2. WORK PLAN

This investigation includes the installation of monitoring wells in the unconfined and confined aquifers underlying the Cimarron facility, sampling and categorizing site soils and bedrock, and collecting and analyzing ground-water samples. The major components of the investigation are summarized in the succeeding sections and include:

- Drilling and well installations
- Field testing
- Ground-water sampling
- Laboratory analyses
- Data evaluation and reporting

2.1 Drilling and Well Installation

Procedures to be followed for drilling borings and obtaining soil and rock samples are specified in Appendix A. The completion procedures to be used for the monitoring wells are specified in Appendix B.

2.1.1 Well Locations.

The installation of monitoring wells at locations down-gradient from the uranium plant yard, closed wastewater disposal ponds, landfill site, and the sanitary lagoons is one of the principal objectives of the investigation plan. The locations of the planned monitoring wells are shown on Figure 1.1. The locations of wells located down-gradient of the possible contamination sources may be adjusted as additional data allows better definition of the hydrologic flow of the site. Well locations may also be moved to minimize disturbance of plant activities and to adjust for cultural and topographic features. Well locations may be adjusted with approval of the Project Manager.

2.1.2 Drilling and Soil Sampling.

Four deep borings will be drilled into the confined Garber Sandstone aquifer. The estimated total depth for each deep boring is 135 feet. The actual termination depth of each boring will be determined by the field geologist and will be sufficient for penetrating a significant portion of the confined, saturated zone.

One additional boring at each of the deep boring locations will be drilled to complete a monitoring well nest of two wells. The monitoring well nest will consist of a shallow well screened in the unconfined aquifer and a deep well screened in the deep, confined aquifer. The shallow well will be drilled approximately thirty feet deep; however, the actual termination depth will be determined by the field geologist. Total depth of the well will be sufficient to penetrate approximately 10 feet into the shallow, unconfined aquifer. Based on sample examination and the appearance of water during drilling, the field geologist will set a ten foot well screen across the water-bearing zone in the borings. Longer lengths of well screen may be permitted with approval of the Project Manager.

Eleven additional borings will be drilled at locations indicated on Figure 1.1. Of the eleven additional borings, four will be drilled in the vicinity of the uranium plant yard, one near the closed wastewater disposal ponds, three adjacent to the new landfill site, and three in the vicinity of the sanitary lagoons. The borings will be approximately 30 feet in depth and will penetrate the shallow, unconfined aquifer. The field geologist will determine the total well depth and the screen interval of these borings based on sample examination and appearance of water during drilling. The borings should extend approximately 10 feet below the water table.

Samples of soil and rock materials will be obtained at each of the four deep borings and eleven additional shallow borings using standard sampling methods appropriate for the type of material present. Continuous sampling of soils is planned; however, this plan might be modified in the field if the nature of the soils indicates that continuous sampling is not possible or is unnecessary. The four shallow borings constructed for the monitoring well nests will not be sampled. Changes to the sampling program will be approved by JLGA.

Rock penetrated in the four deep borings will be sampled by continuous coring. Rock penetrated in the additional eleven shallow borings will be sampled by collection of rock cuttings or by continuous coring. One of the additional shallow borings drilled at each of the four specific areas of investigation will be sampled by continuous coring for correlation purposes. When rock cuttings are collected, they will be composited over each 2 feet interval of rock drilled.

If subsurface conditions are such that the planned drilling or sampling technique does not produce acceptable results, e.g. unstable borehole walls or poor sample recovery, another drilling or sampling technique deemed more appropriate to the type of material present will be used. Changes to the drilling or sampling techniques will be approved by the Project Manager.

A field geologist or geotechnical engineer will monitor all drilling and well installation activities and maintain a log of these activities. The field representative also will keep a detailed, descriptive log of materials penetrated by the boring. An example of the format to be followed for the descriptive log is shown in Appendix A.

Representative soil samples will be selected for physical and chemical properties analyses. Physical tests will be conducted to verify field classification of soil and rock types, and to provide quantitative measures of hydraulic and engineering properties of the subsurface materials. Chemical analyses will be conducted to determine the chemical properties of the subsurface materials. Samples will be selected for testing that are representative of the major strata found within the zone of investigation, including both the unsaturated and saturated zones. Approximately one sample will be selected from each boring in the uranium plant yard and landfill site. Additional samples will be collected from the wastewater treatment pond and sewage lagoon areas. Soil analysis procedures are discussed in Section 2.4.2 and Appendix E.

Representative samples will also be analyzed for the presence of uranium, plutonium, NO3 and F.

2.1.3 Monitoring Well Installation.

Ground-water monitoring wells will be installed in each of the nineteen borings using the procedures outlined in Appendix B. The wells will be screened in either the unconfined or the confined aquifers which underlie the surface deposits. The purpose of the shallow wells is to determine the hydraulic properties of the unconfined aquifer and to determine if any contaminants have migrated through the soils and impacted the shallow ground water. The purpose of the deep wells is to determine the hydraulic properties of the confined aquifer and to determine if contaminants have impacted the deep ground water.

The Garber is composed of interbedded sandstones, siltstones and shales. It is anticipated that both aquifers will be composed of several relatively thin, water-bearing zones separated by fine-grained, less permeable beds. The wells should be screened to include the upper ten feet of the water-bearing strata.

Before the wells are used for monitoring water levels, testing, or taking water samples, they will be thoroughly developed. Development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen. Well development will not be performed until at least 24 hours after well grouting is completed. Well development will be performed after all wells have been installed.

The procedure to be used for well development is included in Appendix B.

The horizontal position and elevation of the measurement datum at the monitoring wells will be surveyed soon after well completion. Surveying will be conducted by a qualified surveyor.

2.2 Field Testing

Procedures to be followed in conducting field tests are included in Appendix C. The following field tests or measurements will be made at the monitoring wells constructed during this investigation and at selected previously existing monitoring wells.

2.2.1 Water-Level Measurement.

Water levels at all monitoring wells constructed during this investigation will be measured within a short time interval so that the water-level data are comparable. Water levels in the monitoring wells will not be measured until the wells are developed. Water levels will also be measured at the following existing monitoring wells: 1307, 1311, 1312, 1313, 1314, 1315, 1316, 1317 and 1318. See Figure 1.1 for approximate locations of these monitoring wells. The depth to water below the measurement datum will be made to the nearest 1/8 inch (0.01 feet).

2.2.2 Slug Tests.

To measure the hydraulic conductivity of the aquifers, "slug tests" will be performed. A slug test will be performed in each of the nineteen monitoring wells installed during this investigation. The procedure involves lowering a slug, or sealed tube, into the water in the well and allowing the raised water level to recover to the pre-insertion level. The slug then is removed quickly and the recovery of the lowered water level to static level monitored, timed, and recorded.

2.3 Ground-Water Sampling

In order to characterize current water quality in the aquifers at the site, the monitoring wells installed during this investigation will be sampled. Ground water samples will also be collected from the existing monitoring wells shown in Figure 1.1. Sampling will be conducted no sooner than 24 hours after the wells have been completed in order for aquifer conditions to stabilize after the disturbance caused by drilling, well installation, and well development. Samples will be collected from all the designated wells on the same day within a relatively short time frame to produce results that are comparable. Ground-water sampling, sample handling, and chain of custody procedures are presented in Appendix D.

2.4 Laboratory Analyses

Laboratory analyses will be performed by Kerr-McGee Technical Center personnel. If the services of an outside laboratory are required, Kerr-McGee laboratory personnel will responsible for ensuring that the proper analyses are performed and that acceptable QA/QC procedures are maintained.

2.4.1 Ground-Water Analyses.

Ground-water samples will be analyzed for the presence of uranium, plutonium, gross alpha and beta, NO3 and F. The number of ground-water samples to be collected at each area of investigation are identified in Table 2.1. Additional samples may be collected with the approval of the Project Manager. Analyses will be conducted under procedures specified by the EPA or NRC for the particular constituents. Specific procedures are identified in Appendix E.

2.4.2 Laboratory Soil Analyses.

2.4.2.1 Physical Analyses.

Physical analyses will be performed on samples of soils and rocks taken from the borings. The results of the tests will verify field descriptions and classifications, and will provide quantitative measures of hydraulic and engineering properties of the subsurface materials. Physical analyses to be performed include particle size distribution, Atterberg limits, Proctor tests, density, moisture content, matric potential, and permeability. Physical tests will be conducted in accordance with the current edition of ASTM Standards, American Laboratory Soils Testing and Materials, Part 19. The recommended testing procedures are identified in Appendix E.

The proposed numbers of these tests are presented in Table 2.2. The numbers of tests in this table represent the current estimate of the number of physical analyses necessary to support the characterization of the subsurface. The number of physical analyses may be increased by the field representative with the approval of the Project Manager if additional tests are necessary to characterize the subsurface strata.

The samples to be tested will be selected by the field representative and the Project Manager. Approximately one sample will be selected from each boring in the uranium plant yard and the landfill site. These samples will be selected to represent the major strata found within the zone of investigation, including both saturated and unsaturated zones. The samples selected to measure matric potential will be selected after the other characterization tests have been completed, and the lithologies in the subsurface has been tentatively delineated. It is expected that the matric potential samples will be selected from the unsaturated zone. At least one matric potential sample will be fabricated from a blend of shallow soils to represent compacted fills constructed during the decommissioning of the facility.

Different samples may be selected for the various analyses at the discretion of the Project Manager.

Additional samples will be selected from the borings in the wastewater pond and sanitary lagoon areas. These samples will be selected to represent any strata not found in the uranium plant yard and landfill site borings and to duplicate tested samples from these locations. The duplication will allow lithologic changes in the major strata to be quantified.

2.4.2.2 Soil Chemical Analyses.

Chemical analyses of soil and rock samples will be completed to quantify the chemical properties of the soils and rocks within the zone of investigation. The tests to be performed to characterize the chemical properties of the soils and rocks include total organic carbon, cation exchange capacity, exchangeable cations, and equilibrium distribution coefficients for uranium and thorium.

The numbers and approximate distribution of tests to be performed are summarized in Table 2.3. The numbers of tests shown in this table are approximate, and may be changed by the Project Manager should additional or fewer tests be found necessary to characterize the subsurface. The samples to be tested will be selected according to the same rationale used to select the soil samples for physical analyses. In most instances, the samples selected for physical analyses will be used for the chemical characterization, although other samples may be selected for testing by the Project Manager. The distribution coefficient samples will be selected after the chemical and physical tests have been completed. These samples will be composites selected to represent the range of chemical and mineral soil conditions within the zones of potential contaminant movement.

2.4.2.3 Soil Contamination Analyses.

Chemical analyses of selected soils will be performed to determine the presence and concentration of potential contaminants on the soil. The contaminants to be tested include uranium, plutonium, nitrate and fluoride. Cimarron has completed an extensive program to detect and characterize radioactivity in the soils in the uranium plant yard. The current program will complement that effort. Table 2.4 lists the numbers of samples for the contamination analyses by area. The actual samples to be tested will be selected by the field representative and the Project Manager from samples at and within the most shallow saturated zone in the uranium plant yard, and from the unsaturated zone and the most shallow saturated zone in the other areas.

2.5 Data Evaluation and Reports

Data analyses, evaluations, and reports to be prepared during the project are described in the following section. The scheduling of these investigation components are discussed in Section 3 and are shown in Figure 3.1.

2.5.1 Data Evaluation.

Upon completion of the field program, all of the pertinent subsurface and hydraulic properties data will be used to prepare a characterization of the site hydrogeologic system and to quantify the impact, if any, which the facility has had on the hydrogeologic system. These data evaluations will be used to prepare a written description of the hydrogeologic system and to prepare graphic depictions (cross-sections, maps, and graphs) necessary to support the description.

2.5.2 Report.

2.5.2.1 Progress Reports.

Brief progress summary reports will be prepared during the course of the investigation to describe activities completed and revisions to the program during the prior 30-day period. Data acquired during the month prior to the report will be included in progress reports, as appropriate. The progress report will identify problems encountered, solutions applied, and possible schedule revisions. The progress report also will list activities planned and products expected to be completed during the following 30-day period.

2.5.2.2 Project Report.

The Project Report will be prepared upon the conclusion of the project. The report will contain a description of the field and laboratory data collection program, including procedures used, and will include all data obtained. The report also will describe analytical activities conducted for this program and present the characterization of the hydrogeologic system.

The report will be submitted first in draft form and later in final form which incorporates any necessary revisions or corrections. Submittal of the draft report is planned for approximately four weeks after receipt of the laboratory test results. The completion of the final report is planned for three weeks later.

TABLE 2.1

Summary of Ground-Water Analyses

Location	Uranium	Plutonium	Gross Alpha,Beta Activity	NO3	F
URANIUM PLANT YARD	8	8	8	8	8
CLOSED WASTEWATER TREATMENT PONDS	6	6	6	6	6
LANDFILL SITE	8	8	8	8	8
SEWAGE LAGOONS	4	4	4	4	4
Total	26	26	26	26	26

TABLE 2.2

Summary of Physical Properties Analyses

Location	Particle Size	Atterberg Limits	Proctor Tests	Density	Moisture Content	Permeabil.	Matric Potential
URANIUM PLANT YARD	6	6	6	6	6	6	1
CLOSED WASTEWATER TREATMENT PONDS	1	1	1	1	1	1	1
LANDFILL SITE	6	6	6	6	6	6	1
SEWAGE LAGOONS	4	4	4	4	4	4	1
Total	17	17	17	17	17	17	4

TABLE 2.3

Summary of Soil Chemical Analyses

Location	Total Organic Carbon	Cation Exchange Capacity, Exchangable Cation	Mineralogy	Equilibrium Distribution Coefficient
URANIUM PLANT YARD	6	6	3	On Three Composite:
CLOSED WASTEWATER TREATMENT PONDS	1	1	1	U Th
LANDFILL SITE	6	6	3	
SEWAGE LAGOONS	4	4	2	
Total	17	17	9	3

TABLE 2.4

Summary of Soil Contamination Analyses

Location	Uranium	Plutonium	NO3, F
URANIUM PLANT YARD	6	6	6
CLOSED WASTEWATER TREATMENT PONDS	1	1	1
LANDFILL SITE	6	6	6
SEWAGE LAGOONS	4	4	4
Total	17	17	17

3. SCHEDULE FOR IMPLEMENTATION

Figure 3.1 shows the anticipated project schedule. This schedule presents the order that the investigation described in the preceding sections will be completed. The investigation is anticipated to commence January 16, 1989. The project as structured will require approximately three months to complete.

The drilling, soil and rock sampling, and well installation is estimated to take approximately three weeks. Well development, slug tests, and ground water sampling will take approximately ten days. The laboratory analyses will take approximately one month to complete. Data reduction and evaluation, and the presentation of a draft report should be completed three weeks after receipt of all analyses.

Project management is shown as a continuous task over the duration of the project. This represents the commitment of the project team to the project. The project management staff are available throughout the project to assure that the project is completed in a timely, orderly, and successful manner.

FIGURE 3.1

PROJECT SCHEDULE

WEEKS AFTER PROJECT COMMENCEMENT

```
                                     1    2    3    4    5    6    7    8    9   10   11   12
                                ---------------------------------------------------------------
Field Program:
 Well drilling, installation      ***************
 Soil sampling                    ***************
 Ground water sampling                           *****
 Slug tests                                      *****

Laboratory Testing                          *************************

Data Reduction, Analysis                              *************************

Reporting
 Progress Reports                                *****               *****
 Project Report (draft)                                                        **********
 Project Report (final)                                                                  *****
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Appendix A Drilling and Sampling Procedures

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APPENDIX A
DRILLING AND SAMPLING PROCEDURES

1. EQUIPMENT DECONTAMINATION PROCEDURES

When drilling through or sampling in potentially contaminated materials, the following procedures will be followed to minimize the potential for introduction of contaminants from the surface or shallow strata into the deeper strata penetrated by drilling activities and to minimize the potential of cross-contamination during sampling:

- Equipment to be used for the project will be steam-cleaned prior to arrival at the site. This includes drilling rigs, water tanks (flushed inside), augers (if used), bits, casings, rods, samplers, tools, etc.

- All sampling tools will be cleaned on-site, prior to use and between each sampling event with clean water and a phosphate-free detergent. A source of potable water, approved by the Field Hydrogeologist, must be used. Other cleaning procedures may be required, but are task specific. These procedures will be described in the task specific sampling protocols.

- The down-hole portion of drilling equipment will be cleaned on-site prior to use and between each boring with a high-pressure, hot-water cleaner using approved water.

- Well completion materials will be cleaned with a high-pressure, hot-water cleaner using approved water prior to use. Materials which cannot be cleaned to the satisfaction of the responsible Field Hydrogeologist will not be used.

- If contaminated soils are encountered during drilling, and the potential for significant cross-contamination is anticipated, modified drilling procedures will be used to prevent the transfer of contaminants to a deeper zone by the drilling method.

- Cleaning and decontamination procedures will be performed in an area that is remote from any site to be sampled, to the extent feasible. All downhole tools and equipment will be checked with a geiger counter or scintillometer after cleaning.

2. DRILLING AND SAMPLING PROCEDURES

2.1 General

A final borehole diameter of between 6.5 and 8 inches will be required for the installation of wells with a two inch inside diameter (i.d.) casing.

Fuel, lubricants, and other similar substances will be handled in a manner consistent with accepted safety procedures and standard operating practices. Well completion materials will not be stored near or in areas which could be effected by these substances.

Surface runoff such as miscellaneous spills and leaks, precipitation, and spilled drilling fluid shall not be allowed to enter any boring or well either during or after drilling/well construction. To prevent this from happening, the use of starter casing, recirculation tanks, berms around the borehole, and surficial bentonite packs, as appropriate, are suggested.

Cuttings and cores will be checked with a geiger counter or scintillometer for radiological contamination. Where contaminants exist in shallow strata, a double-casing procedure will be required to minimize the potential for transferring contaminants to deeper strata. For these installations, a five-inch or larger PVC casing will be grouted through the contaminated strata before the boring is continued to its termination depth.

The Field Hydrogeologist will be present to observe all drilling and well installation activities and maintain a log of these activities. The Field Hydrogeologist also will keep a detailed descriptive log of materials penetrated by the boring. An example descriptive log is shown on Figure A-1.

2.2 Water Supply

Water used in drilling, equipment cleaning, or grouting will be taken from the the local potable water supply. Identification of the water source will be verified by contacting the appropriate plant personnel. If sources of non-potable water are present which might be confused with the proper water source, both the acceptable and unacceptable sources will be clearly marked to avoid possible confusion.

2.3 Soil Drilling and Sampling

Drilling in soil will be performed with equipment and procedures complying with the latest revision of ASTM specifications D 1586 and D 1587. Drilling in soil is planned to be accomplished using a hollow-stem auger drilling technique. If subsurface conditions are such that the planned technique does not produce acceptable results, e.g. unstable borehole walls or poor soil sample recovery, another technique deemed more appropriate to the type of soils present will be used. The procedure used must be appropriate for the subsurface lithologies present and also must be compatible with the efficient soil sampling in accordance with ASTM specifications D 1586 and D 1587 or an alternate soil sampling methods approved in advance by JLGA. If hollow-stem augering is used with the intent of installing the well casing through the augers, the inside diameter of the augers must not be less than four inches.

If borehole caving is experienced, bentonitic drilling fluid can be used only after approval of the Field Hydrogeologist. No organic additives will be used.

Soil sampling will be performed in accordance with ASTM specifications D 1586 or D 1587 or another similar method judged acceptable by the field geologist. Samples will be taken continuously over the full thickness of the soil deposits unless an alternative sampling frequency is requested by the Field Hydrogeologist. Good sample recovery is most important, and procedures will be modified, as necessary, to improve sample recovery.

Samples will be stored in clear glass containers, or waxed cardboard containers, labeled with the project number, boring number and sample number and depth. Exceptions will be thin-wall tube samples which are designated for undisturbed tests. These samples will be described on the basis of materials exposed at the top and bottom of the sample tube and will be sealed in the tube, labeled, and handled in a manner consistent with this work plan and the testing requirements.

The Field Hydrogeologist will be responsible for maintaining a descriptive log of materials recovered, photographing representative samples, and properly labeling and storing samples. A copy of the proposed field soil boring record form is presented in Figure A-1. The descriptive log will contain:

1. sample interval (top and bottom depth);

2. sample recovery;

3. blow count (ASTM D1586) or hydraulic pressure (ASTM D1587);

4. presence or absence of contamination;

5. material description, including: relative density, color, major textural constituents, minor constituents, relative moisture content, plasticity of fines, grain size, structure or stratification, and any other significant observations.

6. lithologic contacts: the depth of contacts between differing lithologic units will be measured and recorded to the nearest 0.05 feet.

2.4 Rock Drilling and Sampling

Drilling in rock will be by diamond core drilling techniques or by a rotary drilling technique. Diamond coring will be conducted in accordance with the latest revision of ASTM D 2113. Rotary drilling, wherein only cuttings samples are returned to the surface, will be used only in conjunction with diamond core drilling. The Field Hydrogeologist will determine the appropriate drilling technique.

For core drilling, the acceptable core diameter will be approximately two inches. The drilling contractor will modify drilling procedures, as necessary, to maximize the recovery of cored rock. The Field Hydrogeologist will monitor drilling production and core recovery and notify the drilling contractor of unacceptable performance.

For rock intervals not cored, cuttings brought to the surface in the drilling fluid will be sampled. Cuttings samples will be composited to represent each 2.0 feet long interval of rock penetrated by the drill bit. Cuttings samples will be placed in properly labeled, clear glass containers.

The Field Hydrogeologist will handle all recovered core or cuttings samples. He will prepare a descriptive log, take photographs, and properly label and store the samples. Recovered rock core will be placed in properly labeled waxed cardboard, plastic, or wood core boxes. Each box will be marked in accordance with ASTM D 2113 with the project name, boring number, depth interval represented, and the box number. Cuttings samples will be places in properly labeled glass container. Container labels will show the project name, boring and sample number, and sample depth.

The descriptive log of recovered core will include:

1. cored interval and recovery;
2. Rock Quality Designation (RQD): RQD = cumulative length of recovered core pieces greater than or equal to four inches in length divided by the total length of the core run;
3. discontinuity description: depth, character, and orientation of joints, fractures, and other non-depositional breaks in the rock;
4. partings description: depth, character, and orientation of depositional (bedding) features;
5. rock weathering: description of weathering or weathered zones;
6. geohydrologic description: qualitative description of permeability;
7. penetration rate: where applicable, a record of the speed of drill bit penetration in minutes per foot;
8. rock lithology: description of rock lithology and depths of significant features or contacts. Description to include rock name, relative hardness, color, texture or grain size, cementation, structure or stratification, and other pertinent information such as accessory minerals or fossils.
9. lithologic contacts: the depth of contacts between differing lithologic units will be measured and recorded to the nearest 0.05 feet.
10. presence or absence of odors or visible evidence of contamination;
11. presence of radionuclides determined by use of a hand-held scintillometer.

Figure A-2 is an example of the form to be used for recording core boring information.

2.5 Site Cleanup

After completion of drilling, any cuttings brought to the surface which might be contaminated will be placed in drums and stored on-site. These materials will be included with other site materials moved to a location identified for long-term stabilization. Temporary on-site storage of such cuttings will be at a controlled location.

BORING FIELD REPORT

BORING NO.

JOB NO.

DRILLER

GROUND SURFACE ELEV.

JOB NAME

HOURS DRILLING

HOURS MOVING

DATE:

WEATHER

PAGE OF

SAMPLING "N"			SCALE	UD	REC	SOIL CLASSIFICATION AND REMARKS
1ST 6"	2ND 6"	3RD 6"				
			0			
			5			
			0			
			5			
			0			
			5			
			0			
			5			
			0			

+STANDARD PENETRATION RESISTANCE IS SUM OF BLOWS FOR 2ND 6" AND 3RD 6" TO DRIVE 1-3/8" I.D., 2" O.D. SPLIT BARREL SAMPLER WITH 140 POUND HAMMER FALLING 30 INCHES.

BORING TERMINATED:

BORING REFUSAL:

WATER TOB DEPTH

WATER 24 HR.: DEPTH

WATER LOSSES

METHOD OF ADVANCING BORING	DEPTH
POWER AUGER	TO
HAND CHOP: W/MUD: W/WATER	TO
ROTARY DRILL: W/MUD: W/WATER	TO
DIAMOND CORE	TO

FIGURE A-2

BORING FIELD REPORT BORING NO. ______

PROJECT NAME ______ PROJECT ______ BORING LOCATION ______

DRILLED ______ LOGGED BY ______ CHECKED BY ______

DRILLING DATES - FROM ______ TO ______ DATUM ______ DATUM ELEVATION ______

DEPTH (FEET)	CORE INFO		ROD		DISCONTINUITIES JOINTS/FRACTURES			PARTINGS BEDDING/FOLIATION			ROCK WEATHERING	GEOHYDROLOGIC INFORMATION	PENETRATION RATE (MIN/FT)	DEPTH	LITHOLOGIC DESCRIPTION	DEPTH (FEET)
	CORE SZ RUN NO	REC. %	PIECE LN.	RQD	NATURE	SPACING	DIP & DIRECTION	NATURE	SPACING	DIP & DIRECTION						

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APPENDIX B

WELL INSTALLATION PROCEDURES

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APPENDIX B
MONITORING WELL INSTALLATION PROCEDURES

1. MONITORING WELL INSTALLATION PROCEDURES

1.1 Materials Decontamination

Well completion materials will be inspected by the Field Hydrogeologist and determined to be clean and acceptable for use. Casing, screen and casing plugs and caps will be cleaned with a high-pressure, hot-water cleaner using approved water prior to use. Pre-packaged sand will be used in well construction and the bags will be inspected for possible external contamination before use. Pre-packaged bentonite and portland cement, inspected for possible external contamination, also will be used. Materials which cannot be cleaned to the satisfaction of the responsible Field Hydrogeologist will not be used.

1.2 Well Casing

Upon completion of drilling to the proper termination depth, a monitoring well casing will be installed in each boring. A schematic representation of a completed well is shown on Figure B-1.

Blank well casing and well screen will be constructed of Schedule 40 PVC with an inside diameter of two inches. All well casing sections will be flush-threaded. Glued joints are not acceptable. The casing at each well will be fitted with a bottom plug and a top cap constructed of the same type material as the well casing.

The Field Hydrogeologist will verify and record the boring depth, the lengths of all casing sections, and the depth to the top of all well completion materials placed in the annulus between the casing and borehole wall. All lengths and depths will be measured to the nearest 0.1 foot.

1.3 Well Screen

Well screens will be constructed of flush-threaded, Schedule 40 PVC with an inside diameter of two inches. Each well will be screened in the water-bearing stratum underlying the soil deposits. The screened intervals will be 10 feet in length. The position of the screen will be selected by the Field Hydrogeologist after consideration is given to the geometry and hydraulic characteristics of the stratum in which the well will be screened.

Each well screen will be isolated from the overlying deposits using an annular seal consisting of a combination of a two-feet thick bentonite pellet seal overlain by an interval of cement/bentonite grout. The grout interval will extend from the top of the pellet seal to the ground surface.

The slots in the screens will be factory cut. A slot size of 0.010 inches is estimated to be appropriate for use in the rock.

1.4 Sand Filter

A graded sand filter will be placed against the screened interval and extend one to two feet above the top of the screen. If the screen is set in sound rock, the filter gradation will be selected so that no more than about ten percent of the filter material is finer than the size of the well screen slots. If fine grained materials are present in the rock, such as joint filling material, the gradation of the sand filter will be intermediate of the mean diameter of the fine-grained material and the screen slot size. The procedure use to select filter grain size is described by Driscoll.[1]

1.5 Annular Sealant

An annular seal will be placed above the sand filter using sodium bentonite pellets. The pellet seal will be a minimum of two feet thick.

---

[1] Driscoll, Fletcher G. "Groundwater and Wells". Johnson Division St. Paul Minnesota. 1986.

A portland cement/sodium bentonite grout will be placed from the top of the pellet seal to the ground surface. The grout mixture used will consist of one 94-pound sack of cement and about five pounds bentonite for each seven gallons of water used. All grouting below the ground-water level or deeper than 10 feet below ground surface will be performed by pumping using a small-diameter tremie pipe positioned several feet above the top of the bentonite pellet seal.

1.6 Protective Surface Casing

Each monitoring well will be completed with a five-foot long, 6 inch diameter, steel protective casing with a hinged, lockable cover. The inside diameter of the protective casing will be at least four inches. A one-half inch diameter drain hole will be drilled in the steel casing just above the ground surface. Each protective casing will be painted with a rust-retardant primer and a bright paint. A 4 foot by 4 foot concrete pad (well apron) will be constructed around each of the wells. The concrete pad will have a minimum thickness of 4 inches, except where underlain by the borehole where a minimum thickness of three feet is required.

1.7 Well Survey

The location and elevation of the new well will be surveyed by a surveyor registered in the State of Oklahoma soon after well completion. The horizontal location will be measured relative to established facility coordinates. Horizontal coordinates will be measured to the nearest 1.0 foot. Vertical location of the ground surface adjacent to the well casing and the measurement datum (top of interior casing), will be measured relative to U.S.G.S. datum. The ground surface elevation will be measured to the nearest 0.1 foot and the measurement datum to the nearest 0.01 foot.

2. WELL DEVELOPMENT

Before a new well can be considered in proper condition for monitoring water levels, testing, or taking water samples, it will be developed. Development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen.

Well development will not be performed until at least 24 hours after well grouting is completed. Well development will be performed within one week of well installation. Development water will be put into barrels and disposed of in the Cimarron wastewater treatment facilities.

2.1 Procedure for Air-Lift Well Development

The following procedure describes an air-lift technique for well development. The hardware used for this technique is installed so that air used to lift water from the water does not contact the well casing and does not enter the well screen.

1. Clean all apparatus to be used down-hole by first steam-cleaning and then using a detergent and tap water wash, tap water rinse, distilled water rinse.

2. Measure and record the depth to ground water and total depth of the well, before development.

3. Assemble the small diameter development tubing (e.g. 1" or 1.5" o.d. for 2" i.d. well casing), with a one-way, check-valve at the bottom and a total length which can extend from the bottom of the well to the ground surface.

4. Place the first section of the development tubing inside the well and place the air line inside the tubing. Assemble and lower additional sections of the development tubing and air line until the tubing rests at, or just above, the bottom of the well.

5. Lift the tubing several inches above the bottom of the well and secure the lifting line to the well protector pipe.

6. Secure the air line to prevent air pressure from lifting the air line.

7. Attach an in-line hydrocarbon filter to the air line.

8. Using the shut-off valve, send a pulse of air down the air line. Shut off the air when a column of water comes out of the well.

9. Water produced during development will be discharged to the ground surface at a location away from the well. Ground water from the water from the rock stratum is not anticipated to have been contaminated by prior activities at the facility and special provisions for management of this water are not planned.

10. Allow the well several seconds (or minutes, if necessary) to recover, then send another "air pulse".

11. Repeat the pulsing process, occasionally moving and securing the tubing at different levels within the well screen.

12. Repeat this process until water from the well is clear (or nearly clear).

13. Record the development time, the number of pulses and the estimated volume of water produced during development, and the color of water at the beginning and end of development.

14. Disconnect and remove the development apparatus from the well for cleaning before use in another well.

15. Verify that the protector pipe drain is functional and development water is not held inside the protector pipe.

16. Measure and record the post-development depth to ground water and total depth of the well.

2.2 Alternate Well Development Procedures

Well development also can be accomplished using surge blocks, cleaned bailers or manual or automatic pumps. A loosely-fitting surge block can be used to agitate the water and sediment in the well before water is removed from the well using bailer or pump. The bailer or pump intake regularly must be lowered to the bottom of the well so that fines which have accumulated in the bottom are agitated and removed from the well in the development water. If a pump is used, the intake level should be moved to different positions within the well screen so as to draw water into the well from different levels.

Development should be continued until a minimum of ten casing volumes of water have been removed from the well and the water produced is clear. If the development water still is turbid after removal of ten casing volumes, development should be continued until the water become clear or the turbidity of the water produced has been stable for the removal of several casing volumes.

2.3 Development Records

Development records should include:

- Well Number
- Date and time of development
- Development method
- Pre-development water level and well depth
- Volume of water produced
- Description of water produced
- Post-development water level and well depth

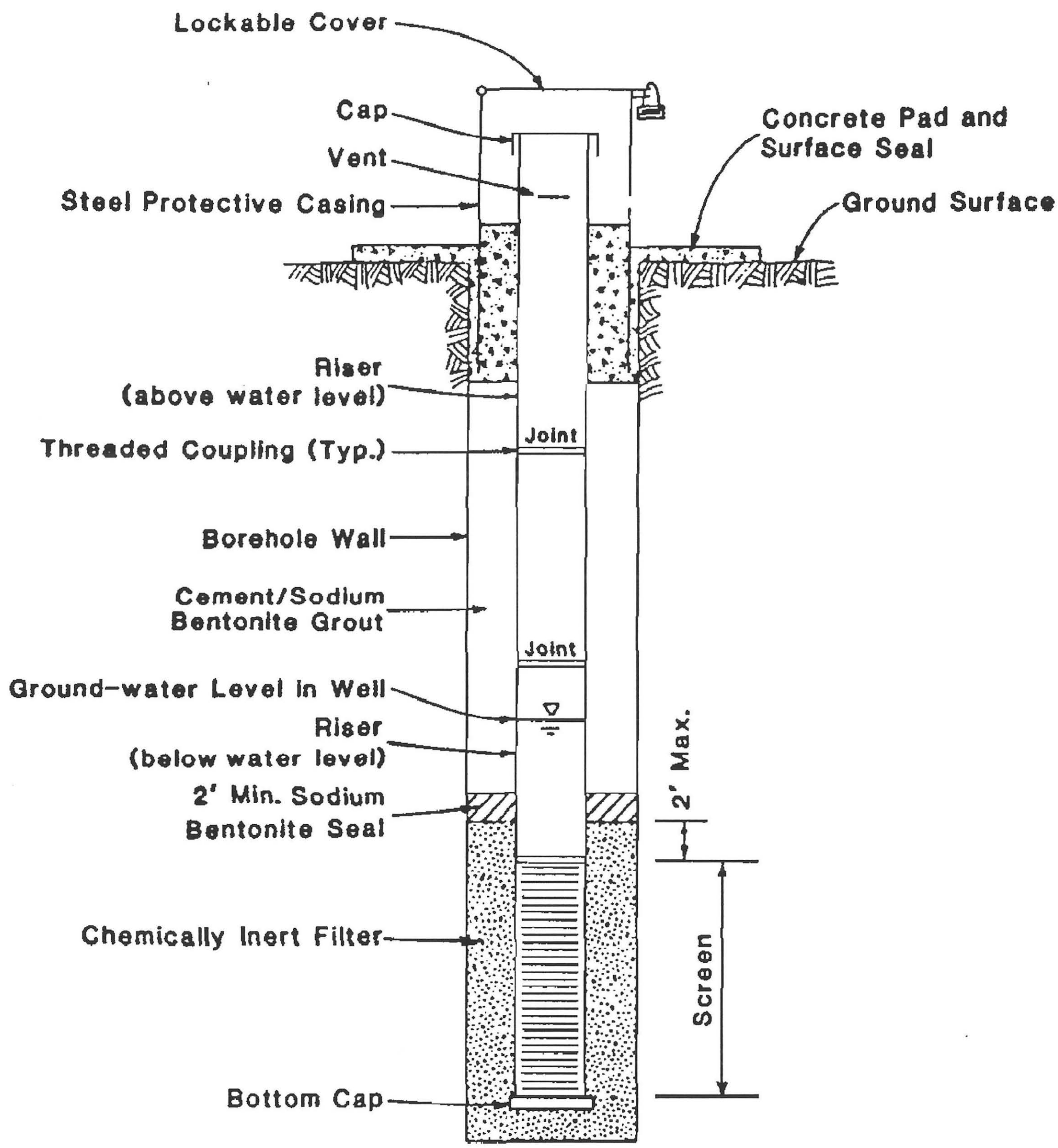
3. WELL ABANDONMENT

Any boring or well to be abandoned shall be sealed by grouting from the bottom of the boring/well to ground surface. This shall be done by placing a grout pipe to the bottom of the boring/well and pumping grout through the pipe until undiluted grout flows from the boring well at ground surface.

A portland cement/sodium bentonite grout will be used for grouting. The grout mixture used will consist of one 94-pound sack of cement and about five pounds bentonite for each seven gallons of water used. Additives or cuttings are not to be added to the grout mixture. The grout materials are to be combined in an above-ground rigid container or mixer and mechanically mixed to produce a thick, lump-free mixture. The mixed grout is to be recirculated through the grout pump prior to placement. These procedures may require some modification to meet state requirements regarding borehole abandonment.

An abandoned well may be grouted with the well screen and casing in place. However, if the integrity of the casing seal is questioned, the Field Hydrogeologist may require that the casing be removed prior to abandonment. In this instant, partial or total hole re-drilling will be necessary prior to sealing the well. Each boring/well that is abandoned must have a record of abandonment completed.

Twenty-four hours after abandonment, the Field Hydrogeologist, or his designate, shall check the abandoned site for grout settlement and specify the addition grout, as necessary. This process is to be repeated until firm grout remains at the surface.



JAMES L. GRANT & ASSOCIATES geotechnical engineering • management • computer science ENGLEWOOD, COLORADO	FIGURE B-1 MONITORING WELL DESIGN

APPENDIX C

FIELD TESTING PROCEDURES

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FIELD TESTING PROCEDURES

1. WATER-LEVEL MEASUREMENT

To determine the ground-water level and flow direction, water levels will be measured at all wells within a short time interval so that the data are comparable. Water levels will not be measured until the water level in the new wells have equilibrated to static conditions. The depth to water below the measurement datum will be made to the nearest 1/8 inch (0.01 feet).

Water-level data will be recorded on an appropriate data form. An example form is presented in Figure C-1.

2. SLUG TEST PROCEDURE

To measure the hydraulic conductivity at new wells, "slug tests" will be performed. The procedure involves lowering a slug, or sealed tube, into the water in the well and allowing the raised water level to recover to the pre-insertion level. The slug then is removed quickly and the recovery of the lowered water level to static level monitored, timed, and recorded. Slug test results will be evaluated in accordance with the methods presented by Bouwer and Rice.[1]

To provide useful data, slug tests usually must be conducted using a recording pressure transducer to measure ground-water levels. In sandy or other permeable aquifers, the useful portion of the recovery curve can occur within the first five seconds of the test. A log-type measurement frequency is necessary to allow very frequent measurements (0.5 second or less) in the first several seconds and less frequent measurements after about 10 to 20 seconds.

Using manual measurement methods, it is unlikely that any measurements can be made in the first several seconds. Manual measurement of recovery probably is adequate in low permeability materials where recovery is very slow.

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[1] Bouwer, H. and R. C. Rice, 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells", Water Resources Research, Vol. 12, No. 3.

Test data from a slug test will be recorded on a Variable Head Permeability Test form, such as the one shown on Figure C-2.

3. STEP-DRAWDOWN TEST PROCEDURE

The step drawdown test procedure involves monitoring drawdown as the well is pumped at several pumping rates. The test results can be used to predict well drawdown from pumping at various rates for extended periods and are useful for selecting the proper pumping rate for 8 hour, 24 hour, or longer pumping tests. The results also can be used to compute specific capacity, transmissivity, and head losses in the well.

During a step-drawdown test, the well is pumped at several rates for short periods. Usually the initial pumping rate is small, often less than five gpm, and the rate is stepped up by approximately doubling the rate on each step. Pumping at each step is continued for about the same length of time. Ideally, the well would be allowed to recover to the initial static level between tests, but it is acceptable to conduct a continuous test by just stepping up the pumping rate at the proper time.

Drawdown measurements at the beginning of the test, and at the beginning of each successive step are made on a frequent interval. As the measurements are made, drawdown and log time are plotted. Examination of the plot allows estimation of the drawdown expected over the pumping period for each pumping rate. The step drawdown test data are evaluated in accordance with procedures presented by Brereton.[2]

The test is continued for several pumping rates. If the results are to be used to determine the proper pumping rate for a longer, constant-rate pumping test, the stepped rates are selected to bracket the required drawdown for the constant-rate test. The proper rate for the constant-rate test is selected using the planned test duration and required drawdown and comparing these numbers to the drawdown curves (from the step test) to select the proper pumping rate.

Pumping rates are measured with an in-line, totalizing water meter, an orifice weir, or timed filling of a container of known volume. Discharge rates will be measured frequently during the test.

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[2] Brereton, N. R., 1979, "Step-drawdown Pumping Tests for the Determination of Aquifer and Borehole Characteristics" Water Research Center Technical Report TR 103 (UK)

Test data are recorded on the following data forms or in the Field Log Book:

- o Aquifer Test Pump Log (Figure C-3) for recording pumping steps and drawdown at the pumping well

- o Aquifer Test Recovery Log (Figure C-4): for recording drawdown changes during recovery

Upon completion of the final pumping test (unless the step test goes directly into a constant-rate test) a recovery test is conducted. Recovery test procedures involve monitoring the rate of water-level rise following cessation of pumping. Recovery test data can be evaluated using the straight-line methods contained in Lohman on pages 23 to 27.[3]

Water produced during a step-drawdown test, if considered contaminated, will be discharged to the ground surface in an area of know surface contamination. Otherwise, the water will be discharged to the Cimarron wastewater treatment facilities.

The equipment used for step-drawdown and constant-rate pumping tests are identical. The following list summarizes these items.

1. Pump - when final drawdowns will not exceed about 12 to 14 feet below ground surface, it is possible to use a surface pump with a suction intake hose set within the well screen. When the final water level is expected to exceed 12 to 14 feet, a submersible pump usually is required. (Jet pumps set at the surface can lift water from depths greater than 12 to 14 feet) Pump size (for submersed operation) and intake or discharge hoses must be sized to allow measurement equipment, power cords, safety lines, etc. to fit in the well.

2. Power source for the pump - "plug-in" electricity is preferable, but a generator properly sized for the pump usually is required. For submersible pumps, a power cable to the pump is required. Surface suction-type pumps often have gasoline engines.

3. Intake hose, properly sized for the well.

4. Discharge hose, to discharge pumped water to a container or to an impoundment.

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[3] Lohman, S. W., 1979, "Ground-Water Hydraulics", U. S. Geological Survey Professional Paper 708.

5. Safety line for submersible pump.

6. Water-level measurement device - electric probe or transducer. When a part of pump flow is recirculated to the well (for low pumping rates) a "stilling well" (0.5 to 1.0 inch i.d. hose) is advisable for measuring water levels in the pumped well. The stilling well is not necessary when a transducer is used in the pumped well.

7. Valves, "T" coupling, and hoses - necessary to recirculate water to the pumped well and control discharge rate. Partial flow recirculation during low pumping rate is advisable during longer tests to prevent pump damage.

8. Discharge measurement device - bucket and stop-watch, water meter, or weir.

9. Tools, electrical tape, measurement tape, etc.

The attached sketch illustrates a typical set-up of pump test equipment.

4. CONSTANT-RATE PUMPING TEST PROCEDURE

A sustained pumping test involves pumping a well at a nearly-constant discharge for several hours to several days. This procedure usually requires monitoring water levels in one or more observation wells in addition to the pumped well. Data are evaluated to determine aquifer transmissivity, storativity, and hydraulic conductivity.

Procedures and set-up for the constant-rate test are essentially identical to those for the step-drawdown test except that pumping rate is controlled at a constant rate. After the initial hour of the test, the measurement of drawdown in the pumped well and observation well(s) and discharge rate is made each half hour to one hour until the test is completed. Upon test completion, a recovery test is conducted.

The drawdown during the constant-rate test must be monitored to make sure the drawdown does not exceed the planned maximum. Usually limitations on drawdown are: pump lift capacity (12-14 feet for suction pumps, variable for submersible pumps), height of water column in the well (usually do not want to draw water level down below the top of the well screen), or a pre-determined maximum drawdown. As drawdown increases, pump lift increases and pumping rate (with set valve openings) decreases. Thus, as drawdown increases, the valve on the discharge hose probably must be opened to maintain a constant discharge rate.

Test data are recorded on the following data forms:

- Aquifer Test Pump Log (Figure C-3): for pumping and drawdown data at the pumping well.
- Aquifer Test Recovery Log (Figure C-4): for recovery data a pumping and observation wells.
- Observation Well Log (Figure C-5): for drawdown data at observation wells.

Constant-rate pump test data for the pumped well usually are evaluated using Lohman's straight-line method. Data for the observation well(s) are evaluated using curve-matching techniques which also are included in Lohman (1979).

Water produced during a step-drawdown test, if considered contaminated, will be discharged to the ground surface in an area of know surface contamination. Otherwise, the water will be discharged to the wastewater treatment system.

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)

Job Name Job Number		WATER LEVEL AND WELL INFORMATION

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Variable Head Permeability Test

Test Performed By ____________________________ Date ____/____/______

Well or Boring No. __________________________ Total Well Depth ____ ft.

Length of Solid Casing _______ ft. Length of Solid Casing ______ ft.

Initial Depth from Datum _____ ft. Quantity of Water Bailed _____ gal.

Datum (check one): Ground Surface ___ Top of Casing ____

Type of Test (check one): Inflow ___ Outflow (Bailing) ____

Time Slug Inserted _____ hrs. ______ min ______ sec

Time Slug Removed _____ hrs. ______ min ______ sec

Time (min.)	Depth* (ft.)	Remarks

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FIGURE C-3

AQUIFER TEST PUMP LOG

... NO.

COMPANY ______

WELL NO. ______

CITY ______ COUNTY ______

STATE ______ JOB NO. ______

WATER MEASURED FROM

ELEV. OF MEASURING POINT

STATIC WATER LEVEL FT.

AQUIFER SCREENED

LOCATION

SEC. ______ TWP ______ RGE ______

DATE

TYPE OF DISCHARGE DEVICE

TIME PUMPING BEGAN HRS. (A.M.) (P.M.) MIN. SEC. DATE

TYPE OF W/L MEASURING DEVICE

TIME PUMPING ENDED HRS. (A.M.) (P.M.) MIN. SEC. DATE

DATA TAKEN BY

TIME	ELASPED TIME (MIN)	TAPE HELD/ NEAREST BAND (FT)	WETTED/ DIST TO NEAREST BAND (FT)	WATER LEVEL (FT)	DISCHARGE MEASUREMENT	DISCHARGE RATE (GPM)	REMARKS

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Englewood, Colorado

FIGURE C-4

AQUIFER TEST RECOVERY LOG

NO.

COMPANY

WELL

CITY COUNTY

STATE JOB NO.

WATER MEASURED FROM

ELEV. OF MEASURING POINT

STATIC WATER LEVEL FT.

AQUIFER SCREENED

LOCATION:

SEC. TWP RGE

DATE

TYPE OF W/L MEASURING DEVICE

TIME PUMPING BEGAN (A.M.) HRS. (P.M.) MIN. SEC. DATE

TIME PUMPING ENDED (A.M.) HRS. (P.M.) MIN. SEC. DATE

DATA TAKEN BY

TIME	ELAPSED TIME (MIN)	TAPE HELD/ NEAREST BAND (FT)	WETTED/ DIST TO NEAREST BAND ± (FT)	WATER LEVEL (FT)	REMARKS	TIME	ELAPSED TIME (MIN)	TAPE HELD/ NEAREST BAND (FT)	WETTED/ DIST. TO NEAREST BAND ± (FT)	WATER LEVEL (FT)	REMARKS

FIGURE C-5

OBSERVATION WELL LOG

FILING NO.

COMPANY ______

WELL ______

WATER MEASURED FROM

CITY ______ COUNTY ______

ELEV. OF MEASURING POINT

STATE ______ JOB NO. ______

STATIC WATER LEVEL FT.

LOCATION:

DATE

AQUIFER SCREENED

SEC. ______ TWP ______ RGE ______

TYPE OF W/L MEASURING DEVICE

TEST PUMP WELL

TEST RECOVERY WELL

DATA TAKEN BY

TIME	ELAPSED TIME (MIN)	TAPE HELD/ NEAREST BAND (FT)	WETTED/ DIST. TO NEAREST BAND (FT)	WATER LEVEL (FT)	REMARKS	TIME	ELAPSED TIME (MIN)	TAPE HELD/ NEAREST BAND (FT)	WETTED/ DIST. TO NEAREST BAND (FT)	WATER LEVEL (FT)	REMARKS

APPENDIX D

GROUND-WATER SAMPLING PROCEDURES

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Appendix D Ground Water Sampling and Analysis Procedures

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GROUND WATER SAMPLING AND ANALYSIS PROCEDURES

1. GROUND-WATER SAMPLING PROCEDURES

1.1 Sampling and Analysis Personnel

Sampling and analysis will be conducted by trained personnel. All sampling and analysis personnel will be trained in the performance of the specific task to which they are assigned. Training documentation will be available if requested.

Sampling personnel will have thoroughly reviewed this Sampling and Analysis Plan prior to conducting sampling and will have a copy of the plan available for reference.

1.2 Summary of Sampling Procedures

Activities which will occur during ground-water sampling are summarized as follows:

- pre-arrangement with testing laboratory
- assembly and preparation of equipment and supplies
- ground-water sampling
  - water-level measurements
  - visual inspection of borehole water
  - well bore evacuation
  - sampling
- sample preservation and shipment
  - sample preparation
  - on-site measurement of parameters
  - sample labeling
- completion of sample records
- completion of chain-of-custody records
- sample shipment

Detailed sampling and analysis procedures are presented in following sections.

1.3 Arrangements with Analytical Laboratory

Prior to sampling, arrangements will be made with an analytical laboratory which will conduct the sample analyses. The requirements for the laboratory are included in Section 2 of this Sampling and Analysis Plan.

The laboratory will provide a sufficient number of sample containers for the wells to be sampled and the blanks to be included. The laboratory will determine the proper type and size for the containers based upon the analyses to be conducted. For samples requiring chemical preservation, preservatives will be added to containers by the laboratory prior to shipping containers to the facility. Shipping containers, ice chests with adequate container padding and cooling media, will be sent to the facility with the containers.

1.4 Preparation for Sampling

Prior to the sampling episode, all equipment to be used will be assembled and its operating condition verified, calibrated (if required), and properly cleaned (if required). In addition, all record-keeping materials will be prepared.

1.4.1 Equipment Check-Out.

This activity includes the verification that all equipment is in proper operating condition. Also, arrangements for repair or replacement of any equipment which is inoperative are made.

1.4.2 Equipment Calibration.

Where appropriate, equipment will be calibrated according to the manufacturer's specifications prior to field use. This applies to the equipment for making on-site chemical measurements of pH, eH, conductivity, and temperature of water.

1.4.3 Equipment Cleaning.

All portions of sampling and test equipment which will contact the sample will be thoroughly cleaned before use for sampling. This includes water-level tapes or probes, pumps, tubing, bailers, lifting line, test equipment for on-site use, and other equipment or portions thereof which are to be immersed.

The procedure for equipment cleaning will depend upon the type of analyses to be conducted with the sample. Changes to the procedure are noted.

- o Clean with potable water and phosphate-free laboratory detergent;
- o Rinse with potable water;
- o Rinse with dilute (0.1N) reagent-grade hydrochloric or nitric acid (for samples planned for inorganic constituent analyses)
- o Rinse with distilled or deionized water;
- o Rinse with reagent-grade acetone (for samples planned for organic constituent analyses)
- o Rinse with reagent-grade hexane (for samples planned for organic constituent analyses)
- o Air dry the equipment prior to use.

Any deviations from these procedures should be documented in the permanent record of the sampling event.

Laboratory-supplied sample containers will be cleaned and sealed by the laboratory before shipping. The type of container provided and the method of container should be in the laboratory's permanent record of the sampling event.

1.5 Sampling Procedures

Special care will be exercised to prevent contamination of the ground water and extracted samples during the sampling activities. The two primary ways in which such contamination can occur are:

- o contamination of a sample through contact with improperly cleaned equipment; or

- o cross-contamination of the ground water through insufficient cleaning of equipment between wells.

To prevent such contamination, sampling equipment and sample containers will be thoroughly cleaned before and after field use and between uses at different sampling locations according to the procedures in Section 1.4.3. In addition to the use of properly cleaned equipment, two further precautions will be followed:

- o a clean pair of new, disposable latex (or similar) gloves will be worn each time a different well is sampled; and
- o sample collection activities will progress from the least affected (up-gradient) area to the most affected (down-gradient) area. Wells described as "background" or "up-gradient" wells will be sampled first.

The following paragraphs present procedures for the several activities which comprise ground-water sample acquisition. These activities will be performed in the same order as presented below. Exceptions to this procedure will be noted in the permanent sampling record.

1.5.1 Preparation of Location.

Prior to starting the sampling procedure, the area around the well should be cleared of foreign materials, such as brush, rocks, debris, etc. A clean (new), disposable, plastic sheet should be placed around the well casing so that the sheet is flat on the ground and the well projects through and above the center of the sheet. Flush-with-ground wells will not project through the sheet. For projecting protective well casings, a clean (new) plastic trash bag should be placed around the projecting casing or protector pipe and secured (with tape) to the casing so that only the interior well casing is visible.

This preparation will prevent sampling equipment from inadvertently contacting the ground or exterior parts of the well.

1.5.2 Water-Level Measurement.

The first sampling operation is water-level measurement. An electrical probe will be used to measure the depth to ground water below the datum to the nearest 1/8 inch (0.01 foot). The datum, usually the top of the inner casing (inside and below the protective steel cover), will be described in monitor well records. A permanent mark or scribe will be visible on inspection of the inner casing.

If the wells to be sampled are closely spaced, such as in well clusters, the water levels at all of the closely-spaced wells should be measured before any of the wells are evacuated. The water level probe should be cleaned with phosphate-free detergent in distilled water and with a distilled water rinse between usage at different wells.

1.5.3 Total Depth Measurement.

Once the water level has been measured and recorded, the water-level probe should be slowly lowered to the bottom of the well. The depth to the bottom should be measured and recorded. The probe then should be slowly withdrawn from the well. The bottom of the probe should be examined after withdrawal to determine if evidence of any viscous, heavy contaminants is apparent. Observations, and measurements if possible, of such materials should be made from examination of the probe.

1.5.4 Visual Inspection of Well Water.

Prior to well evacuation, a small quantity of water will be removed with a bailer, in a manner which will not totally immerse the bailer. The recovered sample is representative of the top of the water column in the well casing. If immiscible materials accumulate at the top of the water column, this technique can allow their detection. The water from the bailer will be decanted into a clean container. If a transparent bailer is used, decanting is unnecessary and the observation can be made through the bailer. The water will be inspected for the presence of any floating films or other indications of immiscible materials. Any sample odors will be noted. These observations regarding odor or visual evidence of immiscible materials will be recorded in the sampling record.

The sample taken in this manner will be discarded unless the site-specific protocol calls for retention of this sample. If the sample is to be discarded but is suspected to be contaminated, the water should be placed in a container for proper disposal.

1.5.5 Well Bore Evacuation.

Water contained within, and adjacent to, the well casing potentially can reflect chemical interaction with the atmosphere (by diffusion of gases down the casing) or the well construction materials (through prolonged residence adjacent to the casing). This water will be removed and discarded.

The volume of water contained within the well bore at the time of sampling will be calculated, and three times the calculated volume will be removed from the well and discarded. The use of a bailer for well evacuation is planned. Calculation of the volume of water to be evacuated will be done as follows.

$$\text{Number of Bailers} = 3 \times \frac{\text{volume of water in well } (V_w)}{\text{volume of bailer } (V_b)}$$

Volume of water in well

$$V_w = \frac{3.142 \times d_w^2}{4} \times L_w$$

where:
V_w = water volume in well (ft^3)
d_w = inside diameter of well (ft)
L_w = length of water column in well (ft)

Volume of water in full bailer

$$V_b = \frac{3.142 \times d_b^2}{4} \times L_b$$

where:
V_b = water volume in bailer (ft^3)
d_b = inside diameter of bailer (ft)
L_b = length of bailer (ft)

Alternatively, the chart in Figure D-1 and be used to determine the evacuation volume.

For wells which can be evacuated to a dry state, the well will be evacuated completely, and the sample taken as soon as sufficient water for sampling is present in the well. Sample compositing, or sampling over a lengthy period by accumulating small volumes of water at different times to eventually obtain a sample of sufficient volume, will not be allowed.

Water produced during well evacuation should be contained in a suitable container and discharge to the ground surface in an area of known surface contamination. In some instances, discharge to the city sanitary sewer also might be acceptable.

1.5.6 Sample Extraction.

A bailer or pump will be used to extract water samples from the well. Care will be taken during insertion of sampling equipment to prevent undue disturbance of water in the well.

If a pump is used, it will be a down-hole, bladder-type pump designed for use in small diameter wells. Pumps which would subject the sample to a negative pressure or could introduce a gas into the sample will not be used for sampling. However, suction pumps might be used for well evacuation.

When a pump is used, the immersed portion of the pump or suction line will be inserted gently into the water and the sample directed into the appropriate containers, or composited in a larger container and then transferred by pumping, siphoning, or carefully pouring into the appropriate container. The discharge line will be placed within the container, such that its end is below the water level in the container, in order to prevent significant aeration of the sample.

When a bailer is used for sampling, the bailer will be constructed of stainless steel or teflon. The bailer will be lowered into the water gently to prevent splashing and extracted gently to prevent creation of an excessive vacuum in the well. The sample will be transferred directly into the appropriate container. While pouring water from a bailer, the water will be carefully poured down the inside of the sample bottle to prevent significant aeration of the sample. If a bottom-discharge bailer is used, the discharge line will be placed so that its end is below the water level in the container. Unless other instructions are given by the analytical laboratory, the sample containers should be completely filled so that no air space remains in the container.

Excess water taken during sampling is placed in a container for proper disposition at the facility wastewater treatment plant.

1.5.7 Quality Control Samples.

Ground-water samples will include one split sample for each sampling event. If more than 20 wells are sampled, one additional split sample will be added. The decision of which sample to split will be made by sampling personnel. The split sample will be given a designation which can not be confused with other samples to be tested.

For each sampling event, a trip blank sample (distilled water) will be shipped from the laboratory to the facility and will be returned to the laboratory for analysis. The blank will not be opened in the field.

One equipment blank sample (distilled water) will be prepared for each day of the sampling event by pouring distilled water into a cleaned, sampling bailer or by pumping distilled water through the cleaned sampling pump and then filling a sample container in the sample manner that would be used for a ground-water sample.

1.5.8 On-Site Parameter Measurement.

Certain chemical and physical parameters in water can change significantly within a short time of sample acquisition. These parameters cannot be accurately measured in a laboratory located more than a few hours from the facility, and so will be measured on-site with portable equipment. These parameters are:

- o pH,
- o eH (if appropriate),
- o specific conductance, and
- o temperature.

These parameters will be measured in unfiltered, unpreserved, "fresh" water taken by the same technique as the samples taken for laboratory analyses. The measurements will be made in a clean glass container separate from those intended for laboratory analysis. The tested sample will be discarded after use. The measured values will be recorded in the sampling record.

1.6 Sample Handling

1.6.1 Sample Preservation.

Water samples will be properly prepared for transportation to the laboratory by refrigeration and chemical preservation (for water samples), if necessary. The laboratory providing sample containers will have added any necessary chemical preservatives to the sealed containers provided. The samples collected for uranium, plutonium and gross alpha and beta analyses will be preserved with 2% by volume concentrated HCl after being filtered.

As a general rule, and in accordance with EPA analytical procedures, water samples will not be filtered in the field, with the following exception. Samples planned for uranium, plutonium, and gross alpha and beta analyses either will be field-filtered before being acid-preserved, or, if the time between sampling and arrival at the laboratory are sufficiently short, the samples will be shipped with no chemical preservation. In the latter instance, the water samples will be filtered in the laboratory.

1.6.2 Container and Labels.

Glass containers and appropriate container lids will be provided by the laboratory. The containers will be filled and container lids will be tightly closed. All sample container lids will be sealed so that it will be obvious if the seal has been tampered with or broken. The label will be firmly attached to the container side (not lid). The following information will be legibly and indelibly written on the label:

- o facility name,
- o sample identification,
- o sample type (ground water, surface water, etc.)
- o sampling date,
- o sampling time,
- o preservatives added
- o sample collector's initials.

1.6.3 Sample Shipment.

In most instances, the concentration and type of compounds present in the ground-water are considered by the U.S. Department of Transportation to be non-hazardous. Thus, the following packaging and labeling requirements for the sample materials are appropriate for shipping the sample to the testing laboratory:

- o package sample so that is does not leak, spill, or vaporize from its packaging;
- o label package with
  - sample collector's name, address, and telephone number;
  - laboratory's name, address, and telephone number;
  - description of sample;

- quantity of sample; and
- date of shipment.

If the materials to be shipped are considered hazardous or if their nature is uncertain, the samples will be appropriately labelled and will be transported by sampling personnel directly to the analytical facility or will be shipped using a carrier licensed to transport hazardous materials.

To comply with packaging regulations and to take practical measures to prevent damage to expensive ground water samples, JLGA will follow packaging and shipping instructions supplied by the certified testing laboratory.

1.6.4 Chain of Custody Control.

After samples have been obtained, chain of custody procedures will be followed to establish a written record concerning sample movement between the sampling site and the testing laboratory. Each shipping container will have a chain of custody form completed by the site sampling personnel packing the samples. The chain of custody form for each container will be completed in triplicate. One copy of this form will be maintained at the site, and the other two copies at the laboratory. One of the laboratory copies will become a part of the permanent record for the sample and will be returned with the sample analyses.

A copy of a sample chain of custody form is shown in Figure D-2. The record must contain the following minimum information:

- o Collector's sample number,
- o Signature of collector,
- o Date and time of collection,
- o Place and address of collection,
- o Material type,
- o Preservatives added,
- o Analyses requested,
- o Signatures involved in the chain of possession,
- o Inclusive dates of possession.

The shipping container will be sealed so that it will be obvious if the seal has been tampered with or broken. The Chain of Custody documentation will be placed inside the container so that will be immediately apparent to the laboratory personnel receiving the container but will not be damaged or lost during shipping.

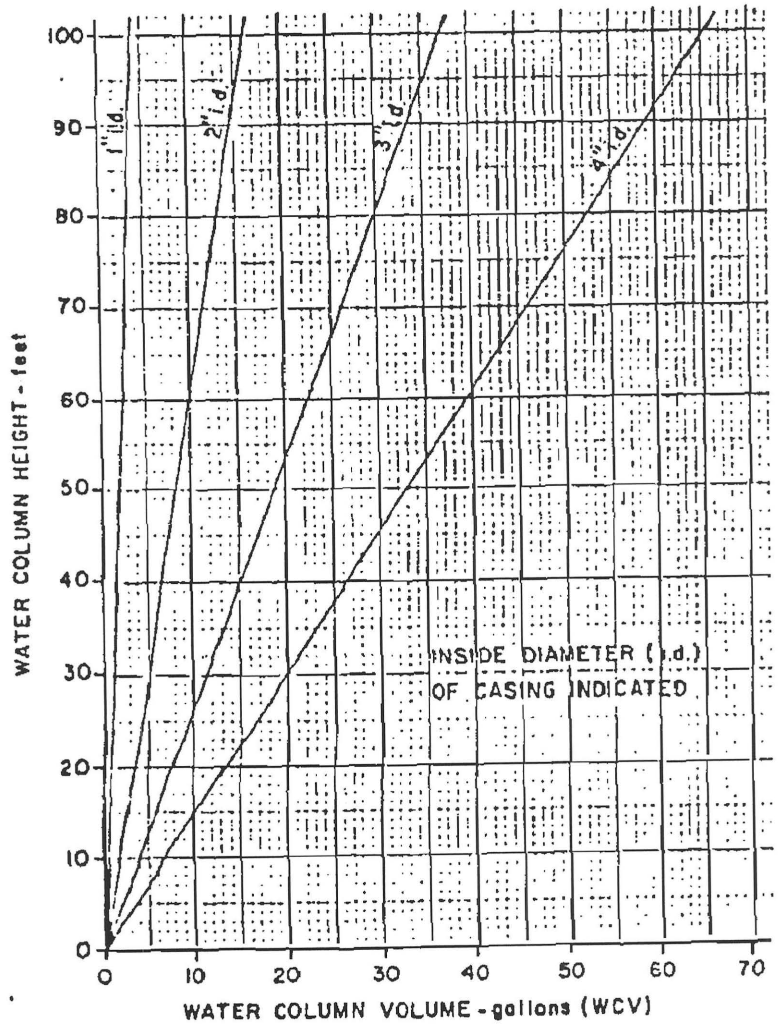
1.7 Sampling Records

To provide complete documentation of sampling, detailed records will be maintained during sampling. These records will include the information listed below:

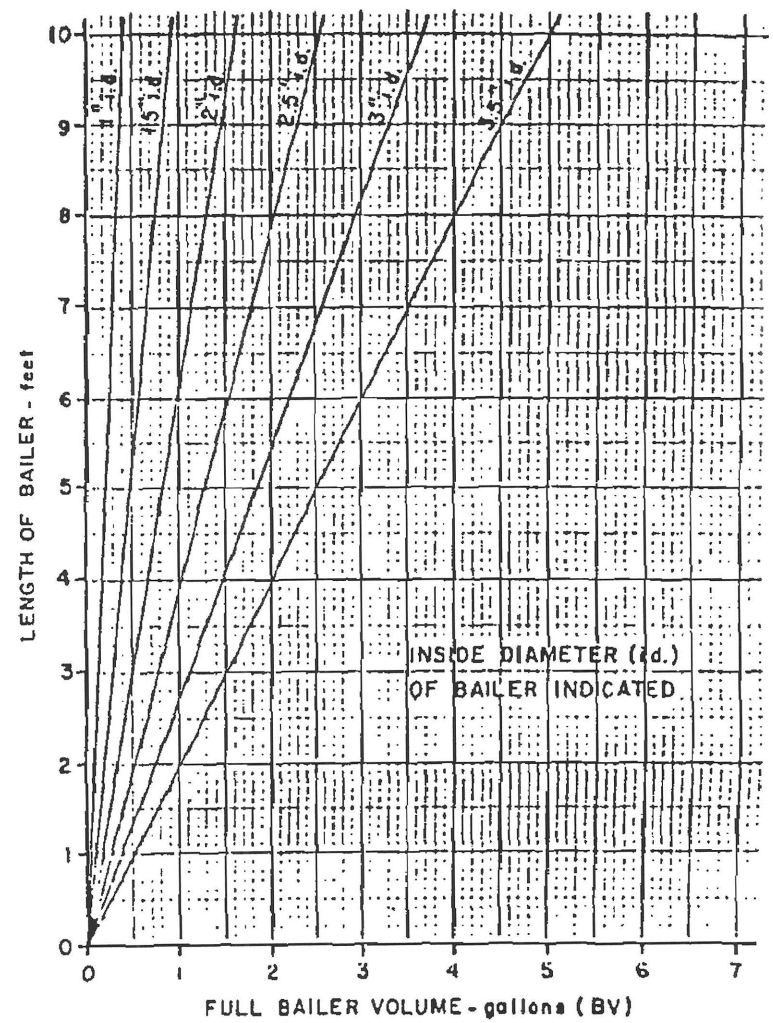
- sample location (facility name);
- sample identification (cleaning area name and sample number)
- sample location map or detailed sketch
- date and time of sampling;
- sampling method;
- field observations of
  - sample appearance,
  - sample odor
- weather conditions;
- sampler's identification; and
- any other information which is significant.

Ground-water sampling information will be recorded on the Water Sampling Record as shown in Figure D-3.

CASING VOLUME



BAILER VOLUME



NUMBER OF FULL BAILERS TO EVACUATE ONE (1) CASING WATER COLUMN VOLUME $= \frac{WCV}{BV}$

JAMES L. GRANT & ASSOCIATES
geotechnical engineering • management • computer science
ENGLEWOOD, COLORADO

CALCULATION OF WELL EVACUATION VOLUMES

FIGURE D-1

FIGURE D-2

Chain-of-( )ody Form.

CHAIN OF CUSTODY RECORD-Environmental Samples

PROJECT	SAMPLING FIRM	SAMPLE
Name	Name	☐ Soil ☐ Groundwater
Address	Address	☐ Waste ☐ Surface Water
	Signature	☐

SAMPLE I.D.	DESCRIPTION	DATE	TIME	WEATHER TEMP	WEATHER PREC	COMP	GRAB	OTHER	MAN	NO. OF CONTAINERS	ANALYSIS REQUIRED	REMARKS

RELINQUISHED BY (SIGNATURE)	RELINQUISHED TO	DATE	TIME	ADDITIONAL REMARKS
RELINQUISHED BY (SIGNATURE)	RELINQUISHED TO	DATE	TIME	
RELINQUISHED BY (SIGNATURE)	RELINQUISHED TO	DATE	TIME	
DISPATCHED BY (SIGNATURE) DATE TIME	RECEIVED FOR LABORATORY (SIGNATURE)	DATE	TIME	LAB PO #
CARRIER	LABORATORY			PO # AND SAMPLE I.D. #'S MUST BE ON THE LAB INVOICE
ADDRESS	ADDRESS			ALL ANALYSIS PERFORMED BY EPA APPROVED PROCEDURES
METHOD OF SHIPMENT				☐ Yes ☐ No. explain above

FIGURE D-3

SAMPLING LOCATION ____________________
SAMPLING DATE(S) ____________________

III. SAMPLING RECORD - MONITOR WELL ________
(number)

REASON FOR SAMPLING: ☐ Regular Sampling: ☐ Special Sampling

DATE AND TIME OF SAMPLING: ____________, 19__ ________ a.m./p.m.

SAMPLE COLLECTED BY: ________________ of ________________

WEATHER: ____________________________________

DATUM FOR WATER DEPTH MEASUREMENT (Describe): ______________

____

____

MONITOR WELL CONDITION:

☐ LOCKED: ☐ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: ______________

INNER PVC CASING CONDITION IS: ______________

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITOR WELL REQUIRED REPAIR (Describe): ____

____

____

.ck-Off

1 ☐ EQUIPMENT CLEANED BEFORE USE WITH ______________

Items Cleaned (List): ______________

____

____

2 ☐ WATER DEPTH ______________ FT. BELOW DATUM

Measured with: ______________

3 ☐ WATER CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: ______________

Odor: ______________

Other Comments: ______________

4 ☐ WELL EVACUATION:

Method: ______________

Volume Removed: ______________

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: ______________

Other comments: ______________

III. Sampling Record - Monitor Well ______________ (cont'd.)
(number)

5 ☐ SAMPLE EXTRACTION METHOD:

☐ Bailer made of: ______________________

☐ Pump, type: ______________________

☐ Other, describe: ______________________

____

Sample obtained is ☐ GRAB; ☐ COMPOSITE SAMPLE

6 ☐ ON-SITE MEASUREMENTS:

Temp: ________ ° ______ Measured with: ______________

pH: ______________ Measured with: ______________

Conductivity: ________ Measured with: ______________

Other: ______________________________

____

7 ☐ SAMPLE CONTAINERS (material, number, size): ______________

____

____

____

8 ☐ ON-SITE SAMPLE TREATMENT:

☐ Filtration: Method ____________ Containers: ____________

Method ____________ Containers: ____________

Method ____________ Containers: ____________

☐ Preservatives Added:

Method ____________ Containers: ____________

Method ____________ Containers: ____________

Method ____________ Containers: ____________

Method ____________ Containers: ____________

9 ☐ CONTAINER HANDLING:

☐ Container Sides Labeled

☐ Container Lids Taped

☐ Containers Placed in Ice Chest

10 ☐ OTHER COMMENTS: ______________________________

____

____

____

____

APPENDIX E

LABORATORY ANALYSIS PROCEDURES

TABLE OF CONTENTS

Appendix E Laboratory Analysis Procedures

APPENDIX E
LABORATORY ANALYSIS PROCEDURES

1. LABORATORY ANALYSIS PROCEDURES

1.1 Chemical Analyses

1.1.1 Ground Water Analyses.

Ground-water samples will be analyzed for uranium, plutonium, gross alpha and beta, nitrate (NO3) and fluoride (F). The suggested procedures for determining gross alpha and beta, and nitrate are EPA methods 9310 and 9200, respectively, found in EPA publication SW-846, "Test Methods for Evaluating Solid Waste". Fluoride may be determined by ASTM method D-1179-72, Method A. Uranium and plutonium may be analyzed using procedures found in ASTM publication "1988 Annual Book of ASTM Standards, Section 11: Water and Environmental Technology", or by an appropriate test method provided in another accepted standard. The laboratory doing the analyses will have a QA/QC program which specifies procedures and references to be used.

1.1.2 Soil Analyses.

Soil samples will be analyzed for uranium, plutonium, nitrate, fluoride, total organic carbon (TOC), cation• exchange capacity (CEC), exchangeable cation (EXC), mineralogy, matric potential, and distribution coefficient for uranium and thorium. The suggested procedures for analyzing for uranium, plutonium, nitrate and fluoride will be the same used for ground water after an appropriate extraction procedure has been applied. Total organic carbon may be analyzed by EPA procedure 9060. Cation ion exchange capacity will be analyzed by EPA procedure 9081. These procedures are found in EPA publication SW-846, "Test Methods for Evaluating Solid Waste". Exchangeable cation, mineralogy, matric potential, and distribution coefficient will be determined by an appropriate test method provided in an accepted standard.

1.2 Physical Analyses

Physical tests will be conducted in accordance with the current edition of ASTM Standards, American Laboratory Soils Testing and Materials, Part 19. Soil classification will be determined according to the Unified Soil Classification System (ASTM D 2487). Liquid limit will be determined by ASTM D 423, and plastic limit and plasticity index will be determined by ASTM D 424. Other tests include particle size analysis (ASTM D 422) and moisture content (ASTM D 2216). Proctor tests will be conducted according to ASTM D 698, and density will be determined by ASTM D 2049, unless the soil composition dictates use of a different method.

1.3 Laboratory Quality Assurance

1.3.1 QA/QC Program Components.

The laboratory doing the analyses will have a QA/QC program which specifies procedures and references to be used. As a minimum, the program will contain:

1. Laboratory instrument calibration procedures and schedules.
2. Specification of adherence to accepted test methods.
3. Equipment inspection and servicing schedules.
4. The regular use of duplicate or split sample analyses.
5. The regular use of standard or spiked sample analyses.
6. Operator or analyst training procedures and schedules.
7. A program of continuous review of results, procedures, and compliance with the QA/QC program.
8. Documentation of compliance with the program.

The QA/QC program will be available for review.

1.3.2 Chemical Laboratory Sample Custody Procedures.

A sample custodian in the chemical analysis laboratory will be assigned to receive the samples. Upon receipt of a sample, the custodian will inspect the condition of the sample and the sample seal, reconcile the information on the sample label against that on the chain of custody record, assign a laboratory number and mark this number on the sample, log in the sample in the laboratory log book, and store the sample in a secured sample storage room or cabinet until assigned to an analyst for analysis. Discrepancies between the information on the sample label and the chain of custody record and the sample analysis request sheet will be resolved before the sample is assigned for analysis.

The laboratory portion of the sample analysis request form will be completed by the laboratory personnel and include:

- Name of person receiving the sample,
- Laboratory sample number,
- Date of sample receipt,
- Sample allocation
- Analyses to be performed.