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GUIDANCE DOCUMENT FOR PREPARING WATER SAMPLING AND ANALYSIS PLANS FOR UMTRA SITES

Final

September 1993

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**GUIDANCE DOCUMENT FOR PREPARING WATER SAMPLING
AND ANALYSIS PLANS FOR UMTRA SITES**

FINAL

September 1993

**Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico**

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LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
cm/sec	centimeters per second
COC	contaminants of concern
DO	dissolved oxygen
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot
ft/yr	feet per year
LTSP	long-term surveillance plan
m	meter
m/yr	meters per year
MCL	maximum concentration limit
ORP	oxidation/reduction potential
QA/QC	quality assurance/quality control
RAP	remedial action plan
SOP	Standard Operating Procedure
SPEAR	Software Program for Environmental Analysis and Reporting
TAC	Technical Assistance Contractor
TAD	Technical Approach Document
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
WSAP	water sampling and analysis plan
yr	year

1.0 INTRODUCTION

A water sampling and analysis plan (WSAP) is required for each Uranium Mill Tailings Remedial Action (UMTRA) site to provide rationale for groundwater and surface water sampling at disposal sites and former processing sites. The WSAP identifies and justifies the sampling locations, analytical parameters, detection limits, and sampling frequencies for the groundwater and surface water monitoring stations at each site.

Section 2.0 of this WSAP Guidance Document describes the WSAP format. Sections 3.0 and 4.0 provide guidance for selecting sampling frequencies and sampling locations, respectively. Section 5.0 contains criteria for selecting analytical parameters. Section 6.0 provides guidance for the contents of each site's WSAP file. Finally, Section 7.0 presents the references used to prepare this document.

The purpose of this guidance document is to provide a consistent technical approach for sampling and monitoring activities performed under WSAPs and a consistent format for WSAP documents. This document is designed for use by the Technical Assistance Contractor (TAC) to prepare WSAPs and by the U.S. Department of Energy (DOE), Nuclear Regulatory Commission, state and tribal agencies, regulatory agencies, and the public to evaluate the contents of the WSAPs. This guidance document may be updated periodically based on new or changing regulations.

2.0 WSAP PREPARATION

2.1 GENERAL WSAP FORMAT

The WSAP is designed to provide the reader with a brief site history and the factors that justify the sampling locations, frequency, and analytes for the recommended monitoring period. It should be a relatively brief but comprehensive document consisting of approximately 20 pages of text and 20 pages of tables and figures. Applicable sections of Standard Operating Procedures (SOPs), other guidance documents, regulations, and reports should be referenced and summarized when necessary to clarify the information presented. Table 2.1 shows the WSAP table of contents.

WSAPs will be updated on an annual basis. They will primarily identify the sampling needs through the end of the upcoming fiscal year, but also will identify long-term sampling goals for such items as risk assessments, characterization studies, and compliance monitoring, as appropriate. Changes to recommended sampling strategies will be based on an evaluation of previously collected data.

Sampling recommendations presented in each WSAP may be modified prior to the next annual update. These interim changes to the sampling recommendations can be from an evaluation of the results of recent sampling events (e.g., to evaluate data anomalies or an exceedance of a water quality standard) and performed in conjunction with the development of planning documents such as remedial action plans (RAP), long-term surveillance plans (LTSP), and risk assessments.

The WSAP consists of five major sections. The Introduction (Section 1.0) provides the WSAP purpose, a site description, and a sampling recommendations summary for the upcoming year. Section 2.0, Site Characteristics, is a technical presentation of the results from previous studies and sampling events; it describes the hydrogeologic system, including water quality results and any water quality data trends. The data collection objectives (Section 3.0) reflect the regulatory and technical reasons for collecting samples. Section 4.0 presents data quality objectives. The information, discussions, data evaluations, and conclusions in Sections 1.0 through 4.0 support the sampling recommendations in Section 5.0.

2.2 WSAP SECTION DETAILS

The contents and purpose of each WSAP section are described below. Where appropriate, the wording from each description can be incorporated into the WSAPs using site-specific information such as site name and location. The reference to "Section" in parentheses following each heading refers to the section number of the WSAP document.

Table 2.1 Table of contents for water sampling and analysis plans for UMTRA sites

1.0	INTRODUCTION
1.1	Purpose
1.2	Site location
1.2.1	Surrounding land use
1.2.2	Surrounding water use
1.3	Site history
1.4	Site status
1.5	Sampling plan summary
1.6	Summary of changes to previously issued WSAP
2.0	SITE CHARACTERISTICS
2.1	Physiographic setting
2.2	Geology
2.3	Hydrology
2.3.1	Groundwater
2.3.2	Surface water
2.4	Water quality
2.4.1	Background water quality wells
2.4.2	Point-of-compliance wells
2.4.3	Plume delineation wells
2.4.4	Surface water sampling locations
2.5	Site conceptual model
3.0	DATA COLLECTION OBJECTIVES
3.1	Regulatory requirements
3.2	Compliance monitoring
3.3	Site characterization
3.4	Risk assessment considerations
3.5	Other considerations
4.0	DATA QUALITY OBJECTIVES
5.0	SAMPLING PLAN
5.1	Sampling locations
5.2	Analyte selection
5.3	Sampling frequency
5.4	Data interpretation methods
5.5	Response to anomalous data
6.0	REFERENCES

References for the information sources used in each WSAP are an important part of the document. They allow the WSAP author to summarize applicable sections from the sources (in an effort to keep the WSAP brief) and allow the reader to access specific source documents for additional information.

Also of major importance are the screened and gravel-packed intervals for wells and the dates for piezometric surface and concentration distribution maps and tables. Furthermore, in statements regarding hydraulic gradient, the measuring points must be specified or the appropriate calculation set referenced. This allows the reader to reproduce the results presented in the WSAP.

2.2.1 Introduction (Section 1.0)

The WSAP Introduction consists of six sections: Purpose, Site Location, Site History, Site Status, Sampling Plan Summary, and Summary of Changes to Last Year's Sampling Plan. The format and content of each section are described below.

Purpose (Section 1.1)

The following information presents the purpose for each site-specific WSAP document and the purpose of the sampling and analyses described within each WSAP. With minor modifications for site-specific references and sampling requirements, the following text may be used as the opening paragraphs of each document.

This *Water Sampling and Analysis Plan* (WSAP) provides the basis for groundwater and surface water sampling at [the site]. Specifically, it identifies and provides justification for the sampling locations, analytical parameters, detection limits, and sampling frequencies for the monitoring stations at [the site]. The data are used for [site characterization and risk assessment, establishment of background and base-line water quality, compliance monitoring]. Major goals of the data collection efforts are to provide an opportunity to detect trends in water quality and trends in head distributions for the water-bearing units beneath the site and to delineate the horizontal and vertical extent of contamination.

The regulatory requirements for monitoring groundwater and surface water at UMTRA sites are contained in 40 CFR Part 192. This WSAP bases monitoring decisions on the regulations, the *Technical Approach Document* (TAD) for UMTRA (DOE, 1989a), UMTRA Standard Operating Procedures (SOPs), and the most effective technical approach for [the site].

Site Location (Section 1.2)

The Site Location section is a one-paragraph statement that includes the county and state and the section, township, and range for the site. Also included are

the distance and direction to the nearest town or city and the distance and direction to the closest highway and highway intersection.

This section contains several figures, all of which can be obtained from the site-specific RAP. The first figure will show the general site vicinity on a map that includes county and section, township, and range lines, plus the highways and towns referenced in the text. The second figure is a map of the site and nearby surrounding features such as the closest highway, nearby residential areas (if present), surrounding water use locations (which include surface water intakes, domestic wells, irrigation wells, and public supply wells), surface water sampling locations, and the surface discharge area for each potentially affected aquifer. The third figure is a detailed map of the site in its present condition, which includes the monitor wells; domestic, irrigation, and public supply wells; and, if possible, the nearby surface sampling sites.

The Site Location section refers to the monitor wells and other sampling points for the first time. Therefore, a table providing the total depth, screened interval, gravel-packed interval, and elevation of the ground surface and water-level measuring point for each well is included. Additionally, a brief text description and separate table describing the legal access to each sampling point are required.

Subsections of Site Location are Surrounding land use (Section 1.2.1) and Surrounding water use (Section 1.2.2), both of which are one or two paragraphs. RAPs and LTSPs can supply the information, but the information should be verified for accuracy and updated. The aforementioned figures will show the water-withdrawal and water-use locations. The water source and approximate quantities of water used should be specified where this information is available. The surrounding land use subsection also will include a brief ecological overview of the site and surrounding areas, current and potential receptors, and current and potential land use. Risk assessment reports or the TAC risk assessment staff can supply the information.

In summary, this section includes the following information:

- The county and state and the section, township, and range within which the site is located.
- The distance and direction to the nearest town or city and the closest highway and highway intersection.
- A description of current surrounding land use.
- A description of current surrounding water use.
- An ecological overview of the site and surrounding area, current and potential receptors, and potential land and water use.

- A table listing all monitoring stations, which will include the screened and gravel-packed zones and elevations for all wells and a table listing the legal access for all sampling locations.
- Figures showing the site location and the locations of all sampling points and nearby domestic, public supply, and irrigation wells.

Site History (Section 1.3)

The Site History section describes previous site operations that resulted in site contamination. The types of ore and the processing chemicals and their byproducts should be stated. The areas for processing, ore storage, and tailings disposal should be described and shown on a figure, as well as the years in which the site was in operation. The figure should be separate from the detailed site map, which shows current site conditions and well locations, to avoid too much information on one figure. However, if possible, the site historical features map should be the same scale as the well locations map to allow direct comparison between monitoring locations and previous potential contaminant sources.

Limiting the discussion of site history to items that have or may have caused contamination will allow this section to remain brief and within the scope and purpose of the WSAPs. Sources of the information and figure are the RAPs and LTSPs. The source or sources used to direct the reader to additional information should be referenced. Significant site historical features also include a site ownership summary, the site size, processing areas, disposal cells, and the amount of material in the disposal cells. Former building locations or a detailed description of site access should not be included unless those items have significance regarding site contamination.

Site Status (Section 1.4)

The Site Status section provides the regulatory site status, the remedial activities status, and the status of major documents prepared for or in preparation for the site. For example, this section will state whether the surface remediation is pending, under way, or completed and the status of the RAPs, LTSPs, baseline risk assessments, and other appropriate site documents.

Sampling Plan Summary (Section 1.5)

The Sampling Plan Summary section presents the recommended sampling locations, frequencies, and analytical parameters for the upcoming year. References to figures showing the sampling locations and a table listing the locations and analytical parameters are included. This section summarizes Section 5.0 of the WSAP, which provides the detailed recommendations and supporting discussions for the sampling activities.

Summary of Changes to Previously Issued WSAP (Section 1.6)

This section identifies the differences between the current WSAP and the previous WSAP or sampling events. Included is an explanation of the basis for the changes.

2.2.2 Site Characteristics (Section 2.0)

The Site Characteristics section presents and evaluates information gathered during previous site investigations. The information should be presented concisely, providing the technical basis for the recommended sampling. Section 3.0, Data Collection Objectives, provides the regulatory and technical bases for the recommended sampling.

The review and evaluation of data previously collected may indicate the need for additional investigations. Although additional investigations are an important aspect of the project, recommendations for additional work are not within the scope of the WSAP. Therefore, statements regarding data gaps, additional data needs, or recommendations for additional work are not included in a WSAP. They should, however, be documented for the site manager in the form of a memo with the technical managers' concurrence.

Physiographic Setting (Section 2.1)

The Physiographic Setting section is one or two paragraphs describing the topographic and geomorphologic features of the site and surrounding areas. Surface water drainage, groundwater recharge areas, and groundwater discharge areas should be included. A physiographic features map or topographic map should be referenced as a figure. LTSPs or RAPs contain most of the necessary information, but their applicable sections may require modifications and additional information provided by the WSAP author.

Because topographic and geomorphologic features result from geologic structure and stratigraphy, and sediment deposition and reworking, this section provides insight into features that may influence groundwater flow paths. For example, alluvial deposits are a heterogeneous and anisotropic layering and interfingering of gravel, sand, and clay beds, but eolian deposits may be relatively homogeneous. The presence of terraces may indicate groundwater discharge areas in the form of seeps along escarpments. The presence and identification of these features can affect the recommended sampling strategy.

Geology (Section 2.2)

The Geology section identifies the names, ages, and physical properties of the geologic formations (rock units) within the site area. Additionally, site-specific geology is correlated with regional geologic information. The geologic framework descriptions should include all units from ground surface to one or two units below the affected water-bearing zone, or aquifer in use within the

region, whichever is deeper. Included in the description for each aquifer and confining unit are the composition of the matrix materials (e.g., grain size and distribution, mineralogy, porosity, cementation and cementing material composition, and the presence or absence of fractures), the type of sediment deposition that formed the geologic units, and the strike and dip of the units. The text for this section should be limited to one page.

In accordance with the TAD (DOE, 1989a), data sources such as well logs, reports, and maps should be used to prepare the geologic descriptions. The information can be obtained from site documents, but it should be reviewed for consistency and updated. Attachment 2 of the RAP is generally a good starting point for geologic information.

Figures in the Geology section are a regional stratigraphic column or regional cross section showing geologic and hydrologic names and site-specific cross sections based on lithologic logs from monitor wells. The site-specific cross sections should be parallel with and perpendicular to the groundwater flow direction. The vertical exaggeration of the cross sections should be kept to a minimum.

Hydrology (Section 2.3)

The Hydrology section is divided into two subsections, Groundwater (Section 2.3.1) and Surface water (Section 2.3.2). As with the Geology section, information can be obtained from site documents, but it should be reviewed for consistency and updated (e.g., the results from an aquifer test or information contained in recent publications).

The Groundwater subsection should be limited to about one page of text describing the names, correlation with geologic rock units, physical properties, and hydraulic properties of each water bearing and confining unit. Each unit from ground surface to the confining unit below the deepest affected aquifer or the aquifer in use in the area, whichever is deepest, is included. This subsection includes figures (including cross sections) showing piezometric surfaces for different zones and seasons, which include specific references to the measurement dates and the screened and gravel-packed zones of the wells used to construct the figures.

The hydraulic properties should be presented in a table and will include the hydraulic conductivity, transmissivity, porosity, effective porosity, groundwater flow direction (horizontal and vertical), groundwater flow velocity (horizontal and vertical), and seasonal water-level fluctuations (in graphical and narrative form) for each water-bearing zone and confining unit. Where available, the range, arithmetic mean, and median of the various hydraulic properties should be presented.

Additional information that should be included are the type and location of the recharge areas and discharge areas for the aquifers, the stage of nearby rivers, groundwater and surface water interactions, and municipal and irrigation pumpage (for both surface water and groundwater). Existing documents supply the source for most of the information; however, the WSAP author may need to construct graphs of water-level fluctuations in the zones monitored by the monitor well network.

Existing data should be evaluated for consistency with the hydraulic and geologic properties of the aquifers and confining units. For example, the hydraulic conductivity of a water-bearing unit consisting of a well-sorted, medium-grained sand may have been reported as 1×10^{-5} centimeters per second (cm/sec) from an average of slug test data. However, this figure may be unreasonably low, based on a published range of about 1×10^{-3} cm/sec to 1 cm/sec for the hydraulic conductivity of medium-grained sand (Freeze and Cherry, 1979).

This potentially unrepresentative hydraulic conductivity will affect transmissivity and velocity estimates. Identifying potential errors or recommending additional work is not the WSAP's purpose. However, existing data should be presented along with a realistic data interpretation, including a calculation for the average linear groundwater velocity based on a literature value for hydraulic conductivity.

The surface water subsection is a one- or two-paragraph description; figures show any major drainage features on and around the site, any local springs or seeps, and any streams or rivers in the site vicinity. The characteristics of each feature (e.g., a perennial stream, a losing or gaining stream, or the approximate flow rates and periods of flow for springs and rivers) should be explained.

Water Quality (Section 2.4)

The Water Quality section presents the water quality results (groundwater and surface water) from previous sampling events. The information is used with the aforementioned sections to provide the technical basis for the sampling recommendations (presented in Section 5.0) for the upcoming year. The data are available on the UMTRA Project Software Program for Environmental Analysis and Reporting (SPEAR) (DOE, 1993a), accessible from the UMTRA Project Office in Albuquerque, New Mexico. The data require compilation and interpretation by the WSAP author.

This section has four subsections: background water quality wells (Section 2.4.1); point-of-compliance wells, if present at the site (Section 2.4.2); plume delineation wells (Section 2.4.3); and surface water sampling locations, if present at the site (Section 2.4.4). The well designations from previous reports should be presented along with screened zones and gravel-packed intervals and any modifications to the designations that the WSAP author feels are justified, based on reinterpretation of older data or interpretation of recent data. For

example, if a well was previously identified as a background well but is now determined to be within the plume, the designation should be changed to a plume delineation well.

Each subsection is organized to present the water quality, geochemistry, and evaluation of any trends using the existing data base. Water quality describes the constituents and range in concentrations and detection limits. Only when directly applicable to the sampling decisions, the geochemistry portion graphically presents the data on trilinear diagrams or Stiff diagrams to show water quality information and categorize the different water quality types. Water quality also should be categorized by total dissolved solids content and pH and if it is oxidizing or reducing. A comparison to Class III water quality should be made. Distinctions between filtered and nonfiltered sample results also are necessary.

The data within each category (i.e., background wells, point-of-compliance wells, plume delineation wells, and surface water) also are evaluated for trends. The first step is to plot water quality versus time and water levels versus time for each well and surface water sampling location. This also should be done for sampling locations that may no longer exist, because those data may be useful in establishing a trend. Again, distinctions between filtered and unfiltered results are necessary.

The trend analyses should be performed with the assistance of a statistician and geochemist. Because each site and data set are different, it is difficult to provide general guidance for the statistical and trend analyses. The end of each subsection summarizes the results of the trend evaluations and statistical analyses. Any graphs or plots used for the trend evaluations and statistical analyses should be included in the WSAP.

Site Conceptual Model (Section 2.5)

The aforementioned sections describe the different components of the groundwater and surface water systems. The Site Conceptual Model section summarizes Section 2.0 of the WSAP and should be limited to about three paragraphs. The basic elements of the site conceptual model are as follows (each of the following items can be developed into one or two sentences):

- Process operations, products, and byproducts that have caused or have the potential to cause contamination.
- The physical and hydraulic properties of each water-bearing and confining unit.
- The geochemical type and quality of background groundwater and surface water.
- The extent of groundwater contamination.

- Groundwater flow rates and directions.
- Groundwater and surface water interactions.
- Current and potential receptors.

2.2.3 Data Collection Objectives (Section 3.0)

Section 3.0 of the WSAP presents the regulatory and technical basis for the sampling activities. This Data Collection Objectives section identifies the samples taken for the surface remediation program and the groundwater program. There are five reasons (objectives) for collecting data: regulatory requirements, compliance monitoring, site characterization, risk assessments, and other considerations. Any sections that do not apply to the site-specific WSAP are not included in the WSAP.

Regulatory Requirements (Section 3.1)

Regulatory requirements for groundwater and surface water sampling at the UMTRA sites are described briefly below. These paragraphs should be used for the Regulatory Requirements section of the WSAP. This information is summarized from a review of the regulations referenced and from the TAD (DOE, 1989a):

Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA Public Law 95-604) establishes the statutory and regulatory framework for the stabilization and control of 24 inactive uranium mill tailings sites (Title I sites). Through UMTRCA, the U.S. Environmental Protection Agency (EPA) is directed to establish general regulations and standards for the cleanup and disposal of contamination at the sites. Work at the Title I sites is to be performed under the DOE UMTRA Project. UMTRCA gives the Nuclear Regulatory Commission concurrence and licensing authority for the UMTRA Project disposal and cleanup activities.

The EPA issued final standards for the Title I sites in 1983 as 40 CFR 192. However, the groundwater portion of the standards, 40 CFR 192.20(a)(2) and (3), was remanded in 1985 as the result of a lawsuit by a number of parties.

In 1987, the EPA published proposed revised groundwater regulations (EPA, 1987). Both the UMTRCA and the Atomic Energy Act state that the DOE is to follow proposed standards pending the issuance of a final rule. The DOE currently is obligated to follow the 1987 proposed rule because it is the only one that has been officially proposed.

Compliance Monitoring (Section 3.2)

Compliance monitoring is required for some sites where surface remediation is complete and a disposal cell has been constructed. For those sites, monitoring requirements are for background groundwater quality locations and near the downgradient edge of the disposal cell, or the point of compliance.

Background water quality is defined as "...the representative water quality after completion of remedial action from a given hydrogeologic unit that has not been impacted by past or present activities at the mill site, or, if impacted by past activities, no longer exhibits the impacts" (DOE, 1986).

The WSAP author must determine the locations of the point of compliance wells and background water quality wells. The point of compliance must be adequately monitored, but sampling closely spaced wells is not necessary if the sampling points are redundant. Input from the risk assessment staff should be obtained for determining the locations and number of background water quality wells and background surface water quality sampling locations to be included in the plan.

The Compliance Monitoring section of the WSAP identifies background and point-of-compliance wells based on the regulatory definitions, results from previous monitoring, and input from the risk assessment staff. Recommendations for adding or deleting wells from this portion of the monitoring well network are also made based on well locations, screened intervals, and trend analyses.

Site Characterization (Section 3.3)

Site characterization may be an iterative process at many of the sites and, therefore, will require periodic sampling activities. The sampling decisions will require input from the site hydrologist, geochemist, risk assessment staff, statistician, and possibly a water treatment engineer.

Sampling locations for site characterization are chosen to determine plume location, constituent concentrations, background water quality, and baseline water quality. Baseline water quality is "...representative water quality from a given hydrogeologic unit that has been impacted by past or present activities at the mill site and is not likely to be affected in the future" (DOE, 1986). Sampling of surface water (e.g., streams, rivers, seeps, and springs), which may be receiving groundwater discharge, may be necessary for site and aquifer characterization, identifying potential receptors, and assisting in the interpretation of surface water and groundwater interactions. Sampling wells other than monitor wells also may be necessary for characterization and risk assessment.

Surface water sampling can be based on a seasonal schedule related to water availability and surface water and groundwater interactions. Some springs and

streams may have water only during the wetter months, remaining dry during the summer except during rainfall events. Determination of surface water and groundwater interactions will identify the water source (e.g., base flow, surface water runoff, or a combination of the two) sampled during each surface water sampling event.

Risk Assessment Considerations (Section 3.4)

Sampling locations for risk assessment can be at both surface water and groundwater locations. The sampling results are used to determine background water quality, baseline water quality, plume locations and movement, analyte concentrations, and water quality at potential receptor points. The risk assessment generally requires unfiltered samples and a distinction between the filtered and nonfiltered samples. Decisions regarding sampling frequencies, analytical parameters, and detection limits should be made by appropriate cross-functional interdisciplinary groups.

Other Considerations (Section 3.5)

Some sites may have special sampling considerations that are part of state, local, or tribal requirements. The Other Considerations section defines those requirements, acknowledges the agency or group requiring the sampling, and specifies the sampling points and constituents to be monitored for those purposes.

2.2.4 Data Quality Objectives (Section 4.0)

The Data Quality Objectives section defines the manner in which the samples are collected, handled, and analyzed. The objectives relate to sample collection and preservation procedures and analytical accuracy and the reproducibility of results. A table prepared for this section of the WSAP will define the following information for the proposed sampling:

- Field analytical methods and analytes.
- Laboratory analytical methods and analytes.
- The quality assurance/quality (QA/QC) control level of sample analysis (e.g., Levels A and B for field analyses, Level C for laboratory analyses).
- Detection limits.
- Filtered and nonfiltered samples.
- Sample holding times.
- Sample preservation methods.

- Sampling order (i.e., the sequence of wells and other sampling points).
- Sampling method (e.g., bailer, submersible pump, directly from a spigot).
- The applicable UMTRA SOP for each element of the table.

2.2.5 Sampling Plan (Section 5.0)

The Sampling Plan section presents the sampling locations, analytes (including indicator parameters), and sampling frequencies for the year. This relatively brief section relies on the data and information presented in the above sections for the sampling recommendations. Included are descriptions of the data interpretation methods for the results of the recommended sampling, a summary of the changes to the previous year's plan, and a plan to address anomalous data that may appear as a result of the recommended sampling. Also in this section is the identification of samples for the surface remediation program and the groundwater program.

Sampling Locations, Analyte Selection, and Sampling Frequency (Sections 5.1, 5.2, and 5.3, respectively)

Section 5.1 identifies the monitor well, surface water, and other well (if applicable) locations that will be sampled in the upcoming year; Section 5.2 identifies the field and laboratory analytical parameters, including indicator parameters; and Section 5.3 identifies the sampling frequency for each sampling station. Because the previous sections provide the technical basis and regulatory basis for sampling, Section 5.0 should only present the sampling point designations and recommendations. The information is presented in a narrative form and on a table. The order in which the wells are sampled and the identification of samples taken for the surface remediation program and groundwater program is provided; filtered and nonfiltered samples are specified.

Data Interpretation Methods (Section 5.4)

The Data Interpretation Methods section describes the data analysis methods planned for data collected in the upcoming year. It will likely include trend analyses and geochemical evaluations similar to the methods used to prepare current WSAP recommendations. Additional methods, as well as an evaluation of potential trends, may be proposed because of an increased data base.

Response to Anomalous Data (Section 5.5)

The Response to Anomalous Data section describes the actions to be taken if results from the recommended sampling are above or below a range of expected values. The parameters include both physical parameters (such as groundwater levels or stream stage) and chemical parameters (such as pH or sulfate concentrations). Possible actions are immediate resampling or waiting for the next sampling event.

2.2.6 References (Section 6.0)

The References section includes all literature referenced in the WSAP. Each reference follows the standard format for UMTRA reports.

3.0 SAMPLING FREQUENCY CRITERIA

A significant aspect of each WSAP is determining sampling frequencies. The following sections provide general guidance to base sampling frequency decisions for groundwater and surface water monitoring points. Factors to consider in determining sampling frequencies are regulations, site-specific hydrologic conditions, risk assessment requirements, and geochemical factors. The sampling frequency should provide a cost-effective basis to monitor groundwater and surface water quality in compliance with water quality regulations and applicable guidance.

Most of the methods presented in this section to evaluate sampling frequencies are based on groundwater flow rates. Other methods, based on statistics, are independent of groundwater flow rates and may be appropriate to use at a site (DOE, 1993b). Because the data base for each site is different and is continually updated, general rules for statistical evaluations cannot be described. Therefore, the data must be reviewed with the project statistician. Other considerations also are independent of groundwater flow velocity. These considerations include frequent sampling during surface remediation to identify the potential for construction-induced impacts and frequent sampling to establish a statistical basis for background and baseline water quality.

3.1 REGULATORY REQUIREMENTS

The current and proposed regulations do not specify sampling frequencies other than those that are "...adequate to define..." background water quality, the location of groundwater contamination, the rate of contaminant movement, and disposal cell performance. An approved LTSP or RAP for a site may specify sampling frequencies; however, the sampling interval may be based only on time. For instance, the sampling interval may be stated as quarterly for the first year, semiannually for several years, and annually thereafter. The specified sampling frequencies may not be the most appropriate for the site-specific hydrologic factors, such as groundwater flow rates and well locations. The WSAP provides an opportunity to evaluate the site-specific factors to determine sampling intervals.

3.2 HYDROLOGIC FACTORS

3.2.1 Groundwater flow rates

The relationship between groundwater flow rates and sampling intervals identifies the distance groundwater has traveled from one sampling event to another. For example, the groundwater flow rate at the Tuba City, Arizona, site assumes flow through porous media between 13 and 140 feet per year (ft/yr) [4 to 40 meters per year (m/yr)] (DOE, 1989b). Because of the relatively slow rate of groundwater flow, groundwater moves only 3 to 35 feet (ft) [1 to 10 meters (m)] between quarterly sampling events, 6 to 70 ft (2 to 20 m) between semiannual sampling events, and 13 to 140 ft (4 to 40 m) between annual sampling events.

Moenkopi Wash, the presumed groundwater discharge area and the closest potential receptor, is about 5000 ft (1500 m) downgradient from the leading edge of the plume. Based on very conservative contaminant transport assumptions and the range in groundwater flow rates, it would take between 36 and 380 years (yr) for the leading edge of the plume to move from its present position to the potential discharge point. These estimates are very conservative because they assume that groundwater originating from the site will actually discharge to the wash. The assumptions overestimate the rate of contaminant transport by assuming that there are no effects from dispersion or from attenuation, which would slow the actual rate of contaminant migration. Additionally, the contaminant concentrations could be diluted to below detectable limits prior to reaching the wash.

Sampling frequencies may be based on a convenient or commonly used time interval that is arbitrarily designated. The sampling intervals may not account for the distance groundwater traveled between sampling events. As demonstrated by the above example, quarterly, semiannual, or annual sampling will not provide a cost-effective means to track plume migration. Even during 1 yr, groundwater has not moved a significant distance or a significant percentage of the distance from the source to the potential receptor.

An important aspect for determining sampling frequencies is the distance that groundwater travels between sampling events. A significant groundwater flow distance for purposes of the WSAP is one-fourth the distance between two areas of concern. Areas of concern can be the disposal cell and the point-of-compliance wells, or the leading edge of the plume and a potential receptor.

Using the above example, the areas of concern are the leading edge of the plume and Moenkopi Wash. The shortest estimated arrival time from the leading edge of the plume to the wash, 36 yr, should be used to provide a conservative sampling frequency (i.e., the shortest practical sampling frequency). One-fourth of that distance will be covered in 9 yr. Therefore, a justifiable sampling frequency should be once every 9 yr. For practical purposes, however, the maximum time interval between sampling events should be 5 yr to allow for checking and maintaining the integrity of the wells.

3.2.2 Water quality

Previous water quality results and groundwater velocity estimates can assist sampling frequency recommendations. Using the UMTRA SPEAR (DOE, 1993a) program and the Tuba City site as an example, sulfate concentrations were plotted from three wells within the plume and three wells outside the plume. Figure 3.1 shows the well and plume locations; Figure 3.2 shows the water quality plots. Sulfate was chosen as an indicator parameter because 1) it is a byproduct of sulfuric acid, which was used at the site throughout the history of mill operation, 2) it generally moves at the same rate as groundwater flow, and 3) its background concentrations are relatively low.

FIGURE 3.1
GROUNDWATER MONITOR WELL LOCATIONS
TUBA CITY, ARIZONA, DISPOSAL SITE

FIGURE 3.2
SULFATE CONCENTRATIONS IN MONITOR WELLS AT THE
TUBA CITY SITE, 1988 THROUGH 1992

A visual examination of the water quality plot shows little to no significant variation in sulfate concentrations for the wells outside the plume (903, 910, and 914). Except for one set of lower sulfate values in March 1991, the sulfate concentrations of wells within the plume (906, 908, and 909) also show little to no variation.

Water levels for all site wells plotted for the same period also showed no significant variation with the exception of one measurement from well 908 (Figure 3.3). The water level in well 908 was about 10 ft (3 m) lower in November 1990 than preceding and succeeding measurements. Other wells, including those in the same well cluster as 908, did not show a drop in water levels. Because all of the wells are completed within the same water-bearing unit, water-level fluctuations in one well would be expected to be expressed in the other wells. Therefore, although it could be correct, the measurement is likely an error. Assuming that the water-level measurement from November 1990 is in error, the water levels for the site have remained relatively constant.

The reason for the consistent drop in sulfate concentrations for March 1991 in the plume wells is unclear, but sulfate concentrations have otherwise remained relatively constant. The relatively consistent values may have a basis in groundwater velocity. Groundwater may have moved as little as 52 ft (16 m) or as much as 560 ft (170 m) during the 4 yr on record. Therefore, the plume has not migrated significantly, relative to the distance to the potential receptor (Moenkopi Wash), which is about 5000 ft (1500 m) downgradient from the leading edge of the plume. The combination of relatively consistent water quality and slow groundwater movement would justify more time between sampling intervals.

3.2.3 Seasonal effects

The primary intent of monitoring is to determine groundwater quality at the time of sampling. The current results are compared with previous results to detect water quality trends. A trend in water quality may indicate plume migration, a change in plume concentrations, or a change in background water quality. Changes in water quality may also indicate seasonal fluctuations, which can make the evaluation of long-term trends difficult. Seasonal fluctuations are short-term variations in water quality that are centered around a certain value or closely spaced values and are not indicative of a long-term trend.

The first step in evaluating seasonal trends is to plot water levels and conservative constituent concentrations versus time (or date) for each well. The data are contained in the UMTRA software, SPEAR (DOE, 1993a).

An additional test for trends compares rainfall and stream gauging data with water levels and groundwater constituent concentrations. Stream gauging data provide daily flow rates, stream stage, and sometimes major ion concentrations. The stream data are typically available through the U.S. Geological Survey. Rainfall data are collected at large airports and many small airports and are available through the National Oceanic and Atmospheric Administration.

FIGURE 3.3
GROUNDWATER ELEVATIONS IN MONITOR WELLS AT THE
TUBA CITY SITE, 1986 THROUGH 1992

The plots can be statistically evaluated for seasonal or temporal trends. If a trend exists, sampling frequencies can be designed to accommodate the trend. One possible strategy is to sample at the historic high and low concentration periods. An alternate sampling strategy is to sample at the historical average period.

The results from the trend evaluation may not show seasonal variations or seasonal trends. However, that does not mean that they do not exist. The data base may not be large enough or the samples may have been consistently taken at average, high, or low periods. If the presence or absence of seasonal trends or variation is an important factor, sampling frequencies or dates may be modified or established to test the hypothesis of seasonal variations or trends.

3.2.4 Surface water sampling

The timing of sampling events for surface water will depend upon the purpose of the surface water sampling and the presence of surface water and meteorologic conditions prior to and during sampling. Springs, seeps, streams, and rivers may flow seasonally depending upon rainfall, snowmelt, and the groundwater and surface water interactions within the drainage basin and groundwater recharge area. Control structures such as dams, which can affect flow both upstream and downstream of the structure, also should be considered for larger rivers or streams.

Stream flow records can indicate typical periods of runoff, low flow, or no flow. However, brief rain storms can dramatically increase flow, or extended dry weather can reduce flow outside of the typical ranges. Because these conditions are not always known prior to sampling, sampling events must be designed to be flexible.

If the purpose of the sampling event is to determine the quality of groundwater discharging into the stream as base flow, sampling must occur during periods of base flow only. Because of the relatively arid conditions at many of the UMTRA sites, low flow may not always indicate base flow or discharge of groundwater into the stream. Low flow may be indicative of a period when stream flow is recharging the aquifer.

If the purpose of the sampling event is to determine the quality of surface water runoff within the drainage area, the stream should be sampled during periods of high flow. There may be more than one typical period of high flow, with one period representing snow melt and another period representing high rainfall. The quality of the runoff may be very different depending upon the runoff source. In summary, a surface water sampling program should identify the type of surface water sample to be taken (e.g., surface runoff, base flow), and stream flow and meteorological conditions must be recorded at the time of sampling to assist in the interpretation of the type of sample actually obtained. Conditions of surface water bodies should be recorded during every sampling event, even if a sample is not obtained, to guide upcoming surface water sampling events.

Meteorologic conditions and groundwater levels are a controlling factor for the occurrence of springs and seeps. The spring or seep conditions also should be recorded during every sampling event, including an estimate of discharge rate.

3.3 RISK ASSESSMENT CONSIDERATIONS

Because sampling provides information for risk evaluations, the WSAP preparation involves input from the risk assessment staff. Therefore, it is necessary to review sampling requirements with the risk assessors and relate site hydrologic conditions to any proposed sampling. For example, sampling intervals that may be required for risk evaluation may be based on a time factor. However, because of the relatively slow movement of groundwater at many of the sites, significant groundwater movement may not occur among quarterly, semiannual, or even annual sampling events. Additional risk assessment considerations are seasonal water level and surface water and groundwater interactions, analyte selection, filtered and nonfiltered samples, and detection limits.

It may be possible, based on hydrologic factors, to design a sampling frequency useful to the risk evaluation and for monitoring purposes. For example, if the groundwater flow rate is about 50 ft/yr (15 m/yr) and a plume is about 5000 ft (1500 m) from a potential receptor such as a stream or seep, it would take 100 yr for the plume to reach the receptor. This is a very conservative estimate that does not account for factors such as dispersion and attenuation, which will slow the rate of plume migration, or dilution, which could cause the plume to be below detectable limits by the time it reaches the receptor. Because of the length of plume travel time, it would be necessary only to establish baseline conditions at the potential receptor with a few sampling events. Monitoring at annual or shorter intervals would not be necessary until the plume is closer to the receptor.

3.4 GEOCHEMICAL CONSIDERATIONS

A number of geochemical factors should be considered, such as attenuation, sorption/desorption, secondary sources in aquifer materials, and reaction kinetics. Generalized applications that could be used at every site are probably not possible due to the site-specific nature of groundwater geochemistry and each site's data base. The WSAP author must be aware of the different geochemical reactions that may affect the sampling and request assistance and evaluations from an UMTRA geochemist as necessary.

4.0 SAMPLING LOCATION SELECTION CRITERIA

4.1 REGULATORY REQUIREMENTS

Depending on site conditions and site status, several different types of monitor wells may control sampling requirements. A typical site could require the sampling of background water quality, point-of-compliance water quality, and plume assessment water quality. For sites with relatively consistent background water quality relative to location, one background water quality monitoring location may be sufficient. Variation due to seasonal effects should influence a sampling frequency decision. If background water quality varies with location or if the purpose of sampling is to determine areal variations in background water quality, additional background water quality locations should be sampled.

A minimum of one sampling location at the downgradient edge of a disposal cell should be established for point of compliance sampling. Additional sampling locations can be added for plume definition, if a plume is within or close to the point of compliance.

Typically, one or more sampling locations for plume delineation can be used as indicators for the lateral and vertical extent of groundwater contamination. Usually only one well of closely spaced wells that monitor the same water-bearing unit needs to be sampled. Screen length and gravel-packed interval also should be considered when selecting wells and well locations. Typically, a well with a long screened and gravel-packed interval is not useful for vertical plume definition.

4.2 HYDROLOGIC FACTORS

The characteristics of the water-bearing units must be considered to design sampling recommendations. Nonhomogeneous materials such as alluvial deposits are likely to have layers of varying porosity, permeability, and groundwater velocity. Therefore, they may require more wells to monitor plume migration than relatively homogeneous formations such as eolian deposits.

The groundwater flow rate also is an important factor for monitoring locations and is related to sampling frequency. Well spacing can be considered as time along flow paths. For example, assume that the groundwater flow rate is 35 ft/yr (10 m/yr) at the Tuba City site (Figure 3.1). Wells 906, 909, and 903 monitor the contamination zone, and the wells are roughly in a straight line parallel with the groundwater flow direction. Wells 906, 909, and 903 are about 200, 800, and 1300 ft (60, 240, and 390 m) from the edge of the disposal cell, respectively.

Using a groundwater flow rate of 35 ft/yr (10 m/yr), it will take approximately 6, 27, and 37 yr for water to travel from the edge of the disposal cell to wells 906, 909, and 903, respectively. These are conservative estimates that do not

account for the effects of dispersion and attenuation, which will slow the migration of contaminants. Because the potential receptor, Moenkopi Wash, is about 5000 ft (1500 m) (or 140 yr) downgradient from well 903, it is not necessary to determine the exact point in time that the plume reaches well 903. Therefore, the next sampling interval for well 903 could occur many years in the future without losing critical information. The sampling frequency would be quite different for a well in a similar location downgradient from the contaminant source, but closer to a potential receptor and within an aquifer with a higher groundwater velocity.

4.3 RISK ASSESSMENT CONSIDERATIONS

In addition to establishing background water quality and the extent of the plume, risk assessment activities may require sampling at or near potential receptor points. The purpose of the sampling is to detect concentration trends or establish background or baseline water quality. The areas to be sampled may be monitor wells, private wells (irrigation or water supply), springs, seeps, ponds, or streams and rivers.

4.4 GEOCHEMICAL CONSIDERATIONS

As stated in Section 3.4, a number of geochemical factors should be considered, such as attenuation, sorption/desorption, secondary sources in aquifer materials, and reaction kinetics. Generalized applications that could be used at every site are probably not possible, due to the very site-specific nature of groundwater geochemistry and each site's data base. The WSAP author must be aware of the different geochemical reactions that may affect the sampling, and request assistance and evaluations from an UMTRA geochemist.

5.0 ANALYTICAL PARAMETER SELECTION CRITERIA

5.1 REGULATORY REQUIREMENTS

According to UMTRCA (42 U.S.C. 7901-7942), the DOE is required to meet proposed groundwater standards for groundwater protection and cleanup until final standards are promulgated. Table 5.1 lists the constituents and maximum concentration limits (MCLs) for groundwater from the proposed regulation. To identify concentrations of any regulated contaminants emanating from the site, the concentrations of each constituent listed in Table 5.1 must be determined initially in background and downgradient wells. In addition, the constituents listed in Appendix IX of 40 CFR 264 must be analyzed initially in background and downgradient wells if samples from the tailings pore fluids are not analyzed.

5.2 CONTAMINANTS OF CONCERN

For processing sites, including stabilization-in-place and stabilization-on-site sites, contaminants of concern (COC) are those constituents listed in Table 5.1 and Appendix IX of 40 CFR 264 that exceeded detection limits in tailings pore fluids. If sufficient volumes of tailings pore fluids are not available for analysis, the initial list of COCs to be measured in processing site groundwater should be the constituents listed in Table 5.1 in addition to the constituents listed in Appendix IX of 40 CFR 264.

With the surface phase of the UMTRA Project nearing completion, the initial lists of COCs have been defined at most UMTRA processing sites. These lists are presented in RAPs and/or LTSPs. As additional sampling rounds are completed at each processing site, these initial COC lists should be updated annually to reflect new data. To establish the list of indicator parameters, organic constituents not detected in the 1988 survey of organic constituents can be deleted from the list. Inorganic COCs not detected in the latest three sampling rounds also can be deleted. Those COCs with MCLs can be deleted from the indicator parameter list if they have not exceeded their respective MCLs for three or more sampling rounds and the most recent analyses do not indicate a consistent increasing trend in concentrations. However, sampling requirements for risk assessment purposes may supersede these guidelines for individual, specific sampling rounds.

At disposal sites, the lists of COCs to be analyzed are also presented in RAPs and/or LTSPs. As in the case of processing sites, these lists may be based on tailings pore fluids analyses, information on chemicals used in processing the ore, and/or the results from disposal site monitoring. However, the lists presented in the RAPs and LTSPs may be revised through the WSAP to reflect more cost-effective sampling strategies.

Because the main concern at disposal sites is potential leakage from the cell, the list of analytes to be sampled should be heavily weighted toward indicator

Table 5.1 Groundwater standards for UMTRA inactive sites(Summarized from EPA^a proposed standards of 9/24/87)
(40 CFR^b Part 192)

<u>Maximum concentration limits</u> (Table 1, 40 CFR 264.94 and Table A, 40 CFR 192.02)		
Arsenic (As)	0.05 mg/L ^c	
Barium (Ba)	1.0	
Cadmium (Cd)	0.01	
Chromium (Cr)	0.05	
Lead (Pb)	0.05	
Mercury (Hg)	0.002	
Molybdenum (Mo)	0.1	
Nitrate (NO ₃ (as N ^d))	10.0	(= 44.0 mg/L NO ₃)
Selenium (Se)	0.01	
Silver (Ag)	0.05	
Endrin	0.0002	
Lindane	0.004	
Methoxychlor	0.1	
Toxaphene	0.005	
2,4-D	0.1	
2,4,5-TP	0.01	
Combined radium (Ra-226 & 228)	5.0	pCi/L ^e
Combined uranium (U-234 & 238)	30.0	" (calc. to be 0.044 mg/L)
Gross alpha (excluding Rn ^f & U ^g)	15.0	"

Appendix IX(Partial list: only inorganics with no MCL^h)(40 CFR 192.02 (9/24/87) refers to Pt. 264.93 (7/1/86), which refers to Append. VIII of Pt. 261. EPA Final Rule (eff. 9/28/87): Append. IX, Pt. 264 replaces Append. VIII for RCRAⁱ groundwater monitoring.

Antimony (Sb)	(No concentration limits
Beryllium (Be)	specified, but must not
Carbon disulfide (CS ₂)	exceed background)
Cobalt (Co)	
Copper (Cu)	
Cyanide (CN)	
Fluorene (F ₂)	
Nickel (Ni)	
Sulfide (S)	
Thallium (Tl)	
Tin (Sn)	
Vanadium (V)	
Zinc (Zn)	

^aU.S. Environmental Protection Agency^bCode of Federal Regulations^cmilligrams per liter^dnitrogen^epicoCuries per liter^fradon^guranium^hmaximum concentration limitsⁱResource Conservation and Recovery Act

parameters. These are parameters that travel at approximately the same rate as groundwater. Indicator parameters are discussed in more detail in the following section (5.3). If indicator parameter breakthrough is detected at a given site, the COC list should be updated in the next sampling round to more clearly reflect the COC list originally presented in the RAPs and/or LTSPs.

5.3 INDICATOR PARAMETERS

Indicator parameters are constituents that travel at approximately the same rate as groundwater and are present in tailings pore fluids at easily detectable concentrations. They provide the clearest indication of plume movement at processing sites and an early warning signal for COC migration from disposal cells. Indicator parameters may or may not be on the COC list for a given site, but are products or byproducts of mill operations. Examples of indicator parameters are chloride, nitrate, sulfate, total dissolved solids, and specific conductance.

The site geochemist, in consultation with the site hydrologist and the statistician, should identify indicator parameters at each processing and disposal site. Once identified, these parameters should be analyzed in each sampling round at the site. The analytical results should be plotted on concentration versus time plots with other historical data for each well sampled at the site. Deviations from historical trend lines that are outside of quoted analytical errors should be analyzed to evaluate whether the deviations are real or artifacts of the analytical or sampling procedures. If analytical or sampling artifacts are not identified, the deviations must be considered as real and may call for additional actions (e.g., evaluative monitoring at disposal sites).

5.4 RISK ASSESSMENT CONSIDERATIONS

Potential human and environmental health concerns of constituents released from the site guides the choice of analytes for risk assessment purposes. The risk assessment COCs may or may not be listed in Table 5.1 or Appendix IX of 40 CFR 264. The critical concern is whether the constituents, in nonfiltered water samples, are elevated above background as a result of site operations. Those constituents with historical concentrations above background are compared to the accepted nutritional range. If the levels in downgradient wells are within the nutritional levels, they are eliminated from the list. The remaining constituents are then evaluated for their toxicity. Those constituents of low toxicity and high dietary range are eliminated from the list. The remaining constituents are listed as risk-based COCs. The site risk assessor, in consultation with the site geochemist, site hydrologist, and statistician, should develop this list of contaminants for each site.

Because risk assessment calculations can involve different COC species in groundwater at a given site, major constituents should be analyzed in filtered risk assessment samples in addition to the COCs. This will allow a calculation to estimate relative concentrations of ionic species in solution.

Constituents that impact fresh water organisms at very low concentrations is another risk assessment concern, mainly for surface water sampling. As an example, the Federal water quality criteria for aluminum, beryllium, lead, and silver are below commonly used detection limits, but these elements in surface waters may impact aquatic life. If contaminated waters from a given site are discharged to a surface water body, it may be useful to establish background concentrations of nonplume constituents that can impact aquatic life prior to the plume reaching the surface water body. Perhaps the water quality in the potential discharge area is unsuitable or is currently impacted due to naturally occurring constituents. Alternatively, the water quality of the potential discharge area may be acceptable for aquatic life, necessitating clean-up of the plume prior to discharge into the surface water body.

5.5 GEOCHEMICAL CONSIDERATIONS

The geochemical considerations that impact the selection of analytes include the following:

- The need for complete major constituent analyses and field parameters to allow species identification of contaminant elements for risk assessment.
- The need for major constituent analyses and field parameters to allow fingerprinting of groundwater types at a site, and potentially to provide a basis for identifying natural or nonsite-related sources of contaminants.
- The need for specific constituent analyses (e.g., total iron) and/or field parameters (e.g., Eh) to support the groundwater protection strategy for the site when it involves a geochemical argument.
- The need for major constituent analyses and field parameters to support potential groundwater restoration strategies and transport modeling efforts at the site.
- The need for complete major component analyses for QA/QC purposes including cation/anion balance and sum of total dissolved solids calculations.

To calculate the speciation of a given chemical element in solution (e.g., filtered groundwater), the concentrations of the major constituents in the solution must be known. Risk assessment calculations commonly require the speciation of certain COCs in groundwater. Therefore, whenever samples are collected for risk assessment purposes, the major constituents and field parameters [i.e., calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, pH, Eh, dissolved oxygen (DO), and temperature] must be analyzed in the water samples collected.

At some UMTRA sites, background groundwater may have relatively high levels of some contaminants generally associated with uranium mill tailings sites. By fingerprinting the various groundwater quality types that may exist at the site

using major element chemistry, it is often possible to distinguish relatively high COC levels in background groundwater from elevated levels resulting from site activities. If high COC levels in background groundwater are suspected at a particular site, historical major element data for the site should be evaluated to distinguish high background COC levels from site-related contamination. The site geochemist, in consultation with the site hydrologist, statistician, risk assessor, and engineer, as appropriate, should conduct this examination. If data are insufficient for this evaluation, additional sampling of major constituents may be warranted.

Groundwater protection strategies involving geochemical retardation arguments may require the documentation of certain geochemical conditions. For instance, if the groundwater protection strategy calls for immobilization of the contaminants through chemical reduction, appropriate data should be collected to document the existence of sufficiently reducing conditions in the aquifer. This could involve the measurement of DO, oxidation/reduction potential (ORP), and appropriate redox couples such as $\text{Fe}^{3+}/\text{Fe}^{2+}$, $\text{SO}_4^{2-}/\text{S}^{2-}$ and $\text{NO}_3^-/\text{NH}_4^+$. The site geochemist, in consultation with the site hydrologist and the site risk assessor, should select appropriate analyses. As a minimum, ORP and DO should be measured in appropriate wells in the field during every sampling round at the site.

Although specific groundwater restoration strategies have not been selected at each processing site, the sampling plan should attempt to anticipate the data needs for evaluating the range of strategies under consideration. Although the detailed data needs for the different strategies available cannot be defined here, the site geochemist, site hydrologist, and site engineer should consider this aspect in annual sampling requirements.

The QA/QC requirements for analyte selection involve checking the charge balance and mass balance. The charge balance check ensures that the analysis of major cationic and anionic constituents was conducted properly. This is particularly critical in relation to major indicator constituents such as sulfate. Trend analysis of sulfate concentrations commonly show isolated spikes, which upon further evaluation with charge and mass balance calculations are found to be due to previously unrecognized analytical errors. Without the charge and mass balance checks, such spikes could not be detected and could lead to regulatory compliance problems. The site geochemist, in consultation with the site hydrologist, data manager, and statistician, as appropriate, should evaluate anomalous data points. If a specific indicator parameter shows an erratic historical trend at a given site, one or more rounds of complete major constituent analysis may be useful to rule out an analytical source for the erratic pattern. The site geochemist, in consultation with the site hydrologist and data managers, should decide whether to conduct major constituent analyses.

6.0 WSAP FILE CONTENTS

The WSAP will be as brief as possible while describing the basis for the sampling decisions. The WSAP will contain the results from a number of calculations and assumptions, but not the back-up information. Such additional detail will be stored in a formal WSAP file in the UMTRA Project Document Control Center.

The WSAP file for a particular site will have subfiles for each year. These subfiles will contain the following items, each within its own folder with the following headings:

- Piezometric surface maps.
- Groundwater level graphs.
- Groundwater quality graphs.
- Groundwater velocity calculations.
- Surface water data.
- Regulatory requirement notes.
- Risk assessment notes.
- Legal access requirements to all wells.
- Maps showing detailed physical access (i.e., roads and gates) to all wells.

7.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this report.

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