of construction tasks to prepare test beds.

	EVENT 1	EVENT 2	EVENT 3
HEST TEST BED			
Dimensions (ft)	100 dia circle	64 x 96 rectangle	120 x 200 rectangle
Area (ft ²)	7,854	6,144	24,000
Topsoil removed (yd ³)	242	189	752
Cavity excavation (yd ³) (including topsoil)	≤ 873	≤ 675	≤ 2,667
Size of scaled Minute- man launch facility (ft)	10 (dia.) x 6 cylinder atop 4 (dia.) x 14 cylinder		20 (dia.) x 12 cylinder atop 8 (dia.) x 28 cylinder
Amount of detonating cord (ft)	131,200	102,000	400,000
Amount of PETN explosive (tons at 0.318 lb/ft ³)	3.75	2.93	11.45
Depth of surcharge (ft)	4	4	4
Amount of surcharge (yd ³)	1,163	890	3,555
Amount of berm (yd ³)	~ 570	~ 590	~ 1,161
BLEST TEST BED			
Dimensions (ft)		300 x 400 ellipse	600 x 800 ellipse
Area (ft ²)		94,000	377,000
Topsoil removed (yd ³)		2,900	11,600
Number of explosive drill holes		235 to 940	942 to 3,770
Depth of earth over- burden above explosives (ft)		18	18
Total amount of AN type explosive (tons)		62.5	250

6. Install wood footings for HEST cavity ceiling supports.
7. Install wooden columns for ceiling supports.
8. Install racks of detonating cord in the 3-foot high HEST cavity.
9. Install wooden roof beams and ceiling for HEST cavity.
10. Using soil excavated from HEST cavity, cover the HEST cavity with four feet of compacted earth (surcharge) surrounded by an earthen berm. "Borrow" soil from other test beds and other areas as needed.

Tasks to prepare the BLEST portions of the tests are:

1. Remove the upper ten inches (average) of topsoil from the BLEST and nearby surrounding areas and stockpile for restoration of the area following execution of the events.
2. Drill required number of holes for placement of BLEST explosive charges.*
3. Install explosive charge in each drill hole approximately 18 feet below ground level.*
4. Install detonators and cables.
5. Backfill and tamp all drill holes.

Instrumentation cables to the instrumentation vans will be installed in protective trenches and detonating wires will be connected to the explosive array to complete the operation.

Construction of Support Facilities

A number of other facilities in addition to the test beds will be required to support the entire operation.

*The exact number, spacing, size, and explosive content of the drill holes for the BLEST array are not yet specified. A total of 500 to 1000 holes with less than one ton of explosive in any one hole will be specified.

It is planned to construct about 2400 feet of 15-foot-wide gravel road to provide access to the test beds from the existing gravel road north of the test site. A graveled parking area will also be constructed near the support area with direct access to the road. These features are shown in Figure 1.

Approximately 2000 feet of electric power lines will be brought into the support and test bed areas from the existing lines on the north boundary of the test area. Some utility poles will have to be installed. Tree trimming will not be required.

Pipes, to bring water for construction, will be laid from the river south of the test beds. Existing wells will be used for drinking water. Numerous holes will be drilled for geological purposes.

Six instrumented vans will be brought in to record the results of the test. A roofed shelter with earthen berm will be constructed to protect these vans from possible debris from the explosions. Four support vans will also be brought into the area; these will not require shelter.

Trenches will be excavated for instrumentation and other cables. Approximately 1000 to 2000 feet of 2-foot-wide by 1-foot-deep, and 3000 to 4000 feet of 1-foot-wide by 2- to 8-foot-deep cable trenches will be required. After installation of cables the trenches will be backfilled.

Portable sheds for explosives will be provided on-site. A work area for preparing the HEST explosive will be required. Explosives safety regulations will be followed.

Other miscellaneous features to be constructed include camera towers, barbed-wire fencing and gates, chemical toilets, materials and equipment storage areas, lightning protection systems, flood-lights, and loudspeakers in the public viewing area.

About ten inches of topsoil will be stockpiled from digging and earth moving operations to be used to restore the area at completion of the tests.

Explosives

Approximately 633,200 feet of detonating cord filled with 400 grains of PETN explosive per foot (18.13 tons total) will be used in

the HEST portions of the test. This detonating cord will be wound on wooden racks at the test site and the completed racks will fill the 3-foot-high HEST cavity.

The angle at which the detonating cord is wound determines the velocity of the airblast wave and the "density" of the explosive (lb/ft^3 of HEST cavity) and the amount and characteristics of the surcharge determines the magnitude and shape of the airblast pulse, as illustrated in Figure 6.

The explosive used for the BLEST portions of the events will either be ammonium nitrate and fuel oil (AN/FO) or an ammonium nitrate gel (AN Gel), i. e., IREGEL 616 or IREGEL 676 manufactured by Ireco Chemicals, Salt Lake City, Utah. IREGEL 616 has approximately 85 percent of the explosive power of AN/FO while IREGEL 676 contains aluminum powder and is approximately equal to the explosive power of AN/FO. The desired amount of IREGEL can be poured into each drill hole to set up into a gel which is not affected by moisture as is AN/FO. Detonators and detonating wire are installed and drill holes backfilled with 18 feet of well-tamped earth.

Two-hundred fifty tons of explosive are to be used in the BLEST portion of the third event, and 62.5 tons are to be used in the second event.

The BLEST charges will be arrayed in lines perpendicular to the length of the HEST test bed. During test execution, the lines will be detonated in a series (starting with the line farthest from the test object) and in such a manner that the ground shock wave is reinforced and shaped to simulate the desired nuclear-weapon-induced ground shock wave at the scaled Minuteman launch facility.

Use of Facilities and Resources of Area

The construction workers will be furnished by a local contractor and will be from the local area. The AFWL personnel will be housed in motels and apartments in the area. Local businesses will be used for supplies and maintenance to the maximum extent possible.

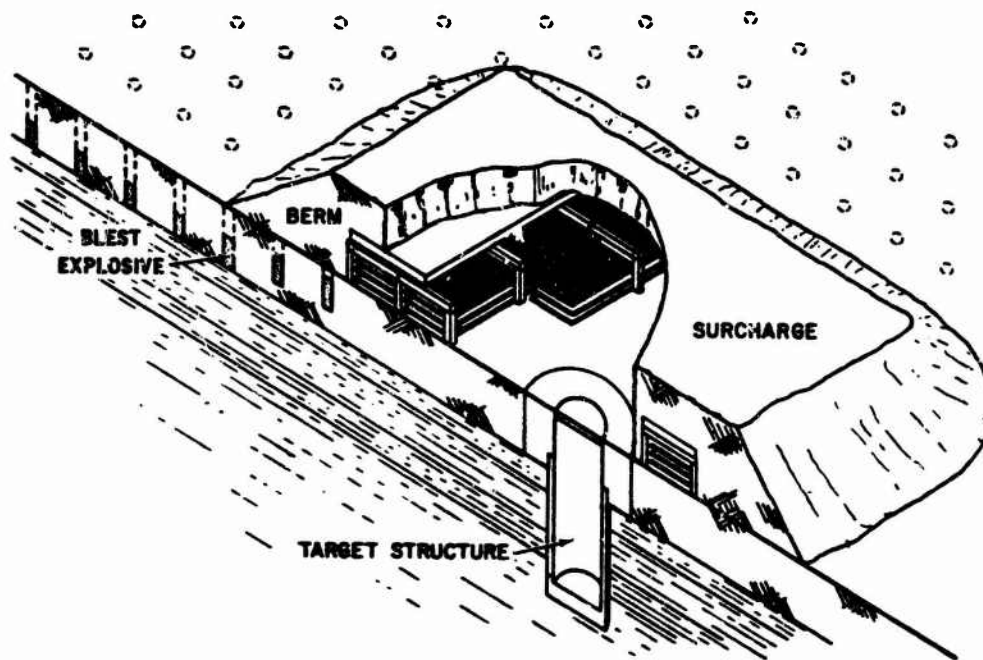


Figure 6a HEST/BLEST configuration.

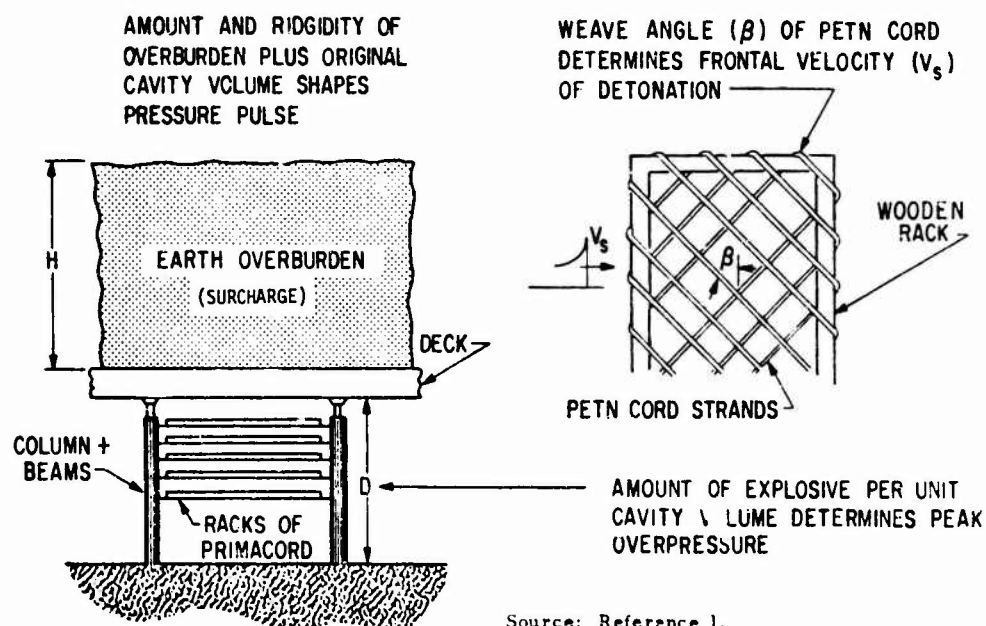


Figure 6b. HEST explosive installation and characteristics.

transit-mixed concrete will be used as opposed to building a concrete batch plant. Well water will be used for drinking on site. Construction water will be obtained either from the river located south of the test beds, or the pond southeast of the site. The amount of construction water used will not affect the level of the larger pond or the river.

Restoration of Area

The area will be restored to as near its current condition as is reasonably possible. All construction will be dismantled and removed, and the test beds will be cleared of structural debris. Excavations will be filled with surcharge and berm soil. The stockpiled topsoil will be put back in place and the previously grassed area will be reseeded in fescue. Utility lines and poles and trenched cables will be removed.

Portions of the fences and access roads will remain at the discretion of the property owner.

SITE DESCRIPTION

This site description is based primarily on observations made during a field trip in mid-May, 1974.

The proposed site for the HARD PAN I test series is on private property leased by the Air Force in a rural area of east-central Kansas near the Missouri border. The land is essentially flat with scattered woods and marshes.

Population centers are small and scattered. The climate has extremes of moderately harsh winters and hot humid summers. A variety of wild life exists in the nearby wooded areas. The major industry is farming. Winter wheat, grain sorghum and corn are the major crops. Much of the surrounding land is planted to perennial fescue as pasture for beef cattle. The test site is representative of the local area. The east portion is pasture, the west portion is wheat, and the south (between the dike and the river) is now native vegetation including a few trees. This area may have been farmed in the past.

A secondary local industry is timber cutting. A small portable sawmill supports a clear cut timber operation about 1-1/2 miles to

the southeast of the site. Most of the residents derive their income from farming and farm-related enterprises; however, the nearest village, Trading Post, caters both to travelers along highway U.S. 69 and to hunters and fishermen. A few residents are employed at the coal strip-mine operation 7 miles to the north. Presumably local people are employed at the nearby Marais des Cygnes Game and Waterfowl area and at the power plant, also 7 miles to the north.

Location and Relative Position of Significant Features

The proposed HARD PAN I test site is located at geographic coordinates 38°15' N latitude and 94°39' W longitude in east-central Kansas (62 miles south of Kansas City and 2 miles west of the Missouri border) in the southwest quarter of Section 3, T 21 S, R 25 E, Linn County, Kansas. The site location is shown in Figure 7.

Trading Post (population 50) is slightly over 1 mile west of the test site. The next nearest community is Pleasanton, the largest town in Linn County, with a population of 1098, approximately 5 miles SSW of the test site. Fort Scott, with a population of 8967, is 27 miles south of the test site.

Figure 8 is an aerial photograph of the test area and vicinity with some of the significant features noted.

The test area consists of cultivated fields and pastures bounded on the north by a county gravel road leading to Trading Post. Primary electric power lines on the north side of the road deadend at an abandoned farm building west of the test site. A telephone line is buried along the south side of the road. The road crosses a small metal and concrete bridge near the northwest corner of the test site area.

The test site is bounded on the west and south by a flood control levee. The top of the levee, near the middle of the test area, is about 15 feet above the pasture to the north and the floodplain to the south. The floodplain is (in May) about 20 feet above the level of the river. The levee ends on the western part of the test area where the general land elevation approaches the height of the levee.

Along the north side of the levee, in line with the middle of the test area, is a small stock pond. A somewhat larger manmade pond with a dike along its western edge is located about 1/2 mile to the southeast.

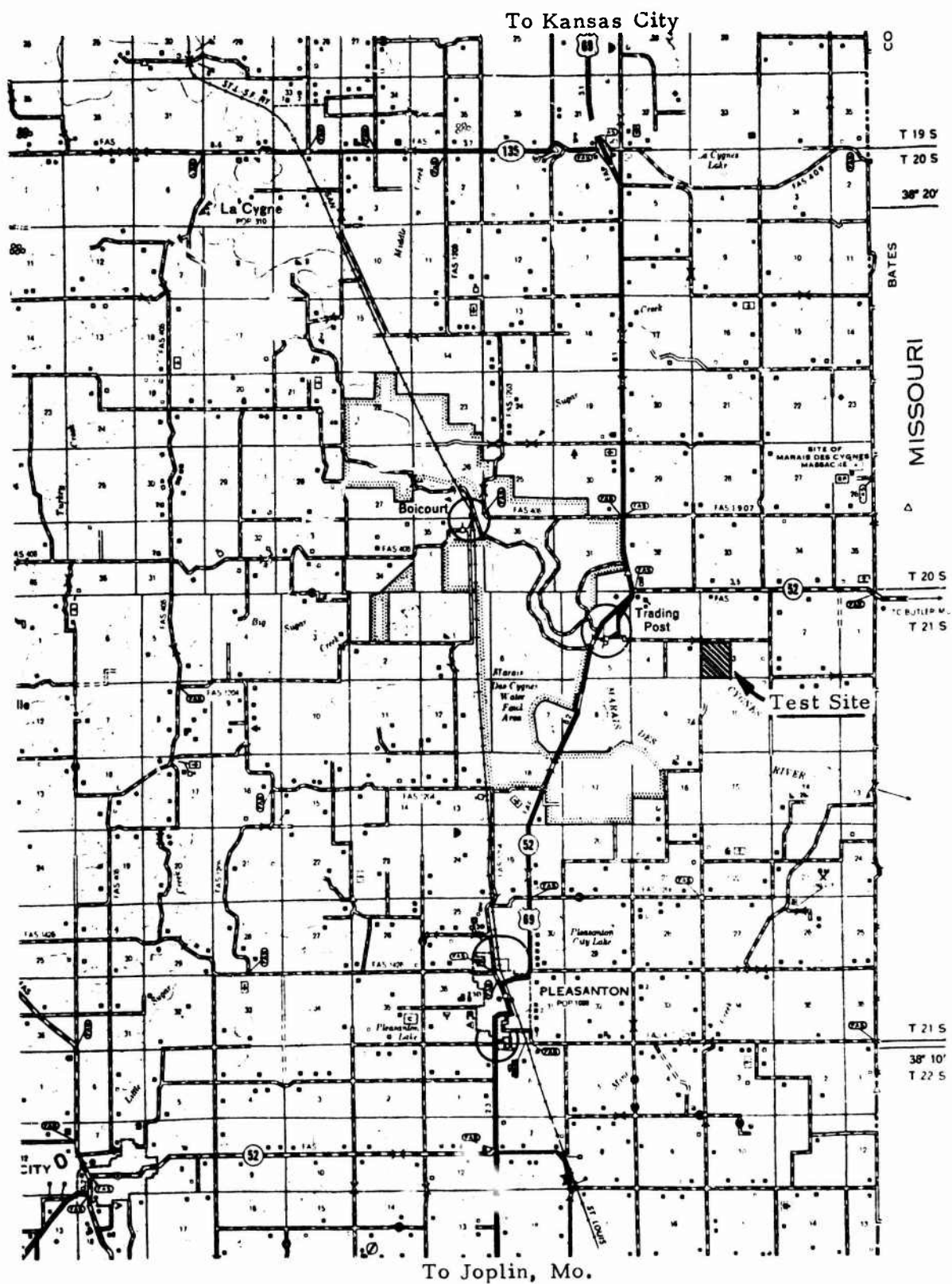


Figure 7. Map of test site area (1/2 inch = 1 mile)

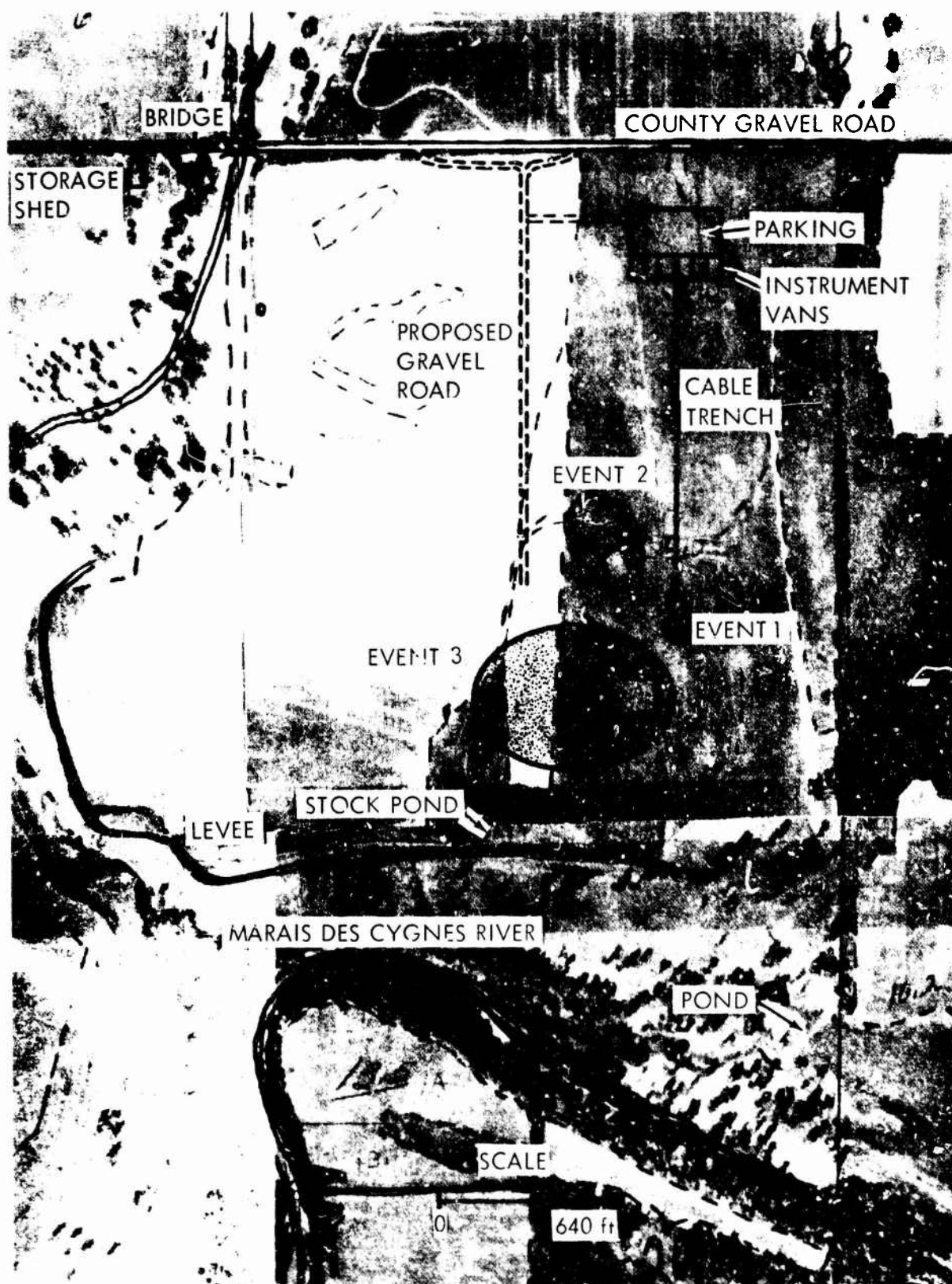


Figure 8. Aerial photograph of test site area.

Between the levee and the Marais des Cygnes River is an area with native vegetation.

The levee on the south border will be close to the test bed for Event 3. Beyond the levee to the west a small stream runs south through scattered trees to the Marais des Cygnes River. This moderate-sized rather muddy river runs east near the south border of the test site. Table 2 shows monthly water heights in the river near the site for 1971 through May 1974. The banks of the river are steep and heavily wooded. The Marais des Cygnes River drains the Marais des Cygnes Water Fowl Area, a managed game area which is slightly over one mile from the test site area. (No water fowl were observed during the field trip to the test site.) A hedgerow of trees abuts the east boundary of the test site.

There are few dwellings near the test site. The nearest inhabited dwellings, three farm houses and a mobile home, are approximately 1 mile from the test beds. A few abandoned buildings, in very poor condition but apparently used for occasional storage, are approximately 1/2 to 1 mile from the test site.

Table 2. Water heights of the Marais des Cygnes River near Trading Post, Kansas

Month	Height, feet			
	1971	1972	1973	1974
January	24.57	11.44	17.25	31.13
February	19.50	3.55	23.58	11.85
March	19.15	3.00	28.42	24.85
April	2.80	4.20	27.62	15.80
May	4.85	23.10	27.27	20.80
June	9.20	3.35	18.10	
July	10.65	4.00	17.45	
August	4.95	3.45	3.90	
September	2.73	2.95	28.25	
October	5.05	2.45	30.80	
November	2.60	6.27	20.55	
December	23.80	5.27	21.43	
Note: Flood Height = 24 feet.				

Figure 9 shows distances from the proposed location of the half-scale Minuteman launch facility, which is the test object for the largest explosive test.

Table 3 summarizes the man-made facilities and natural features as a function of distance from the half-scale launch facility.

Topography and Geology

The test area is quite flat with elevations varying from approximately 780 to 797 feet.

Exposed bedrock of the test area and environs consists of cyclothem formations of the Pennsylvania Period, Desmoinesian series, Cherokee group, Cabaniss subgroup, composed predominantly of shale and sandstone with several workable coal beds. The nearby area is geologically of the Marmaton group, with predominant limestone units and containing several coal beds. The entire Pennsylvania Period sedimentary strata dips gently westward.

The test area is commonly referred to as unglaciated claypan prairie and prairie sandstone. County soil maps indicate that the soil is light clay and claypan at the test site with silty and clayey soils along the streams and rivers.

Meteorology

Based on 1971 climatological records, temperatures in nearby Kansas cities varied from a high of about 100 degrees to a low of -6 to -20, with an average annual temperature of approximately 55 degrees. Daytime relative humidity averaged about 60 percent. Winds were generally from the northwest. There were about 80 to 90 days of rain (0.01 inches or more) with about 50 days of thunderstorms. There were about 30 inches of rain and 30 inches of snow. Table 4 lists the monthly rainfall records since 1971.

Strong winds and tornadoes are not uncommon.

Land and Water Use

The western portion of the test site is currently planted in winter wheat by a tenant farmer. The eastern portion is a seeded hay meadow. Active pasture land borders the test site area. Farms are scattered and many

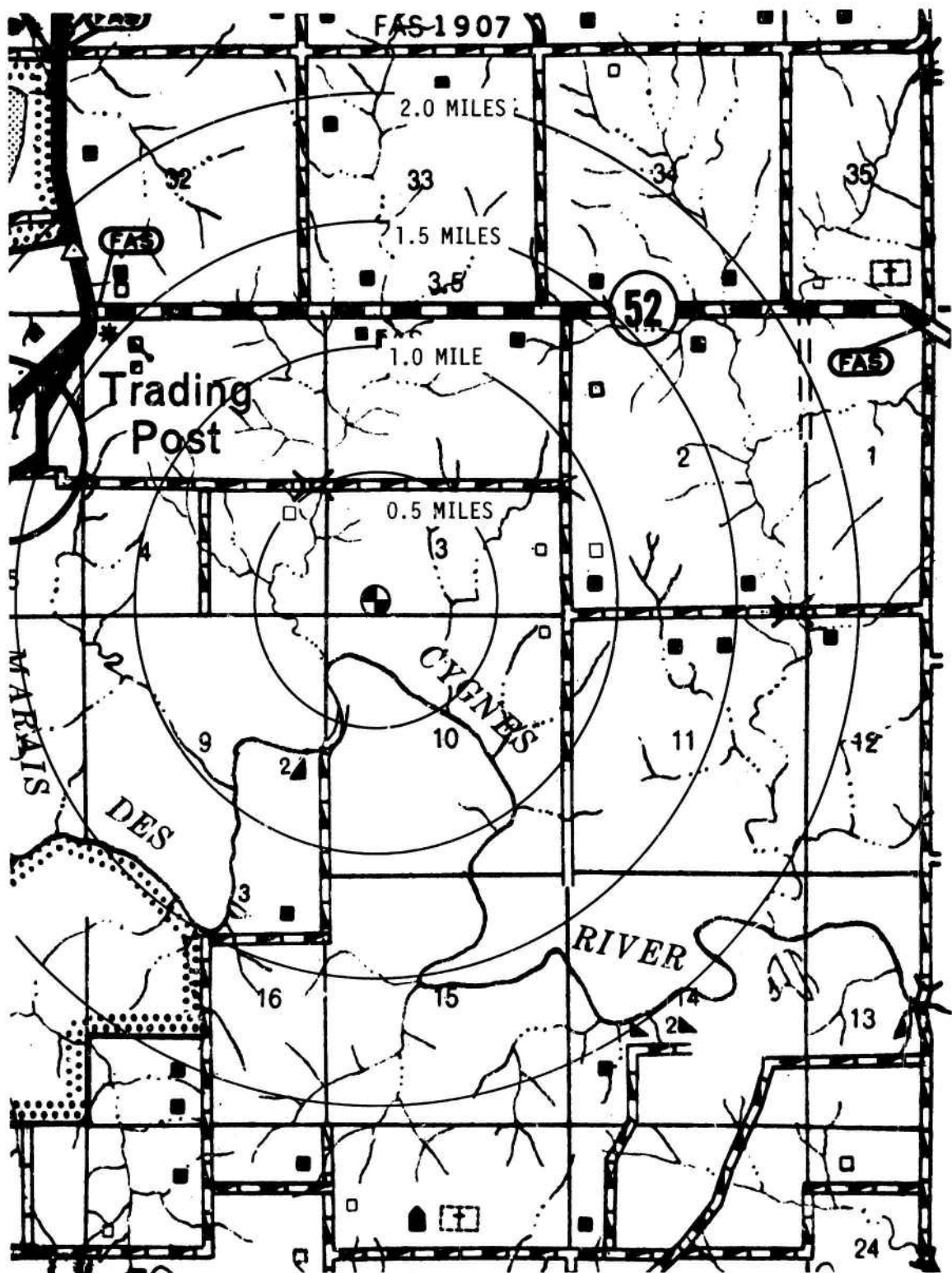


Figure 9. Distances measured from test object of Event 52.

Table 3. Distances of facilities and natural features from the half-scale Minuteman launch facility.

Distance	Facilities and Natural Features
Within 0.5 mile	Gravel road ^a Electric power lines ^a Underground telephone cable ^a Levee Marais des Cygnes River ^a Manmade pond Stock pond Streams, trees ^a
0.5 to 1 mile	1 farmhouse ^b 1 mobile home 1 small bridge Livestock loading pen Abandoned farm buildings used for storage. ^a
1 to 1.5 miles	Village of Trading Post (population 50) 9 other dwellings Edge of Marais des Cygnes Waterfowl Area
1.5 to 2 miles	Village of Trading Post and other dwellings State Highway 69 and roadside businesses Lake
Notes: ^a These also occur in all greater range bands. ^b Occupied dwellings are indicated by small solid squares in Figure 9 (some may now be abandoned).	

farm houses have been abandoned. The test site will be leased from the Pittsburg and Midway Mining Company, which also owns much of the surrounding area and plans to mine it for coal at some future date.

The river and lake areas are used for recreation (hunting and fishing) and watering livestock. Drinking water in the dwellings nearest the site is from wells. The nearest well, and associated underground cistern, is located at an abandoned house site 1/2 mile northwest of the test area. This location is marked "storage shed" on Figure 8. The nearest well known to be in recent use is at an abandoned house 1 mile to the east of the site. This well is 62 feet deep with a water level of 22 feet (Reference 2). The nearest well in active use is slightly over a mile distant. It is 53 feet deep with water at 15 feet. Reference 2 concludes that the water flow in the Pennsylvania

Table 4. Rainfall near Trading Post, Kansas (inches).

Month	Year			
	1971	1972	1973	1974
January	2.50	0.40	4.73	1.42
February	2.00	1.27	1.41	2.13
March	0.48	2.54	13.30	5.60
April	1.66	3.00	9.12	3.30
May	3.61	2.72	4.58	3.72
June	4.88	0.60	4.90	
July	7.20	5.77	5.05	
August	0.17	5.31	0.65	
September	4.35	5.74	15.38	
October	4.50	2.81	4.95	
November	1.50	4.04	3.49	
December	4.93	1.60	11.73	

formation is very small, about 1 gal per day. Below about 100 feet it is too mineralized for use. Most of the town of Trading Post uses "rural water" piped in from a reservoir at La Cygne to the north although a few families still use well water. The town of Pleasanton maintains a reservoir (Pleasanton City Lake) for domestic water about 3-1/2 miles south of the test area.

Biology

Two ecological factors were considered for this assessment.* First, whether the site is unique in the sense that it affords a habitat for plants and animals that is unavailable elsewhere, and second, whether any rare, threatened or endangered species are dependent on the site for part of their life cycle. During the May 1974 visit the site was determined to be not unique, but representative of the surrounding area. A literature survey based on material found in Biological Abstracts failed to locate specific references to the use of the site environs by any vulnerable species. An exception might be the

*The AFWL has performed a separate ecological reconnaissance. The results of this study are given in Appendix B.

Peregrine Falcon, an endangered species, which is known to be in eastern Kansas in the fall and winter.

During the site visit few animals were observed near the test areas, but small game and deer are apparently abundant in the wooded areas. Waterfowl are also apparently abundant at certain times of the year. The nearby wildlife areas are not sanctuaries, but are managed for hunting and fishing for those species not protected by State law. The following is a summary of Kansas hunting regulations.

Species	Hunting Season
Rabbit	All year - no limit
Coyote	All year - no limit
Birds ^a	Generally mid- November through December (rails September to November)
Deer	2 1-month periods, October and December
Raccoon, Fox, other fur ^a	October through February
Note: ^a Owls and Hawks, Muskrat, Mink, Swift fox, Weasel, Beaver, Ferret and Otter are protected.	

Other Characteristics

Little information was available regarding the population and economy of the area, except that the population is sparse, with agriculture and related activities the major industry.

Recreational resources, other than hunting and fishing, appear to be scarce.

The National Register of Historic Places (1972) lists the Marais des Cygnes Massacre Site as the only registered historical site in Linn County. However, Reference 3 also lists the Battle of Mine Creek Site. The massacre site, named for an incident dating to the pre-Civil War Free-State Slave-State controversy between Kansas and Missouri and located about 3-1/4 miles north of the test site, is now a large well-kept picnic area and state park. An early building, housing a museum, is preserved there. The building, constructed

of local stone in the 1860s or 1870s, was restored in 1962 and is in excellent condition. The Battle of Mine Creek Site, location of the largest Civil War Battle in Kansas, is on privately owned land 2 miles south of Pleasanton. No trenches or earthworks are located at the Mine Creek Site.

A literature search was conducted to determine if any archaeological sites existed near the test area. The Abstracts in Anthropology indicated that the periodical Plains Anthropologist is the best source of anthropological/archaeological articles for Kansas. No specific reference could be found for Linn County. The majority of the active work is being conducted in central Kansas. Search of older literature (Miscellaneous Collections of the Smithsonian and Collections of the Minnesota Historical Society) confirm that most archaeological sites are found in central Kansas. There appears to be a low probability of occurrence of a site in the test area.

The literature search was followed by contact with the U. S. Department of Interior Office of Archaeology and Historic Preservation. Mr. Thomas Witty, chief archaeologist for the Kansas State Historical Society, was suggested by them as the authority on Kansas archaeology. Mr. Witty stated that there was no controlled archaeological site in the test area, and that there was low potential for a significant find. The nearest excavations were conducted about 7 miles north of the test area at the power plant cooling area, La Cygnes Lake, prior to its construction. In the event that archaeological or historic relics are uncovered during construction, the Kansas State Historical Society will be contacted for guidance.

EXPLOSIONS PHENOMENA

This subsection describes the physical phenomena expected to result from the test detonations. The environmental impact of these phenomena is assessed in Section 2.

The physical phenomena considered here include: airblast, anomalous blast propagation and noise; ground shock; cratering and ejecta; dust rise and transport; and explosive detonation products. The numerical values cited in this subsection are not necessarily self-consistent; that is, all may not refer to the same test parameters. This is because at the time of preparation of this assessment some of the explosive placement parameters were not completely defined. For example, the charge size in individual BLEST holes could range from about 1/4-ton to 1 ton, the grid spacing could be 10 to 20 feet, or the BLEST explosive could be AN/FO or AN Gel. For each phenomenon considered, values of variable parameters which maximized the phenomenon being discussed were used (unless stated otherwise); thus this assessment represents a worst-case analysis.

Airblast

Overpressure

Figure 10 shows the predicted maximum peak overpressures as a function of distance for the three tests. These are empirical predictions based on yield scaling from previous HEST tests. The depth of burial of the BLEST charges will greatly attenuate the airblast from them, thus the major contributor to the predicted peak pressure will be the HEST detonation. The sequential detonation of the BLEST charges will modify the front face of the blast wave by causing a rise time to peak pressure of 40 to 45 msec rather than the instantaneous rise seen in most blast waves. Figure 11 shows a predicted pressure pulse from the largest test at about the range of the manmade pond to the southeast of the test area. The actual pressure field may not be symmetrical around the test area due to the non-symmetrical placement of the explosives. This relationship should have no effect on the assessment of damage since we consider the peak, or highest overpressure at any range.

The explosives used may also make a small difference in observed overpressure. AN Gel has been reported to produce an overpressure about 3 to 5 percent lower than that produced by AN/FO under similar

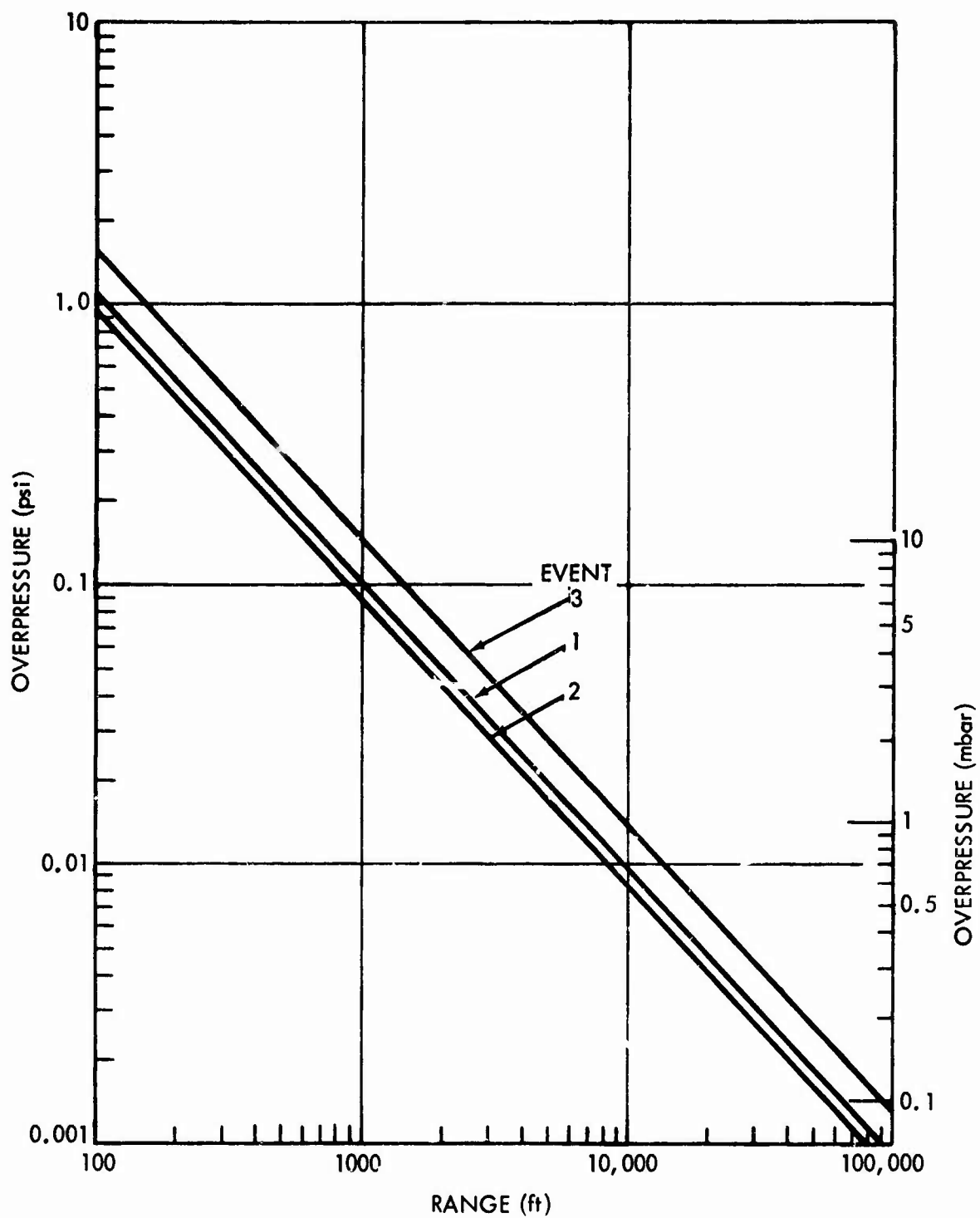


Figure 10. Predicted HARDPAN maximum overpressures.

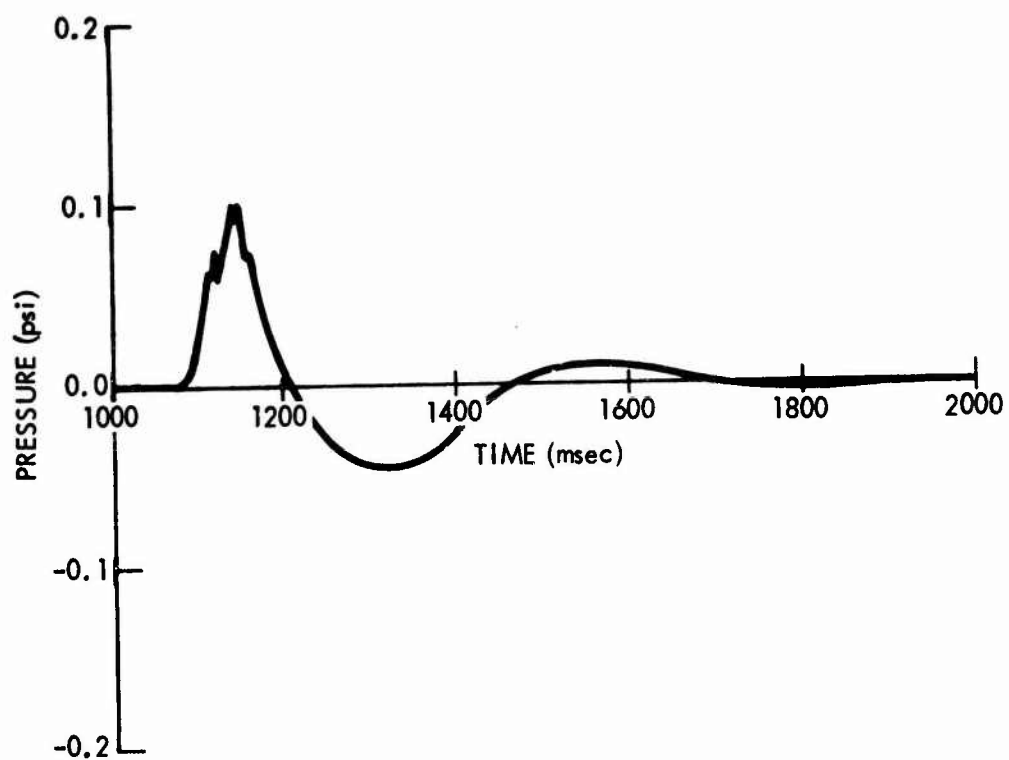


Figure 11. Event 3 far-field pressure prediction (1500 ft range).

burst conditions (Reference 4). The data, however, show great variation and it is not clear if this is a scalable relationship. Evidently the AN/FO vents while still burning, thus coupling more energy into the airblast wave. However, since the major contribution to airblast is HEST. This phenomenon is not significant.

Anomalous Propagation

Local atmospheric conditions can modify the blast wave. Overpressures upwind from the test could be reduced 5 percent. Strong temperature gradients or inversions can influence even relatively close-in pressures. The overpressure is reduced by atmospheric temperature decrease with altitude, while an inversion may slightly increase the pressure.

The major effect of atmospheric conditions concerns long-range propagation. Atmospheric refraction and winds aloft may create conditions which bend or focus blast-ray paths either toward or away from the earth. This has the effect of either enhancing or decreasing blast amplitudes when related to homogeneous atmospheric propagation. Reed (Reference 5) presents a method to calculate these effects as a function of local ambient conditions at the time of the test event. Enhancements as great as a factor of 3 or 4 have been measured in past tests. This could extend the threshold of window breakage to three or four miles. Monitoring of local conditions will be required to provide final estimates of anomalous propagation.

Noise

Noise, as a nuisance factor, is more subjective than objective. The sudden "bangs" associated with an explosion are more irritating than are semisustained high-level sounds which can be more physically damaging. The fright associated with sudden noise adds to its undesirability. Unfortunately most work on noise has been done with a relatively continuous source as opposed to the impulsive-type noise produced by a blast.

The physical or acoustical measurement of noise involves understanding of three characteristics: intensity, frequency, and duration. The intensity is relative to the overpressure, and decibels (dB) are dimensionless units used to describe the sound level. Figure 12 from Reference 6 shows the sound level of a blast wave in relation to its overpressure.

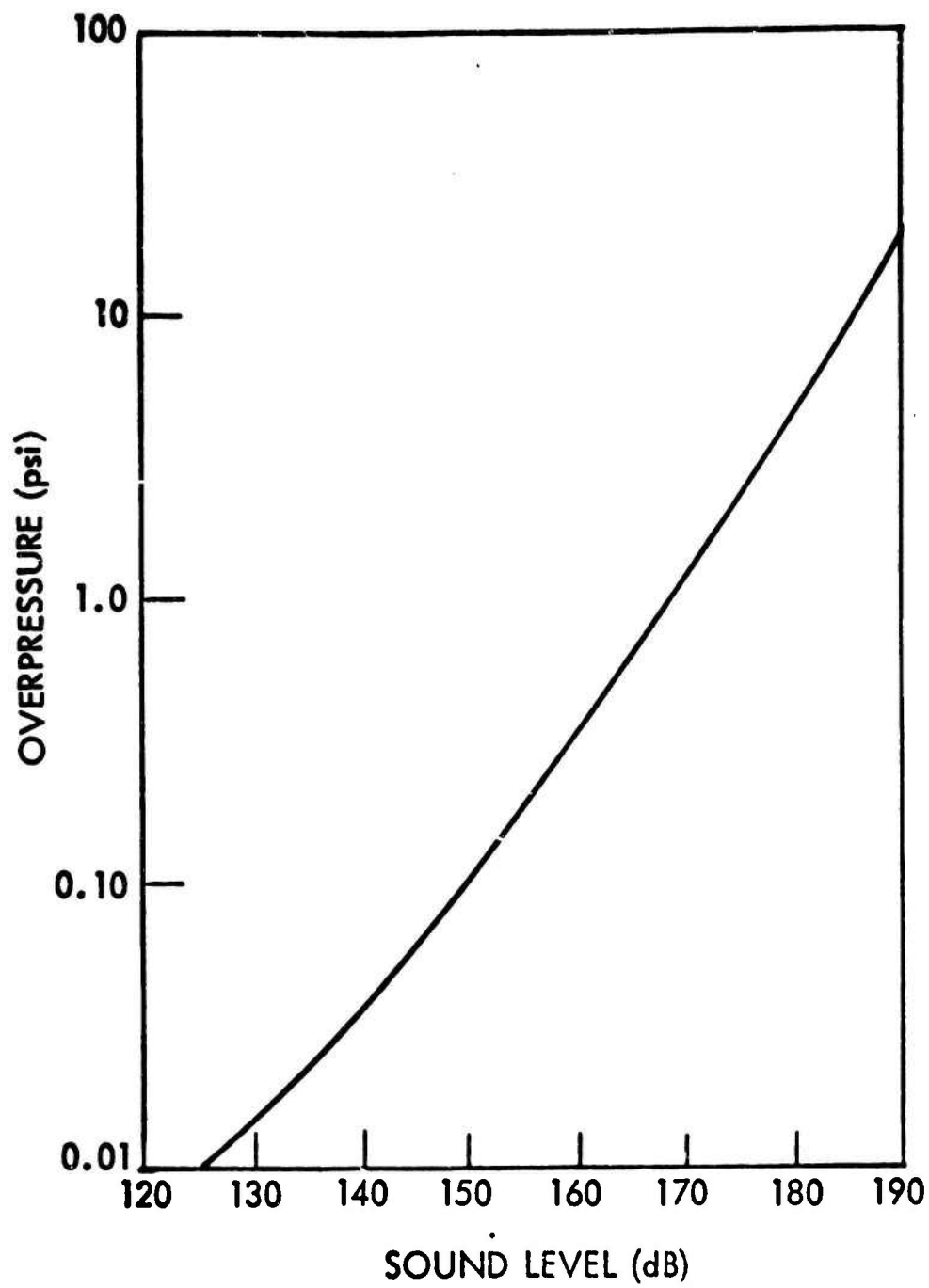


Figure 12. Sound level in a blast wave.

The frequency spectrum for a 100-lb surface charge produces maximum sound wave frequencies from 100 to 500 hertz (Hz) (Reference 7). The energy concentration of larger charges, and buried charges, is displaced toward the low end as explosive yield increases.

Ground Shock

The predicted ground motions generated by the three events are shown in Figure 13. The theory behind the projected maximum motions is that there is some array of row charges in which earth pressure waves merge and reinforce each other causing the source to appear higher in yield. The local geology attenuates the amplitude of the seismic waves. This attenuation is due to internal friction and to the geometric spreading of the seismic pulse radiated outward from the detonation. The actual seismic pulse may not be as large as indicated. The BLEST charges are sequenced to produce maximum reinforcement and movement at the test structures. Shock waves arriving from different directions may not reinforce each other as the seismic signal propagates from the test bed.

Cratering and Ejecta

Neither the DISC HEST nor the HEST portions of the other two tests will produce a crater. No typical parabolic crater will be formed by the BLEST portion of the tests; but rather a large undulating area of broken soil and rock. The first row of charges* detonated in the moist clay soil will produce a linear furrow approximately 50 to 60 feet longer than the length of the row of charges about 60 feet wide and 12 to 15 feet deep (Reference 8). The existence of bedrock close to the surface will probably make the initial furrow somewhat shallower and broader.

The ejecta from each succeeding sequenced-row detonation will tend to fill the last furrow produced since the ejecta, except that produced by the outermost charges, cannot leave the test bed except as a dust cloud. Actually, the second row of charges is detonated while the ejecta from the first row has started its upward trajectory, but the final result will be the same. The BLEST should produce a disturbed area somewhat larger (but with the same shape) than the original test bed, with alternate transverse furrows and mounds 2 to 4 feet

*The size of each BLEST charge has not been determined; in this description it is assumed each charge is 1-ton.

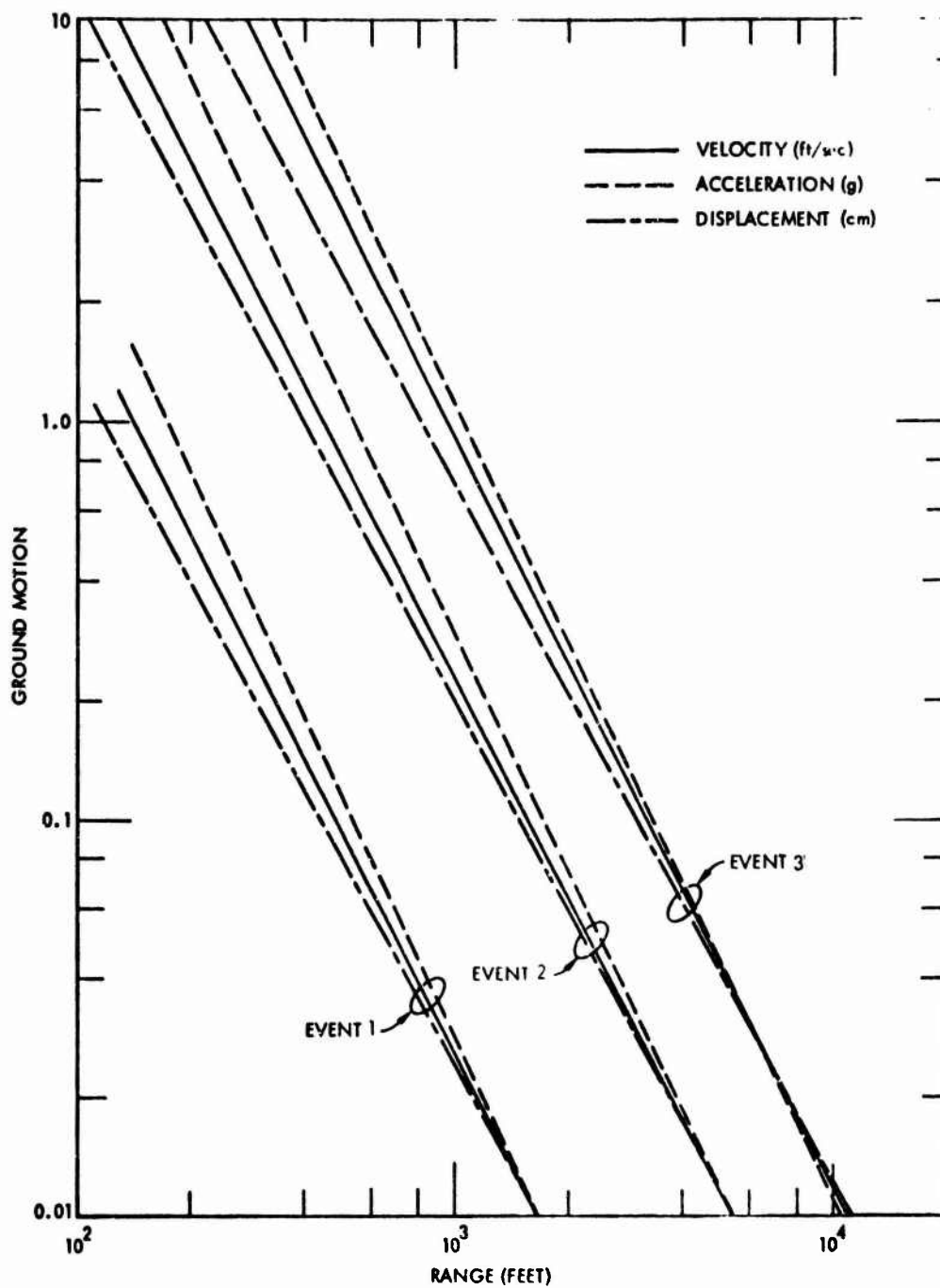


Figure 13. Predicted surface seismic motions.
(Predictions based on total impulse.)

high. The test bed will be encircled by a lip of rubble approximately 4 feet high. The area of continuous ejecta will extend 80 feet beyond the test bed in all directions (and somewhat farther downwind).

The ejecta from the HEST detonations will form a cross-like pattern (except Event 1, the DISC HEST event, which will produce a circular pattern) with the greatest ejecta amount and greatest distances found at right angles to the sides of the HEST test bed. The ejecta field will be elongated in the direction of the wind. For Event 1 continuous ejecta will be cut to about 900 feet and the maximum range of missiles (2-3 inches in diameter) will be 1400 feet. For Event 2 the continuous ejecta ranges from about 400 feet, at the cross intersection to about 1300 feet. The ejecta of the largest test will range from 500 to 1450 feet.

Generally, ejecta particle size will decrease with range; however some discrepancies may occur. Maximum missile range for a single event would range from 1500 feet for a HEST charge to 910 feet for an 18-foot depth of burst 1-ton BLEST (Reference 9). There should be no enhancement of these ranges due to multiple charges.

Dust Rise and Transport

The explosion-produced dust cloud will be composed of two parts: a low, flat base surge produced by dust left behind by the lofted ejecta, and a more or less spherical main explosion cloud produced by dust raised aloft by the vortex action of the venting explosion gases. Based on empirical scaling from data presented in Reference 10, the maximum credible cloud size for the largest test, prior to wind transport, will be:

Base surge:	980 x 780 x 75 feet high
Stem:	500-foot radius, 200 feet high
Main Cloud:	1000 x 800 x 450 feet

The cloud top should rise approximately 500 to 650 feet.

The surface winds will move the cloud and the individual dust particles will fall at speeds proportional to their diameter. If it is assumed that 1 pound of explosive lofts 1 pound of dust into the air* (Reference 11), then the initial dust loading, or concentration, of the

*This lofting figure includes both dust and ejecta and is probably an order of magnitude high for dust alone.

cloud will be about 17.5 g/m^3 at the time of maximum growth, when it starts to be transported by the winds. The size distribution of the particles in the cloud is the same as the size distribution of the earth over the charge. The parameters of the dust in the cloud are:

SIZE (μ)	ASSUMED SOIL SIZE DISTRIBUTION	CLOUD LOADING (gm/m^3)	FALL RATE (ft/min.)
	(%)		
10-20	20	5.51	1
20-50	40	7.02	9
50-200	30	5.26	60
200-500	6	1.05	400
500-1000	4	.70	700

Using these data, Figure 14 was constructed showing cloud dust density as a function of time assuming no process other than mechanical particle fall diffused and diluted the dust cloud.

The data from Figure 14 is used in Table 5 which shows the dust concentration at various downwind distances for four wind speeds. The values shown represent the maximum credible concentrations. Real wind fields will dilute the dust-air mixture by diffusion and shear so that the actual concentration should be much lower. *

Table 5. Dust concentration of non-diffusive cloud for various distances and wind speeds.

WIND SPEED (knots)	DUST CONCENTRATION (g/m^3)			
	Distance Downwind, in miles			
	1/2	1	2	5
1	6	3.5	2.5	1.5
3	10	8.0	5.0	2.4
5	12	9.0	7.2	3.6
10	14	12.0	9.0	6.0

*The only dust concentration measurement in an explosion cloud was made after a 500-ton surface burst (Reference 12). At 20-minutes after the burst measured maximum concentrations were 0.01 g/m^3 , the average concentration was 0.003 g/m^3 .

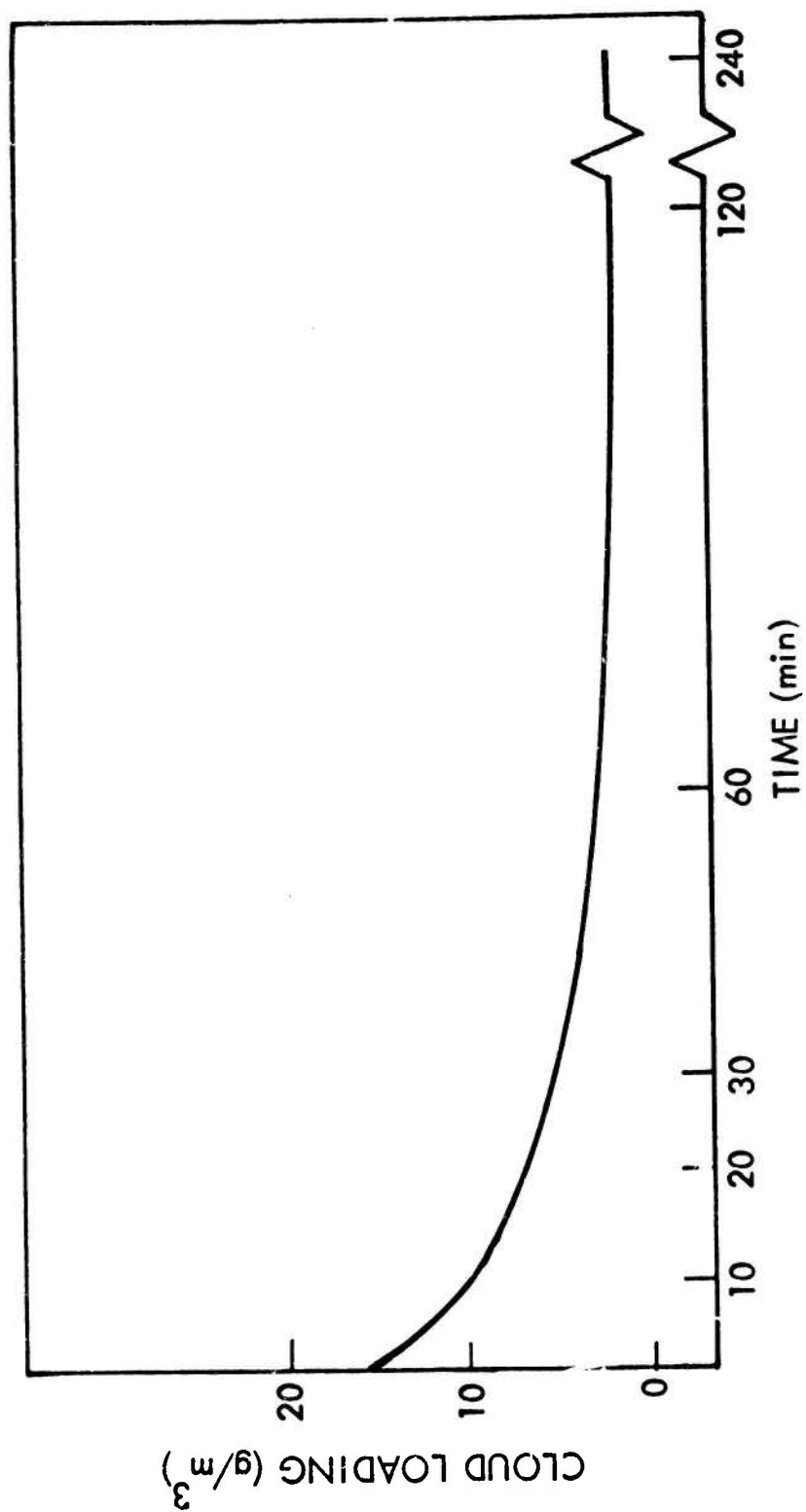


Figure 14. Explosion cloud dust concentration.

Detonation Products

Detonation products will be produced from combustion of the explosives when the events are executed. Table 6 shows the products which are expected to result from the combustion of the PETN and AN Gel explosives. The products of AN/FO are similar to those from AN Gel. Intermediate products will not survive the thermal energy of the explosion.

The PETN products shown are based on experimental observations by Ornellas, et al (Reference 13). Other PETN products, and different proportions of the products shown in Table 6 are reported by Cook (Reference 14) and others, but are based on theoretical analysis or experiments using small explosive charges where the thermal energy in the fireball is much lower than that which will result from the HEST explosions.

Table 7 is based on the percentages shown in Table 6 and shows the total amounts of detonation products resulting from the execution of each event. All of these detonation products are found naturally to some degree in the atmosphere or the earth's crust.

Table 6. Products of detonation expressed in parts by weight.

	PETN ^a (percent)	AN Gel ^b	
		IREGEL616 (percent)	IREGEL676 (percent)
Water	19.7	~ 60	~ 55
Carbon dioxide	48.7	~ 15	~ 10
Nitrogen	17.7	~ 25	~ 25
Aluminum oxide	-	-	~ 10
Carbon	-	<0.5	<1.0
Sulfur	-	<0.03	<0.03
Carbon monoxide	13.8	-	-
Hydrogen	0.638	-	-
Ammonia	<0.001	-	-
Methane	<0.001	-	-
a) Based on Reference 13.			
b) Source : Reference 15.			

Table 7. Amounts of detonation products (pounds).

	EVENT 1	EVENT 2		EVENT 3	
		HET	BLEST ^a	HET	BLEST ^a
Water	1, 477	1, 152	75, 000 (68, 750)	4, 521	300, 000 (275, 000)
Carbon dioxide	3, 652	2, 846	18, 750 (12, 500)	11, 171	75, 000 (50, 000)
Nitrogen	1, 327	1, 025	31, 250 (31, 250)	4, 062	125, 000 (125, 000)
Aluminum oxide	-	-	- (12, 500)	-	- (50, 000)
Carbon	-	-	<625 (<1, 250)	-	<2, 500 (<5, 000)
Sulfur	-	-	< 38 (<38)	-	<150 (<150)
Carbon Monoxide	1, 035	806	-	3, 167	-
Hydrogen	48	37	-	147	-
Ammonia	<1	<1	-	<1	-
Methane	<1	<1	-	<1	-

a) Amounts shown are for IREGEL 616; numbers in parentheses are for IREGEL 676, the aluminized AN Gel.

The detonation products from the HEST explosions will largely be expelled into the atmosphere. The detonation products from the AN Gel or AN/FO may be expelled into the atmosphere or contained in the ground, depending on the size of each explosive charge in the BLEST array.

SECTION 2

ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

A description of the HARD PAN I construction operations, test site and surrounding area, and predicted explosions phenomena are in the previous section. Based on these descriptions, the probable environmental impact of HARD PAN I, as proposed, on the natural and socio-economic environment is evaluated here.

ENVIRONMENTAL IMPACT OF CONSTRUCTION AND OPERATIONS

No significant environmental impact is expected due to the construction and operations.

There should be negligible impact on wild life. Wild animals will probably vacate the area due to the intrusion of man if they have not already done so due to the activities in the area. Hunting should be only slightly affected since most of the surrounding farmland is posted "no hunting." No significant amount of wild game habitats will be disturbed because the construction is in cultivated fields.

Approximately 160 acres of land will not be usable for farming until the completion of the project. The land will be temporarily disturbed, but the upper ten inches (average) of organically useful soil will be replaced at the completion of the project. The stockpiled topsoil will be protected from erosion with protective covering or fast growing ground cover. Land erosion should not be a great problem since the test site is flat, and the presence of the dike originally designed to keep flood water from the site will also effectively keep erosion-produced silt on the site. The major construction activities will take place with the dike as a buffer to the river. Surcharge and topsoil will be stored on the site where a heavy rain will not introduce this material into the river.

Introduction of the workforce of approximately 25 contractor personnel and 15 AFWL personnel should be beneficial to the socio-economic environment of the area. Some jobs will be created for local workers and local businesses will benefit from the living expenses of workers and the purchase of supplies and materials. Use of resources of the area should not produce scarcities and the facilities of the area should not be overloaded. The amount of river water used for construction will not have any significant environmental impact.

There will be the usual noise, dust, and traffic associated with a construction project, but the nearest inhabited dwellings are one mile away. The short stretches of public gravel roads will suffer from the traffic of heavy vehicles and may require additional maintenance. The dirt road adjoining the site to the north is not a main thoroughfare. At present the major traffic is trucks hauling cut timber. The major East-West road in the area is a paved highway a mile north of the test site. When explosives are on site the dirt road will be closed. This plan has been coordinated with the County Road Department. This closure should pose little inconvenience to the five families living to the east of the site since alternate routes are available.

ENVIRONMENTAL IMPACT OF EXPLOSIONS PHENOMENA

The predictions of the explosions phenomena resulting from execution of the three events are contained in Section 1. Based upon these predictions and upon the site description, also contained in Section 1, the effects of the explosions phenomena on natural and man-made features of the test area can be predicted. A damage assessment can then be made using information on the vulnerabilities of these natural and man-made systems to the phenomena.

The environmental impact of (1) airblast, (2) ground shock, (3) cratering and ejecta, (4) dust, and (5) explosive detonation products are evaluated here. Table 8 summarizes an extensive literature review of threshold levels for damage vulnerability to components of the environment for airblast and ground shock and the distance from the three events at which these threshold levels occur. In the analyses below only the largest detonation (Event 3) is discussed since it represents a worst case. The logic here is that if this worst case proves to be acceptable the lesser cases should also prove individually acceptable. The possibility of cumulative effects is addressed later.

Table 8. Summary of detonation-produced blast and shock environmental damage criteria and the distances at which the criteria are met.

Phenomena	Target	Criteria	Level	Reference	Distance from Event (ft)		
					1	2	3
Airblast	Biota	Eardrum rupture (1% of pop.)	3 psi	6	40	32	51
		Noise - Tinnitus	162 dB	29	260	230	380
		Noise - thunder sound	130 dB	29	6,800	5,800	9,200
		Incipient small mammal damage	2 psi	18	58	49	75
		Tree breakage (10% trees down)	3.5 psi	19	33	27	45
	Structures	Windows - threshold of breakage	.028 psi	26	3,600	3,200	5,000
		Superficial plaster cracks	.06 psi	24	1,700	1,500	2,400
		Wall and plaster cracks	.09 psi	24	1,150	1,000	1,600
		Broken tile and mirrors	0.1 psi	24	1,050	900	1,450
		Broken brick-a-brac	0.15 psi	24	700	600	1,000
Ground Shock	Biota	Door failure (10% probability)	0.4 psi	21	270	230	390
		Roof failure (10% probability)	1.6 psi	21	71	60	95
		Chimney breakage (10% probability)	1.8 psi	21	45	55	85
		"Unpleasant" Perceptible	0.8 in/sec	32	600	1,900	3,900
			.004 in/sec	32	-	-	13 mi.
	Structures	Fine crack threshold	4 in/sec	34, 35	260	825	1,700
		Plaster cracks	6 in/sec	34, 35	210	660	1,380
		Falling plaster, structural weakening	9 in/sec	34, 35	160	500	1,100
		Structural weakening-outbuildings	9 in/sec	34	160	500	1,100
		Trailer - move-off foundation crib	9 in/sec	34	160	500	1,100

Airblast

Section 1 noted that peak overpressure is usually considered the main criterion for blast damage; however, the conditions for detonation for HARD PAN I will not produce a classical blast wave but rather one which exhibits a relatively modest overpressure in relation to its long duration (the same situation as would be found a great distance from a megaton nuclear detonation), and a relatively slow rising pressure pulse. In this vulnerability analysis every effort was made to consider damage data from long duration pulses; however, for convenience the vulnerabilities are listed in terms of peak overpressure. The effects due to overpressure, anomalous propagation and noise are considered separately.

Overpressure

The threshold of lethality for birds in flight is 10 to 30 psi (Reference 16). This pressure level occurs at a distance at which other phenomena predominate. Most studies of overpressure response on mammals (and humans) have been concerned with lethality rather than threshold damage, but it is generally conceded that small mammals such as mice and rabbits are less tolerant to overpressures than are larger ones, like deer or man. One percent mortality could occur at 15 to 20 psi for small mammals and 25 to 35 psi for larger ones (References 17 and 18). The primary credible mechanisms of blast damage to land animals are the indirect effects of missiles (discussed later) and tumbling and subsequent impact. The tumbling threshold (which in turn might produce injury) is about 2 psi for small mammals (Reference 18). This occurs about 72 feet from the Event 3 test bed. Human eardrum rupture threshold is about 3 psi (Reference 6). Broadleaf trees, such as maples and beeches, may be broken at overpressures of 3.5 to 5 psi (Reference 19), although branches will be broken at lesser overpressures.

Only a small portion of the airblast energy is coupled into water. The overpressure at the pond to the southeast is about .09 psi and about 0.1 psi at the river. These overpressures are not harmful to aquatic life (Reference 20).

All of the direct overpressure vulnerability levels listed above occur at distances from the test bed where the major damage mechanism is missiles and ejecta.

Assessment of damage to structures is dependent on the type of construction and the intended use of the structure as well as the overpressure. Figures 15, 16 and 17 (Reference 21) relate the probability of failure to overpressure for three types of structures common to the area. Reference 22 indicates that damage to a two-story wood frame house, like the nearest farm dwelling, subjected to a 1.6 psi overpressure level represented 23 percent of the value of the house. This pressure level would be realized less than 100 feet from the test bed. Assessments of incipient damage levels have been made on past nuclear tests, high-explosive tests, from studies of sonic booms and empirical data derived from accidental explosions. Each of these studies recognizes that minor damage, such as superficial plaster cracking, while possibly unacceptable in a dwelling, would be of little concern to a nondwelling farm structure. Based on these studies (References 23 and 24), the following damage threshold criteria are generally accepted:

Superficial cracks in brittle surfaces	.06 psi
Wall and plaster cracks	.09 psi
Broken tile and mirrors	.10 psi
Broken bric-a-brac	.15 psi

These thresholds do not affect the strength of the primary structure. The same damage is also associated with settling, curing of green lumber and dehydration of cementitious material.

Residential window glass failure occurs at a lower pressure level than any other type of structural failure. An older Bureau of Mines report recommended a "safe" airblast pressure level of 0.5 psi (Reference 25); however this recommendation is based on small charge data. Recent sonic boom studies (Reference 24) verified a rule-of-thumb from nuclear test experience (Reference 23) that the approximate threshold for breakage of pre-stressed window glass was 4 mbar (0.057 psi). The most recent (Reference 26) analysis suggests that 2 mbar be considered as a damage threshold. At this level there is less than one chance in 200,000 of breaking a window (at the 4 mbar level there is one chance in 3000 of breakage). Laboratory tests with shock waves have failed to break glass at levels below 0.145 psi (10 mbars). An analysis (Reference 27) which relates probability of failure to both glass thickness and area, indicates this threshold may be low (Figure 18). The conservative approach would use the 2 mbar criteria. This level occurs about 5000 feet from Event 3.

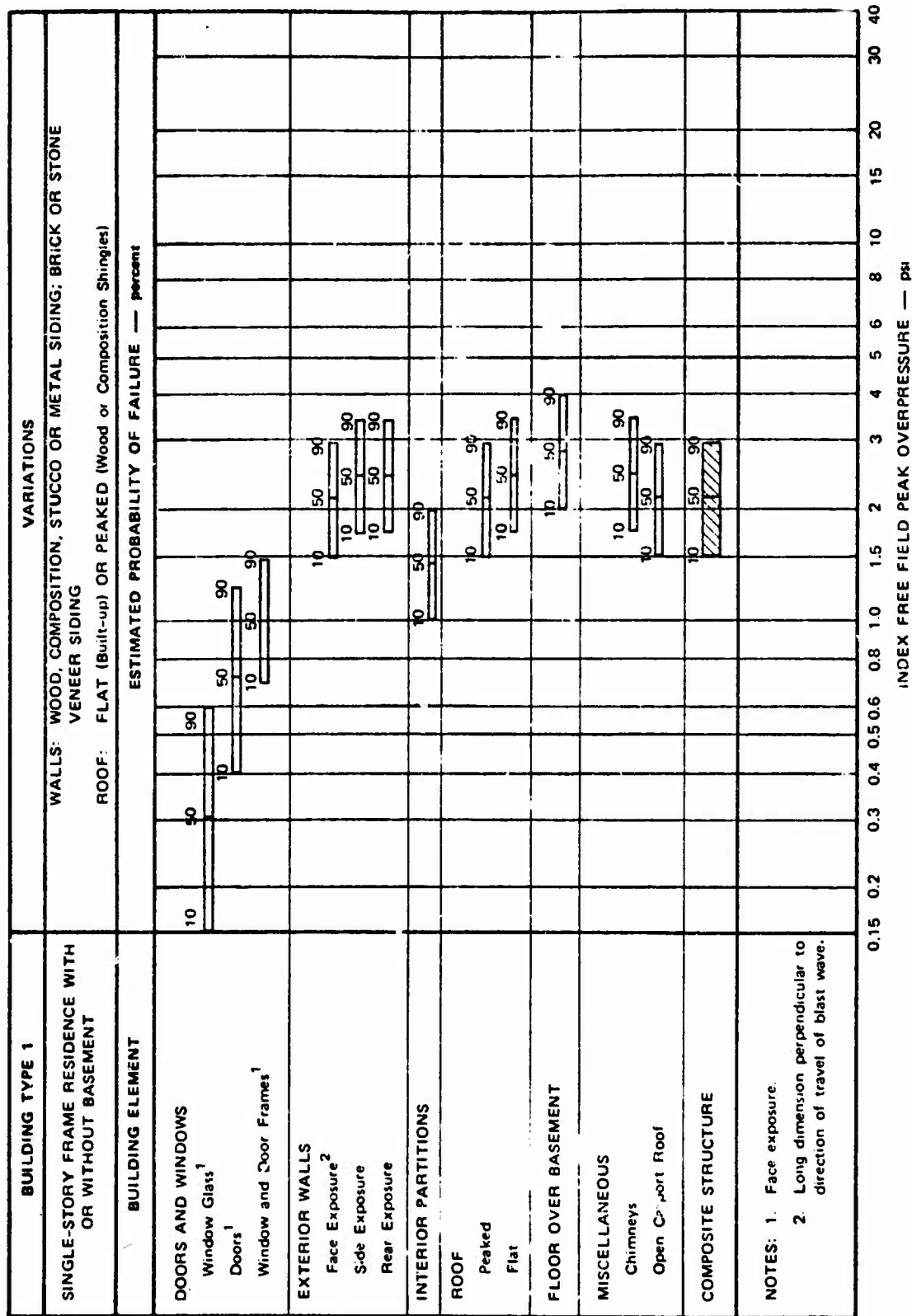


Figure 15. Overpressure effects on a single-story dwelling.

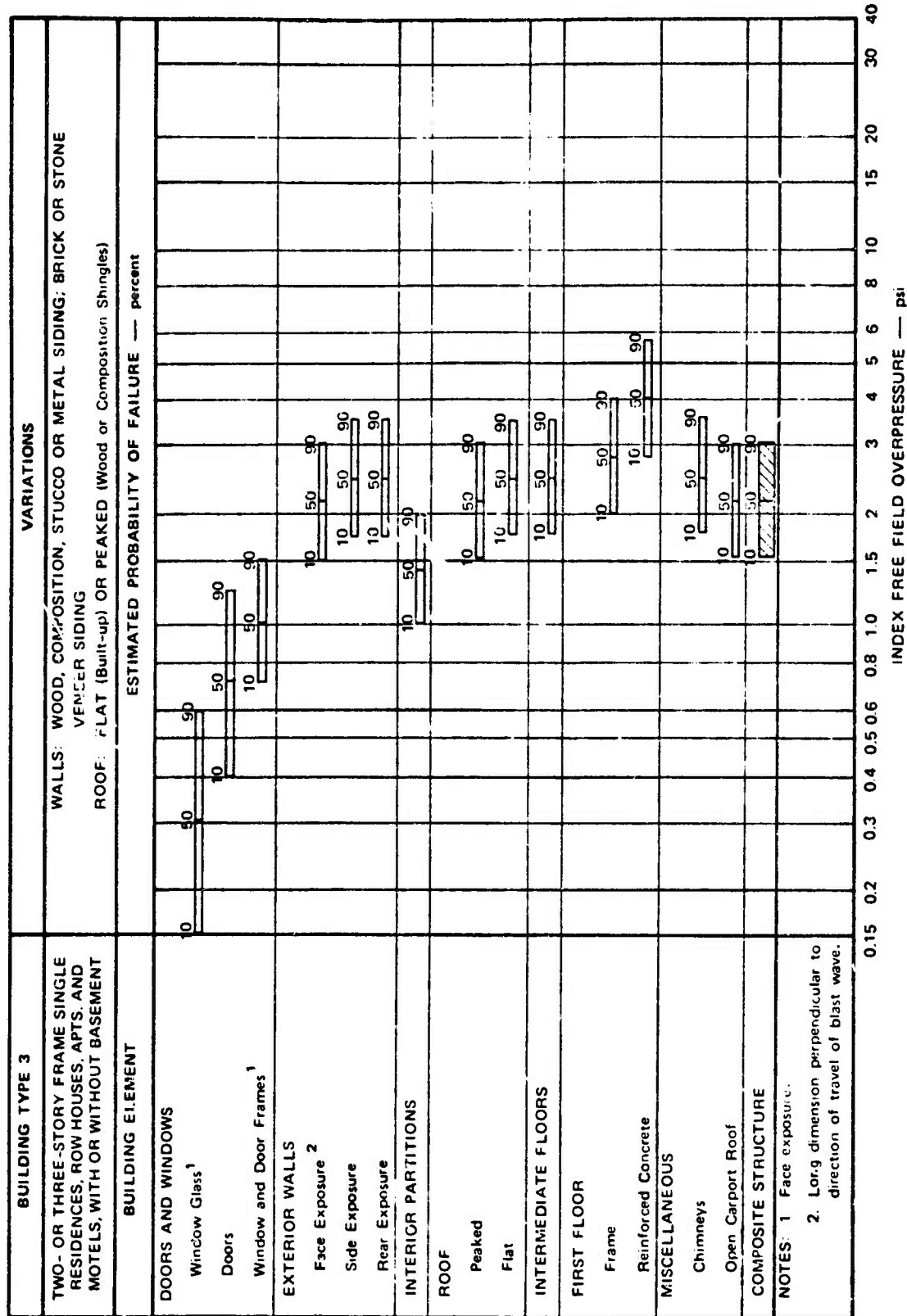


Figure 16. Overpressure effects on a two-story dwelling.

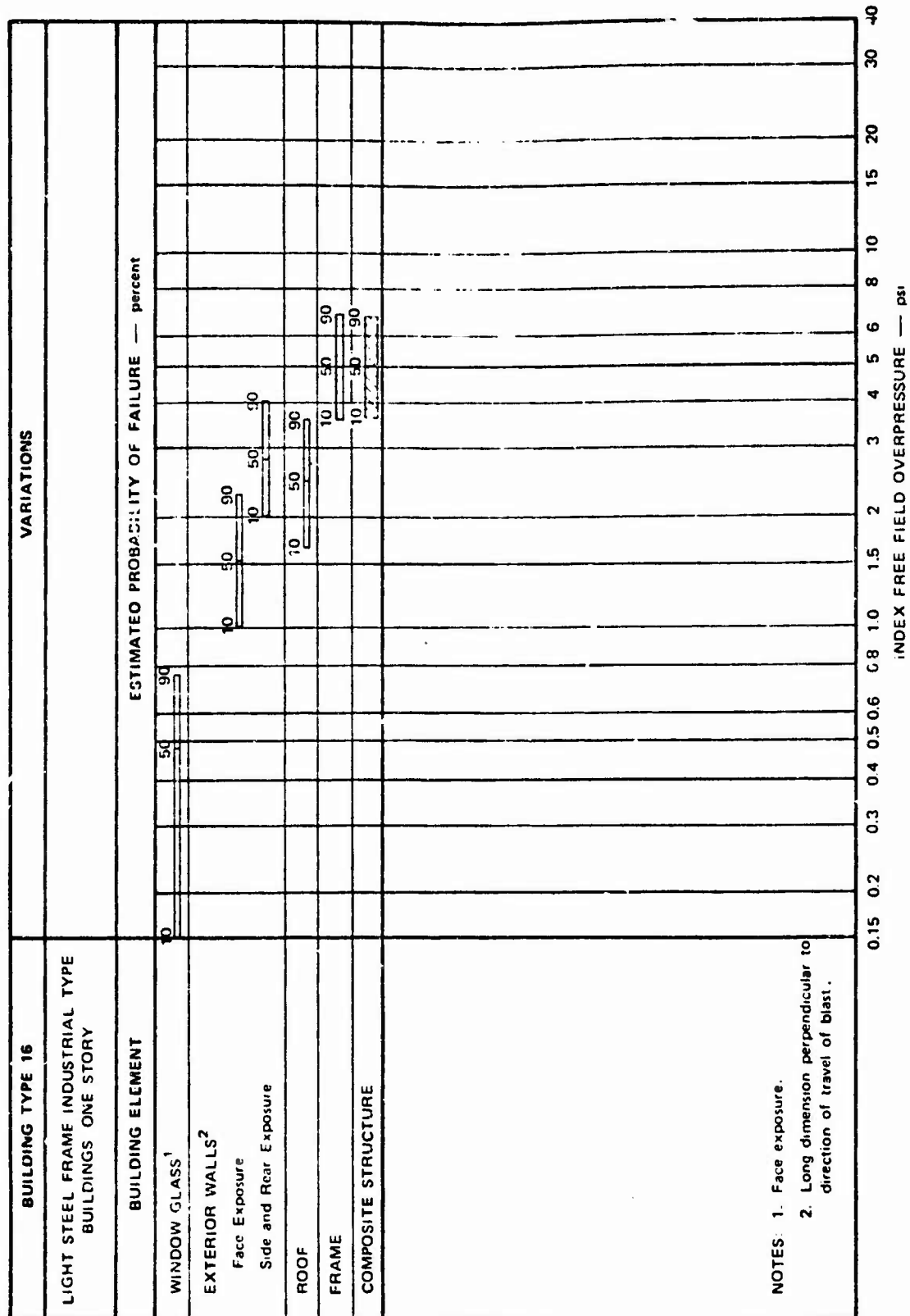


Figure 17. Overpressure effects on a light steel building.

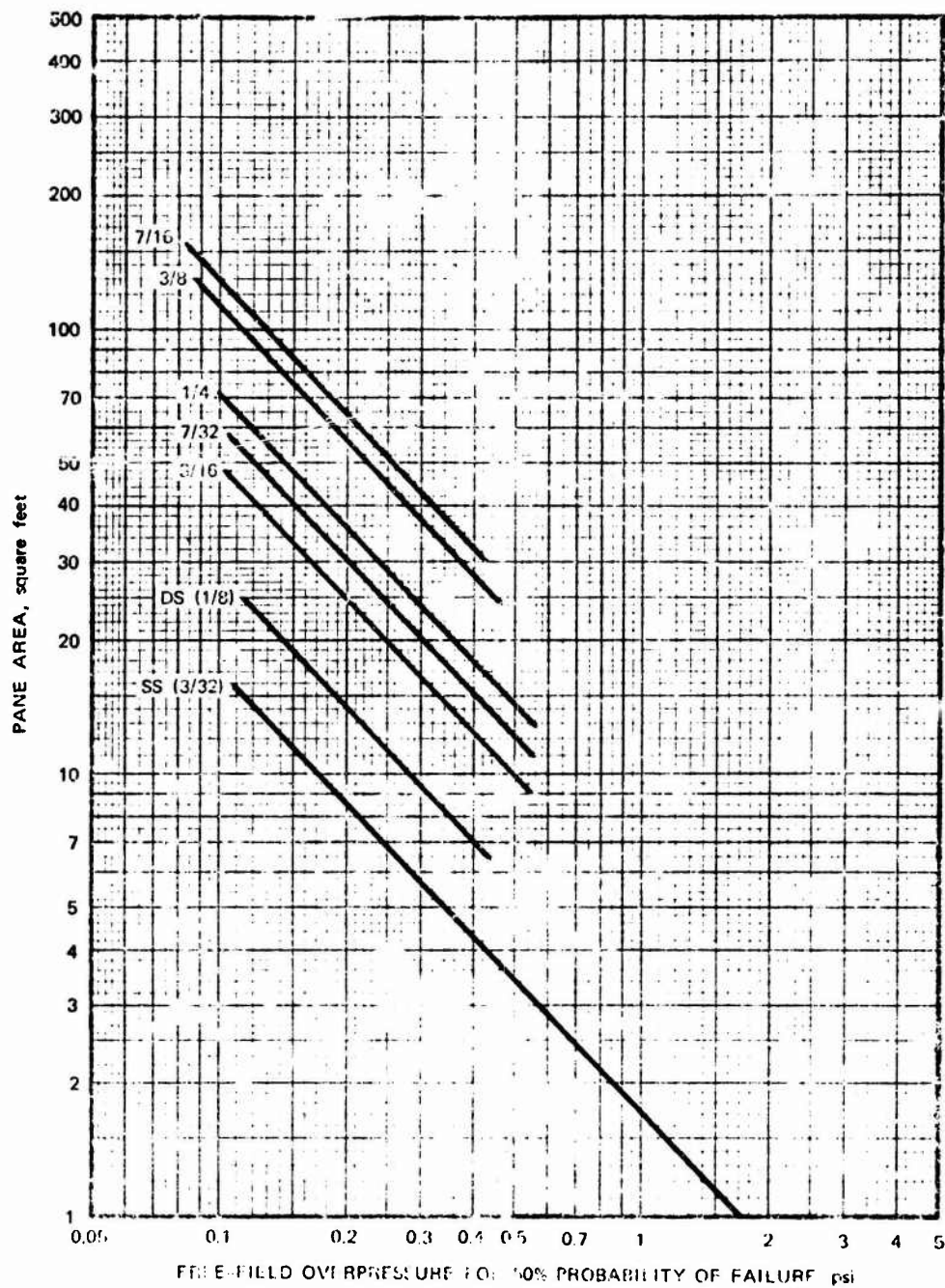


Figure 18. Sheet glass incipient failure pressures for front-face loading as a function of pane area and thickness.

The nearest inhabited dwellings are approximately one mile from the test bed for Event 3. At this distance the peak overpressure is predicted to be less than the most conservative value for window damage. Therefore, there should be no damage to residences from airblast. The abandoned buildings which are used for storage purposes and the bridge will receive less than 0.1 psi peak overpressure, which should not produce any damage. A few abandoned structures within 1-1/2 miles of the test site are in very poor condition. All are owned by the corporate landowner, the Pittsburg and Midway Coal Company and are slated for destruction in the near future. Any damages to these abandoned structures will be negotiated on an individual basis with the coal company.

Anomalous Propagation

Atmospheric effects may duct, focus or refract blast waves away from, or toward, the ground. Past high-explosive test experience (Reference 28) has shown that nonhomogeneous, windy atmospheric conditions may cause propagated blast amplitudes at long range to vary from about one-tenth to ten times the standard amplitude based on acoustic propagation equations. Amplifications of more than 3 to 4 times are very rare. An amplification of 4-1/2 times could extend the threshold of glass breakage to about 4 miles downwind. If the wind is from the east, the homes in Trading Post are within the 4-mile range. Weather conditions will be closely monitored to assure that the events will not be executed when meteorological conditions conducive to anomalous blast propagation exist. It is rare when these atmospheric conditions exist for periods longer than 2 or 3 days.

Noise

A transient degeneration in hearing at conversational frequencies and tinnitus or "ringing" can be produced by an impulsive sound of 160 dB. (As a comparison, distant thunder noise level is about 120 dB, close thunder 130 dB and a sonic boom can be as great as 160 dB.) (Reference 29) The level of 160 dB occurs about 400 feet from Event III, whereas the nearest people will be in the instrument vans, considerably farther away. The public is known to complain at levels of about 118 dB (0.002 psi). These complaints are

based more on "startle" factor rather than damage (an unexpected sonic boom or mine blast can be very unnerving). The Air Force will do everything possible to make local residents aware of the time of the blasts so as to reduce this startle effect.

Ground Shock

Studies specifically designed to determine the effect of ground shock on subsurface animals, plant roots and soil microbes (References 30 and 31) produced essentially negative results for blast-like pressure pulses. Subjective human response to vibratory motions mostly based on earthquake studies, in the frequencies associated with an underground detonation have shown motions of 0.004 in/sec to be perceptible and motions of 0.8 in/sec to be "unpleasant" (Reference 32). These levels occur at 13 miles and 3900 feet, respectively, from Event 3.

Subjective summaries of the effects of ground motion from nuclear tests on large animals (Reference 33) indicates no physical damage to beef cattle, dairy cattle, feral horses and deer at accelerations of 4 g and velocities of 230 cm/sec. A 30 animal dairy herd (0.36 g) at NTS showed no signs of decrease in milk production shot day or on following days.

In a review of ground shock damage levels and criteria, Cauthen (References 34 and 35) recommended the following:

Opening of old cracks:	4.3 in/sec
Superficial plaster cracks:	6 in/sec
Falling plaster, some structural weakening:	9 in/sec

The 4-inch/sec threshold occur 1700 feet from Event 3. Nonresidential buildings can withstand higher motions, since condition is impaired only in aesthetic ways by the threshold values. Thus wooden buildings could tolerate the threshold of structural damage (9 in/sec). Prefabricated metal buildings and plywood "field office" type structures reported no damage at higher velocities. Trailers have withstood velocities as high as 12 in/sec without damage (Reference 34).

All man-made structures are at least one half mile away and thus well below the threshold of damage due to ground shock. The levee near the test bed for Event 3 will be subjected to about 3 g acceleration (1.6 cm displacement). A levee near the Middle Gust test which was actively holding water withstood an acceleration of 3.6 g (.89 cm) with no apparent harm. However, since the levee is only in use during periods of flood, a condition unlikely at the time of test, it can, and will if necessary, be repaired. The levee holding back the pond to the southeast will experience an acceleration of 0.45 g. No effect is anticipated. Ground shock at the nearest well in use is 0.4 in/sec (0.04g). Prior experience has shown that shock levels of 0.1 g do not affect wells.

Dust

There is no evidence that the dust raised by any event will constitute irreparable damage to the environment. Within 10 to 20 minutes after the detonation the dust concentrations in the cloud will approximate that observed in wind generated dust storms. No value of concentration when considered along with the time of cloud passage at a given point constitutes a health hazard to humans or animals and does not affect the growth of plants. At distances greater than three miles it is doubtful if the cloud will be visible. The general direction of the normal prevailing wind (hence dust) travel is away from population centers.

Crater and Ejecta

Soil and rock fragments will be ejected from the test bed during the explosions. Continuous ejecta is expected from about 80 feet to 1420 feet beyond the test bed. Missiles up to fist size will impact several hundred feet beyond the limits of continuous ejecta. The areal density of missiles decreases rapidly as range increases, so little damage to biota is expected. The missiles will decompose rapidly under normal weather cycles. Ejecta may fill or modify the stock pond. This pond will be restored if required.

Detonation Products

The worst-case atmospheric contamination by detonation products would be the vertical eruption of the geologic debris and the

gaseous fumes in the shape defined by the placement of explosives. The areas involved by each test were given in Table 1 and formed the basal area of the solid figure obtained by limiting the detonation cloud rise to 500 feet above the ground surface. The volume of the cloud calculated by this method for the three events is given in Table 9 along with the instantaneous reaction product concentrations in milligrams per cubic meter (mg/M^3), and the Federally established limits for continuous exposure (an 8-hour working day) to industrial workers (Reference 36). The contaminated volume of air is computed as if no lateral spread occurs, or if it were only possible for the cloud to expand vertically.

The gases produced in greatest quantity are water vapor, nitrogen, and carbon dioxide. Water and nitrogen are innocuous gases for which limits have not been necessary. Carbon dioxide levels for Event 3 is well beneath concentrations hazardous to humans confined within the cloud for 8 continuous hours exposure. The levels for Event 2 are near that threshold value. The carbon dioxide level projected for Event 1 exceeds the concentration allowable for 8-hour exposure immediately above the site.

Solid particles of carbon, alumina and sulfur are to be expected from the rapid cooling of the explosion cloud and all are considered inert to the biota. Standards have not been set on a toxicological basis for them.

Hydrogen and methane are both highly reactive when combined with oxygen at elevated temperatures. Both would contribute to the explosion energy as atmospheric oxygen interfaced with the fireball surface. Water and carbon dioxide would be produced, in small amounts compared to the main detonation.

Carbon monoxide concentrations from the tests will exceed the recommended levels of $55 \text{ mg}/\text{M}^3$ within the effective fireball volume. Carbon monoxide is susceptible to autoignition down to a temperature of 1200°F and would contribute to the secondary thermal reactions where the luminous-atmosphere interfaces; in the worst possible case, no reduction in carbon monoxide is postulated.

The detonation products of concern appear to be carbon dioxide from Event 1 and carbon monoxide for all three events. Two factors will lower these levels of concentration. First, the cloud volume is not defined by the area of the test bed. Experience has shown that

Table 9. HARD PAN I detonation products generated each event (mg/M³).

	EVENT 1 ^a	EVENT 2 ^a	EVENT 3 ^a	Threshold Limiting Value ^b
Cloud Volume (cubic meters) (Isothermal Rise to 500 feet)	1.1 x 10 ⁵	1.4 x 10 ⁶	5.6 x 10 ⁶	
Detonation Products (mg/M ³)				
Water	6,000	34,750 (33,415)	35,220 (33,400)	9,000
Carbon dioxide	15,000	9,735 (6,900)	9,735 (6,900)	
Nitrogen	5,500	16,860 (15,330)	16,860 (15,330)	
Aluminum oxide	None	None (6,000)	None (6,000)	55
Carbon	None	318 (600)	318 (600)	
Sulfur	None	19 (18)	19 (18)	
Carbon monoxide	4,260	255 (255)	255 (255)	35
Hydrogen	197	12 (12)	12 (12)	
Ammonia	.03	<0.018 (<0.018)	<0.018 (<0.018)	
Methane	.3	<0.018 (<0.018)	<0.018 (<0.018)	

^a Amounts shown are for IREGEL 616; numbers in parentheses are for IREGEL 676, the aluminized AN Gel.

^b TVL for 8-hour continuous exposure. Source: Reference 36.

the cloud radius is two to three times the extent of the explosive array. This increase in the cloud volume will reduce the above-site concentrations from 5 to 10 times. Second, lateral expansion and diffusion as the cloud is moved by winds away from the site will increase cloud volume and decrease concentration.

A calculation was performed using Sutton's equations for instantaneous point source release, as described in Reference 36, to calculate the worst-case carbon monoxide concentrations at the nearest dwelling. Event 1 was selected as it represented the concentration which exceeded the threshold limit value by the greatest amount. Conservative values were used in the calculation: the wind speed assumed to be 1 meter/second (2.23 mph) and stable atmospheric conditions; the initial concentration was a point source defined by the size of the test bed. Under these conditions the average CO concentration at the nearest dwelling is 46 mg/m^2 , which is below the 8 hour continuous exposure TLV.

There should be no change in the quality of ground water in the vicinity of the test beds due to detonation products. The transmissibility of the clay overburden above bedrock is low so that little penetration into water-bearing strata is possible in the few milliseconds of overpressure. A long series of water samples have been collected by the Air Force from the MIDDLE GUST test beds, which were clay over shale, as here, without finding contamination in the water, or degradation of water quality. In those tests individual detonation masses were as large as 20 tons TNT equivalent, while here the individual charges are no larger than 8 tons equivalent of TNT, maximum, and even smaller for the ammonium nitrate charges.

Chemical analyses for explosive product contamination in the soil from the MIDDLE GUST crater were performed without finding any chemical species which exceeded the levels found in control samples. Analysis was performed for total carbon, carbonate, organic carbon, sulfur, phosphorus and nitrogen. If these analyses were in error, or if some deleterious product unknown at this time were introduced into the soil, it would have no effect on water quality since water movement in the aquifer is only 0.34 ft/day (Reference 2). At that rate it would take about 10 years to reach the river (where it would be diluted) and 40 years to the nearest well. The area will be strip-mined during this time period.

Cumulative Effects

The tests are individual events. There is no evidence, based on experience at the Canadian Blast Test Range and at sites in the United States, that the three events which are spaced both temporally and spacially will produce any cumulative adverse effect.

SECTION 3

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

To summarize Section 2, there will be no significant adverse effects on the environment.

The environmental effects are about equally distributed between the effects of the tests and the effects attendant with any large construction project, e.g., noise, dust, landform change. The land will be disturbed but will be restored. Federal and State air quality standards will be temporarily exceeded by the cloud of dust and detonation products from execution of the events, but this occurs with many types of transient operations. The events will not be executed when meteorological conditions conducive to anomalous airblast propagation exist. Possibly the major effect, although not strictly an environmental issue, will be the loss of 18 months of productivity as farmland.

SECTION 4

ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to the proposed action include:

1. Conduct the project at a different test site.
2. Reduce the size of the project
3. Simulate in a laboratory
4. Cancel the project.

CONDUCT THE PROJECT AT A DIFFERENT SITE

The tests must be executed in a geology similar, but with 1/2 the layer depth, to the geology in which the majority of Minuteman launch facilities near Whiteman AFB are constructed. The proposed test site was selected because it has the necessary geology and is relatively remote from man-made structures which would be subject to damage. For these reasons, conducting the project at a different site in the time required is not a viable alternative.

REDUCE THE SIZE OF THE PROJECT

The amount of explosive to be used has already been reduced to approximately one-third of the originally planned amount. Further reduction would reduce the confidence in the ability to apply the results to predictions of the response of Minuteman launch facilities under nuclear attack. This reduction is not warranted in view of the fact that no significant environmental impact is predicted.

SIMULATE IN A LABORATORY

As a model becomes increasingly smaller than its full scale, there is less confidence in applying scaling factors to relate simulation results to real-world situations. All relationships do not scale at the same rate in the same manner. For example, the 1/2

scale test will give data which can be related to real-world situations with more confidence than the 1/4 scale test. For the evaluation of the combined effects of airblast and ground-shock, a laboratory simulation on perhaps a 5-foot missile silo would not yield data which could be usefully applied to an actual situation involving an 80-foot silo. There is evidence that the geological conditions required by the tests cannot be reproduced in a laboratory.

PROJECT CANCELLATION

The need for the program is discussed in Section 1. The importance of the technical objectives, the potential savings of millions of dollars when upgrading the hardness of Minuteman facilities, and the lack of significant environmental impact justify the proposed project.

SECTION 5

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed action will have no effect on the long-term productivity of the test site. The land will be restored to its current use as cultivated farmland and pasture.

SECTION 6
IRREVERSIBLE AND IRRETRIEVABLE
COMMITMENTS AND RESOURCES

There are no known irreversible and irretrievable significant commitments of natural resources. Financial and material resources will be expended in the construction aspects of the project, as is so with any construction project. The need for the project justifies this commitment of resources.

SECTION 7
DETAILS OF UNRESOLVED CONTROVERSIES

There are no known controversies at this time. Since (1) the test site is relatively remote, (2) the project will not significantly affect the environment, and (3) the project will provide some stimulus to local businesses, it is not likely that the project will become controversial.

APPENDIX A

KANSAS ENVIRONMENTAL LAWS

The environmental laws for the State of Kansas are summarized below from Reference 38.

Air Quality

The Air Quality Conservation Commission of the State of Kansas, acting as an advisory body, places responsibility for air quality conservation and control of air pollution with the State Board of Health. Applications for variances from regulations governing emissions should be made to the Board at least 60 days before an activity is initiated.

The definitions of air contaminants, unallowable emissions, and durations of contamination given in the regulations refer to 1-to 24-hour periods or to continuing situations or permanent installations or equipment. Specific reference is not made to emissions resulting from the HARD PAN type of explosion. However, if it can be inferred that the words "any source or operation that emits any contaminant that may be adjudged to be or tend to be significantly injurious to human health or welfare, animal or plant life, or property or capable of unreasonably interfering with the enjoyment of life or property because of its specific chemical or physical nature or the quantity of discharge" could be applied to HARD PAN, plans should be reported to the Kansas State Department of Health.

"On site open burning of structures, vegetation or other combustible materials" is included among the contaminating acts for which the Department does grant exceptions to the regulations. Such burning shall be carried out at least 1000 feet from any occupied dwelling or public roadway and at least one mile from any airport, and burning operations shall not be initiated until at least one hour after sunrise.

The compounds for which emission levels are specified include: sulfur, hydrocarbons, and carbon monoxide. Ground level particulate concentrations at the property line equal to or exceeding 2.0 milligrams per cubic meter above background concentrations for any time period aggregating more than 20 minutes during any hour are not permissible without prior approval of the Board.

Water Quality

Kansas water pollution control laws and water quality criteria are administered by the Division of Environmental Health of the State Department of Health. Authority includes preservation of waters from pollution detrimental to human, animal, plant, or aquatic life.

Specific criteria relate to bacteria, dissolved oxygen content, temperature, pH (hydrogen ion activity), ammonia, oil and grease, organic and inorganic solids, turbidity, taste, odor, color, and toxic substances. Basically, limitations are to "established beneficial use".

Included among the water courses to which the beneficial use criteria are applied is the Marais Des Cygnes River Basin, which is designated for public water supply, industrial water supply, recreation (including sport fishing), agriculture, and to receive treated wastes. Water quality degradation is not permitted below the 1962 U. S. Public Health Service drinking water standard, standards acceptable to fishery environments, and other established beneficial uses.

Solid Waste and Refuse

Solid waste and refuse disposal is administered by the Kansas Department of Health. Under the regulations of the Department, it is unlawful for any person to dump or deposit any solid wastes or refuse onto the surface of the ground or into the water of the state without having obtained a permit, except that individuals are not prohibited from dumping solid wastes from their own residential or agricultural activities onto the surface of the land owned or leased by them when such wastes do not create a public nuisance or adversely affect public health.

Hazardous wastes, including flammable or explosive materials, must be stored "in a manner which will prevent spillage, leakage of liquids, and/or the concentration or generation of harmful or explosive vapors or offensive odors from the stored materials." The safe handling of hazardous materials must be provided for and fire hazards prevented.

APPENDIX B

ECOLOGICAL ASSESSMENT

SECTION I
PURPOSE AND SCOPE

This study was conducted to make an ecological assessment of the HARD PAN I Field Test Site, and to determine associated environmental impact of the test series. The study identifies the major ecological and biological factors related to the site and surrounding areas. The study is based on field observations (24 June through 27 June 1974) and a review of historical and scientific literature.

SECTION II

DESCRIPTION OF THE TEST SITE

The test site is located in a field in Linn County in east central Kansas, approximately 62 miles south of Kansas City. The site with its respective tree lines, crops and levees is typical of the surrounding area (figure B-1).

1. ECOLOGICAL CONSIDERATIONS

The ecological features of the test site are shown in figure B-1. A hay meadow, grain-sorghum patch, and winter-wheat field comprise the immediate test site area. The primary meadow grass is fescue with a mixture of dense forbs in some areas. Fescue was planted in 1970 and 1972. A community of Missouri gooseberry (*Ribes missouriense*) is found in the southeastern quadrant of the hay meadow.

Timbered areas border the site on the east, south, and west. The area to the north is active farmland. The trees of the flood-plain pasture area to the west are mainly pecan (*Carya illinoensis*). A small intermittent stream runs through the flood-plain pasture area and empties into the river. The tree line on the east side of the test site is a fence row dominated by osage orange (*Maclura promifera*). This species was once widely planted for living fences before the use of barbed wire. The south flood-plain area adjacent to the Marais des Cygnes River is a sparsely wooded oak-hickory association. Pecan dominates the beginning of the woodland at the meadow's edge.

The woodland area east of the test site is a mixed stand of secondary-growth deciduous forest with dense undergrowth. A small meadow between the woodland and test site has not been disturbed for several years.

A large pond and associated marsh area is located approximately 1500 feet southeast of Event 3. Scattered dense stands of box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), and cattail (*Typha latifolia*) are found along its border.

Three ravines traverse the test site and flood plain and empty into the river.

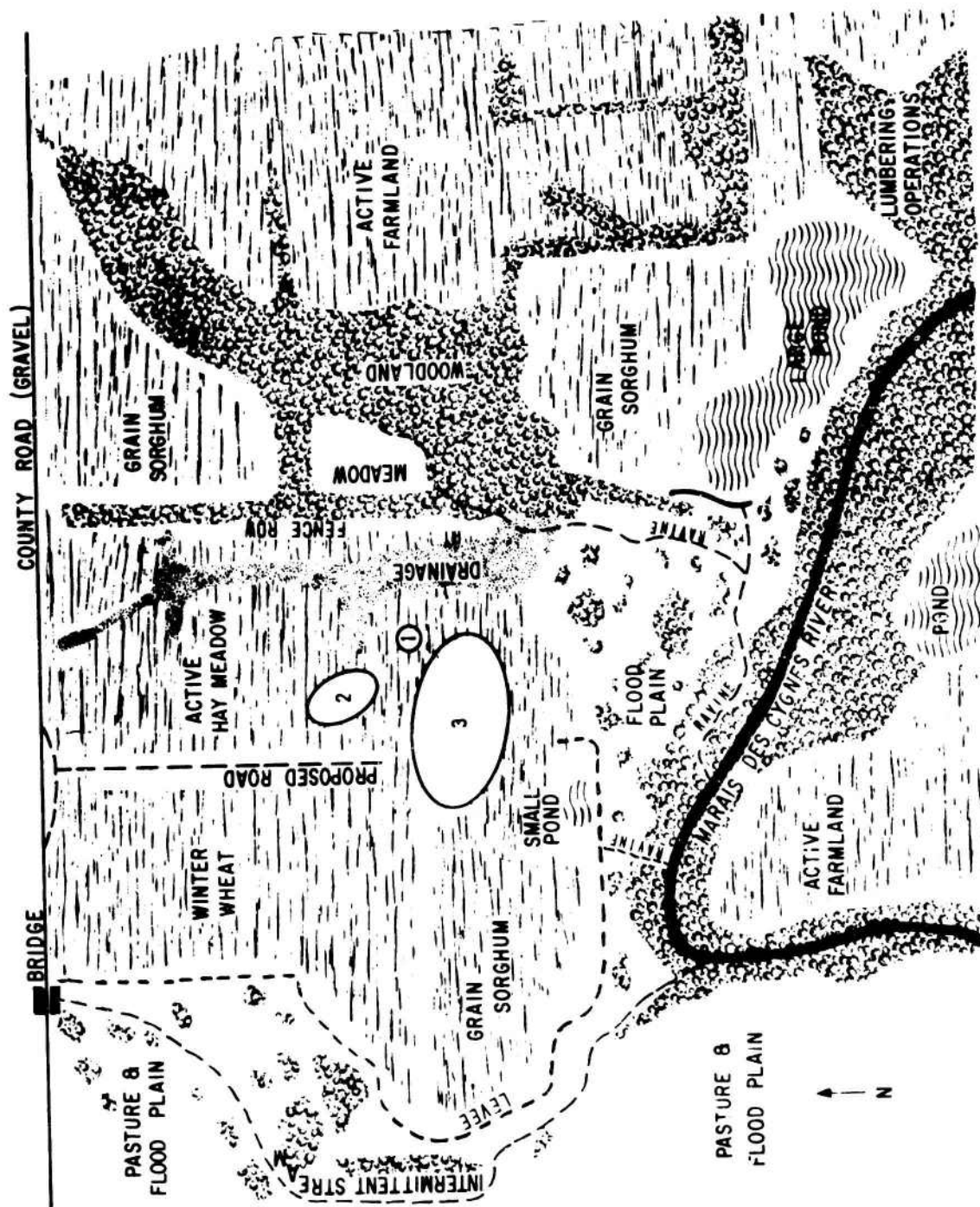


Figure 1-1 Ecological Features of Test Site and Numbered Test Events

The test site and areas immediately surrounding it provide a diversity of habitats for birds, mammals, and reptiles. A review of aerial photographs of the county indicate that similar habitats occur throughout the county where farmland and woodlands extend to the river basin. Present logging of woodlands southeast of the large pond and test site is decreasing the amount of wildlife habitat in the area.

Eastern Kansas is rather unique ecologically because it represents the edge of the range for many eastern and western species of plants and animals.

The Marais des Cygnes Waterfowl Management Area is located to the west and southwest of the test site (figure B-2). Unit "C" is the closest section and is approximately 1.25 miles southwest of the site. The Waterfowl Management Area is a manmade marsh constructed by the Kansas Forestry, Fish and Game Commission. The area has been designed and is being managed to furnish a resting and feeding place for migratory waterfowl and to provide more public hunting opportunities for Kansas sportsmen. The area contains 6646 acres including 1800 acres of water contained in manmade lakes. Unit "A" (Burr Oak Lake) and Unit "B" (Wood Duck Lake) were completed in 1955. A third lake, Unit "G" (Flathead Lake), was completed in 1958. Hunting is permitted in all units except Unit "G" which serves as a game refuge.

The avian fauna of the management area and its relationship to the test site will be discussed in section IV.

Waterfowl, deer, quail, rabbit, squirrel, and doves are hunted in season. Other kinds of wildlife in the area include raccoons, opossums, coyotes, foxes, muskrat, mink, and beaver.

2. FLORA

The potential natural vegetation for this area of Kansas is bluestem prairie and oak-hickory forest (table B-1, ref. 39). However, the test site and surrounding areas have been modified from their native vegetation due to farming and logging.

A random survey of plant communities was made to determine the dominant plant species. Samples were not sufficient for statistical analysis. A list of these species and location of occurrences are given in table B-2.

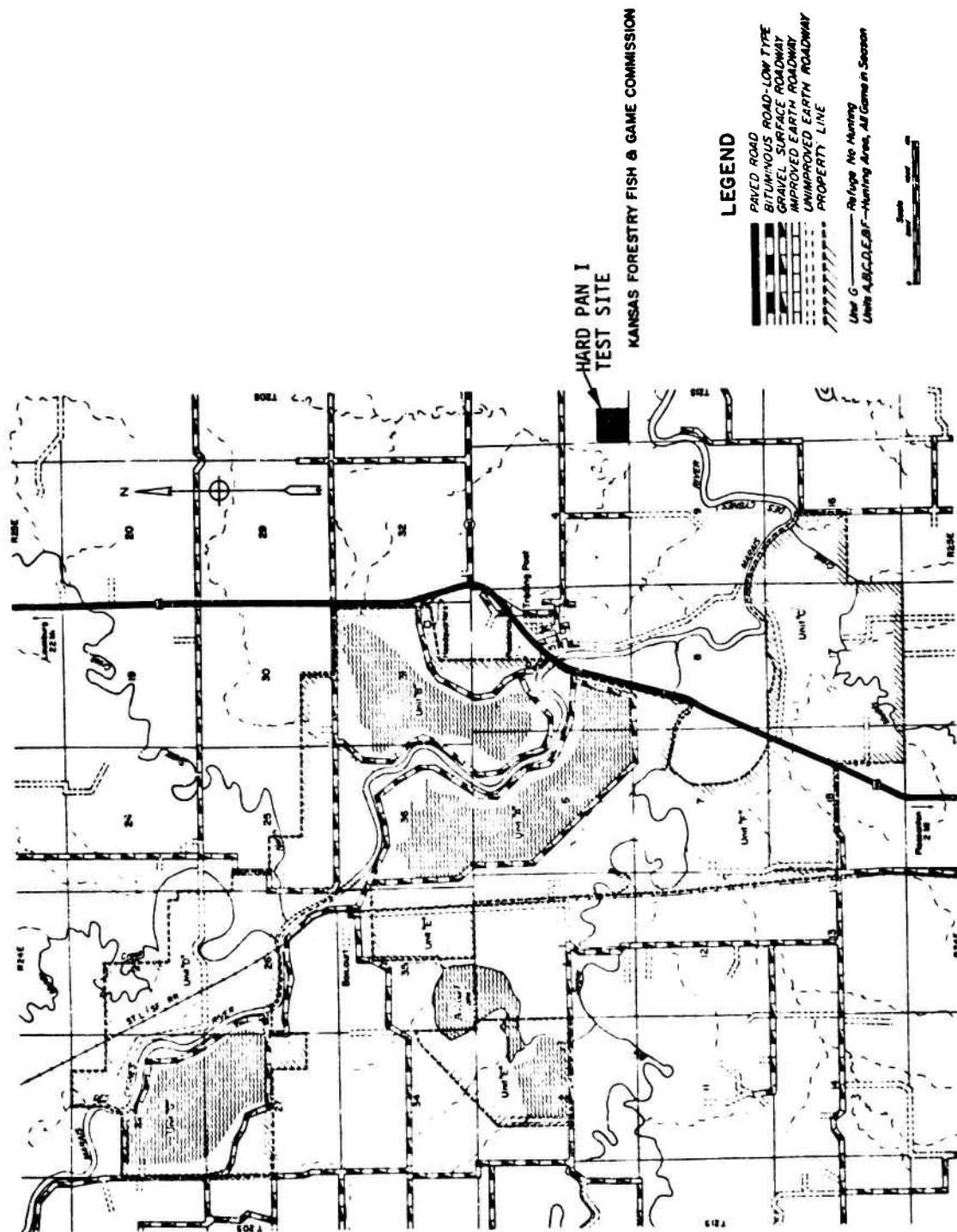


Figure B-2. Marais des Cygnes Waterfowl Management Area

Table B-1

POTENTIAL NATURAL VEGETATION OF KANSAS*

Bluestem Prairie (*Andropogon-Panicum-Sorghastrum*)

Physiognomy:	Dense vegetation of tall grasses and many forbs
Dominants:	Big bluestem (<i>Andropogon gerardi</i>) Little bluestem (<i>Andropogon scoparius</i>) Switchgrass (<i>Panicum virgatum</i>) Indian grass (<i>Sorghastrum nutans</i>)
Other Components:	<i>Amorpha canescens</i> , <i>Antennaria neglecta</i> , <i>Aster ericoides</i> , <i>A. laevis</i> , <i>Baptisia leucantha</i> , <i>B. leucophaea</i> , <i>Bouteloua</i> <i>curtipendula</i> , <i>Erigeron strigosus</i> , <i>Galium tinctorum</i> , <i>Helianthus grosseserratus</i> , <i>Koeleria cristata</i> , <i>Liatris</i> <i>aspera</i> , <i>L. punctata</i> , <i>L. scariosa</i> , <i>Panicum leibergii</i> , <i>P. serotinum</i> , <i>Phlox pilosa</i> , <i>Psoralea argophylla</i> , <i>P. floribunda</i> , <i>Ratibida columnifera</i> , <i>R. pinnata</i> , <i>Rosa arkansana</i> , <i>Silphium laciniatum</i> , <i>Solidago altissima</i> <i>S. missouriensis</i> , <i>S. rigida</i>
Occurrences:	North Dakota and Minnesota southward to Oklahoma

*Taken in part from A. W. Kuchler, 1964 (ref. 39).

Table B-1 (cont'd)

	Oak-Hickory Forest (<i>Quercus-Carya</i>)
Physiognomy:	Medium tall to tall broadleaf deciduous forests
Dominants:	Bitternut hickory (<i>Carya cordiformis</i>) Shagbark hickory (<i>Carya ovata</i>) White oak (<i>Quercus alba</i>) Red oak (<i>Quercus rubra</i>) Black oak (<i>Quercus velutina</i>)
Other Components:	Pignut hickory (<i>Carya glabra</i>), White ash (<i>Fraxinus americana</i>), Black walnut (<i>Juglans nigra</i>), Black cherry (<i>Prunus serotina</i>), Chinquapin oak (<i>Quercus muehlenbergii</i>), Basswood (<i>Tilia americana</i>), American elm (<i>Ulmus americana</i>). In the northern part also: Jack oak (<i>Quercus ellipsoidalis</i>), Shingle oak (<i>Q. imbricaria</i>). In the southern part also: Black hickory (<i>Carya texana</i>), Mockernut hickory (<i>C. tomentosa</i>), Spanish oak (<i>Quercus falcata</i>), Overcup oak (<i>Q. lyrata</i>), Black Jack oak (<i>Q. marilandica</i>), Shumard oak (<i>Q. shumardii</i>), Post oak (<i>Q. stellata</i>).
Occurrences:	Central United States

Table B-2
DOMINANT PLANT SPECIES FOR TEST AREA

Habitat	Plant Type	Common Name	Scientific Name
Meadow	Forbs	Black-eyed Susan	<i>Rudbeckia hirta</i>
		Daisy fleabane	<i>Erigeron annuus</i>
		Milkweed	<i>Asclepias</i> spp.
		Common ragweed	<i>Ambrosia artemisiifolia</i>
		Great ragweed	<i>Ambrosia trifida</i>
		Curled dock	<i>Rumex crispus</i>
		Sow thistle	<i>Sonchus</i> spp.
		Goldenrod	<i>Solidago</i> spp.
		Yarrow	<i>Achillea millefolium</i>
		Liatris	<i>Liatris</i> spp.
		Lead plant	<i>Amorpha canescens</i>
		Prairie clover	<i>Petalostemum</i> spp.
		Red clover	<i>Trifolium pratense</i>
		Daisy fleabane	<i>Erigeron annuus</i>
Hay Meadow	Forbs	Milkweed	<i>Asclepias</i> spp.
		Common ragweed	<i>Ambrosia artemisiifolia</i>
		Great ragweed	<i>Ambrosia trifida</i>
		Curled dock	<i>Rumex crispus</i>
		Common sunflower	<i>Helianthus annuus</i>
		Yarrow	<i>Archillea millefolium</i>
		Lead plant	<i>Amorpha canescens</i>

Table B-2 (cont'd)

Habitat	Plant Type	Common Name	Scientific Name
Hay Meadow (cont'd)	Forbs	Red clover	<i>Trifolium pratense</i>
		White sweet clover	<i>Melilotus alba</i>
		Yellow sweet clover	<i>Melilotus officinalis</i>
		Alfalfa	<i>Medicago sativa</i>
		White clover	<i>Trifolium repens</i>
		Dandelion	<i>Taraxacum officinale</i>
Flood Plain	Forbs	Cattail	<i>Typha latifolia</i>
		Broad-leaved arrowhead	<i>Sagittaria latifolia</i>
		Water plantain	<i>Alisma triviale</i>
		Common ragweed	<i>Ambrosia artemisiifolia</i>
		Great ragweed	<i>Ambrosia trifida</i>
		Smartweed	<i>Polygonum sp.</i>
		Lambsquarters	<i>Chenopodium album</i>
		Curled dock	<i>Rumex crispus</i>
		Sow thistle	<i>Sonchus sp.</i>
		Common sunflower	<i>Helianthus annuus</i>
		Horse nettle	<i>Solanum carolinense</i>
		Plantain	<i>Plantago major</i>
		Horseweed	<i>Erigeron canadensis</i>

Table B-2 (contd')

Habitat	Plant Type	Common Name	Scientific Name
Flood Plain (cont'd)	Trees	Silver maple	<i>Acer saccharinum</i>
		Willow	<i>Salix</i> sp.
		Pin oak	<i>Quercus palustris</i>
		Shagbark hickory	<i>Carya ovata</i>
		Black walnut	<i>Juglans nigra</i>
		Bur oak	<i>Quercus macrocarpa</i>
		American elm	<i>Ulmus americana</i>
		Pecan	<i>Carya illinoensis</i>
		Bitternut hickory	<i>Carya cordiformis</i>
		White oak	<i>Quercus alba</i>
		Shellbark hickory	<i>Carya laevis</i>
		Sycamore	<i>Platanus occidentalis</i>
Marsh	Forbs	Cattail	<i>Typha latifolia</i>
		Broad-leaved arrowhead	<i>Sagittaria latifolia</i>
		Water plantain	<i>Alisma triviale</i>
Marsh Edge	Trees	Box elder	<i>Acer negundo</i>
		Green ash	<i>Fraxinus pennsylvanica</i>
		Red maple	<i>Acer rubrum</i>
	Shrubs and Vines	Missouri Gooseberry	<i>Ribes missouriense</i>
		Grape	<i>Vitis</i> sp.
		Poison ivy	<i>Rhus radicans</i>
		Sumac	<i>Rhus</i> sp.
		Rose	<i>Rosa</i> sp.

Table B-2 (cont'd)

Habitat	Plant Type	Common Name	Scientific Name
Woodland	Trees	Pin oak	<i>Quercus palustris</i>
		Basswood	<i>Tilia americana</i>
		Common persimmon	<i>Diospyros virginiana</i>
		Pecan	<i>Carya illinoensis</i>
Fence Row	Trees	Pin oak	<i>Quercus palustris</i>
		American elm	<i>Ulmus americana</i>
		Honey Locust	<i>Gleditsia triacanthos</i>
		Hackberry	<i>Celtis occidentalis</i>
		Osage orange	<i>Maclura pomifera</i>

SECTION III

MAMMALS, AMPHIBIANS, AND REPTILES

A list of vertebrates with corresponding habitats that might occur in the area are given in appendixes A (Mammals) and B (Reptiles and Amphibians). These were prepared from the literature containing range distribution maps (refs. 40 and 41).

The following mammals were identified as being part of the site fauna by observation or tracks: white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), red fox (*Vulpes fulva*), fox squirrel (*Sciurus niger*), eastern cottontail (*Sylvilagus floridanus*), opossum (*Didelphis marsupialis*), raccoon (*Procyon lotor*), and muskrat (*Ondatra zibethicus*).

Several snakes and turtles were seen but no attempt was made to identify these species.

1. RARE AND ENDANGERED MAMMALS IN KANSAS

Special consideration was given to rare and endangered species that may occur in the area. The list of mammals in this category is being compiled by the Soil Conservation Service and the Conservation Committee of the Kansas Academy of Science. This unpublished list was provided by Dr. Dwight Platt, Chairman of the Conservation Committee.

The following list identifies those species which might occur in the test site vicinity or general area and gives the recommendations by the Academy for their preservation.

- a. Endangered species (None)
- b. Rare species (None)
- c. Species endangered in Kansas but not nationally

Eastern chipmunk, *Tamias striatus*

Range: Easternmost counties, perhaps extirpated there and uncommon.

Recommendations: Preserve selected areas of climax timber in eastern Kansas and protect them from grazing, especially areas with rocky ledges and hazelbrush.

d. Species rare in Kansas but not nationally

(1) Woodchuck, *Marmota monax*

Range: Forest edge in eastern Kansas west to Manhattan, but now rare; the subspecies *bunker* is known only from west of the Missouri River in eastern parts of Nebraska and Arkansas.

Recommendations: Avoid use of biocides in rural areas where woodchucks persist.

(2) Franklin's ground squirrel, *Spermophilus franklinii*

Range: Isolated populations remain in relict areas of tall grass prairie.

Recommendations: Encourage development of a Tallgrass Prairie National Park; encourage landowners to leave a swath of native grass around plowed fields; encourage the Highway Department to restrict mowing to a minimum and permit native prairie cover to develop on roadsides.

(3) Southern flying squirrel, *Glaucomys volans*

Range: Deciduous forest in eastern one-third of state.

Recommendations: Preserve selected areas of climax timber in eastern Kansas and protect them from grazing.

(4) Southern lemming-mouse, *Synaptomys cooperi*

Range: Statewide in dense stands of grass, particularly around marshes or in riparian grasslands.

Recommendations: Preserve existing marshy areas.

(5) Spotted skunk, *Meutecus pardalis*

Range: Statewide, except southwest and extreme west-central area; now missing from large areas of eastern half of Kansas where the species was abundant in the period 1912 to 1929.

Recommendations: None at present because the cause and significance of the population decline is not known.

(6) Bobcat, *Lynx rufus*

Range: Statewide but spotty.

Recommendations: Regulate hunting of bobcats and educate hunters about hunting regulations and seasons for this species.

e. Species with peripheral populations in Kansas

Big Free-tailed bat, *Tadarida macrotis*

Range: Distribution is spotty; this bat possibly passes over the state during migration.

Recommendations: None.

2. RARE AND ENDANGERED AMPHIBIANS AND REPTILES OF KANSAS

The following list identifies those amphibians and reptiles which might occur in the test site or in Linn County. This information was provided by Dr. Joseph Collins, Kansas Museum of Natural History.

- a. Endangered species (none)
- b. Rare species (none)
- c. Species endangered in Kansas but not nationally (none)
- d. Species rare in Kansas but not nationally

(1) Broad-headed Skink, *Eumeces laticeps*

Range: Known from Franklin, Miami, Linn, Anderson, Crawford, and Cherokee Counties; prefers deciduous forests where it lives high in the hollows of rotten tree trunks.

Recommendations: Halt lumbering operations on areas in eastern Kansas where this species is known to occur; protect some natural forest habitat with decaying trees.

(2) Newt, *Notophthalmus viridescens*

Range: Three known localities in deciduous forest along the eastern border of Kansas (Linn and Miami Counties).

Recommendations: Designation of any breeding sites located on state, federal, or county property or on private property of willing landowners as sanctuaries to be protected from disturbance.

(3) Spring peeper, *Hyla crucifer*

Range: Deciduous forest area of eastern border including the Shoal Creek drainage area (three known localities in Miami, Linn, and Cherokee Counties); present status poorly known.

Recommendations: Same as for newt.

SECTION IV

AVIAN FAUNA

1. COMMON RESIDENTS OF THE AREA

The diversity of habitats surrounding the test area accommodate a wide variety of avian fauna. During this study, it was assumed that all species observed were common summer residents of the area and most likely nesting within suitable habitat. A total of 30 species were actually observed within a one-half mile radius of the test site. Listed under their general habitat, the dominant species are as follows.

Meadow and grassland

Eastern Meadowlark, *Sturnella magna*
 Dickcissel, *Spiza americana*
 Horned Lark, *Eremophila alpestris*

Open woodland and edge habitats

Mourning Dove, *Zenaidura macroura*
 Eastern Kingbird, *Tyrannus tyrannus*
 Bobwhite, *Colinus virginianus*
 Red-tailed Hawk, *Buteo jamaicensis*
 Loggerhead Shrike, *Lanius ludovicianus*
 Robin, *Turdus migratorius*

Woodland

Blue Jay, *Cyanocitta cristata*
 Cardinal, *Richmondena cardinalis*
 Indigo Bunting, *Passerina cyanea*
 Brown Thrasher, *Toxostoma rufum*
 Black-capped Chickadee, *Parus atricapillus*
 Tufted Titmouse, *Parus h. 1 r*
 Catbird, *Dumetella carolinensis*
 Red-headed Woodpecker, *Melanerpes erythrocephalus*

Red-bellied Woodpecker, *Centurus carolinus*

Downy Woodpecker, *Dendrocopos pubescens*

Brown-headed Cowbird, *Molothrus ater*

Marsh and pond

Red-winged Blackbird, *Agelaius phoeniceus*

Great Blue Heron, *Ardea herodias*

Wood Duck, *Aix sponsa*

Appendix C contains a list of all species observed within a one-half-mile radius of the test site. Also included in the list are species known to be present at other times of the year or likely to occur because of their expected range and the availability of suitable habitat. The appendix summarizes general habitat preference, egg dates, migration dates, and seasonal occurrence of each species.

Of special significance to bird life in the area is the Marais des Cygnes Waterfowl Management Area located approximately 2 miles west and 1.25 miles southwest of the test area at its nearest points. About 200 species of bird have been recorded on the area. Although favorable habitat exists for a variety of bird life, the area was specifically designed and is actively managed to furnish a resting and feeding place for migratory waterfowl and to provide more public hunting opportunities for Kansas sportsmen. During the migration season as many as 150,000 ducks have been recorded with over 70,000 normally remaining throughout the winter (ref. 42). The most common migratory waterfowl include the Mallard (*Anas platyrhynchos*), Pintail (*Anas acuta*), Blue-winged Teal (*Anas discors*), Green-winged Teal (*Anas carolinensis*), Baldpate (*Mareca americana*), Gadwall (*Anas strepera*), Wood Duck (*Aix sponsa*), American Merganser (*Mergus merganser*), Canada Geese (*Branta canadensis*), and Snow Geese (*Chen caerulescens*). Local weather conditions and availability of food will determine the importance of the area for wintering waterfowl. During the nesting season the Wood Duck is the dominant species.

Significant visitors to the Waterfowl Management Area other than waterfowl include the Bald Eagle (*Haliaeetus leucocephalus*), the Golden Eagle (*Aquila chrysaetos*), and the American Osprey (*Pandion haliaetus*). These species as well as other threatened and endangered species are discussed more thoroughly in the following section.

2. RARE AND ENDANGERED BIRDS IN KANSAS

A list of birds in this category is being compiled by the Soil Conservation Service and the Conservation Committee of the Kansas Academy of Science. The unpublished list was provided by Dr. Dwight Platt, Chairman.

The following list includes species that may occur in the test site vicinity or general area and includes recommendations by the Academy for their protection. Those on the list that are known to occur in the area are discussed in greater detail later.

a. Endangered Species

(1) Peregrine, *Falco peregrinus*

Range: Fall and spring transient and winter resident, typically around marshes, lakes, and rivers.

Recommendations: Educate the public as to its status and identification. Preserve and protect sites where it still regularly occurs as a transient or in winter.

(2) Whooping Crane, *Grus americana*

Range: Transient in March and April and in October. Whooping crane migration occurs further west in approximately central Kansas and has normally been completed by November (refs. 43 and 44).

Recommendations: Educate public as to status and identification and continue practice of closing areas to all hunting when these cranes stop over.

(3) Eskimo Curlew, *Numenius borealis*

Range: Probable spring migrant (March through June), mainly in the eastern part of the state; last record in 1891.

Recommendations: None. It is so rare as to be beyond help.

b. Threatened Species

(1) Bald Eagle, *Haliaeetus leucocephalus*

Range: Transient and winter resident, chiefly around reservoirs and marshes. One species, *H. l. leucocephalus*, is on the federal endangered list, but it is believed that most individuals in Kansas are *H. al. leucocephalus*.

which is not endangered. Owing to construction of many large reservoirs in Kansas in recent years, eagle populations have increased. Since the subspecies of a given bird cannot be determined in the field and since the reservoirs tend to concentrate individuals making them susceptible to disturbance, it seems wise to assign the entire species to status in this category.

Recommendations: Educate public to realize that eagles can be seen in Kansas and stress their threatened status, continue protection of frequented sites, and enforce existing protection laws for raptors.

(2) Prairie Falcon, *Falco mexicanus*

Range: Occasional summer visitant, transient, and winter resident in grasslands; formerly more abundant in Kansas.

Recommendations: Educate public as to status and identification; enforce existing protection laws for raptors.

(3) Burrowing Owl, *Speotyto cunicularia*

Range: Summer resident in western part of state; migrant in east. Listed as status undetermined on federal list. The species depends mostly upon prairie dog towns for nest sites, although holes of other burrowing rodents are used. Some dog towns have owls, while others do not. Until its specific habitat requirements are known, it is best to place the species in this category.

Recommendations: Preserve prairie dog towns that have owls; further study of its habitat requirements.

c. Species Endangered in Kansas but not Nationally. (None)

d. Species Threatened in Kansas but not Nationally.

(1) Red-shouldered Hawk, *Buteo lineatus*

Range: Summer resident, transient, and occasional winter resident in riparian woodlands in eastern part of state; has bred in Woodson and Linn Counties, but has been decreasing in Kansas in recent years.

Recommendations: Protect existing tracts of mature forest along water courses in eastern third of state; enforce existing protection laws for raptors.

(2) Osprey, *Pandion haliaetus*

Range: Transient and temporary resident around reservoirs and smaller lakes, rivers, and marshes; occurs most frequently in April and May and in September and October; once regular, but now much less frequently observed.

Recommendations: Continue establishment of refuge areas on reservoirs and enforce protection laws for raptors.

(3) Merlin, *Falco columbarius*

Range: Transient and winter visitant across state in open woodlands; considered relatively common in late nineteenth and early twentieth centuries; now considered rare.

Recommendations: Enforce existing protection laws for raptors.

(4) Whippoorwill, *Caprimulgus vociferus*

Range: Summer resident in upland forest in eastern part of state as far west as Riley County; once considered locally common, but in most of former range appears to be much less frequent.

Recommendations: Causes for decline not known; therefore, studies to determine causes of decline would be appropriate; protect upland deciduous forest to enhance survival in state.

e. Species with Peripheral Populations in Kansas

(1) Common Gallinule, *Gallinula chloropus*

Range: Local and infrequent summer resident in marshes; breeding records from Douglas, Coffey, and Barton Counties.

Recommendations: Protect existing marsh habitat and develop additional marsh habitat.

(2) Tree Swallow, *Iridoprocne bicolor*

Range: Common transient but only breeding record from Doniphan County; some observers in central Kansas believe migrant population declining.

Recommendations: Protect known nesting sites.

(3) Worm-eating Warbler, *Helminthos vermivorus*

Range: Rare summer resident in deciduous forests along eastern edge of state.

Recommendations: Protection of forest habitat is critical in the eastern part of state due to increased pressures from urbanization and industrial development. This species as well as several of the following species are dependent upon the availability of proper habitat to maintain their low, but stable populations in state.

(4) Blue-winged Warbler, *Vermivora pinus*

Range: Uncommon-to-rare summer resident in forest edge communities along eastern edge of state.

Recommendations: Preserve appropriate habitat.

(5) Cerulean Warbler, *Dendroica cerulea*

Range: Rare summer resident in mature deciduous forests along eastern edge of state.

Recommendations: Preserve suitable habitat.

(6) Yellow-throated Warbler, *Dendroica dominica*

Range: Rare breeding species in flood plain forest in eastern third of state.

Recommendations: Preserve suitable habitat.

(7) Prairie Warbler, *Dendroica discolor*

Range: Local summer resident in edge habitats in Wyandotte, Johnson, and Cherokee Counties.

Recommendations: Particularly in highly urban counties (Wyandotte and Johnson), preserve sufficient habitat to maintain this species.

(8) Hooded Warbler, *Wilsonia citrina*

Range: Rare summer resident in wet deciduous forests along eastern edge of state.

Recommendations: Preserve suitable habitat.

(9) Henslow's Sparrow, *Ammodramus henslowii*

Range: Local summer resident in wet pastures; recorded breeding in Shawnee, Douglas, Morris, and Anderson Counties.

Recommendations: Preserve sites where species has been known to breed.

SECTION V

AQUATIC ECOLOGY

The principal aquatic ecosystem in the area of the test site is the Marais des Cygnes River. This river gathers tributaries from eastern Kansas and flows approximately 10 miles into Missouri before joining the Osage River.

Recordings of river flood stages for the last 3 years and the first 5 months of 1974 are shown in table B-3. A flood stage is considered to be 24 feet. The data indicate that at least one flood stage can be anticipated in a normal year of precipitation. The flood stages inundate large flood plain areas which are diked to prevent flooding of croplands. During the flood stages, many small, intermittent streams in the area also carry significant amounts of water and silt, in many cases flooding, before reaching the main riverbed.

The proposed test area is bounded on the south (1600 feet from test site) by the Marais des Cygnes River, with a ravine paralleling the river at approximately 1500 feet that flows intermittently during high precipitation periods. The ravine heads at a levee which, with two other levees, contains a pond of approximately 40 acres with a depth of from 3 to 6 feet. The mouth empties into the river.

A ravine 4 to 10 feet deep and 10 to 15 feet wide runs along the eastern fence row of the test site area. This ravine had no intermittent pools or areas of standing water during this study and the bottom consisted of coarse sand and gravel.

An intermittent stream runs through the flood plain and pasture area to the west. Several shallow pools were found in this streambed. Numerous aquatic insects as well as small sunfish (1 to 2 inches) were observed. No collections were made.

Historical records (ref. 45) do not indicate the presence of permanent impoundments which contain fish life in this area. However, because of the overflow floodwaters from the Marais des Cygnes River to the 40-acre pond, it

Table B-3

RIVER HEIGHTS--MARAIS DES CYGNES
(Flood Stage = 24 feet)

1971		1972	
Month	Highest Level (feet)	Month	Highest Level (feet)
January	24.57	January	11.44
February	19.50	February	3.55
March	19.15	March	3.00
April	2.80	April	4.20
May	4.85	May	23.10
June	9.20	June	3.35
July	10.65	July	4.00
August	4.95	August	3.45
September	2.73	September	2.95
October	5.05	October	2.45
November	2.60	November	6.27
December	23.80	December	5.27

1973		1974	
Month	Highest Level (feet)	Month	Highest Level (feet)
January	17.25	January	21.13
February	23.50	February	11.85
March	28.42	March	24.85
April	27.62	April	15.80
May	25.27	May	20.80
June	18.10		
July	17.45		
August	3.90		
September	28.25		
October	30.80		
November	20.55		
December	21.43		

can be assumed that those fish species present in the river which can survive in a lentic ecosystem will be present in the pond. This would include species of sunfish, bass, carp, catfish, and crappie as well as various smaller minnows of the Cyprinid family and members of the perch family (Percidae).

Table B-4 (refs. 45 to 48) lists the species of fish considered to be in a threatened status in Kansas. Additionally, the Brindled madtom, *Noturus miurus*-Jordan, is being considered for placement in a threatened status (Dr. Joseph Collins). This fish occurs only in extreme southeastern Kansas. The mosquitofish, *Gambusia affinis*, was also observed in the area of the 40-acre pond in a small stagnant backwater. The mosquitofish is essentially ubiquitous in the United States but not confirmed by Cross for this area. Table B-5 lists the species of fish in Kansas which are considered to be peripheral populations (ref. 48).

Cross (ref. 45) has identified fishes throughout Kansas and provides a geographical breakdown of the occurrences of each species. The fish which are known to occur in Linn County are listed in appendix D (refs. 45, 46). The third column of the appendix indicates the number of locations within the state where that particular species has been identified. The numbers indicate occurrences in greater than 10 or greater than 20 locations or, in the case of "no," that the species occurs or has occurred in less than 10 other locations. The fourth column provides a brief statement concerning habitat and spawning requirements of each species.

The Marais des Cygnes River provides the type of habitat required for many of the species listed in appendix D. The river has a broad meandering course and flood plain and carries a large silt load over a medium to shallow gradient. These factors make it typical of geologically older rivers.

The Marais des Cygnes River is part of the Missouri River Basin drainage and is included in the grouping of rivers which comprise the tributaries of the Kansas and Osage Rivers. South of the Osage and Kansas Rivers, the drainage is into the Arkansas River Systems. Cross (ref. 45) notes that little likelihood exists of interchange of fish species in modern times but that the basins were not always isolated.

Table B-4
THREATENED FISHES OF KANSAS

Common Name	Scientific Name	Status	Habitat
Lampreys *Chestnut Lamprey	<i>Ichthyomyzon castaneus</i>	1 (Rare)	Missouri River; parasitic. Swift shallow riffles for spawning.
Sturgeons *Pallid (white)	<i>Scaphirhynchus altus</i>	2 (Rare)	Mainstream of Missouri and lower Kansas River. Muddy turbid waters.
Suckers *River Redhorse	<i>Moxostoma valenciennianum</i>	1 (Depleted)	Rare in Kansas except in Arkansas River system.
*Blue Sucker	<i>Cycorephus elongatus</i>	2 (Not listed)	Neosho River, Kansas River, Douglas County.
Catfish (Freshwater) *Neosho Madtom	<i>Noturus placidus</i>	3 (Endangered)	Clear waters over gravel riffles; Neosho River
*Brindled Madtom	<i>Noturus miurus</i>	2 (Not listed)	Limited to southeastern Kansas.
Topminnows Plains Topminnow	<i>Fundulus sciaticus</i>	4 (Rare)	Limited to Shoal Creek, Cherokee Creek, and inhabits spring bed pools and backwaters.
Perches Arkansas Darter	<i>Etheostoma caeruleum</i>	(Depleted)	Endemic to Arkansas River Basin; small springs and seeps
*Least Darter	<i>Etheostoma caeruleum</i>	4 (Rare)	From a single locale in Cherokee County. Occurs in headwaters of streams in calm water. Eggs deposited singly.

Table B-4 (cont'd)

Common Name	Scientific Name	Status	Habitat
*Greenside darter	<i>Etheostoma blennioides</i>	1 (Not listed)	Little Osage and Mormaton Rivers, Bourbon County; Shoal River and Spring Creek, Cherokee County
*Bluntnose darter	<i>Etheostoma chlorosomum</i>	2 (Not listed)	Spring River system
*Slough darter	<i>Etheostoma gracile</i>	2 (Not listed)	Clear Creek and Second Cow Creek, tributaries of Neosho River
Minnows and Carp *Gravel chub	<i>Hybopsis x-punctata</i>	1 (Not listed)	Gravel Bottoms of larger streams of Neosho system
*Hornyhead chub	<i>Hybopsis biguttata</i> (<i>Nocomis</i>)	1 (Not listed)	Clear, permanent rocky creeks. Occurs in Marais des Cygnes system
*Redspot chub	<i>Nocomis asper</i>	1 (Not listed)	Spring River and Shoal Creek, Cherokee County
*Highfin carpsucker	<i>Carpodacus velifer</i>	1 (Not listed)	Neosho River, Neosho County
*Hogsucker	<i>Hypentelium nigricans</i>	1 (Not listed)	Shoal Creek, Cherokee County
*Brassy minnow *Brassy minnow	<i>Hybognathus hankinsoni</i>	2 (Not listed) 2 (Not listed)	Missouri and Kansas Rivers
Eels *American Eel	<i>Anguilla rostrata</i>	2 (Not listed)	Missouri mainstream, Lower Kansas River

Table B-4 (cont'd)

Common Name	Scientific Name	Status	Habitat
Strippled darter	<i>Etheostoma punctulatum</i>	4 (Rare)	Cherokee County in brooks or springs in small clear pools. Reproduction is probably in April.
*Speckled darter	<i>Etheostoma stigmaeum</i>	4 (Rare)	Spring River and Shoal Creek, Cherokee County, in large clear streams with moderate or swift gradients.
*Blackside darter	<i>Percina maculata</i>	1 (Rare)	Occurs in Mill Creek, clear medium-sized streams in shallow pools, moderate currents and gravel/sand bottoms. Reproduction is in spring, April-May.

Source for threatened species: Miller, R. R., Threatened Freshwater Fishes of the United States (ref. 9). Status in parentheses are from Miller.

*Indicates confirmation or sole information from Tran. Kansas Acad. Science, Vol. 76, No. 2, 1973, published 21 February 1974.

- 1 Endangered in Kansas, not nationally.
- 2 Rare in Kansas, not nationally.
- 3 Endangered species.
- 4 Peripheral in Kansas (from Tran. Kansas Acad. Science).

Table 8-5
PERIPHERAL FISH POPULATIONS IN KANSAS

Common Name	Scientific Name	Occurrence
Tadpole Madtom	<i>Noturus gyrinus</i>	Marais des Cygnes River, Franklin County, Marais des Cygnes Waterfowl Management Area, Linn County
Burbot	<i>Lota lota</i>	Missouri Mainstream
Studfish	<i>Fundulus catenotus</i>	Greywood Creek, Crawford County
Rock bass	<i>Ambloplites rupestris</i>	Shoal Creek, Cherokee County
River darter	<i>Percina shumardi</i>	Neosho River, Labette County Spring River, Cherokee County
Banded darter	<i>Etheostoma zonale</i>	Spring River and Shoal Creek, Cherokee County
Banded Sculpin	<i>Cottus caroliniae</i>	Shoal Creek, Cherokee County
Spotted Gar	<i>Lepisosteus oculatus</i>	Neosho River
Skipjack	<i>Alosa chrysochloris</i>	Missouri and Lower Kansas River
Sicklefin chub	<i>Hybopsis meeki</i>	Mainstream of Missouri, lower Kansas River
Silverband shiner	<i>Notropis shumardi</i>	Mainstream of Missouri River
Central Common shiner	<i>Notropis chrysocephalus</i>	Shoal Creek, Cherokee County

Table B-5 (cont'd)

Common Name	Scientific Name	Occurrence
Spotfin shiner	<i>Notropis spilopterus</i>	Spring River and Shoal Creek, Cherokee County
Bigmouth shiner	<i>Notropis dorsalis</i>	Missouri River and tributaries
Ozark minnow	<i>Dionda nubil</i>	Shoal Creek, Cherokee County
Black redborse	<i>Moxostoma draquesnei</i>	Spring River and Shoal Creek, Cherokee County

Source: Trans. Kansas Acad. Science, Vol. 76, No. 2, 1973. Published 21 February 1974.

The fishes listed below are those whose habitat preferences, spawning requirements and tolerance of current, siltation and oxygen changes make their occurrences in the area of the proposed tests unlikely.

Goldeye
Golden shiner
Rosey-faced shiner
Yellow bullhead
Black-striped topminnow
Slender-headed darter
Creek chub
Horneyhead
Red shiner
Sand shiner
Hogsucker
Slender madtom

SECTION VI

ENVIRONMENTAL IMPACT

1. PROBABLE ENVIRONMENTAL IMPACT OF PROPOSED ACTION

a. Effect on Water and Aquatic Organisms

The major aquatic ecosystem in the area of the proposed test site is the Marais des Cygnes River.

Ground shock effects of the tests are not expected to affect the river-bed, based on prediction of acceleration forces (g) at the distance from the tests (1600 feet). Using the "worse possible" effects criteria (Event 3) the bottom of the river is expected to sustain only minor disturbances. The extent of these disturbances is not expected to cause any long-term, detrimental effects on the river bottom, the siltation load, or the river banks.

Additional aquatic ecosystems in the area include a 40-acre pond located approximately 1500 feet from the test area and a small (60 x 30 feet) pond located 465 feet from the center of Event 3.

The 40-acre pond is contained by three levees. The northwestern levee is approximately 80 feet long with a 40-foot base and a 20-foot top. A small culvert (approximately 16-inch diameter) runs through the levee. A smaller levee, approximately 25 feet long with a 26-foot base and 17-foot top borders the western edge of the pond and separates the pond from a ravine which drains westward and then southward to the Marais des Cygnes River. At the southeastern edge of the pond is a large levee, 190 feet long, 50 feet at the base, and 17 feet at the top. From observations of the area, it is evident that there were originally two separate ponds. The high water which existed during this study has covered the island/peninsula between the two ponds.

Ground shock effects on the pond and the levees surrounding it are predicted to be minimal. Ground motion reaching the area will be less than one (1) g.

The possibility of a seiche (periodic oscillation) being generated in the 40-acre pond was considered. However, the ground shock levels at that distance are not expected to provide sufficient energy to generate a seiche.

The small stock pond located southwest of the test site is retained on its south side by a large levee (figure B-1) which runs along the southern boundary of the immediate test area and separates it from the flood plain of the Marais des Cygnes River. The pond is contained on the remaining three sides by the natural slope of the land. Depth of the pond varies with precipitation and averages about 3 to 4.5 feet.

Due to its proximity to Event 3, the stock pond will receive ejecta from the test. Consideration was given to the effect of this occurrence and planning for restoration of the area includes reestablishment and renovation of the pond if it is necessary.

A checklist of the fish species known to occur in the Linn County area is appended to this report. As discussed in the main body of this document (section V) no detrimental effects are anticipated to occur in any of the aquatic ecosystems with the exception of the small stock pond. Effects on fish and other aquatic organisms are therefore predicted to be minimal and transitory. Some siltation is anticipated from the shock waves in both the 40-acre pond and the river. However, these effects will not significantly increase siltation in either ecosystem and will be extremely transitory in nature.

b. Vertebrate Fauna and Other Organisms

Construction and operational activities are not expected to have a lasting or adverse impact on wildlife and small mammal populations in the area. Some habitats will be destroyed or disrupted for small mammals that prefer open grassland, fields, and fairly dry open prairies. These kind of habitats are not limited or restricted to the immediate area. The majority of small mammals in this locality occupy undisturbed habitats near water edges, native grassland, and where grasslands meet woodlands. Essentially, none of these kinds of habitats will be disrupted.

Deer, raccoons, squirrels, and foxes are found in nearby woodland areas. Activity on the site may cause some displacement of these animals. No adverse impact is expected on the populations of these species, due to the availability of other suitable habitat.

The blast and ground motion results of Event 2 and 3 are not expected to have an adverse impact on the population of small mammals. Colonization of the test site by these individuals should be minimal due to previous use as active farmland.

The effects on large animals of ground motion from underground nuclear tests (ref. 33) indicate no physical damage to beef cattle, dairy cattle, feral horses, and deer at accelerations of 4 g and velocities of 230 cm/sec. Ground motion at the nearest point of the river for Event 3 has been calculated to be less than 1 g. Deer habitat and that for other large animals will be out of the impact range.

No adverse impact will occur on small or large mammals in the area due to overpressure. The overpressure at 72 feet from the Event 3 test bed is about 2 psi which is the tumbling threshold (condition that might produce injury for small mammals) (ref. 18). Small and large mammals will likely be outside of this range due to pretest activity.

A herd of beef cattle often water in the small stream that flows through the pasture flood plain (figure B-1). These cows should be removed from this area before detonation of Events 2 and 3. The loud noise associated with the blast may cause the cows to stampede.

There will be minimal impact on the reptile and amphibian fauna. Virtually all species in this group require an aquatic edge habitat. None of these types of habitats will be disrupted with the exception of the small stock pond. Since this pond has been used as an active stock pond, it is unlikely that it is colonized by any unique species. These species would require virtually an undisturbed aquatic edge that would have extensive plant growth around its borders.

Newcombe (ref. 30) has reported on the effects of underground shock on terrestrial organisms and indicated that some damage occurs to soil invertebrates with very slight soil movement. The effect is chiefly abrasive, a result of the soil particles moving over the organism's body surface. However, due to the nature of the life cycles of these organisms, the effects are expected to be transitory.

c. Avian Fauna

The anticipated impact on the avian fauna is related to three factors: the actual habitat destruction associated with the test, the timing of the tests as related to the changing bird life and the phenomenon involved with the scheduled explosions.

Construction activities in the immediate test area will result in the physical disruption of the habitat. The habitat destruction will be minimal and confined to previously active farmland (seeded hay meadow, winter wheat, and grain sorghum). The dominant species of this habitat, the Eastern Meadowlark and Dickcissel, will be temporarily displaced to other nearby suitable habitat. Both species were noted as being very abundant throughout the general area. The only other species observed in this habitat was the Horned Lark. Test site construction activities will be similar to common farming practices normally experienced in the area. When the habitat is restored after the test series it should compare favorably with its pretest condition. The increased activity associated with the construction will be confined to the area immediately around the test site and should therefore have a minimal impact on the surrounding bird life. Although on a larger scale the activity will be similar to normal farming or lumbering operations now present in the area.

The proposed tests are to occur in September 1974, November 1974, and July 1975. This will encompass portions of the migratory, wintering, and nesting seasons.

The effects on migratory species will be minimal. Activities and preparations around the test site should discourage most species from using the immediate area. The threshold of lethality for birds in flight is 10 to 30 psi (ref. 16). In the proposed tests this pressure will occur only very close to the site of detonation (the calculated pressure in the largest test is only 3 psi at 51 feet). Possible injury resulting from ejecta is also minimal. The calculated ejecta from the largest test is predicted to range from 500 to 1450 feet and the particle size is expected to decrease with increasing range from the crater.

The noise associated with the blast will be the most notable effect experienced by the surrounding birds. This may be anticipated to have a startling or unpleasant effect to the nearby bird population. A 162 dB level is calculated at 380 feet from the largest test. Such a sound level, although not physically harmful, will induce tinnitus or ringing in the ears. A noise comparable to a "thunder sound" of 130 dB will be experienced at 9200 feet from the largest event. This sudden noise will undoubtedly startle all fauna within range but the effects may be considered minimal and transitory, particularly for migratory or wintering species.

The July test will occur during a part of the normal nesting season. Egg dates for birds actually observed or possibly breeding in the area are listed in appendix C. Although the egg dates for several species extend into July and in some cases occur as late as September, the majority of nesting occurs during May and June. Most nesting and rearing of young therefore will have been completed before the July test so adverse impact at this time will be generally avoided.

Additionally, in a study conducted by Teer and Truett (ref. 49) on the effects of sonic booms on birds it was determined that sonic disturbance had no effect on bird reproduction in both field and laboratory tests.

The environmental impact of the explosion phenomenon is detailed in the assessment and summarized in table 8. As indicated in the table, the serious effects of the blasts will be confined to the immediate area.

The impact on the Marais des Cygnes Waterfowl Management Area will be limited to the noise associated with the blast. The nearest portion of the Waterfowl Management Area is approximately 1.25 miles to the southwest (Unit "C"). This area is primarily low timber and upland cover and is generally poor waterfowl habitat with the possible exception of the included segment of the Marais des Cygnes River. The nearest water area within the Waterfowl Management Area is Unit "A" about 2 miles directly west of the test site. At these distances the noise associated with the blast may startle the waterfowl in the area but will not cause any lasting physical effects.

The greatest waterfowl usage on the Management Area is during the migratory and wintering seasons that extend from November through March. Although some migration occurs as early as August large numbers do not normally occur until November. Some waterfowl do breed in the area, primarily Wood Ducks that are confined to the wooded areas adjacent to water. With the possible exception of the November test, waterfowl usage during the test series will be minimal.

d. Flora

Very little native vegetation, if any, will be destroyed as a result of construction or tests. Most of the land that will be denuded of vegetation consists of a previously cultivated grain field and a seeded hay meadow containing

an array of forbs that are characteristic of disturbed lands. Since the topsoil will be removed from test beds and replaced after the tests, the land can be restored to its original use.

The trees in the area will not be adversely impacted. The closest trees to Event 3 are approximately 400 feet away. Tree breakage (10 percent of trees down) is estimated to occur at 3.5 psi, 39 feet from Event 3. Based on these calculations no adverse impact is expected to occur in forested areas in the vicinity of the test site.

e. Rare and Endangered Species

(1) Mammals

There will be no impact on rare and endangered mammals. Habitats that may support these animal in the vicinity of the test site will not be disturbed by activities associated with the tests. For a review of these habitats and recommendations for the species preservation see section III.

(2) Reptiles and Amphibians

There will be no impact on rare and endangered reptiles and amphibians. Although several are associated with Marais des Cygnes River System (see section V for habitat preference) they are restricted to oxbow habitats and other quiet aquatic ecosystems. These tests and construction operations will not disturb such aquatic habitats. The stock pond habitat that will be disturbed is unlikely to have any of these species since it has been used as an active cattle watering area until recently.

The Broad-headed Skink requires large dead standing trees and will not be affected by these tests. The only stand of dead trees that occurs in the area is located in the large pond southeast of the test site.

(3) Fish

Threatened fish species in Kansas are discussed in section V of this document. The species and status of each are presented in tabular form in table 4. Information concerning habitat requirements and known occurrences of threatened species indicate that no fish species in a threatened status has been documented in the proposed test area.

(4) Birds

There is no anticipated impact on rare or endangered birds that may occur in the area. As indicated earlier, potentially hazardous effects associated with the tests will be confined to the immediate test site. The Bald Eagle, Osprey, and Red-shouldered Hawk are all known to occur in the general area but their habitat preferences should keep them at a safe distance from the blast. Of these three species only the Red-shouldered Hawk breeds in the area. It prefers moist deep woods, swamps and river timber. Egg laying and hatching generally occurs early in the season with most activity completed before June (ref. 50).

All other species of concern do not prefer any of the habitats close to the test site, consequently, little danger is anticipated.

2. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED ACTION BE IMPLEMENTED

The most significant adverse effect of the tests will be the generation of ground and air shock waves accompanying the noise of the explosion. The adverse effect will be comprised of (1) minor disturbance of fauna in the area; (2) shifting of soil strata; (3) deposition of ejecta in the small stock pond, and (4) minor disturbances of the river and pond bottoms.

The effects listed above are predicted to be minimal and transitory. Additionally, some birds and small mammals in the immediate test area may be displaced to nearby suitable habitats.

3. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This short-term use of a small portion of the environment will not adversely affect the long-term productivity of man's environment. Restoration of the disturbed area and reseedling of the cultivated crops in the fields will essentially return the area to its pretest condition ecologically.

4. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

Some loss of natural resources will occur in the form of reduced animal activity and disruption of the ecosystem in the area as a result of the tests. These effects are predicted to be transitory and minimal.

APPENDIX A

CHECKLIST OF MAMMALS

CHECKLIST OF MAMMALS

Common Name	Scientific Name	Habitat and Distribution
Opossum	<i>Didelphis marsupialis virginianus</i>	This species is nocturnal and prefers timbered and brushy areas. <u>Range:</u> Statewide.
Short-tailed Shrew	<i>Blarina brevicauda</i>	This animal lives on the ground and in shallow burrows of wooded or brushy areas. <u>Range:</u> Eastern Kansas
Little Short-tailed Shrew	<i>Cryptotis parva</i>	This shrew uses runways of burrows of mice and makes burrows of its own in leaf mold of the topsoil. <u>Range:</u> Statewide.
Eastern Mole	<i>Scalopus aquaticus macrinoides</i>	This mole may be found along streams; prefers moist sandy loam; lawns, golf courses, gardens, fields, meadows. <u>Range:</u> Statewide
Eastern Cottontail	<i>Sylvilagus floridanus mearnsi</i>	These animals may be found in heavy brush. Strips of forest with open areas nearby, edges of swamps, weed patches. <u>Range:</u> Statewide.
Black-tailed Jack Rabbit	<i>Lepus californicus</i>	This species avoids timber and prefers open grassland. <u>Range:</u> Statewide.
Gray Squirrel	<i>Sciurus carolinensis</i>	This species occurs in remaining stands of oak-hickory woods. <u>Range:</u> Eastern part of state.

Common Name	Scientific Name	Habitat and Distribution
Fox Squirrel	<i>Sciurus niger</i>	In Kansas this is the common tree squirrel. Spends a lot of time on ground searching for food; nuts are a common part of its diet. <u>Range:</u> Statewide; more dense in east.
Woodchuck	<i>Marmota monax</i>	The habitat of this animal is open woods, brushy and rocky ravines. Mating occurs in March and April. They eat green plants. <u>Range:</u> Eastern fourth of state.
Thirteen-Lined Ground Squirrel	<i>Spermophilus tridecemlineatus</i>	Occurs in native prairies and closely mowed grasses. Individuals live a solitary existence. <u>Range:</u> Statewide.
Franklin's Ground Squirrel	<i>Spermophilus franklinii</i>	Found in fairly tall grass or herbs, borders of fields, open woods, and edges of marshes. <u>Range:</u> Eastern half of state.
Eastern Chipmunk	<i>Tamias striatus venustus</i>	Stone fences and hedges in timber that is dense enough to prevent the growth of much grass, where there is hazel brush and some kind of nut-bearing trees make up the preferred habitat. The animal eats nuts, acorns, berries, other wild seeds, and some insects. This chipmunk is absent from most areas in eastern Kansas where the species formerly occurred. The grazing of cattle is thought to have caused their disappearance. <u>Range:</u> Eastern one-fourth of state.

Common Name	Scientific Name	Habitat and Distribution
Southern Flying Squirrel	<i>Glaucomys volans</i>	Occurs in woodlots and forests of deciduous or mixed deciduous-coniferous trees. <u>Range:</u> Eastern fourth of state.
Beaver	<i>Castor canadensis</i>	Found in the area of streams and lakes with trees or alders on banks. <u>Range:</u> Statewide
Fulvous Harvest Mouse	<i>Reithrodontomys fulvescens</i>	This mouse has been taken in lowlands along streams where areas of grass alternate with areas of brush. <u>Range:</u> Southeast corner of state.
Deer Mouse	<i>Peromyscus maniculatus bairdii</i>	Occupies dryland grassland habitat. <u>Range:</u> Statewide
Woods Mouse	<i>Peromyscus leucopus noveboracensis</i>	Woody and brushy areas are preferred. <u>Range:</u> Most of state.
Hispid Cotton Rat	<i>Sigmodon hispidus</i>	Makes surface runways along which may be found small piles of cut grass stems. Feeds chiefly on green vegetation, also eats eggs of ground-nesting birds. <u>Range:</u> Most of state.
Eastern Wood Rat	<i>Neotoma floridana osagensis</i>	In eastern Kansas it favors the crevices and slitlike caves in outcropping ledges of limestone where brush and trees occur. <u>Range:</u> Most of state.

Common Name	Scientific Name	Habitat and Distribution
Raccoon	<i>Procyon lotor</i>	Desires timbered and scarce timbered areas along stream and lake borders. <u>Range:</u> Statewide.
Mink	<i>Mustela vison</i>	The mink lives in and along streams; eats rodents, frogs, fish, and turtle eggs; often lives in muskrat burrows. <u>Range:</u> Statewide
Long-tailed Weasel	<i>Mustela frenata prinalina</i>	It is found in all land habitats that are near water.
Striped Skunk	<i>Mephitis mephitis aria</i>	Found in partially wooded, brushy areas. <u>Range:</u> Statewide.
Spotted Skunk	<i>Spilogale putorius</i>	Shelter is required for den sites. <u>Range:</u> Statewide.
Bobcat	<i>Lynx rufus rufus</i>	Occupies swamps and forests in east. At one time the bobcat occurred throughout the state but now is absent in most areas and rare in the others.
White-tailed Deer	<i>Odocoileus virginianus</i>	It is a creature of the edge-environment along streams. <u>Range:</u> Increasing numbers in eastern Kansas.
Southern Lemming-mouse	<i>Synaptomys cooperi</i>	Specimens have been found in, and at the edges of, marshes and bogs; and dry upland in dense stands of bluegrass and in ungrazed bluestem. <u>Range:</u> Statewide or almost so.

Common Name	Scientific Name	Habitat and Distribution
Muskrat	<i>Ondatra zibethicus cinnamominus</i>	These animals may be found by marshes, edges of ponds, lakes, and streams; cattails, rushes, water lilies, open water. <u>Range:</u> Statewide
Prairie Vole	<i>Microtus ochrogaster</i>	Usually prefers fairly dry places; open prairies; fence rows. <u>Range:</u> Statewide.
Pine Vole	<i>Microtus pinetorum</i>	Prefers a forest floor with a thick layer of duff. <u>Range:</u> Eastern third of state.
Norway Rat	<i>Rattus norvegicus</i>	Occupies creek banks, fields, houses. <u>Range:</u> Statewide.
House Mouse	<i>Mus musculus</i>	Occupies houses of man. <u>Range:</u> Statewide.
Meadow Jumping Mouse	<i>Zapus hudsonius</i>	In Kansas this species seems to occur principally where native grasslands meet woodlands. <u>Range:</u> Eastern fourth of state.
Coyote	<i>Canis latrans frustror</i>	Occupies prairies, open woodlands, brushy or boulder-stream areas. <u>Range:</u> Statewide.
Red Fox	<i>Vulpes fulva</i>	Lives where patches of timber alternate with pastures and cultivated fields. <u>Range:</u> Eastern half of state.

APPENDIX B

CHECKLIST OF AMPHIBIANS AND REPTILES

AMPHIBIANS AND REPTILES CHECKLIST

Common Name	Scientific Name	Habitat and Distribution
SALAMANDERS		
Hellbender	<i>Cryptobranchius alleganiensis</i>	The required habitat is permanent streams or rivers with several feet of water and objects on the bottom that may be used as cover. Food consists of crayfish, small fish, snails, worms, insects, and a great variety of animal refuse. Breed in fall; usually September. <u>Range:</u> Extreme southeastern corner of state.
Eastern Newt	<i>Notophthalmus viridescens</i>	Terrestrial forms live on land amongst leaves, under logs, on brush piles; sometimes at rather great distances from water. Aquatic forms are confined to either temporary or permanent pools, swamps, and other standing bodies of water. Food consists mainly of worms, insects and their larvae, tadpoles, small crustaceans, and snails. <u>Range:</u> Extreme eastern Kansas south of the Missouri River.
Spotted Salamander	<i>Ambystoma maculatum</i>	Most abundant in deciduous woods where ponds, slow streams, and temporary pools offer suitable breeding places. Food consists of earthworms, snails, slugs, spiders, and various insects. <u>Range:</u> Extreme eastern Kansas south of the Missouri River.
Narrow-mouthed Salamander	<i>Ambystoma texanum</i>	Generally found in damp regions close to ponds or pools. The winter probably is spent in crayfish holes or other holes near water. Food consists largely of earthworms but also of insects. <u>Range:</u> Eastern fourth of state.

Common Name	Scientific Name	Habitat and Distribution
Tiger Salamander	<i>Ambystoma tigrinum</i>	Ponds, temporary pools and watering tanks are habitats of the larvae and breeding adults. Nonbreeding adults may be found hidden under debris near pools of water, or at considerable distances from water in holes of crayfish and mammals. <u>Range:</u> Statewide.
Mudpuppy	<i>Necturus maculosus</i>	These salamanders are found only in streams and well-drained ponds where the water is usually 3 feet or more in depth, and where the bottom is provided with suitable cover for nesting sites. <u>Range:</u> Eastern fourth of Kansas.
TOADS AND FROGS		
American Toad	<i>Bufo terrestris</i>	They live in wooded areas where rainfall is moderately high. Hibernation occurs probably in underground burrows. They emerge in the middle of March and congregate at more or less permanent pools of water to breed. <u>Range:</u> Eastern quarter of the state.
Garden Toad	<i>Bufo woodhousii</i>	They are most abundant in long-grass and mixed-grass prairie, but also enter the periphery of wooded areas, especially in more sparsely-wooded areas and in oak-hickory associations. <u>Range:</u> Statewide.
Northern Cricket Frog	<i>Acris crepitans</i>	These frogs generally are found in low vegetation on the banks of any permanent or semi-permanent bodies of water. They emerge early in spring (late February) and remain active until late in the fall. <u>Range:</u> Statewide, except perhaps the southwestern corner.

Common Name	Scientific Name	Habitat and Distribution
Striped Chorus Frog	<i>Pseudacris nigrita</i>	The usual habitat is swampy, marshy places. Usually abundant in spring. <u>Range:</u> Eastern two-thirds of state.
Spring Peeper	<i>Hyla crucifer</i>	This species occurs in marshes, swamps, ditches, ponds, any pools (whether transient or permanent), in timbered areas and in untimbered lowlands. The breeding season is early--March 15 to March 24 in Kansas, so far as is known. <u>Range:</u> Extreme eastern Kansas.
Common Tree Frog	<i>Hyla versicolor</i>	This species is restricted to permanent wooded bodies of water, such as lakes, permanent swamps, and streams, only in water during breeding season; found in trees, on grubs or shrubs the rest of the time. <u>Range:</u> Eastern third of Kansas.
Gopher Frog	<i>Rana areolata</i>	These frogs generally are found in low meadow-land, in crayfish holes, and seldom leave the holes except in the spring, when breeding. Chorus form in temporary pools. <u>Range:</u> Southeastern fifth of state.
Bullfrog	<i>Rana catesbeiana</i>	They are restricted to permanent bodies of water such as lakes, rivers, and swamps with deep water. <u>Range:</u> Statewide.
Green Frog	<i>Rana clamitans</i>	Restricted to permanent pools or streams. Breeding habits unknown in Kansas. Elsewhere emerges in April; breeding follows much later. <u>Range:</u> Extreme eastern Kansas south of the Missouri River; recorded in the Marais des Cygnes River near Osawatomie in Miami County.

Common Name	Scientific Name	Habitat and Distribution
Pickereel Frog	<i>Rana palustris</i>	This frog frequents cold springs, permanent, clear streams, ponds, lakes, and the like where vegetation at the water's edge is sufficient for concealment. <u>Range:</u> Extreme southeastern Kansas.
Leopard Frog	<i>Rana pipiens burlingieri</i>	This frog is found in practically every roadside pool, stream, pond, lake, swamp, and river especially during the breeding season and early summer. <u>Range:</u> Statewide. This subspecies is in eastern Kansas.
Western Narrow-mouthed Frog	<i>Gastrophryne olivacea</i>	This frog is found in wooded areas, sometimes in rocky zones. Rocks are the usual cover in Kansas. <u>Range:</u> Southeastern two-thirds of the state.
TURTLES		
Common Musk Turtle	<i>Stemotherus odoratus</i>	This animal is found in sluggish or still deep waters, with mud bottoms, along river banks, in ponds, lakes, and marshes. <u>Range:</u> Southeastern part of state.
Yellow Mud Turtle	<i>Kinosternon flayescens</i>	Any mud-bottomed waters, shallow or deep, make suitable habitats for this species. It is mainly a bottom dweller, and a rather poor swimmer. <u>Range:</u> Statewide except perhaps the northeastern and northwestern corners of the state.
Common Snapping Turtle	<i>Chelydra serpentina</i>	Practically any permanent waters are inhabited by this species. Preferred habitats are mud-bottomed ponds and streams. It is a bottom dweller and a poor swimmer. <u>Range:</u> Statewide.

Common Name	Scientific Name	Habitat and Distribution
Carolina Box Turtle	<i>Terrapene carolina</i>	Fields and woods on relatively flat terrain are favored where there is normally a considerable growth of trees. <u>Range:</u> Eastern third of state, east of the Flint Hills, and south of the Kansas River.
Map Turtle	<i>Graptemys geographica</i>	The preferred habitat is a large, permanent body of water with considerable plant growth and mud bottom. Marshes, lakes, and large rivers meet this turtle's needs. Food consists almost entirely of snails and clams. <u>Range:</u> Eastern third of state.
False Map Turtle	<i>Graptemys pseudogeographica</i>	Habitat closely corresponds to the turtle above. This species is palatable to man and in parts of its range is sold on the turtle market. In Kansas it is too rare to be used frequently as food. <u>Range:</u> Eastern third of state.
Painted Turtle	<i>Chrysemys picta</i>	These turtles occupy shallow, warm waters, with some plant growth, such as ponds, jitches, streams, lakes, and still pools in rivers. The food consists of about half-and-half plant and animal material. Eggs are laid in June and early July. The turtles hibernate in mud at the bottom of the bodies of water in which they live in November and emerge in April. <u>Range:</u> Statewide.
Saw-toothed Slider	<i>Pseudemys floridana</i>	Completely aquatic, this species is at home in permanent bodies of still or slow-moving shallow water. A soft bottom and plenty of vegetation is preferred. <u>Range:</u> Southern half of eastern third of state.

Common Name	Scientific Name	Habitat and Distribution
Elegant Slider	<i>Pseudemys scripta</i>	These turtles are found in permanent bodies of water such as lakes, rivers, creeks, large ponds, and marshes. Still waters with mud bottoms are preferred. <u>Range:</u> Southeastern half of state.
Smooth Soft-shelled Turtle	<i>Apemda mutica</i>	These are typically river and stream turtles, although they are found in nonstagnant lakes. Waters with mud bottoms and aquatic vegetation are preferred. <u>Range:</u> Eastern two-thirds of state.
Spiny Soft-shelled Turtle	<i>Amyda ferox</i>	Rivers and streams are the usual habitat, where soft bottoms are available. Well-drained lakes and ponds may be inhabited, but temporary waters are shunned. <u>Range:</u> Statewide.
SNAKES		
Worm Snake	<i>Carrhophis amoenus</i>	This snake is commonly found in the eastern part of the state in moist woods under stones or logs. <u>Range:</u> Eastern third of state.
Rough Green Snake	<i>Opheodrys aestivus</i>	Found in open woods, fields, and marshes. <u>Range:</u> Eastern two-fifths of state.
Smooth Green Snake	<i>Opheodrys vernalis</i>	This snake is found in relatively moist grassy situations. <u>Range:</u> Not well known, but probably statewide.
Racer	<i>Coluber constrictor</i>	A ground snake. <u>Range:</u> Statewide.

Common Name	Scientific Name	Habitat and Distribution
Pilot Black Snake	<i>Elaphe obsoleta</i>	This snake is partial to moist, wooded regions. It is largely diurnal in habit. <u>Range:</u> Eastern half of state.
Bull Snake	<i>Pituophis melanoleucus</i>	This is a terrestrial, diurnal species characteristic of plains regions. In wooded areas it occurs in open meadows, fields, and grasslands. <u>Range:</u> Statewide.
Blotched King Snake	<i>Lampropeltis calligaster</i>	This snake is nocturnal. They are most frequently found wandering about at night in open fields, along roads, about pastures, or near barns. <u>Range:</u> Statewide, except northwestern corner.
Speckled King Snake	<i>Lampropeltis getulus holbrooki</i>	Nocturnal; occurs in a rather wide variety of habitats in which ample moisture seems the most characteristic feature. <u>Range:</u> Probably statewide.
Red King Snake	<i>Lampropeltis triangulum sspila</i>	Nocturnal; occurs in a wide variety of habitats. It burrows and is frequently found in plowing. <u>Range:</u> Statewide.
Plains Ground Snake	<i>Sonora spisaopa</i>	Characteristic of plains; found most frequently under stones and other surface debris on sides and crests of grassy hills. Nocturnal. <u>Range:</u> Southern half of state.
Yellow-bellied Water Snake	<i>Natrix erythrogaster</i>	Almost any permanent stream, river, or lake harbors this species. It is nocturnal. <u>Range:</u> Southeastern half of state.

Common Name	Scientific Name	Habitat and Distribution
Graham Water Snake	<i>Natrix grahami</i>	Probably found near ponds and streams. It is noted to feed on crayfish and live in their holes. <u>Range:</u> Eastern half of state.
Diamond-backed Water Snake	<i>Natrix rhombifera</i>	Nocturnal water snake. <u>Range:</u> Southeastern half of state.
Ribbon Snake	<i>Thamnophis sauritus</i>	This species is more often confined to the immediate vicinity of more or less permanent bodies of water than any other species of garter snake in the state. <u>Range:</u> Statewide.
Common Garter Snake	<i>Thamnophis ordinatus</i>	One of the most ubiquitous snakes of this state. It is found in greater abundance in aquatic habitats but also found elsewhere. <u>Range:</u> Statewide.
Lined Snake	<i>Tropidoclonion lineatum</i>	May be found emerging in the day from hiding places under stones, logs, rocks, fences, and other cover on the surface of the ground. May be nocturnal or diurnal. <u>Range:</u> All except western border of state.
Copperhead Snake	<i>Ancistrodon contortrix</i>	This species is found in wooded areas, generally on hillsides where rock is exposed. The snake is partial to the moist eastern part of the state, avoiding the drier western portions. Extremely heavy woods are not inhabited. <u>Range:</u> Eastern third of state.
Massasauga	<i>Sistrurus catenatus</i>	Characteristically found in swampy places except in summer when they may move into drier situations. <u>Range:</u> Throughout state except northwestern quarter.

Common Name	Scientific Name	Habitat and Distribution
Timber Rattlesnake	<i>Crotalus horridus</i>	Usually found in wooded hills where there is a limestone outcrop. In summer they probably wander away from the hills into adjacent open valleys and plains. <u>Range:</u> Northeastern sixth of state.
Common Water Snake	<i>Natrix sipedon</i>	Probably the most ubiquitous species of water snakes in the state. It is the species commonly found about streams, rivers, marshes, permanent ponds, and lakes. <u>Range:</u> Statewide except for extreme southwestern corner.
De Kay Snake	<i>Storeria dekayi</i>	This species is nocturnal and frequents moist situations, generally under rocks, logs, or other cover in creek beds and in woods. <u>Range:</u> Eastern two-thirds of state.
Red-bellied Snake	<i>Storeria occipitomaculata</i>	Restricted to moist areas, where it is found under boards, stones, logs, and other surface debris. <u>Range:</u> Eastern fifth of state.
Western Ground Snake	<i>Haldea valeriae</i>	These are nocturnal, terrestrial snakes which live in wooded areas where they hide beneath stones, logs, and other surface cover. <u>Range:</u> Southeastern quarter of state.
Plains Garter Snake	<i>Thamnophis radix</i>	Characteristic of the plains, where it is found most abundantly in marshy or swampy areas, along streams or other bodies of water. <u>Range:</u> Statewide.

Common Name	Scientific Name	Habitat and Distribution
LIZARDS		
Brown Skink	<i>Scincella laterale</i>	These skinks are found in wooded areas on the ground among leaves and other debris; moist places, frequently near streams are preferred. <u>Range:</u> Eastern third of state.
Coal Skink	<i>Eumeces anthracinus</i>	Typically this skink is found on wooded hill-sides in rotten logs, piles of debris, and under loose stones; in moist areas fairly near water. <u>Range:</u> Southeastern fifth of state.
Common Five-lined Skink	<i>Eumeces fasciatus</i>	This species is commonly found in wooded areas, usually on the ground, under stones, in piles of leaves and in rotten logs. A moist but not wet environment is preferred. <u>Range:</u> Eastern third of the state.
Glass-snake Lizard	<i>Ophisaurus attenuatus</i>	These lizards are found on the ground in moist, grassy open areas in wooded regions. <u>Range:</u> Eastern half of the state.

APPENDIX C
CHECKLIST OF BIRDS

The following list summarizes the resident and migratory avian fauna most likely to occur in the vicinity of the test area. The species that were actually observed during the period of this assessment are indicated by an asterisk. All others were chosen based on previous reports, inclusion within a general range or presence of suitable habitat.

Egg dates when listed indicate probable nesting of the species within the state. The dates give the range of times that eggs have been found for a particular species. The date in parentheses indicates the date on which most egg laying has occurred.

Migration dates indicate the range of times for spring arrival or autumn departure. The date in parentheses indicates the median date prior to and after which an equal number of first yearly records were secured.

SUMMARY OF OBSERVED AND POTENTIAL AVIAN FAUNA

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Pied-billed Grebe	<i>Podilymbus podiceps</i>	Marshes, ponds, lakes, ditches, and rivers	1 May-30 Jun (15 May)	1 Mar-13 Apr (21 Mar) 13 Nov-18 Nov (24 Oct)	Common transient and local summer resident (refs. 44, 52)
White Pelican	<i>Pelecanus erythrorhynchos</i>	Water areas	---	25 Mar-27 Apr (8 Apr) 24 Sep-22 Nov (13 Oct)	Common transient (refs. 44, 51, 52)
Double-crested Cormorant	<i>Phalacrocorax auritus</i>	Lakes and rivers	Late Apr-May	21 Feb-24 May (26 Apr) 7 Sep-15 Dec (7 Oct)	(refs. 44, 51, 52)
*Great Blue Heron	<i>Ardea herodias</i>	Water areas	1 Mar-30 Apr (5 Apr)	4 Feb-8 Apr (20 Mar) 10 Oct-29 Nov (23 Oct)	Common (refs. 44, 52, 55)
Green Heron	<i>Butorides virescens</i>	Water areas	21 Apr-20 Jun (5 May)	29 Mar-1 May (27 Apr) 1 Sep-30 Oct (9 Sep)	(refs. 44, 52, 55)
*Little Blue Heron	<i>Florida caerulea</i>	Water areas	---	---	Recorded Apr, May, Jul, Aug, and Sep (refs. 44, 52, 55)
Snowy Egret	<i>Leucophoyx thula</i>	Water areas	---	---	Recorded late Mar to Oct (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Canada Goose	<i>Branta canadensis</i>	Water areas and grassland	May - Jun	16 Apr-13 May (29 Apr) 18 Sep-18 Oct (10 Oct)	Recorded nesting in Marais des Cygnes Waterfowl Management Area (refs. 44, 51, 52)
White-fronted Goose	<i>Anser albifrons</i>	Wetlands and Prairies	---	8 Apr-12 Jun (17 Apr) 24 Sep-12 Oct (4 Oct)	Common transient (refs. 44, 51, 52)
Snow Goose	<i>Chen caerulescens</i>	Wetlands and Prairies	---	29 Apr-11 May (3 May) 2 Oct-21 Oct (11 Oct)	Common transient (refs. 44, 51, 52)
Mallard	<i>Anas platyrhynchos</i>	Wetlands	1 Apr-10 Jun (5 May)	---	Common transient and winter resident, local summer resident. Nesting records Marais des Cygnes WMA (refs. 44, 51, 52, 55)
Black Duck	<i>Anas rubripes</i>	Wetlands	---	---	Recorded 29 Sep-8 May. Uncommon transient and winter resident (refs. 44, 51, 52)
Gadwall	<i>Anas strepera</i>	Wetlands	---	---	Common transient, uncommon winter resident (refs. 44, 51, 52)
Pintail	<i>Anas acuta</i>	Wetlands	21 Apr-10 Jun (5 May)	---	Most abundant Sep-May (refs. 44, 51, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Green-winged Teal	<i>Anas carolinensis</i>	Wetlands	---	10 May-11 Jun (25 May) 30 Aug-1 Oct (24 Sep)	Common transient (refs. 44, 51, 52)
Blue-winged Teal	<i>Anas discors</i>	Wetlands	1 May-20 Jun (15 May)	9 Mar-5 Apr (23 Mar) 7 Oct-26 Nov (20 Oct)	Common transient Local summer resident (refs. 44, 51, 52)
Shoveler	<i>Spatula clypeata</i>	Wetlands	---	14 Feb-26 Mar (9 Mar) 15 Oct-17 Nov (7 Nov)	Common transient (refs. 44, 51, 52)
American Widgeon	<i>Mareca americana</i>	Wetlands	---	1 May-10 Jun (21 May) 1 Oct-27 Oct (22 Oct)	Common transient (refs. 44, 51, 52)
*Wood Duck	<i>Aix sponsa</i>	Wooded Wetlands	21 Mar-10 May (mid-Apr)	---	Recorded 5 Mar to 8 Dec. Most numerous in Oct. Nests in Marais des Cygnes WMA. (refs. 44, 51, 52, 55)
Ring-necked Duck	<i>Aythya collaris</i>	Wetlands	---	Chiefly present 11 Feb-10 Mar 23 Oct-14 Nov	Uncommon transient (refs. 44, 51, 52)
Lesser Scaup	<i>Aythya affinis</i>	Wetlands	---	7 May-19 Jun (27 May) 4 Sep-29 Oct (18 Oct)	Common transient (refs. 44, 51, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, Reference:
Common Goldeneye	<i>Bucephala clangula</i>	Wetlands	---	---	Recorded 8 Nov-8 May. Uncommon transient. (refs. 44, 51, 52)
Common Merganser	<i>Mergus merganser</i>	Wetlands	---	20 Apr-9 May (30 Apr) 21 Oct-18 Nov (11 Nov)	Common transient and winter resident. (refs. 44, 51, 52)
*Turkey Vulture	<i>Cathartes aura</i>	Varied	21 Apr-10 Jun (1 May)	7 Mar-30 Mar (15 Mar) 24 Sep-28 Oct (5 Oct)	Common transient, regular summer resident throughout state. (refs. 44, 52)
Sharp-shinned Hawk	<i>Accipiter striatus</i>	Woodlands	April	---	Most evident Sep and Jan through May (refs. 44, 52, 54)
Cooper Hawk	<i>Accipiter cooperii</i>	Woodlands	21 Mar-30 May (25 Apr)	---	Uncommon resident (refs. 44, 52, 54)
*Red-tailed Hawk	<i>Buteo jamaicensis</i>	Grasslands and edge	21 Feb-10 Apr (5 Mar)	---	Common resident (refs. 44, 52, 54)
Red-shouldered Hawk	<i>Buteo lineatus</i>	Riparian habitats	---	10 Feb-14 Mar (26 Feb) Oct-Dec	Uncommon resident and transient. (refs. 44, 54)
Swainson Hawk	<i>Buteo swainsoni</i>	Grasslands	11 Apr-10 Jun (25 Apr)	10 Mar-28 Apr (12 Apr) 5 Oct-2 Nov (12 Oct)	(refs. 44, 54)
Rough-legged Hawk	<i>Buteo lagopus</i>	Grasslands	---	---	Recorded 21 Sep-8 Apr. Common winter resident chiefly west (refs. 44, 52, 54)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Golden Eagle	<i>Aquila chrysaetos</i>	Grasslands	---	---	Recorded 28 Oct-19 Jun Winter visitor at Marais des Cygnes WMA (refs. 44, 51, 52)
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Around lakes and marshes	---	---	Occurs 17 Oct-4 May, transient and local winter resident at Marais des Cygnes WMA (refs. 51, 52)
Marsh Hawk	<i>Circus cyaneus</i>	Marshes and open fields	11 Apr-20 May (5 May)	---	Common transient and resident (refs. 44, 52, 54)
Osprey	<i>Pandion haliaetus</i>	Around lakes, marshes and rivers	---	---	Uncommon transient and winter resident. Occurs most frequently in Apr, May, Sep, Oct. (refs. 44, 52)
Sparrow Hawk	<i>Falco sparverius</i>	Open woodlands	21 Mar-20 May (10 Apr)	---	Common resident and transient (refs. 44, 52, 54)
*Bobwhite	<i>Colinus virginianus</i>	Open and broken woodlands	1 May-20 Sep (25 May)	---	Common resident (refs. 44, 52)
Turkey	<i>Meleagris gallopavo</i>	Flood plain woodland	---	---	Reintroduced into Marais des Cygnes WMA (ref. 44)
Virginia Rail	<i>Rallus limicola</i>	Marsh	May-Jun	19 Apr-18 May 1 Sep-30 Oct	Common transient (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Sora Rail	<i>Porzana carolina</i>	Marsh	May-Aug	11 Apr-9 May (1 May) 30 Sep-9 Nov (18 Oct)	Common transient, local summer resident (refs. 44, 52)
American Coot	<i>Fulica americana</i>	Marsh and ponds	11 May-30 Jun (25 May)	---	Common transient, local summer resident (refs. 44, 51, 52, 55)
*Killdeer	<i>Charadrius vociferus</i>	Meadowland, pond margins	21 Mar-30 Jun (20 May)	---	Present early Feb- early Dec. Common summer resident. (refs. 44, 52)
Spotted Sandpiper	<i>Actitis macularia</i>	Water edges	May	29 Mar-30 Apr (24 Apr) 2 Sep-10 Oct (18 Sep)	(refs. 44, 52)
Solitary Sandpiper	<i>Tringa solitaria</i>	Near water	---	28 Mar-24 May (5 May) 9 Jul-5 Oct (15 Aug)	Common transient (refs. 44, 52, 55)
Greater Yellowlegs	<i>Totanus melanoleucus</i>	On and near wetlands	---	14 Mar-12 Apr (26 Mar) 7 Oct-22 Nov (15 Oct)	Common transient (refs. 44, 52)
Lesser Yellowlegs	<i>Totanus flavipes</i>	On and near wetlands	---	15 Mar-18 Apr (4 Apr) 24 Sep-8 Nov (11 Oct)	Common transient (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Pectoral Sandpiper	<i>Erolia melanotos</i>	Near wetlands	---	14 Mar-31 Mar (25 Mar) 16 Sep-28 Oct (19 Sep)	Common transient (refs. 44, 52)
Least Sandpiper	<i>Erolia minutilla</i>	Around wetlands	---	28 Mar-9 May (1 May) 22 Sep-29 Oct (17 Oct)	Common transient (refs. 44, 52)
Lung-billed Dowitcher	<i>Limodromus scolopaceus</i>	Around wetlands	---	10 Mar-21 Apr (16 Apr) 1 Oct-2 Nov (17 Oct)	Common transient (refs. 44, 52)
Semipalmated Sandpiper	<i>Ereunetes pusillus</i>	Wetlands	---	14 Mar-22 Apr (19 Apr) 5 Sep-21 Oct (28 Sep)	Common transient (refs. 44, 52)
Wilson Phalarope	<i>Steganopus tricolor</i>	Marshes, ponds	21 May-20 Jun (5 Jun)	2 Apr-29 Apr (24 Apr) 5 Sep-14 Oct (30 Sep)	Common transient (refs. 44, 52)
Ring-billed Gull	<i>Larus delawarensis</i>	Near wetlands, recently plowed fields	---	17 Feb-16 Mar (8 Mar) 17 Oct-18 Nov (6 Nov)	Locally common transient (refs. 44, 52)
Franklin's Gull	<i>Larus pipixcan</i>	Near wetlands, recently plowed fields	---	1 Apr-27 Apr (13 Apr) 13 Oct-17 Nov (25 Oct)	Common transient (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Black Tern	<i>Chlidonias niger</i>	Wetlands	11 Jun-20 Jul	30 Apr-29 May (14 May) 2 Sep-30 Sep (11 Sep)	Common transient, local summer resident (refs. 44, 52)
*Mourning Dove	<i>Zenaidura macroura</i>	Open and edge habitats	21 Mar-10 Aug (5 May)	---	Most abundant Mar-Nov. Common transient and summer resident (refs. 44, 52, 53)
*Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	Heavy riparian shrubby and second growth	11 May-10 Sep (5 Jun)	29 Apr-22 May (12 May) 13 Sep-12 Oct (23 Sep)	Common transient and summer resident (refs. 44, 52)
Great Horned Owl	<i>Bubo virginianus</i>	Woodland	11 Jan-20 Mar (10 Feb)	---	Common resident (refs. 44, 52)
Barred Owl	<i>Strix varia</i>	Woodland	March	---	Local resident in heavy woodland in east. (ref. 44)
Common Nighthawk	<i>Chordeiles minor</i>	Woodland	11 May-30 Jun (10 Jun)	29 Apr-23 May (15 May) 13 Sep-25 Oct (23 Sep)	Common summer resident throughout state (refs. 44, 52)
Chimney Swift	<i>Chaetura pelagica</i>	Crimneys	11 May-30 Jun (25 May)	2 Apr-30 Apr (22 Apr) 18 Sep-30 Oct (4 Oct)	Common summer resident in east. (refs. 44, 52, 53)
Belted Kingfisher	<i>Megasceryle alcyon</i>	Near water	21 Apr-20 May	---	Greatest numbers Mar- Nov. (refs. 44, 52, 55)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
*Yellow-shafted Flicker	<i>Colaptes auratus</i>	Open woodlands	11 Apr-10 Jun (10 May)	---	Common resident in east. (refs. 44, 52, 53, 54)
*Red-bellied Woodpecker	<i>Centurus carolinus</i>	Woodland	1 Mar-30 Jun (25 Apr)	---	Common resident in east. (refs. 44, 52, 54)
*Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	Open woodland	1 May-10 Aug (5 Jun)	---	Common summer resident throughout, local winter resident in east. (refs. 44, 52, 54)
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	Woodlands	---	28 Sep-14 Nov (1 Oct) 6 Apr-24 Apr (12 Apr)	Uncommon transient (refs. 44, 52, 54)
Hairy Woodpecker	<i>Dendrocopos villosus</i>	Woodlands	21 Mar-30 May (5 May)	---	(refs. 44, 52)
*Downey Woodpecker	<i>Dendrocopos pubescens</i>	Woodlands	11 Apr-10 Jun (5 May)	---	Common resident (refs. 44, 52, 54)
*Eastern Kingbird	<i>Tyrannus tyrannus</i>	Open country and woodland edge	11 May-20 Jul (15 Jun)	22 Apr-30 Apr (28 Apr) 1 Sep-24 Sep (13 Sep)	Common transient and summer resident. (refs. 44, 52, 53)
Great Crested Flycatcher	<i>Myiarchus cineritus</i>	Woodland and edge	11 May-10 Jul (5 Jun)	15 Apr-4 May (29 Apr) 1 Sep-21 Sep (9 Sep)	Common transient and summer resident. (refs. 44, 52, 53)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Eastern Phoebe	<i>Sayornis phoebe</i>	Woodland edge	21 Mar-20 Jul (25 Apr; 5 Jun)	3 Mar-31 Mar (22 Mar) 3 Oct-27 Oct (9 Oct)	Common transient and summer resident. (refs. 44, 52)
Empidonax Flycatchers	<i>Empidonax</i> spp.	Woodlands	May-July	---	Variable transients and summer residents (refs. 44, 52)
Eastern Wood Pewee	<i>Contopus virens</i>	Woodland and edge	1 Jun-20 Jul (15 Jun)	2 Apr-28 May (19 May) 30 Aug-18 Sep (6 Sep)	Common transient and summer resident in east. (refs. 44, 52)
*Horned Lark	<i>Eremophila alpestris</i>	Open country with short vegetation	11 Mar-10 Jun (25 May)	---	Common resident, transient and winter resident (refs. 44, 52, 53)
Tree Swallow	<i>Iridoprocne bicolor</i>	Open woodland	21 May-20 Jun (25 May)	5 Apr-30 Apr (24 Apr) 3 Sep-21 Oct (8 Oct)	Common transient east, local summer resident. (refs. 44, 52)
*Barn Swallow	<i>Hirundo rustica</i>	Around buildings	1 May-10 Aug (15 May south) (25 May north)	31 Mar-29 Apr (21 Apr) 22 Sep-25 Oct (7 Oct)	Common transient and summer resident. (refs. 44, 52)
*Blue Jay	<i>Cyanocitta cristata</i>	Woodlands	10 Apr-10 Jul (15 May)	---	Common resident and transient (refs. 44, 52, 53)
*Common Crow	<i>Corvus brachyrhynchos</i>	Woodland and open	10 Mar-31 Mar (5 Apr)	---	Common resident, transient. (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
*Black-capped Chickadee	<i>Parus atricapillus</i>	Woodland	21 Mar-10 Jun (15 Apr)	---	Common resident (refs. 44, 52)
*Tufted Titmouse	<i>Parus bicolor</i>	Woodland	21 Mar-10 Jun (25 Apr)	---	Common resident (refs. 44, 52, 53)
White-breasted Nuthatch	<i>Sitta carolinensis</i>	Often oak woodlands	May-Apr	---	Low density resident and winter visitor (refs. 44, 52)
House Wren	<i>Troglodytes aedon</i>	Woodlands and towns	11 Apr-31 Jul (20 May)	3 Apr-27 Apr (19 Apr) 19 Sep-13 Oct (30 Sep)	Common summer resident (refs. 44, 52, 53)
Carolina wren	<i>Thryothorus ludovicianus</i>	Edge habitats	11 Apr-10 Aug (15 Apr)	---	Common resident south (refs. 44, 52, 53)
*Catbird	<i>Dumetella carolinensis</i>	Woodland and second growth	11 May-31 Jul (25 May)	25 Apr-14 May (6 May) 20 Sep-16 Nov (26 Sep)	Common transient and summer resident. (refs. 44, 52, 53)
*Brown Thrasher	<i>Toxostoma rufum</i>	Woodland and second growth	1 May-20 Jul (15 May)	1 Apr-25 Apr (19 Apr) 19 Sep-13 Oct (28 Sep)	Common transient and summer resident. (refs. 44, 52, 53)
*Robin	<i>Turdus migratorius</i>	Open woodland	1 Apr-20 Jul (25 Apr)	March October	Common transient and summer resident (refs. 44, 52)
Swainson's Thrush	<i>Hylocichla ustulata</i>	Woodland under-story and edge	---	23 Apr-30 Apr (27 Apr) 3 Sep-13 Sep (9 Sep)	Common transient (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Gray-cheeked Thrush	<i>Hylocichla minima</i>	Woodland under-story and edge	---	11 Apr-30 Apr (27 Apr) Not recorded autumn	Medium density transient in east. (refs. 44, 52)
Eastern Bluebird	<i>Sialia sialis</i>	Woodland edge	1 Apr-20 Jul (25 Apr)	---	Common resident (refs. 44, 52, 53)
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>	Woodland and edge	20 Apr-20 Jun (10 May)	---	Present 30 Mar-13 Sep. Common transient and summer resident east. (refs. 44, 52)
Golden-crowned Kinglet	<i>Regulus satrapa</i>	Woodland	---	31 Mar-16 Apr (6 Apr) 8 Oct-22 Oct (13 Oct)	Common transient (refs. 44, 52)
*Loggerhead Shrike	<i>Lanius ludovicianus</i>	Open and edge habitats	1 Apr-30 Jun (15 Apr)	9 Mar-31 Mar (21 Mar) 19 Oct-19 Dec (1 Nov)	Common resident and transient. (refs. 44, 52)
Starling	<i>Sturnus vulgaris</i>	Near towns and farms	1 Mar-30 Jun (15 Apr)	---	Common resident (refs. 44, 52)
Bell's Vireo	<i>Vireo bellii</i>	Riparian and second growth	1 May-20 Jul (25 May)	14 Apr-20 May (8 May) 26 Aug-27 Sep (6 Sep)	Common transient and summer resident. (refs. 44, 52)
Red-eyed Vireo	<i>Vireo olivaceus</i>	Woodlands	21 May-31 Jul (5 Jun)	16 Apr-10 May (4 May) 2 Sep-7 Oct (10 Sep)	Common transient and summer resident. (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Wartling Vireo	<i>Vireo gilvus</i>	Woodlands	1 May-20 Jun (5 Jun)	15 Apr-9 May 2 Sep-6 Oct (9 Sep)	Common transient and summer resident. (refs. 44, 52)
Prothonotary Warbler	<i>Protonotaria citrea</i>	Understory of riparian or swampy woodland	11 May-10 Jul (5 Jun)	24 Apr-25 May (8 May) 6 Aug-10 Sep (22 Aug)	Local transient and summer resident east. (refs. 44, 52)
Orange-crowned Warbler	<i>Vermivora celata</i>	Woodlands	---	14 Apr-17 May 10 Sep-19 Oct	Common transient, inconspicuous winter resident. (refs. 44, 52)
Nashville Warbler	<i>Vermivora ruficapilla</i>	Woodlands and second growth	---	25 Apr-17 May 29 Aug-22 Sep (3 Sep)	Common transient (refs. 44, 52)
Parula Warbler	<i>Parula americana</i>	Woodland	Mid-May- mid-Jun	31 Mar-5 May (23 Apr) 12 Sep-7 Oct (18 Sep)	Common transient and summer resident east. (refs. 44, 52)
Yellow Warbler	<i>Dendroica petechia</i>	Woodland and riparian groves	11 May-20 Jun (25 May)	21 Apr-7 May (30 Apr) 28 Aug-1 Oct (4 Sep)	Common transient and summer resident. (refs. 44, 52)
Baltimore Oriole	<i>Icterus galbula</i>	Woodlands	11 May-10 Jul (5 Jun)	18 Apr-5 May (28 Apr) 6 Sep-19 Sep (10 Sep)	Common transient and summer resident east. (refs. 44, 52)
Rusty Blackbird	<i>Euphagus carolinus</i>	Fields and marshes	---	23 Sep-11 Oct (4 Oct) 13 Mar-19 Apr (12 Apr)	Transient and local winter resident east. (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
*Common Grackle	<i>Quiscalus quiscula</i>	Edge habitats	11 Apr-30 Jun (5 May)	2 Mar-27 Mar (17 Mar) 15 Oct-14 Nov (31 Oct)	Common transient and summer resident. (refs. 44, 52)
*Brown-headed Cowbird	<i>Molothrus ater</i>	Woodlands and edge	6 Apr-20 Jul (15 May)	---	Common transient and summer resident. (refs. 44, 52)
*Cardinal	<i>Cardinalis cardinalis</i>	Woodlands	1 Apr-20 Sep (1 May)	---	Common resident east. (refs. 44, 52, 53)
*Indigo Bunting	<i>Passerina cyanea</i>	Woodlands	11 May-20 Aug (15 Jun)	20 Apr-15 May (6 May) 23 Aug-31 Oct (10 Oct)	Common transient and summer resident east. (refs. 44, 52)
*Dickcissel	<i>Spiza americana</i>	Woodland-grassland edge	1 May-10 Jul (5 May)	17 Apr-10 May (4 May) 7 Sep-11 Oct (18 Sep)	Common transient and summer resident. (refs. 44, 52, 53)
Myrtle Warbler	<i>Dendroica coronata</i>	Woodland	---	30 Mar-20 Apr (16 Apr) 3 Sep-4 Oct (10 Oct)	Common transient (refs. 44, 52)
Yellow Throat	<i>Geothlypis trichas</i>	Marshlands	11 May-10 Jun (1 Jun)	2 Apr-10 May (3 May) 8 Sep-3 Oct (17 Sep)	Common transient and summer resident. (refs. 44, 52)
American Redstart	<i>Setophaga ruticilla</i>	Woodlands	May-Jun	22 Apr-20 May (12 May) 1 Sep-7 Oct (10 Sep)	Common transient, local summer resident in east. (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
*House Sparrow	<i>Passer domesticus</i>	Near buildings, human activity	20 Mar-20 Jul (5 Apr)	---	Common resident (refs. 44, 52)
*Eastern Meadowlark	<i>Sturnella magna</i>	Lowland fields	10 Apr-20 Jul (5 May)	---	Common transient and summer resident. (refs. 44, 52, 53)
*Red-winged Blackbird	<i>Agelaius phoeniceus</i>	Marsh	1 May-30 Jul (25 May)	---	Common transient and summer resident. (refs. 44, 52)
Orchard Oriole	<i>Icterus spurius</i>	Woodlands	11 May-10 Aug (5 Jun)	18 Apr-14 May (2 May) 5 Aug-15 Sep (9 Aug)	Common transient and summer resident. (refs. 44, 52)
American Goldfinch	<i>Spinus tristis</i>	Woodlands and edge	20 Jun-10 Sep (5 Aug)	---	Common resident (refs. 44, 52)
Lark Sparrow	<i>Chondestes grammacus</i>	Woodland-grassland edge	1 May-20 Jul (25 May)	29 Mar-2 Apr (18 Apr) 13 Sep-16 Oct (12 Oct)	Common transient and summer resident. (refs. 44, 52)
Slate-colored Junco	<i>Junco hyemalis</i>	Woodlands	---	23 Sep-19 Oct (10 Oct) 16 Apr-2 May (20 Apr)	Common transient and winter resident. (refs. 44, 52)
Tree Sparrow	<i>Spizella arborea</i>	Woodlands	---	7 Oct-30 Oct (21 Oct) 1 Apr-14 Apr (4 Apr)	Common transient and winter resident. (refs. 44, 52)

Common Name	Scientific Name	Habitat	Egg Dates	Migration Dates	Comments, References
Field Sparrow	<i>Spizella pusilla</i>	Grasslands edge	21 Apr-10 Sep (5 May)	4 Mar-28 Apr (7 Apr) 5 Oct-12 Nov (30 Oct)	Common transient and summer resident. (refs. 44, 53)
Harris Sparrow	<i>Zonotrichia querula</i>	Understory edge of woodlands	---	3 Oct-27 Oct (15 Oct) 1 May-6 Jun (11 May)	Common transient and winter resident. (refs. 44, 52)
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>	Understory edge of woodlands	---	28 Sep-19 Oct (12 Oct) 3 May-30 May (9 May)	Common transient and winter resident. (refs. 44, 52)
Song Sparrow	<i>Melospiza melodia</i>	Heavy cover near water	---	1 Sep-22 Oct (7 Oct) 6 Apr-9 May (26 Apr)	Common transient and winter resident. Summer resident northeast. (refs. 44, 52)

APPENDIX D
CHECKLIST OF FISH

FISH OF LINN COUNTY, KANSAS

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Paddlefish (Spoonbill) Paddlefish	Family Polyodontidae <i>Polyodon spathula</i>	No	Confined to the Missouri River, lower main-streams of the Kansas, Marais des Cygnes, and Arkansas Rivers. Spawning occurs in mid-stream, over submerged gravel, when the river is high and muddy in the spring, approximately 60°F. Large pools having silty bottoms are the principal feeding areas of paddlefish. Occurrence is on the border of Linn County.
Gars Short-Nosed Gar	Family Lepisosteidae <i>Lepisosteus platostomus</i>	10	Mainstreams of the Blue, Kansas, Marais des Cygnes, Neosho, and Arkansas Rivers. Feeds mostly upon small crustaceans and the fry of other fishes. Spawning in May and June, in vegetation or over silt-free rocky bottoms in calm water. Gars eat mainly other fish. Important in predatory function to reduce surplus production of prey species.
Bowfin Bowfin	Family Amiidae <i>Amia calva</i>	No	Records are from before 1915. All other evidences that the Bowfin still exists in Kansas are unsubstantiated.
Shads Gizzard Shad	Family Clupeidae <i>Dorosoma cepedianum</i>	20	Large streams of eastern Kansas and reservoirs. Shad spawn pelagically, with no nest preparation, in late May; occasionally in June, July. Succumb to abrupt changes in temperature or reduction in dissolved oxygen.

Source: Cross, F. B., "Handbook of Fishes of Kansas, Musc. Pub. No. 45, University of Kansas, Museum of Natural History, 1967.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Mooneyes Goldeye	Family Hiodontidae <i>Hiodon alosoides</i>	10	Common in the lower Kansas River, scarce elsewhere. Spawn in early spring. Few records indicate use of shallow, flowing water over rocky or gravelly bottoms, shoal waters of lakes.
Minnows Carp	Family Cyprinidae <i>Cyprinus carpio</i>	20	Probably abundant in many waters since early 1900; in Marais des Cygnes also. Spawning is intermittent over the year--March to July. Eggs are scattered over vegetation in shallow water.
Golden Shiner	<i>Notemigonus crysoleucas</i>	20	More common in eastern than western Kansas. Abundance has increased in past years. Prefers deep, quiet pools and lakes. Spawns in late spring/summer; eggs are scattered in weedbeds.
Creek Chub	<i>Semotilus atromaculatus</i>	20	Kansas River Basin; small tributaries. Reproduction early in the year. Males are tuberculate in March. Males construct and guard nests. Spawn occurs when streams are at their clearest. Opportunist carnivore.
Hornyhead (Chub)	<i>Ilybopsis biguttata</i>	10	Confined to clear, permanent, rocky creeks in Kansas. Occurs widely in the Marais des Cygnes system. Range and abundance in Kansas have decreased in the last century. Spawns in late spring--May through June or as early as April. Male builds and guards nest. Siltation reduces suitable spawning areas.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Sucker-mouthed Minnow	<i>Phenacobius mirabilis</i>	20	Statewide in occurrence. Adapted for a riffle existence. Tolerant of fluctuating water levels and high turbidity. Reported in the Marais des Cygnes River in 1961. Fish is sedentary in habit. Spawn from April to August with two peak periods.
Rosy-faced Shiner	<i>Notropis rubellus</i>	20	Upland streams of Kansas, Osage, and Arkansas River Systems. Spawns between late April and early June. Schools congregate for spawning, use coarse gravel, loosely deposited and free of silt. Intolerant of continuous siltation.
Red-finned Shiner	<i>Notropis umbratilis</i>	20	Occurs in the eastern part of Kansas. Reported in the Marais des Cygnes drainage. Spawning occurs mainly in June at water temperatures of 70°F.
Red Shiner	<i>Notropis lutrensis</i>	20	One of the most abundant fish in Kansas. Least common in the clearest, most stable streams of southeastern Kansas. Spawning occurs in calm water or in shallow riffles over bottoms of fine gravel.
Sand Shiner	<i>Notropis stramineus</i>	20	One of the most common fish in Kansas. Reproduction is over a long period of time. Tuberculate males have been taken from April to August.
Ghost Shiner	<i>Notropis buchanaui</i>	20	Larger streams of eastern Kansas. Greatest abundance in Neosho, Verdigris, and Marais des Cygnes Rivers. Occupy gentle eddies; silted ends of gravel bars. Spawning is from May to mid-August.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Fat-head Minnow	<i>Pimephales promelas</i>	20	Most widespread and ubiquitous fish in Kansas--in creeks having bottoms of mud or firm clay. Spawning season is long--April to August. Eggs are attached to an object above the stream bottom and attended by the male.
Blunt-nose Minnow	<i>Pimephales notatus</i>	20	Occurs widely in Kansas, in pools of clear streams. Increases in the Marais des Cygnes River were noted in 1957-1959. Spawns from May through June; temperature higher than 70°F. Eggs are attached to underside of stones or miscellaneous materials. Male protects the nest.
Stoneroller	<i>Carpostoma anomalum</i>	20	Inhabits most small streams of Kansas and occurs in rivers. Stonerollers are tolerant of moderate siltation and turbidity. Construction of nests begins when water in the shallows reaches 60°F. Nests are in gravel bottom of moderately clear water with a deeper pool nearby.
Trout	Family Salmonidae		Reported to be variously distributed throughout the state due to stocking. Fish require water in which the temperature does not exceed 70°F.
Suckers Pig-mouth Buffalo	Family Catostomidae <i>Ictiobus cyprinellus</i>	20	Occurs in calm water in or adjacent to large, lowland rivers of eastern Kansas. Partly pelagic in nature. Spawns in the spring after runoff raises the water level. Eggs are scattered.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Black Buffalo	<i>Ictiobus niger</i>	20	Occurs in the larger rivers of eastern Kansas, in deep fast riffles.
Small-mouth Buffalo	<i>Ictiobus bubalus</i>	20	Occurs in various habitats of larger streams of eastern Kansas. Usually occurs in shallower water over firmer bottoms than big-mouth buffalo. Fish is of considerable commercial value. Lives on small bottom-dwelling organisms. No spawning information.
River Carpsucker	<i>Carpionodes carpio</i>	20	Most abundant and widely distributed sucker in Kansas. Ubiquitous occurrence. Feeds on microorganisms, mainly diatoms. Spawning season is extremely protracted--May to July or later.
Highfin Carpsucker	<i>Carpionodes velifer</i>	No	Almost extirpated in Kansas. Records for Linn County are for before 1915.
Golden Redhorse	<i>Moxostoma erythrum</i>	20	Occurs in the Marais des Cygnes drainage. Inhabits pools that drain soils of lime-origin and have a moderate to high gradient. Feeds on larval insects. Reproduction occurs in May in Kansas at 70°F over rocky bottom spawning sites.
Northern Redhorse	<i>Moxostoma macrolepidotum</i>	20	Ranges westward into the Marais des Cygnes drainages. Occurs in riffles. Spawn is from April to May in rubble- or gravel-covered bottom areas.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Northern Hogsucker	<i>Hypentelium nigricans</i>	No	Rare in Kansas; reported in the Marais des Cygnes in 1911. Spawn in April-May riffles. Siltation adversely affects.
White Sucker	<i>Catostomus commersoni</i>	20	Occurs in Kansas River Basin. Spawns in April-May, in streams in shallows over clean rocky bottoms.
Catfishes (Freshwater) Black Bullhead	Family Ictaluridae <i>Ictalurus melas</i>	20	Occurs throughout Kansas. Habitat is in areas of soft bottoms and high turbidity. Nests are usually concealed. Fish are omnivorous.
Yellow Bullhead	<i>Ictalurus natalis</i>	20	Stream fish, most common in clear, rocky bottomed water. No reproduction information.
Channel Catfish	<i>Ictalurus punctatus</i>	20	Common in most streams in Kansas. Reproduction is from May to early June at approximately 80°F. No specific bottom type is required.
Blue Catfish (Mississippi White)	<i>Ictalurus furcatus</i>	No	Rarely in the Kansas River. Exists in the lower Marais des Cygnes River. Habitat-- seems to avoid silted waters. Spawns in June/July in 70-75°F water. Feeds on fish, crayfish, insects.
Flathead (Catfish)	<i>Pylodictis olivaris</i>	20	Common in rivers of eastern Kansas. Occupy deep holes in river beds. Spawn is in June, in silt-free nests.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Tadpole Madtom	<i>Noturus gyrinus</i>	No	Found only in the Osage River system in Kansas; known from other tributaries in Missouri. No life history data. Spawn is probably in May or June on foreign objects. Feed on insect's larvae.
Freckled Madtom	<i>Noturus nocturnus</i>	10	Occurs in streams having moderate or low gradients. No other data.
Slender Madtom	<i>Noturus exilis</i>	20	Occurs in all major drainage basins in Kansas, but is restricted to small streams. Spawns in June on riffles littered by large stones.
Stonecat	<i>Noturus flavus</i>	20	Largest and most widespread madtom in Kansas. Found over rocky bottoms in currents of large streams.
Topminnows Blackstripe Topminnow	Family Cyprinodontidae <i>Fundulus notatus</i>	20	Inhabits clear, small streams in south-eastern Kansas with rocky or muddy bottoms. Spawn is from May to August and the mated fish tend to remain together. Food is surface insects.
Silversides Brook Silversides	Family Atherinidae <i>Labidesthes sicculus</i>	20	Streams of the Osage, Marais des Cygnes. Prefers calm, clear water. Found in pools that have rocky bottoms. Feed on crustaceans. Spawn in May-July.
Sunfishes Largemouth (bass)	Family Centrarchidae <i>Micropterus salmoides</i>	20	Occurs throughout Kansas. Common in the Marais des Cygnes River. Food--obligate carnivore.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Green Sunfish	<i>Lepomis cyanellus</i>	20	Solitary in nature and ubiquitous in Kansas. Food is mainly insects. Reproduction occurs throughout warm months; mostly May-June. Nests occur in groups. Significant sport fish.
Bluegill	<i>Lepomis macrochirus</i>	20	Bluegill was uncommon earlier. Now occurs widely in ponds. Reproduction extends from April to September when temperatures exceed 68°F. Almost any substrate.
Orange-spotted Sunfish	<i>Lepomis humilis</i>	20	Occurs throughout Kansas. Habitat preference is obscured. Lengthy reproduction season, from warm months peaking in May and June. Nests in fine gravel or sand.
Longear	<i>Lepomis megalotis</i>	20	Abundant in eastern part of Arkansas River system, in clear and unsilted bottoms of stone or firm clay. Reproduction season is long. Early May to late June in temperatures of 75-87°F.
White Crappie	<i>Pomoxis annularis</i>	20	One of the most common fish in Kansas. Tolerant of silt.
Perches Logperch (Darter)	Family Percidae <i>Percina caprodes</i>	20	Inhabits large tributaries of all major rivers in eastern Kansas. Spawn begins in April. Food is immature insects.
Greenside darter	<i>Etheostoma blennioides</i>	20	Occurs in lower corner of Linn County. Reproduction in April.

Common Name	Scientific Name	Occurrence in 10/20 Locations	Habitat/Spawning Requirements
Iowa Darter	<i>Etheostoma exile</i>	No	Reported by Hubbs in 1943 in Marais des Cygnes. No other collections have recorded this fish.
Orangethroat darter	<i>Etheostoma spectabile</i>	20	Three subspecies in Kansas; typical subspecies is in Osage River system. Occurs in small streams on shallow riffles having fine gravel or mixed gravel and sand bottoms. Most widely spread of Kansas darters. Tolerates moderate turbidity. Spawn is early in spring at 60-70°F in small riffles. Food is principally black-fly larvae and other insect larvae.
Fantail darter	<i>Etheostoma flabellare</i>		Occupies shallow riffles in clear tributaries of the Spring, Osage, and Cottonwood Rivers. Reproduction occurs in April and May on stones on bottom.
Slenderhead darter	<i>Percina phoxocephala phoxocephala</i>	20	Swiftly flowing shallow water, loose gravel. Spawns March to May at 70°F in water 18 inches deep.
Drums Freshwater Drum	Family Sciaenidae <i>Aplodinotus grunniens</i>	20	Occurs commonly in rivers of eastern Kansas. Communicates by "booming" during June, July, and August; thought to be connected to reproduction.

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