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Identification of Technical Guidance Related to Ground Water Monitoring

Raimund R. Vogelsberger
Ellen D. Smith
Marian Broz
John C. Wright, Jr.

Environmental Sciences Division
Publication No. 2834

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ENVIRONMENTAL SCIENCES DIVISION

IDENTIFICATION OF TECHNICAL GUIDANCE RELATED TO GROUND WATER MONITORING

Raimund R. Vogelsberger*, Ellen D. Smith,
Marian Broz*, and John C. Wright, Jr.*

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Publication No. 2834

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CONTENTS

LIST OF TABLES

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We consulted with several outside authorities to obtain information on regulations and to supplement our literature search. Individuals who were especially helpful include Valerie Orr and Chris Reimer, both of the National Water Well Association's National Ground Water Information Center in Dublin, Ohio, and Anthony Montrone of the U.S. Environmental Protection Agency (EPA) Hazardous Waste Ground Water Task Force, Washington, D.C. We are also grateful to Robin Gelormini of IT and her word processing staff, including Janet Seigworth, Shawn Stockman, and Mary Ann Dittsworth, for excellent and efficient support in text preparation and electronic transmission during the development of this report.

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ABSTRACT

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Monitoring of ground water quality is a key element of ground water protection and is mandated by several federal and state laws concerned with water quality or waste management. Numerous regulatory guidance documents and technical reports discuss various aspects of ground water monitoring, but at present there is no single source of guidance on procedures and practices for ground water monitoring. This report is intended to assist U.S. Department of Energy (DOE) officials and facility operating personnel in identifying sources of guidance for developing and implementing ground water monitoring programs that are technically sound and that comply with applicable regulations.

Federal statutes and associated regulations were reviewed to identify requirements related to ground water monitoring, and over 160 documents on topics related to ground water monitoring were evaluated for their technical merit, their utility as guidance for regulatory compliance, and their relevance to DOE's needs. For each of 15 technical topics involved in ground water monitoring, the report presents (1) a review of federal regulatory requirements and representative state requirements, (2) brief descriptions of the contents and merits of available guidance documents and technical references, and (3) recommendations of the guidance documents or other technical resources that appear to be most appropriate for use in DOE's monitoring activities. The contents of the report are applicable to monitoring activities involving both radioactive and nonradioactive substances. The main sources of regulatory requirements considered in the report are the Atomic Energy Act (including the Uranium Mill Tailings Radiation Control Act), Resource Conservation and Recovery Act, Comprehensive Environmental Response, Compensation and Liability Act, Safe Drinking Water Act, Toxic Substances Control Act, and Federal Water Pollution Control Act.

Although this report was prepared for use by DOE, the majority of the technical materials reviewed and the recommendations in the report are equally applicable to ground water monitoring activities carried out by other organizations and agencies.

1. INTRODUCTION

Monitoring of ground water quality is a key element of ground water protection and is mandated by various federal and state laws concerned with water quality or waste management. The present report is intended to provide technical background for use by the U.S. Department of Energy (DOE) Office of Environmental Guidance (OEG) in developing DOE Orders and associated guidance for DOE ground water monitoring.

At present, there is no single source of guidance on procedures and practices for ground water monitoring. To assist the DOE in identifying procedures and practices that should be followed in DOE ground water monitoring activities, OEG asked the Oak Ridge National Laboratory (ORNL) to compile the present report, identifying applicable regulatory requirements and technical resources that could be used by DOE. ORNL received major technical support in this effort from International Technology (IT) Corporation. IT personnel had principal responsibility for identifying and reviewing regulations and technical resources and for preparing this report.

Major steps in the development of this report included the identification of federal statutes and regulations relevant to ground water and the preparation of a compendium containing brief descriptions and evaluations of existing government documents, books, and recent journal articles addressing topics related to ground water monitoring. A review of significant state ground water policies and regulations is also included. From the information gathered in the compendium, a summation of the most applicable regulations and most appropriate regulatory and technical guidance has been developed.

The remainder of Section 1 contains a description of the framework used to organize technical information about ground water monitoring, a discussion of statutes and regulations concerned with ground water monitoring, and suggestions for efficient use of the report. Section 2 presents a list of the technical guidance documents and other technical references that were identified as potentially relevant to DOE monitoring activities. Section 3 is a compendium of technical information sources. In this section, regulatory requirements, available guidance documents, and other technical references relevant to each of 15 technical topics are listed and described, and a brief evaluation of the merits of each technical item is reported. The most relevant regulations and recommended regulatory and technical guidance are identified for each of the 15 technical topics in Section 4, which is intended to be a summation of the information in Section 3. Federal statutes and associated regulations related to ground water monitoring are listed in the appendix.

1.1 TECHNICAL TOPICS OF GROUND WATER MONITORING

The general subject of ground water monitoring has been divided into 15 technical topics to facilitate the organization of the information in this report. The topics were selected on the basis of general sequence of activities and decision-making steps for a typical ground water monitoring project and are listed below. While some parts of the topics may not necessarily play a large role in every case, consideration was given to the wide range of monitoring situations which officials of DOE may encounter.

The technical topics of ground water monitoring and a description of the items included within each topic follow:

- Purpose and Need to Monitor Ground Water - Regulations that specifically require monitoring or that require hydrogeologic data as part of an environmental evaluation or site characterization and technical considerations related to the need for monitoring or assessment of ground water quality, regardless of regulatory requirements.

- Monitoring System Design - Determination of the appropriate number and location of wells or other monitoring devices required for the monitoring activity. Includes guidance on preliminary hydrogeologic investigation of a site.

- Drilling Methods - Determination of the appropriate drilling method for the construction of monitoring wells.

- Well Data - Proper handling and recording of boring logs, well elevations, aquifer permeability, and geology. (The determination of ground water elevations prior to sampling is covered under Sample Collection and Frequency.)

- Well Design and Construction/Development - Selection of the well diameter, screen length, casing material compatibility, purging methods, and related items. Also includes procedures for proper well abandonment.

- Health and Safety Procedures - Personal exposure regulations and selection of respiratory equipment and protective clothing. Also includes prevention of physical injuries from drilling equipment and heat stress during monitoring activities.

- Monitoring Parameters - Monitoring parameters specified by certain regulations and the selection of appropriate parameters to be monitored if none are specified by regulations.

- Sample Collection and Frequency - Strategy for developing sampling plans, techniques for sample collection, recommended or required frequency of sampling, selection of sampling equipment, procedures for well evacuation, and procedures for decontaminating sampling equipment between wells.

- Sample Preservation and Handling - Selection of containers, preservative methods, and handling procedures.

- Sampling Quality Assurance and Chain of Custody - Preparation of quality assurance (QA) plans, chain-of-custody procedures, and maintenance of field logbooks.

- Analytical Procedures - Required and recommended analytical procedures for the field and laboratory.

- Laboratory Quality Assurance - Quality assurance and quality control (QA/QC) plans for laboratories.

- Reporting of Data - Recommended and required data format and data management systems.

- Evaluation of Data - Required statistical analysis and methods for the modeling of ground water contaminant migration.

- Ground Water Standards and Alternate Concentrations Limits - Maximum contaminant levels (MCLs), drinking water standards, and other prescribed concentration limits, and procedures for establishing alternate concentration limits (ACLs).

Items which pertain to ground water monitoring but do not readily fit into any of the topics are included under "Purpose and Need to Monitor Ground Water." The reader should be aware that the above-defined topics do not provide comprehensive coverage of the ground water field and that several important ground water topics are largely outside the scope of this report. For example, extensive literature exists on the investigation of natural ground water systems, and it is desirable to have a thorough understanding of the hydrogeologic setting of a site (such as might be obtained through a comprehensive investigation) when implementing a program to monitor or evaluate ground water quality. Approaches for comprehensive ground

water investigations are handled only peripherally in this report as this type of investigation is rarely a direct part of ground water monitoring and information on this subject is available elsewhere.

1.2 STATUTES AND REGULATIONS RELEVANT TO GROUND WATER MONITORING

1.2.1 Federal Statutes and Regulations

At present, there are no comprehensive federal statutes regulating ground water quality and monitoring. Rather, ground water requirements are to be drawn from a number of distinct laws enacted at various dates to protect other resources or to regulate specific sources of contamination. The relevant legislation includes:

- Atomic Energy Act (AEA) of 1954, as amended by the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980
- Federal Water Pollution Control Act (FWPCA), as amended by the Clean Water Act (CWA) of 1977
- Nuclear Waste Policy Act (NWPA) of 1982
- Public Health Service Act (PHSA) of 1965
- Resource Conservation and Recovery Act (RCRA) of 1976 including the Hazardous and Solid Waste Amendments (HSWA) of 1984
- Safe Drinking Water Act (SDWA)
- Solid Waste Disposal Act (SWDA)
- Toxic Substances Control Act (TSCA).

Sections of these statutes and associated regulations from the Code of Federal Regulations (CFR) that deal in some way with ground water monitoring are outlined in Appendix A. The Federal Insecticide, Fungicide, and Rodenticide Act, the Surface Mining Control and Reclamation Act, and the National Environmental Policy Act or their associated regulations also contain provisions to prevent contamination of ground water but do not specifically address ground water monitoring or establish water quality standards which may affect DOE installations. These statutes and associated regulations are not included in Appendix A.

A matrix of the ground water monitoring topics and applicable federal regulations is presented in Table 1. Since applicable

Table 1. Technical topic and regulations matrix

TECHNICAL TOPIC	REGULATIONS																		
	10 CFR PARTS						40 CFR PARTS												
	20	40*	50	60	61	70*	136	141	143	144	146	191	192	241	257	264	265	300	761
ACT:	AEA			NWPA	AEA		FWPCA	PHSA	SDWA			NWPA	AEA	SWDA	RCRA			CERCLA	TSCA
Purpose and Need to Monitor	-	.31 App.A	-	.21 .140 .141 .142	.12 .53	.59	-	.1 to	.3	.12 .28	.32	.14	.20 .32	.204	3-4	.90 .302	.11	.68	.75
Monitoring System Design	-	App.A	-	-							.13 .23 .33	-	.20	.204	-	.97	.91	-	.75
Drilling Methods	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well Data	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well Design and Construction/ Development	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.97	.91	-	.75
Health and Safety	.202	-	-	.31	.83	-	-	-	-	-	-	-	-	.211	-	-	-	.57	-
Monitoring Parameters	-	-	-	-	-	-	-	-	-	.28	-	.32 .33	-	-	-	.93 .98 .99 .100	.92 .93	.68	.75
Sample Collection and Frequency	-	-	-	-	-	-	.3	.23 .26 .27	-	-	-	-	-	-	-	.97 .98 .99	.92	-	.75
Sample Preservation and Handling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.97	.92	-	-
Sampling Quality Assurance and Chain of Custody	-	-	App.B	.151 .152	-1	-	-	-	-	-	-	-	-	-	-	.97	.92	-	.75 .180
Analytical Procedures	-	-	-	-	-	-	.3	.23 .24 .25 .27 .28	-	.28	-	..	-	-	-	.97	.92	-	.75
Laboratory Quality Assurance	-	-	App.B	.151 .152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reporting of Data	.4 .5	-	-	-	-	-	-		-	.28 .23 .33	.13					.98	.94	-	-
Evaluation of data	-	-	-	-	-	-	-	.23 to .26	-	-	-	-	.32	-	-	.97 .98 .99	.93	.68	-
Ground Water Standards and Alternate Concentration Limit	.106	-	-	.113	.41	-	-	.11 to .16	.3	.12	.4	.16	.02 .12 .20 .32 .33	.204	.3-4 App.I	.92 .94 .99	.92	-	-

*The regulations of this part exempt the DOE to the extent that its activities are subject to 10 CFR 60.

LEGEND

AEA = Atomic Energy Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
FWPCA = Federal Water Pollution Control Act
NWPA = Nuclear Waste Policy Act of 1982
PHSA = Public Health Service Act of 1965
RCRA = Resource Conservation and Recovery Act of 1976
SDWA = Safe Drinking Water Act
SWDA = Solid Waste Disposal Act
TSCA = Toxic Substance Control Act of 1976

sections of the CFR are listed for each particular topic area, the matrix permits a rapid regulatory check for any stage of a ground water monitoring project.

The following federal environmental laws were reviewed but were found to have no direct bearing on ground water protection or monitoring or would not be applicable to DOE facilities: the Coastal Zone Management Act of 1972; Federal Land Policy and Management Act of 1976; Hazardous Materials Transportation Act of 1975; Marine Protection, Research, and Sanctuaries Act of 1972; National Preservation Act of 1966; National Trails System Act; Open Spaces Land Act; Reclamation Act of 1972; the Water Resources Planning Act; Wild and Scenic Rivers Act of 1968; and the Wilderness Act.

1.2.2 State Statutes and Regulations

In addition to federal statutes that authorize programs and activities for ground water protection, many states are also developing and implementing ground water policies, statutes, and strategies. Often, states have the authority or "primacy" to administer several federal environmental laws. Under this authority, states may, and often do, impose more stringent requirements than the federal government. In many states, state agencies, regional authorities, and local government share responsibilities for protecting ground water. Public involvement in ground water programs is also being actively encouraged at the state level.

State ground water monitoring requirements focus primarily on nonhazardous waste sites, hazardous waste sites, salt water intrusion, pesticides, and drinking water. Some states have site-specific ground water monitoring requirements for road construction sites, irrigation wells, and areas near water supplies. To carry out their ground water policies, states are also developing control programs that focus on land use, septic tanks, agricultural contamination, underground storage tanks, response to contamination incidents, brine disposal, and radionuclides. Contaminants covered by ground water quality standards vary from state to state and about half the states have adopted or proposed some type of classification system for ground water.

Additional information on state ground water policies and regulations is obtainable from three documents listed in Section 2: 85-EPA-8, 85-EPA-14, and Applied Managment Sciences (1985). (Reference citations are coded to Sections 2.2 and 2.3)

1.3 SUGGESTIONS FOR USING THIS REPORT

Most users of this report will first want to consult the summation (Section 4), which is intended for ready-reference use. It contains concise discussions of the technical topics and briefly identifies those items that define recommended approaches to ground water monitoring activities. By consulting the summation for a particular technical topic, the reader may: (1) obtain a general understanding of the nature of the activities and concerns associated with that topic,

(2) identify those federal regulations and DOE orders that must be followed in carrying out those activities, (3) identify the technical and regulatory guidance documents that need to be consulted to comply with regulations and orders, and (4) identify the sources of technical guidance that should be used in designing or implementing a monitoring program in accordance with best current practices. Regulations listed in the summation must be followed when DOE is involved in monitoring activities covered by the listed regulations, and personnel should be required to consult applicable regulatory guidance when they are involved in regulated monitoring activities. Technical guidance listed in the summation is that which, in the opinion of the authors of this report, embodies good current practice in the technical areas covered by the technical topic. In general, these items should be consulted for guidance on aspects of monitoring activity that are not prescribed by regulations or regulatory guidance. The introduction to Section 4 provides further information on the contents and use of the summation.

Descriptions in the summation of regulations and guidance materials are abbreviated to permit rapid identification of key materials. Technical users requiring more information may refer back to the appropriate portion of the compendium (Section 3) for more detailed descriptions of applicable regulations and guidance documents. Also, Table 1 may be useful for an overview of the regulations associated with individual technical topics. Section 3 also may be consulted to identify additional sources of technical information or guidance to supplement those identified in the summation. For almost every technical topic there are several good sources of current technical guidance that were not included in the summation because they are not as recent or not as comprehensive as the items selected for the summation. These items are listed and described in the compendium, and technical users may sometimes find them to be useful as supplements to the primary sources of guidance listed in the summation.

Because the compendium and summation identify documents according to abbreviated codes, the user should refer either to the reference list associated with the summation or to the complete list of documents in Section 2 to obtain complete reference citations. Both codes and full citations are given in these sections.

The reader should recognize that the information in this report is subject to change, due both to changing technology and changing regulatory requirements. The majority of the information herein was current as of June 1986, and significant events that occurred through October 1, 1986 (e.g., U.S. Environmental Protection Agency [EPA] September 1986 publication of a final version of the RCRA Ground-Water Monitoring Technical Enforcement Document) have been reflected in the body of the report. Recent statutory changes and regulatory initiatives that can be expected to modify requirements and procedures discussed in this report include the following:

- Public Law 99-339, which was signed by President Reagan on June 19, 1986, reauthorized and amended the SDWA. Among the provisions of the amended Act is a requirement that EPA issue new drinking water standards for 83 specified substances over the next three years (i.e., by 1989) and for an additional 25 substances by 1991. In addition, states are required to establish "wellhead protection areas" to protect drinking water supply wells from contamination.

- The EPA has issued a proposed rule (51 FR 26632, July 24, 1986) that would narrow the list of chemicals that RCRA hazardous waste facilities must test for when ground water contamination is suspected. The proposal would create Appendix IX to 40 CFR 264, consisting of a list of 250 chemicals that would, for ground water monitoring purposes, replace the list of hazardous constituents in Appendix VIII to 40 CFR 261. The new list would not include those Appendix VIII chemicals that are unstable in water or that are not amenable to analysis, and it would include 25 substances not on the Appendix VIII list that are currently monitored at CERCLA sites.

- In an advanced notice of proposed rulemaking issued August 20, 1986 (51 FR 29812), the EPA indicated its intent to modify requirements (in 40 CFR 264 and 265, Subparts F) for statistical evaluation of RCRA ground water monitoring data. Currently prescribed test procedures would be replaced by new sampling and statistical procedures, with the intent of reducing the probabilities of false positives and false negatives.

- The Nuclear Regulatory Commission NRC has proposed (51 FR 24697, July 8, 1986) revisions to 10 CFR 40, Appendix A, that would more fully incorporate the EPA ground water protection requirements for management of uranium and thorium by-product material (40 CFR 192) into NRC's rules for disposal of uranium mill tailings.

- An advanced notice of proposed rulemaking issued by EPA on June 18, 1986 (51 FR 22264) discussed EPA's intent to develop residual radioactivity criteria for contaminated land and facilities at decommissioned nuclear facilities and at other sites where radioactive materials, including naturally occurring and accelerator-produced radioactive materials, have been used. These criteria could affect ground water monitoring activities at affected sites.

2. TECHNICAL GUIDES FOR GROUND WATER MONITORING

2.1 INTRODUCTION

This section represents a reasonably comprehensive listing of the major government and nongovernment technology guides related to ground water monitoring. The documents listed have been reviewed and are discussed in Section 3, the compendium. Other documents were identified during the investigation but were not reviewed (and are not listed in this report) because they were judged to be peripheral or irrelevant to the purpose of the report and/or the difficulty of acquisition was judged to be in excess of their perceived minimal value. The listings of journal articles and proceedings are limited to recent papers whose findings are not yet reflected in the more comprehensive manuals and to other papers that appear to have exceptional value as technical guidance for ground water monitoring.

The following listings are organized by government or nongovernment guidance documents. Government documents, including those prepared by government contractors, are grouped by issuing agency. Under each issuing agency heading, the reports are listed in chronological order starting with the most recent publication. For each publication year, government reports are listed by year of publication and alphabetically by author and/or title within each year. The nongovernment documents are organized under two major headings:

- Guides, manuals, standards, and textbooks
- Journal articles and conference papers.

Under each of the headings, nongovernment references are listed in alphabetical order by the principal author's last name and year of publication.

The listings presented in this section are coded to facilitate the referencing of these documents in the subsequent compendium (Section 3) and summation (Section 4). The coding system for government documents consists of the year published, government agency, and a sequential number. An abbreviated title is also used in coding. For nongovernment documents, the coding system consists of the principal author and year published.

2.2 GOVERNMENT DOCUMENTS

CODE	TITLE
U.S. ENVIRONMENTAL PROTECTION AGENCY	
86-EPA-1 Tank Leak Detection	Niaki, S. and J. A. Broscious (IT Corporation), 1986, "Underground Tank Leak Detection Methods: A State-of-the-Art Review," EPA/600/2-86/001, U.S. EPA, Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio.
86-EPA-2 GW Task Force Report	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1986, "Evaluation of the RCRA Subpart F Ground Water Monitoring Program," prepared by the Hazardous Waste Ground Water Task Force, U.S. EPA, Washington, D.C.
86-EPA-3 STORET	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1986, "Ground Water Data Management with STORET," EPA/600/M-86/007, U.S. EPA, Washington, D.C.
86-EPA-4 Appendix VIII Guide	U.S. Environmental Protection Agency, 1986, "Guidance on Issuing Permits to Facilities Required to Analyze Ground Water for Appendix VIII Constituents," U.S. EPA, Washington, D.C.
86-EPA-5 TEGD	U.S. Environmental Protection Agency, Office of Waste Programs Enforcement, 1986, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document," U.S. EPA, Washington, D.C.
85-EPA-1 Practical Guide GW Samp.	Barcelona, M. J., et al. (Illinois State Water Survey), 1985, "Practical Guide for Ground-Water Sampling," EPA/600/2-85/104, U.S. EPA, Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, Ada, Oklahoma.
85-EPA-2 Rem. Act. HW Sites	Boutwell, S. H., et al. (Anderson-Nichols & Company, Inc.), 1985, "Modeling Remedial Actions at Uncontrolled Hazardous Waste Sites," EPA/540/2-85/001, U.S. EPA, Office of Solid Waste and Emergency Response, Washington, D.C.
85-EPA-3 GW Monit/ Stat. Proc. HW Facilities	Doctor, R. G., et al. (Pacific Northwest Laboratory), 1985, "Ground Water Monitoring Plans and Statistical Procedures to Detect Leaking at Hazardous Waste Facilities (Draft)," U.S. EPA, Washington, D.C.

GOVERNMENT DOCUMENTS (continued)

85-EPA-4 ACL Guide	U.S. Environmental Protection Agency, Office of Solid Waste, 1985, "Alternate Concentration Limit Guidance Based on 264.94(b) Criteria," U.S. EPA, Washington, D.C.
85-EPA-5 GW Mont. Strat.	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Ground Water Monitoring Strategy," U.S. EPA, Washington, D.C.
85-EPA-6 CERCLA Feasibility Studies	U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1985, "Guidance on Feasibility Studies under CERCLA," EPA/540/G-85/003, U.S. EPA, Washington, D.C.
85-EPA-7 Interim Crit. HW Mgt. Prog.	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1985, "Interim National Criteria for a Quality Hazardous Waste Management Program," U.S. EPA, Washington, D.C.
85-EPA-8 State GW Prog. Summaries Vol. 1	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Overview of State Ground Water Program Summaries," Vol. 1, U.S. EPA, Washington, D.C.
85-EPA-9 State GW Prog. Summaries Vol. 2	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "State Ground Water Program Summaries," Vol. 2, U.S. EPA, Washington, D.C.
85-EPA-10 GW Mont. Workshop Planning	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Planning Workshop to Develop Recommendations for a Ground Water Monitoring Strategy," U.S. EPA, Washington, D.C.
85-EPA-11 RCRA GW Monit. Guide	U.S. Environmental Protection Agency, Office of Waste Programs Enforcement, 1985, "RCRA Ground Water Monitoring Compliance Order Guide," U.S. EPA, Washington, D.C.
85-EPA-12 TEGD	U.S. Environmental Protection Agency, Office of Waste Programs Enforcement, 1985, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document (Draft)," U.S. EPA, Washington, D.C. [Replaced by 86-EPA-5.]
85-EPA-13 GW Mont. Workshop Resource Doc.	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Resource Document for the Ground Water Monitoring Strategy Workshop," U.S. EPA, Washington, D.C.

GOVERNMENT DOCUMENTS (continued)

CODE	TITLE
85-EPA-14 State/Territory GW Class.	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Selected State and Territory Ground Water Classification Systems," U.S. EPA, Washington, D.C.
85-EPA-15 TSCA GW Prot. Strat.	U.S. Environmental Protection Agency, 1985, "TSCA Ground Water Protection Strategy."
85-EPA-16 CLP Inorganic Protocol	U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, 1985, "Chemical Analytical Services for Multi-Media Multi-Concentration Metals and Inorganics," WA85-J839, U.S. EPA, Las Vegas, Nevada.
85-EPA-17 CLP Organic Protocol	U.S. Environmental Protection Agency, Environmental Monitoring System Laboratory, 1985, "Organic Protocol," WA85-J178, U.S. EPA, Las Vegas, Nevada.
84-EPA-1 GW Prot. Strat.	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1984, "Ground Water Protection Strategy," U.S. EPA, Washington, D.C.
84-EPA-2 Permit App. Guide HW Facilities	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities (Final Draft)," EPA/530/SW-84/004, U.S. EPA, Washington, D.C.
84-EPA-3 Permit Writ. Guide HW Facilities	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Permit Writers' Guidance Manual for Hazardous Waste Land Storage and Disposal Facilities, Phase I: Criteria for Location Acceptability and Existing Applicable Regulations (Final Draft)," U.S. EPA, Washington, D.C.
84-EPA-4 Rem. Investigations Guide	U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, 1984, "Remedial Investigations Guidance Document," U.S. EPA, Cincinnati, Ohio.
84-EPA-5 Soil Properties SW-925	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Soil Properties, Classification, and Hydraulic Conductivity Testing (Draft)," SW-925, U.S. EPA, Washington, D.C.

GOVERNMENT DOCUMENTS (continued)

CODE	TITLE
84-EPA-6 Standard Oper. Safety Guide	U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1984, "Standard Operating Safety Guides," U.S. EPA, Washington, D.C.
84-EPA-7 Rem. Response HW Sites	U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1984, "Summary Report: Remedial Response at Hazardous Waste Sites," EPA/540/2-84/002a, U.S. EPA, Washington, D.C.
84-EPA-8 Waste Analysis Plans	U.S. Environmental Protection Agency, Office of Solid Waste, 1984, "Waste Analysis Plans: A Guidance Manual," EPA/530/SW-84/012, U.S. EPA, Washington, D.C.
83-EPA-1 Guide to Matl. Selection ISWS-327	Barcelona, M. J., et al. (Illinois State Water Survey), 1983, "A Guide to the Selection of Materials for Monitoring Well Construction and Ground-Water Sampling," ISWS Contract Report 327, EPA Contract No. CR-809966-01, Illinois State Water Survey, Department of Natural Resources, Champaign, Illinois.
83-EPA-2 Rem. Act. Tech. Plans	Ehrenfeld, J. and J. Bass (Arthur D. Little, Inc.), 1983, "Handbook for Evaluating Remedial Action Technology Plans," EPA/600/2-83/076, U.S. EPA, Municipal Environmental Research Laboratory, Office of Research and Development, Cincinnati, Ohio.
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Johnson 1981 GW Monit. Rev.	Johnson, T. M., 1981, "Monitoring of Leachate Migration in the Unsaturated Zone in the Vicinity of Sanitary Landfills," Ground Water Monitoring Review, Vol. 1, No. 3, pp. 55-63.
Kill 1985 Natl. Env. Health Assoc. Proc.	Kill, D., 1985, "Ground Water Monitoring and Practical Applications for Environmental Health Personnel," in National Environmental Health Association 49th Annual Educational Conference, National Environmental Health Association, Denver, Colorado.
McBean 1985 GW Monit. Rev.	McBean, E. A. and F. A. Rovers, 1985, "Analysis of Variances as Determined from Replicates vs. Successive Sampling," Ground Water Monitoring Review, Vol. 5, No. 3, pp. 61-64.
Miller 1984 NWWA/API Proc.	Miller, M. D. and F. C. Kohout, 1984, "RCRA Ground Water Monitoring Statistical Comparisons: A Better Version of Student's T-Test," in Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water Prevention, Detection, and Restoration, National Water Well Association, Dublin, Ohio.

NONGOVERNMENT DOCUMENTS (continued)

CODE	TITLE
Nielson 1985 GW Monit. Rev.	Nielson, D. M. and G. L. Yeates, 1985, "A Comparison of Sampling Mechanisms Available for Small Diameter Ground Water Monitoring Wells," Ground Water Monitoring Review, Vol. 5, No. 2, pp. 83-99.
Osiensky 1984 Ground Water	Osiensky, J. L., et al., 1984, "Monitoring and Mathematical Modeling of Contaminated Ground Water Plumes in Fluvial Environments," Ground Water, Vol. 22, No. 3, pp. 298-306.
Rail 1985 J. Env. Health	Rail, C. D., 1985, "Groundwater Monitoring Within an Aquifer: A Protocol," Journal of Environmental Health, Vol. 48, No. 3, pp. 128-132.
Ross 1984 NWWA/API Proc.	Ross, L. and R. Elton, 1984, "Maximizing the Statistical Performance of Ground Water Monitoring System," in Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water Prevention, Detection, and Restoration, National Water Well Association, Dublin, Ohio.
Schmidt 1985 American Water Resources Assoc.Proc.	Schmidt, K. D., ed., 1985, "Groundwater Contamination and Reclamation," Proceedings of a Symposium held in Tucson, Arizona, August 14-15, 1985, American Water Resources Association, Bethesda, Maryland.
Splitstone 1986 HMCRI Proc.	Splitstone, D. E., 1986, "A Statistician's View of Ground Water Monitoring," in Proceedings of the National Conference on Hazardous Waste and Hazardous Materials, Hazardous Materials Control Research Institute, Silver Spring, Maryland, pp. 8-12.

3. COMPENDIUM OF REGULATIONS AND TECHNICAL GUIDANCE RELATED TO GROUND WATER MONITORING

3.1 INTRODUCTION

This section presents a compendium of regulations and technical guidance for each of the technical topics of ground water monitoring. For each technical topic, applicable regulations from the Code of Federal Regulations (CFR) are identified and briefly described. Regulations are listed beneath abbreviations of the federal statute upon which the regulation was based. Details on the federal statutes are presented in the appendix.

Following the regulations, relevant DOE orders are listed and described. Technical documents prepared by federal agencies, or contractors to the agencies, are listed under the "Guide" heading. Coded references for the technical guides are presented in this and subsequent sections of the report. Complete reference citations are presented in Section 2.

Portions from each technical guide relevant to the topic are described and comments are given on the regulatory and/or technical guidance merits of the document. Only where a document has been issued by an agency for the express purpose of providing regulatory guidance for a particular regulation will a comment appear regarding regulatory guidance. If a document description contains no comment regarding regulatory guidance, then the document is not intended for use as a guide for regulatory compliance.

Comments on the technical guidance of a document differ, depending on the level of value of the guidance information. Comments are generally presented in a standard language which is explained as follows:

- Good technical guidance - The document contains a large amount of useful technical guidance for a particular topic and/or some guidance which may not be contained in other documents
- Some value as technical guidance - The document may contain a fair amount of useful guidance
- Limited technical guidance - A small amount of technical information was found
- No technical guidance - The document contained no relevant technical information, but a statement may be included describing some other type of useful information in the document
- Current - Applicable guidance for existing regulations or current technical guidance

- Partially superseded - Portions are no longer applicable guidance for current regulations, or technical content is partially out of date due to recent developments

- Out-of-date - No applicable guidance for current regulations, or technical content is out of date due to recent developments. (Some materials included are out-of-date in full or in part, but they are described to assist the user in evaluating their applicability.)

If guidance is general or limited to a particular part of a topic, the comments are worded as such.

A list of relevant nongovernment references (books, journal articles, and papers from proceedings) follows the list of government documents. Descriptions of and comments on these references are similar to those given for the government documents.

At the end of each topic compendium, a section is included describing some examples of state regulations which differ substantially from federal regulations or procedures. The discussion on state regulations is not meant to be all-encompassing but to describe the general regulatory directions in which some states are proceeding and to demonstrate that in many instances compliance with federal regulations will not suffice to meet state, or even local, concerns.

3.2 TOPICAL COMPENDIA

PURPOSE AND NEED TO MONITOR GROUND WATER

REGULATION	DESCRIPTION
AEA	
10 CFR 40.31(h)	Requires that applications for a Nuclear Regulatory Commission (NRC) license for activities related to uranium or thorium milling meet criteria of 10 CFR 40 Appendix A. (Not directly applicable to DOE.)
10 CFR 40 Appendix A	Requires in Criteria 5 and 7 that applicants for an NRC license for disposal of uranium or thorium mill tailings gather subsurface hydrogeologic data to determine baseline conditions and environmental effects of the mill tailings disposal system. (Not directly applicable to DOE.)
10 CFR 61.12 and 61.53	Requires applications for NRC licenses for low-level radioactive waste land disposal to contain specific technical information including geotechnical and hydrologic characteristics; requires preoperational and operational ground water monitoring.
10 CFR 70.59	Requires persons licensed by the NRC to possess and use special nuclear material to periodically submit a report of radionuclides released in liquid and gaseous effluents. (Does not specify ground water monitoring.)
40 CFR 192.20	Applicable to the management of inactive uranium and thorium processing sites; requires ground water monitoring to assist in assuring compliance with long-term waste containment standards. (See Ground Water Standards and Alternate Concentration Limits.)
40 CFR 192.32	Requires the establishment of a detection monitoring system (per 40 CFR 264.98) at NRC-licensed facilities for the disposal of uranium and thorium processing residues.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

REGULATION	DESCRIPTION
NWPA	
10 CFR 60.21	Prescribes contents of NRC license applications for high-level radioactive waste repositories. Required contents include analyses of hydrogeology and a description for control and monitoring of radioactive effluents to maintain compliance with limits of 10 CFR 20. (See Ground Water Standards and Alternate Concentration Limits.)
10 CFR 60.140 to 60.142	Requires monitoring and measurement to confirm geotechnical and design parameters.
40 CFR 191.14(b)	Requires the monitoring of high-level radioactive waste disposal sites regulated by the NRC or operated by the DOE.
PHSA	
40 CFR 141.1 to 141.33	Establishes primary drinking water regulations, variances and exemptions, and siting requirements for public water systems. Lists maximum contaminant levels (MCLs) for inorganic and organic chemicals, turbidity, coliform bacteria, and radioactivity. Sets forth monitoring and analytical requirements for suppliers of water. Outlines reporting and recordkeeping requirements and special monitoring regulations.
SDWA	
40 CFR 143.3	Establishes recommended secondary MCLs for public water systems.
40 CFR 144.12(a)	Requires owner and operator of underground injection facility to show that contamination of underground drinking water sources is not occurring.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

REGULATION	DESCRIPTION
40 CFR 144.12(b)	If contamination of underground sources of drinking water is indicated, U.S. Environmental Protection Agency (U.S. EPA) or State Director may require corrective action, including ground water monitoring.
40 CFR 144.28(g)(1)	Requires use of monitoring wells to determine migration of fluids into underground sources of drinking water if required by the Director.
40 CFR 146.32(e)	For Class III underground injection wells, requires the installation of monitoring wells if the receiving formation contains water with less than 10,000 milligrams per liter (mg/L) total dissolved solids (TDS) and gives certain criteria which the wells must meet.
40 CFR 146.32(g)	For Class III underground injection wells, requires the installation of monitoring wells if the injection well penetrates a drinking water source in an area subject to subsidence or catastrophic collapse and gives certain criteria which the wells must meet.
40 CFR 241.204	Requires that nonhazardous land disposal sites be constructed and operated to meet most stringent applicable water quality standards to protect underground and surface drinking water supplies and recommends the installation of observation wells.
RCRA	
40 CFR 257.3-4	Applicable to all solid waste disposal facilities; prescribes certain factors, including ground water and hydrogeological characteristics, to be considered when determining an alternate solid waste boundary.
40 CFR 264.90(a)	Requires all hazardous waste land disposal facilities to establish a ground water monitoring system, unless exempted per 40 CFR 264.90(b).

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

REGULATION	DESCRIPTION
40 CFR 264.90(a) (continued)	New facilities or existing facilities which have not had ground water contamination must implement the detection monitoring program (264.98); facilities where statistically significant increases in ground water indicator parameters were detected per the detection monitoring program must implement a compliance monitoring program (264.99); facilities in which the ground water monitoring during the compliance monitoring program indicated violation of the protection standard must implement a corrective action program (264.100) and associated monitoring.
40 CFR 264.302	Provides an exemption to the ground water quality monitoring requirements of 264.90 for double-lined landfills which meet certain requirements, including leak detection and leachate collection and removal.
40 CFR 265.117	Applicable to Resource Conservation and Recovery Act (RCRA) land disposal facilities closed under interim status regulations; requires that ground water monitoring and reporting be continued throughout the postclosure period, unless all waste and contaminated soils are removed.
CERCLA	
40 CFR 300.68(f)	Applicable to releases or threat of releases of hazardous substances to the environment; requires lead agency or responsible party to determine nature and extent of the contamination, including use of sampling and monitoring as necessary.
TSCA	
40 CFR 761.75(b)	Prescribes certain technical standards for chemical waste landfills used for the disposal of materials containing polychlorinated biphenyls (PCBs), including requirements for the establishment of a ground water monitoring system.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

DOE ORDER	DESCRIPTION
5484.1, Chapter III.1	Requires an environmental survey prior to start-up of new DOE facilities or processes which might adversely impact the environment. The survey is to include determination of background contaminant levels, characterization of the site, and identification of exposure pathways.
5484.1, Chapter III.4	Monitoring at DOE sites required to determine compliance with DOE Order 5480.1, Chapters I, XI, and XII, to establish background levels and determine compliance with other applicable environmental standards.
5480.2, Chapter I	For general hazardous waste program requirements, prescribes that each operation office assure facility compliance with 40 CFR 260-263 and 265 and achieve compliance with 264 as early as possible, including ground water monitoring requirements of RCRA 40 CFR 264, Subpart F or 40 CFR 265, Subpart F.
5480.2, Chapter II.2	Requires that DOE Order 5820.1 be applied for high-level radioactive waste and transuranic mixed waste, and requires that environmental protection for low-level radioactive mixed waste be equivalent to RCRA 40 CFR 264 and 265.
5820.2, Chapter I	Requires that disposal of waste (other than high-level nuclear wastes) comply with U.S. EPA standards and, to the extent practical, with NRC requirements. Disposal of high-level wastes will comply with applicable laws and requirements.
5820.2, Chapter II.3.c	Requires that transuranium radionuclide (TRU) waste buried in shallow landfills be periodically monitored to assess radioactive and nonradioactive hazards.
5820.2, Chapter III.3.d	Requires that designs for low-level waste disposal sites include environmental monitoring.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

EXECUTIVE ORDER	DESCRIPTION
Executive Order 12088	Requires that federal facilities maintain compliance with federal environmental pollution control standards, including Toxic Substances Control Act (TSCA), Federal Water Pollution Control Act (FWPCA), Solid Waste Disposal Act (SWDA), and others, and delegates responsibility to the head of each executive agency to ensure compliance by that agency.

GUIDE	DESCRIPTION
86-EPA-2 GW Task Force Report	This report presents the results of a wide-ranging study conducted by the U.S. EPA's Ground Water Monitoring Task Force to evaluate the status of the RCRA ground water monitoring program. The Task Force report identifies problems with the implementation of the program and makes recommendations for improvement. Major concerns include inadequate guidance documents, insufficient training of agency personnel, gaps in ground water monitoring technology, regulations in need of revision, and organizational and administrative problems within the agencies. Good current general guidance on RCRA ground water requirements. The U.S. EPA has begun to implement some of the recommendations presented in this report.
85-EPA-5 GW Monit. Strat.	Sets forth the ground water monitoring strategy to be followed by the U.S. EPA and the states, as developed by several offices within the U.S. EPA. Includes the U.S. EPA's action plans for characterizing the nation's ground water resources, identifying new sources of contamination, assessing existing problems, assuring regulatory compliance, evaluating program effectiveness, improving data quality, and developing a data management system. Represents current U.S. EPA strategy; no specific technical or regulatory guidance for this topic area.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
85-EPA-7 Interim Crit. HW Mgt. Prog.	Key questions regarding the enforcement program criteria for RCRA programs are presented in this document. The national enforcement strategy includes a plan to inspect all ground water monitoring facilities each year. These inspections are to include complete review of sampling quality assurance/quality control procedures. Some value as background information on federal RCRA policy, including revisions by the 1984 amendments to RCRA.
85-EPA-8 State GW Prog. Summaries Vol. 1	Chapter I discusses the nature and sources of ground water contamination. Appendix A discusses for each state and U.S. territory ground water monitoring programs, types and sources of ground water contamination, status of policy, development, and interagency agreements. Good source of general information on state ground water programs (through fiscal year 1985).
85-EPA-10 GW Monit. Workshop Planning	Presents a summary of topics discussed during a U.S. EPA-sponsored workshop to help formulate federal ground water policy. Helpful tables in Part II outlining U.S. EPA monitoring requirements. Also presents a brief summary of state approaches to ground water monitoring. Some value as background information on federal/state policy.
85-EPA-11 RCRA GW Mont. Guide	This document addresses the regulatory requirements for ground water monitoring under RCRA 40 CFR 265 (interim status regulations) and 40 CFR 264, and is intended to guide state and U.S. EPA officials in developing administrative orders to enforce RCRA ground water monitoring violations at interim status facilities.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
85-EPA-11 (continued)	Current EPA guidance for RCRA regulatory compliance. No technical guidance for this topic area.
85-EPA-13 GW Mont. Workshop Resource Doc.	Section III of this document provides a detailed summary of specific statutory authorities [in RCRA, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Clean Water Act (CWA)] and their respective monitoring provisions and objectives. Some value as general information on federal ground water statutes.
85-EPA-15 TSCA GW Prot. Strat.	Document outlines a plan for using TSCA to address selected ground water contamination problems as part of the U.S. EPA's Ground-Water Protection Strategy issued in August 1984. Four goals of this plan are: (1) developing information on existing ground water problems, (2) determining health effects of specific contaminants, (3) improving assessment methods, and (4) adopting controls to prevent future contamination. Good source of background information on federal policy regarding TSCA-regulated substances.
84-EPA-3 Permit Writ. Guide HW Facilities	Section 2.3.1 discusses hazardous waste facility locations in a zero recharge zone as a possible setting for exemption from RCRA ground water monitoring. Provides guidance for evaluating zero recharge areas; minor modifications to this document anticipated by end of 1986.
84-EPA-4 Rem. Investigations Guide	Chapter 7 provides guidance on performing characterizations of CERCLA sites, including the level of investigation warranted (7.2) and the necessity for certain ground water information (7.3.1.3).

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
84-EPA-4 (continued)	Good guidance for regulatory compliance with CERCLA. Limited specific technical guidance for this topic area.
84-EPA-7 Rem. Response HW Sites	This report presents findings of a survey of 395 uncontrolled hazardous waste sites and a detailed study of 23 sites at which some form of cleanup activity is in progress. No specific technical or regulatory guidance, but may be useful background information for planning cleanups required at disposal sites.
83-EPA-1 Guide to Matl. Selection ISWS-327	Section 3 presents a brief overview of the ground water monitoring requirements under RCRA and CERCLA and notes that some states may have requirements which differ from federal regulations. Limited regulatory guidance for compliance with RCRA and other regulations. Good general technical guidance for physical aspects of ground water monitoring.
83-EPA-2 Rem. Act. Tech. Plans	Chapter 5.0 of this document discusses the ground water monitoring for both remedial action assessments and design effectiveness. Some value as technical guidance for this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapters 1 and 3 discuss the objectives of a ground water monitoring network. Chapter 2 provides guidance to regulators on evaluating requests for exemptions and waivers. Provides good overview of RCRA regulatory goals. Partially superseded by the Technical Enforcement Guidance Document (TEGD) for regulatory compliance with RCRA monitoring waiver requirements.
83-EPA-8 PCB/TSCA	This document presents 130 wide-ranging questions and answers regarding PCB regulations under TSCA. Questions 9, 10, and 11 address PCB spill cleanup requirements,

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
83-EPA-8 (continued)	and Question 42 briefly addresses requirements for PCB disposal sites. Represents current U.S. EPA policy on PCB regulations, but contains only limited specific guidance for regulatory compliance with PCB disposal requirements. No technical guidance for PCB disposal site monitoring.
83-EPA-9 Permit App. Guide Gen. Fac. Stds. SW-968	Section 5.3.7 presents a summary of major points to be considered as general requirements for a Part B RCRA permit application but does not include ground water monitoring requirements. Limited technical guidance for this topic area.
82-EPA-2 Rem. Act. Waste Disp. Sites	Appendix A of this document discusses the basic objectives for monitoring the ground water after remedial actions have been completed. Some value as technical guidance for this topic area.
80-EPA-2 Western Coal Preliminary Designs	Recommends strategies for determining need for monitoring, describes alternative monitoring strategies (e.g., source sampling, unsaturated zone monitoring), and gives some recommendations on selection of parameters for potential ground water contaminant sources associated with strip mining of coal in the Rocky Mountain region. Technical guidance for this topic area limited in value because many recommendations are specific to the Rocky Mountain region or to coal-related wastes.
80-EPA-3 HW Leachate SW-871	Section 7 describes the need for leachate monitoring to characterize aqueous wastes which result from the disposal of hazardous wastes. Good general guidance for this topic area.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
80-EPA-4 BD GW Monit.	This background document presents the U.S. EPA's rationale for inclusion or exclusion of public comments received in response to proposed regulations for ground water monitoring at interim status hazardous waste facilities. Some value as background information on the U.S. EPA policy toward ground water monitoring.
80-EPA-5 Enf. Consid. HW Sites	Section VI-4 defines the detection of potential leachate contamination as the primary objective for monitoring ground water at land disposal sites. Limited technical guidance for this topic area.
79-EPA-1 Western Coal Pollution Sources	Describes existing and potential sources of ground water contamination in the vicinity of areas of coal-mining development in Wyoming and suggests priorities for mitigation and monitoring. Pollutants considered include contaminants from agriculture, coal strip mining, oil and gas extraction, construction, coal conversion, sewage treatment ponds and sludges, septic tanks, and a solid waste landfill. Limited value as technical guidance on identifying potential contaminant sources.
78-EPA-1 Contam. Potential Surface Impound.	This document presents the Surface Impoundment Assessment (SIA) Program devised to rate the contamination potential of ground water from surface impoundments. The evaluation system applies a numerical rating scheme to impoundments which yields a first-round approximation of the relative ground water contamination potential of these impoundments. Limited guidance for evaluating monitoring needs of surface impoundments.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

GUIDE	DESCRIPTION
76-EPA-1 Monit. GW: Economic	Section III discusses the overall costs and benefits to society involved in ground water monitoring from an economic viewpoint. Section V presents ideas on regulatory alternatives for preventing and mitigating ground water pollution. No regulatory or technical guidance. Some value as source for evaluating economic aspects of pollution control.
82-NRC-3 Characterizing Sites Low-Level Radioactive Wastes	Part I lists the technical requirements of 10 CFR 61. These requirements have been partially superseded by subsequent amendments to 10 CFR 61. Limited value as technical guidance for this topic area.
84-OTA-1 Protecting GW	This document presents the status (in 1983) of knowledge about ground water contamination, federal and state programs, constraints to ground water protection, activities, and funding for ground water protection, and includes recommendations for national policy, technical assistance, and research and development. Chapter 2 analyzes current knowledge about the sources, impacts, and extent of ground water contaminants. Chapter 3 summarizes existing federal laws and programs to protect ground water quality, while Chapter 6 describes federal efforts regarding hydrogeologic investigations, drinking water and ground water monitoring, and potential contamination source inventories. Chapters 4 and 7 discuss the status and shortcomings of state ground water programs, which principally involve inventories, source monitoring, water supply monitoring, and ambient water quality monitoring to detect contamination. Good source of background information on the nationwide status of ground water protection (as of 1983).

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett, 1980	Chapter II, Section 1, contains statements to the effect that excessive ground water pollution is due to a lack of well-specified and enforceable property rights for ground water, so ground water resources must be managed by public agencies. The purpose of monitoring systems should be to collect, analyze, and manage ground water data and to determine hydrogeologic information as necessary to allow public agencies to fulfill their oversight responsibilities. Portions of several federal statutes are listed which pertain to ground water protection. Section 2 describes sources and causes of pollution, including animal wastes, industrial disposal ponds, sewer leaks, oil field brines, highway deicing, and others. Some value as general technical guidance, with interesting viewpoints on socioeconomic aspects of ground water management.
Natl Res. Council 1986 GW Prot. State/ Local Strategy	This report analyzes numerous state and local ground water programs, focusing on the prevention of contamination. Pollution sources studied include: solid waste disposal; hazardous waste treatment, storage, and disposal; septic systems; agricultural chemical applications; petroleum production; and others. Chapter 2 presents a summary of conclusions and recommendations by the Committee on Ground Water Quality Protection, which prepared this report. Good current general guidance on state requirements and policies for preventing ground water contamination.

RELEVANT STATE REGULATIONS

The majority of states have adopted by reference the federal ground water regulations for hazardous waste facilities. Some states, however, have enacted more stringent requirements. New Jersey, for example, prohibits waiver of all ground water monitoring requirements for hazardous waste management facilities and industrial waste

management facilities. Additionally, monitoring requirements for hazardous waste facilities in California include monitoring of ground water, monitoring of the unsaturated zone, and monitoring of air. Wisconsin has five classifications of monitoring activities, including (1) problem assessment monitoring applicable to community and private water supply wells, (2) regulatory monitoring applicable at existing solid waste disposal and wastewater operations, (3) at-risk well monitoring applicable at known contamination sites, (4) management practice monitoring for applied research, and (5) monitoring planning for coordinating and carrying out monitoring practices and objectives.

Under New Jersey's Environmental Cleanup Responsibility Act (ECRA), industrial property owners are responsible for the cleanup of hazardous waste before property can be sold or transferred.

California is establishing a ground water data base and is developing county maps which describe patterns of (1) restricted pesticide use, (2) pesticides detected in ground water, (3) soil types, and (4) depth to ground water.

Some states have site-specific ground water monitoring requirements for road construction sites, irrigation wells, and areas near water supplies. For example, New Jersey requires the testing of ground water for contaminating substances at road construction sites; Arkansas requires monitoring of selected irrigation wells for possible contamination from agricultural practices; and Arizona requires monitoring near Phoenix's water supply. To control pesticide contamination of ground water, Connecticut has regulations similar to federal rules under the Federal Insecticide, Fungicide and Rodenticide Act regulations that restrict the use of some pesticides by requiring that they be applied only by a licensed operator.

To carry out their ground water policies, states are also developing control programs that focus on land use (e.g., Massachusetts, Florida), septic tanks (e.g., Pennsylvania, New Jersey, Mississippi), agricultural contamination (e.g., Iowa, North Dakota), underground storage tanks (most states), response to contamination incidents (e.g., Maine, North Carolina), brine disposal (e.g., New Mexico, North Dakota), and radionuclides (e.g., Texas, New Jersey).

MONITORING SYSTEM DESIGN

REGULATION	DESCRIPTION
AEA	
10 CFR 40 App. A	Applicable to operational uranium mills and tailings sites; requires in Criterion 5 that ground water protection methods be determined on a site-specific basis and specifies certain subsurface geologic and hydraulic information which should be determined.
40 CFR 192.20(a)(2)	Requires that the hydrogeologic assessment conducted at each inactive uranium or thorium processing or waste depository site should include a monitoring system sufficient to establish background data and identify presence or movement of contaminant plumes.
10 CFR 61.53	Applicable to the land disposal of low-level radioactive by-product, source, and special nuclear material under an NRC license; requires the establishment of an environmental monitoring program to evaluate potential environmental impacts and to detect radionuclide releases prior to their leaving the site boundary.
SDWA	
40 CFR 146.13(b)	Specifies monitoring requirements for Class I underground injection wells, including analyses of the injected fluids, monitoring of flows and pressures, and monitoring of wells installed to detect any migration into the source of drinking water.
40 CFR 146.23	Specifies monitoring requirements for Class II injection wells, including monitoring of the nature of the injected fluids and observation of flows and pressures.
40 CFR 146.33(b)	Specifies monitoring requirements for Class III injection wells, including monitoring of the nature of injected fluids, pressures, and flow rates; monitoring of the fluid level in the injection zone; and parameters necessary for measuring water quality in wells specified by 146.32(e). (See Purpose and Need to Monitor Ground Water.)

MONITORING SYSTEM DESIGN (continued)

REGULATION	DESCRIPTION
40 CFR 241.204-2	Recommends that design plans include proposed locations of observation wells, sampling stations, and testing programs, when appropriate, at nonhazardous solid waste disposal sites.
RCRA	
40 CFR 264.97(a)	Specifies that ground water monitoring systems at all hazardous waste land disposal facilities must consist of a sufficient number of wells to yield samples which represent background conditions and conditions at the point of compliance.
40 CFR 264.97(b)	Allows use of a single monitoring system for multiple regulated hazardous waste units, provided the system would detect migrating constituents.
40 CFR 265.91(a)	Requires that the number, location, and depth of wells in the ground water monitoring system at hazardous waste land disposal facilities operating under interim status must (1) be sufficient to yield ground water samples that are representative of background water quality and include at least one hydraulically upgradient well and (2) be capable of detecting any significant amount of waste migration and include at least three hydraulically downgradient wells.
TSCA	
40 CFR 761.75(b)(6)(ii)	Applicable to PCB disposal landfills; requires minimum of three ground water monitoring wells, depending on hydrogeologic conditions, and prescribes well spacing requirements.

GUIDE	DESCRIPTION
86-EPA-1 Tank Leak Detection	Section V briefly describes several types of ground water monitoring wells which may be used to detect leaks in underground storage tanks and presents diagrams to show correct spacing and screening.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
86-EPA-1 (continued)	Some value as technical guidance; good reference source for obtaining additional current information on underground storage tank monitoring.
86-EPA-5 TEGD	Chapter 1 presents a list of hydrogeologic techniques which, at a minimum, should be used to characterize a disposal site; describes necessary components of a boring program; and gives procedures and examples for identifying ground water flow paths. Chapter 2 presents criteria for U.S. EPA officials to use in determining the adequacy of a facility's detection monitoring well system, including locations of downgradient wells, horizontal spacing between wells, depth of wells, and vertical sampling intervals. Chapter 6 discusses direct and indirect techniques for identifying and characterizing contamination. Current technical guidance for RCRA regulatory compliance. Good technical guidance for this topic area.
85-EPA-11 RCRA GW Mont. Guide	Chapter 2 presents an overview of RCRA ground water regulations and describes the intended designs of detection and compliance monitoring and corrective action programs. Current regulatory guidance for compliance with RCRA (40 CFR 264 and 265). Limited value as technical guidance for this topic area.
84-EPA-2 Permit App. Guide HW Facilities	Section 9.3 provides guidance for complying with RCRA regulations requiring the identification of the uppermost aquifer and its characteristics, and Section 9.4 provides guidance for determining the waste management area, point of compliance, and well locations. Good regulatory guidance for compliance with RCRA. Partially superseded by TEGD for technical guidance for compliance with RCRA.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
84-EPA-3 Permit Writ. Guide HW Facilities	Section 2.3 discusses the ability to monitor at a location as a criterion for an acceptable hazardous waste facility site. Section 3.2.1 provides regulatory guidance for RCRA ground water requirements. Section 3.3.2 provides guidance to regulators on combining more than one ground water protection program in a facility permit. Section 4 presents four case studies to illustrate how the location criteria should be applied when regulators evaluate RCRA permit applications. Does not reflect the requirements of the 1984 RCRA amendments, but update of this document is anticipated by end of 1986. Some value as general guidance for reviewing RCRA ground water monitoring systems.
84-EPA-5 Soil Properties SW-925	Presents a review of state-of-the-art procedures for soil characterization and hydraulic conductivity testing, which are essential for evaluating a site and designing a ground water monitoring system. Good technical guidance for site characterization.
83-EPA-1 Guide to Matl. Selection ISWS-327	Section 5 contains a brief discussion on selecting well locations, but does not address the design of monitoring systems in general. Limited technical guidance for this topic area.
83-EPA-2 Rem. Act. Tech. Plans	Table 5-1 evaluates monitoring program design considerations for remedial action assessments. Items considered include exposure/health effects, site assessment, and evaluating the effects of the remedial actions. Some value as technical guidance for designing monitoring systems for remedial actions.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapter 3 provides guidance for use in evaluating the general design of monitoring networks, including the necessary site characterizations. Provides helpful information on the selection of well locations under special circumstances such as ground water mounding and tidal influences. Good technical guidance for RCRA permit writers and applicants. Partially superseded by TEGD for regulatory compliance with RCRA well location requirements.
83-EPA-5 GW Guide Int. Status SW-9632.2	Section 1 discusses the requirements of 40 CFR 265 and the intent of the U.S. EPA regarding RCRA ground water monitoring. Section presents methods for determining and evaluating site characteristics and choosing well depths and locations. Limited applicability as current guidance for regulatory compliance since RCRA facilities must now attempt to comply with 40 CFR 264 requirements rather than 40 CFR 265 interim status standards. Good general technical guidance for this topic area.
82-EPA-2 Rem. Act. Waste Disp. Sites	Appendix A discusses the importance of establishing a solid ground water quality background data base to ensure that analytical results of the monitoring well data are interpreted properly. Limited for technical guidance for this topic area.
81-EPA-1 GW Quality Samp.	Sections 3 and 4 discuss preliminary site evaluations and hydrogeologic considerations in characterizing sites and determining depths and locations of monitoring wells. Good general technical guidance for this topic area.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
81-EPA-2 NEIC GW Investigations	Section V covers the purpose of monitoring wells and the planning of monitoring well networks, including external requirements such as local regulations and buried utilities, necessary hydrogeologic data, and well placement strategy. Gives examples for well placement and recommends well nests (clusters) for defining plume movement. Good general technical guidance for this topic area.
80-EPA-1 HW Land Treat.	Chapter 9 of this document discusses monitoring the unsaturated zone by pressure-vacuum lysimeters, vacuum extractors, and trench lysimeters, and describes ground water monitoring with well clusters. Some value as technical guidance on monitoring of the unsaturated zone.
80-EPA-2 Western Coal Preliminary Designs	Recommends strategies for determining need for monitoring, describes alternative monitoring strategies (e.g., source sampling, unsaturated zone monitoring), and gives some recommendations on selection of parameters for potential ground water contaminant sources associated with strip mining of coal in the Rocky Mountain region. Limited technical guidance for this topic area; many recommendations are specific to the Rocky Mountain region or to coal-related wastes.
80-EPA-3 HW Leachate SW-871	Section 7 describes the design of a leachate monitoring program as highly site-specific. The major objective should be to minimize the number and types of analyses performed while still generating data sufficient to satisfy the objective of the monitoring program. Some value as technical guidance for this topic area.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
80-EPA-5 Enf. Consid. HW Sites	Section VI-4 states that a ground water monitoring system should provide the following: depth to water table, natural rate and direction of flow, locations of potential or actual recharge and discharge areas, types and interconnection of the aquifers, and ground water use in the vicinity. Limited technical guidance for this topic area.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Sections 1.6 and 1.7 discuss factors to consider during the site assessment and preliminary investigations. Chapter 2 covers the design of the monitoring well network, including an excellent discussion of hydrogeologic factors that affect contaminant movement, and should be considered in determining well placement. Good technical guidance; still current for this topic area. Written for nonhazardous solid waste facilities, but applicable to all types of monitoring.
76-EPA-4 Monit. GW: Examples	This report presents five case histories of ground water contamination and the monitoring techniques employed at each site, and discusses monitoring of the land surface, vadose zone, and saturated zone for several examples. Some value as general technical guidance for this topic area; has been superseded by more recent technical guidance for regulatory compliance with TSCA and RCRA.
76-EPA-5 Monit. GW: Monit. Meth.	This document presents a 15-step methodology for implementing a ground water monitoring program. Some value as technical guidance for this topic area. Has been superseded by more recent documents for design of systems required by federal radioactive or hazardous waste regulations.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
86-DOE-1 GW Poll. Monit.	This document contains citations concerning the monitoring of various ground water pollutants. Monitoring methods, contaminant migration, and pollution regulations are discussed. Good source of information for locating additional references on specific ground water topics.
83-DOE-1 Effluent Radio- logical Meas. DOE	Section 5.3 presents monitoring system design considerations for the quantification of gamma-emitting radionuclides in liquid effluents. Good technical guidance for monitoring of radioactive waste facilities.
85-NRC-3 GW Contam. Nuclear Accidents Vol. 1	This document evaluates the feasibility and desirability of utilizing specific ground water containment and mitigation techniques to control radionuclide migration in ground water flow systems following a nuclear core melt accident. Section 3 presents the method by which 97 U.S. nuclear power plant sites were characterized using five hydrogeologic criteria. Good technical guidance regarding radionuclide transportation in ground water and hydrogeologic classifications.
83-NRC-1 Subsurface Monit. Low-Level Radioactive Waste	Part II describes ten potential pathways of waste migration into soil and ground water, and Part III presents methods for monitoring the pathways in both saturated and unsaturated zones. Part IV presents examples of existing monitoring station networks and points out factors to be considered in designing systems. Good technical guidance for design of monitoring systems, especially applicable to the types of facility designs used at low-level radioactive waste disposal sites.

MONITORING SYSTEM DESIGN (continued)

GUIDE	DESCRIPTION
82-NRC-3 Characterizing Sites Low-Level Radioactive Wastes	Parts II and IV summarize parameters that must be quantified and used for baseline and detection monitoring. Part III lists monitoring system design parameters considered most important at representative sites in four states. Appendices A, B, and C define geological characteristics, soil/rock material classification, and zoning parameters, respectively. Appendix D defines hydrological parameters, and Appendix F describes geotechnical parameters which are useful in planning monitoring programs. Good technical guidance for this topic area.
78-NRC-1 GW Elements Uranium Mining	Chapter 3 describes the design of monitoring networks at two in situ leach uranium mining sites to detect excursions of the lixiviants into ore-zone aquifers. Initially, wells are installed to obtain background information followed by two rings of wells around the ore body. Good technical guidance for monitoring system design at in situ leach uranium mining sites; many aspects of the guidance are also applicable to other types of facilities.
84-OTA-1 Protecting GW	Chapter 5 discusses status, objectives, information requirements, and uncertainties of hydrogeologic investigations. Chapter 6 includes a summary of ground water monitoring requirements for 16 federal statutes. Good source of background information needed for monitoring system design.

NONGOVERNMENT REFERENCES	DESCRIPTION
ASTM 1981	This text is a collection of papers presented at an American Society for Testing and Materials (ASTM) symposium. The papers deal mainly with permeability, which is only one of the factors required to predict ground water contaminant transport.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
ASTM 1981 (continued)	Good technical guidance on soil permeability is presented in a series of case studies.
Cheremisinoff 1984	Chapter 5 describes the active and passive types of monitoring systems. The advantages and drawbacks of the two monitoring systems are discussed, and factors involved in choosing a monitoring system are covered. Limited technical guidance for this topic area.
Cibrik 1985 NWWA Proc.	This paper describes the various steps taken to resolve the deficiencies in an existing RCRA monitoring system. Four major problems with an existing RCRA monitoring system were discussed: (1) only the soil zone above the bedrock was monitored, (2) no detailed characterization of the bedrock had been conducted, (3) there were no upgradient wells, and (4) no wells were located at the hydraulically downgradient limit of the impoundment area. The paper provides information on the development of designs for ground water monitoring systems which are suitable for specific hazardous waste management sites. Good technical guidance for designing a RCRA monitoring system; also applicable to other systems.
Clark 1980 Groundwater	This article presents results of a survey of state monitoring practices at waste disposal sites in 1979. Topics in the survey include regulatory framework for requiring monitoring, chemical parameters analyzed, recommended methods of monitoring well construction and sample collection, laboratory quality control, data interpretation, and postoperational monitoring requirements. Good source of background information on state ground water programs prior to RCRA.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Driscoll 1986	Chapter 21 discusses ground water monitoring techniques. The correct locations and depths for monitoring wells should ensure that the maximum information concerning the extent of the contamination is obtained. Chapter 16 presents the procedures involved in the collection and analysis of pumping test data. These tests are conducted to determine the performance characteristics of a well and the hydraulic parameters of an aquifer. Good technical guidance for this topic area.
Everett 1980	Chapter I, Section 3, presents a detailed 15-step approach to forming a framework for the planning and development of a monitoring program. Consideration is given to various sources of pollution and types of contaminants likely to be encountered and includes several examples of monitoring system designs. Chapter III discusses actual monitoring methods and costs for monitoring at the land surface, in the vadose zone, and in the zone of saturation. Chapter V covers the monitoring of waste disposal wells and includes very informative sections on the acquisition and interpretation of subsurface data, the prediction of aquifer response to injection activities, and the design of monitoring systems for underground injection wells. Numerous example calculations are given for predicting aquifer response. Five case histories of ground water pollution with evaluations of the monitoring systems are presented in Chapter VI. Good technical guidance for this topic area, especially for monitoring underground injection wells.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett 1981 GW Monit. Rev. Vol. 1, No. 1	The paper addresses some of the more specific ground water monitoring methods for the zone of saturation. Topics such as geological sampling, borehole geophysics, water level measurements, water sampling, well hydraulics, and time changes in quality are discussed. Good general guidance for this topic area.
Everett 1981 GW Monit. Rev. Vol. 1, No. 2	This paper provides an overview of topsoil and vadose zone monitoring techniques for observing storage changes, monitoring water movement (flux), and sampling both soil and water in unsaturated and perched water zones. Some value as general guidance for this topic area.
Everett 1982 Ground Water	The purpose of the paper is to review alternative selection criteria for vadose zone monitoring at hazardous waste sites, categorize specific premonitoring and monitoring methods relative to the selection criteria, and to exemplify a possible vadose zone monitoring package for a hazardous waste impoundment. Many tables and figures are presented which describe such items as premonitoring, sampling methods, nonsampling methods, and alternative methods for vadose zone monitoring. Good technical guidance for the design of vadose zone monitoring systems.
Everett 1984	Contains extensive discussions of factors to be considered in monitoring system design, including the hydrogeologic setting of waste disposal sites, characterization of subsurface geologic conditions and unsaturated zone hydrology, and capabilities and limitations of available monitoring devices. Primary emphasis is on characterizing and monitoring the unsaturated zone, but it also contains information and

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett 1984 (continued)	recommendations on saturated zone monitoring and on determining whether unsaturated zone monitoring is required. Includes (Chapters 7 and 8) discussions of special considerations in monitoring in various distinct hydrogeologic settings (coastal plains, glacial deposits, river floodplains, fine-grained sediment over karst limestone, deserts, and fractured rock) and recommended conceptual designs for combined saturated-unsaturated zone monitoring for several hypothetical waste sites. Good technical guidance for unsaturated zone monitoring system design; some value as general technical guidance for the topic area.
Freeze 1979	This book provides a very good, broad, interdisciplinary coverage of ground water principles such as physical properties, chemical properties, ground water geology, flow nets, the hydrologic cycle, chemical evolution of natural ground water, resource evaluation, contamination, geotechnical problems, and geologic processes which would be important for site characterization and monitoring system design. Although the text gives an overview of the above-mentioned topics, the operational aspects of these topics and others are not presented. Good source of technical background information; widely quoted in the literature.
Fukui 1985 J. Hydrology	This paper describes a continuous monitoring method for radon-222 concentrations in unconfined ground water which was used to obtain information on lower boundary concentrations of radon in the aerated zone. This method can be used to detect radium-226 migration from a nuclear waste repository and generally can assist in understanding radon dynamics in unconfined ground water close to the ground surface.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Fukui 1985 (continued)	Good source of technical guidance for radium and radon monitoring.
Guswa 1984	Book contains several discussions of physical and chemical factors that may affect the distribution of contaminants in the subsurface; several case studies of ground water contamination investigations are reported. Part II, Chapter 3, includes a comprehensive review of geophysical techniques for site investigation. Good technical guidance for this topic area; emphasis is on monitoring to investigate existing contamination.
Johnson 1981 GW Monit. Rev.	The paper discusses and compares the use of observation wells and pressure-vacuum lysimeters for monitoring water quality in the unsaturated zone below three sanitary landfills. Studies at the landfills found that samples of soil moisture obtained by pressure-vacuum lysimeters indicated the presence of leachate beneath the landfill, while samples at the monitoring wells generally did not show leachate contamination. Some limitations to the use of lysimeters are given, such as small sample volume and plugging of the cup pores. Some value as technical guidance for the use of lysimeters.
Liggett 1985 ASTM STP 867	This article recommends the installation of some RCRA monitoring wells close together and to the same depth in order to eliminate spatial variations during data evaluation. Some value as guidance for possible alternatives to standard RCRA design procedures.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Mandel 1981	Section 5.2 describes the selection of well sites and lists six hydrogeologic items of information that must be specified for any proposed drilling site. This section also covers typical dilemmas that are often encountered in drilling campaigns and possible alternatives for each. The design criteria for production and observation boreholes are discussed in Sections 5.3 and 5.4. Some value as technical guidance for well siting but provides little information on overall monitoring system design for contaminant detection.
Osiensky 1984 Ground Water	This paper discusses ground water monitoring procedures for delineating the geometry of a contaminant plume migrating through buried stream channel deposits. The study focuses on ground water monitoring at uranium mill waste disposal sites located in fluvial environments. Good technical guidance for designing monitoring systems at uranium mill waste disposal sites.
Rail 1985 J. Env. Health	The paper describes the basics for establishing a systematic ground water monitoring plan to avoid or identify water-related problems. Six basic steps to follow when constructing a ground water monitoring plan are listed, and an example of implementing a plan on a local level is given. Good overall technical guidance for this topic area.
Walton 1970	This book provides a general understanding of hydrogeologic concepts such as basic principles, fundamental equations, hydrogeologic modeling, ground water quality analysis, and development and management of aquifers.

MONITORING SYSTEM DESIGN (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Walton (continued)	Good source of background information on hydrogeologic principles.
Wood 1984	Chapter 4 provides the conceptual framework for monitoring network system designs. Figure 4.1 shows the elements involved in the monitoring design process. Several case studies are reviewed, and the main conclusion is that the performance of a monitoring network is most appropriately measured by the accuracy of associated ground water model predictions and parameter estimates.
	Good technical guidance for topic area.

RELEVANT STATE REGULATIONS

New Jersey hazardous waste regulations require that monitoring wells be placed to detect migration of hazardous constituents into ground water as opposed to the federal requirement of detection in the uppermost aquifer. California requires monitoring of ground water and the normally unsaturated zone.

DRILLING METHODS

REGULATION	DESCRIPTION
No specific regulatory requirements.	

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Section 3.1 briefly discusses six drilling methods and presents a table of preferred methods based on the geologic environment. Some value as technical guidance for this topic area.
83-EPA-1 Guide to Matl. Selection ISWS-327	Section 5 briefly describes various well drilling methods and lists factors to consider for selecting the appropriate method. Refers reader to 81-EPA-1. Limited technical guidance for this topic area.
83-EPA-2 Rem. Act. Tech. Plans	Table 5-2 of this document outlines six different drilling techniques, with associated maximum depths and typical diameters. Limited technical guidance for this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 4.1 discusses available drilling methods and their capabilities and potential applications to monitoring well installation. Good technical guidance for this topic area.
81-EPA-1 GW Quality Samp.	Section 5.B contains a detailed description of 12 drilling methods, including diagrams of equipment and a list of criteria for selecting the appropriate method, and describes advantages and disadvantages of each method. Appendix A contains information on the impact of well construction/drilling methods on the chemical properties of sample water. Good technical guidance for this topic area.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Section 3.5 briefly discusses various commonly used drilling methods, related equipment requirements, and the advantages and disadvantages of the various methods.

DRILLING METHODS (continued)

GUIDE	DESCRIPTION
77-EPA-2 (continued)	Good general technical guidance for topic area.
76-EPA-2 Monit. GW: Meth. Costs	Section III includes a discussion of various methods of constructing shallow and drilled wells for monitoring in the vadose zone. Cost estimates for drilling are included but are outdated. Some value as technical guidance on drilling methods in the vadose zone.

NONGOVERNMENT REFERENCES	DESCRIPTION
Bouwer 1978	Section 6.3.2 describes various drilling techniques and discusses the advantages and complications that may be encountered for each drilling method. Refers reader to other references for further detail. Good general technical guidance for this topic area.
Cheremisinoff 1984	In Section 5, four of the major types of drilling methods are discussed. A table listing the advantages and disadvantages of each method is presented. Limited technical guidance for this topic area.
Davis 1966	Chapter 8 discusses various methods of water well drilling. Figures 8.19, 8.20, and 8.21 illustrate the major components of common drilling equipment. Good technical guidance for this topic.
Driscoll 1986	Chapter 10 discusses well drilling methods and includes numerous pictures of each method. The advantages and disadvantages of each method are presented at the end of each description. Table 10.9 lists the relative

DRILLING METHODS (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Driscoll 1986 (continued)	performance of different drilling methods in various types of geologic formations. Good technical guidance for topic area.
Ericson 1985 GW Monit. Rev.	This paper was completed as part of the DOE's Uranium Mill Tailings Remedial Action Program. To prevent ionic exchange between the dissolved cationic metals and the cations in bentonite drilling fluids at sites involving inactive uranium mill tailings, organic-based fluids are used to install monitoring wells. Certain types of organic drilling fluids seem to be preferable for these applications, and several basic recommendations are given. Good technical guidance for topic area covered.
Everett 1980	Methods for drilling shallow and deep wells for monitoring the vadose zone are given in Chapter III, Section 3. Section 4 includes a brief discussion on the types of drilling methods available for monitoring the saturated zone and contains several charts for estimating well drilling costs. Cost estimates are no longer accurate, as they are based on 1974 prices. Some value as technical guidance for this topic area.
Gillham 1983	Section 3 describes four drilling methods, the main factors that warrant consideration in the choice of drilling methods, and the assessment of the potential for hydrochemical disturbance during drilling. Table 3.3 lists the advantages and disadvantages of the four commonly used drilling methods. Good technical guidance when considering sources of sample bias in selected drilling programs.

DRILLING METHODS (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Guswa 1984	In Part II, Chapter 3, a brief description of various drilling methods is given, along with a summary of the advantages and disadvantages of each method. Several illustrations are included. Some value as general technical guidance for this topic area.
Mandel 1981	Section 5.1 discusses drilling techniques and presents a table which compares relative merits of the two principal drilling methods: percussion drilling and rotary drilling. The section is very brief and provides limited technical guidance for this topic area.
Marino 1982	Sections 11.1.E.1 through 11.1.E.3 describe three basic drilling methods: cable tool (also known as percussion), hydraulic rotary, and reverse hydraulic rotary. Schematics of each method are depicted and some advantages and disadvantages for each method are mentioned. Some value as technical guidance for this topic area.
Ross 1984 NWWA/API Proc.	This article recommends drilling with hollow-stem augers and without liquid drilling fluids where possible to minimize the variability of water quality measurements on samples from wells. Some value as technical guidance for this topic area.
Todd 1980	Chapter 5 (Water Wells) contains sections on drilling methods for shallow and deep wells. The methods described for shallow wells are digging, boring, driving, or jetting. For deep wells cable tool or rotary drilling

DRILLING METHODS (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Todd 1980 (continued)	methods are described. Table 5.1 lists water well construction methods and applications, and Table 5.2 lists the performance of drilling methods in various types of geologic formations. Several drawings are also presented which illustrate each method. Good technical guidance for this topic area.

RELEVANT STATE REGULATIONS

In order to drill a well for any purpose, Missouri requires well drillers to get operating permits and to register each well. Missouri does not allow underground injection of hazardous waste and has banned the construction of new injection wells. Florida requires drilling permits and approved drillers for installation of monitoring wells at hazardous waste facilities.

WELL DATA

REGULATION	DESCRIPTION
No specific regulatory requirements.	
GUIDE	**DESCRIPTION**
86-EPA-5 TEGD	Section 3.5 provides a list of items which should be documented during the construction of monitoring wells. Good technical guidance for this topic area.
85-EPA-1 Pract. Guide for GW Samp.	Section 2 describes several mechanical and electronic methods for measuring water levels, and describes methods for determining hydraulic conductivity by means of slug tests, pumping tests, and analysis of water level data. Good technical guidance for determining water levels and hydraulic conductivity.
81-EPA-2 NEIC GW Investigations	Section III - On-Site Wells and Depth to Ground Water describes the electric sounder, chalk tape, and popper methods for determining the level of water in wells, and presents advantages and disadvantages of these methods. Good technical guidance for determining water levels in monitoring wells.
78-EPA-1 Contam. Potential Surface Impound.	Step 1 of the SIA evaluation system requires identification and classification of earth materials in the unsaturated zone. The classification of earth materials is based on general relationships between grain size/surface area and permeability/sorption. Figures and tables provide some technical guidance for the utilization of well data.

WELL DATA (continued)

GUIDE	DESCRIPTION
80-USGS-1 GW Data Acquisition	Section 2.E of this document discusses the process of drilling and the subsurface data resulting from drilling. Section 2.H describes general procedures and aquifer test methods used to determine the properties of water-bearing formations. Some value as technical guidance for this topic area.

NONGOVERNMENT REFERENCES	DESCRIPTION
Davis 1966	Chapter 8 discusses interpretation of drillers, geophysical, and resistivity logs. Chapters 9, 10, and 11 describe porosity, permeability, and well yield of different rocks and sediments. Good technical guidance for this topic area.
Everett 1980	Chapter III, Section 4 includes a brief discussion of well inventory and well data collection and states that well data may include drilling logs, electric logs, water level measurements, pump tests, and chemical analyses. The proper collection of well data will promote the proper interpretation of subsequent monitoring data. Limited technical guidance for this topic area.
Mandel 1981	Section 5.5 provides a brief description of proper sample collection techniques used during operations. Borehole sample boxes are recommended for storage of samples obtained during drilling. This section is very brief, but some technical guidance for drilling sample preservation and handling is provided. Some value as technical guidance for proper handling of drilling samples.

WELL DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Marino 1982	Section 12.3A is very brief but does provide one example of a well log constructed through examination of drilling samples. Limited technical guidance for this topic area.
Todd 1980	Chapter 6 provides detailed coverage of ground water levels and environmental influences. This chapter describes many effects which produce a change in pressure on ground water and cause the ground water level to vary. Nine causes of ground water fluctuations are discussed, and many graphs of depths to water table versus time are shown. Good technical guidance on ground water levels. Only a very brief explanation of other well data, such as geologic logs (p. 433), is provided.
Verruijt 1970	Table 2.1 is a listing of the orders of magnitude of the permeabilities of natural soils. This is a general list and represents very limited information concerning well data. The book does, however, discuss several methods for analyzing ground water flow. Some value as general technical guidance for analyzing well data.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT

REGULATION	DESCRIPTION
RCRA	
40 CFR 264.97(c)	Applicable to RCRA-permitted hazardous waste land disposal facilities; requires (1) that wells be cased to maintain integrity of the borehole, (2) that casing be screened and packed with sand or gravel when necessary, and (3) that annular space be sealed.
40 CFR 265.91(c)	Applicable to hazardous waste land disposal facilities operating under interim status; requires (1) that wells be cased to maintain integrity of the borehole, (2) that casing be screened and packed with sand or gravel when necessary, and (3) that annular space be sealed.
TSCA	
40 CFR 761.75(b)(6)(ii)	Applicable to chemical waste landfills containing PCB materials; requires wells to be cased and prescribes measures for backfilling and plugging the annular space, designing the well opening, and evacuating the well prior to sampling.

GUIDE	DESCRIPTION
85-EPA-1 Pract. Guide for GW samp.	Section 2 discusses well placement and construction, including drilling and completion methods, well design, and well development and purging strategy. Good current technical guidance for this topic area.
86-EPA-5	Section 3.2 contains recommendations for the use of various well materials (e.g., polyvinyl chloride, fluorocarbon resins, and stainless steel) and combinations of materials, depending on hydrogeologic conditions and the parameters being monitored. Also, recommendations are presented for the use of natural and synthetic filter packs and annular sealants. Section 3.3 specifies some criteria for

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

GUIDE	DESCRIPTION
86-EPA-5 (continued)	design of monitoring well intakes. Section 3.4 briefly discusses well development, but does not present details on development methods. A decision chart is shown in Figure 3-4 for use if a well produces turbid samples. Section 3.6 provides guidance for specialized well designs where dedicated pumps or samplers are used or where immiscible layers may be present. Current technical guidance for RCRA regulatory compliance. Some value as general technical guidance for topic area.
83-EPA-1 Guide to Matl. Selection ISWS-327	Chapters 4, 5, 7, and 8 discuss well design, selection of construction materials, and costs. Partially superseded by TEGD as technical guidance for regulatory compliance with RCRA. Good technical guidance for topic area.
83-EPA-2 Rem. Act. Tech. Plans	Chapter 5.0 of this document discusses well screens, annular spacing, and well development. Table 5-4 presents principal data considerations for monitoring wells. Limited technical guidance for this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapter 4 presents recommendations for selecting well construction materials and designing the well intake, gravel pack, and sealing of the annular space. Also describes the construction of cluster wells and multiple screen wells. Good technical guidance for this topic area.
83-EPA-5 GW Guide Int. Status SW-963	Section 2.3 contains a general statement citing the need for sound engineering design and gives design and planning factors (2.3.1) and well construction methods (2.3.2). Some value as technical guidance; has been superseded by more recent technical guidance documents for complying with RCRA hazardous waste regulations.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

GUIDE	DESCRIPTION
82-EPA-1 Sample Preservation Water/Wastewater	Section 9.5 of this document describes the general requirements for construction of ground water monitoring wells, including diameter, depths, screen length, and casing materials. Well development is discussed as best accomplished by causing the formation water in the well to move in and out of the screen, agitating fine materials into the screen. Some value as technical guidance for this topic area.
82-EPA-2 Rem. Act. Waste Disp. Sites	Figures A-2 and A-3 in Appendix A of this document show typical single and multiple well clusters. Appendix A discusses the applications of these well types and makes recommendations for chemical landfill sites. Some value as technical guidance for this topic area.
77-EPA-1 Abandoned Wells GW	Section 3 contains 12 recommendations by the National Water Well Association (NWWA) for state legislation concerning proper methods of well abandonment. Section 4 presents specific case histories of ground water pollution caused by improper well abandonment, and Section 5 contains a review of specific state regulations regarding well abandonment. State regulations may have been updated since publication of this document in 1977. Good technical guidance for well abandonment procedures.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Chapter 3 includes discussions of lysimeter, piezometer, and well installations, including costs and construction details such as casing and screen material selection (3.5.2). Good technical guidance; has been superseded by more recent technical guidance documents for complying with RCRA hazardous waste regulations.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

GUIDE	DESCRIPTION
76-EPA-2 Monit. GW: Meth. Costs	Section IV of this document details well casing materials, well screens and perforated casings, gravel packing, and well sealing. Methods of well development such as mechanical surging and high velocity jetting are also discussed. Some value as technical guidance for this topic area.
82-NRC-3 Characterizing Sites Low-Level Radioactive Wastes	Appendix G emphasizes the need for permanent survey control points to assist in the description of monitoring locations. Good general guidance on surveying well locations.
78-NRC-1 GW Elements Uranium Mining	Section 4 contains specific details regarding the design and installation of monitoring well networks, including materials, development, and costs. Some value as technical guidance for this topic area.

NONGOVERNMENT REFERENCES	DESCRIPTION
Bouwer 1978	Section 6.3.3 discusses types of well screens, perforations, and gravel envelopes, and the installation of each. Sources are suggested for additional information on well screens, perforated casings, and selecting slot and gravel-pack sizes. Section 6.3.3 briefly covers well cementing, and Section 6.3.5 describes the development, stimulation, and sterilization of wells. Some value as overall general technical guidance for this topic area.
Canter 1985	This book addresses ground water quality protection and treatment in three major areas: technologies, decision-making, and case studies and applications. The book has detailed sections on physical control measures and treatment of ground water, but

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Canter 1985 (continued)	has only a very brief section on well design and construction. Refers to other books, including Driscoll (1986), for better discussions on well design and construction. Limited technical information for this topic area.
Driscoll 1986	Chapters 13, 14, and 15 discuss water well design, installation and removal of well screens, and development of water wells. The design and construction of monitoring wells are examined more closely in Chapter 21, which deals with ground water monitoring techniques. Some value as technical guidance for this topic area; emphasis is on water well construction.
Everett 1980	Chapter III, Section 4, contains brief discussions of well casings and related costs, well screens, gravel packing, well sealing, and well development. Test pumping is recommended to evaluate the effectiveness of the well development actions. Some value as technical guidance for this topic area but more detailed information may be found in other documents.
Everett 1984	Chapter 5 reviews the properties and design of devices that can be installed for collecting water from the unsaturated zone. Few of the devices discussed are commercially available. Good technical guidance on design and materials for unsaturated zone monitoring devices.
Gillham 1985	This publication is based on a field study devised to evaluate the appropriate methods and volumes of well development. Tracer tests were utilized to indicate reliable and efficient well flushing.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Gillham 1985 (continued)	Good technical guidance on well development.
Guswa 1984	Part II, Chapter 3, discusses monitoring well construction and includes several illustrative drawings. Some technical guidance for this topic area.
Kill 1985 Natl. Env. Health Assoc. Proc.	This paper provides a list to aid in selecting material for ground water monitoring wells. The advantages and disadvantages of drilling methods, well casing and screen materials, well screen types, fitting types, filter packs, grouting materials, and water quality sampling devices are discussed. Good technical guidance for this topic area.
Liggett 1985 ASTM STP867	This article recommends that RCRA monitoring wells be constructed to prevent surface water from entering the well and to prevent contamination from the structural components of the well. Some value as technical guidance for this topic area.
Marino 1982	Sections 11.2 through 11.4 contain a detailed discussion of well design, selection of construction materials, well installation, well development, well maintenance, and costs. Many schematics and tables are used to supplement the material presented in the text. Good technical guidance for this topic area.
Ross 1984 NWWA/API Proc.	This article recommends construction of RCRA monitoring wells in the same aquifer so background characteristics in all wells will be the same if the facility is not leaking. Casing joint glue is not recommended since contamination of well samples may result.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Ross 1984 (continued)	Some value as technical guidance for this topic area.
Todd 1980	Chapter 5 describes well completion methods involving placement of casing, cementing of casing, placement of well screens, and gravel packing. Several tables which are useful in well design are also presented. Eight methods for well development are described in Chapter 5. Good general technical guidance for well design and construction/development.

RELEVANT STATE REGULATIONS

Most states have standards for well construction. Pennsylvania specifies casing and protective installation requirements for monitoring wells at hazardous waste facilities. Missouri also has casing requirements and requires all wells to be of a certain depth.

HEALTH AND SAFETY PROCEDURES

REGULATION	DESCRIPTION
AEA	
10 CFR 20	Establishes standards for radiation protection for activities under licenses issued by the NRC and requires that every effort be made to reduce radiation exposures as low as is reasonably achievable.
10 CFR 20.202	Requires NRC licensees to supply certain personnel with appropriate radiation monitoring equipment.
10 CFR 61.43	Applicable to NRC-licensed facilities for the land disposal of radioactive wastes; requires that operations be conducted in compliance with the radiation protection standards of 10 CFR 20 and that every effort be made to minimize radiation exposure.
NWPA	
10 CFR 60.31	Applicable to geologic repositories for high-level radioactive waste; prescribes that the NRC may authorize facility construction if certain safety criteria are met.
SWDA	
40 CFR 241.211	Requires that land disposal sites for nonhazardous solid wastes be designed, constructed, and operated to protect the health and safety of operations personnel and refers to the Occupational Safety and Health Administration (OSHA) for applicable regulations. Recommends that a safety manual be developed and that certain operational procedures be followed.
CERCLA	
40 CFR 300.57	Requires the On-Scene Coordinator (OSC) at "Superfund" waste sites to ensure that persons entering CERCLA response areas follow safety precautions and applicable OSHA regulations and that they possess proper training.

HEALTH AND SAFETY PROCEDURES (continued)

DOE ORDER	DESCRIPTION
5480.1A	Establishes prescribed and recommended health and safety practices for DOE operations, including general standards and requirements for radiation protection (Ch. XI).
5484.1	Prescribes guidelines for the submittal of environmental protection, safety, and health protection reports, including radiation exposure to employees and visitors (Ch. IV).

GUIDE	DESCRIPTION
85-EPA-6 CERCLA Feasibility Studies	Section 4.5.5 states that OSHA has the authority to inspect CERCLA sites and to issue citations for unsafe conditions, and briefly discusses other relevant agencies. Current regulatory guidance for compliance with CERCLA. Limited technical guidance for this topic.
84-EPA-6 Standard Oper. Safety Guide	Provides guidance for health and safety personnel responding to incidents involving hazardous materials. Although this manual has been developed for hazardous materials incidents, many of the techniques identified are applicable to the protection of ground water monitoring personnel at hazardous waste sites. Descriptions of decontamination techniques, levels of protection, and site safety plans are especially relevant. The appendix addresses dermal toxicity and provides useful information for evaluating chemicals for potential skin hazard. Good general technical guidance for this topic area.
81-EPA-2 NEIC GW Investigations	Chapter II and Appendix G discuss health and safety considerations at hazardous waste sites and present numerous references for additional health hazard information. Good technical guidance for this topic area.

HEALTH AND SAFETY PROCEDURES (continued)

GUIDE	DESCRIPTION
DOE Facility HP Manuals	Technical guidance for compliance with DOE orders, applicable to all monitoring involving radioactive or mixed wastes. Each DOE contractor facility has its own manual or set of manuals. They contain facility-specific health and safety procedures for working in radioactive contaminated areas, including requirements for posting of areas with elevated radioactivity, specifications for protective clothing for work in these areas, personnel radiation monitoring requirements, etc. Good guidance for complying with DOE radiation protection orders.
85-NIOSH-1 Safety Guide HW Site	Provides guidance to managers responsible for health and safety of ground water monitoring employees at inactive hazardous waste sites. Topics include site hazards and personal protection equipment. This document is a general but comprehensive occupational safety and health manual and should be supported by detailed text according to site-specific conditions. Good general technical guidance for this topic area.
84-NIOSH-1 Personal Protective Equipment	Provides guidance in selecting personal protective equipment for response to hazardous materials incidents. While not specifically designed for the protection of ground water monitoring personnel at hazardous waste sites, many of the techniques advanced should be useful. Selection algorithms, step-by-step selection guides, calculations for personal protective equipment service life, and training models are presented. The technique for calculating tolerance to heat stress should be very useful at hazardous waste sites. Good technical guidance for this topic area.
83-NIOSH-1 Drilling Safety	Presents guidelines for analyses of occupational hazards and suggests means for preventing injury and disease among oil and

HEALTH AND SAFETY PROCEDURES (continued)

GUIDE	DESCRIPTION
83-NIOSH-1 (continued)	gas drilling workers. While not prepared specifically for the ground water monitoring industry, the safety techniques presented would also be applicable to monitoring well drilling. Sections of special interest include hazard assessment of the drilling industry, how injuries occur in drilling operations, and safety guidelines for well drilling machinery. Additionally, a review of drilling accident case histories is presented. Good general guidance on hazard protection at the drilling rig.

NONGOVERNMENT REFERENCES	DESCRIPTION
ACGIH 1985 Clothing	Prescribes guidelines for the selection of personal protective garments used during ground water monitoring activities at hazardous waste sites. The sections on use limitations and permeation theory are especially useful when ground water sampling involves potential exposure to unknown chemicals. A selection matrix is included that rates the effectiveness of personal protective garment types with various hazardous chemicals. A vendor directory is included which aids in obtaining the selected equipment. Of specific interest to ground water monitoring personnel is the section on the "Donning and Doffing" of protective garments at hazardous waste sites. Good technical guidance for the selection of protective clothing.
ACGIH 1985 TLVs	Provides threshold limit values (TLVs) designed to control exposure to harmful airborne chemical substances and physical agents. Of particular interest to ground water monitoring personnel are the "skin" notations for certain chemicals which refer to the ability of a chemical to contribute to overall exposure by the cutaneous route. Included is a list of defined and suspect human carcinogens.

HEALTH AND SAFETY PROCEDURES (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
ACGIH (continued)	Good technical guidance for evaluating risk from airborne pollutants at waste sites.
AIHA 1982	This engineering field manual presents a collection of commonly used information that may be used in the field to protect ground water monitoring personnel at hazardous waste sites. Included are chapters on heat stress, noise, ionizing radiation, and respiratory protection; a variety of handy tables, charts, and formulas; and other relevant topics to ground water monitoring activities. Good general technical guidance for this topic area.
Birkner n.d.	This manual supplies site safety personnel with information necessary to establish and operate a respiratory protection program to comply with the OSHA respiratory protection standard. Includes a detailed discussion on medical surveillance required for ground water monitoring personnel, and provides information on the selection of respiratory equipment for emergency citations. In addition, the various types of respiratory equipment which ground water monitoring personnel may be required to wear are discussed in detail. Good technical guidance for the selection of respiratory protection equipment.
Driscoll 1986	Chapter 21 contains a section on personnel safety at monitoring sites, and lists some of the most significant dangers involved with drilling monitoring wells. Several practices and habits which should be followed at any known or suspected hazardous waste site are also listed. Limited technical guidance for this topic area.

HEALTH AND SAFETY PROCEDURES (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Levine 1985	Recommends procedures for the recognition, evaluation, and control of occupational health hazards at hazardous waste sites. The medical surveillance section discusses the importance of periodic and preemployment screening of ground water monitoring personnel. The proper use of goggles, gloves, and respirators, all standard equipment during ground water monitoring at hazardous waste sites, is addressed in the personal protective equipment section. Of special interest to ground water monitoring personnel who work in hot environments is a novel approach to body temperature monitoring advanced in the heat stress section. Good general guidance for personnel protection.
Shapiro 1972	Provides information on personal protection during monitoring at radioactive sites, including the recognition, evaluation, and control of exposure to radionuclides. Explains types of radiation, dose calculations, and radiation measurement techniques but provides only general information on specific personal protection equipment. Good technical guidance on identifying radiation risks. Other references should be consulted for specific types of protective equipment.

MONITORING PARAMETERS

REGULATION	DESCRIPTION
SDWA	
40 CFR 144.28(g)	Applicable to underground injection wells; requires periodic monitoring of the injected fluids to determine constituents in the fluids.
AEA	
40 CFR 192.32(a)(2)	Applicable to NRC-licensed facilities for the disposal of uranium and thorium processing residues; requires that uranium by-product materials will be managed to conform with 40 CFR 264.92 (Ground Water Protection Standard) and requires the establishment of a detection monitoring program (per Part 264.98).
40 CFR 192.33	Requires that a corrective action program be put into operation as soon as practical if the ground water standards of 40 CFR 192.32(a)(2) are exceeded at the site.
RCRA	
40 CFR 264.93(a)	Applicable to RCRA-permitted hazardous waste land disposal sites; requires the U.S. EPA Regional Administrator (RA) to specify hazardous constituents from Appendix VIII of Part 261 which are to be monitored pursuant to a RCRA permit.
40 CFR 264.93(b) and (c)	Specifies factors to be considered by the RA for excluding certain constituents from monitoring.
40 CFR 264.98(a)	Requires a detection monitoring program to monitor for indicator parameters as specified by the RA in the facility's RCRA permit and specifies factors to be considered in determining the appropriate monitoring parameters.
40 CFR 264.98(c)	Requires the determination of background values for the specified monitoring parameters.

MONITORING PARAMETERS (continued)

REGULATION	DESCRIPTION
40 CFR 264.98(h)	If a statistically significant increase in a monitoring parameter is determined (per 264.98(g)), the owner/operator is required to (1) determine concentrations of all Appendix VIII constituents in all monitoring wells, (2) establish a background value for each Appendix VIII constituent detected at the compliance point, and (3) submit an application to the RA for a permit modification to establish a compliance monitoring program which must include, among other items, proposed changes to the ground water monitoring system (per 40 CFR 264.99) and proposed concentration limits for hazardous constituents detected at the compliance point.
40 CFR 264.99(f)	Applicable to facilities with RCRA detection monitoring programs; requires the monitoring of all Appendix VIII constituents at least annually from monitoring wells at the compliance point.
40 CFR 264.100	Requires RCRA facilities with a corrective action program to monitor for constituents specified by the RA, and other constituents as appropriate, to determine the effectiveness of the corrective action program.
40 CFR 265.92(b)	Applicable to RCRA hazardous waste facilities operating under interim status; requires monitoring for parameters specified in Appendix III of 40 CFR 265 and certain parameters specified in 40 CFR 265.92(b)(2) and (3).
40 CFR 265.93	Establishes procedures to be followed for the monitoring of additional parameters, if monitoring under 40 CFR 265.92 indicated significant increases in downgradient pollutant concentrations.
CERCLA	
40 CFR 300.68(f)	Recommends that remedial investigations at "Superfund" waste sites (per Phase VI of CERCLA actions) include monitoring and

MONITORING PARAMETERS (continued)

REGULATION	DESCRIPTION
40 CFR 300.68(f) (continued)	sampling as necessary to determine the extent of required remedial actions. General requirement; does not specify parameters.
TSCA	
40 CFR 761.75(b)(6)(iii)	Specifies certain parameters which must be analyzed in monitoring wells at landfills containing PCB materials.

GUIDE	DESCRIPTION
85-EPA-1 Pract. Guide for GW Samp.	Section 2, Information Needs and Analyte Selection, presents recommendations for the selection of ground quality parameters, pollution indicator parameters, and specific chemical constituents. Also identifies minimum chemical and hydrologic parameters needed to design a detection or assessment monitoring program for hazardous waste facilities. Good current technical guidance for parameter selection at hazardous facilities; may also be applied to nonhazardous facilities.
85-EPA-11 RCRA GW Monit. Guide	Section 3.1.2 compares the requirements for RCRA detection monitoring programs under 40 CFR Parts 264 and 265, and states that permit writers have greater latitude in selecting specific monitoring parameters for Part 264 programs. Section 3.3 clarifies the requirements for assessment monitoring under Part 265.93(d) for interim status facilities. Section 5.4.2 presents criteria to be used by U.S. EPA officials in selecting monitoring parameters to confirm leakage at interim status facilities. Good regulatory guidance for compliance with RCRA. No general technical guidance for this topic area.
85-EPA-16 CLP Inorganic Protocol	This document prescribes standard protocol to be followed by laboratories performing inorganic analyses under the U.S. EPA Contract Laboratory Program (CLP). Exhibit C

MONITORING PARAMETERS (continued)

GUIDE	DESCRIPTION
85-EPA-16 (continued)	lists the 23 inorganic elements to be determined under the CLP, along with the contract-required detection level for each parameter. Good technical guidance for compliance with U.S. EPA's CLP requirements for inorganic analyses.
85-EPA-17 CLP Organic Protocol	This document prescribes standard protocol to be followed by laboratories performing organic chemical analyses under the U.S. EPA CLP. In Exhibit C, the 130 organic parameters of the Hazardous Substance List (HSL) are given along with the contract-required detection levels for each parameter. Good technical guidance for compliance with U.S. EPA's CLP requirements for organic analyses.
84-EPA-2 Permit App. Guide HW Facility	Section 9.6.3.1 presents criteria to be considered in the selection of monitoring parameters, including both indicator parameters and hazardous constituents for RCRA detection monitoring programs. Section 9.7.3.2 identifies constituents which should be monitored for characterization of contamination under RCRA compliance monitoring programs. Good regulatory guidance for RCRA compliance. Limited value as general guidance for parameter selection at hazardous facilities.
84-EPA-3 Permit Writ. Guide Facilities	Section 3.3.1 provides guidance for excluding Appendix XIII constituents from monitoring requirements based on hazardous waste facility location above Class I or Class II ground water. Section 3.3.3 discusses the extension of the post-closure care period for hazardous waste facilities located above Class I or Class II ground water.

MONITORING PARAMETERS (continued)

GUIDE	DESCRIPTION
84-EPA-3 (continued)	Some value as regulatory guidance for this topic area; minor modifications to this document anticipated by the end of 1986.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapters 8, 9, and 10 supply guidance for use when developing the specifications for complete detection monitoring, compliance monitoring, and corrective action programs, respectively. Sections 8.2.1, 8.2.4, 9.2.3, and 10.4.3 provide guidance for reviewing the monitoring parameters selected for these RCRA ground water monitoring programs. Good regulatory guidance for RCRA permit writers and applicants.
81-EPA-2 NEIC GW Investigations	Section IV discusses general sampling considerations for hazardous waste sites, and provides a useful table of potential ground water contaminants associated with various industrial categories. Recommends analysis for priority pollutants at sites with unknown chemical wastes. Good technical guidance for parameter selection at hazardous waste sites.
80-EPA-2 Western Coal Preliminary Designs	Contains some recommendations on selection of monitoring parameters for potential ground water contaminant sources associated with strip mining of coal in the Rocky Mountain region. Some value as technical guidance for this topic area.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Sections 4.1 to 4.5 present factors for determining the physical and biological leachate indicators at solid waste disposal facilities. Good technical guidance for nonhazardous facilities; partially superseded by more recent guidance.

MONITORING PARAMETERS (continued)

GUIDE	DESCRIPTION
85-NRC-1 GW Contam. Uranium Mining	The section entitled "Excursion Detection" presents criteria for the selection of parameters for determining aquifer contamination resulting from in situ leach uranium mining. Describes constituents monitored at a mining site in Texas and recommends TDS and uranium as good indicators, depending on soil conditions. Good technical guidance for parameter selection at in situ leach uranium mining sites.
83-NRC-1 Subsurface Monit. Low-Level Radioactive Waste	Part I briefly describes radioactive and nonradioactive parameters and soil properties needed for the characterization of low-level radioactive waste disposal sites. Refers to 82-NRC-3 and 82-NRC-1 for additional information on this topic area. Limited technical guidance for parameter selection at radioactive waste disposal sites.
82-NRC-3 Characterizing Sites Low-Level Radioactive Waste	Part II and Appendix E recommend parameters for monitoring at radioactive waste sites. Part III presents examples of monitoring parameters selected at representative sites in four states. Good technical guidance for selecting monitoring parameters at radioactive waste sites.
78-NRC-1 GW Elements Uranium Mining	Baseline monitoring parameters for water level and water quality are provided in Section 3. Excursions are primarily detected by monitoring for changes in water level and conductivity (measured by TDS concentration). Does not recommend uranium as a good indicator because of its rapid removal from aqueous systems. Some value as technical guidance for in situ leach uranium mining sites.

MONITORING PARAMETERS (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett 1980	Chapter I, Section 2, identifies several types of industries and the pollutants which are commonly associated with these industries. Some guidance on selecting appropriate parameters may be obtained from the discussion and evaluation of ground water pollution case histories in Chapter VI. Limited value as technical guidance for this topic area.
Everett 1984	Chapter 6 presents data on pollutants associated with municipal, agricultural, industrial, and petroleum activities. Chapter 5 briefly reviews the transformation and fate of inorganic and organic chemicals and radionuclides in the unsaturated zone, noting that information on environmental fate is useful in selecting monitoring parameters and in interpreting monitoring results.
Guswa 1984	Part I, Chapter 2, includes a brief discussion on selecting monitoring parameters and flow charts that outline a logral sequence of organic and inorganic monitoring parameters for investigating groundwater contamination. Some technical guidance for this topic area.
Wood 1984	Table 4.2 identifies the ten organic chemicals most commonly detected in public water system wells. Some value as technical guidance for selecting monitoring parameters in ground water supplies.

RELEVANT STATE REGULATIONS

Numerous states are conducting monitoring programs for pesticides in ground water with the most extensive programs occurring in Iowa, Florida, Wisconsin, Texas, Nebraska, and Washington. In New Jersey, hazardous waste facilities must include TDS as an indicator parameter in ground water programs.

SAMPLE COLLECTION AND FREQUENCY

REGULATION	DESCRIPTION
PHSA	
40 CFR 141.23	Requires that community water systems using ground water sources conduct an inorganic analysis at three-year intervals.
40 CFR 141.26	Prescribes the monitoring frequency requirements for radioactivity in community water systems.
40 CFR 141.27	Requires that monitoring frequencies prescribed in 40 CFR 141 may not decrease, even if alternate analytical techniques are approved.
FWPCA	
40 CFR 136.3	Identifies approved test procedures for 115 listed parameters and references sample collection procedures for many of the parameters.
RCRA	
40 CFR 264.97(d),(e) and (f)	Requires ground water monitoring programs at RCRA-permitted land disposal facilities to include consistent procedures and techniques for sample collection, preservation and shipment, analytical procedures, and chain-of-custody control. Also requires appropriate sampling and analytical methods and the determination of the ground water surface elevation each time a sample is taken.
40 CFR 264.97(g)	Requires a ground water monitoring program to establish background ground water quality for each monitoring parameter and specifies procedures to be followed.
40 CFR 264.98(c)(3)	Requires sampling as part of a detection monitoring program to be from a monitoring system which complies with 40 CFR 264.97.
40 CFR 264.99(g)	Requires RCRA facilities with compliance monitoring programs to utilize sampling and analysis procedures which comply with 40 CFR 264.97(d) and (e).

SAMPLE COLLECTION AND FREQUENCY (continued)

REGULATION	DESCRIPTION
40 CFR 265.92(a) and (e)	Requires the development of a ground water sampling analysis plan which includes procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain-of-custody control, and requires the determination of the ground water surface elevation each time a sample is taken.
TSCA	
40 CFR 761.75(b)(6)	Requires sampling at PCB landfills to be conducted prior to commencement of operations, and requires sampling methods to comply with those specified in 40 CFR 136. (See Analytical Procedures.)

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Sections 4.1 and 4.2 present recommended elements of sampling and analysis plans and give procedures for sample collection, including water level measurements, detection of immiscible layers, well evacuation, and withdrawal of the sample. Recommended acceptable sampling devices are described in Section 4.2.4, and a preferred sequence is given for collection of samples for typical monitoring parameters. Sections 6.7 and 6.9 discuss sample collection for facilities in the RCRA assessment monitoring program. Current technical guidance for RCRA regulatory compliance. Good technical guidance for this topic area.
85-EPA-1 Pract. Guide for GW Samp.	Section 2 includes well purging strategies, recommendations for sampling mechanisms and materials, and guidance on establishing a sample collection protocol. Also contains guidance and example problems for calculating appropriate purging rates and volumes prior to sampling. Good technical guidance for this topic area.

SAMPLE COLLECTION AND FREQUENCY (continued)

GUIDE	DESCRIPTION
85-EPA-11 RCRA GW Monit. Guide	Sections 3.1.3 and 3.2.3 compare the sampling frequencies required under 40 CFR 264 and 265 for detection and compliance monitoring. Section 3.1.4 compares sampling techniques appropriate for compliance with 40 CFR 264 and 265. Current U.S. EPA guidance for regulatory compliance with RCRA. No technical guidance for this topic area.
84-EPA-4 Rem. Investigations Guide	Chapter 3 provides guidance on developing sampling plans for remedial investigations at CERCLA sites, including determining sampling locations and frequency (3.2.6), preparation for sampling (3.2.7), sampling personnel (3.3.3), and decontamination/disposal of equipment (3.3.4). Utilized by U.S. EPA Regional Project Officers as regulatory guidance for determining compliance with CERCLA. Good technical guidance for this topic area.
83-EPA-1 Guide to Matl. Selection ISWS-327	Section 6 discusses the effects of subsurface conditions on sampling strategy and methods for determining the proper evacuation rates and volumes prior to sampling. Section 7 presents an evaluation of sample collection materials and the influence of various materials on the analytical results of the samples. Section 8 gives cost considerations for ground water monitoring systems, including sample collection. Good technical guidance for this topic area.
83-EPA-2 Rem. Act. Tech. Plans	Ground water sampling techniques during drilling are discussed in Chapter 5.0. Limited technical guidance on this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 5.1 provides a discussion of the factors that should be considered when specifying sample collection procedures. Sections 8.2.4, 9.2.3, and 10.4.3 provide guidance in specifying sampling and analysis

SAMPLE COLLECTION AND FREQUENCY (continued)

GUIDE	DESCRIPTION
83-EPA-4 (continued)	and frequency of monitoring for the various RCRA ground water monitoring programs. Good technical guidance for this topic; superseded by TEGD for RCRA regulatory guidance.
82-EPA-1 Sample Preservation Water/Wastewater	Section 9.6.1 of this document discusses the advantages and disadvantages of the various apparatus used in sample collection (i.e., bailers, pumps, etc.). Good technical guidance for selecting sample mechanisms.
82-EPA-2 Rem. Act. Waste Disp. Sites	Appendix A briefly discusses ground water sample collection methods, including the use of permanent pumps, portable pumps, and airlift methods. Limited technical guidance for this topic area.
82-EPA-3 Test Meth. Solid Waste SW-846	Section 1.1 describes the development of appropriate sampling plans, considering regulatory objectives and sampling statistics concepts. Contains detailed calculations and examples for determining the appropriate number of random samples to be taken to characterize a waste. Section 1.2 describes various types of sampling equipment and presents criteria for equipment selection. Current technical guidance for regulatory compliance with RCRA. Technical guidance directed at sampling of surface water; Section 3, which is to include guidance on ground water monitoring, is still "reserved."
81-EPA-1 GW Quality Samp.	Section 6 describes procedures for the pumping or bailing of wells prior to sampling, discusses seven methods for withdrawing samples and respective advantages and disadvantages, and provides illustrations of sampling devices. Also, special considerations for obtaining organic samples are presented.

SAMPLE COLLECTION AND FREQUENCY (continued)

GUIDE	DESCRIPTION
81-EPA-1 (continued)	Good technical guidance for this topic area.
81-EPA-2 NEIC GW Investigations	Section III - On-Site Wells and Depth to Ground Water - describes the electric sounder, chalk tape, and popper methods for determining the level of water in wells and presents advantages and disadvantages of these methods. Good technical guidance for determining water levels in monitoring wells.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Section 6 describes procedures for sample withdrawal, records maintenance, chain of custody, and sample preservation. Recommended reference in 40 CFR 265.92 for sampling and analysis procedures. Good technical guidance for this topic area.
76-EPA-2 Monit. GW: Meth. Costs	Section IV of this document describes ground water sample collection in cased and uncased boreholes. Sampling methods described include airlifting, bailing, pumping, and mechanical or inflatable packers. Some value as technical guidance for this topic area.
73-EPA-1 HASL Procedure Manual	Section B contains procedures for the sampling of radionuclides in gases, aerosols, water, soil, foods, and wastes, and from animal bioassays. For each sample type, sample and handling methods are given and the necessary equipment is described. Good technical guidance for sampling of radionuclides.
83-DOE-1 Effluent Radiological Meas. DOE	Section 5.2.7 discusses special considerations concerning liquid effluent sampling to detect radionuclides. Eight considerations are listed which distinguish sampling liquid effluent from sampling airborne effluent.

SAMPLE COLLECTION AND FREQUENCY (continued)

GUIDE	DESCRIPTION
83-DOE-1 (continued)	Good technical guidance for sampling of radionuclides.
81-DOE-1 Radiological Surveillance DOE	Section 4.3.2.1 describes periodic grab sampling as the choice method for ground water sampling for radionuclide monitoring concern. Some value as technical guidance for sampling radioactive ground water.
85-NRC-1 GW Contam. Uranium Mining	The section entitled Field Sampling Procedures describes the procedures followed by researchers during their study of in situ uranium mining. Some value as technical guidance for this topic area.
82-NRC-1 Disposal Low-Level Radioactive Waste	This document briefly describes the sampling of water from the unsaturated zone by using either soil analysis or pressure-vacuum lysimeters. It also discusses sampling from screened wells and well clusters from the saturated zone. Limited technical guidance on sampling of the unsaturated zone.
78-NRC-1 GW Elements Uranium Mining	Section 4.2 briefly describes methods of sample withdrawal, sample collection, field analysis, and settling and filtration of ground water samples. No information regarding quantity of well water to evacuate prior to sampling. Limited technical guidance for this topic area.
81-USGS-1 GW Sample Collection Guide	Contains a brief discussion on sampling from natural springs, monitoring wells, and the unsaturated zone. Limited technical guidance for this topic area.

SAMPLE COLLECTION AND FREQUENCY (continued)

GUIDE	DESCRIPTION
80-USGS-1 GW Data Acquisition	Section 2.G.1 discusses sampling methods, including site selection, necessary equipment, and recordkeeping. Some value as technical guidance for this topic area.

NONGOVERNMENT REFERENCES	DESCRIPTION
Cheremisinoff 1984	Section G describes two methods of sampling generally used in leachate studies. In addition to sample methodology, three sample withdrawal methods are discussed. Limited technical guidance for this topic area.
Driscoll 1986	Chapter 21 presents 11 reasons why samples taken may not be representative of actual ground water conditions. Table 21.10 lists the advantages and disadvantages of various water quality sampling devices for monitoring wells. Limited technical guidance for topic area.
Everett 1980	Chapter II, Section 3, presents a brief discussion on determining appropriate sampling frequencies and states that trial and error methods are often used to establish adequate frequencies for determining changes in quality and seasonal fluctuations. Chapter III, Section 4, describes procedures for determining water levels using steel tape, electric sounder, air line, and mechanical recorded methods. Chapter III also includes discussions of sampling methods for monitoring at the land surface, in the vadose zone, and in the saturated zone. Some value as technical guidance for this topic area, although other documents such as 85-EPA-1 contain more specific information on sampling procedures.

SAMPLE COLLECTION AND FREQUENCY (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett 1984	Chapter 5 reviews and evaluates methods for collecting water samples from the unsaturated zone; also discusses some saturated zone sampling techniques. Good technical guidance for sample collection in the unsaturated zone.
Everett 1985 GW Monit. Rev.	This paper discusses the physical operation of lysimeters and procedures for testing lysimeters. Information gathered in the tests performed for the paper is to be included in an upcoming U.S. EPA guidance document entitled "Unsaturated Zone Monitoring at Hazardous Waste Land Treatment Units." Good technical guidance for sampling from lysimeters.
Gillham 1983	Section 4 describes in detail the potential sources of sample bias that can occur as a result of the method of sample collection, including contamination as a result of contact with materials used to construct the sampling device, cross-contamination, induced chemical alternatives occurring as a result of degassing or atmospheric contamination, and bias introduced by sampling stagnant water in the installation. Section 5 discusses the various sources of bias in results of a sampling program which can be attributed directly or indirectly to the type of installation used. The section covers the uncertainty concerning the flushing of standing water from the installations prior to sampling. Good technical guidance for this topic area.
Guswa 1984	Part II, Chapter 3, Section 4, contains a good brief review of sampling devices (with diagrams) and considerations in their selection.

SAMPLE COLLECTION AND FREQUENCY (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Guswa 1984 (continued)	Good general technical guidance on sampling; technical information dates from 1980 or earlier and may be superseded by more recent guidance.
Liggett 1985 ASTM STP867	This article recommends resampling of each RCRA monitoring well after a period of several days, as opposed to taking replicate samples, to better assess sampling error. Good current guidance for alternatives to the U.S. EPA's standard sample collection requirements.
McBean 1985 GW Monit. Rev.	For upgradient RCRA monitoring wells, this article recommends obtaining multiple samples from a single well, followed by individual analysis, as opposed to replicate analyses of one sample, to reduce errors induced by sampling variations. Good current guidance on alternative to the U.S. EPA's sample collection procedures.
Morrison 1983	Part I describes techniques for monitoring in the vadose zone and includes measurement of the soil moisture potential and soil moisture content using laboratory and field procedures, soil salinity using salinity sensors and electrical probes, temperature, and soil pore water using various types of lysimeters and other methods. Part II covers techniques for monitoring the saturated zone and includes single and multiscreened wells, well clusters, piezometers, and well points. Sampling equipment, including bailers and various types of pumps, is described in Part III. Numerous sketches and photographs of monitoring equipment are given. Although this book only contains approximately 100 pages, references include over 480 citations, of which 380 concern monitoring in the vadose zone. Good technical guidance for this topic area, particularly for monitoring in the vadose zone.

SAMPLE COLLECTION AND FREQUENCY (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Nielsen 1985 GW Monit. Rev.	The paper deals with sampling equipment available for use in small-diameter ground water monitoring wells. The devices available are discussed in three broad categories: grab mechanisms (including bailers and syringe devices), suction-lift mechanisms (including centrifugal and peristaltic pumps), and positive-displacement mechanisms (including gas-driven devices, gas-operated bladder pumps, electric submersible pumps, and gas-driven piston pumps). The paper examines the operation, advantages, and disadvantages of each type of sampling device available. Limited technical guidance for selection of sampling equipment.
Ross 1984 NWWA/API Proc.	This article recommends obtaining four independent samples, one per month, from RCRA monitoring wells to replace the current requirement of four replicate analyses of one sample. For new hazardous waste facilities under construction, it is recommended that samples be obtained monthly to increase the power of the statistical test by increasing the baseline sample size at each well. Good current guidance for alternatives to the U.S. EPA's standard sample collection requirements.
Splitstone 1986 HMCRI Proc.	This paper recommends the collection of true replicate, or independent, samples from each RCRA ground water monitoring well by sampling a well, allowing it to recover, and then reevacuating and resampling to obtain a new data set. The U.S. EPA's present method is to sample one time and then divide the sample into four containers for analysis. The recommended collection in both upgradient and downgradient wells will result in the determination of a new background value for each monitoring period.

SAMPLE COLLECTION AND FREQUENCY (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Splitstone 1986 (continued)	Good current guidance for alternatives to the U.S. EPA's standard sample collection requirements.

RELEVANT STATE REGULATIONS

The majority of states require replicate analyses of ground water samples obtained adjacent to hazardous waste facilities.

In West Virginia, four independent samples of ground water are required from each RCRA monitoring well on a quarterly basis as opposed to four replicate analyses of ground water samples. New Jersey requires at least monthly sampling of ground water at hazardous waste facilities.

SAMPLE PRESERVATION AND HANDLING

REGULATION	DESCRIPTION
RCRA	
40 CFR 264.97	Applicable to RCRA-permitted land disposal facilities. Requires ground water monitoring program to include consistent procedures and techniques for sample collection, preservation and shipment, analytical procedures, and chain-of-custody control; and appropriate sampling and analytical methods.
40 CFR 265.92	Applicable to RCRA land disposal facilities operating under interim status. Requires ground water monitoring program to include consistent procedures and techniques for sample collection, preservation and shipment, analytical procedures, and chain-of-custody control; and appropriate sampling and analytical methods.

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Section 4.3 provides detailed information on proper sample containers, sample preservation, and special handling of samples containing organics, metals, and field blanks. Refers to 82-EPA-3 (SW-846) for additional preservation methods. Current regulatory guidance for compliance with RCRA. Good technical guidance for this topic area.
85-EPA-1 Pract. Guide for GW Samp.	Section 2 discusses the field preparation, storage, and handling of ground water samples, including details on field filtration of samples. Good technical guidance for this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 5.2 provides brief guidance for RCRA permit writers for reviewing sample preservation and shipment methods. Limited technical guidance for this topic; superseded by TEGD for compliance with RCRA.

SAMPLE PRESERVATION AND HANDLING (continued)

GUIDE	DESCRIPTION
83-EPA-7 Chem. Analysis Water/Wastes	Contains test procedures approved for water and waste monitoring under the Safe Drinking Water Act (SDWA) and the CWA National Pollutant Discharge Elimination System (NPDES) program. The procedures address preservation and handling for each sampling parameter. One of several optional technical guidance documents prescribed in 40 CFR 141.23(f). Good technical guidance for metals and inorganic constituents.
82-EPA-1 Sample Preservation Water/Wastewater	Chapter 17 of this document discusses methods of ground water sample preservation with chemical addition being the most convenient method. Tables 17.1 and 17.2 provide references, preservation methods, and storage and holding procedures for different parameters. Some value as technical guidance for this topic area.
82-EPA-3 Test Meth. Solid Waste SW-846	Chapters 7, 8, and 9 present methods for the analysis of inorganic, organic, and miscellaneous parameters, respectively. For each parameter, methods for sample preservation and handling are detailed. Good technical guidance for this topic area.
80-EPA-3 HW Leachate SW-871	Section 7.2.3 of this document discusses the advantages and disadvantages associated with refrigerating and/or adding preservatives to leachate samples. Some value as technical guidance for sample preservation methods.
80-EPA-5 Enf. Consid. HW Sites	Section VI-4 details appropriate containers and preservatives and shipping and storage temperatures for environmental samples requiring organic analysis and various other chemical analyses.

SAMPLE PRESERVATION AND HANDLING (continued)

GUIDE	DESCRIPTION
80-EPA-5 (continued)	Some value as technical guidance for this topic area.
81-DOE-1 Radiological Surveillance DOE	Reference 8 of this document lists various preservative methods and permissible storage times according to chemical species. Section 4.3.2.1 describes the numerous actions that can occur inside sample containers which can cause the removal of radioactivity from solution. Some value as technical guidance for handling radioactive samples.
DOE Facility HP Manuals	Technical guidance for compliance with DOE orders, applicable to all monitoring involving radioactive or mixed wastes. Each DOE contractor facility has its own manual or set of manuals. They include facility-specific requirements for handling and transfer of samples that contain radioactivity. Good guidance for complying with DOE radiation protection orders when conducting monitoring at DOE facilities.
82-NRC-1 Disposal Low-Level Radioactive Waste	Table A.2 in the appendix to this document summarizes special sampling and handling requirements for most of the parameters included under organic, inorganic, and water quality categories. This table also provides guidance on containers, sample size, preservation, and storage time. Some value as technical guidance for this topic area.
78-NRC-1 GW Elements Uranium Mining	Table 4.3 provides specific requirements for appropriate sample volume, container, preservative, and holding time for numerous inorganic analytical parameters. Some value as technical guidance for this topic area.

SAMPLE PRESERVATION AND HANDLING (continued)

GUIDE	DESCRIPTION
80-USGS-1 GW Data Acquisition	Chapter 5.0 of this document gives information on selecting the type of container, method of filtration, field treatment, preservation, and storage of samples depending on the particular inorganic, organic, and radioactive constituents to be determined. Some value as technical guidance for this topic area.

NONGOVERNMENT REFERENCES	DESCRIPTION
Barcelona 1985 Ana. Chem.	This paper provides the results of laboratory sorption experiments which were conducted with five common flexible tubing materials to determine the impact of sorptive bias for chloroform, trichloroethylene, trichloroethane, and tetrachloroethylene. The main conclusion of the paper was that tubing made of Teflon showed the least absorption and leaching problems and should be the tubing material of choice for detailed organic sampling purposes. Good technical guidance for selecting sampling materials.
Cheremisinoff 1984	Table 6-2 provides information on sample containers, volume requirements, preservation techniques, holding times, and standard methods of analysis. Different steps which must be taken to ensure proper sample handling are also covered. Good technical guidance for this topic area.
Dunbar 1985 GW Monit. Rev.	The paper describes a set of anomalies encountered during well monitoring, including abnormally high pH values, detectable tetrahydrofuran (THF), detectable trihalomethanes (THM), and cross-contamination during sampling for volatile organics. The article describes the

SAMPLE PRESERVATION AND HANDLING (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Dunbar 1985 (continued)	specific anomalies and their corresponding causes. Suggestions for minimizing such anomalies are also given. Good technical guidance for subject area.
Everett 1980	Chapter III, Section 5, contains recommended sampling volumes, preservatives, and holding times for organic and inorganic chemicals and radiological and bacteriological samples, and refers the reader to Methods for Chemical Analysis of Water and Wastes (83-EPA-7). Extensive bibliography provided for additional references. Some value as technical guidance for this topic area.

SAMPLING QUALITY ASSURANCE AND CHAIN OF CUSTODY

REGULATION	DESCRIPTION
AEA	
10 CFR 50 Appendix B	Applicable to NRC-licensed nuclear power plants and fuel reprocessing plants. Establishes comprehensive quality assurance requirements for the design, construction, and operation of these facilities.
NWPA	
10 CFR 60.151	Requires a quality assurance program for all systems and components important to safety, design, and characterization of waste isolation barriers at high-level radioactive waste repositories operated by the DOE and licensed by the NRC.
10 CFR 60.152	Requires DOE to implement a quality assurance program at high-level waste disposal sites based on criteria of 10 CFR 50, Appendix B - Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.
RCRA	
40 CFR 264.97	Applicable to RCRA-permitted land disposal facilities; requires ground water monitoring program to include consistent procedures and techniques for sample collection, preservation, and shipment; analytical procedures; chain-of-custody control; and appropriate sampling and analytical methods.
40 CFR 265.92	Applicable to hazardous waste land disposal facilities operating under interim status; requires ground water monitoring program to include consistent procedures and techniques for sample collection, preservation, and shipment; analytical procedures; chain-of-custody control, and appropriate sampling and analytical methods.
TSCA	
40 CFR 761.75(b)(6)(iii)	Requires records of sampling and analysis at PCB land disposal facilities to be maintained per 761.180(d)(1).

SAMPLING QUALITY ASSURANCE AND CHAIN OF CUSTODY (continued)

REGULATION	DESCRIPTION
40 CFR 761.180(d)	Specifies requirements for the collection and maintenance of monitoring and disposal data at PCB land disposal facilities.

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Section 4.4 provides information on sample labeling and maintenance of a field logbook and chain-of-custody record. Section 4.6.1 provides recommendations for a field quality assurance/quality control program as part of the facility's sampling and analysis plan. Good technical guidance for this topic area.
85-EPA-1 Pract. Guide for GW Samp.	Section 1 presents a general discussion of sampling accuracy, precision, detection/quantitation limits, and completeness. Section 2 presents details on the use of field blanks, standards, and quality assurance, and provides a sample chain-of-custody form. Good technical guidance for this topic area.
83-EPA-1 Guide to Matl. Selection ISWS-327	Section 7 discusses potential sources of error during ground water monitoring and how they may be minimized. Some value as technical guidance for this topic area.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 5.4 discusses chain-of-custody procedures which should be specified in a RCRA permit. Good technical guidance for this topic area.
83-EPA-10 Int. Guide/ QA Plans	This document describes the elements of quality assurance plans required for all U.S. EPA-related measurement or monitoring projects, including sampling procedures, sample custody, and analytical procedures Required procedures for U.S. EPA project applicants but also useful as general guidance for this topic area.

SAMPLING QUALITY ASSURANCE AND CHAIN-OF-CUSTODY (continued)

GUIDE	DESCRIPTION
82-EPA-1 Sample Preservation Water/Wastewater	Section 15.2 outlines chain-of-custody procedures, including sample custody, field custody, and transfer of custody and shipment. Figure 15.3 shows a blank chain-of-custody form. The document suggests sample tags, field sheets, and a notebook to be kept of significant field events. Some value as technical guidance for this topic area.
82-EPA-3 Test Meth. Solid Waste SW-846	Section 1.3 presents details on the documentation of chain-of-custody procedures and numerous examples of chain-of-custody forms. Good technical guidance for this topic area.
80-EPA-3 HW Leachate SW-871	Section 7.2.3 recommends adequate recordkeeping and use of proper sample containers. It also suggests that a detailed sampling plan be developed prior to any sampling operations. Limited technical guidance for this topic area.
80-EPA-5 Enf. Consid. HW Sites	Section VIII of this document presents an outline for maintenance and documentation of sample possession. The outline covers sample custody, field custody procedures, and transfer of custody and shipment. Figure VIII-3 shows an example of a blank chain-of-custody form. Some value as technical guidance for this topic area.
83-DOE-1 Effluent Radiological Meas. DOE	Section 6.3 covers quality control for sampling, and refers reader to other documents for establishing written sampling procedures and aqueous sample preservation methods. Limited technical guidance for this topic area.

SAMPLING QUALITY ASSURANCE AND CHAIN-OF-CUSTODY (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Cheremisinoff 1984	A detailed list of proper recordkeeping and guidelines for maintaining a legally acceptable chain of custody are listed in Section 6. Good technical guidance for this topic area.
Everett 1980	Chapter III, Section 5, briefly describes chain-of-custody procedures from sampling preparation to sample collection. Recommends that a minimum number of persons handle samples, field blanks be obtained, log books be maintained, and pictures of the sampling point be taken. Some value as technical guidance for this topic area.
Guswa 1984	A quality assurance/quality control plan is outlined on Page 24. Eleven areas covered by a quality assurance/quality control program are listed. Some technical guidance for designing quality assurance/quality control plans.

ANALYTICAL PROCEDURES

REGULATION	DESCRIPTION
FWPCA	
40 CFR 136.3	Prescribes list of approved test procedures for parameters required to be analyzed pursuant to the NPDES program and 40 CFR 761.75 (land disposal facilities containing PCB).
PHSA	
40 CFR 141.23	Applicable to public water systems utilizing ground water and/or surface water sources; prescribes sampling frequency and analytical procedures for inorganic chemicals. Requires communities using only ground water as drinking source to repeat organic analyses every three years. Establishes procedures for notification of state for exceedances of MCLs. Specifies analytical methods for inorganics.
40 CFR 141.24	Prescribes sampling and analytical procedures for organic chemicals (other than THM). Surface water users must determine compliance with organic MCLs using specific methods. Communities using only ground water must complete analyses per state requirements.
40 CFR 141.25	Prescribes analytical methods for radioactivity monitoring and gives detection limits for MCLs.
40 CFR 141.27	Prescribes procedure for obtaining permission from the state and U.S. EPA to use an alternate analytical technique.
40 CFR 141.28	Requires that only state-approved laboratories may be used for determining compliance with monitoring and analytical requirements (with several exceptions).
SDWA	
40 CFR 144.28(g)	Applicable to Class I, II, or III hazardous waste injection wells. Specifies that analytical procedures of Table I of 40 CFR 136.3 or of Appendix III of 40 CFR 261 must be used for the monitoring of injected fluids.

ANALYTICAL PROCEDURES (continued)

REGULATION	DESCRIPTION
RCRA	
40 CFR 264.97	Requires RCRA-permitted land disposal facilities to have a ground water monitoring program which includes consistent procedures and techniques for sample collection, preservation and shipment; analytical procedures; chain-of-custody control; and appropriate sampling and analytical methods.
40 CFR 265.92	Requires RCRA land disposal facilities operating under interim status regulations to have a ground water monitoring program which includes consistent procedures and techniques for sample collection, preservation, and shipment; analytical procedures; chain-of-custody control; and appropriate sampling and analytical methods.
TSCA	
40 CFR 761.75(b)(6)(iii)	Applicable to land disposal sites containing PCB materials; requires analytical procedures to comply with those specified in 40 CFR 136.

GUIDE	DESCRIPTION
86-EPA-4 Appendix VIII Guide	This document presents the U.S. EPA's latest views on the analytical potential of each of the RCRA Appendix VIII constituents and provides guidance for RCRA permit writers on requiring these analyses. Represents current U.S. EPA regulatory policy (not necessarily followed by state RCRA officials). Good regulatory guidance for compliance with RCRA. Some value as general technical guidance for this topic area.
86-EPA-5 TEGD	Section 4.5 provides general information on addressing analytical procedures in the sampling and analysis plan of a RCRA Part B permit application.

ANALYTICAL PROCEDURES (continued)

GUIDE	DESCRIPTION
86-EPA-5 (continued)	Current technical guidance for RCRA regulatory compliance. Limited technical guidance for this topic area.
85-EPA-16 CLP Inorganic Protocol	This document describes standard protocol to be followed by laboratories performing analysis of inorganic substances under the U.S. EPA Contract Laboratory Program (CLP). Exhibit D prescribes the analytical procedures to be used by the contractors using inductively coupled plasma emission spectroscopy; flame, flameless, and cold vapor atomic absorption spectroscopy; and others. Good technical guidance for compliance with U.S. EPA's CLP requirements for inorganic analysis.
85-EPA-17 CLP Organic Protocol	This document prescribes standard protocol to be followed by laboratories performing organic chemical analysis under the U.S. EPA CLP. Exhibit D gives the specific analytical procedures to be used by the contractor, including instructions for sample preparation, gas chromatographic screening, mass spectrometric identification, and data evaluation. Good technical guidance for compliance with U.S. EPA's CLP requirements for organic analysis.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 5.3 provides guidance for specifying analytical procedures in a RCRA permit. Includes lists of Appendix VIII constituents which are unstable in water and for which there are no specific analytical methods available. Good technical guidance for this topic area.
83-EPA-7 Chem. Analysis Water/Wastes	Contains test procedures approved for water and waste monitoring under the SDWA and CWA NPDES program.

ANALYTICAL PROCEDURES (continued)

GUIDE	DESCRIPTION
83-EPA-7 (continued)	One of several optional technical guidance documents prescribed in 40 CFR 141.23(f). Good technical guidance for analysis of metals and inorganics.
82-EPA-3 Test Meth. Solid Waste SW-846	This document covers the determination of RCRA hazardous waste characteristics and approved methods for organic and inorganic analyses. Current technical guidance for regulatory compliance with RCRA. Good general technical guidance for analysis of solid waste and wastewater samples.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Discusses analytical methods to be used for leachate analysis and refers reader to American Public Health Association (APHA), ASTM, and 83-EPA-7 for additional analytical methods. Includes short discussion of the advantages and disadvantages of field testing and mobile laboratories. Some value as general technical guidance for this topic area.
75-EPA-1 Int. Rad. Meth. D.W.	Prescribes radiochemical procedures for determining radionuclide concentrations in drinking water. The nuclides addressed are those for which the U.S. EPA has established MCLs under the interim primary drinking water standards. Mandatory technical guidance for compliance with 40 CFR 141.25(a), unless an optional method is used.
73-EPA-1 HASL Procedure Manual	Contains comprehensive procedures for the analysis of radionuclides. Section A includes a general discussion of the fundamentals of radioactivity, particle counting, and counting statistics. Section B covers sampling techniques. Procedures for the field measurement of radionuclides are discussed in Section C. Section D covers radiochemical and radiometric analyses, and

ANALYTICAL PROCEDURES (continued)

GUIDE	DESCRIPTION
F3-EPA-1 (continued)	Section E presents detailed chemical procedures for an extensive list of radionuclides. One of several optional sources of technical guidance prescribed in 40 CFR 141.25(b). Good technical guidance in this topic area.
73-EPA-2 Anal. Reactor Solutions	This document presents 38 methods that have been found appropriate by the U.S. EPA for measuring radionuclides in coolant and wastewater at nuclear power stations. The authors recommend that, considering the various waste streams generated and the wide-ranging concentrations of radionuclides and chemical constituents, analytical samples may require additional treatment to effect desired decontamination. For each method, the principle of the method is given, followed by the required reagents, step-by-step procedures, calculations, and method of confirmation. Mandatory guidance for regulatory compliance with 40 CFR 141.25(b). Good technical guidance for analysis of radionuclides.
85-NRC-1 GW Contam. Uranium Mining	The section entitled Analytical Methods describes the analytical procedures used by researchers during their study of in situ uranium mining. General description only; specific methods not given. Some value as technical guidance for this topic area.
82-NRC-1 Disposal Low-Level Radioactive Waste	The appendix to this document describes tests for over 100 waste site characterization parameters, including physical and chemical properties and radioactivity. Discusses test methods, equipment requirements, and additional references. Good technical guidance for this topic area.

ANALYTICAL PROCEDURES (continued)

GUIDE	DESCRIPTION
81-USGS-1 GW Sample Collection Guide	Contains procedures for the preparation and field analysis of certain parameters during ground water sampling. Good technical guidance for this topic area.
80-USGS-1 GW Data Acquisition	Section 2.G.2 describes on-site measurements of unstable constituents. This discussion includes descriptions of methods and equipment for various tests such as pH, specific conductance, temperature, and dissolved oxygen. Some value as technical guidance for this topic area.
79-USGS-1 Inorganics in Water/Fluvial	Contains detailed procedures for the laboratory analysis of inorganic contaminants in water and fluvial sediment. Update and expansion of 1970 version of this document. One of several optional sources of technical guidance prescribed in 40 CFR 141.23(f). Good technical guidance for this topic area.
84-OTA-1 Protecting GW	Chapter 5 discusses detection of contaminants in ground water; outlines analytical methods for measuring organics, inorganics, radionuclides, and microorganisms; and discusses the limitations of some methods. Good general summary of analytical methods for various ground water contaminants.

NONGOVERNMENT REFERENCES	DESCRIPTION
APHA 1985	Contains widely used standardized test procedures for all types of pollutants, including organics, microbial contaminants, and radioactivity.

ANALYTICAL PROCEDURES (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
APHA 1985 (continued)	One of several optional sources of technical guidance prescribed in 40 CFR 141.23(f) and 141.25(a). Good general technical guidance for water quality monitoring.
ASTM 1978	This manual is a concise reference source on water, covering numerous subjects ranging from water supply principles and industrial wastewater treatment to the measurement of radioactivity. Chapter 11 discusses general procedures for measuring organic, inorganic, radiological, and bacteriological parameters, and refers to other sources for detailed analytical methods. Some value as general background information on water analysis. One of several optional technical guidances prescribed in 40 CFR 141.23(f).
Guswa 1984	General analytical techniques are reviewed on Pages 221 through 235; discussion includes the advantages and disadvantages of each analytical method. Good technical guidance for this topic area; written for technical personnel who are not familiar with modern analytical techniques.
IAEA 1981	Describes and discusses some procedures for analysis of inorganic chemicals, radionuclides, and microorganisms in water and sediment. Some value as technical guidance for this topic area.

LABORATORY QUALITY ASSURANCE

REGULATION	DESCRIPTION
NWPA	
10 CFR 60.151 and 60.152	Applicable to high-level radioactive repositories operated by the DOE and licensed by the NRC; requires DOE to implement a quality assurance (QA) program based on criteria of Appendix B of 10 CFR 50.

DOE ORDER	DESCRIPTION
5700.6A	States that DOE laboratories and contractors are expected to establish and maintain QA programs. Where available, national consensus QA standards are to be applied (as selected by the DOE cognizant program secretarial offices). For nuclear projects, American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) NQA-1 standards should be utilized to meet requirements of 10 CFR 50.

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Section 4.4.6 discusses the maintenance of a laboratory logbook for incoming samples, and Section 4.6.2 provides recommendations for a laboratory quality assurance/quality control (QA/QC) program. Some value as technical guidance for this topic area.
85-EPA-1 Pract. Guide for GW Samp.	Section 1 presents steps for establishing a laboratory quality control program and includes a list of sources of analytical error. Some value as technical guidance for this topic area.
85-EPA-16 CLP Inorganic Protocol	This document describes standard protocol to be followed by laboratories performing analysis of inorganic substances under the U.S. EPA Contract Laboratory Program (CLP). Exhibit E presents QA/QC procedures to be

LABORATORY QUALITY ASSURANCE (continued)

GUIDE	DESCRIPTION
85-EPA-16 (continued)	followed by contractors, including equipment calibration and verification, preparation blank analysis, duplicate sample analysis, and others. Refers reader to 79-EPA-3 (QC Water/Wastewater Labs) for additional information. Good technical guidance for compliance with U.S. EPA's CLP requirements for inorganic analysis.
85-EPA-17 CLP Organic Protocol	This document describes standard protocol to be followed by laboratories performing analysis of organic chemical analysis under the U.S. EPA CLP. Exhibit E presents general QA/QC considerations for contractors, including standard operating procedures, organization and personnel, facilities and equipment, and others. Specific QA/QC requirements include equipment calibration, reagent blank analysis, surrogate spike analysis, and others. Examples of laboratory evaluation checklists are provided. Good technical guidance for compliance with U.S. EPA's CLP requirements for organic analysis.
83-EPA-6 RCRA Permit Writ. Manual GW Prot.	Section 5.3.2 presents criteria for the evaluation of laboratories proposed by RCRA permit applicants. Refers to 79-EPA-3 for information on quality control in laboratories. Good general guidance for this topic area.
83-EPA-10 Int. Guide/ QA Plans	This document describes the elements of QA plans required for all U.S. EPA-related measurement or monitoring projects, including sampling procedures, sample custody, and analytical procedures.

LABORATORY QUALITY ASSURANCE (continued)

GUIDE	DESCRIPTION
83-EPA-10 (continued)	Required procedures for U.S. EPA project applicants but also useful as general guidance for this topic area.
79-EPA-3 QC Water/Wastewater Labs	Chapter 1 discusses the importance of quality control and following chapters address quality control of laboratory services, instrument selection, glassware, data handling, radiochemistry, and other topics. Good technical guidance for this topic area.
79-EPA-4 129 Priority Pollutants	Provides a comprehensive description of laboratory quality control procedures and analytical and extraction procedures for the analysis of pesticides and related compounds. Good technical guidance for this topic area. (Although pesticide analysis may not be directly relevant, most of the information presented can be applied to other types of analyses as well.)
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Section 7.9 briefly discusses the importance of laboratory quality control. Refers reader to 79-EPA-3. No technical or regulatory guidance for this topic area.
79-USGS-1 Inorganics in Water/ Fluvial	Contains a discussion of laboratory quality control, including accuracy of analysis, documentation of procedures, and basic laboratory requirements. Some value as general technical guidance for this topic area.
84-OTA-1 Protecting GW	The use of QA/QC programs to minimize uncertainties of analytical results is discussed in Chapter 5. Some value as general guidance for this topic area.

LABORATORY QUALITY ASSURANCE (continued)

RELEVANT STATE REGULATIONS

Wisconsin is one state which requires certification for commercial laboratories and registration of in-house laboratories which analyze samples from environmental monitoring programs. Laboratories required to be certified or registered must follow minimum criteria for test methodology, alternate methodologies, reference sample testing, quality control, and record maintenance. Certification and registration must be renewed annually.

REPORTING OF DATA

REGULATION	DESCRIPTION
AEA	
10 CFR 20.4 and 20.5	Prescribes standard units for the measurement of radioactivity at all facilities licensed by the NRC.
SDWA	
40 CFR 144.28(h)	Applicable to Underground Injection Control (UIC) programs administered by states. Specifies the applicable reporting requirements for the monitoring of injected fluids in Class I, II, and III underground injection wells.
40 CFR 146.13(c), 146.23(c), and 146.33(c)	Applicable to UIC programs administered by states. Specifies reporting requirements for Class I, II, and III injection wells, respectively.
RCRA	
40 CFR 264.98(d)	Requires RCRA-permitted land disposal facilities which have a detection monitoring program to express ground water quality data in a form appropriate for the statistical determination required under 40 CFR 264.97(h). (See Evaluation of Data.)
40 CFR 264.98(h)(ii)	Requires background values in a detection monitoring program to be expressed in a form appropriate for the statistical determination required under 40 CFR 264.97(h).
40 CFR 264.99(c)(3)	Requires RCRA-permitted land disposal facilities which have a compliance monitoring program to express background values in a form appropriate for the statistical determination required under 40 CFR 264.97(h).
40 CFR 264.99(d)	Requires RCRA permitted land disposal facilities which have a compliance monitoring program to express ground water quality data from each well at the compliance point in a form appropriate for the statistical determination required under 40 CFR 264.97(h).

REPORTING OF DATA (continued)

RCRA

40 CFR 265.94	Applicable to RCRA facilities operating under interim status regulations; requires certain procedures and frequencies for the reporting of ground water monitoring data to the U.S. EPA.

DOE ORDERS	DESCRIPTION
5484.1, Chapter III.4.b	Applicable to all DOE and DOE contractor operations. Describes contents and format of annual environmental monitoring report. (Form DOE F 5821.1, Annual Effluent Data Form.)
5484.1, Chapter III.4.c	Describes contents and format of annual environmental summary (applicable to those DOE operations which are exempt from Environmental Management Report).
5484.1, Chapter III.4.d	Prescribes units and format to be used for reporting data.
5484.1, Chapter III.5.d	General requirement that monitoring and reporting be adequate for preparation of annual radioactive release summaries.

GUIDE	DESCRIPTION
86-EPA-3 STORET	Chapter 3 of this document shows how the EPA's STORET data management system can be utilized to organize data for a RCRA ground water monitoring program. Good technical guidance for organization of monitoring data.
86-EPA-5 TEGD	Section 4.7 provides information on data reporting, including "less than" values, significant digits, missing values, "outliers," and proper units. Section 5.1 recommends the use of standardized data reporting sheets for reporting data as required by 40 CFR 265.94 and refers reader

REPORTING OF DATA (continued)

GUIDE	DESCRIPTION
86-EPA-5 (continued)	to the U.S. EPA memo of November 30, 1983, "Guidance on Implementation of Subpart F Requirements for Statistically Significant Increases in Indicator Parameter Values." Current regulatory guidance recommended for RCRA compliance. Good general technical guidance for this topic area.
84-EPA-2 Permit App. Guide HW Facilities	Section 9 provides guidance for RCRA permit applicants for complying with RCRA ground water monitoring requirements and includes example format sheets for the reporting of ground water data. Good technical guidance on reporting formats. Current regulatory guidance for RCRA interim status facilities.
76-EPA-3 Monit. GW: Data Mgt.	This document discusses the requirements of data management information systems for ground water quality monitoring programs and evaluates the existing federal systems of STORET, WATSTORE, and NAWDEX. Limited value as technical guidance for this topic area.

NONGOVERNMENT REFERENCES	DESCRIPTION
Everett 1980	Chapter IV covers ground water data management, presents formats for the handling of data, and describes the STORET, WATSTORE, and NAWDEX data management systems. Recommended approaches to data collection, communication, storage, processing, and retrieval are presented. The final section recommends specific changes to the existing STORET data systems. Good general technical guidance for data management.
Liggett 1985 ASTM STP867	This article recommends that laboratories include measurements on various blanks and calibration standards instead of reporting results as "none detected." For linear data

REPORTING OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Liggett 1985 (continued)	reduction, it suggests subtracting the background value from the response and reporting the result even if it is negative. Good current technical guidance for alternate methods for evaluating monitoring data.

EVALUATION OF DATA

REGULATION	DESCRIPTION
AEA	
40 CFR 192.32(a)(2)	Requires that a detection monitoring program (40 CFR 264.98) be established at designated uranium or thorium mill tailing depository sites. (See RCRA 40 CFR 264.98(g) below.)
PHSA	
40 CFR 141.23 and 141.24	Applicable to public water systems; specifies the methods for determining exceedance of the MCLs for inorganic and organic chemicals.
40 CFR 141.25(d) and 141.26	Applicable to public water systems; specifies the methods for determining compliance with MCLs for radioactive contaminants.
RCRA	
40 CFR 264.97(h)	Applicable to RCRA-permitted land disposal facilities; specifies procedures for using the Behrens-Fisher Student's t-test in determining compliance with ground water quality standards and gives requirements for alternate statistical methods (refers to Part 264, Appendix IV - Tests for Significance).
40 CFR 264.98(g)	Requires that RCRA facilities with detection monitoring programs follow the Student's t-test or an equivalent alternate statistical procedure prescribed in 40 CFR 264.97(h).
40 CFR 264.99(h)	Requires that RCRA facilities with compliance monitoring programs follow the Student's t-test or an equivalent alternate statistical procedure prescribed in 40 CFR 264.97(h).
40 CFR 265.93(b) and (c)	Applicable to RCRA land disposal facilities operating under interim status standards; specifies that statistical procedures be followed to determine significant increases over background levels (refers to 40 CFR 265, Appendix IV).

EVALUATION OF DATA (continued)

REGULATION	DESCRIPTION
CERCLA	
40 CFR 300.68	Applicable to U.S. EPA "Superfund" sites; presents factors for evaluating alternatives for remedial actions based on gathered data.

GUIDE	DESCRIPTION
86-EPA-5 TEGD	Chapter 5 addresses the statistical analysis of detection monitoring data as required by RCRA regulations. Section 5.2 gives recommendations for the selection of t-tests and their use and discusses the components of variability in background wells and the handling of false positive results. Information is also presented regarding the manipulation of nonnormally distributed data points. Section 5.3 briefly discusses the statistical analysis of background data. Section 5.4 gives guidance on statistical comparisons of background data with downgradient data and subsequent background sampling data and explains when assessment monitoring must be recommended. Section 6.6 contains a brief discussion of the use of computer models in assessing contaminant migration. Section 6.10 describes procedures for evaluating data collected in the assessment monitoring phase, including the proper listing of data, statistical tabulation, and data simplification. Section 6.11 presents procedures for determining the rate of migration. Current technical guidance for RCRA regulatory compliance. Good technical guidance for this topic area.
85-EPA-2 Rem. Act. HW Sites	Volume 3 of this document provides detailed guidance on the use of numerical models of subsurface controls for remedial actions. Subsurface modeling parameters are divided into two categories: (1) flow-related parameters, including dispersivity, porosity, bulk density, sorption, and degradation rate and (2) transport-related parameters.

EVALUATION OF DATA (continued)

GUIDE	DESCRIPTION
85-EPA-2 (continued)	Good technical guidance for subsurface modeling.
85-EPA-3 GW Monit/Stat. Proc. HW Facilities	This report describes statistical procedures for designing ground water monitoring programs and statistical analyses of monitoring data for determining the presence of contamination. The recommended long-term monitoring technique is to use comparisons of each well over time, combined with a graphical procedure for determining whether the current average concentration is above or below a set of control limits established for that well. The report presents a step-by-step procedure for using the graphical techniques, tolerance limits, tests for trends, and control charts to determine leakage at hazardous waste facilities. Good technical guidance for use of alternate statistical tests at RCRA facilities; may also be useful for other facilities.
85-EPA-11 RCRA GW Mont. Guide	Section 3.1.5 compares the statistical evaluations of detection monitoring data required under 40 CFR 264 and 265, and Section 3.2.4 discusses statistical evaluations of compliance monitoring data. Current regulatory guidance for RCRA compliance. No technical guidance for this topic area.
84-EPA-4 Rem. Investigations Guide	Chapter 3 provides guidance on developing sampling plans for remedial investigations at CERCLA sites, including the evaluation of existing data, and Chapter 4 covers the management of data obtained during this investigation. Good guidance for regulatory compliance with CERCLA. Good technical guidance for this topic area.

EVALUATION OF DATA (continued)

GUIDE	DESCRIPTION
83-EPA-3 Stat. Proc. GW Modeling	This report compares three versions of the Student's t-test statistical procedures required for RCRA interim status facilities. It was found that the Cochran's test and equal-variance t-test have high false positive rates and the test based on quarterly averages of analytical replicates may have too large a false negative rate. Until the U.S. EPA revises the present statistical tests, the report recommends using the Cochran's test and the average replicate test in tandem, and those data sets failing both tests should be given highest priority. Good technical guidance for statistical analyses of ground water monitoring data.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapter 6 provides a detailed discussion of the factors that must be considered when reviewing proposed statistical procedures. Sections 8.2.2, 8.3.5, 9.2.1, 9.4.5, and 10.4.4 provide guidance in specifying statistical procedures appropriate for the various RCRA ground water monitoring programs. Good technical guidance for this topic area; partially superseded by TEGD for RCRA compliance.
83-EPA-6 Risk Assmnt. RCRA Landfill	Section 3 discusses exposure assessments for hazardous waste landfills, including data requirements and the development of ground water, runoff, and air dispersion models. Good technical guidance for this topic area.
79-EPA-4 129 Priority Pollutants	Presents detailed information on the aquatic transport and fate of pollutants (identified in Section 307(a)(1) of the 1977 CWA) which may be useful in evaluating or modeling ground water contamination.

EVALUATION OF DATA (continued)

GUIDE	DESCRIPTION
76-EPA-4 (continued)	Good technical guidance for determining significance of contamination.
78-EPA-1 Contam. Potential Surface Impound.	The SIA evaluation system separates two phases of impoundment evaluation: (1) the rating of the ground water contamination potential itself and (2) the rating of the relative magnitude of potential endangerment to current users of underground drinking water sources. Several specific hydrogeologic and spatial factors are given numerical values, resulting in an overall ranking of impoundment sites. Some value as guidance for evaluating monitoring needs at surface impoundments.
85-DOE-1 Model Code Selection Vol. 1 and 2	This document was designed to assist ground water modelers in selecting transport codes for assessing the performance of shallow land burial facilities for low-level radioactive waste. Volume 1 presents nine key steps for developing successful simulation models and presents numerous recommendations such as the use of proven codes and the enlistment of the aid of professional modelers. Volume 2 contains four special test case examples using the guidelines established in Volume 1. Although the document addresses radioactive waste burial sites, much of the modeling information would apply to other types of land disposal facilities as well. Good technical guidance for the use of computer models.
83-DOE-1 Effluent Radiological Meas. DOE	Section 7 details methods of data analysis and statistical treatment to detect trends and resolve any anomalies. Good technical guidance for this topic area.
85-NRC-2 Radionuclide Migration GW	Describes radionuclide migration in ground water observed at several low-level radioactive waste disposal sites. Presents

EVALUATION OF DATA (continued)

GUIDE	DESCRIPTION
85-NRC-2 (continued)	results of studies performed to determine the behavior of the radionuclides in ground water and describes attempts to model observed behavior. Good technical guidance for the evaluation of radionuclide data.
82-NRC-1 Disposal Low-Level Radioactive Waste	The appendix of this document discusses the evaluation of ground water systems by using cross sections and contour maps. Limited technical guidance for this topic area.
82-NRC-2 GW Flow Unsaturated Zone	Appendices D and E contain detailed summaries of selected modeling codes which include specific descriptions of each of the codes, assumptions, simplifications, major variables, applicability, limitations, validity, and completeness. Good technical guidance for computer modeling of flow in the unsaturated zone.

NONGOVERNMENT REFERENCES	DESCRIPTION
Bachmat 1980	This report discusses all types of ground water models and their applications in the management of water resource systems. Attention is focused on the kinds of models that have been developed and their specific and general roles in management. The availability of the models and the information, data, and technical expertise needed for their operation and use are also discussed. The appendix contains various tables describing the 250 models covered by the survey. Some value as technical guidance for ground water modeling.

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Bouwer 1978	Chapter 7 presents an analysis of data for underground flow systems. The simpler systems are analyzed mathematically, while more complex flow systems are described using physical, analog, or numerical models. Good overall technical guidance for this topic area.
Campbell 1985 GW Monit. Rev.	This paper describes a system consisting of a checklist of criteria, grouped into four major categories, which can be applied to laboratory or field measurements. Two tables summarize the data evaluation systems used for field and laboratory data. Good general technical guidance for this topic area.
Cheremisinoff 1984	This book was prepared as a guide in the development, use, and limitations of ground water models for predicting movement of contaminated leachate plumes located near solid waste disposal facilities. Good technical guidance for use of ground water models.
Fried 1975	The book stresses mathematical modeling. Several case histories of aquifer pollution are given and a broad overview of mathematical ground water modeling is provided. Good technical guidance for ground water modeling.
Gliet 1985 Env. Sci. Tech	This paper deals with analyzing data sets which contain a reasonable percentage of "below detection limit" entries. Several possible estimators are proposed and tested via simulation. "Fill in with expected values" was shown to be the best estimator.

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Gliet 1985 (continued)	Good technical guidance for statistical approaches for analyzing small normal data sets with detection limits.
Greenhouse 1985 GW Monit. Rev.	This paper discusses two broad geophysical applications, monitoring and mapping, both of which identify contaminated ground water because of the enhanced electrical conductivity associated with abnormally high concentrations of dissolved solids. A fictitious landfill is used to illustrate design possibilities and to provide perceptions which may be of interest when considering geophysical monitoring. Limited technical guidance on geophysical evaluation methods.
Guswa 1984	Part III presents a methodology for rapid assessment of potential ground water contaminants under emergency response conditions. Several steps used in evaluating ground water contamination data are listed, and detailed assessments of contamination problems are given. Good technical guidance for assessment of data in potential ground water contamination cases involving emergency response.
Javandel 1984	Reviews the characteristics, uses, and limitations of analytical, semianalytical, and numerical methods for assessing and predicting the extent and implications of subsurface contamination. Limited to methods for modeling nonreactive transport. Includes several examples of applications, and provides computer code listings for specific analytical and semianalytical methods discussed in the text. Intended as a practical guide to the selection of mathematical models and the application of the simpler (i.e., nonnumerical) techniques.

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Javandel 1984 (continued)	Good current technical guidance on techniques for evaluating the consequences of ground water contamination and need for corrective action in situations where monitoring data indicate that contaminants are present.
Liggett 1985 ASTM STP867	This paper proposes that ground water monitoring designs for evaluation of ground water data incorporate separation of the contamination of interest from the background, use of independent replicates to assess sampling and measurement error, and the reporting of intermediate laboratory results where analytical results would otherwise indicate none detected. Such an integrated design is proposed for monitoring total organic halides. This paper also illustrates some difficult design problems that involve nonnormality and nonlinear measurement methods. Provides current guidance on an alternative method for designing ground water systems for data evaluations.
Marino 1982	The text covers the evaluation of data from several ground water contamination problems. Among the problems covered are control of shallow water table, seepage under dams and other hydraulic structures, flow to wells, evaluation of aquifer tests, construction and maintenance of wells, and exploration for ground water. Good technical guidance for this topic area.
Matthess 1982	This book contains extensive information on the chemical properties of ground water, particularly the causes of natural variability in ground water chemistry (e.g., seasonal changes, relationships between rock type and water chemistry). Review of the relevant literature includes numerous references to European as well as North American literature.

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Mathess 1982 (continued)	Good technical reference for use in interpreting water quality data; especially helpful for understanding natural influences on water chemistry and possible causes of apparent anomalies in background water quality.
McBean 1985 GW Monit. Rev.	For RCRA upgradient monitoring wells, this article recommends the use of multiple samples from a single well as opposed to replicate analyses on one sample to overcome the shortcoming of including only the analytical error and not the sampling error in the variance estimate. Current guidance on alternative statistical procedures for evaluating ground water data.
Miller 1984 NWWA/API Proc.	This article recommends an alternate version of the Student's t-test to correct "false positive" results in the U.S. EPA's procedure. The alternate version involves averaging and treating the four replicate analyses on each sample as a single result prior to calculating the Behrens-Fisher t-statistic. Current guidance on alternative statistical procedures for evaluating ground water data.
National Research Council 1984	The text presents various papers dealing with ground water contamination. One paper which presented information on the Love Canal Area, New York, deals with ground water flow modeling. Limited technical guidance for using models to evaluate ground water data.
Page 1984	This report describes the results of research conducted in New Jersey on the prediction of the presence of contaminated ground water based on certain municipal characteristics. Several models were developed containing such

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Page 1984 (continued)	factors as population income and race, extent of industrial zoning, and age of industrial facilities. The models were able to successfully predict 75 to 85 % of the "contaminated" or "not contaminated" municipalities. Although these models may be useful to government planners, they are not intended for predicting the rate and extent of ground water contamination from waste disposal units. Limited value as technical guidance for this topic area.
Ross 1984 NWWA/API Proc.	This article recommends that, for an accurate statistical test, a RCRA monitoring program be designed to eliminate the influence of natural spatial variability, to secure independent samples, and to select appropriate statistical techniques. For small sample sizes, for nonnormal distributions where variance in two sample sets are significantly different, and where remedial action is influencing the data at some of the wells, the Mann-Whitney U-test is recommended for statistical analysis. Current guidance on alternative statistical procedures for evaluating ground water data.
Splitstone 1986 HMCRI Proc.	This paper illustrates the statistical evaluation of analytical data from true replicate sampling of ground water (by multiple sampling of a well rather than by the U.S. EPA's method of multiple analysis of a single sample). Controls the risk of "false positive" test results to a small specified probability. Provides current technical guidance on an alternative statistical model to the statistical test prescribed by the U.S. EPA for RCRA monitoring networks.

EVALUATION OF DATA (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Todd 1980	Chapter 10 discusses the evaluation of data through the use of various ground water modeling techniques. Various models are described and several sketches are presented. Good technical guidance for ground water modeling.
UNESCO 1982	The text discusses different ground water models and their applicability to different geologic settings. Many case histories are presented and, through these various studies, conclusions are derived for several models. Good technical guidance for ground water modeling in various geologic conditions.
Wang 1981	This text describes evaluation of ground water data through the use of modeling. The objective throughout the book is to solve ground water flow problems with the digital computer. Examples of programs can be run on a FORTRAN compiler. Good technical guidance for ground water flow modeling.

RELEVANT STATE REGULATIONS

Most states follow the U.S. EPA procedure for requiring that background ground water quality be determined on the basis of data from the first four calendar quarters of monitoring in the upgradient well in the RCRA monitoring network.

West Virginia is one state where background values of ground water at hazardous waste facilities are redetermined each quarter for use in statistical evaluation of ground water data.

Wisconsin requires utilization of the following statistical procedures which will provide a 95% level of confidence for determining if a ground water standard has been attained or exceeded: Student's t-test, temporal or spatial trend analysis, or other scientifically valid statistical analyses. As part of its review of the quality of

EVALUATION OF DATA (continued)

sampling data, the Wisconsin Department of Natural Resources (DNR) evaluates the sampling procedures, precision and accuracy of the analytical test, size of data set, and the quality control and quality assurance procedures used. If there is insufficient information to evaluate the reliability of the sampling data, the Wisconsin DNR can require additional samples or other changes in monitoring programs.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS

REGULATION	DESCRIPTION
AEA	
10 CFR 20.106	Requires that concentrations of radioactive material released to unrestricted areas from NRC-licensed facilities not exceed limits specified in Appendix B, Table II, of 10 CFR 20 and prescribes procedures for obtaining revised limits.
10 CFR 61.41	Prescribes maximum concentrations of radioactive materials which may be released to the environment from facilities licensed by the NRC for the land disposal of radioactive wastes.
40 CFR 192.02	Establishes maximum radon release rates from inactive uranium processing sites and establishes a time period for control of the site.
40 CFR 192.12	Establishes maximum residual radium concentrations for remedial actions undertaken at inactive uranium processing sites and specifies levels for radon decay and gamma radiation.
40 CFR 192.20(a)(3)	Provides general guidance for determining the need for remedial or protective action in cases where contaminated ground water is present at inactive uranium or thorium processing facilities subject to remedial action by DOE. Decision is to take into account state and federal water quality criteria for anticipated or existing uses of the water as well as other factors.
40 CFR 192.32(a)	Requires that the management of uranium mill tailings and processing wastes at NRC-licensed sites conform with the ground water protection standard of 40 CFR 264.92, with the addition of parameters specified in Table A of 40 CFR 192.32, and provides for the establishment of alternate concentration limits (ACLs).

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

REGULATION	DESCRIPTION
40 CFR 192.33	Requires that a corrective action program (per 40 CFR 264.100) be put into operation if the standards of 40 CFR 192.32 are exceeded.
NWPA	
10 CFR 60.113	Prescribes certain performance criteria for closed high-level radioactive waste disposal sites and authorizes the NRC to specify radionuclide release rates on a case-by-case basis.
40 CFR 191.16	Prescribes maximum concentrations of certain radionuclides which may be released into the ground water from high-level radioactive waste disposal sites.
PHSA	
40 CFR 141.11, 141.12, and 141.13	Establishes MCLs in community water systems for inorganic and organic chemicals and turbidity.
40 CFR 141.14	Establishes MCLs in community and noncommunity water systems for coliform bacteria.
40 CFR 141.15	Establishes MCLs in community water systems for radium-226, radium-228, and gross alpha radioactivity.
40 CFR 141.16	Establishes maximum annual radioactive dose equivalents to the body from community water systems and specifies that dose equivalents shall be calculated from Table A in 40 CFR 141 and the methods in the National Bureau of Standards (NBS) Handbook 69 (63-DOC-1).
SDWA	
40 CFR 143.3	Establishes recommended secondary MCLs in public water systems for 12 inorganic contaminants.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

REGULATION	DESCRIPTION
40 CFR 144.12(a)	Prohibits underground injection activities from causing a violation of any primary drinking water regulation under 40 CFR 142 or otherwise adversely affecting the health of persons.
40 CFR 146.4	Establishes criteria for exempting aquifers as underground sources of drinking water.
40 CFR 241.204	General requirement of nonhazardous solid waste disposal sites to conform with water quality standards and provide protection of ground and surface waters used as drinking water supplies.
40 CFR 257.3, 257.4	Applicable to nonhazardous solid waste disposal facilities (with certain exceptions); prohibits facilities from contaminating underground drinking water sources and prescribes MCLs for certain parameters (refers to 40 CFR 257, Appendix I).
40 CFR 264.92	Applicable to RCRA-permitted land disposal facilities; requires that concentrations of hazardous constituents in the uppermost aquifer beyond the compliance point not exceed concentration limits set in the permit.
40 CFR 264.94(a)	States that the RCRA permit will specify concentration limits in the ground water for the hazardous constituents established in 40 CFR 264.93 and constituent concentrations may not exceed permit background levels or limits in Table 1 of 40 CFR 264.94 (if background level is less than that indicated in Table 1) or an ACL.
40 CFR 264.94(b)	Provides for the establishment of ACLs. Rationale for determining ACLs to be based on 19 factors to protect human health and the environment. Optional waiver to MCLs, applicable to RCRA monitoring.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

REGULATION	DESCRIPTION
40 CFR 264.99(a),(b), and (c)	States that the RCRA permit will specify concentration limits of hazardous constituents for facilities in a compliance monitoring program.
40 CFR 265.92(b) and (c)	Applicable to RCRA land disposal facilities operating under interim status standards. Specifies certain parameters which must be analyzed and requires the establishment of background concentrations for these parameters which will be used as basis of statistical comparison to determine ground water contamination.

GUIDE	DESCRIPTION
85-EPA-4 ACL Guide	Describes in detail the procedures for RCRA permit applicants to establish an ACL as a ground water protection standard (instead of using background levels or maximum concentration limits). Contains a chapter on each of the ACL request criteria listed in 40 CFR 264.94(b). Good current regulatory and technical guidance for compliance with RCRA (40 CFR 264.94).
85-EPA-6 CERCLA Feasibility Studies	Section 4.3 discusses how the U.S. EPA Ground Water Protection Strategy affects the degree of remediation at CERCLA sites. Section 4.7 presents a table of federal requirements applicable at CERCLA sites, including those affecting ground water, and Section 5.4 compares federal water quality standards for various hazardous constituents. Current regulatory guidance for compliance with CERCLA. Limited technical guidance for this topic area.
85-EPA-8 State GW Prog. Summaries Vol. 1	Chapter II and Appendix A summarize various ground water protection activities which have been incorporated into state ground water programs. Activities discussed include

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

GUIDE	DESCRIPTION
85-EPA-8 (continued)	ground water protection policies, quality standards, ground water programs, control programs, and interagency agreements. Appendix A contains tables which describe for each state and U.S. territory ground water classification systems, ground water quality standards, agency responsibilities, and assessment activities. Good summary of the basic elements of state ground water protection programs.
85-EPA-11 RCRA GW Mont. Guide	Section 3.2.2 briefly addresses options for establishing background concentrations and concentration limits. Current regulatory guidance for RCRA compliance. No technical guidance for this topic area.
85-EPA-14 State/Territory GW Class	This document describes ground water classification systems utilized by several states to determine appropriate levels of protection and cleanup of ground water supplies. Good general background information on state ground water standards.
84-EPA-3 Permit Writ. Guide HW Facilities	Section 3.3.1 provides guidance on the appropriateness of ACL demonstrations, depending on ground water vulnerability. Good general guidance on ground water vulnerability and its relationship to hazardous waste facility siting; minor modifications to this document anticipated by the end of 1986.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapter 7 provides guidance establishing the individual components of the RCRA ground water protection standard, which includes setting concentration limits and ACLs.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

GUIDE	DESCRIPTION
83-EPA-4 (continued)	Good technical and regulatory guidance for compliance with RCRA. Partially superseded by a more recent document (85-EPA-6) for specific guidance on ACLs.
83-DOE-1 Effluent Radiological Meas. DOE	Section 2.1 discusses the basic radiation standards and regulatory requirements for the DOE. Good technical guidance for this topic area.
63-DOC-1 Max. Body Burdens	This document describes the measurement of radiation exposure to industrial workers and residential areas and contains tables giving maximum permissible doses of various radionuclides to the body organs. Mandatory technical guidance for compliance with 40 CFR 141.16(b).

NONGOVERNMENT REFERENCES	DESCRIPTION
Applied Management Sciences 1985	Report describes state ground water protection programs and regulations, including ground water classification systems and numerical standards. Good current reference on state standards.
Mandel 1981	Section 9.6 presents a table which provides an abbreviated list of standards for the chemical composition of drinking water. In addition, a commonly used criterion for the soil-water relationship is defined. The section is brief and provides only limited technical guidance concerning drinking water standards.
Miller 1980	Page 507 has two tables relevant to ground water standards: the U.S. Public Health Service Chemical Standards of Drinking Water,

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

NONGOVERNMENT REFERENCES	DESCRIPTION
Miller 1980 (continued)	1962, and the U.S. EPA National Interim Primary Drinking Water Standards, December 1975. Limited value as technical or regulatory guidance.

RELEVANT STATE REGULATIONS

Contaminants covered by ground water quality standards vary from state to state. For example, New York regulates more than 80 chemicals. Florida has set minimum water quality criteria to prohibit discharges of carcinogens, teratogens, and toxins into all ground water except confined aquifers not expected to be used for drinking water. In California, ground water quality standards are set by the nine regional water quality control boards.

Wisconsin has established two sets of ground water quality standards for 36 substances of health concern and 10 substances of welfare concern. The two sets of standards include an enforcement standard which defines when a violation has occurred and a preventive action limit which serves as a design code for facilities/management practices and as a trigger for remedial actions. The preventive action limit is set at 10 to 50% of the enforcement standard, depending on the level of health concern. Preventive action limits apply everywhere ground water is monitored, while enforcement standards apply at any point of ground water use, any point beyond the property boundary of a regulated facility, and any point outside the design management zone for regulated activities.

Many states have adopted or proposed nondegradation, limited degradation, or differential policies to protect ground water from all contaminant sources. Missouri is planning to issue a ground water protection plan based on a nondegradation standard. About half the states, however, have adopted or proposed some type of ground water classification system to establish general levels of protection, often based on TDS or chloride concentrations. The number of ground water classes varies from two in states such as Hawaii, Maine, New Mexico, Idaho, and Vermont to seven in Wyoming. The criteria for classification may include types of uses, degree of treatment, salinity-quality levels, vulnerability to contamination, environmental importance of aquifers, and availability of other water supplies. Connecticut, for example, classifies ground water in a four-tiered class system based on its purity, need for treatment before use as a drinking water, and extent and nature of contamination. State supreme courts have upheld these standards against attempted law suits by corporate dischargers.

4. SUMMATION OF REGULATORY AND RECOMMENDED TECHNICAL GUIDANCE FOR GROUND WATER MONITORING

4.1 INTRODUCTION

This section summarizes the most relevant compendium entries (from Section 3) for each of the technical topics of ground water monitoring. A summation section is provided for each technical topic. The summation section (1) briefly reviews applicable regulations, (2) recommends sources of specific guidance on complying with particular regulations, and (3) recommends sources of technical guidance on the aspects of ground water monitoring covered by the technical topic. Table 2 presents an overview of the documents listed in the summation and the technical topics for which they are recommended.

Each technical topic is introduced with a topic description, which defines the items included in the topic and gives a brief explanation of the applicability of the topic to ground water monitoring.

The next part of each summation section contains a listing of applicable regulations from the Code of Federal Regulations (CFR) followed by a list of applicable DOE Orders. These regulations and orders should be regarded as mandatory for the regulated ground water monitoring activities to which they apply. Those regulations in the compendium which do not contain specific requirements are not included in the summation. Resource Conservation and Recovery Act (RCRA) interim regulations that are less stringent than corresponding final RCRA regulations are also not included.

The identification of recommended guidance is divided into guidance on regulatory compliance and technical guidance. "Recommendations for Regulatory Compliance" identifies documents which provide current guidance on complying with regulatory requirements. In many cases, this is guidance issued by the regulatory agency to expand upon its regulations. These documents thus appear to present regulatory agency positions on how to comply with regulatory requirements. Where possible, this part of the summation section also suggests a general strategy for regulatory compliance or provides additional information on use of the recommended regulatory guidance. Many regulatory requirements exist, however, for which there are no corresponding guidance documents to assist facility owners in complying with the requirements.

"Recommended Technical Guidance" identifies technical materials from the compendium that offer current state-of-the-art guidance relevant to the technical topic and that are recommended for use in aspects of ground water monitoring covered by the technical topic. Where several documents reviewed in the compendium present similar information, only the most recent or comprehensive document is included in the summation. Also included are those documents that provide information not found in more recent or comprehensive documents. Descriptions in this part of the summation identify those portions of a document that are pertinent to the technical topic or that are particularly recommended, and they may indicate the specific activities

Table 2. Technical topic and reference codes matrix[a]

REFERENCE CODE \ TECHNICAL TOPIC	PURPOSE AND NEED TO MONITOR	MONITORING SYSTEM DESIGN	DRILLING METHODS	WELL DATA	WELL DESIGN AND CONS./DEV.	HEALTH AND SAFETY	MONITORING PARAMETERS	SAMPLE COLLECTION AND FREQUENCY	SAMPLE PRES. AND HANDLING	SAMPLING QA AND CHAIN-OF-CUSTODY	ANALYTICAL PROCEDURES	LABORATORY QA	REPORTING OF DATA	EVALUATION OF DATA	GROUND WATER STANDARDS AND ACL's
86-EPA-2	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86-EPA-3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
86-EPA-4	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
86-EPA-5	-	1,2	-	3.5	3.2 to 3.6	-	-	4, 6	4.3	4.4, 4.6	4.5	-	4.7, 5.1	5, 6	-
85-EPA-1	-	-	-	2	2	-	2	2	2	1, 2	-	-	-	-	-
85-EPA-2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
85-EPA-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.
85-EPA-5	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85-EPA-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4, 5
85-EPA-8	1, App.A	-	-	-	-	-	-	-	-	-	-	-	-	-	II, App.A
85-EPA-11	Ent.	2	-	-	-	-	3.1, 5.4	-	-	-		-		-	3.2
85-EPA-16	-	-	-	-	-	-	Exh. C	-	-	-	Exh. D	Exh. E	-	-	-
85-EPA-17	-	-	-	-	-	-	Exh. C	-	-	-	Exh. D	Exh. E	-	-	-
84-EPA-2	-	-	-	-	-	-	9.6, 9.7	-	-	-	-	-	9	-	-
84-EPA-3	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84-EPA-4	7	-	-	-	-	-	-	-	-	-	-	-	-	3, 4	-
84-EPA-5	-	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-
84-EPA-7	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-	
83-EPA-1	-	-	-	-	4,5,7,8	-	-	6, 7	-	-	-	-	-	-	-
83-EPA-4	-	-	-	-	-	-	-	-	-	5.4	-	-	-	-	7
83-EPA-6	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
83-EPA-7	-	-	-	-	-	-	-	-	Ent.	-	Ent.	-	-	-	-
83-EPA-10	-	-	-	-	-	-	-	-	-	Ent.	-	Ent.	-	-	-
82-EPA-1	-	-	-	-	-	-	-	9.6	-	-	-	-	-	-	-
82-EPA-3	-	-	-	-	-	-	-	1.1	7,8,9	1.3	Ent.	-	-	-	-
81-EPA-1	-	-	5, App.A	-	-	-	-	6	-	-	-	-	-	-	-
81-EPA-2	-	-	-	-	-	11, App.G	-	-	-	-	-	-	-	-	-
80-EPA-5	-	-	-	-	-	-	-	-	VI-4	-	-	-	-	-	-
79-EPA-3	-	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-
79-EPA-4	-	-	-	-	-	-	-	-	-	-	-	Ent.	-	Ent.	-
77-EPA-1	-	-	-	-	3,4,5	-	-	-	-	-	-	-	-	-	-
77-EPA-2	-	1.7, 2	-	-	-	-	4.1 to 4.5	6	-	-	-	-	-	-	-
75-EPA-1	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
73-EPA-1	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
73-EPA-2	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-

83-DOE-1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
DOE HP Manuals	-	-	-	-	-	Ent.	-	-	Ent.	-	-	-	-	-	-
5480.1A	-	-	-	-	-	XI	-	-	-	-	-	-	-	-	-
5480.2	I, II	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5484.1	III	-	-	-	-	IV	-	-	-	-	-	-	III	-	-
5700.6A	-	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-
5820.2	I, II, III	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12088 Exec. Ord.	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84-NIOSH-1	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
83-NIOSH-1	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
85-NRC-2	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
83-NRC-1	-	II, III, IV	-	-	-	-	-	-	-	-	-	-	-	-	-
82-NRC-2	-	-	-	-	-	-	-	-	-	-	-	-	-	App.D, E	-
82-NRC-1	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
82-NRC-3	-	-	-	-	-	-	II, App.E	-	-	-	-	-	-	-	-
78-NRC-1	-	-	-	-	-	-	-	-	4.3	-	-	-	-	-	-
79-USGS-1	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
84-GTA-1	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63-DOC-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.
ACGIH 1985 Clothing	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
ACGIH 1985 TLVs	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
AIHA 1982	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
AMS 1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.
APHA 1985	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
ASTM 1978	-	-	-	-	-	-	-	-	-	-	Ent.	-	-	-	-
ASTM 1981	-	Ent.	-	-	-	-	-	-	-	-	-	-	-	-	-
Birkner n.d.	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
Cheremisinoff 1984	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
Driscoll 1986	-	16, 21	10	-	-	-	-	-	-	-	-	-	-	-	-
Everett 1980	-	I,III,V,VI	-	-	-	-	-	-	-	-	-	-	-	-	-
Everett 1984	-	7, 8	-	-	-	-	-	5	-	-	-	-	-	-	-
Gliet 1985	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
Guswa 1984	-	-	-	-	-	-	-	-	-	p. 24	-	-	-	Part III	-
Javandel 1984	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
Levine 1985	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
Morrison 1983	-	-	-	-	-	-	-	Ent.	-	-	-	-	-	-	-
Shapiro 1972	-	-	-	-	-	Ent.	-	-	-	-	-	-	-	-	-
Todd 1980	-	-	-	6	-	-	-	-	-	-	-	-	-	10	-
UNESCO 1982	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
Campbell 1985	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-
Liggett 1985	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	Ent.	-
Splitstone 1986	-	-	-	-	-	-	-	-	-	-	-	-	-	Ent.	-

[a] NOTES:

- Reference codes are keyed to the Section 3.9 Reference List.
- "Ent." indicates that the Entire document generally addresses the technical topic.
- Numbers or Roman numerals alone refer to applicable chapters or sections of the document.
- "App." indicates Appendix.
- "Exh." indicates Exhibit.

for which a document is recommended or the special reasons for a document's inclusion in the summation section. Except where noted otherwise, the items identified in this part of the summation are applicable to all types of monitoring that DOE may encounter [e.g., inorganic, organic, and radioactive constituents; "mixed wastes"; polychlorinated biphenyl (PCB) monitoring], even though some items have been written for a narrower purpose.

Following the recommended guidance is a brief statement on noteworthy state regulations that differ substantially from federal regulations and which should be considered when performing activities relevant to the technical topic.

Citations to the guidance items in this section are presented in the reference list at the conclusion of the technical topic summations.

In addition to the recommended guides in each of the technical topics, persons with ground water monitoring responsibilities should have access to some good general references on ground water science and engineering. The following books are highly recommended for this purpose:

Driscoll, F. G., 1986, Ground Water and Wells, 2nd ed., Johnson Division, St. Paul, Minnesota.

Freeze, R. A. and J. A. Cherry, 1979, Groundwater, Prentice-Hall, Englewood Cliffs, New Jersey.

4.2 TOPICAL SUMMATIONS

PURPOSE AND NEED TO MONITOR GROUND WATER

TOPIC DESCRIPTION

This topic includes regulations that specifically require monitoring or that require hydrogeologic data as part of an environmental evaluation or site characterization and technical considerations related to the need for monitoring or assessment of ground water quality, regardless of regulatory requirements.

Ground water monitoring may be necessary to ascertain the quality of ground water at the point of use (e.g., monitoring of public water supplies), to investigate causes of any observed water quality problems, or to measure the impacts on ground water from waste disposal or material storage facilities. Nearly every on-land waste disposal facility (landfill, disposal impoundment, waste pile, etc.) is required to have some form of ground water monitoring. Some regulations (e.g., RCRA 40 CFR 264 and 265) contain specific monitoring well requirements while others (e.g., SDWA 40 CFR 241) contain general recommendations for the protection of drinking water supplies.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 40	U.S. Nuclear Regulatory Commission (NRC) licensed uranium and thorium mill sites (not directly applicable to DOE).
10 CFR 60.21 and 60.140 to 60.142	NRC-licensed high-level radioactive waste repositories.
10 CFR 61.12 and 61.53	Low-level radioactive waste disposal sites.
40 CFR 191.14	High-level radioactive waste repositories operated by DOE.
40 CFR 192.20 and 192.32	Inactive uranium and thorium processing sites (UMTRAP) (under DOE).
40 CFR 141 and 143.3	Primary and secondary drinking water standards.
40 CFR 144 and 146	Hazardous waste underground injection wells (UIC Program).
40 CFR 241.204	Land disposal sites for nonhazardous solid waste.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

Applicable Regulations (continued)

40 CFR 257.3, 257.4	All solid waste disposal facilities.
40 CFR 264.90 and 264.302	RCRA-permitted land disposal facilities.
40 CFR 265.117	RCRA land disposal facilities closed under interim status.
40 CFR 300.68(f)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites with releases (or threat of releases) of hazardous substances.
40 CFR 761.75(b)	Toxic Substances Control Act (TSCA) land disposal sites for PCB materials.

Applicable DOE and Executive Orders

5480.2 Chap. I, II	Hazardous and Radioactive Mixed Waste Management (December 13, 1982).
5484.1 Chap. III	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (February 24, 1981).
5820.2 Chap. I, II, III	Radioactive Waste Management (February 6, 1984).
Executive Order 12088	Federal Compliance with Pollution Control Standards (President Jimmy Carter, October 13, 1978)

RECOMMENDED TECHNICAL GUIDANCE

Recommendations for Regulatory and DOE and Executive Order Compliance:

85-EPA-11 RCRA GW Monit. Guide	Helpful for compliance with monitoring requirements of RCRA 40 CFR 264 and 265.
84-EPA-3 Permit Writ. Guide HW Facilities	Section 2.3.1 provides information on obtaining exemption to RCRA ground water monitoring requirements by locating a facility in a zero recharge zone.

PURPOSE AND NEED TO MONITOR GROUND WATER (continued)

RECOMMENDED TECHNICAL GUIDANCE (continued)

84-EPA-4 Rem. Investigations Guides	Chapter 7 provides guidance for determining the need for ground water monitoring at CERCLA sites.
86-EPA-2 GW Task Force Report	Good review of problems with RCRA's ground water program and insight to revisions which the U.S. EPA may be taking.
85-EPA-5 GW Monit. Strat.	Represents current U.S. EPA ground water monitoring strategy.
85-EPA-8 State GW Prog. Summaries Vol. 1	Chapter 1 and Appendix A describe sources of ground water contamination and provide information on state monitoring programs and policies.
84-EPA-7 Rem. Response HW Sites	Helpful information on previous cleanup activities at uncontrolled hazardous waste sites, including actions taken to determine the impact of remedial activities on ground water.
84-OTA-1 Protecting GW	Excellent description of the nation's status regarding ground water protection; includes summary of laws and statutes.

RELEVANT STATE REGULATIONS

The states have wide-ranging ground water monitoring requirements, from monitoring road construction sites (New Jersey) and agricultural contamination (Iowa) to monitoring of unsaturated zones (California). State regulations should be considered prior to the start of any ground water-related activity as some states have regulations substantially stricter than those at the federal level.

MONITORING SYSTEM DESIGN

TOPIC DESCRIPTION

This topic includes the determination of the appropriate number and location of wells or other sampling devices required for the monitoring activity. It includes guidance on preliminary hydrogeologic investigation of a site.

Design requirements may differ somewhat, depending on the type of potential contaminant source being monitored and applicable regulations, but all systems involve the determination of background or baseline data and the detection of downgradient contamination. Systems may be designed to monitor the closest drinking water aquifer and/or to detect leakage from the facility into the unsaturated zone before the contaminants are able to enter the aquifer. Extensive investigation of site hydrogeology often must be undertaken as part of the process of designing an appropriate monitoring system.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 192.20	Inactive uranium/thorium processing sites (UMTRAP).
10 CFR 61.53	Low-level radioactive waste land disposal sites.
40 CFR 241.204	Nonhazardous solid waste facilities.
40 CFR 264.97	RCRA-permitted land disposal facilities.
40 CFR 761.75(b)	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-5 TEGD; 85-EPA-11 RCRA GW Monit. Guide	Chapters 1 and 2 of the Technical Enforcement Guidance Document (TEGD) and Chapter 2 of the RCRA Ground Water Monitoring Guide represent current U.S. EPA guidance on monitoring system design for compliance with RCRA 40 CFR 264 and 265.

MONITORING SYSTEM DESIGN (continued)

Recommended Technical Guidance

86-EPA-5 TEGD	Chapters 1 and 2 give the most current guidance for designing monitoring systems at hazardous waste sites; also applicable to nonhazardous waste sites.
84-EPA-5 Soil Properties SW-925	Detailed current methods for determining hydrogeological characteristics of a site.
83-NRC-1 Subsurface Monit. Low-Level Radioactive Waste	Parts II, III, and IV provide specific criteria for monitoring radionuclide migration and designing trench well systems.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Section 1.7 and Chapter 2 provide comprehensive factors for designing well systems for nonhazardous solid waste facilities, although guidance is also useful for other monitoring applications.
ASTM 1981	Good technical guidance on soil permeability as it relates to ground water contaminant transport. Document is limited in scope concerning other factors affecting contaminant transport.
Driscoll 1986	Good technical guidance for evaluating pumping test data.
Everett 1980	Detailed 15-step procedure for designing monitoring systems at solid waste treatment and disposal facilities. Good technical guidance for monitoring underground injection wells.
Everett 1984	Comprehensive technical guidance for unsaturated zone monitoring system design.

RELEVANT STATE REGULATIONS

California hazardous waste regulations require monitoring of "soil-pore liquids," and New Jersey hazardous waste regulations specify monitoring of "ground water" versus U.S. EPA's RCRA requirements to monitor the uppermost aquifer.

DRILLING METHODS

TOPIC DESCRIPTION

This topic includes the determination of the appropriate drilling method for the construction of monitoring wells.

The selection of appropriate drilling methods depends on the required depth of the borehole, the stratigraphy of the site, and the nature of the substances to be monitored. For example, some drilling methods are unsuitable for certain rock types, some are inappropriate for the installation of monitoring wells because they lead to vertical transport of contaminated material, and some methods use drilling fluids that may interfere with analysis for metals and volatile organics.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

Federal regulations do not require the use of specific drilling methods.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

Not applicable.

Recommended Technical Guidance

81-EPA-1 GW Quality Sampl.	Section 5.B provides a very comprehensive discussion of well drilling methods. Appendix A of the report contains information, not found in other documents, on the effects of the various drilling methods and well construction materials on the chemical properties of the water sample.
Driscoll 1986	Chapter 10 provides details for various well drilling methods and lists the advantages of each. This report also details the relative performance of the different methods in various types of geologic formations.

DRILLING METHODS (continued)

RELEVANT STATE REGULATIONS

Some states require drilling permits and the use of approved drillers (e.g., Florida, for hazardous waste monitoring wells; Missouri, for any type of well).

WELL DATA

TOPIC DESCRIPTION

This topic includes the proper handling and recording of boring logs, well elevations, aquifer permeability, and geology. (The determination of ground water elevations prior to sampling is covered under Sample Collection and Frequency.)

Well data, such as water levels during drilling and geological/hydraulic properties of materials encountered in drilling, are important in determining or confirming the characterization of the site. This information should be retained to aid in interpreting subsequent monitoring results.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

Federal regulations do not require specific well data to be obtained.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

Not applicable.

Recommended Technical Guidance

86-EPA-5 TEGD	Section 3.5 provides a detailed list of data to be documented during well construction.
85-EPA-1 Pract. Guide for GW Samp.	Document provides current technical information regarding drilling techniques for various types of geologic settings and excellent descriptions of hydraulic conductivity testing.
Todd 1980	Chapter 6 provides good information regarding variations in ground water levels.

WELL DATA (continued)

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified regarding this topic.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT

TOPIC DESCRIPTION

This topic includes selection of the well diameter, screen length, casing material compatibility, purging methods, and related items. It also includes procedures for proper well abandonment.

Monitoring wells must be designed and constructed to permit access to collect samples that are representative of water in the unit of interest, to measure water levels, to minimize chemical interactions between water samples and the well and the atmosphere, and to prevent cross-contamination between the monitored zone and surface waters or other ground water zones. In many cases, for example, well diameter is dictated by the need to allow for the placement of submerged pumps for sample collection. Some of the recent guidance places a great deal of emphasis on selection of chemically inert materials for monitoring well and sampling equipment. Well development (e.g., by surging or jetting) is usually required after construction to correct clogging and compaction of the formation which occurs during drilling, thereby allowing for better flow into the well.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 264.97(c)	RCRA-permitted land disposal facilities.
40 CFR 761.75(b)(c)(ii)	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-5 TEGD	Represents the U.S. EPA position on RCRA compliance. However, there may be some latitude with respect to some specifications in the TEGD. 83-EPA-1 (Guide to Material Selection, ISWS No. 327) should be consulted for technical guidance on possible exceptions to recommendations in the TEGD.

WELL DESIGN AND CONSTRUCTION/DEVELOPMENT (continued)

Recommended Technical Guidance

85-EPA-1 Pract. Guide for GW Sampling	Section 2 contains comprehensive information on monitoring well design and includes sections on well development for both high and low hydraulic conductivity wells and example calculations for determining required volumes for well purging.
83-EPA-1 Guide to Matl. Selection ISWS No. 327	Chapters 4, 5, 7, and 8 give very comprehensive information on the design and construction of monitoring wells, especially with regard to the effects of various pollutants on the construction materials.
77-EPA-1 Abandoned Wells GW	Provides recommendations for avoiding ground water contamination caused by improper well abandonment.

RELEVANT STATE REGULATIONS

Some states (e.g., Missouri and Pennsylvania) have established requirements for well casings and protective installations. Most states have regulations which, to some degree, address well abandonment, with Texas and Louisiana having the most stringent requirements.

HEALTH AND SAFETY PROCEDURES

TOPIC DESCRIPTION

This topic includes personal exposure regulations and selection of respiratory equipment and protective clothing. Also includes prevention of physical injuries from drilling equipment and heat stress during monitoring activities.

A variety of regulatory standards exist for the protection of ground water monitoring personnel from exposure to hazardous and radioactive contaminants. Numerous guidelines and recommendations exist for the selection of respiratory equipment, protective clothing, and other general safety equipment. Risks at monitoring sites include exposure to contaminants as well as physical injury from equipment operations. Heat stress resulting from the use of restrictive protective clothing and physical exertion is also a major concern at hazardous waste sites.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 20	Radiation Protection Standards for NRC-licensed facilities.
10 CFR 60.31	DOE-operated high-level waste repositories.
40 CFR 241.211	Nonhazardous solid waste facilities.
40 CFR 300.57	CERCLA "Superfund" sites.
29 CFR 1900 to 1999	Occupational Safety and Health Administration (OSHA) standards for all facilities.

Applicable DOE Orders

5480.1A Chap. XI	For radiation protection at DOE facilities; reports on radiation exposure to be prepared per DOE Order 5484.1.

RECOMMENDED GUIDANCE

Recommendations for Regulatory and DOE Order Compliance

DOE Facility HP Manuals	Guidance for complying with DOE Orders regarding radiation protection; required during any monitoring activity at a DOE site.

HEALTH AND SAFETY PROCEDURES (continued)

Recommendations for Regulatory and DOE Order Compliance (continued)

Birkner n.d.	Guidance for establishing a respiratory protection program in compliance with OSHA.

Recommended Technical Guidance

81-EPA-2 NEIC GW Investigations	Chapter 11 and Appendix G discuss health and safety considerations at hazardous waste sites and present numerous references for additional health hazard information.
84-NIOSH-1 Personal Protective Equipment	Useful information on calculating tolerance to heat stress.
83-NIOSH-1 Drilling Safety	Guidance on injury prevention during drilling operations.
ACGIH 1985 Clothing	Selection and use of personal protective garments.
ACGIH 1985 TLVs	Evaluation of risk from exposure to airborne substances.
AIHA 1982	Field manual covering safety procedures for heat stress, ionizing radiation, respiratory protection, and noise protection.
Birkner n.d.	Selection of respiratory equipment.
Levine 1985	Use of standard protective equipment and unique information on body temperature monitoring.
Shapiro 1972	Determination of risk at radioactive sites includes dose calculations and radiation measurement techniques. For selection of protective clothing at radioactive sites, ACGIH 1985 (Clothing) should be consulted.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified regarding this topic.

MONITORING PARAMETERS

TOPIC DESCRIPTION

This topic includes the monitoring parameters specified by certain regulations and the selection of appropriate parameters to be monitored if none are specified by regulations.

Regulations under laws such as RCRA and TSCA contain specific requirements for the monitoring of certain parameters, while other laws such as CERCLA allow for site-specific selection of monitoring parameters. The number of monitored parameters should be adequate to fulfill the intent of the monitoring system design while minimizing sampling and analysis costs. Often, monitoring plans specify several indicator parameters to be monitored, followed by a more extensive list of parameters should the indicators show possible contamination.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 192.32(a)(2)	Uranium by-product processing sites (based on 40 CFR 264 requirements).
40 CFR 264.93, 264.98, 264.99, and 264.100	Detection and compliance monitoring programs and corrective action programs at RCRA-permitted land disposal facilities.
40 CFR 265.92 and 265.93	RCRA interim status land disposal facilities.
40 CFR 300.68(f)	CERCLA "Superfund" sites.
40 CFR 761.75(b)(iii)	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

85-EPA-11 RCRA GW Mont. Guide	Chapters 3.1.2 and 5.4.2 address parameter requirements for compliance with RCRA 40 CFR 264.93 to 264.100, which also apply to 40 CFR 193.32(a)(2).

MONITORING PARAMETERS (continued)

Recommendations for Regulatory Compliance (continued)

84-EPA-2 Permit App. Guide HW Facilities	Sections 9.6.3.1 and 9.7.3.2 address parameter requirements for compliance with RCRA 40 CFR 264.93 to 264.100, which also apply to 40 CFR 192.32(a)(2).

Recommended Technical Guidance

85-EPA-1 Pract. Guide for GW Samp.	Section 2 is applicable to hazardous or nonhazardous chemical waste disposal facilities.
85-EPA-16 CLP Inorganic Protocol	Exhibit C identifies inorganic parameters to be analyzed under U.S. EPA's Contract Laboratory Program (CLP).
85-EPA-17 CLP Organic Protocol	Exhibit C identifies organic parameters to be analyzed under U.S. EPA's CLP.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Sections 4.1 to 4.5 are applicable to conventional solid waste disposal facilities.
82-NRC-3 Characterizing Sites Low-Level Radioactive Wastes	Part II and Appendix E are applicable to ground water monitoring at radioactive waste sites.

RELEVANT STATE REGULATIONS

Some states require additional indicator parameters [e.g., New Jersey requires total dissolved solids (TDS)] at hazardous waste sites, and many states are conducting pesticide monitoring programs.

SAMPLE COLLECTION AND FREQUENCY

TOPIC DESCRIPTION

This topic includes the strategy for developing sampling plans, techniques for sample collection, recommended or required frequency of sampling, selection of sampling equipment, procedures for well evacuation, and procedures for decontaminating sampling equipment between wells.

Ground water samples may be acquired from monitoring wells, lysimeters, or other sampling devices in the vadose zone, water supply wells, or natural springs. Steps in water sampling normally include measurement of water level (in monitoring wells), evacuation of the well or spring hole to remove any stagnant water, acquisition of a water sample, and decontamination of any portable sampling equipment. Ground water monitoring may also involve sampling of stream sediments. Numerous guidance documents exist concerning the proper ground water sampling technique, which varies with the type of analysis to be performed and the medium from which samples are taken. For example, in selecting a sampling device for use in a monitoring well, one must consider whether a particular pump or device is capable of sampling at the depth of interest, whether chemical interactions could occur between the sample and the sampling device, whether use of a submersible pump or airlift sampler might alter sample pH and redox characteristics, and whether the sample might contain volatile organic compounds (VOCs) that would be lost from the sample unless a syringe or similar sampling device is used to prevent degassing. Optimal sampling frequency is sometimes determined by a combination of hydrogeologic and practical considerations, but some regulations (e.g., the RCRA hazardous waste rules) specify minimum sampling frequency.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 141.23, 141.26, and 141.27	Community water systems using ground water sources.
40 CFR 136.3	National Pollutant Discharge Elimination System (NPDES) permitted discharges.
40 CFR 264.97 to 264.99	RCRA-permitted land disposal facilities.
40 CFR 265.92(a) and (c)	RCRA interim status land disposal facilities.
40 CFR 761.75(b)(6)	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

SAMPLE COLLECTION AND FREQUENCY (continued)

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-5 TEGD	Sections 4.1 and 4.2 present general sampling protocols and procedures; Sections 6.7 and 6.9 are specific to RCRA Assessment Monitoring Programs.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Recommended in 40 CFR 265.92 for sampling and analysis procedures at hazardous waste sites.

Recommended Technical Guidance

85-EPA-1 Pract. Guide for GW Samp.	Current technical guidance for many aspects of ground water sampling.
83-EPA-1 Guide to Selection ISWS-327	Sections 6 and 7 show how to determine proper evacuation rates and impact on analytical results of materials used in casing and sampling devices.
82-EPA-1 Sample Preservation Water/Wastewater	Section 9.6.1 contains helpful information on selection of sampling equipment.
82-EPA-3 Test Meth. Solid Waste SW-846	Section 1.1 contains excellent information for calculating number of random samples needed to characterize a waste.
81-EPA-1 GW Quality Samp.	Section 6 contains good general guidance, with additional helpful information on obtaining samples of organic constituents.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	Recommended in 40 CFR 265.92 for sampling and analysis procedures; applicable to hazardous and nonhazardous disposal sites.
Everett 1984	Comprehensive review of sampling techniques for the unsaturated zone.

SAMPLE COLLECTION AND FREQUENCY (continued)

Recommended Technical Guidance (continued)

Morrison 1983	Good technical guidance for selecting and using equipment to monitor the unsaturated zone. Long list of additional references.

RELEVANT STATE REGULATIONS

Some states require more frequent monitoring. For example, New Jersey requires monthly monitoring at RCRA and industrial waste facilities.

SAMPLE PRESERVATION AND HANDLING

TOPIC DESCRIPTION

This topic includes the selection of containers, preservative methods, and handling procedures.

The proper preservation and handling of ground water samples is necessary to obtain accurate analytical results. Sample preservation techniques, which typically include refrigeration and/or addition of acids, are generally designated in those documents which specify analytical procedures. Also, there often are maximum sample holding times, particular containers, or other special handling requirements associated with individual analytical procedures. Field filtration of samples is required for some types of analyses. Samples containing radioactivity may require special handling in accordance with DOE orders on transfer and handling of radioactive materials.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 264.97	RCRA-permitted land disposal facilities.
40 CFR 265.92	RCRA interim status land disposal facilities.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-5 TEGD	Current guidance for developing RCRA sampling and analysis plans.
DOE Facility HP Manuals	Guidance for complying with DOE Orders regarding radiation protection; site-specific requirements for handling radioactive samples.
85-EPA-1 Pract. Guide for GW Samp.	Section 2 gives details on field filtration.

SAMPLE PRESERVATION AND HANDLING (continued)

Recommended Technical Guidance

82-EPA-3 Test Meth. Solid Waste SW-846	Sections 7, 8, and 9 present sample preservation and handling methods approved for RCRA monitoring.
83-EPA-7 Chem. Analysis Water/Wastes	Describes sample preservation methods approved for NPDES and UIC monitoring.
80-EPA-5 Enf. Consid. HW Disp. Sites by Contractors	Section VI-4 presents useful procedures for handling of organic parameters.
78-NRC-1 GW Elements Uranium Mining	Table 4.3 contains information especially useful for handling of inorganic parameters.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified regarding this topic.

SAMPLING QUALITY ASSURANCE AND CHAIN OF CUSTODY

TOPIC DESCRIPTION

This topic includes the preparation of quality assurance (QA) plans, chain-of-custody procedures, and maintenance of field logbooks.

Error in ground water data is generally considered to be due more to sampling error in the field than to analytical error in the laboratory. This underscores the importance of including QA measures in any sampling plan. Chain-of-custody procedures provide additional control over samples and are mandatory for some types of monitoring (e.g., at RCRA hazardous waste facilities or for monitoring data which may be cited in court).

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 50 Appendix B	NRC-licensed power plants and fuel reprocessing plants.
10 CFR 60.151 and 60.152	High-level radioactive waste repositories (requires QA program based on 10 CFR 50, Appendix B).
40 CFR 264.97	RCRA-permitted land disposal facilities.
40 CFR 265.92	RCRA interim status land disposal facilities.
40 CFR 761.75 and 761.180	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommended Regulatory Compliance

83-EPA-10 Int. Guide/ QA Plans	Preparation of QA plans required for all U.S. EPA-sponsored monitoring projects.

SAMPLING QUALITY ASSURANCE AND CHAIN-OF-CUSTODY (continued)

Recommended Technical Guidance

85-EPA-1 Pract. Guide for GW Samp.	Sections 1 and 2 provide a discussion of sampling accuracy and precision and use of field blanks and standards. Applicable to any type of monitoring system.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Section 5.4 provides chain-of-custody procedure for RCRA permits. May be applied to other systems as well.
82-EPA-3 Test Meth. Solid Waste SW-846	Section 1.3 provides good examples of chain-of-custody forms.
Guswa 1984	Some general information on preparing quality assurance/quality control (QA/QC) plans.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified regarding this topic.

ANALYTICAL PROCEDURES

TOPIC DESCRIPTION

This topic includes the required and recommended analytical procedures for the field and laboratory.

Procedures for the analysis of ground water samples are described in several standard reference sources. In addition to chemical analysis, it is often useful to conduct physical analyses of water and soil properties.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 136.3	NPDES parameters and testing at PCB land disposal sites.
40 CFR 141.23 to 141.28	Public water systems using ground water.
40 CFR 144.28(g)	Underground injection wells (UIC program).
40 CFR 264.97	RCRA-permitted land disposal facilities.
40 CFR 265.92	RCRA interim status land disposal facilities.
40 CFR 761.75(b)(c)	TSCA land disposal sites for PCB materials.

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-4 Appendix VIII Guide	Current interim guidance on RCRA ground water analysis requirements. Issued for use by the U.S. EPA in reviewing land-based hazardous waste facility permit applications.
83-EPA-7 Chem. Analysis Water/Wastes	Approved test procedures for NPDES and UIC programs.

ANALYTICAL PROCEDURES (continued)

Recommendations for Regulatory Compliance (continued)

82-EPA-3 Test Method Solid Waste SW-846	Approved procedures for determining hazardous characteristics of wastewater streams as defined by RCRA (but contain no specific methods for ground water analysis).
75-EPA-1 Int. Rad. Meth. DW, and APHA 1985	Procedures for compliance with 40 CFR 141.25(a) regarding radioactivity monitoring.
73-EPA-2 Anal. Reactor Solutions, and 73-EPA-1 HASL Procedure Manual	Procedures for compliance with 40 CFR 141.25(b) regarding radioactivity monitoring.
APHA 1985, ASTM 1978, and 79-USGS-1 Inorganics in Water/Fluvial	Procedures for compliance with 40 CFR 141.23(f) regarding organic analysis.

Recommended Technical Guidance

86-EPA-5 TEGD	Helpful information for preparation of sampling and analysis plans.
85-EPA-16 CLP Inorganic Protocol	Exhibit D prescribes analytical procedures for inorganic parameters under U.S. EPA's Contract Laboratory Program.
85-EPA-17 CLP Organic Protocol	Exhibit D prescribes analytical procedures for organic parameters under U.S. EPA's Contract Laboratory Program.
83-EPA-7 Chem. Analysis Water/Wastes	Widely used procedures, especially for inorganic substances.
82-NRC-1 Disposal Low-Level Radioactive Waste	Procedures for determining numerous chemical and physical properties, including radioactivity.

ANALYTICAL PROCEDURES (continued)

Recommendations for Regulatory Compliance (continued)

79-USGS-1 Inorganics in Water/Fluvial	Especially useful for inorganics in river sediment.
APHA 1985	Widely used standard methods for general water and wastewater analyses.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified for this topic.

LABORATORY QUALITY ASSURANCE

TOPIC DESCRIPTION

This topic includes quality assurance/quality control (QA/QC) plans for laboratories.

Laboratory QA/QC programs are necessary to obtain repeatable and accurate analytical results. The implementation of laboratory quality control programs is required for laboratories used in DOE activities.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 50, Appendix B	NRC licensing requirements.
10 CFR 60.151 and 60.152	High-level waste sites operated by DOE (refers to 10 CFR 50).

Applicable DOE Orders

DOE ORDER 5700.6A	Prescribes use of American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) NQA-1 standards for compliance with 10 CFR 50.

RECOMMENDED GUIDANCE

Recommendations for Regulatory and DOE Order Compliance

83-EPA-10 Int. Guide/QA Plans	Recommended guidance for compliance with U.S. EPA policy which requires that each monitoring project have a written and approved QA plan.

Recommended Technical Guidance

85-EPA-16 CLP Inorganic Protocol	Exhibit E presents QA/QC procedures for laboratories under the U.S. EPA's Contract Laboratory Program.
85-EPA-17 CLP Organic Protocol	Exhibit E presents QA/QC procedures for laboratories under the U.S. EPA's Contract Laboratory Program.

LABORATORY QUALITY ASSURANCE (continued)

Recommended Technical Guidance (continued)

79-EPA-3 QC Water/Wastewater Labs	General laboratory quality control criteria, with helpful checklist in Appendix A.
79-EPA-4 129 Priority Pollutants	Contains very detailed quality control procedures for instrument operations and analyses of pesticides but also covers other parameters such as PCBs.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified regarding this topic.

REPORTING OF DATA

TOPIC DESCRIPTION

This topic includes recommended and required data format and data management systems.

Ground water monitoring data should be reported in a manner that will allow quick review of the data, comparison with applicable standards, and ease in performing evaluations of the data. Although specific formats are not prescribed, some guidance documents contain examples of recommended format sheets.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 20.4 and 20.5	All NRC-licensed facilities.
40 CFR 144.28 and 146.13, 146.23, and 146.33	Underground injection wells (UIC program).
40 CFR 264.98 and 264.99	RCRA-permitted land disposal facilities.
40 CFR 265.94	RCRA interim status land disposal facilities.

Applicable DOE Orders:

5484.1 Chapter III.4 and 5	All DOE and DOE contractor operations.

RECOMMENDED GUIDANCE

Recommendations for Regulatory and DOE Order Compliance

86-EPA-5 TEGD	Guidance for accurate reporting of ground water data at hazardous waste facilities.
84-EPA-2 Permit App. Guide HW Facilities	Guidance for permit applicants regarding reporting format for interim status ground water monitoring data at hazardous waste facilities.

REPORTING OF DATA (continued)

Recommended Technical Guidance

86-EPA-3 STORET	Technical guidance for using STORET to organize RCRA ground water monitoring data.
86-EPA-5 TEGD	Technical guidance for laboratory reporting and for presenting ground water analytical data in technical reports.
Liggett 1985 ASTM STP 867	Technical guidance for alternative laboratory reporting of "none detected" analytical data.

RELEVANT STATE REGULATIONS

No noteworthy state regulations identified for this topic.

EVALUATION OF DATA

TOPIC DESCRIPTION

This topic includes required statistical analysis and methods for the modeling of ground water contaminant migration.

Evaluation of data obtained in ground water monitoring may be aimed at determining whether changes are occurring in ground water, assessing compliance with standards, predicting future changes in ground water quality, or evaluating the potential effectiveness of remedial action or control measures. Statistical comparisons are often necessary to assess compliance with standards or to determine whether contaminant levels are increasing above background levels, and some regulations (e.g., the RCRA hazardous waste rules) specify statistical tests to be performed by the facility owner or operator. Generally, however, requirements for evaluating ground water data are absent or vague. Numerous mathematical models exist for predicting or evaluating ground water behavior; these may be useful in explaining observed conditions, predicting future changes in ground water quality, and evaluating potential remedial action measures. Texts and other materials on the fundamentals of ground water hydrology and hydrochemistry are often helpful in the qualitative and quantitative evaluation of monitoring data.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

40 CFR 192.32(a)(2)	Surface impoundments at uranium by-product material disposal sites.
40 CFR 141.23 to 141.26	Community water systems using ground water sources.
40 CFR 264.97 to 264.99	RCRA-permitted land disposal facilities.
40 CFR 265.93	RCRA interim status land disposal facilities.
40 CFR 300.68	CERCLA "Superfund" sites.

Applicable DOE Orders

None identified.

EVALUATION OF DATA (continued)

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

86-EPA-5 TEGD	Current regulatory guidance for evaluation of RCRA ground water monitoring data.
84-EPA-4 Rem. Investigations Guide	Guidance for regulatory compliance concerning data evaluation and management at CERCLA sites.

Recommended Technical Guidance

86-EPA-5 TEGD; Splitstone 1986 HMCRI Proc.; Liggett 1985 ASTM STP867	Current guidance for statistical analysis of RCRA ground water monitoring data. Splitstone (1986) and Liggett (1985) present alternative methods for designing ground water systems for data evaluation to control the risk of "false positive" test results.
83-EPA-6 Risk Assmnt. RCRA Landfill	Technical guidance on data requirements and model development for exposure assessments of hazardous waste landfills.
79-EPA-4 129 Priority Pollutants	Source of information on aquatic transport and fate of 129 priority pollutants. Useful for evaluating or modeling ground water contamination.
85-NRC-2 Radionuclide Migration GW; 83-DOE-1 Effluent Radiological Meas. DOE	Good guidance for radiological data evaluation. Mobility and adsorption behavior of radionuclides are covered in 85-NRC-2. Methods of data analysis and statistical treatment of radiological measurements are covered in 83-DOE-1.

EVALUATION OF DATA (continued)

Recommended Technical Guidance (continued)

82-NRC-2 GW Flow Unsaturated Zone; 85-EPA-2 Rem. Act. HW Sites; UNESCO 1982; Todd 1980; Cheremisinoff 1984	Good technical guidance for ground water modeling. Computer modeling of flow in the unsaturated zone is discussed in 82-NRC-2. 85-EPA-2 provides detailed guidance on numerical modeling of subsurface controls for remedial actions using flow-related and transport parameters. Chapter 10 of Todd (1980) describes models useful for evaluation of ground water data. UNESCO (1982) provides technical guidance for ground water model selection in different geologic settings. Cheremisinoff (1984) is a good source of technical guidance for development, use, and limitations of ground water models to predict contaminated leachate plume movement.
Campbell 1985 GW Monit. Rev.	General guidance for setting up systems for evaluating quality of ground water monitoring data.
Gliet 1985 Env. Sci. Tech.	Guidance for handling of data sets with numerous "below detection limit" entries.
Guswa 1984	Technical guidance for assessment of ground water data under emergency response conditions.
Javandel 1984	Source of technical guidance on selecting mathematical methods for evaluating the consequences of ground water contamination and/or the need for corrective action. If mathematical modeling must be done, however, this handbook will generally be insufficient as guidance for model application.

RELEVANT STATE REGULATIONS

The majority of states follow the federal regulations for evaluation of RCRA ground water monitoring data. One exception is West Virginia, where background values of ground water at hazardous waste facilities are redetermined each quarter for comparison with downgradient values.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS

TOPIC DESCRIPTION

This topic includes maximum contaminant levels (MCLs), drinking water standards and other prescribed concentration limits, and procedures for establishing alternate concentration limits (ACLs).

Although no federal ground water concentration standards exist per se, various regulations prescribe maximum exposure concentrations, drinking water standards, and MCLs for certain parameters. In many cases, the question of "how clean is clean?" is negotiated between the facility owner and government agency. Several states, and even some localities, have established specific ground water quality standards. RCRA regulations prescribe procedures for the optional establishment of ACLs where facilities violate existing standards or background levels.

APPLICABLE REGULATIONS AND ORDERS

Applicable Regulations

10 CFR 20.106	Radioactive releases to unrestricted areas from NRC-licensed facilities.
10 CFR 61.41	NRC-licensed low-level and radioactive waste land disposal facilities.
40 CFR 192	Inactive uranium and thorium processing sites (UMTRAP) and uranium mill tailings disposal sites.
10 CFR 60.113	Closed high-level radioactive waste disposal sites.
40 CFR 191.16	High-level radioactive waste disposal sites.
40 CFR 141.11 to 141.16	Underground sources of drinking water for community water systems.
40 CFR 144 and 146	Underground injection of hazardous waste (UIC program).
40 CFR 241.204 and 257.3-4	Nonhazardous solid waste facilities.
40 CFR 264.92, 264.94 and 264.99	RCRA-permitted land disposal facilities.
40 CFR 265.92	RCRA interim status land disposal facilities.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

Applicable DOE Orders

None identified.

RECOMMENDED GUIDANCE

Recommendations for Regulatory Compliance

85-EPA-4 ACL Guide	Guidance for establishing ACLs under RCRA (40 CFR 264.94(b)).
85-EPA-6 CERCLA Feasibility Studies	Sections 4 and 5 provide guidance on CERCLA remedial actions and ground water.
85-EPA-11 RCRA GW Mont. Guide	Section 3.2.2 provides guidance for establishing concentration limits for RCRA compliance.
63-DOC-1 Max. Body Burdens	Mandatory technical guidance for compliance with 40 CFR 141.16(b).

Recommended Technical Guidance

85-EPA-4 ACL Guide	Very helpful guidance for establishing ACLs under RCRA.
85-EPA-8 State GW Prog. Summaries Vol. 1	Provides detailed information on state ground water programs and protection standards.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Chapter 7 provides excellent guidance on establishing ground water protection standards, directed to RCRA permit writers.
Applied Management Sciences 1985	Good source of information on state ground water protection programs and standards.

GROUND WATER STANDARDS AND ALTERNATE CONCENTRATION LIMITS (continued)

RELEVANT STATE REGULATIONS

Many states have adopted ground water classification systems and specific ground water standards for various parameters. Some states (e.g., West Virginia) prohibit degradation beyond background parameter levels.

4.3 SUMMATION REFERENCES

CODE	TITLE
U.S. ENVIRONMENTAL PROTECTION AGENCY	
86-EPA-3 STORET	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1986, "Ground Water Data Management with STORET," EPA/600/M-86/007, U.S. EPA, Washington, D.C.
86-EPA-4 Appendix VIII Guide	U.S. Environmental Protection Agency, 1986, "Guidance on Issuing Permits to Facilities Required to Analyze Ground Water for Appendix VIII Constituents," U.S. EPA, Washington, D.C.
86-EPA-5 TEGD	U.S. Environmental Protection Agency, Office of Waste Programs Enforcement, 1986, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document," U.S. EPA, Washington, D.C.
85-EPA-1 Pract. Guide for GW Samp.	Barcelona, M. J., et al. (Illinois State Water Survey), 1985, "Practical Guide for Ground Water Sampling," EPA/600/2-85/104, U.S. EPA, Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, Ada, Oklahoma.
85-EPA-2 Rem. Act. HW Sites	Boutwell, S. H., et al. (Anderson-Nichols & Co., Inc.), 1985, "Modeling Remedial Actions at Uncontrolled Hazardous Waste Sites," EPA/540/2-85/001, U.S. EPA, Office of Solid Waste and Emergency Response, Washington, D.C.
85-EPA-4 ACL Guide	U.S. Environmental Protection Agency, Office of Solid Waste, 1985, "Alternate Concentration Limit Guidance Based on 264.94(b) Criteria," U.S. EPA, Washington, D.C.
85-EPA-5 GW Monit. Strat.	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Ground Water Monitoring Strategy," U.S. EPA, Washington, D.C.
85-EPA-6 CERCLA Feasibility Studies	U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1985, "Guidance on Feasibility Studies under CERCLA," EPA/540/G-85/003, U.S. EPA, Washington, D.C.
85-EPA-8 State GW Prog. Summaries Vol. 1	U.S. Environmental Protection Agency, Office of Ground Water Protection, 1985, "Overview of State Ground Water Program Summaries," Vol. 1, U.S. EPA, Washington, D.C.

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85-EPA-12 TEGD	U.S. Environmental Protection Agency, Office of Waste Programs Enforcement, 1985, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document (Draft)," U.S. EPA, Washington, D.C.
85-EPA-16 CLP Inorganic Protocol	U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, 1985, "Chemical Analytical Services or Multi-Media Multi-Concentration Metals and Inorganics," WA85-J839, U.S. EPA, Las Vegas, Nevada.
85-EPA-17 CLP Organic Protocol	U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, 1985, "Organic Protocol," WA85-J178, U.S. EPA, Las Vegas, Nevada.
84-EPA-2 Permit App. Guide HW Facilities	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities (Final Draft)," EPA/530/SW-84/004, U.S. EPA, Washington, D.C.
84-EPA-3 Permit Writ. Guide HW Facilities	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Permit Writers' Guidance Manual for Hazardous Waste Land Storage and Disposal Facilities, Phase I: Criteria for Location Acceptability and Existing Applicable Regulations (Final Draft)," U.S. EPA, Washington, D.C.
84-EPA-4 Rem. Investigations Guide	U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, 1984, "Remedial Investigations Guidance Document," U.S. EPA, Cincinnati, Ohio.
84-EPA-5 Soil Properties SW-925	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1984, "Soil Properties, Classification, and Hydraulic Conductivity Testing (Draft)," SW-925, U.S. EPA, Washington, D.C.

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84-EPA-7 Rem. Response HW Sites	U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1984, "Summary Report: Remedial Response at Hazardous Waste Sites," EPA/540/2-84/002a, U.S. EPA, Washington, D.C.
83-EPA-1 Guide to Matl. Selection ISWS-327	Barcelona, M. J., et al. (Illinois State Water Survey), 1983, "A Guide to the Selection of Materials for Monitoring Well Construction and Ground-Water Sampling," ISWS Contract Report 327, U.S. EPA Contract No. CR-809966-01, Illinois State Water Survey, Department of Natural Resources, Champaign, Illinois.
83-EPA-4 RCRA Permit Writ. Manual GW Prot.	Kuhlthau, R. H. and C. R. Faust (Geotrans), 1983, "RCRA Permit Writer's Manual Ground Water Protection 40 CFR Part 264 Subpart F," U.S. EPA, Office of Solid Waste and Emergency Response, Washington, D.C.
83-EPA-6 Risk Assmnt. RCRA Landfill	U.S. Environmental Protection Agency, Office of Policy Analysis, 1983, "Health Risk Assessment Methodologies for RCRA Landfill Regulations," U.S. EPA, Washington, D.C.
83-EPA-7 Chem. Analysis Water/Wastes	U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, 1983, "Methods for Chemical Analysis of Water and Wastes," EPA/600/4-79/020, Revised March 1983, U.S. EPA, Cincinnati, Ohio.
83-EPA-10 Int. Guide/ QA Plans	U.S. Environmental Protection Agency, Office of Research and Development, 1983, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," EPA/600/4-83/004, U.S. EPA, Washington, D.C.
82-EPA-1 Sample Preservation Water/Wastewater	U.S. Environmental Protection Agency, Office of Research and Development, 1982, "Handbook of Sampling and Sample Preservation of Water and Wastewater," EPA/600/4-82/029, U.S. EPA, Cincinnati, Ohio.
82-EPA-3 Test Meth. Solid Waste SW-846	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1982, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, U.S. EPA, Washington, D.C.

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81-EPA-2 NEIC GW Investigations	U.S. Environmental Protection Agency, National Enforcement Investigations Center, 1981, "NEIC Manual for Ground Water/Subsurface Investigations at Hazardous Waste Sites," EPA/330/9-81/002, U.S. EPA, Denver, Colorado.
80-EPA-5 Enf. Consid. HW Disp. Sites by Contractors	U.S. Environmental Protection Agency, National Enforcement Investigations Center, 1980, "Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Disposal Sites," U.S. EPA, Denver, Colorado.
79-EPA-3 QC Water/ Wastewater Labs	U.S. Environmental Protection Agency, Office of Research and Development, 1979, "Handbook for Analytical Quality Control in Water and Wastewater Laboratories," EPA/600/4-79/019, U.S. EPA, Cincinnati, Ohio.
79-EPA-4 129 Priority Pollutants	U.S. Environmental Protection Agency, Monitoring and Data Support Division, 1979, "Water-Related Environmental Fate of 129 Priority Pollutants," Vol. 1, "Introduction and Technical Background, Metals and Inorganics, Pesticides and PCBs," EPA/440/4-79/029a, U.S. EPA, Washington, D.C.
77-EPA-1 Abandoned Wells GW	U.S. Environmental Protection Agency, Office of Research and Development, 1977, "Impact of Abandoned Wells on Ground Water," EPA/600/3-77/095, U.S. EPA, Ada, Oklahoma.
77-EPA-2 GW Monit. Solid Waste Fac. SW-611	U.S. Environmental Protection Agency, Office of Water and Waste Management, 1977, "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities," SW-611, U.S. EPA, Washington, D.C.
75-EPA-1 Int. Rad. Meth. D.W.	U.S. Environmental Protection Agency, Environmental Support Laboratory, 1975, "Interim Radiochemical Methodology for Drinking Water," EPA/600/4-75/008, U.S. EPA, Cincinnati, Ohio.

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73-EPA-2 Anal. Reactor Solutions	Krieger, H. L. and S. Gold, 1973, "Procedures for Radiochemical Analyses of Nuclear Reactor Aqueous Solutions," EPA/R4-73/014, U.S. EPA, Cincinnati, Ohio.
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83-DOE-1 Effluent Radiological Meas. DOE	Corley, J. P. and C. D. Corbit (Pacific Northwest Laboratory), 1983, "A Guide for Effluent Radiological Measurements at DOE Installations," DOE/EP-0096, U.S. DOE, Office of Operational Safety, Washington, D.C.
DOE Facility HP Manuals	DOE contractor facility "Health Physics" or "Radiation Protection" Procedures Manuals. Usually undated. Prepared and published by individual U.S. DOE contractor facilities.
U.S. DEPARTMENT OF ENERGY ORDERS	
5480.1A	Environmental Protection, Safety, and Health Protection Program for U.S. DOE Operations (August 13, 1981).
5480.2	Hazardous and Radioactive Mixed Waste Management (December 13, 1982).
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (February 24, 1981).
5700.6A	Quality Assurance (August 13, 1981).
5820.1	Management of Transuranic Contaminated Material (September 30, 1982).
5820.2	Radioactive Waste Management (February 6, 1984).
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84-NIOSH-1 Personal Protective Equip.	National Institute for Occupational Safety and Health, Division of Safety Research, 1984, "Personal Protective Equipment for Hazardous Materials Incidents: A Selection Guide," NIOSH, Morgantown, West Virginia.
83-NIOSH-1 Drilling Safety	National Institute for Occupational Safety and Health, Division of Safety Research, 1983, "Comprehensive Safety Recommendations for Land-Based Oil and Gas Well Drilling," NIOSH Publication 83-127, NIOSH, Morgantown, West Virginia.
U.S. NUCLEAR REGULATORY COMMISSION	
85-NRC-2 Radionuclide Migration GW	Fruchter, J. S. (Pacific Northwest Laboratory), 1985, "Radionuclide Migration in Ground Water," NUREG/CR-4030, U.S. NRC, Division of Radiation Programs and Earth Sciences, Office of Nuclear Regulatory Research, Washington, D.C.
83-NRC-1 Subsurface Monit. Low-Level Radioactive Waste	Lutton, R. J., et al. (U.S. Army Engineer Waterways Experiment Station), 1983, "Subsurface Monitoring Programs at Sites for Disposal of Low-Level Radioactive Waste," NUREG/CR-3164, U.S. NRC, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, Washington, D.C.
82-NRC-1 Disposal Low-Level Radioactive Waste	Lutton, R. J., et al. (U.S. Army Engineer Waterways Experiment Station), 1982, "Tests for Evaluating Sites for Disposal of Low-Level Radioactive Waste," NUREG/CR-3038, U.S. NRC, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, Washington, D.C.
82-NRC-2 GW Flow Unsaturated Zone	Oster, C. A. (Pacific Northwest Laboratory), 1982, "Review of Ground Water Flow and Transport Models for the Unsaturated Zone," NUREG/CR-2917, U.S. NRC, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, Washington, D.C.
82-NRC-3 Characterizing Sites Low-Level Radioactive Wastes	U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, 1982, "Parameters for Characterizing Sites for Disposal of Low-Level Radioactive Wastes," NUREG/CR-2700, U.S. NRC, Washington, D.C.

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79-USGS-1 Inorganics in Water/ Fluvial	Skougstad, M. W., et al., 1979, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 5, Chapter A1: Methods for Determination of Inorganic Substances in Water and Fluvial Sediments, U.S. Geological Survey.
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84-OTA-1 Protecting GW	U.S. Congress, Office of Technology Assessment, 1984, "Protecting the Nation's Groundwater from Contamination," Chapter 3: "Federal Institutional Framework to Protect Groundwater from Contamination," OTA-O-233, U.S. Congress, Washington, D.C.
U.S. DEPARTMENT OF COMMERCE	
63-DOC-1 Max. Body Burdens	U.S. Department of Commerce, "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," NBS Handbook 69 as amended August 1963.
GUIDES, MANUALS, STANDARDS, AND TEXTBOOKS	
ACGIH 1985 Clothing	American Conference of Governmental Industrial Hygienists, 1985, Guidelines for the Selection of Chemical Protective Clothing, Vol. 1, Field Guide, 2nd ed., ACGIH, Cincinnati, Ohio.
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Everett 1984	Everett, L. G., L. G. Wilson, and E. W. Hoylman, 1984, Vadose Zone Monitoring for Hazardous Waste Sites, Noyes Data Corporation, Park Ridge, New Jersey.
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LIST OF ACRONYMS AND ABBREVIATIONS USED IN THIS DOCUMENT

AAS	atomic absorption spectrometry
ACGIH	American Conference of Governmental Industrial Hygienists
ACL	alternate concentration limit
AEA	Atomic Energy Act
AIHA	American Industrial Hygiene Association
AMS	Applied Management Sciences (Silver Spring, Maryland)
ANSI	American National Standards Association
APHA	American Public Health Association
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program (EPA)
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DW	drinking water
DNR	Department of Natural Resources (Wisconsin)
ECRA	Environmental Cleanup Responsibility Act (New Jersey)
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration

FWPCA	Federal Water Pollution Control Act
FR	Federal Register
GW	ground water
HASL	Health and Safety Laboratory (New York)
HMCRI	Hazardous Materials Control Research Institute Silver Spring, Maryland
HP	health physics
HSL	Hazardous Substance List (EPA)
HSWA	Hazardous and Solid Waste Amendments of 1984
HW	hazardous waste
IAEA	International Atomic Energy Agency
ISWS	Illinois State Water Survey
IT	International Technology Corporation
MCL	maximum contaminant level
NBS	National Bureau of Standards
NEIC	National Enforcement Investigations Center (EPA)
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NTIS	National Technical Information Service
NWPA	Nuclear Waste Policy Act
NWWA	National Water Well Association (Dublin, Ohio)
OEG	Office of Environmental Guidance (DOE)
OSHA	Occupational Safety and Health Administration
ORNL	Oak Ridge National Laboratory
OSC	On-Scene Coordinator

OTA	Office of Technology Assessment
PCB	polychlorinated biphenyl
PHSA	Public Health Service Act of 1965
PNL	Pacific Northwest Laboratory (Richland, Washington)
QA/QC	quality assurance/quality control
QA	quality assurance
RA	Regional Administrator (EPA)
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SIA	Surface Impoundment Assessment
SWDA	Solid Waste Disposal Act
TDS	total dissolved solids
TEGD	Technical Enforcement Guidance Document
THF	tetrahydrofuran
THM	trihalomethane
TLV	threshold limit value
TRU	transuranic
TSCA	Toxic Substance Control Act of 1976
TSD	treatment, storage, or disposal
UIC	Underground Injection Control (Program, SDWA)
UMTRAP	Uranium Mill Tailings Remedial Action Program
UMTRCA	Uranium Mill Tailings Radiation Control Act
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	U.S. Geological Survey
VOC	volatile organic compound

APPENDIX A

STATUTES AND REGULATIONS RELEVANT TO GROUND WATER MONITORING

- Relevant statutes - Pertinent sections of federal statutes dealing with ground water monitoring and their applicability to various facilities and owner/operators.

- Relevant regulations - Applicable parts of the Code of Federal Regulations (CFR) relevant to ground water monitoring.

RELEVANT STATUTES

ATOMIC ENERGY ACT OF 1954, AS AMENDED BY THE URANIUM MILL TAILINGS RADIATION CONTROL ACT OF 1978
(Enacted by PL 83-703, August 20, 1954 as amended by PL 95-604, November 8, 1978)

PERTINENT SECTIONS AND HEADINGS		APPLICABILITY/DESCRIPTION
Section 108	Remedial Action	Facilities not in compliance with Section 275a of the Atomic Energy Act.
Section 206	Authority of EPA regarding certain by-product material. (This creates Section 275 in Atomic Energy Act - Health and Environmental Standards for Uranium Mill Tailings)	Standards for inactive uranium mill tailings sites and depositories.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980
(Enacted by PL 96-510, December 11, 1980, as amended through PL 98-396, August 2, 1984)

PERTINENT SECTIONS AND HEADINGS		APPLICABILITY/DESCRIPTION
TITLE I - HAZARDOUS SUBSTANCES, RELEASES, LIABILITY, COMPENSATION		Authorizes EPA to respond to releases of hazardous substances which may present an imminent and substantial threat to public health or welfare.
Section 102	Reportable Quantities	Owner/operators of waste sites with hazardous releases.
Section 104	Response Authorities (President has authority to arrange for remedial action, monitoring, etc., relating to released substances)	Owner/operators of waste sites with hazardous releases.
Section 105	National Contingency Plan	All releases of pollutants to air, land, water (unless exempted by law).
Section 106	Abatement Action	Actual or threatened release of a hazardous substance from a facility.

FEDERAL WATER POLLUTION CONTROL ACT, AS AMENDED BY THE CLEAN WATER ACT OF 1977
(Enacted by PL 92-500, October 21, 1976, as amended through PL 99-88, August 15, 1985)

PERTINENT SECTIONS AND HEADINGS		APPLICABILITY/DESCRIPTION
TITLE I - RESEARCH AND RELATED PROGRAMS		Interaction between EPA Administrator, federal, state, and other agencies.
Section 102	Comprehensive Programs for Water Pollution Control	All navigable waters and ground waters.
102(a)	(Administrator shall prepare programs for preventing and eliminating pollution of ground waters)	All navigable waters and ground waters.
TITLE III - STANDARDS AND ENFORCEMENT		All point dischargers from publicly owned treatment works and other dischargers (does not usually include ground water).
Section 308	Inspections, Monitoring and Entry	All point source dischargers.
308(a)	(Administrator may require monitoring as deemed necessary)	All point source dischargers.
Section 311	Oil and Hazardous Substance Liability	All facilities.
TITLE IV - PERMITS AND LICENSES		Applicants for NPDES permits to discharge to navigable waters.
Section 402	National Pollutant Discharge Elimination System	All point sources discharges, including discharges to wells.
402(a)	(establishing NPDES permitting system to ensure compliance with Act)	
Section 404	Permits for Dredged or Fill Material	
404(c)	(Administrator may prohibit discharge of materials which may adversely affect municipal supplies	Any dredged or fill material in waters or wetlands.

NUCLEAR WASTE POLICY ACT OF 1982
(Enacted by PL 97-425, January 7, 1983)

TITLE I - DISPOSAL AND STORAGE OF HIGH-LEVEL RADIOACTIVE WASTE, SPENT NUCLEAR FUEL, AND LOW-LEVEL RADIOACTIVE WASTE

SUBTITLE A - REPOSITORIES FOR DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL

PERTINENT SECTIONS AND HEADINGS		APPLICABILITY/DESCRIPTION
Section 112	Recommendation of Candidate Sites for Site Characterization	
112(a)	Guidelines (for considering various factors including hydrology and water supply)	Candidate sites for high-level radioactive waste disposal.
Section 113	Site characterization	
113(a)	In General (minimize environmental impact of site characterization activities)	Candidate disposal sites.
Section 124	Consideration of Effect of Acquisition of Water Rights	Water resources in disposal area.

RELEVANT STATUTES
(Continued)

PUBLIC HEALTH SERVICE ACT

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
SUBCHAPTER XII - SAFETY OF PUBLIC WATER SYSTEMS	
Section 300g-1 National Drinking Water Standards	Establishes procedures for the promulgation of national primary and secondary drinking water regulations.
Section 300g-4 Variances	Establishes conditions under which variances from an applicable national primary drinking water regulation may be granted by a state to public water systems.
Section 300g-5 Exemptions	Establishes conditions under which a state may exempt a public water system from any requirement, regarding a maximum contaminant level and/or any treatment technique, of an applicable national primary drinking water standard.
Section 300h-3 Interim Regulation of Underground Injections	Establishes necessity for underground injection well operation permits.
Section 300i Emergency Powers	Authorizes the Administrator to take actions against imminent and substantial endangerment to health from contaminants which are present or likely to enter a public water system.
Section 300j-4 Records and Inspection	Requires water suppliers or others subject to a national primary drinking water regulation to establish and maintain records and reports and conduct monitoring deemed necessary by the Administrator.

RESOURCE CONSERVATION AND RECOVERY ACT OF 1976, INCLUDING THE HAZARDOUS AND SOLID WASTE AMENDMENTS (HSWA) OF 1984
(Enacted by PL 94-580, October 21, 1976; as amended through PL 98-616, November 9, 1984)

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT	Generators of more than 110 kg/month of hazardous waste (as defined by 40 CFR 261.3) and anyone who transfers, treats, stores, or disposes of hazardous wastes.
Section 3004 Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities	
3004 (o) Minimum Technological Requirements	New land fills or surface impoundments, or replacement and lateral expansions permitted after November 8, 1984 (with some exemptions).
3004 (p) Ground Water Monitoring	All land disposal units (with provisions for case-by-case exemptions).
3004 (u) Continuing Releases at Permitted Facilities	Any TSD facilities with releases from a solid waste management unit.
3004 (v) Corrective actions beyond Facility Boundary	Any facility requiring corrective actions.
3004 (w) Underground Tanks	Standards for tanks which cannot be entered for inspection.
Section 3005 Permits for Treatment, Storage, or Disposal of Hazardous Waste	
3005 (e)(2) Interim Status Certification of Compliance	All interim status land disposal facilities.
3005 (i) Interim Status (Ground water standards)	Any interim status land disposal facility which received hazardous waste after July 26, 1982.
3005 (j) Interim Status Surface Impoundments	Any surface impoundment in existence on November 8, 1984 (with provisions for exemptions).
Section 3008 Interim Status Concerning Corrective Action Orders	Interim status facilities.
Section 3013 Monitoring, Analysis, and Testing	Any treatment, storage, or disposal facility.
Section 3015 Expansion During Interim Status	
3015 (a) Waste Piles	Interim status waste piles being expanded.
3015 (b) Landfills and Surface Impoundments	Interim status landfills and surface impoundments being expanded.
SUBTITLE D - STATE OR REGIONAL SOLID WASTE PLANS	Requires EPA to promulgate guidelines for state and regional solid waste management plans.
Section 4003 Requirements for Approval of Plans	Nonhazardous solid waste disposers.
Section 4004 Criteria for Sanitary Landfills, Sanitary Landfills Required for all Disposal	Nonhazardous landfills.
Section 4010 Adequacy of Certain Guidelines and Criteria	Requires EPA to study adequacy of non-RCRA ground water guidelines and criteria.
SUBTITLE G - MISCELLANEOUS PROVISIONS	
Section 7010 Interim Control of Hazardous Waste Injection	
7010 (a) Underground Source of Drinking Water	Prohibits injection of hazardous waste into underground sources of drinking water.
7010 (b) Actions Under CERCLA	Provides some exemptions to (a).
7010 (c) Enforcement	Per Sections 7002, 7003, and Safe Drinking Water Act.
SUBTITLE I - REGULATION OF UNDERGROUND STORAGE TANKS	Owners and operators of tanks, the volume of which is at least 10 percent below ground surface and which contain hazardous substances or liquid petroleum products.
Section 9003 Release Detection, Prevention, and Correction Regulations	All underground storage tanks.
9003 (c) Requirements	Requires EPA to issue release detection, prevention, and correction regulations by February 1987.
9003 (e) New Tank Performance Standards	Requires EPA to issue regulations by February 1987.
Section 9005 Inspections, Monitoring & Testing	All underground storage tanks.

RELEVANT STATUTES
(Continued)

SAFE DRINKING WATER ACT
(Enacted by PL 93-523, December 16, 1974, as amended through PL 96-502, December 5, 1980)

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
TITLE XIV - SAFETY OF PUBLIC WATER SYSTEMS	All public water supplies using surface or ground water sources.
Part B - Public Water Systems Coverage	
Section 1412 National Drinking Water Regulations	Each public water system.
Part C - Protection of Underground Sources of Drinking Water	Public water supplies using ground water sources.
Section 1421 Regulations for State Programs (UIC)	State underground injection control programs for underground sources of drinking water.
Section 1424 Interim Regulation of Underground Injections	Injection wells in sole source aquifers.
Part E - General Provisions	
Section 1445 Records and Inspections	Anyone subject to an underground injection control program.

SOLID WASTE DISPOSAL ACT

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
SUBCHAPTER III - HAZARDOUS WASTE MANAGEMENT	
Section 6924 Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities	Authorizes EPA to establish standards for hazardous waste TSD facilities, including incorporation of the 1984 Hazardous and Solid Waste Amendments regarding ground water monitoring and continuing releases.
Section 6925 Permits for Treatment, Storage, or Disposal of Hazardous Waste	Establishes permit requirements for hazardous waste TSD facilities.
Section 6934 Monitoring, Analysis, and Testing	Authorizes the EPA Administrator to issue an order requiring monitoring, testing, analysis, and reporting to ascertain the nature and extent of hazard to human health and the environment from hazardous waste practices or releases of hazardous waste.
SUBCHAPTER IV - STATE OR REGIONAL SOLID WASTE PLANS	
Section 6944 Criteria for Sanitary Landfills; Sanitary Landfills Required for all Disposal	Authorized EPA to establish criteria for sanitary landfills.
Section 6945 Upgrading of Open Dumps	Prohibits open dumping of solid or hazardous waste.
CHAPTER VII - MISCELLANEOUS PROVISIONS	
Section 6973 Imminent Hazard	Authorizes the EPA Administrator to bring suit against any person whose past or current hazardous waste practices present an imminent and substantial endangerment to health or the environment.

TOXIC SUBSTANCES CONTROL ACT
(Enacted by PL 94-469, October 11, 1976 as amended by PL 97-129, December 29, 1981)

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
Section 4 Testing of Chemical Substances and Mixtures Section 6 Regulation of Hazardous Chemical Substances and Mixtures Section 8 Reporting and Retention of Information	Users, disposers, etc., of chemical substances and mixtures.

RELEVANT REGULATIONS

TITLE 10 - ENERGY

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
CHAPTER I - NUCLEAR REGULATORY COMMISSION	
Part 20 - Standards for Protection Against Radiation (20.1 to 20.601)	All persons who receive, possess, use, or transfer radioactive material licensed pursuant to the regulations in this chapter.*
Part 40 - Domestic Licensing of Source Material (40.1 to 40.81)	All persons requesting licenses to receive title to, receive, possess, use, transfer, or deliver source and by-product materials.
Part 50 - Domestic Licensing of Production and Utilization Facilities (Appendix B)	Establishes quality assurance requirements for the design, construction, and operation of structures, systems, and components of nuclear power plants and fuel reprocessing plants.
Part 60 - Disposal of High-Level Radioactive Wastes in Geologic Repositories (60.1 to 60.162)	Prescribes rules governing the licensing of the U.S. Department of Energy (DOE) to receive and possess source, special nuclear, and by-product material at a geologic repository operations area.
Part 61 - Licensing Requirements for Land Disposal of Radioactive Waste (61.1 to 61.83)	Establishes procedures, criteria, and terms and conditions upon which the NRC issues licenses for the land disposal of radioactive wastes containing by-products, source, and special nuclear material received from other persons. (Does not apply to high-level wastes addressed in Part 60, uranium mill tailings addressed to Part 40, or licensed material addressed in Part 20 of this chapter).
Part 70 - Domestic Licensing of Special Nuclear Material	Establishes procedures and criteria for the issuance of licenses to receive title to own, acquire, deliver, possess, and transfer nuclear material.

TITLE 40 PROTECTION OF ENVIRONMENT

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
SUBCHAPTER D - WATER PROGRAMS	
Part 136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants (136.1 to 136.5)	Lists approved test procedures for waste constituents to be measured pursuant to an NPDES application or permit (under Section 402 of the FWPCA) or a state certification (under Section 401 of the FWPCA).
Part 141 - National Interim Primary Drinking Water Regulations	Establishes national primary drinking water regulations pursuant to Section 1412 of the Public Health Service Act (PHSA) as amended by the Safe Drinking Water Act (SDWA), applicable to each public water system.
Subpart B - Maximum Contaminant Levels (141.11 to 141.16)	Establishes maximum levels for organic, inorganic, microbiological, and radiological contaminants in drinking water.
Subpart C - Monitoring and Analytical Requirements (141.21 to 141.30)	Suppliers of water for community and noncommunity water systems.
Part 143 - National Secondary Drinking Water Regulations (143.1 to 143.4)	Establishes national secondary drinking water regulations pursuant to Section 1412 of the PHSA as amended by the SDWA. (Not federally enforceable, but guidelines for States).
Part 144 - Underground Injection Control Program	Sets forth the regulatory framework for the program requirements of the Underground Injection Control (UIC) Program, promulgated under Part C of the SDWA.
Part 146 - Underground Injection Control Program: Criteria and Standards (146.1 to 146.42)	Sets forth the technical criteria and standards for the UIC program.
SUBCHAPTER F - RADIOLOGICAL PROTECTION PROGRAM	
Part 191 - Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes	Establishes standards for the management and disposal of spent nuclear fuel and high-level and transuranic radioactive wastes generated by activities regulated by the NRC and to the disposal of similar materials generated by atomic energy defense activities under DOE jurisdiction.
Part 192 - Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	
Subpart A - Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites (192.00 to 192.02)	Control of residual radioactive material at inactive uranium processing or depository sites designated under Section 108 of the Uranium Mill Tailings Radiation Control Act (UMTRCA) and restoration of the sites following any use of subsurface minerals.
Subpart B - Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials From Inactive Uranium Processing Sites (192.00 to 192.02)	Land and buildings that are part of any inactive uranium processing site designated under Section 102 of UMTRCA.

*The Federal Register of January 9, 1986, contains proposed revisions to 10 CFR 20 which would substantially increase the detail of required bodily radiation monitoring and generally lower the allowable radiation doses.

RELEVANT REGULATIONS
(Continued)

TITLE 40 (CONTINUED)

PERTINENT SECTIONS AND HEADINGS	APPLICABILITY/DESCRIPTION
Subpart C - Implementation (192.20 to 192.22)	Guidance and criteria for achieving standards of Subparts A and B.
Subpart D - Standards for Management of Uranium By-Product Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended (192.30 to 192.34)	Management of uranium by-product materials during and following processing of ores, and restoration of disposal sites.
Subpart E - Standards for Management of Thorium By-product Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended (192.40 to 192.43)	Management of thorium by-product materials during and following processing of ores, and restoration of disposal sites.
SUBCHAPTER I - SOLID WASTES	
Part 241 - Guidelines for the Land Disposal of Solid Wastes	Recommended procedures for land disposal of all solid waste (except hazardous agricultural and mining wastes) to achieve minimum levels of performance for disposal sites.
241.204 Water Quality	Location, design, construction, and operation of sites to protect ground and surface waters.
Part 257 - Criteria for Classification of Solid Waste Disposal Facilities and Practices	Establishes criteria for use under RCRA in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. Provides guidelines for sludge utilization and disposal under Section 405(d) of the Clean Water Act.
Part 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.	Owners and operators of all facilities which treat, store, or dispose of hazardous waste, unless specifically exempted.
Subpart F - Ground Water Protection (264.90 to 264.101)	Owners and operators of facilities that treat, store, or dispose of hazardous waste in surface impoundments, waste piles, land treatment, or landfills.
Subpart G - Closure and Post-Closure (265.110 to 265.120)	Establishes ground water monitoring and reporting requirements during post-closure care period for owners and operators of hazardous waste disposal facilities where waste remains in place after closure.
Part 265 - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	Owners and operators of facilities that treat, store, or dispose of hazardous waste who are in compliance with interim status requirements.
Subpart F - Ground Water Monitoring (265.90 to 265.94)	Owners and operators of a surface impoundment, landfill, or land treatment facility used to manage hazardous waste.
Part 267 - Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	Requirements of this part are no longer applicable as they have been superseded by Part 264.
SUBCHAPTER J - SUPERFUND PROGRAMS	
Part 300 - National Oil & Hazardous Substances Pollution Contingency Plan	Response taken under the National Contingency Plan pursuant to CERCLA and Section 311 of the Clean Water Act (for releases of oil or hazardous substances into the environment).
Subpart E - Operational Response Phases for Oil Removal (300.57)	Specifies special considerations for safety of personnel during response to a discharge of oil.
Subpart F - Hazardous Substance Response (300.61 to 300.71)	Methods and criteria for determining appropriate extent of response under CERCLA for releases or substantial threat of releases into the environment.
SUBCHAPTER R - TOXIC SUBSTANCES CONTROL ACT	
Part 761 - PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibition	All persons who manufacture, process, distribute, use, or dispose of materials containing 50 parts per million (ppm) or greater of PCBs.
Subpart D - Storage and Disposal (761.60 to 761.79)	Establishes requirements for the storage, landfilling, and incineration of PCB materials, including ground water monitoring.
Subpart J - Records and Reports (761.180 to 761.185)	Establishes requirements for the monitoring of disposal activities and associated recordkeeping.

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