1.0 Introduction

1.1 What is Visual Sample Plan?

Visual Sample Plan (VSP) is a software tool for selecting the right number and location of environmental samples so that the results of statistical tests performed on the data collected via the sampling plan have the required confidence for decision making. More than 4000 users from every state as well as many in other countries have registered a downloaded copy of VSP. Users include employees of the federal government, state and local governments, and private industry. Sponsors of this public domain software include the U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), U.S. Department of the Defense (DOD), U.S. Department of Homeland Security (DHS) , National Institute for Occupational Safety and Health (NIOSH) within the Centers for Disease Control and Prevention (CDC), and the U.K. Atomic Weapons Establishment (AWE).

VSP provides sample designs and sample-size equations needed by specific statistical tests appropriate for several types of environmental problems. Table 1.1 is a list of the sampling goals that can be addressed in the current version of VSP.

Table 1.1. List of Sampling Goals

Sampling Goal	User's Guide Section
Compare Average to Fixed Threshold	3.2.1
Compare Average to Reference Average	3.2.2
Estimate the Mean	3.2.3
Construct Confidence Interval on Mean	3.2.4
Compare Proportion to Fixed Threshold	3.2.5
Compare Proportion to Reference Proportion	3.2.6
Estimate the Proportion	3.2.7
Locating a Hot Spot	3.2.8
Find UXO Target Areas	7.1-7.4
Assess degree of confidence in UXO presence	7.5
Non-statistical sampling approach	3.2.11
Establish boundary of contamination	3.2.12
Sampling within Buildings	3.2.13

VSP is easy to use, highly visual, and graphic. It has extensive online help and tutorial guides. Reports produced by VSP can be pasted directly into a quality assurance project plan or a sampling and analysis plan. VSP can be used to implement EPA's systematic planning process (EPA 2000a) for a variety of problems: selection between clearly defined alternatives [Step 7 of the Data Quality Objectives (DQO) process], studies where a confidence interval on an estimated parameter is needed, or determination of whether a hot spot or target exists. The user specifies the criteria for "how good" the answer has to be (Step 6 of the DQO Process), and VSP uses this as input to the formula for calculating the required sample size. VSP is unique in this regard.

VSP is designed primarily for project managers and users who are not statistical experts, although those individuals with statistical expertise also will find the software very useful.

1.2   What's New in VSP5.0?

VSP 5.0 is a major new release of the software. Features new since version 4.0 include:

Sampling Designs

- New design methods for: Combined Judgment / Probability Sampling, Eliminating redundancy in well networks, eliminating redundancy of analytes, trend analysis, and Compliance sampling of Unexploded Ordnance (UXO) Anomalies, Seasonal Kendall test for monotonic trend.

- New Data Analysis Features: Outlier Tests, Handling of Non-Detects, Geostatistical Analysis, and Correlation Analysis of Analytes.

- For UXO designs, the user may save power curves and choose which saved curve to display in the report view.

- Updated Transect Sampling for UXO Target Detection

- Simplified UXO transect design user-interface

- Simplified / Streamlined data handling for UXO target analysis

- Power curve generation for UXO transect designs

- Grid cell sampling added for UTL Designs

- One sample t-test tabs and report views where data fails normality test now shows MARSSIM sign test results.

- Mann-Kendall trend test added for time-series data

- Added DQA support for more sampling designs

Building Features:

- **Surface Type** Definitions

- **Surface Overlays** for embedding a different surface type in a sampling surface or for creating elevated horizontal surfaces such as the top of furniture.

Maps:

- Support for Latitude / Longitude maps

- New **Map Layers** command for exporting estimates and variances of kriged data.

- New **Create Lines for Areas** command for creating outlines around sample areas that don't currently have them.

- New **Color by Value** command to automatically color samples as well as sample areas based on the value of a built-in or user-defined parameter.

- New **Snap Edges** command to perfectly align edges and corners of adjacent sample areas when they do not exactly match up.

- New **Bisect** command to split a sample area into one or more parts.

- The **Sample Information** dialog now shows the type of **Surface** on which the sample is located.

- **3D** view of maps including 3D navigation tools, 3D sample areas, and 3D sample placement.

- User-defined properties capability added for Samples

- Improved map export / import.

- Ability to toggle target markers, swaths, and anomalies for UXO Designs

Miscellaneous

- The **Expert Mentor** is now available from the **Help** menu. This a menu of tutorials giving guidance and suggestions on **Systematic Planning** and **Setting Up VSP Sites and Maps**.

- Multiple Analyte support for most sampling designs including analyte input page, calculation of number of samples for each analyte, data analysis for each analyte, and updated reports showing each analyte.

- A **RCRA Version** is now available from the **Select VSP Version** dialog

- Data import directly from file

- Improved copy/paste support for data input page

- Support connection for COMPASS software

- Updated on-line Help and tutorials
- New/Updated reports

1.3   Installation and System Requirements

VSP 5.0 runs on Microsoft Windows operating systems (98, NT, 2000, Millennium Edition, CE, and XP). *Visual Sample Plan (VSP) Models and Code Verification* (Gilbert et al. 2001) documents the successful installation of VSP on personal computers operating with Windows® 95, 98, Millennium Edition, and Windows 2000. VSP is developed and successfully runs under Windows XP.

VSP will not run on Windows 95 or earlier Windows operating systems. VSP currently does not run on Macintosh® or UNIX®/Linux systems. Any personal computer with sufficient hardware to run one of the supported operating systems should run VSP. The *minimum* hardware recommended is

- 1 GHz processor
- 64 MB RAM
- 30 MB of free space on the hard drive.

The current version of the VSP setup file is available from **http://dqo.pnl.gov/VSP**. After the setup file is downloaded, installation of VSP is almost automatic. Simply run the VSP setup file, VSP50.exe (or later version), and follow the on-screen instructions. The VSP program and auxiliary files will be copied by default to the C:\Program Files\Visual Sample Plan folder (subdirectory). However, you may specify a different location for the files.

Once installation is complete, you will start VSP using option **Start > Program Files > Visual Sample Plan > Visual Sample Plan.** Alternatively, you may place a VSP shortcut on the desktop by selecting **New > Shortcut** from the menu obtained by right-clicking the mouse on the desktop. The appropriate command line for the default folder is

"C:\Program Files\Visual Sample Plan\VSample.exe".

VSP may be uninstalled using the Control Panel icon labeled Add/Remove Programs. You may access this option using the **Start** button and **Settings > Control Panel.**

New versions of VSP are often released as prototypes for testing. These demonstration versions have expiration dates. After the expiration date has passed, you will be given the option of continuing with the current version or going to the VSP website to download the latest version. Version 5.0 is not a demonstration version and does not have an expiration date.

1.4   Overview of VSP

Sampling is the process of gaining information about a *population* from a portion of that population called a *sample*. A key goal of *sampling design* is to specify the sample size (number of samples) and sampling locations that will provide reliable information for a specific objective (called the **Sampling Goal)** at the least cost. VSP does the required calculations for sample size and sample location and outputs a sampling design that can be displayed in multiple formats. VSP does not address sample collection methods. It assumes the sample support (amount of material in the sample) is sufficient and the sample is representative of the population. A few designs in VSP assume the sample is taken across an entire grid (say a 10 x 10 cm swipe), but most designs assume the sample is a point sample taken at an X,Y coordinate location, and has sufficient volume for measurement and testing. VSP addresses the trade-off between repeated analytical measurements on a single sample to reduce overall sample result variability (measurement quality objectives / MQOs) and provides a sensitivity table for comparing analytical methods of varying accuracy and cost.

VSP can be used to develop a new sampling design. It can also be used to compare alternative designs. VSP automates the mechanical details of calculating sample size, specifying random sampling locations, and

comparing sample costs with decision error rates. These activities can be accomplished in the context of your own site map displayed onscreen with various sampling plans overlain on sample areas that you select.

The first thing you will do after opening the program is to import or construct a visual map of the study site. Next, you select the area or areas to be sampled. The **Sample Area** may be only a portion of the study site (see the circular sample area in Figure 1.1, upper left window).

Then, for the Sampling Goal that you select, VSP will lead you through the quantitative steps of the DQO process (Steps 6 and 7) so that the program has the information needed to compute the recommended minimum number of samples (sample size). You can enter sampling costs and test alternative designs against a fixed budget.

The locations of the samples over the Sample Area are determined by the specific sampling design (pattern) that you select. For some Sampling Goals, and for some assumptions about the population, only certain designs are allowed from a statistical theory perspective. For example, sequential sampling is appropriate only for the sampling goal of **Compare Average to a Fixed Threshold** when the population units can be assumed to be distributed normally. When there is a choice of designs, VSP displays a dropdown menu of the allowable designs.

VSP can be used for designing samples for environmental settings as well as building/room/surface settings. For environmental settings, site maps and aerial pictures can be loaded into VSP for sample placement. For buildings and rooms, a CAD drawing or floor plan are loaded. **Map View** displays samples placed on maps and room drawings. On a site map, VSP displays the sample locations for easy visualization (see Figure 1.1, upper left window). VSP also lists the geographical coordinates of the sample locations (see Figure 1.1, lower right corner), which can be saved and exported as a Drawing Exchange Format (DXF) or SHP file for use in a geographical information system (GIS) or saved as a text file for use in global positioning system (GPS) software.

Two additional output formats for the design created in VSP are available: a **Graph View** of the design (see Figure 1.1, upper right window), and a **Report View** (see Figure 1.1, lower left window). The Graph View displays either a Decision Performance Goal Diagram for Sampling Goals that involved selecting between alternative actions, or a performance graph comparing number of samples to a design parameter for the other classes of sampling goals. The Report View is a text report that describes the sampling design in detail. The report contains the input values, the assumptions, the cost of the design, VSP output, technical description of the sample size formula and algorithms used, and a sensitivity analysis table to assess what would happen if more or fewer samples are collected than the optimal number calculated by VSP.
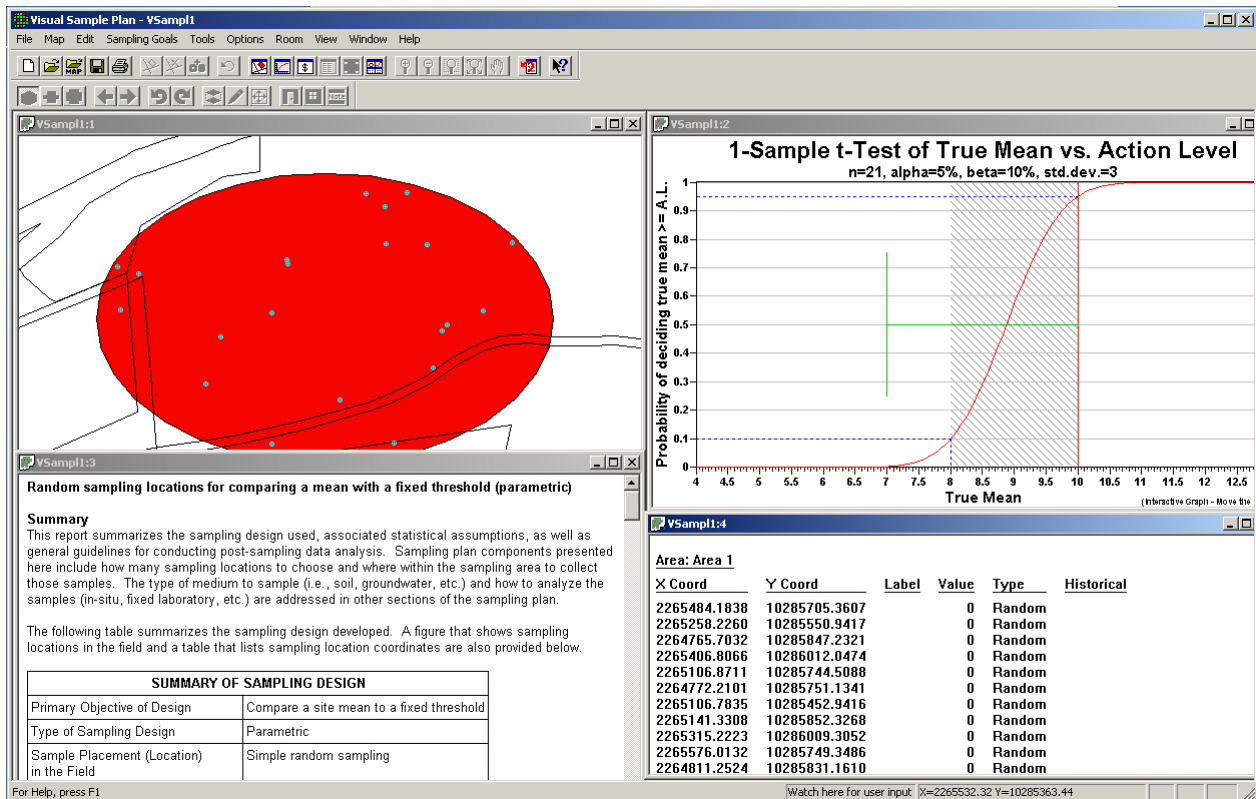
Figure 1.1.   Screen Capture from VSP Using Quad Window Option (**Window > Quad Window**)

The analytical value of lab results for samples can be input into VSP for Data Analysis -- summary statistics of results, statistical tests applied to results for making decisions, and graphical displays of results. One of the designs, Sequential Sampling, requires intermediate results to be input to VSP so that VSP can determine whether further sample collection is required.

1.5   How Do I Use VSP to Provide a Defensible Sampling Plan?

To defend a sampling plan to a regulator concerned about safety *and* to a citizens' group concerned about saving taxpayer dollars requires balancing cost and risk. Defensible means that sufficient samples are taken, in a non-biased way, in order to make a decision, estimate a proportion, or declare an area free of UXO with a stated level of confidence. Additionally, once samples are taken and the results processed, someone needs to apply a statistical test to actually make a decision based on the data or calculate a confidence interval. VSP incorporates all this into the code it uses to calculate a sample size and sample locations. It asks the user to enter the assumptions, acceptable risk, and costs it needs for these calculations.

VSP follows the EPA-sanctioned planning approach for data collection and decision-making called the Data Quality Objectives (DQO) process. The DQO process achieves the user's limit on acceptable risk, at a minimum cost. See EPA (2000) for an extended discussion of the DQO process. There are 7 steps in the DQO process. Users must complete Steps 1 through 6 in order to have the inputs VSP needs. Then, using VSP, the user can complete Step 7, "Optimize the Design for Obtaining Data," because VSP can be used to try out different sampling designs and find the optimal design for the current problem.

Users familiar with the DQO process know that often a single site may have multiple sampling goals and multiple Sample Areas, each requiring its own set of DQO inputs and hence different sample requirements. VSP can help because it allows rapid prototyping and has many features that allow the overlay of designs and comparisons across designs.