

Chemistry of Phase I Phytoremediation Soils: Work Plan for the Monument Valley, Arizona, UMTRA Project Site

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UMTRA Ground Water Project

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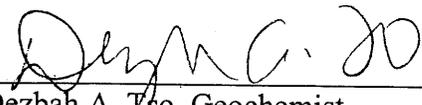
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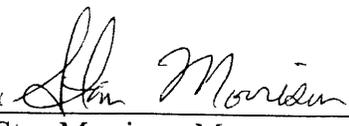
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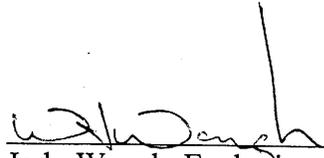
Chemistry of Phase I Phytoremediation Soils: Work Plan

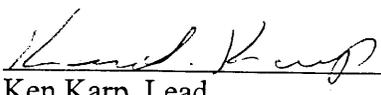
UMTRA Ground Water Project
Monument Valley, Arizona, Site

September 2001

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Acronyms and Abbreviations

ACL	(GJO) Analytical Chemistry Laboratory
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESL	(GJO) Environmental Sciences Laboratory
ft	feet
GJO	Grand Junction Office
HCl	hydrochloric acid
IDW	investigation derived waste
MCL	Maximum Concentration Limits
MΩ	mega ohm
mg/kg	milligrams per kilogram
mm	millimeters
NEPA	National Environmental Policy Act
SOWP	Site Observational Work Plan
UA-ERL	University of Arizona – Environmental Research Laboratory
UMTRA	Uranium Mill Tailings Remedial Action Project

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1.0 Introduction

1.1 Purpose and Scope

This work plan describes a study to evaluate the soil chemistry of soils where phytoremediation shrubs are growing poorly in the phytoremediation planting area at the Uranium Mill Tailings Remedial Action (UMTRA) Project site at Monument Valley, Arizona. The U.S. Department of Energy (DOE) is developing plans to remediate ground water at the Monument Valley UMTRA site. Soils and ground water at the site were contaminated as a consequence of milling operations between 1955 and 1968. Surface remediation was completed in 1994. Analyses of ground water samples in from 1982 to the present indicate that nitrate levels exceed U.S. Environmental Protection Agency (EPA) standards for protection of human health. Residual ammonium and nitrate in the subpile soils where surface tailings piles were removed may be a continuing source of ground water nitrate. Ground water and soil contamination at any UMTRA site depend upon a variety of factors; some of these factors can include ore and host rock mineralogy, geology of the site, the milling process (Merritt 1971), chemicals used, aquifer characteristics, geochemical interactions between fluids (milling fluids and water) and solids (tailings, site bedrock, etc.), and biological characteristics. These factors make the contaminants present and their lateral and horizontal distribution unique to a particular site.

In the summer and fall of 1999, a native plant phytoremediation operation was initiated remove ammonia and nitrate from the subpile soils, Figure 1–1. Figure 1–1 shows the four plant zones of the phytoremediation planting area. Fourwing saltbush (*Atriplex canescens*) and some greasewood (*Sarcobatus vermiculatus*) were planted in a 1.8 hectare area (DOE 1998a). These native phreatophytes have been shown to enhance extraction of nitrate and ammonium from the alluvial aquifer. Phreatophytes are plants that survive in the desert by rooting into ground water.

Atriplex and *Sarcobatus* survival was only 80 percent over the first growing season (UA–ERL 2000). A malfunctioning irrigation system caused some of the fatalities. The irrigation system was repaired and dead transplants were replaced for the 2000 growing season. Evaluation of the plants in September 2000 revealed a 97.3 percent survival rate (UA–ERL 2000). A dark mottled layer of soil occurs just below the surface within the western part of the planting area and is visible on the surface in some places. Also visible on the surface are salt deposits. Many plants within this stained and salty area suffer from poor growth. Salt deposits are visible on soil surfaces throughout the valley. Within the site, salt deposits and mottled soil seem to appear more often in the area of poor plant growth and may be related to poor plant growth.

To help determine the effects of the dark mottled soil layer and salt chemistry on plant growth, this work plan describes a pilot study designed to evaluate the soil chemistry in the area of poor growth. Background information concerning the geologic setting is summarized in Section 2.0. Information regarding the source of ground water and soil contamination is summarized in Section 3.0. Section 4.0 summarizes the data needed. The experimental design of the study, field sampling methods, and analytical methods are described in Section 5.0.

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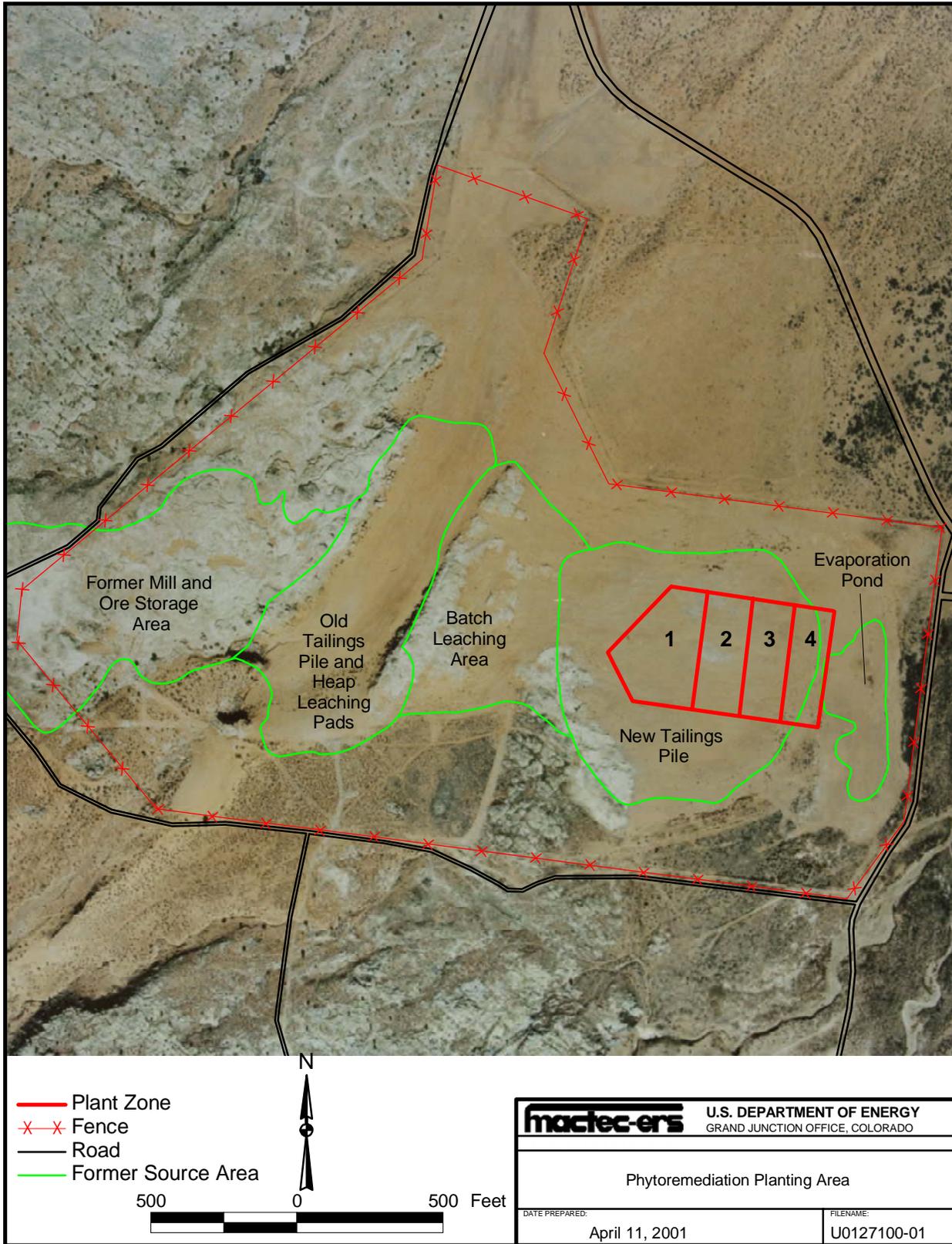


Figure 1-1. Subpile Soil Phytoremediation Location With Plant Zones and Former Contamination Source Areas

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2.0 Site Background

2.1 Geology

Information in this section is from DOE 1999a. The Monument Valley site is located on the west side of Cane Valley and is accessible from Bureau of Indian Affairs Navajo Service Road 6440, approximately 5 miles south of the Arizona-Utah border. The elevation of the valley floor along Cane Valley Wash east of the former tailings pile is approximately 4,800 feet above the National Geodetic Vertical Datum of 1929. Cane Valley drains to the north. Comb Ridge, a 600-ft-high escarpment of Navajo, Kayenta, and Wingate Sandstones, forms the border of Cane Valley on the east.

2.1.1 Geology

The geologic formations that underlie the Monument Valley site have been described by Witkind and Thaden (1963). In descending order, they include Quaternary material, the Shinarump Member of the Chinle Formation, Moenkopi Formation, and De Chelly Sandstone Member of the Cutler Formation. Surface exposures within the site boundary include Quaternary material and the Shinarump Member of the Chinle Formation.

Unconsolidated Quaternary deposits dominate the fenced area of the site. Quaternary deposits lie unconformably over the Shinarump conglomerate and portions of the Shinarump are difficult to differentiate from Quaternary material. The Shinarump Member of the Triassic Chinle Formation crops out in the southwest area of the site.

2.1.2 Quaternary Material

Quaternary deposits consist of alluvial (sand and minor gravel), eolian (fine grained and very fine grained sand), and minor lacustrine (sandy clay) material. Quaternary material at the site is typically as much as 90 ft thick. Active and partly stabilized sand dunes 15 ft high cover much of the valley immediately north-northeast of the former processing site. Sand dunes are visible at the surface in the southwest area of the site.

2.1.3 Chinle Formation

The Shinarump Member of the Chinle Formation is composed of a heterogeneous combination of mainly light gray, firmly cemented, crossbedded sandstone, conglomerate, and minor mudstone beds. These sediments were deposited in a series of meandering channels. The resistant member is 50 to 90 ft thick and forms an irregular, hummocky slope that dips eastward at approximately 4 to 6 degrees where it is exposed in the western part of the site. In the subsurface of the central and eastern parts of the site, the eastward dip of the Shinarump becomes shallower at only 2 to 3 degrees. The basal fluvial channels of the Shinarump have contained important vanadium and uranium deposits in the Colorado Plateau area. This depositional environment hosted vanadium and uranium mineralization at the Monument No. 2 mine just west of the site.

2.2 Ground Water Hydrology

The aquifer of interest is the uppermost aquifer in the unconsolidated Quaternary deposits. The uppermost aquifer is limited in areal extent and varies in thickness. The unit is thickest in the center of Cane Valley but thins toward each edge of the valley and is not present at the bedrock exposures along the eastern and western sides of the valley. Ground water within the uppermost aquifer is unconfined. Depth to ground water ranges from 8 ft to 50 ft below ground surface.

In the vicinity of the site, uppermost ground water generally flows north with some localized variations. Recharge to the aquifer is from precipitation and from upward leakage from the aquifers below. The Monument Valley area receives approximately 8 inches of precipitation annually, only "a fraction (DOE 1999a)" enters the aquifer. Discharge from the uppermost aquifer is through evapotranspiration, evaporation where the water table is at or near land surface, and occasional discharges to Cane Valley Wash. Pumping from the uppermost aquifer is limited because of the sporadic water quality and the lower yields when compared to the deeper aquifers.

2.3 Climate

The site is in an arid climate. The two driest months are generally May and June. Most precipitation usually occurs during two time periods: July through August and December through February (DOE 1996). Rainfall during the summer commonly occurs as high-intensity, short-duration storms, which result in runoff. Precipitation during the winter usually occurs during low-intensity, longer duration storms (DOE 1996).

The weather station closest to the Monument Valley site is in Mexican Hat, Utah approximately 14 miles north of the site. The average annual pan evaporation rate, determined from 1951 through 1980 is 84.4 inches at Mexican Hat (DOE 1996). Pan evaporation rates exceed precipitation every month except January. The highest rates are from May through August, when pan evaporation exceeds 10 inches per month.

The potential for rainfall infiltration and recharge to the ground water system may be limited in the summer months due to the rainfall patterns, high evaporation rates, and evapotranspiration from plants. However, the rainfall pattern in the winter months, combined with lower evaporation rates and limited evapotranspiration from plants (due to the freezing temperatures) increases the potential for ground water recharge during those months.

2.4 Plant Ecology

The subpile soil planting is a type of phytoremediation. The term phytoremediation (*phyto* = plant and *remediation* = to correct a wrong) is the name given to a set of technologies that use plants to clean contaminated sites (EPA 2000). Phytoremediation techniques apply information that has been known for years in agriculture and range science to solving an environmental problem. Therefore, the phytoremediation planting is an application of plant ecology. Ideally, the planting will serve several functions in the disturbed ecosystem: (1) extract ammonium and nitrates from the subpile soils, (2) convert ammonium and nitrates in useful plant biomass, (3) minimize water infiltration and leachate movement, and (4) enhance restoration of disturbed plant communities.

Phreatophytes (literally “well plants”) at the Monument Valley site may act, in essence as passive, solar-powered, pump-and-treat systems for ammonium and nitrate. Two phreatophytes populations grow in the area: *Sarcobatus vermiculatus* (black greasewood) and *Atriplex canescens* (fourwing saltbush). *Sarcobatus* is an obligate phreatophyte requiring a permanent ground water supply and can transpire water from aquifers as deep as 18 meters below the land surface (Nichols 1993). *Atriplex* is a facultative phreatophyte; it takes advantage of ground water when present but can tolerate periods of low water availability. The rooting depth of *Atriplex* may exceed 12 meters (Foxx et al. 1984).

Table 2–1 lists all plant species identified at the site. The occurrence and relative abundance of species, coupled with knowledge of their physiological and ecological tolerances, provide measures of the health of the ecosystem and provide evidence of environmental conditions that is of importance for evaluating phytoremediation. *Sarcobatus* and *Atriplex* are the dominant native shrubs in the area. Results of a gradient analysis suggest that some dominant species are associated and that associations overlap—a given stand may occur in more than one association. Four associations occur in the vicinity of the former millsite, named for their two most abundant shrubs:

- *Sarcobatus vermiculatus* (black greasewood) and *Atriplex confertifolia* (shadscale),
- *Atriplex canescens* (fourwing saltbush) and *Haplopappus pluriflorus* (jimmyweed),
- *Poliomintha incana* (bush mint) and *Ephedra torreyana* (joint fir), and
- *Salsola iberica* (Russian thistle) and *Ambrosia acanthacarpa* (bur ragweed).

Table 2–1. Plants Growing in the Vicinity of the Former Monument Valley Millsite

Scientific Name ^a	Acronym ^b	Common Names ^c
Shrubs		
<i>Artemisia filifolia</i> Torr.	AFRI	sand sagebrush, old-man sagebrush
<i>Atriplex canescens</i> (Pursh) Nutt.	ATCA	fourwing saltbrush, cenizo, chamizo
<i>Atriplex confertifolia</i> (Torr. & Frem.) Wats.	ATCO	shadscale, spiny saltbush, sheep fat
<i>Chrysothamnus nauseosus</i> (Pall.) Britt.	CHNA	rubber rabbitbrush, chamisa
<i>Ephedra torreyana</i> S. Wats.	EPTO	joint fir, Mormon tea, Brigham tea
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	GUSA	broom snakeweed
<i>Haplopappus pluriflorus</i> (Gray) Hall	HALP	jimmyweed, jimmy goldenbush
<i>Lycium pallidum</i> Miers	LYPA	tomatillo, desert wolfberry
<i>Opuntia phaeacantha</i> Engelm.	OPPH	prickly pear, many-spined cactus
<i>Poliomintha incana</i> (Torr.) Gray	POIN	bush mint, rosemary-mint, purple sage
<i>Sarcobatus vermiculatus</i> (Hook) Torr.	SAVE	black greasewood, chico, chicobush
<i>Senecio douglasii</i> DC.	SEDO	threadleaf groundsel, creek senecio
<i>Tamarix ramosissima</i> Ledeb.	TARA	tamarisk, salt cedar, tamarisco
<i>Yucca angustissima</i> Engelm.	YUAN	Tsá'ázi'ts'óóz, narrowleaf yucca, fineleaf yucca

^aThe scientific nomenclature and authorities are consistent with Voss (1983) and the choices of Welsh et al. (1987).

^bAcronyms combine the first two letters of the genus and species names.

^cEnglish and Spanish common names are from a variety of sources (Dodg 1985; Dunmire and Tierney 1995; Elmore and Janish 1976; Whitson 1992).

Table 2–1. (continued) Plants Growing in the Vicinity of the Former Monument Valley Millsite

Scientific Name ^a	Acronym ^b	Common Names ^c
Grasses		
<i>Aristida purpurea</i> Nutt.	ARPU	Purple threeawn, wiregrass
<i>Bromus tectorum</i> L.	BRTE	Zéé'ilwo'ii, cheatgrass brome, downy brome
<i>Festuca microstacys</i> Nutt.	FEMI	small fescue, vulpia
<i>Hilaria jamesii</i> (Torr.) Benth.	HIJA	galleta, curly grass
<i>Oryzopsis hymenoides</i> (R. & S.) Ricker	ORHY	Indian ricegrass, sand bunchgrass
<i>Sporobolus airoides</i> (Torr.) Torr.	SPAI	alkali saccaton
<i>Sporobolus cryptandrus</i> (Torr.) Gray	SPCR	sand dropseed
<i>Sporobolus contractus</i> A.S. Hitchc.	SPCO	spike dropseed
<i>Sporobolus giganteus</i> Nash	SPGI	giant dropseed
Forbs		
<i>Tripterocalyx carneus</i> (Greene) Galloway	TRCA	wooton sandverbena
<i>Chenopodium album</i> L.	CHAL	common lambsquarter, goosefoot
<i>Ambrosia acanthacarpa</i> Hook.	AMAC	bur ragweed
<i>Amsinkia tessellata</i> Gray	AMTE	rough fiddleneck
<i>Arabis</i> L. species	AR sp.	rockcross mustard
<i>Astragalus</i> L. species	AS sp.	milkvetch, locoweed
<i>Datura wrightii</i> Regel	DAWR	sacred datura, angels trumpet
<i>Descurainia pinnata</i> (Walter) Britt.	DEPI	pinnate tansey-mustard
<i>Erigeron</i> L. species	ER sp1.	Daisy
<i>Eriogonum Michx.</i> Species	ER sp2.	wild buckwheat, skeletonweed
<i>Kochia scoparia</i> (L.) Schrader	KOSC	kochia, summer cypress
<i>Lepidium</i> L. species	LE sp.	pepperweed, peppergrass
<i>Lupinus</i> L. species	LU sp.	Lupine
<i>Machaeranthera</i> Nees. Species	MA sp.	Aster
<i>Oenothera albicaulis</i> Pursh	OEAL	white-stemmed evening primrose
<i>Plantago patagonica</i> Jacq.	PLPA	wooly plantain
<i>Salsola iberica</i> Sennen & Pau	SAIB	Russian thistle, tumbleweed
<i>Sphaeralcea coccinea</i> (Pursh) Rydb.	SPCO	scarlet globemallow, falsemallow
<i>Sphaeralcea parvifolia</i> A. Nels	SPPA	Nelson globemallow

^aThe scientific nomenclature and authorities are consistent with Voss (1983) and the choices of Welsh et al. (1987).

^bAcronyms combine the first two letters of the genus and species names.

^cEnglish and Spanish common names are from a variety of sources (Dodge 1985; Dunmire and Tierney 1995; Elmore and Janish 1976; Whitson 1992).

3.0 Sources of Contamination

Contaminants to both ground water and soils and sediments were derived from ore and from chemicals used during ore processing.

3.1 Ground Water Contamination

Some ground water contamination probably occurred during the ore processing period (1955 to 1968) as a result of water draining from tailings that were placed as slurry. The primary contaminants would have been relatively soluble components of the ore, such as uranium, calcium, and sulfate. Infiltration of the contaminated water would have occurred at the former mill and old tailings areas, Figure 3-1.

Process chemicals were an additional source of sulfate, nitrate, calcium, and ammonium. Both the batch- and heap-leaching operations used sulfuric acid to sequester and remove uranium. The sulfuric acid solutions were neutralized to pH 4 with ammonia. Quicklime (calcium oxide) was then added to raise the pH to 7 and produce a bulk precipitate.

Ammonium, calcium, nitrate, and manganese are the site-related constituents most prevalent in the alluvial aquifer and are the constituents that most frequently exceed the upper limit of natural background (DOE 1999a, Section 5.3.3.1). Less frequently other site-related constituents that exceed the upper limits of natural background are sulfate, magnesium, potassium, iron, uranium, strontium, and gross alpha (DOE 1999a, Section 5.3.3.1).

Ammonium and nitrate provide the greatest contrast to natural background concentrations in the alluvial aquifer. The maximum ammonium concentration is 423 times the upper range in natural background and the maximum nitrate concentration is 22 times the upper range in natural background (DOE 1999a, Section 5.3.3.1). Maximum concentrations of calcium, magnesium, and sulfate occur between 5 to 11 times the upper ranges in natural background. Maximum concentrations of potassium, strontium, uranium, and gross alpha occur at levels less than 5 times the upper range of natural background (DOE 1999a, Section 5.3.3.1).

Nitrate and uranium are the only site-related constituents with ground water concentrations that exceed established maximum concentration limits (MCLs) established in 40 CFR 192. Nitrate concentrations frequently exceed the 44 micrograms per liter (mg/L) MCL; uranium concentration only slightly exceeds the 0.044 mg/L MCL at one isolated location (DOE 1999a).

3.2 Soils and Sediment Contamination

Previous investigations have measured the concentrations of manganese, nitrate, strontium, sulfate, uranium, and vanadium in soils and sediments (DOE 1996, 1999a, 2001; UA-ERL 2000). Concentrations of other constituents, such as ammonium, arsenic, calcium, iron, and potassium, have been measured and discussed by the previous studies (DOE 1996; UA-ERL 2000). Sampling locations are shown in Figure 3-1. However, together these investigations reveal inconsistent data.

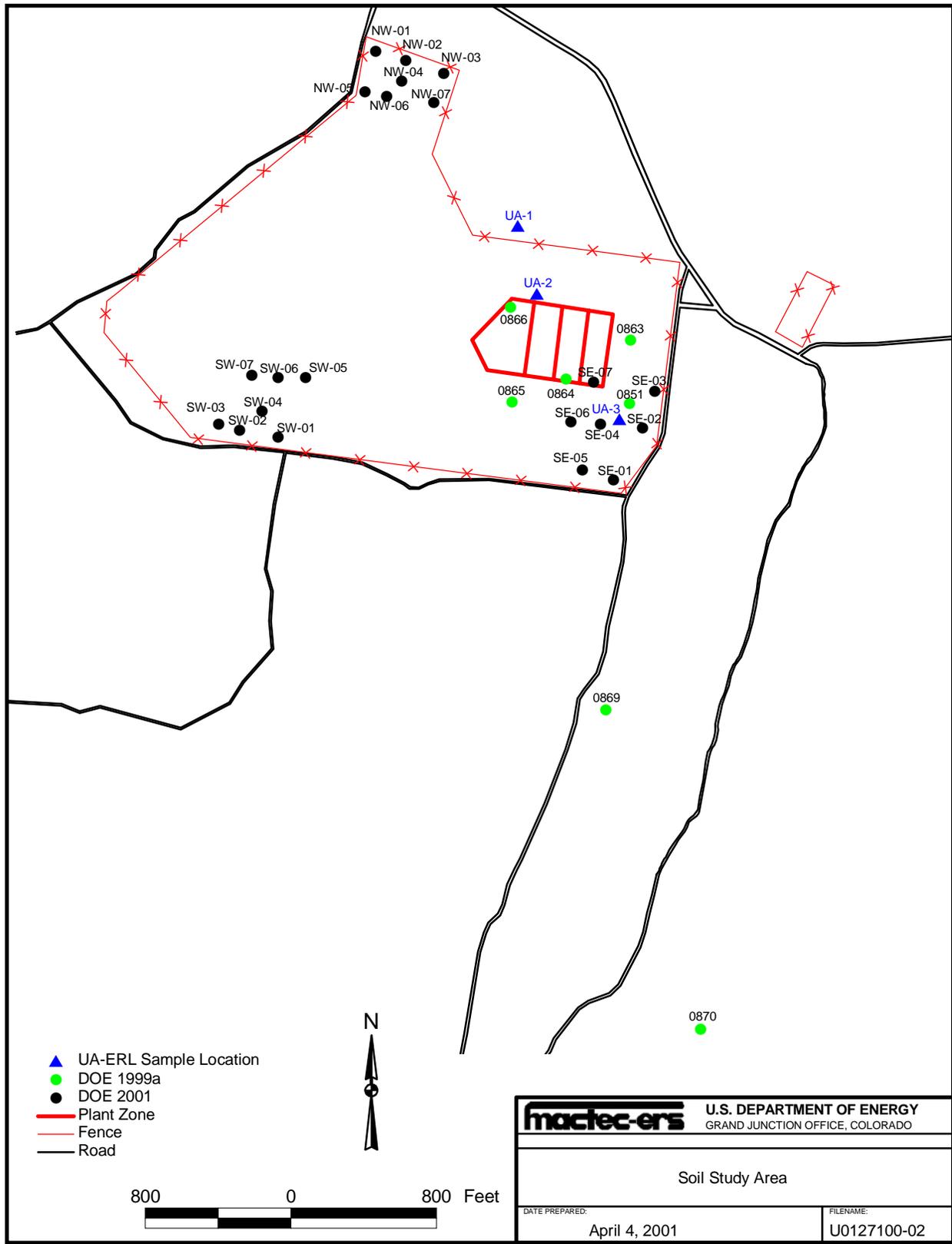
Table 3–1 lists the soils studies conducted at the site, the constituents analyzed, and the type of sample processing method, and the lixiviant. To compare constituent concentrations of two studies, the lixiviant must be the same. Constituent concentrations of manganese, nitrate, sulfate, strontium, uranium, and vanadium from DOE 1999a and UA–ERL 2000 are comparable because 18 mega ohm (MΩ) deionized water was the lixiviant used. Similarly, DOE 1999a and DOE 2001a are comparable because both used 5-percent hydrochloric acid (HCl) for leaching. Samples in DOE 1999a were sequentially leached. To make a better comparison with DOE 2001a, the results of the first three leaching steps (Table 3–1) from DOE 1999a are combined.

Table 3–1. Previous Soil and Sediment Studies

Study	Total Constituents	Sample Preparation	Leaching Steps	Lixiviant
DOE 1996	As, NO ₃ ⁻ , SO ₄ ²⁻ , Sr, U, V, Zn	Unknown	---	Unknown
DOE 1999a	Mn, NH ₄ ⁺ , NO ₃ ⁻ , SO ₄ ²⁻ , Sr, U, V	Sequential leaching	1	18 MΩ deionized water
	Mn, NH ₄ ⁺ , NO ₃ ⁻ , SO ₄ ²⁻ , Sr, U, V		2	Site-derived ground water
	Mn, NH ₄ ⁺ , NO ₃ ⁻ , SO ₄ ²⁻ , Sr, U, V		3	5-percent HCl
	Mn, Sr, U, V		4	Total digestion
DOE 2001a	Mn, NO ₃ ⁻ , SO ₄ ²⁻ , Sr, U, V	Batch leaching	1	5-percent HCl
UA–ERL 2000	Ca, Fe, K, Mg, Mn, NO ₃ ⁻ , Na, SO ₄ ²⁻ , Sr, U, V	Batch leaching	1	18 MΩ deionized water

Figure 3–2 shows a comparison of data from two soils studies obtained by leaching with 18 MΩ deionized water: *Phytoremediation of Subpile Soil Nitrogen at Monument Valley: Results After Two Years, Final Report, Year 2000* (UA–ERL 2000) and the *Final Site Observational Work Plant for the UMTRA Project Site at Monument Valley, Arizona* (DOE 1999a). The three samples from the UA–ERL 2000 study are listed as UA–1, UA–2, and UA–3. Sample UA–1 was collected from an area outside the site fence. UA–2 was collected from the phytoremediation planting in an area where surface soil had a dark stain (see Section 1.1). Sample UA–3 was collected within the phytoremediation planting but in an area where no soil staining was apparent. The dominant constituents in the UA–ERL 2000 samples are strontium, manganese, and vanadium; the dominant constituent in DOE 1999a is nitrate. Despite the proximity of the sample locations, the results are dissimilar.

Figure 3–3 shows a comparison of data from two DOE studies: *Evaluation of Contamination in Soils and Sediments, Monument Valley, Arizona, Site* (DOE 2001a) and the *Final Site Observational Work Plant for the UMTRA Project Site at Monument Valley, Arizona* (DOE 1999a). The DOE (2001a) data represent results of soil samples leached with 5 percent HCl. Data from the DOE 1999a study represent a sum of concentrations from three extractions: 18 MΩ deionized water leach, a site ground water leach, and a 5 percent HCl acid leach. The samples from the DOE 1999a study have higher total concentrations of manganese, nitrate, strontium, uranium, and vanadium, than the samples from the DOE (2001a) study; nitrate concentrations in the DOE 1999a samples are significantly higher.



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Figure 3-1. Soil and Sediment Sampling Locations of Previous Studies

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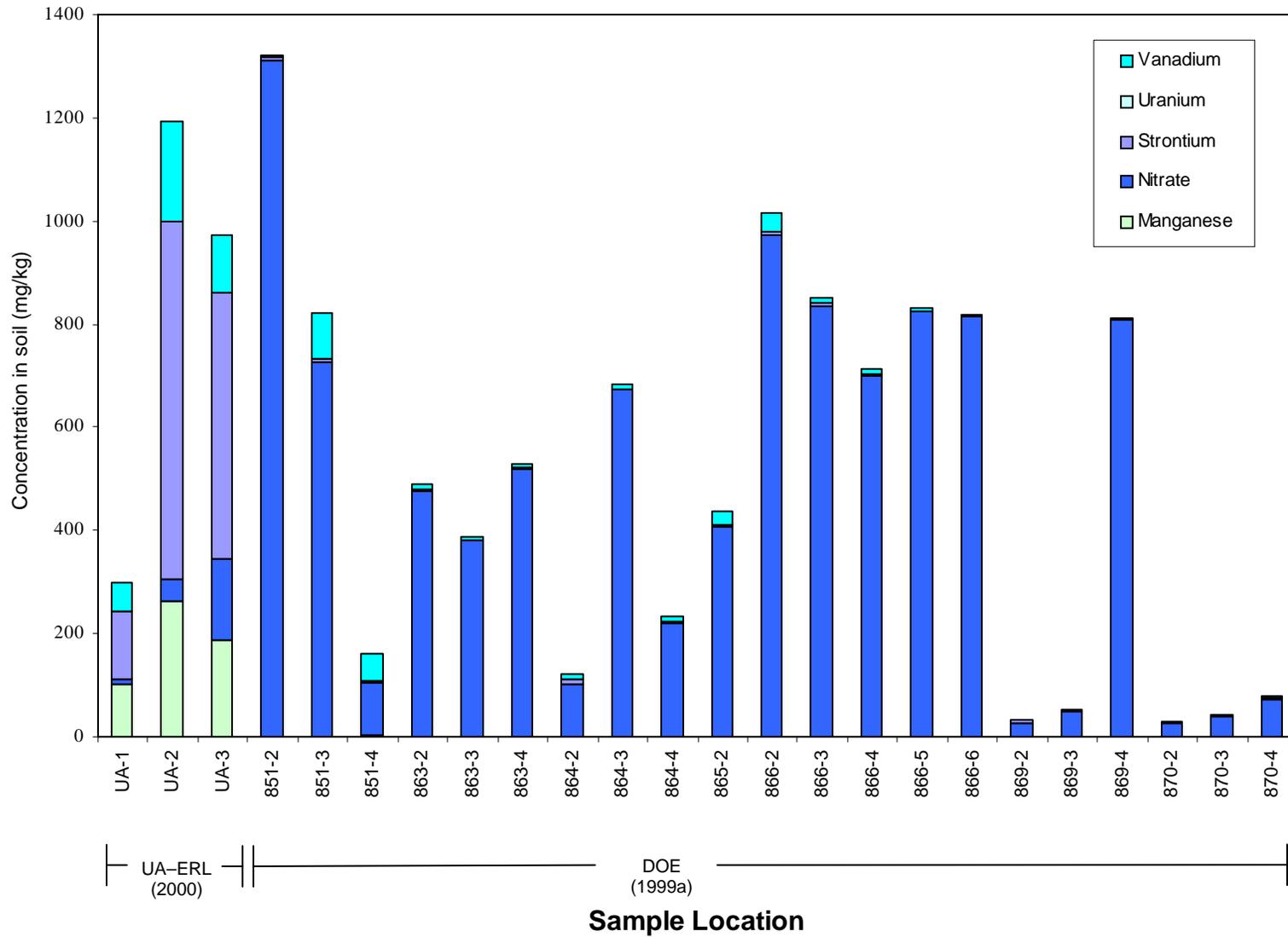


Figure 3-2. Manganese, Nitrate, Strontium, Uranium, and Vanadium Results From Soils Leached With Deionized Water

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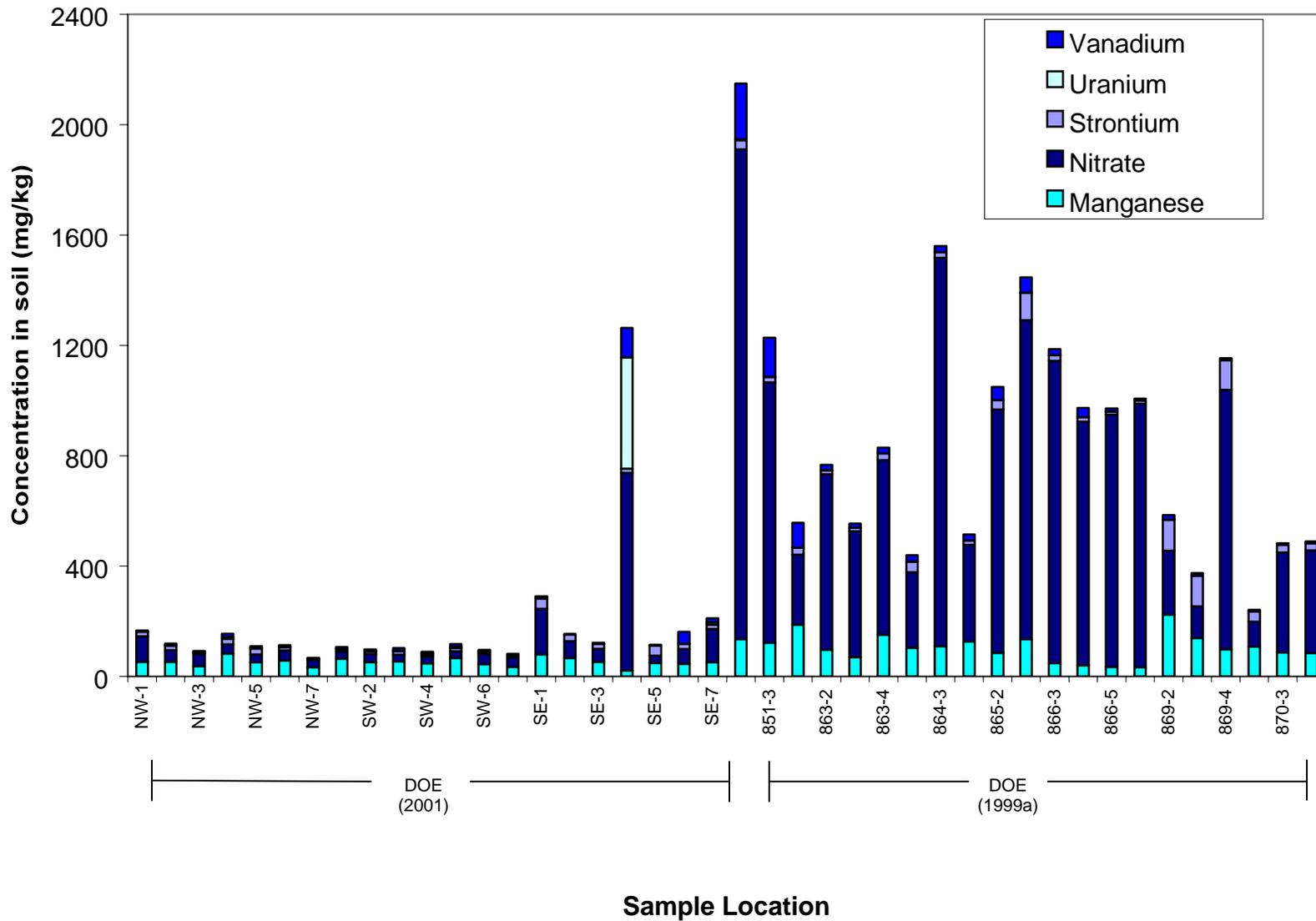


Figure 3–3. Manganese, Nitrate, Strontium, Uranium, and Vanadium Results From Soils Leached With 5 Percent Hydrochloric Acid

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Differences in the data from each comparison could be attributed to variations in chemical concentrations, between locations, and variations in sampling technique, sample collection depth, preparation, and handling. Overall, the data do not provide sufficient information to fully evaluate the poor growth of *Atriplex canescens* in Zones 1 and 2 of the phytoremediation planting (Figure 1-1). The samples were not collected from areas of poor growth within the phytoremediation planting. Also, the measured constituents do not include all major ions or other common metals, such as iron and magnesium.

End of current text

4.0 Soil Data and Quality Assurance

An evaluation of existing information on the Monument Valley millsite indicates that additional soil data are needed to determine the types and concentrations of chemical constituents present within the phytoremediation planting area. These data may be used later to study the effect of these constituents on plant growth.

Tasks associated with additional characterization will include soil and sediment sampling and sample preparation and analysis.

4.1 Soil and Sediment Data

DOE and UA-ERL collected soil and sediment samples from the site in 1997 and September 2000, respectively. Samples from previous investigations were collected and analyzed for different purposes. Previous samples did not adequately cover the area of poor growth, and the constituents of interest were too few.

Plants in Zones 1 and 2 (Figure 1-1) in the western part of the planting area are not thriving. Residual chemicals from uranium milling may have altered the chemical and physical characteristics of the soil to sufficiently impede plant growth. Salts can form in arid environments through the evaporation of capillary water. Calcium, sodium, carbonate, bicarbonate, sulfate, and chloride can precipitate and accumulate as a crust over the surface of the soil. This process occurs throughout the Monument Valley area. Salt crusts are present in road cuts, dry arroyos, and other surfaces throughout the area and are also present at the site and within the planting.

The poor growth experienced by some stands of *Atriplex canescens* may be due to elevated levels of some chemical constituent, such as copper or vanadium. Soils collected at the site will be leached and analyzed for the 19 constituents: alkalinity and total inorganic carbon, calcium, chloride, copper, iron, magnesium, manganese, nitrate, phosphate, potassium, silica, sodium, strontium, sulfate, total dissolved solids, uranium, vanadium, and zinc.

Constituents may have sorbed or precipitated in the upper few feet of the Quaternary material beneath the areas of the former tailings piles and evaporation ponds. Previous investigation of ground water indicated that nitrate concentrations exceeded the EPA standards. EPA standards do not exist for soils; however, residual ammonium in soils may be a continuing source of ground water nitrate. The target analytes were chosen to provide soil chemistry information for evaluating the reason for poor plant growth in some areas of the phytoremediation planting area.

4.2 Quality Assurance

The Monument Valley study will be conducted in accordance with the requirements of the *UMTRA Ground Water Project Quality Assurance Program Plan* (DOE 1998b). This plan details the project quality assurance program and includes requirements for personnel training and qualification, quality improvement, control and distribution of documents, control of records, control of work processes, audits, and surveillances.

Quality assurance for sampling and analysis is accomplished by following detailed procedures to maximize data precision and ensure adequate representation and comparability. Quality control samples are also collected to assess the effectiveness of field procedures, such as equipment decontamination. Standard operating procedures and quality assurance measures for soil sampling are specified in the *Environmental Procedures Catalog* (DOE 1998c)

The GJO Environmental Sciences Laboratory (ESL) will prepare the samples collected for this investigation. Quality assurance measures and analytical procedures are detailed in the *Environmental Sciences Laboratory Procedures Manual* (DOE 1999b). Analyses will be conducted at the GJO-ACL and ESL. The quality assurance program for the GJO-ACL is specified in the *Analytical Chemistry Laboratory Administrative Plan and Quality Control Procedures* (WASTREN 2000); laboratory analytical procedures are detailed in the *Analytical Chemistry Laboratory Handbook of Analytical and Sample Preparation Procedures* (WASTREN 1999).

5.0 Methods

5.1 Experimental Design

The study will proceed through two phases. The first phase will be an assessment to provide information for the second phase. The second phase will examine the chemical composition of soil at particular locations.

In the first phase, composite samples will be collected from the surface and from the subsurface at approximately 18 inches depth where the soil becomes mottled in appearance. These surface and subsurface samples will be collected from the area where *Atriplex canescens* plants are thriving and from an area where the shrubs are stunted. In the characterization phase, there will be a total of four composite samples. Each of these samples will be leached first with 18 MΩ deionized water, and the residual solid will be leached with 5 percent hydrochloric acid. Leachates will be submitted to the GJO-ACL for analysis of 19 constituents: alkalinity, total inorganic carbon, calcium, chloride, copper, iron, magnesium, manganese, sulfate, nitrate, sodium, potassium, phosphorus, silica, strontium, total dissolved solids, uranium, vanadium, and zinc. Alkalinity, chloride, and total dissolved solids will not be measured on the acid leached fraction.

The second phase of sampling will depend upon the results of the first phase. It is anticipated that the number of measured constituents will decrease in this second phase. Results from the first phase may indicate that subsurface samples will provide more information than those from the surface. In this second phase, the samples will be individual grab samples. The measured concentrations will represent concentrations at a particular location.

5.2 Field Sampling Methods

Samples will be collected according to procedures SL-1(P) and SL-3(P) (DOE 1998c). Samples will be selected from areas of the site that show the best plant growth and unaltered soil and from poor plant growth areas that exhibit surface staining and salt crystallization.

Surface composite samples will be collected using a stainless steel scoop. The soil will be placed into an aluminum pan, mixed, and then placed into a precleaned jar.

To access subsurface samples, a small shallow trench will be dug with a shovel. After the subsurface is exposed, the subsurface samples will be collected in the same manner as the surface samples.

5.3 Analytical Methods

Samples will be delivered to ESL where they will be placed in stainless steel pans and air dried. After the samples are dry, they will be passed through a 2 mm (No. 10 mesh) sieve. The fraction less than 2 mm will be used for leaching. The ESL laboratory procedure "Standard Batch Leaching" (DOE 1999b) will be used to prepare the samples.

The constituents present will be determined for two sequential leaching fractions. Samples will be first leached with 18 MΩ deionized water. This fraction will help characterize ions available to the plants from precipitation. The residual solid from the first leaching will be processed using 5 percent HCl. The 5 percent HCl fraction will assist in characterizing constituents present in the soil.

6.0 Environmental Compliance Requirements/Actions

Actions described below are based upon a review of the requirements under federal, state, tribal, and local laws and regulations. In many cases, it is assumed that Navajo laws and regulations supersede federal and state authority. Exemptions from regulatory requirements and/or negotiated requirements have been documented.

6.1 National Environmental Policy Act Assessment

The actions proposed were reviewed to determine the need for assessment under the DOE's National Environmental Policy Act (NEPA) Regulations. On the basis of initial review it appears that the soil samples fall within the scope of actions already assessed in previous categorical exclusions. In addition, the proposed work will occur in areas that were disturbed during surface remediation or during characterization activities. No new surface disturbance outside disturbed areas is expected to occur. The categorical exclusion was approved in accordance with DOE's NEPA Regulations, 10 CFR 1021. Therefore, an environmental checklist will not be prepared for these actions.

None of the proposed actions will prejudice or influence the selection of remediation action alternative, which will be proposed in an environmental assessment.

6.2 Cultural Resource Issues

Cultural resources will be protected in accordance with federal and state laws and regulations. Cultural resource inventories have been conducted in the areas of proposed soil sampling.

6.3 Threatened and Endangered Species

On the basis of the environmental assessment completed for surface remediation and subsequent research, no threatened or endangered species are anticipated to be affected.

6.4 Sensitive Ecological Areas/Wetlands

No activities will occur in any sensitive ecological areas including wetlands, prime or unique farmlands, wilderness areas, floodplains, etc.

6.5 Off-Road Activities

Existing roads and trails (including previous routes used to access locations) will be used wherever possible. All off-road activities, routes, and access will be cleared through GJO Environmental Services and the Navajo Nation to minimize adverse effects to soils, vegetation, and other natural resources. In any event, particularly during periods of inclement weather, the field supervisor will consult with the on-site tribal representative to determine under what conditions off-road travel will be permitted. Any adverse effects created (as a result of off-road travel) including rutting and erosion potential will be mitigated. Mitigation will be coordinated through the designated Navajo Nation representative and may include recontouring and reseeded.

6.6 Waste Management

Investigation derived waste (IDW) will be managed under the guidance of the *Management Plan for Field-Generated Investigation Derived Waste* (DOE 2000). Proper implementation of this strategy will ensure that the IDW is managed in a manner that is protective of human health and the environment and in accordance with regulatory requirements.

The IDW to be generated during sampling and analysis will consist of liquid and solid media. Decontamination water for equipment will be the primary liquid IDW. Solid IDW will include miscellaneous trash generated during sampling and excess sample material. The trash will be disposed of at a refuse transfer station or landfill. The excess sample material will be handled according to the *ESL Waste Management and Disposal Plan* (DOE 2001b draft).

6.7 Sample Transportation

The collector will transport samples to GJO with proper documentation and in accordance with U.S. Department of Transportation regulations.

7.0 Health and Safety

7.1 General

Field sampling work will be performed according to the project safety plan for ground water sampling.

Any other fieldwork to be performed will be completed under specific safe work permits and job safety analysis developed and prepared for each task in accordance with GJO Health and Safety Standards Manual (GJO 2).

7.2 Biological Hazards

Biological hazards, which include direct, harmful contact with animals and vegetation, could be encountered on-site that pose a significant risk to site personnel. Personnel shall notify their immediate supervisor of any occurrences. No attempts will be made to capture any wild or semi-wild animals, for example cats, rats, birds, mice, snakes, etc., due to the possibility of being bitten or parasite infestation.

Animal/spider bites, poison plants, and insect stings usually cause localized swelling, itching, and minor pain that can be handled by first aid treatment. Some individuals may be more seriously affected and require hospitalization. Snake bites are usually painful and medical attention should be sought immediately. To care for someone bitten, wash and immobilize the wound immediately and keep it lower than the heart, if possible. If contact with vegetation is expected, appropriate clothing will be worn to prevent contact with skin.

End of current text

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