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POSTER SESSION
ELIPGRID-PC

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Abstract - ELIPGRID-PC, a new personal computer program, has been developed to provide easy access to Singer's ELIPGRID algorithm for hot-spot detection probabilities. Three features of the program are the ability to determine: 1) the grid size required for specified conditions, 2) the smallest hot spot that can be sampled with a given probability, and 3) the approximate grid size resulting from specified conditions and sampling cost. ELIPGRID-PC also provides probability of detection versus cost data for graphing with spreadsheets or graphics software. The program has been successfully tested using Singer's published ELIPGRID results. An apparent error in the published ELIPGRID code has been uncovered and an appropriate modification incorporated into the new program.

INTRODUCTION

The standard approach for calculating the probability of detecting small, highly contaminated areas called hot spots is based on a punch-card-era computer program developed over 20 years ago. This program, ELIPGRID (Singer 1972), is the foundation for three programs developed by Oak Ridge National Laboratory (ORNL) for the IBM® personal computer (PC): ELIPGRID-1, a PC version of ELIPGRID; ELIPGRID-2, a modified PC version; and ELIPGRID-PC, a user-friendly PC version containing several new options not found in ELIPGRID.

ELIPGRID-1 is a direct translation of ELIPGRID to the PC and retains a coding error found in ELIPGRID's rectangular grid routine. ELIPGRID-2 is similar to ELIPGRID-1 but corrects the rectangular grid error. ELIPGRID-PC, though based on ELIPGRID's algorithms, is a new program that simplifies input file selection, data entry, and file output.

ELIPGRID-1 and ELIPGRID-2 can be viewed as transitional programs used to work out technical problems involved in moving ELIPGRID to the PC. They are documented here to provide a record of this transition. ELIPGRID-PC, however, is intended as a full replacement for the ELIPGRID program.

PREVIOUS WORK

In 1969, Singer and Wickman published a mathematical procedure for determining the probability of locating elliptical geological deposits (Singer and Wickman 1969). Using this procedure, five computer programs were written to calculate values published as probability tables for various target shapes, grid types, and grid sizes. These programs were run on an IBM® System 370/67 computer.

In 1972, Singer published ELIPGRID, a FORTRAN IV program based on Singer and Wickman's mathematical procedure (Singer 1972). This program calculated the probability of success in locating elliptical targets with square, rectangular, and hexagonal (triangular) grids. The data input and code were designed for the then-standard punch-card computer.

Zirschky and Gilbert developed a nomographic procedure based on ELIPGRID to assist with the detection of highly contaminated areas at chemical- or nuclear-waste disposal sites (Zirschky and Gilbert 1984). Gilbert used these nomographs as the basis for the chapter "Locating Hot Spots" in his widely referenced book on environmental statistical methods (Gilbert 1987). These nomographs were subsequently used by the U.S. Environmental Protection Agency (EPA) to develop tables for calculating the probability of missing various hot-spot shapes using triangular and square sampling grids (U.S.EPA 1989).

Gilbert's nomographs and the EPA tables have some inherent limitations not in the original ELIPGRID program. Three limitations are:

1. Probabilities for only one rectangular sampling grid

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are given in Gilbert's nomographs; no data for rectangular grids are given in the EPA tables.
2. Specific orientation angles for suspected hot spots are not allowed. For example, if the probability of detecting a given target with a given grid for a specific orientation angle is desired, the tables and nomographs do not provide this information.
3. Data extracted from a graph are less likely to be accurate than output from a computer program given the same input information.

ELIPGRID-PC removes these limitations by: 1) allowing a large number of rectangular grids, 2) allowing orientation angles for suspected hot spots to be specified, and 3) calculating the results with a computer algorithm.

PROGRAM ASSUMPTIONS

The following assumptions underlie both the original ELIPGRID and ELIPGRID-PC:

1. The target (hot spot) is assumed to be circular or elliptical. See Fig. 1 for an illustration of an elliptical subsurface pocket of contamination.
2. Samples or measurements are taken on a square, rectangular, or triangular grid. Fig. 2 illustrates the various grid configurations.
3. The distance between grid points is much larger than the size of the sample being measured or cored at grid points; that is, a very small portion of the area being studied can actually be measured.
4. The definition of a hot spot is clear and unambiguous.
5. There are no measurement misclassification errors; that is, no errors are made in deciding when a hot spot has been detected.

PROGRAM DESCRIPTIONS

ELIPGRID-1

ELIPGRID-1 is a PC program, written in Lahey FORTRAN, that closely conforms to the original ELIPGRID FORTRAN code structure. It was written to demonstrate that ELIPGRID code could work on a PC. The format for data input is the same as the original ELIPGRID punch-card format. The program does not provide any user-interface features other than a simple help screen and various messages relating to data input file errors.

ELIPGRID-1 contains the original algorithm used by the RECT subroutine in the published version of ELIPGRID. However, the output from ELIPGRID-1 does not match the published output for a number of rectangular grid cases (Singer 1972). These discrepancies revealed the need to modify the RECT subroutine that resulted in the ELIPGRID-2 program.

Hardware requirements for the program include an IBM® PC (or compatible) with an Intel® 386™, i486™, or Pentium™ central processing unit, with a minimum of 512 kilobytes (KB) free random access memory (RAM) recommended. Additionally, a math co-processor is required and a fixed hard disk drive is recommended.

ELIPGRID-2

ELIPGRID-2 is essentially the same program as ELIPGRID-1, with the key difference being the modified RECT subroutine. With this modification in place, ELIPGRID-2 is able to reproduce the results of the published data (Singer 1972). The hardware requirements for ELIPGRID-2 are the same as those for ELIPGRID-1.

ELIPGRID-PC

ELIPGRID-PC is a new program incorporating the corrected version of the ELIPGRID algorithm found in ELIPGRID-2. Although the algorithm was recoded into CA-Clipper® for ELIPGRID-PC, no changes were made to underlying mathematical algorithm.

ELIPGRID-PC provides some output features not directly available in ELIPGRID:

- ELIPGRID-PC calculates a grid size, given the desired probability of detecting a specified hot spot.
- ELIPGRID-PC calculates an approximate grid size, given desired cost and hot-spot specifications. Note that this is an approximate grid size since the underlying EPA formula for determining the number of samples for a given area is itself approximate (U.S.EPA 1989).
- ELIPGRID-PC calculates the smallest hot spot that can be detected with a given probability and grid size.
- ELIPGRID-PC provides the capability for graphing with spreadsheets or graphics software the probability of detection versus cost. Fig. 3 is an example of this for a square grid.

Designed to be user-friendly, ELIPGRID-PC includes the following features:

- A simplified input format (SIF) file option. SIF files provide an *easier-to-use input file structure* than the ELIPGRID format input files.

- Screen input and output in either meters or feet.
- Conversion from acres to m^2 or to ft^2 using the F10 key. The program also calculates the length of the hot spot semi-major axis from the area of the hot spot.
- Change of the basic unit of length from meters to feet as a command-line option using the letter F. Command-line option M will force a monochrome screen, and command-line option H provides usage information.
- Input and output files located on any drive and subdirectory.
- Temporary exit to DOS. DOS commands or other programs may then be executed.

The hardware requirements for the program include an IBM® PC (or compatible), with a fixed hard disk drive and a minimum of 512 KB free RAM recommended.

SUMMARY

Singer and Wickman's ELIPGRID algorithm for calculating hot-spot sampling probabilities has been successfully made available to the PC environment. ELIPGRID-PC provides the algorithm in CA-Clipper®-compatible format. The program additionally calculates the grid size required for specified conditions, the smallest hot spot that can be sampled with a given probability, and the approximate grid size resulting from specified conditions and sampling cost. ELIPGRID-PC also provides probability of detection versus cost data for graphing with spreadsheets or graphics software.

ELIPGRID-PC has been successfully tested using Singer's published ELIPGRID results and includes corrections to the rectangular and triangular grid routines of the original ELIPGRID.

REFERENCES

Gilbert, R. O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York.

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U.S.EPA. 1989. *Methods for Evaluating the Attainment of Cleanup Standards. Volume 1. Soils and Solid Media*. EPA/230/02-89/042. U.S. Environmental Protection Agency.

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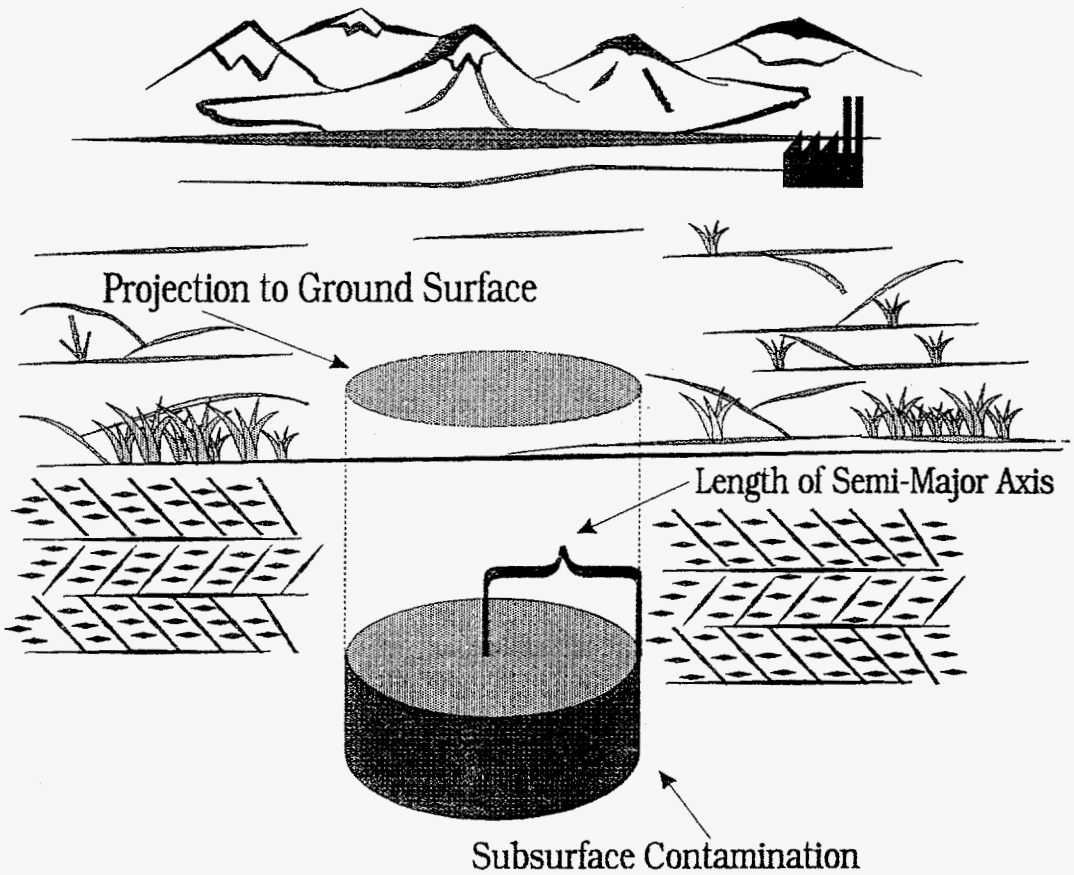


Fig. 1. Hypothetical subsurface pocket of contamination.

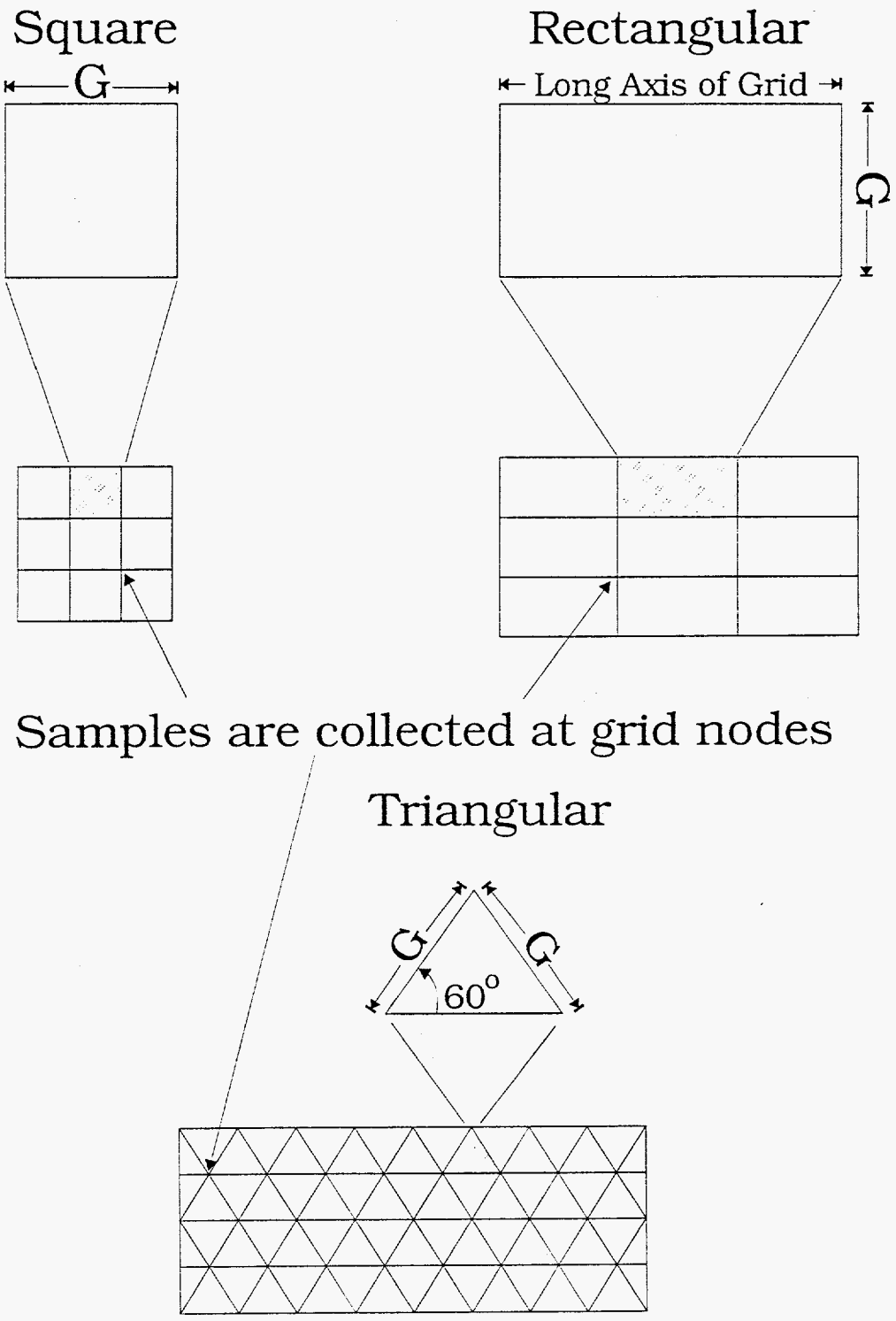
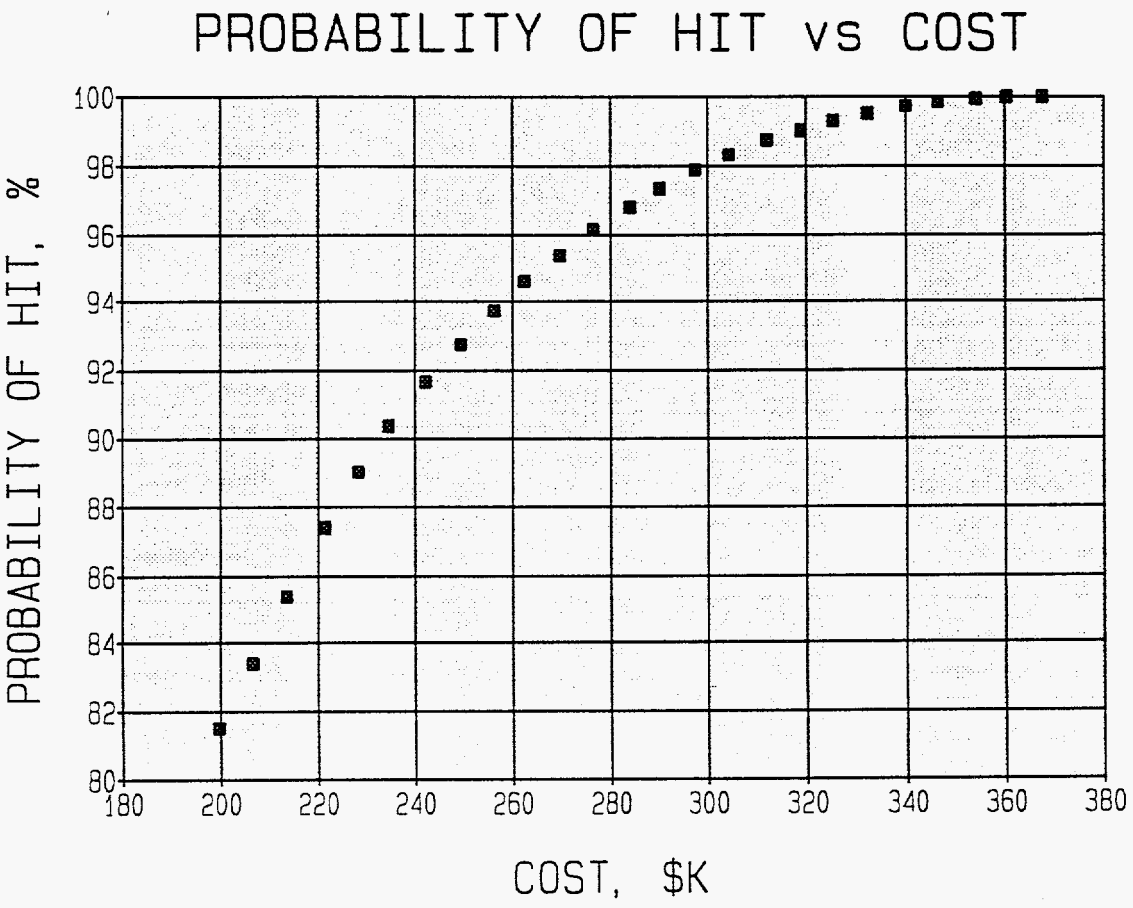


Fig. 2. Grid configuration for finding hot spots.



Input File: C:\CLIPPER2\EDITOR\EGPC\Graph.Dat
Print Date: 08/31/94
Print Time: 1:38:41 pm
Grid type chosen.....: Square
Shape of the elliptical hot spot: 0.80
Length of semi-major axis.....: 3.15 m
Angle of orientation to grid....: 0.0°
Total area to sample.....: 8093.0 m²
Individual sample cost.....$: 700.00

Fig. 3. Probability of hit versus total sample cost for a square grid.