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AN ENVIRONMENTAL ASSESSMENT
FOR OPEN AIR TESTING OF MUNITIONS
INVOLVING DEPLETED URANIUM AT MICOM

Final Technical Report

Prepared for:
Commander
U.S. Army Missile Command
DRSMI

Department Of Physics

Alabama Agricultural And Mechanical University

Normal, Alabama 35762

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Contract No.: DAAH0182P4838

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35809

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report summarizes the results of a project to assess the likely impact on the environment of an open air testing program involving depleted uranium (DU) at MICOM. Technical aspects of DU are briefly reviewed and the topography and climate of the proposed test sites are characterized. Under the assumptions of the analysis used in preparing this report no biologically significant concentrations of DU in air are anticipated. Establishment of an onsite monitoring program to test for DU in air, soil and water is viewed as an essen-

Abstract (cont.)

tial component of the testing program. Detailed examination of the life cycle of DU in the environment is recommended.

NOTICE

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

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I. Introduction

The objective of this project has been to determine the possible impact to man and the environment of a proposed open air testing program involving munitions containing depleted uranium (DU) at the U.S. Army Missile Command, Redstone Arsenal, Alabama. The proposed testing program is intended to achieve the optimal design characteristic for an armor piercing shoulder mounted anti-tank weapon system designated as the Rattler. The warhead for this system is made of DU, a source material, which is a byproduct of the uranium enrichment process. Prior to the implementation of the testing program it is therefore necessary to address adequately the questions of storage and handling of the warhead and its components, the possible dispersal of DU to the environment as a result of warhead firing, as well as the storage/disposal of contaminated portions of the test apparatus. This report contains the results of a project to identify, gather and interpret the applicable technical and regulatory information from the standpoint of the impact of these operations on man and the environment. Previous monthly technical reports submitted to the Rattler Management Office form part of this Final Report by reference.

II. Test Site Geography and Proposed Action

A. Geography - Redstone, Alabama

The MICOM test sites are located on the Redstone Arsenal which is in the southwestern portion of Madison County. The Arsenal is approximately 6 miles wide and 10 miles long and occupies 60.4 square miles (38,659 acres). The installation is adjacent to the southwest limits of the City of Huntsville, Alabama; other cities within a 100-mile radius include Birmingham, AL, Chattanooga, TN, and Nashville, TN. Of the installation's total acreage, 36,818 acres are controlled by the Department of the Army (DA) and 1841 acres are leased on a long-term basis to the George C. Marshall Space Flight Center, National Aeronautics and Space Administration (NASA). In addition, 2,900 acres are owned by the Tennessee Valley Authority.

B. Proposed Action

The sites on which the testing is planned are designated as Test Area-1, Test Area-5 and Test Area-6. The approximate locations of these sites are indicated in figure No. 1. Test Area-5 is located in the south central-most area of the Redstone Reservation, immediately east of Igloo Area #2. Approximately 100 to 150 static test firings are planned for this site with an objective of determining the warhead design for optimum depth of armor plate penetration. Fifteen of the ammunition bunkers in Igloo Area #2 have been identified for modification to permit the safe storage of DU munitions and subsequently contaminated test equipment components.

At Test Area-1, 30 to 50 firings are planned using the sled track apparatus with another 25 to 50 shots scheduled for flight testing. Production acceptance testing would be conducted at Test Area-6, involving 500 to 1000 firings.

III. Depleted Uranium - Technical Data

Depleted uranium is a radioactive byproduct of the uranium enrichment process and as such is composed primarily of the isotope ^{238}U with less than 0.7% ^{235}U. The precise value of the ^{235}U isotopic content in DU varies depending upon the process used to enrich the original (natural) uranium. Also, as a result of the enrichment process, DU contains relatively minor amounts of ^{226}Ra and ^{222}Rn when compared to natural uranium.

The principal nuclear radiations emitted from DU are alpha and beta particles. Alpha particles have a relatively short range and can be stopped by thin sheets of paper. Alpha radiation from DU thus poses a biological hazard only if ingested into the body. Beta radiations have a longer range and may present a hazard via external exposure of the skin with an attendant internal hazard should ingestion occur. However, because of the relatively long half-life of the ^{238}U ($T_{1/2} = 4.9 \times 10^9$ years) and the small amounts of ^{235}U ($T_{1/2} = 7.0 \times 10^8$ years) present, the radioactivity associated with DU is relatively low when compared with other radioactive materials. DU does, however, possess characteristics of a heavy metal poison with approximately the same chemical toxicity as lead.

DU will ignite and burn rapidly in air if temperatures of 700 - 1000°C are reached. The principal oxides of uranium which are formed upon burning at these temperatures are U_3O_8 and UO_2.

IV. Environmental Impact Considerations

A. Soil Composition

The soils of the county occur in considerable variety. They are however mostly cherty silt loams, silt loams and silty clay loams. Undulating and rolling relief predominate. Nearly level soils cover about 30 percent of the country occurring along streams on the bottom lands or in gentle depressions in red lands.

B. Drainage and Topography

The county is drained by the Tennessee River and surface drainage is generally dendritic. Poor soil drainage is confined to some of the nearly level areas on old stream terraces or on old general alluvium, and to the young alluvium on bottom lands along larger streams.

Test Area-1 and -6 are characterized by swampy regions with relatively level areas whereas Test Area-5 shows a drop in altitude of approximately 100 ft from the static test stand to the adjacent igloo storage areas.

C. Climate

The climate of the proposed test sites is mild and temperate. The average annual temperature for Madison County is 62°F. The average summer Temperature is 77°F and the average winter temperature is 47°F. Freezing temperatures seldom continue for more than 48 hours and summer temperatures are not excessive. The average annual snowfall is 3 inches and the average rainfall is 48 inches. The month with the highest average rainfall is March with 5.6 inches and October is lowest with 2.7 incheas of rain. Floods are most common from mid-December to mid-April and extensive floods are infrequent. Prolonged droughts are rare but moderately dry conditions generally prevail throughout the autumn.

The prevailing winds are from the southeast, however, winds from the north and south are also common. The average wind velocity is highest in winter and lowest in summer. The average annual wind speed is 8 mi/hr.

V. Estimate of Amounts of DU Released to the Environment

In order to make an evaluation of the possible impact of depleted uranium upon man and the surrounding environment, it is necessary to first arrive at an estimate of the amounts of the depleted uranium to which the air, soil and water will ultimately be exposed. In an open air testing program the major source of DU released to the environment will probably result from the aerosolization of the DU munition. It has been conservatively assumed for the purpose of developing this environmental assessment that, upon firing, the total amount of DU contained in the warhead is released to the atmosphere in the form of an aerosol. Further, an average mass of 506 g of DU per warhead is assumed and that the atmospheric dispersion of the aerosolized DU follows a gaussian distribution for an instantaneous ground level release. The maximum ground level air concentration (g/m^3) of DU at the nearest site boundary from a test area was calculated to be less than 0.1% of the NRC standard for occupational exposure, based upon chemical toxicity. Although this estimate is well below the NRC standard for occupational and uncontrolled areas, it should be noted that it is based upon the firing of a single warhead. Thus the concentrations achieved under actual test conditions will be affected by the exact number of shots and the frequency with which they occur in the testing period. It should, however, be possible to schedule within a given test period sequences of firings such that the standard is not exceed. Further, it should be noted that the standard for chemical toxicity is at least as restrictive as the standard for radiobiological exposure.

VI. Environmental Monitoring Program Considerations

Prior to the initiation of testing, it is imperative that a program be established to quantitatively determine the background levels, or upper limits on levels, of DU in the soil and water. Measurements of DU concentrations made during and subsequent to testing can be compared directly to these "benchmark" values to access whether any significant changes occur. At the time of this report, there had never been a program in effect at the Arsenal which specifically tested for DU in the soil and ground and surface waters. It was determined however, that there is presently an established ground water monitoring program at the Arsenal for which 76 sampling wells have been drilled at various locations on the arsenal site as shown in figure 2. All analyses of ground and surface water samples are done in accordance with procedures specified in 40 CFR 265.92. The radioactivity measurements consist of quantitative testing for gross alpha, gross beta and total radium levels. These analyses procedures would be modified to test additionally for DU. Further, core samples of the soil in the immediate area of the test sites as well as background positions located at the site boundary would be taken and tested for DU levels.

The most sensitive method developed to date for the measurement of DU in soil and water makes use of neutron activation wherein the isotopic ratio $^{235}U/^{238}U$ is determined. This ratio is assumed to be a constant (0.0072) for natural uranium occurring in the crust of the earth. Detected ratios which fall below this value are attributed to the presence of DU. In the method, epithermal neutrons are used to activate the ^{238}U in a given sample and the ^{235}U is subsequently activated with thermal neutrons and then is determined via delayed neutron emission. Using this technique, DU can be detected down to 10 ng in soil and 100 ng in water.

Further, an environmental air monitoring program would need to be established to test for DU concentrations in the air during and after the program.

All monitoring procedures and the reporting of results for DU effuents should be done in accordance with guidelines specified in 10 CFR Part 40, section 40.65.

VII. Committment of Resources

Fifteen munitions bunkers have been identified for storage of DU warhead components and waste materials. In order to meet the regulations specified in DARCOM HDBK385-1.1-78 for the handling and storage of DU, nine (9) the bunkers have undergone modifications in their construction. These modifications include:

a) the installation of vents to allow purging of the air volume inside the bunker immediately prior to and during its occupancy by workers

b) construction of concrete loading pads at the entrance of the bunkers to facilitate forklift handling of materials

and

c) inclusion of a shower facility external to the bunker for emergency washing.

In addition, construction has begun to improve the underground drainage system in the immediate area of the bunkers and to modify the landscape grading to enhance the runoff of precipitation and ground water.

Other committments include funds expended to acquire new empirical data which can be used to characterize DU cloud formation, concentration levels in air, particle size information and chemical forms and fallout properties that result from test firings.

VIII. Alternatives to the Proposed Action

Munitions of the Rattler design concept have been shown to be effective penetrators of armor plate typical of armored personnel carriers. The DU material which is used is readily available from existing stockpiles and has good properties of machinability. Further, the fabricated munitions can be safely and easily stored for long periods. Alternative materials such as tungsten - copper alloys are not as promising because tungsten is not as readily available as DU and its development as a munitions material would involve additional fabrication, development and production studies.

Another alternative is to perform the firings inside an enclosure. Facilities such as USABRL's Large Caliber Target Enclosure at Spesutie Island exist, but are specifically constructed for munitions involving kinetic energy penetrators. They are not deisgned to accommodate the higher pressures generated upon detonation of Rattler munitions and thus do not offer an immediately available technical alternative to open air testing.

Discontinuation of the testing of DU munitions could seriously affect the capability of the armed forces for defeating armored targets. While the alternatives of not testing the Rattler would not pose any questions refarding harm to the environment, the Army would incur an increased risk of being able to effectively combat improved armored threats. Thus, if no action is chosen, the defense posture of the Army would be significantly affected.

IX. Conclusions

Rattler Munitions containing DU can be employed effectively for the penetration of armor plate. The major source of release of DU to the environment during an open range testing program will come during the detonation of the warhead. Under the assumptions of the analysis used in preparing this report, open range of testing of munitions containing DU will not result in biologically significant concentration levels of DU. It is likely that actions alternative to an open air program for testing munitions involving DU would result in a reduced capacity of the Army to combat armored vehicles.

It is recommended that 1) an onsite environmental monitoring program be established to measure for DU in the environment prior to the initiation of the test program and that 2) the work performed during this project be extended to include life cycle operations of testing of munitions involving DU.

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APPENDIX A

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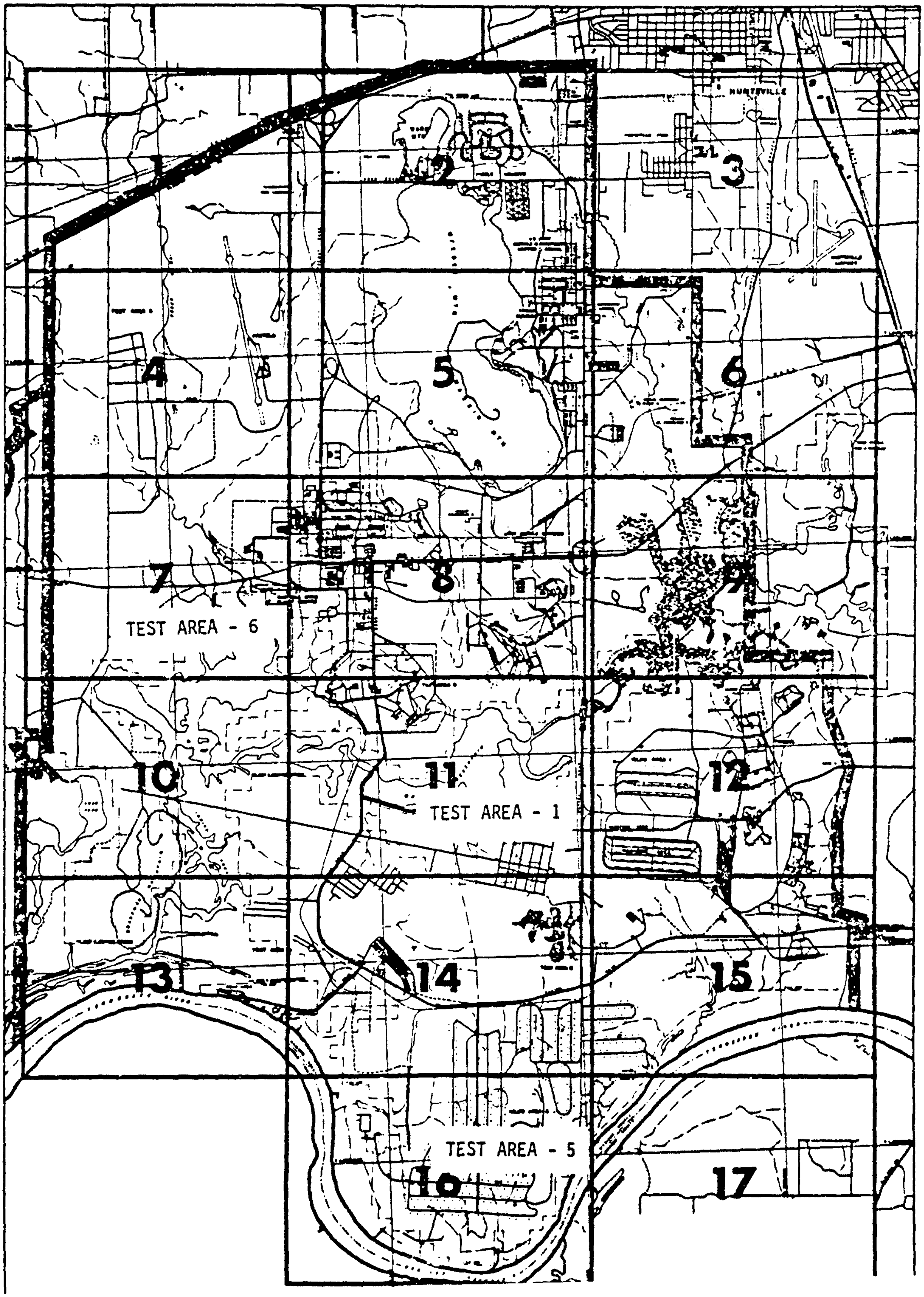
Figure 1.



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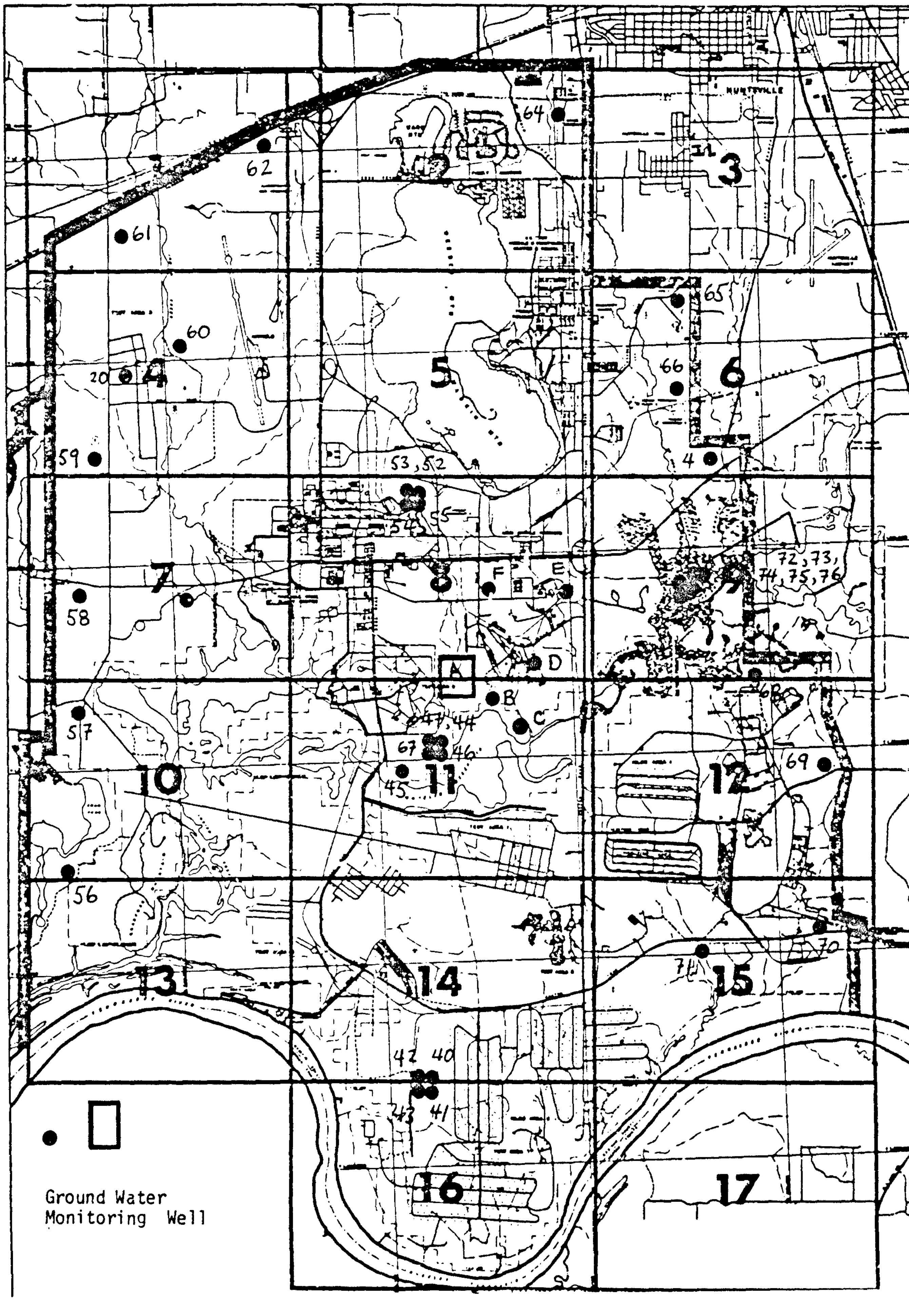
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