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Sound ethical decisions based on data! [SM]

Fundamentals of Statistical Design and Analysis
with STATGRAPHICS
for the
Environmental Industry

Foundation for Sound Decisions with Integrity

(First course of two-course sequence: Foundation & Advanced)

Course Code: *Fnd-Env* Course, 5 Days, 4.0 CEUs [for 2nd course see *Adv-Env* outline]
Prerequisites: Experience working with data, some elementary statistical training
College course in statistics helpful, but not required
Reference Texts and Guidelines:
Helsel, Dennis R. and Robert M. Hirsch. 1992. *Statistical Methods in Water Resources.* Elsevier, Amsterdam. (Excellent text for dealing with peculiarities of any environmental data.)
Other texts and EPA reference material will be used depending on client needs and their specific focus. Examples and exercises come from broad areas of environmental data.
Manual and Course Materials: Copy of all PowerPoint presentation slides plus additional notes, exercises and data files.
STATGRAPHICS: Get training and experience using the software; buy from **Alpine Analytics**

Who this course is for: Environmental scientists, engineers, technicians and other professionals who must acquire, analyze, understand, interpret, and summarize environmental data and then communicate results; also environmental and natural resource managers who must make sound environmental decisions with integrity based on environmental data. *Professional areas would include:* Geologists and geochemists, geo-hydrologists, water quality and watershed specialists, environmental chemists and toxicologists, soil scientists, field botanists and plant ecologists, air quality specialists, animal ecologists, general and community ecologists.

I. Framework for Statistical Thinking
A. Context of Statistical Thinking: Environmental Decision Environment
B. Conceptual Framework Model and Scientific Method
C. Decision Context Overview: *The Environmental Industry*
1. **EPA Regulatory Environment**
2. **Environmental Data and Sampling**
3. **Environmental Fields**

II. Basic Sample Statistics and STATGRAPHICS
A. STATGRAPHICS Software Fundamentals
B. Basic Sample Statistics: *Characterizing data with numbers and graphs*

III. Statistical Inference and the Framework
A. Inference Cycle and Probability Models: *Normal and Non-normal Data; Drawing Conclusions from Models*

B. Repeated Sampling and Sampling Distributions: *T, χ^2, F, many others*

C. Statistical Uncertainty: *Concepts and Measures*

D. Estimation and Testing: *Normal and Non-normal Data; Statistical Confidence; Statistical Significance and Practical Significance; Types of Error Uncertainty, Decision Risk and Statistical Power*

E. Power and Sample Size Determination in Statistical Design: *Sample size decisions and budget constraints*

IV. Data Distribution Models and Decision Uncertainty

A. Quantifying Natural Variation of Environmental Phenomena

   1. Modeling Data Distributions

   2. Estimating Percentiles/Quantiles: Point & Interval Estimation

   3. Decision Application: Does a dataset conform to specified limits? How should we formulate this question? How close to the limits?

B. Environmental Standards and Regulatory Compliance

   1. Environmental Compliance Studies

      a) EPA Regulatory Environment

         (1) Regulatory Law: RCRA, CERCLA/SARA, and others

         (2) Environmental Standards and Tolerances: Background and Risk-Based

      b) Environmental Data: Characteristics, EPA Data Quality Objectives (DQO), Nondetects, Assay Validation

   2. Statistical Tolerance Analysis: When is the environment at statistically significant risk?

   3. Non-normality and Outlier Detection: Typical of Environmental Data

   4. Six-Sigma Concepts: Interpretation in an Environmental Context

V. Nondetects in Geochemical and Pollution Data: *Left Censoring*

VI. Analyzing Sources of Variation: Building Explanatory Statistical Models

A. Introduction and Terminology: *Statistical Framework*

B. Categorical Factors with Continuous Response Variables: *Two-Sample Analysis; Paired Data; ANOVA; Single and Multifactor Analysis; Interaction*

C. Continuous Factors with Continuous Response Variables: *Linear & Curvilinear Regression; Single and Multiple Variables; Model Building and Assumption Checking*

D. Associations Among Variables: *Correlations and Contingency Tables*

VII. Monitoring Environmental Processes Over Time

A. Statistical Process Control Concepts

B. Environmental Process Monitoring and Control Charts

   1. Nature and Objectives of Environmental Monitoring

   2. Statistical Basis of Control Chart Design: *Variables and Attributes*

   3. Control Charts for Rapid Detection of Small Environmental Changes

   4. Monitoring Multivariate Environmental Data

C. Detecting Outliers and Extreme Values: *Pollution Hot Spots and Plumes*

D. Detecting and Forecasting Environmental Trends and Seasonality

E. Economics of Environmental Monitoring: *Risks, Hazards and Protection*