Statistical Analysis Of Groundwater Monitoring Data At

"A very well-written handbook." --Ground Water (on the Second Edition) "Presented in a very readable and understandable format." --The Hazardous Waste Consultant (on the Second Edition) The foremost in-depth survey of federal hazardous waste regulations in the United States--now in a new edition The Complete Guide to the Hazardous Waste Regulations is a proven source of clear information on a regulatory system that many find frustratingly complex. Now updated to include additional compliance checklists, Internet resources, and more, this Third Edition provides vital information on all aspects of hazardous materials, from proper on-site management and transportation to appropriate off-site management and cleanup. Author Travis Wagner, one of the nation's leading experts on the subject, provides a step-by-step approach to compliance that goes beyond summarization to help industry professionals truly understand regulations and how they relate to real-world situations. Complete with dozens of user-friendly checklists, flow charts, text boxes, and tables, this indispensable resource includes: * Information on EPA interpretations of regulations not included in other handbooks * Clear explanations of many state-level hazardous waste requirements * A new chapter on spill reporting, giving a step-by-step explanation with attention to multiple federal laws * An appendix listing the Superfund and EPCRA reportable quantity for each RCRA hazardous waste * Additional appendices covering RCRA hazardous wastes, hazardous constituents, groundwater monitoring constituents, permit modification classifications, additional information sources, and important acronyms

Completely revised and updated, the Second Edition of Site Assessment and Remediation Handbook provides coverage of new procedures and technologies for an expanded range of site investigations. With over 700 figures, tables, and flow charts, the handbook is a comprehensive resource for engineers, geologists, and hydrologists conducting site investigation, and a one-stop, technical reference for environmental attorneys.

Discharges of wastes from activities associated with the federal governmentâ€™s Los Alamos site in northern New Mexico began during the Manhattan Project in 1943. Now designated the Los Alamos National Laboratory (LANL), the site is operated under contract by the Department of Energy (DOE). Through past and ongoing investigations, radioactive and chemical contaminants have been detected in parts of the complex system of groundwater beneath the site. Since effective protection of groundwater is important for LANLâ€™s continuing operations, DOEâ€™s Office of Environmental Management requested technical advice and recommendations regarding several aspects of LANLâ€™s groundwater protection program. This interim report summarizes the committeeâ€™s information-gathering activities and identifies issues within the scope of its task that have risen to the committeeâ€™s attention without offering any findings or recommendations. The final report is expected to be released in May 2007 and it is the hope that results of the final study will provide guidance and impetus for dialogue and agreement among DOE, LANL, and other stakeholders on a focused, cost-effective program for protecting the groundwater in and around the site.

This report documents information collected by the Pacific Northwest Laboratory {sup (a)} at the request of Westinghouse Hanford Company. Presented in this report is the interpretation of the hydrogeologic environment at the 2101-M Pond, located in the 200-East Area of the Hanford Site. This information and its accompanying interpretation were derived from sampling and testing activities associated with the installation of four ground-water monitoring wells, in addition to data gathered from several previously existing wells. The new monitoring wells were installed as part of a groundwater monitoring program initiated in 1988. The four new monitoring wells were installed around the 2101-M Pond between May 23 and August 27, 1988. Geologic sampling, aquifer testing, and initial ground-water sampling were performed during the installation of these wells. Laboratory analyses of the sediment samples for particle size, calcium carbonate content, and selected natural and contaminant constituents were performed. A full year of quarterly ground-water sampling and the first statistical analysis of background and downgradient data have also been performed. 112 refs., 49 figs., 18 tabs.

A new edition of the most comprehensive overview of statistical methods for environmental monitoring applications Thoroughly updated to provide current research findings, Statistical Methods for Groundwater Monitoring, Second Edition continues to provide a comprehensive overview and accessible treatment of the statistical methods that are useful in the analysis of environmental data. This new edition expands focus on statistical comparison to regulatory standards that are a vital part of assessment, compliance, and corrective action monitoring in the environmental sciences. The book explores quantitative concepts useful for surface water monitoring as well as soil and air monitoring applications while also maintaining a focus on the analysis of groundwater monitoring data in order to detect environmental impacts from a variety of sources, such as industrial activity and waste disposal. The authors introduce the statistical properties of alternative approaches, such as false positive and false negative rates, that are associated with each test and the factors related to these error rates. The Second Edition also features: An introduction to Intra-laboratory Calibration Curves and random-effects regression models for non-constant measurement variability Coverage of statistical prediction limits for a gamma-distributed random variable, with a focus on estimation and testing of parameters in environmental monitoring applications A unified treatment of censored data with the computation of statistical prediction, tolerance, and control limits Expanded coverage of statistical issues related to laboratory practice, such as detection and quantitation limits An updated chapter on regulatory issues that outlines common mistakes to avoid in groundwater monitoring applications as well as an introduction to the newest regulations for both hazardous and municipal solid waste facilities Each chapter provides a general overview of a problem, followed by statistical derivation of the solution and a relevant example complete with computational details that allow readers to perform routine application of the statistical results. Relevant issues are highlighted throughout, and recommendations are also provided for specific problems based on characteristics such as number of monitoring wells, number of constituents, distributional form of measurements, and detection

frequency. Statistical Methods for Groundwater Monitoring, Second Edition is an excellent supplement to courses on environmental statistics at the upper-undergraduate and graduate levels. It is also a valuable resource for researchers and practitioners in the fields of biostatistics, engineering, and the environmental sciences who work with statistical methods in their everyday work.

Due to the increasing demand for adequate water supply caused by the augmenting global population, groundwater production has acquired a new importance. In many areas, surface waters are not available in sufficient quantity or quality. Thus, an increasing demand for groundwater has resulted. However, the residence of time of groundwater can be of the order of thousands of years while surface waters is of the order of days. Therefore, substantially more attention is warranted for transport processes and pollution remediation in groundwater than for surface waters. Similarly, pollution remediation problems in groundwater are generally complex. This excellent, timely resource covers the field of groundwater from an engineering perspective, comprehensively addressing the range of subjects related to subsurface hydrology. It provides a practical treatment of the flow of groundwater, the transport of substances, the construction of wells and well fields, the production of groundwater, and site characterization and remediation of groundwater pollution. No other reference specializes in groundwater engineering to such a broad range of subjects. Its use extends to: The engineer designing a well or well field The engineer designing or operating a landfill facility for municipal or hazardous wastes The hydrogeologist investigating a contaminant plume The engineer examining the remediation of a groundwater pollution problem The engineer or lawyer studying the laws and regulations related to groundwater quality The scientist analyzing the mechanics of solute transport The geohydrologist assessing the regional modeling of aquifers The geophysicist determining the characterization of an aquifer The cartographer mapping aquifer characteristics The practitioner planning a monitoring network

It is common in environmental analyses to deal with censored data. Censored data characteristically arise through laboratory analysis of samples with contaminant concentrations less than what the analytical method is able to reliably detect. These data are called "less than detectable." Comparisons between downgradient or monitoring groundwater wells and upgradient or background wells are frequently done to determine if downgradient wells are more contaminated than background or some established maximum concentration limits (MCL's). In addition, parameter estimates are often desired. The presence of censored data complicates the statistics that can be used as estimators for individual populations or to estimate differences between two populations. This paper describes the current process at Savannah River Site (SRS) to determine constituents of concern (COC's) for complying with groundwater monitoring and clean-up regulations. COC's are analytes found in downgradient monitoring wells in concentrations significantly greater than in background wells or significantly greater than the MCL'S. Both parametric and non-parametric statistics are explored. Data plots are examined for outliers, trends, laboratory or sampling contamination, and unusually large detection limits for censored results. Wells are grouped by similar concentration levels to form a "characteristic" well, improving the estimation and decision process.

STATISTICS IN PRACTICE Statistical methods for interpreting and analyzing censored environmental data Nondetects And Data Analysis: Statistics for Censored Environmental Data provides solutions for environmental scientists and professionals who need to interpret and analyze data that fall below the laboratory detection limit. Adapting survival analysis methods that have been successfully used in medical and industrial research, the author demonstrates, for the first time, their practical applications for studies of trace chemicals in air, water, soils, and biota. Readers quickly become proficient in these methods through the use of real-world examples that are solved using MINITAB® Release 14, a popular statistical software package, as well as other commonly used software packages. Everything needed to master these innovative statistical methods is provided, including: Accompanying Web site featuring answers to book exercises and datasets, as well as MINITAB® macros to perform methods, which are not available in the commercial version Methods for data with multiple detection limits Solutions for research studies in which all data are below detection limits Techniques for constructing confidence, prediction, and tolerance intervals for data with nond-tects Methods for data with multiple detection limits Chapters are organized by objective, such as computing intervals, comparing groups, and correlations, which enables readers to more easily apply the text to their particular research and goals. Extensive references to the literature for more in-depth research are provided; however, the text itself avoids complex math and calculus making it accessible to anyone in the environmental sciences. Environmental scientists and professionals will find the hands-on guidance and practical examples invaluable.

A variety of statistical methods exist to aid evaluation of groundwater quality and subsequent decision making in regulatory programs. These methods are applied because of large temporal and spatial extrapolations commonly applied to these data. In short, statistical conclusions often serve as a surrogate for knowledge. However, facilities with mature monitoring programs that have generated abundant data have inherently less uncertainty because of the sheer quantity of analytical results. In these cases, statistical tests can be less important, and "expert" data analysis should assume an important screening role. The WSRC Environmental Protection Department, working with the General Separations Area BSRI Environmental Restoration project team has developed a method for an Integrated Hydrogeological Analysis (IHA) of historical water quality data from the F and H Seepage Basins groundwater remediation project. The IHA combines common sense analytical techniques and a GIS presentation that force direct interactive evaluation of the data. The IHA can perform multiple data analysis tasks required by the RCRA permit. These include: (1) Development of a groundwater quality baseline prior to remediation startup, (2) Targeting of constituents for removal from RCRA GWPS, (3) Targeting of constituents for removal from UIC, permit, (4) Targeting of constituents for reduced, (5)Targeting of monitoring wells not producing representative samples, (6) Reduction in statistical evaluation, and (7) Identification of contamination from other facilities.

Statistical methods are required in groundwater monitoring programs to determine if a RCRA-regulated unit affects groundwater quality beneath a site. This report presents the results of the statistical analysis of groundwater monitoring data acquired at B Pond and the 300 Area process trenches during a 2-year trial test period.

Water Quality Data emphasizes the interpretation of a water analysis or a group of analyses, with major applications on ground-water pollution or contaminant transport. A companion computer program aids in obtaining accurate, reproducible results, and alleviates some of the drudgery involved in water chemistry calculations. The text is divided into nine chapters and includes computer programs applicable to all the main concepts presented. After introducing the fundamental aspects of water chemistry, the book focuses on the interpretation of water chemical data. The interrelationships between the various aspects of geochemistry and between chemistry and geology are discussed. The book describes the origin and interpretation of the major elements, and some minor ones, that affect water quality. Readers are introduced to the elementary thermodynamics necessary to understand the use and results from water equilibrium computer programs. The book includes a detailed overview of organic chemistry and identifies the simpler and environmentally important organic chemicals. Methods are given to estimate the distribution of organic chemicals in the environment. The author fully explains all accompanying computer programs and presents this complex topic in a style that is interesting and easy to grasp for anyone.

Published in 1991, the first edition of The Practical Handbook of Ground-Water Monitoring quickly became the gold standard reference on the topic of ground-water monitoring. But, as in all rapidly evolving fields, regulations change, technology advances, methods improve, and research reveals flaws in prior thinking. As a consequence, books that document the state of the science, even widely acknowledged definitive works, become outdated and need to be rewritten periodically to stay current. Reflecting this and renamed to highlight its wider scope, The Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring, Second Edition provides an updated look at the field. Completely revised, the book contains so much new information that it has doubled in size. Containing the most up-to-date information available, this second edition emphasizes the practical application of current technology. It covers environmental site characterization and ground-water monitoring in great detail, from the federal regulations that govern environmental investigations, to the various direct and indirect methods of investigating and monitoring the subsurface, to the analysis and interpretation of complex sets of environmental data. Cheaper, better, faster was the mantra of the 1990s, resulting in more streamlined approaches to both environmental site characterization and ground-water monitoring, but also pitting the application of good science against the mandate to get a project done as quickly and inexpensively as possible. This book provides unbiased, technical discussions of the tremendously powerful tools developed in the last decade, helping environmental professionals strike a balance between good science and economics.

"The unified guidance provides a suggested framework and recommendations for the statistical analysis of groundwater monitoring data at RCRA facility units subject to 40 CFR Parts 264 and 265 and 40 CFR Part 258, to determine whether groundwater has been impacted by a hazardous constituent release." - - p. iii.

Statistical Analysis of Ground-water Monitoring Data at RCRA FacilitiesInterim Final GuidanceStatistical Analysis of Groundwater Monitoring Data at RCRA FacilitiesUnified Guidance

GIS and Geostatistical Techniques for Groundwater Science provides a detailed synthesis of the application of GIS and geostatistics in groundwater studies. As the book illustrates, GIS can be a powerful tool for developing solutions for water resource problems, assessing water quality, and managing water resources. Beginning with an introduction to the history of GIS and geostatistical techniques in groundwater studies, the book then describes various spatial techniques, including case studies for various applications, from quality assessment, to resource management. This book assembles the most up-to-date techniques in GIS and geostatistics as they relate to groundwater, one of our most important natural resources. Provides details on the application of GIS and statistics in groundwater studies Includes practical coverage of the use of spatial analysis techniques in groundwater science Bridges the gap between geostatistics and GIS as it relates to groundwater science and management Offers worldwide case studies to illustrate various techniques and applications in addressing groundwater issues

This title addresses the theoretical background necessary to accomplish planning and management of groundwater systems, and presents up-to-date applications of the decision-aid techniques in this field.

This book discusses a broad range of statistical design and analysis methods that are particularly well suited to pollution data. It explains key statistical techniques in easy-to-comprehend terms and uses practical examples, exercises, and case studies to illustrate procedures. Dr. Gilbert begins by discussing a space-time framework for sampling pollutants. He then shows how to use statistical sample survey methods to estimate average and total amounts of pollutants in the environment, and how to determine the number of field samples and measurements to collect for this purpose. Then a broad range of statistical analysis methods are described and illustrated. These include: * determining the number of samples needed to find hot spots * analyzing pollution data that are lognormally distributed * testing for trends over time or space * estimating the magnitude of trends * comparing pollution data from two or more populations New areas discussed in this sourcebook include statistical techniques for data that are correlated, reported as less than the measurement detection limit, or obtained from field-composited samples. Nonparametric statistical analysis methods are emphasized since parametric procedures are often not appropriate for pollution data. This book also provides an illustrated comprehensive computer code for nonparametric trend detection and estimation analyses as well as nineteen statistical tables to permit easy application of the discussed statistical techniques. In addition, many publications are cited that deal with the design of pollution studies and the statistical analysis of pollution data. This sourcebook will be a useful tool for applied statisticians, ecologists, radioecologists, hydrologists, biologists, environmental engineers, and other professionals who deal with the collection, analysis, and interpretation of pollution in air, water, and soil.

Tremendous improvements in ground-water sampling methodologies and analytical technologies have made it possible to collect and analyze truly representative samples to detect increasingly lower levels of contaminants-now in the sub-parts-per-billion range. Though these new methods produce more accurate and precise data and are less expensive, many

This form updates the groundwater monitoring plan for the B Pond system and documents revision agreed upon with the Washington State Department of Ecology concerning well network, constituent list, statistical analysis, and report procedures.

Introduction to Statistical Analysis of Laboratory Data presents a detailed discussion of important statistical concepts and methods of data presentation and analysis Provides detailed discussions on statistical applications including a comprehensive package of statistical tools that are specific to the laboratory experiment process Introduces terminology used in many applications such as the interpretation of assay design and validation as well as “fit for purpose” procedures including real world examples Includes a rigorous review of statistical quality control procedures in laboratory methodologies and influences on capabilities Presents methodologies used in the areas such as method comparison procedures, limit and bias detection, outlier analysis and detecting sources of variation Analysis of robustness and ruggedness including multivariate influences on response are introduced to account for controllable/uncontrollable laboratory conditions

Data on water quality and other environmental issues are being collected at an ever-increasing rate. In the past, however, the techniques used by scientists to interpret this data have not progressed as quickly. This is a book of modern statistical methods for analysis of practical problems in water quality and water resources. The last fifteen years have seen major advances in the fields of exploratory data analysis (EDA) and robust statistical methods. The 'real-life' characteristics of environmental data tend to drive analysis towards the use of these methods. These advances are presented in a practical and relevant format. Alternate methods are compared, highlighting the strengths and

weaknesses of each as applied to environmental data. Techniques for trend analysis and dealing with water below the detection limit are topics covered, which are of great interest to consultants in water-quality and hydrology, scientists in state, provincial and federal water resources, and geological survey agencies. The practising water resources scientist will find the worked examples using actual field data from case studies of environmental problems, of real value. Exercises at the end of each chapter enable the mechanics of the methodological process to be fully understood, with data sets included on diskette for easy use. The result is a book that is both up-to-date and immediately relevant to ongoing work in the environmental and water sciences.

This report (269 pages, 4 plates) presents hydrogeologic, groundwater-monitoring, and hydrochemical studies by the Utah Geological Survey (UGS) in Snake Valley, Tule Valley, and Fish Springs Flat in Millard and Juab Counties, west-central Utah. Data From the newly established UGS groundwater-monitoring network establish current baseline conditions, and will help quantify the effects of future variations in climate and groundwater pumping. New hydrochemical data show that groundwater quality is generally good, major-solute chemistry varies systematically from recharge to discharge areas, and suggest that most groundwater was recharged over one thousand years ago, implying low recharge rates and/or long or slow flow paths. Two aquifer tests yield estimates of transmissivity and storativity for the carbonate-rock and basin-fill aquifers. Variations in the potentiometric surface, hydrogeology, and hydrochemistry are consistent with the hypothesis of regional groundwater flow from Snake Valley northeast to Tule Valley and Fish Springs. Collectively, our work delineates groundwater levels, flow, and chemistry in Snake Valley and adjacent basins to a much greater degree than previously possible, and emphasizes the sensitivity of the groundwater system to possible increases in groundwater pumping.

In 2002, radium 226 and 228 measurements elevated above the 5 pCi/L groundwater protection standard (GWPS) and gross alpha measurements above the 15 pCi/L GWPS were noticed in several groundwater monitoring wells at the SRS Sanitary Landfill. An additional four quarters of confirmatory measurements for Ra in the SLF groundwater were taken during 2003 as directed by the SC Department of Health and Environmental Control. Elevated radium concentrations in groundwater of the Aiken County area are a common occurrence. Price and Michel (1990) compiled radium concentrations in drinking water wells of this area and showed several instances of the concentrations exceeding the regulatory limit. Ra226 is an alpha emitter and contributes much of the natural alpha radioactivity found in uncontaminated groundwater. Thus, the elevated radium concentrations are usually accompanied by elevated gross alpha concentrations. Appendix A2 indicates that this is the case at the SLF where Ra226 accounts for almost all elevated gross alpha.