SNL NUCLEAR WASTE REPOSITORY TECHNOLOGY DEPARTMENT EXPERIMENT PROCEDURE

GEOLOGIC SURFACE AND TRENCH MAPPING NEAR PROSPECTIVE SURFACE FACILITIES

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1.0 GENERAL INFORMATION

1.1 Scope

This Experiment Procedure (EP) states the requirements and describes the procedures for work that will be conducted for the Yucca Mountain Project (YMP) study to evaluate the location and recency of faulting near prospective surface facilities of a high-level nuclear waste repository at Yucca Mountain, Nye County, Nevada (Gibson et al., 1989). This EP applies specifically to surface and trench mapping and sample collection that will be conducted at the Midway Valley study area by Sandia National Laboratories (SNL), the SNL geotechnical contractor, and Department of Energy/Nevada Test Site (DOE/NTS) support contractors. The requirements of the Operations and Safety (O/S) Plan for this study, included in this EP as Attachment III--Safe Operating Procedure for Geotechnical Studies Within Midway Valley at the Nevada Test Site, apply to the work conducted for this experiment.

1.2 Definitions

The following terms are used in this EP. Technical terms not listed here may be found in the references listed in Section 14, Appendices A and B of Attachment III, and other standard geologic references.

Contract Geologist - The employee of the SNL geotechnical contractor who is responsible for the technical input into the experiment by the contractor.

Contract Manager - The employee of the SNL geotechnical contractor who is responsible for the organization and management of the contractor's personnel and equipment.

DOE/NTS support contractors - Contractors that will perform support work during the experiment, such as acquisition of aerial photography, surveying, photography of trench faces for photogrammetry, and excavation, cleaning, and preparation of trenches.

Excavation - Any manmade cavity or depression in the earth's surface, including its sides, walls, or faces, formed by earth removal and producing unsupported earth conditions by reason of the excavation. If installed forms, shoring, or similar structures reduce the depth-to-width relationship, an excavation may become a trench.

Exploratory trenches - Trenches that are ~6 m long; may be excavated to a greater length if necessary.

Geotechnical contractor - The SNL contractor that will perform surface and trench mapping.

Long trenches - Trenches that are generally longer than 100 m.

Photogrammetry - The process of obtaining reliable measurements from photographs. For this EP, photogrammetry is restricted to use within trenches. A sequence of photographs are taken of the trench face to record the exposed geologic features and to provide an accurate record of the reconnaissance mapping of trenches.

Principal Investigator (PI) - The SNL employee who is responsible for a specific study. This individual, or an alternate designated by the responsible SNL division supervisor, directs all aspects of the study, including preparation of the study plan, experiment procedures, and technical procedures; data acquisition; data analysis; and final report writing.

Significant late Quaternary faults - Faults that have an average slip rate of >0.001 mm/yr over the last 100 Ka ("Ka" = 1,000 yr).

Soil pit - A general term for any small pit or hole used to determine subsurface materials or conditions. For this procedure, such pits will be used for reconnaissance and will include any shallow excavation that exposes rock and/or soil horizons. As used here, soil pits are 1-2 m deep

and approximately the width of a backhoe scoop (<1 m). For this EP, it is assumed that most soil pits will be made by backhoes.

Supplemental trenches - Trenches with dimensions similar to those for exploratory trenches (~6 m long) that are excavated and mapped during Activity 2 to provide further understanding of features and relationships found in the long trenches; may be excavated to a greater length, if necessary.

Surface geologic mapping - The identification and recording of geologic data available from the interpretations of aerial photographs or from direct observations in the field. Examples of geologic data to be recorded in the field include geomorphologic, lithologic, stratigraphic, and structural characteristics of rock and/or sediment exposed in outcrops or soil pits.

Task Leader - The SNL employee who is responsible for the overall Work Breakdown Structure (WBS) element under which a specific study is included. Several separate studies may be included within one WBS element. A task leader may be assisted in a study by one or more principal investigators.

Technical Consultant - An individual who will provide specialized expertise, as required.

Trench - A narrow manmade excavation made by ground removal at the surface and producing unsupported earth conditions by reason of the excavation. In general, the depth is greater than the width, but the width of a trench is generally not more than 15 ft. For this EP, it is assumed that most trenches will be excavated by bulldozer.

Trench mapping - The identification and recording of selected geologic data that are directly observable on vertical or near-vertical exposures in excavated trenches. Examples of geological data to be recorded include lithologic, stratigraphic, and structural characteristics and relationships

of lithologic and surficial units. This information will be used in analyzing the neotectonic setting of the site.

1.3 Objective

The objective of this experiment is to gather geologic data to characterize the existence of late Quaternary faults in Midway Valley, the proposed site for repository surface facilities. If faults are found in Midway Valley, the information collected during this experiment will be used to determine fault displacement rates. These data will be used to support the siting of the surface facilities and an assessment of the effect of fault displacement on repository design.

1.4 Related Study

This experiment is associated with Study 8.3.1.17.4.2 of the Site Characterization Plan (SCP) (DOE, 1988), Evaluate the Location and Recency of Faulting Near Prospective Surface Facilities. The study plan (Gibson et al., 1989) presents the detailed rationale for, and description of the study.

2.0 DESCRIPTION OF WORK

Midway Valley, located directly east of Yucca Mountain, Nye County, Nevada, has been identified as a potential location for the surface facilities of the Yucca Mountain repository (Attachment III, Figures 2 and 3). As part of the site characterization for the repository, the potential for fault displacement near the surface facilities must be evaluated.

Geologic investigations will be conducted to collect the data necessary for developing an understanding of the neotectonic history of Midway Valley; determining the existence of late Quaternary (<100,000 yr) faults in the area; identifying, if possible, areas where late Quaternary faults are absent; and, if these faults are present, determining their

displacement rates. These data will be used to support the siting and design of repository surface facilities.

The related study plan (Gibson et al., 1989) presents the rationale for, and a description of the two interrelated activities planned for the study. During Activity 1, a detailed map of the surface geology will be prepared, based on interpretation of new and existing aerial photographs, field mapping, soil pits and exploratory trenches, and selected geophysical data. Detailed tasks for Activity 1 may include literature, map, and data review; photogeologic interpretation; field inspection; use of geophysical and remote sensing techniques; examination of soil pits; detailed geologic mapping; close-range photogrammetry; reconnaissance and detailed mapping of exploratory trenches; collection of samples for age determination; determination of locations for long trenches; and report preparation.

Activity 2 is an extensive trenching program during which long trenches will be excavated and mapped. Detailed tasks for Activity 2 may include trench layout and excavation, reconnaissance trench mapping, close-range photogrammetry, detailed trench mapping, collection of samples for age determination, and report preparation.

The step-by-step technical procedures to accomplish the tasks for Activities 1 and 2 are presented in Section 4 of this EP. Section 4.4 presents the procedure for surface mapping; Section 4.5 presents the procedure for trench mapping; and Section 4.6 presents the procedure for collection, handling, and control of samples.

2.1 Management

The work described in this EP will be conducted under WBS No. 1.2.3.2.1.2.2, Site Faulting Potential, and will be accomplished by SNL, the SNL geotechnical contractor (Geomatrix), the U.S. Geological Survey (USGS), and various DOE/NTS support contractors. The PI, or an alternate designated by the Division 6315 Supervisor, has the overall responsibility for management of and interfaces for this experiment. The Contract Manager

will be the primary point of contact between the PI and the geotechnical contractor's experiment team. The Contract Geologist will report directly to the Contract Manager and has responsibility for day-to-day execution of work in the field. The Geologic Staff will report to the Contract Manager. Any technical consultants will report directly to the PI. Principal organizational interfaces and functions are presented in the O/S Plan (Attachment III, Figure 4).

Primary responsibility for the execution of the procedures for this experiment rests with the PI or an alternate designated by PI's division supervisor. Secondary responsibility rests with geotechnical and support contractor personnel. Table 1 lists the responsibilities and procedural controls for each organization involved in the experiment. Organizational and individual responsibilities are also presented in the following paragraphs.

Sandia National Laboratories - responsible for the overall management of the study and preparation of final reports to be submitted to the YMP Office.

Geomatrix (geotechnical contractor) - The SNL contractor that will perform surface and trench mapping.

Contract Manager: responsible for overall management of Geomatrix staff.

Contract Geologist: responsible for implementation of procedures, review of field activities, coordination with field contractors, and liaison with the PI.

Geologic Staff: responsible for implementing procedures, conducting the surface and trench mapping, documenting unusual occurrences during mapping, checking and maintaining the operational status of geologic field equipment and instruments, and informing the Contract Geologist

TABLE 1

SPECIFIC EFFORTS

Responsibility	Organization	Procedural Controls
Surface and Trench Mapping	SNL Geotechnical Contractor (Contract 75-4350)	a. Contract Statement of Work b. EP-0001 c. Operations and Safety (O/S) Plan d. Appropriate contractor Standard Operating Procedures
Excavation and Trench Face Preparation	REECo	a. Letter of Criteria (LOC) b. EP-0001 c. O/S Plan d. Appropriate in-house Standard Operating Procedures
Surveying	H&N	a. LOC b. EP-0001 c. O/S Plan d. Appropriate in-house Standard Operating Procedures
Aerial Photography	EG&G	a. LOC b. EP-0001 c. O/S Plan d. Appropriate in-house Standard Operating Procedures
Trench Photography	Pan American World Services	a. LOC b. EP-0001 c. O/S Plan d. Appropriate in-house Standard Operating Procedures
Age Determination and Photogrammetry Equipment	USGS	a. Interagency Agreement b. EP-0001 c. USGS Technical Procedures d. O/S Plan
Contract Monitoring	SNL	a. EP-0001 b. O/S Plan c. SNL Department 6310 Policy

of the status of field activities, schedules, equipment requirements, and changes.

Reynolds Electric and Engineering Co., Inc. (REECo) - the excavation contractor responsible for excavation of trenches and test pits as well as assistance in cleaning trench faces, as required.

Holmes and Narver (H&N) - the survey contractor responsible for surveying support for surface and trench mapping.

EG&G - responsible for acquisition of color and color infrared photography at both high- and low-sun angle and cartographic/geographic information system support.

Pan American World Services (Pan Am) - the photography contractor responsible for photography for the photogrammetric surveys.

U.S. Geological Survey - responsible for providing equipment for photogrammetry, i.e., a photogrammetric tripod and rail system for use on the NTS and a digitizing work station in Denver, and for age-determination and other analyses of samples collected as part of the surface and trench mapping.

Technical Consultants - responsible for providing specialized expertise to the PI and Contract Geologist, as required.

Supervisory control for contract personnel does not extend to the PI. Similarly, one contractor may not directly supervise another contractor. Changes to work statements and letters of criteria are made formally through established procedures of the SNL Purchasing Department and/or the NTS Support Office. Deviations of activities are handled by immediate remedial action, where appropriate, and by formal reporting [Quality Assurance Procedure (QAP) 16-2]. Contractor data reports will be used as primary inputs for formal SNL reports that will present data synthesis and interpreted information.

The requirements and additional details of the work for this EP will be formally transmitted to other organizations by the following methods: (1) Statements of Work, for SNL contractors, (2) Letters of Criteria (LOC), for DOE/NTS support services (Attachment II), and (3) Interagency Agreement with the USGS. While this EP is the primary implementation document for this experiment, the combination of the procedural controls listed in Table 1 for each organization, respectively, govern its work for this experiment.

2.2 Specific Personnel Responsibilities and Qualifications

SNL personnel and other personnel under direct contract to SNL who are assigned to this experiment will be certified for the YMP as specified in Department Operating Procedure (DOP) 2-6. Contract personnel of NTS support contractors, including REECo and H&N, will be certified under their respective YMP-approved QA programs. Pan Am and EG&G are direct DOE contractors and will deliver standard items as specified in their respective LOCs (Attachment II).

For this experiment, certification under SNL's QA program will be achieved by application of requirements for minimum levels of education, experience, and indoctrination and training for each category of personnel represented in the experiment organization. Contract personnel conducting geologic mapping and excavation will include persons qualified to determine the safety and stability of trenches.

The minimum requirements for education and experience for the geotechnical contractor's personnel and for technical consultants are presented below.

Contract Geologist - will have a Bachelor's or higher degree in the geologic sciences or a related field from a recognized college or university and at least one year of experience in field mapping and detailed geologic studies for research or for design application to engineered facilities.

Contract Manager - will have a Bachelor's or higher degree in the geologic sciences or a related field from a recognized college or university and at least two years of experience in managing geotechnical field investigations.

Geologic Staff - will have a Bachelor's or higher degree in the geologic sciences or a related field from a recognized college or university and at least one year of experience conducting detailed surface and subsurface geological studies.

Technical Consultants - Consultants will be selected by the PI, in conjunction with the geotechnical contractor, and will have a Bachelor's or higher degree in their field of expertise. The principal criteria for selection of technical consultants are experience and reputation, rather than specific educational background.

2.3 Location of Activities

Literature review and photogeologic interpretation will be conducted at SNL and at the geotechnical contractor's office and may continue at the field office. Field work, including surface and trench mapping and collection of samples, will be conducted at the Midway Valley study area and may be initiated before the literature review and photogeologic interpretation are completed. The generation of the digitized trench maps from photogrammetric data will be conducted at the USGS facility in Denver. As required, formal documentation of experiment results, including reports and topographic and geologic maps, will be prepared at contractors' facilities, with final SAND report preparation at SNL.

2.4 Environmental Restrictions

Poor weather conditions may result in access or mapping problems that could cause minor delays. In addition, severe weather conditions such as electrical storms, high wind, or snow will result in the suspension of field activities as defined in the O/S Plan (Attachment III).

2.5 Constraints

Constraints on the field activities include those imposed by YMP logistics, NTS policies, Occupational Safety and Health Administration (OSHA) requirements (DOL, 1988) (Attachment III, Appendix A), and applicable (REECo) occupational safety codes (Attachment III, Appendix B). Constraints described in the O/S Plan (Attachment III) are also applicable to the experiment. The main constraints imposed by logistics include coordination of the various field activities for different contractors. These activities include geologic mapping, geophysics, remote sensing, and excavations, as well as obtaining required approvals and permits. Potential constraints that result from NTS policy include the following:

- NTS security or access requirements;
- total field working time, including commute, of 12 hr;
- no off-road travel of field vehicles, except by special permit;
- no photography without permit; and
- Archeological and environmental inspections.

Trench conditions must be safe for personnel performing the excavation and subsequent mapping tasks. Trenches will not be mapped until they have been inspected for unstable conditions by the PI, or his designated representative, and personnel responsible for trench mapping and excavation. Appropriate measures will be taken to ensure the safety of the mapping crew. Guidelines for safe excavation and work within trenches are included in Appendixes A and B of Attachment III.

2.6 Support

Support requirements necessary to perform surface and trench mapping include the following:

- approved access to the NTS, including badges;
- third order survey support, as required;
- archeological and environmental permits and/or reports;

- excavation permits for soil pits and trenches;
- soil pit excavation, fencing, shoring, protection, and restoration;
- trench excavation, fencing, shoring, and protection;
- trench cleaning and maintenance (including ladders and pumps);
- trench site restoration;
- access to reproduction facilities on a daily basis;
- use of technical consultants; and
- base maps and aerial photography.

3.0 EXPERIMENT METHODS

The procedures described in this EP were developed from standard practices and approved methods for geologic and geotechnical investigations. The technical work to be conducted for this experiment builds upon site-specific (e.g., Scott and Bonk, 1984) and general (e.g., Compton, 1962) references for geologic investigations. The initial data assessment tacitly assumes that some differences in professional opinion will exist and that revisions and refinements will be made as work progresses. This may result from increasing (refining) the mapping detail (scale), but also from the evolution of concepts regarding the particular area being investigated.

Acquisition and interpretation of aerial photography will provide a visual record of the area at a scale close to the map scale (≈1:6000). Stereoscopic viewing will enable the mapping specialist to observe field features in three-dimensions in ways and from a vantage that is not possible in the field. This viewing enables the geologist to conceptualize the distribution of mappable units and the processes active in the present setting as well as those from the geologic past.

For this study, surface mapping involves the correlation of the features evident on aerial photographs with the geologic features found on the earth's surface. Lithostratigraphic distinctions are commonly manifested in reflectance variations on aerial photographs. Usually, but

not always, these variations are discernible on the surface during field work.

The process of surface mapping involves judgment and interpretation. Commonly, much time is spent at the outset to establish mappable units. In mapping alluvial units, soil pits may be required to establish the continuity of surface units with depth. A tentative stratigraphy is formulated that accounts for the distribution of map units in space and time. The actual mapping involves filling in details and explaining nuances. Increased detail in mapping scale commonly produces increased understanding. The process of geologic mapping involves much time and skill on the part of the mapper(s). How closely the resulting map and interpretations reflect reality is largely dependent on the skill and experience of those performing the work. For the NTS, Hoover et al. (1981) and Swadley et al. (1984) have established a basic stratigraphy for Quaternary and Tertiary units. This stratigraphy may need to be refined. Because the basic stratigraphy already exists, geologic mapping should proceed more rapidly than mapping in an area where the stratigraphy is completely unknown.

The selection of trench locations will be based partly on the distribution and relative age of map units. Much of the age determination of units involves extrapolation from known ages at other locations and relies on substantial skill on the part of the interpreter. In this respect, procedures for accomplishing these subjective skills cannot be defined precisely because there is no prescribed means for doing so. The requirement to specify locations in writing and to approve the locations, also in writing, creates a formal mechanism to document the decision process.

Excavation by support personnel is generally straightforward and will be overseen, but not supervised, by the geotechnical contractor and SNL. This excavation will follow OSHA requirements (Attachment III, Appendix A) as well as REECo occupational safety codes (Attachment III, Appendix B). Design of the excavation or trench will depend on its depth, width, and the

material being removed. It is anticipated that benching will be preferred over shoring for worker safety. The YMP office will conduct appropriate environmental and archeological surveys before excavation for this study begins. Archeological artifacts, if uncovered, will be preserved, if necessary. The excavation is to be accomplished in a manner such that the impact on the environment is minimized. Thus far, with the excavation of more than 25 trenches, minimum environmental impact at Yucca Mountain has occurred; nonetheless, excavation will be closely overseen by the PI or his designated representative. If deemed necessary, for any reason and at any time, the overseers may stop the excavation.

Mapping of trenches will begin only after all excavation machinery has stopped and been removed from the trench. The evaluation of trench wall stability is a joint responsibility of the PI or his designated representative, and the personnel responsible for trench mapping and excavation. All must agree that the trench is safe; otherwise, mapping will not begin. If any subsequent slumping, sloughing, or caving occurs, mapping will cease and the trench will be re-evaluated with respect to safety.

Trench mapping involves a subjective approach similar to that of surface mapping (Hatheway and Leighton, 1979b). Considerable study and thought is required to delineate geologic features. The identification of map units may require collaboration by numerous individuals and consultants; agreement by all persons may not necessarily result. Horizons may be sampled for age determination (Hatheway and Leighton, 1979a). Results of age determination analyses may take several weeks or even months. These dates may resolve conflict or may require additional collaboration and re-examination. The explanation of trench features is generally evolutionary, and time is needed to reach understanding and consensus.

During mapping, hold points may be required for safety, security, or quality assurance reasons; consideration of hold points for these reasons will take precedence over technical work.

The interpretations of fault displacement will commonly depend on supporting data such as ages of geological samples taken from specific horizons or geophysical measurements (Hatheway and Leighton, 1979a).

The interpreted data is used by geologists, geophysicists, and engineers in their analyses and predictions of surface fault rupture and ground motion. These methods are described by URS/Blume & Associates (1986 and 1987). Engineering designers apply these data to their facility designs. Safety analyses are then conducted for these specific designs and site-specific conditions.

Sample collection is almost never routine and requires individualized attention. Consequently, an individual approach to sample collection, documented by a letter or memo to the PI and a sample collection report, is required for every sample. Each sample requires accountability, i.e., chain-of-custody traceability. Each of these actions must be documented as described in Section 4.6 of this EP and in DOP 8-1.

Geologic age-determination analyses will be coordinated through the USGS. Most of the samples involved in this experiment may require a specialized technique (uranium-trend), available only at the USGS. The USGS will perform other age-determination analyses, as required. Technical procedures for each specific technique that may be used for analysis of samples will be completed and approved 30 days before use.

3.1 Experiment Configuration

Trench and soil pit configurations are highly individualized and site specific. Locations, lengths, depths, and details of mapping for trenches and soil pits will be determined as part of the mapping activities. Plans for individual trenches will be described in the geotechnical contractor's recommendation to SNL, to be documented and presented in writing for review and approval by the PI before start of work on each trench.

3.2 Instruments and Equipment

Typical field instruments that are used for geologic mapping activities are included in Table 2. Other equipment may be necessary if the scope of the study is expanded.

3.3 Equipment Inspection/Calibration

At the start of each week of field work, geologic staff will inspect geologic field equipment for proper working condition. The equipment check will be documented in the field notebooks. Compasses will be inspected weekly for proper working condition and adjustment. The inspection and

TABLE 2

EQUIPMENT LIST

Typical Geologic Field Equipment	hand lens, pick, rock hammer, field notebook, camera, film, camera supplies, shovel, sampling bags, brushes, whisk broom, labeling materials, measuring tapes and rulers, aerial photographs, stereoscope, scale-stable topographic base maps, mapboards, color charts, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), pocket altimeter, Abney level, Jacob's staff, pocket transit (Brunton compass or equivalent), portable mapping grid, safety supplies (hard hats, safety glasses, etc.).
Excavation Equipment	bulldozer, backhoe, field notebook, camera, film, camera supplies, safety supplies (hard hats, safety glasses, etc.).
Surveying Equipment	theodolite, survey rod, measuring tapes and rulers, field notebook, camera, film, camera supplies, calculator, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), safety supplies (hard hats, safety glasses, etc.).
Photogrammetric Equipment	metric camera, sliding camera mount, tripod rail, measuring tapes and rulers, field notebook, camera, film, camera supplies, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), safety supplies (hard hats, safety glasses, etc.).

operations check are described in standard field geology texts such as Compton (1962). Each compass will be checked at the beginning of each work week by comparison to a reference line of known azimuth and inclination. Adjustment will be made if the compass reading is more than ±2° off the reference azimuth or inclination. The compass readings and any necessary adjustment will be documented in the field notebooks along with a brief description of the reference point including azimuth and inclination.

The excavation contractor will inspect excavation equipment for proper working condition before any excavation work is conducted for the day. The equipment check will be documented in the field notebooks.

The survey contractor will inspect survey equipment for proper working condition before any survey work is conducted for the day. Equipment operation check and, if required, calibration will be conducted in accordance with the contractor's procedure for survey work (NNWSI-017). The equipment check, including necessary adjustments and calibration, will be documented in the field notebooks.

The photography contractor will inspect photogrammetry equipment for proper working condition before any photogrammetry is conducted for the day. The equipment check will be documented in the field notebooks.

3.4 Measurement Requirements

The measurement standard for survey work is state plane coordinates (ft). However, when possible, all measurements for this experiment will be recorded in SI units. Reports or maps may include other units in parentheses. All equipment and instruments used in the field will preferably be graduated in SI units to reduce the potential for error resulting from conversion of units.

Trench setup for measurement will include at least one continuous horizontal measuring line to be established along the entire trench wall for each trench.

3.4.1 Map Scales

The photogeologic interpretation will use available black and white, color, and false color infrared aerial photographs of the relevant study area. Acquisition of additional color and color infrared photographs at a scale of ≈1:6000 is planned as part of this experiment. The aerial photographs acquired for this study will be standard 9 x 9 in. format. The topographic and geologic maps generated for this experiment will also be produced at a scale of ≈1:6000.

Close-range photogrammetry will document the mapping of the trench face on 2.25 x 2.25 in. format film at a scale of ≈1:20. A 3.75 x 3.75 ft area will fill the film negative. After the photogrammetric data has been digitized, it can be reproduced at a scale appropriate to the features found in each portion of the trenches.

3.4.2 Measurement Tolerances

Depending on the size and continuity of the mapped feature, geologic details will be located on photographs and maps by using topographic features, sightings on prominent landmarks, and measurement to survey markers or points with known coordinates. Delineation of geologic features will depend upon the degree of exposure and the distinctiveness of the geologic or tectonic feature, the base map scale, the quality of the mapping base, and the proximity of mapped features to points with known coordinates. Selected outcrops or features may be surveyed at a later time to improve location. Large-scale maps also require a topographic base with a comparable horizontal and vertical scale. The accuracy of location varies with the presence of superficial cover, topographic irregularity, and variations in the geologic features.

3.5 Sample Custody and Sample/Site History

Samples must be accounted for and site information documented in accordance with DOP 8-1 and this EP.

3.6 Sample/Site Preparation

The excavation contractor will clean and prepare exposures in the trenches for subsequent procedures as specified in this EP and in the associated LOC (Attachment II). Samples will be collected from a clean trench exposure in a manner that prevents contamination, i.e., fresh exposure with no infall from above or from the excavation process. The collection of samples may occur at any time during the study, but most sample collection will probably occur after mapping is nearly completed. Collection of samples will be performed in accordance with DOP 8-1, Section 4.6 of this EP, and applicable USGS procedures. Differences in these procedures will be resolved as they arise. The differences and resolutions will be documented in the field notebooks. Specific details regarding individual sample treatment will depend on the analysis for which a sample will be used and will be determined through consultation with the USGS and technical consultants, if necessary.

3.7 Field Notebooks

Bound field notebooks will be numbered and issued by the PI to individuals working on the project at the completion of appropriate indoctrination and training. The notebooks will contain all technical information not recorded on separate maps, sketches, or data forms. Each page in the notebook will be numbered, signed, and dated as it is filled. Errors will be lined through with a single line but must remain legible. Corrections will be initialed and dated. Notebook pages may not be removed for any reason. Each individual will be responsible for maintaining notebooks in accordance with DOP 11-2. As notebooks are filled, they will be submitted to the PI who will transmit them to the appropriate file of the SNL NWRT Department Data Records Management System (DRMS).

3.8 Related Analyses and Experiments

Fault investigations of a more regional nature are being performed by USGS scientists (Gibson et al., 1989, Table 1-4). These investigations are

related primarily to understanding regional tectonics and seismicity as it affects postclosure repository performance. The results of these studies are being compared by the participating individuals. Although the application is somewhat different, much of the same information is relevant to the preclosure performance period. Several trenches have already been investigated (e.g., No. 14 located on the west side of Exile Hill). Interpretations from these nearby existing trenches may prove useful in analyzing the trenches within Midway Valley.

SCP Study 8.3.1.14.2.1 will investigate the soil and rock properties near surface facilities. Although evidence of faulting is not a goal of Study 8.3.1.14.2.1, the results of the study will increase the knowledge of the geology at the surface facilities site.

3.9 Deviation From and Changes to Procedures During Use

Deviation from this EP is acceptable when irretrievable loss of data or an unforeseen unsafe operation will occur if the EP is followed. Intentional and unintentional deviations from the procedures in this EP will be reported verbally to the PI as soon as possible after occurrence and documented within 5 days of occurrence in accordance with QAP 16-2. The reason for and circumstances leading to the deviation, along with the change in procedure will be documented in the field notebooks.

If the EP needs revision to reflect future operation, it will be done as soon as resolution of the situation is made and before subsequent use of the EP. These procedures shall be revised only under the control and approval of the responsible PI or his designee. Revisions cannot be made to this EP except by provisions and control requirements stated in DOP 6-1 and DOP 11-1.

4.0 TECHNICAL PROCEDURES

This section presents the detailed procedures, including technical procedures, required to perform the work for this experiment. Table 3

lists the tasks for Activities 1 and 2 (Section 2.0) in the sequence in which they will be performed and the sections that present the corresponding procedures.

4.1 Experiment Prerequisites

Table 4 lists the prerequisites that will be verified for each technical procedure and the person with the primary responsibility for verifying each prerequisite. It may be necessary to verify some prerequisites on a daily basis. SNL and contractor staff will note in field notebooks that necessary prerequisites have been verified. The PI is responsible for confirming that all prerequisites have been verified.

TABLE 3

TECHNICAL PROCEDURES FOR ACTIVITIES 1 AND 2

Activity Tasks	Corresponding Procedures
Activity 1	
1. Literature, map, and data review	§4.4.1
2. Photogeologic interpretation	§4.4.2
3. Field inspection	§4.4.3
4. Detailed geologic mapping	§4.4.4
• layout and excavation of soil pits and exploratory trenches	§4.5.1
• reconnaissance mapping of soil pits and exploratory trenches (including sample collection)	§4.5.2 (§4.6)
• close-range photogrammetry	§4.5.3
• detailed mapping of exploratory trenches (including sample collection)	§4.5.4 (§4.6)
• geophysical and remote sensing	§4.5.4
5. Determination of locations for long trenches	§4.4.5
6. Report preparation	§4.4.6
Activity 2	
1. Layout and excavation of trenches	§4.5.1
2. Reconnaissance mapping of trenches	§4.5.2
• close-range photogrammetry	§4.5.3
• collection of samples for age determination	§4.6
3. Detailed trench mapping	§4.5.4
• collection of samples for age determination	§4.6
4. Report preparation	§4.5 5

TABLE 4

EXPERIMENT PREREQUISITES

Prerequisite	Responsible Person
1. Verify that necessary personnel training and qualification have been completed and approved.	PI
2. Verify that required personnel are available.	Contract Geologist
3. Verify that current revisions of implementing procedures (the EP, DOPs, QAPs, etc.) are being used. A signature on the Daily Log (Attachment I) and field notebooks by the PI or his designated representative constitutes verification that current revisions of implementing procedures are being used.	Contract Geologist
4. Verify that any necessary hold points have been defined and that systems are in place to ensure they will be made.	Contract Geologist
5. Verify that all required equipment/items are present and ready.	Applicable DOE/NTS Contractor Staff or Geologic Staff
6. Verify applicable initial conditions.	
• locations of samples and sites	Contract Geologist
• acquisition of required permits and clearances	PI
• calibration of instruments	Applicable DOE/NTS Contractor Staff or Geologic Staff
• provisions for data acquisition	Contract Geologist

4.2 Experiment Postrequisites

Table 5 lists the experiment postrequisites that will be verified for each technical procedure and the person with the primary responsibility for verifying the postrequisite. It may be necessary to verify some postrequisites on a daily basis. SNL and contractor staff will note in field notebooks that necessary postrequisites have been verified. The PI is responsible for confirming that all postrequisites have been verified.

TABLE 5

EXPERIMENT POSTREQUISITES

Prerequisite	Responsible Person
1. Verify that all necessary information has been collected and recorded.	Contract Geologist
2. Verify that required sign-offs have been made.	PI
3. Verify that samples/sites and data have been identified and data collected in accordance with the instructions in this EP. Sample collection reports should have been completed, as specified in Section 4.6 of this EP and DOP 8-1.	Contract Geologist
4. Verify and document applicable closing conditions, e.g., post-experiment calibration check of instruments. Normally, these types of conditions will not apply, but if necessary, this information will be recorded in field notebooks.	Geologic Staff
5. Verify that samples and excess material have been returned to the SNL NWRT Department Samples Library for permanent final storage, consistent with the requirements of DOP 8-2, DOP 8-1, and Section 4.6 of this EP.	Contract Geologist
6. Verify that all collected data have been submitted to the appropriate DRMS file.	PI
7. If necessary, restore trench sites as described in the O/S Plan.	Excavation Contractor

4.3 Hold Points

To verify that work is proceeding as outlined in the EP, hold points for safety, security, or quality assurance reasons are defined as part of the procedures for this experiment; consideration of hold points for these reasons will take precedence over technical work. The Contract Geologist, Contract Manager, and/or the PI are responsible for reviews and approvals at hold points. Before proceeding to the next task following a hold point, the person(s) responsible for the hold point will conduct the indicated review, verify that work preceding the hold point has been performed and

documented as outlined in the procedures, and determine that work can proceed to the next task. The person(s) responsible for a hold point must sign off before work can proceed to the next task. Signoff of hold points will be documented in field notebooks and in the remarks section of the Daily Log.

The person(s) responsible for a hold point can determine that work ha- not been performed and documented adequately or that conditions exist that will adversely affect subsequent work. If this occurs, the person(s) responsible for the hold point will meet with the groups responsible for doing the work to determine what steps must be taken to obtain approval for the hold point. If necessary, procedure steps will be repeated to obtain results that will meet the requirements for the hold point. Rejection of hold points, including the reasons for the rejection and the steps that must be taken to obtain approval, will be documented in field notebooks and the remarks section of the Daily Log.

4.4 Procedure for Surface Geologic Mapping

The task sequence described below consists of the steps that will be followed for the surface geologic mapping procedure. Included in the steps are hold points that require signoff by the Contract Geologist, Contract Manager or PI before proceeding to the next task. The geotechnical contractor has the primary responsibility for performing the work described in this procedure. Aerial photography to be acquired as part of this procedure is the responsibility of EG&G. Any excavations conducted as part of this procedure is the responsibility of REECo. Each task listed below will be initiated and supervised by the Contract Geologist in accordance with the geotechnical contractor's Statement of Work or by the appropriate support contractor personnel in accordance with the corresponding LOC (Attachment II).

4.4.1 Literature, Map, and Data Review

This task includes a review of the published and unpublished literature, maps, and data available for the study area. The steps for this task are described in the following paragraphs.

1. Collect available literature, maps, and data for the area of interest. Conduct a thorough review of both published and unpublished literature and data relevant to the analysis and evaluation of the stratigraphy, structure and tectonics of the area of interest. Resources from university libraries, the USGS library loan services, and contractor library facilities will be used. Emphasis will be on previous studies that are similar to the present experiment. When possible, contact and interview previous researchers to ensure a complete review of all available geologic information for the area of interest. Similar studies may concern the following topics:

    - geomorphology,
    - remote sensing lineament analyses,
    - Quaternary stratigraphy and lithology,
    - Tertiary bedrock stratigraphy and lithology,
    - geologic and tectonic history,
    - soil development and weathering,
    - subsurface geologic and structural conditions,
    - nature and age of faults,
    - age-datable materials and age-determination techniques, and
    - previous trench mapping.

2. Review and evaluate each item collected as part of the literature search and each interview for its usefulness and application to the project. Reference relevant documents from the literature search in the geotechnical contractor's report (Section 4.4.6). Summarize literature reviews and interviews in field notebooks. If new or unpublished information is revealed during interviews, document this information in a letter or memo to the PI.

3. Prepare a preliminary geologic base map at a scale of 1:6000 based on the information reviewed in Steps 1 and 2.

HOLD POINT (for review by the PI of the preliminary geologic base map)

4.4.2 Photogeologic Interpretation

This task includes an evaluation of available aerial photography for the area of interest. Also, additional aerial photography will be acquired as part of this task. The steps for this task are described in the following paragraphs.

1. Acquire additional color and color infrared aerial photography as specified by SNL in a LOC (Attachment II). EG&G will use standard industry practices to accomplish this step and will be responsible for obtaining the required permits for air access on the NTS.

2. Compile aerial photographs relevant to the study for interpretation at the geotechnical contractor's facilities or geologic field office. Index the photographs and indicate photo coverage on an appropriate base map (e.g., 1:6000 scale topographic map).

3. Conduct independent photogeologic interpretations of the aerial photographs. At least two members of the project geologic team will accomplish this step with additional interpretations to be conducted, as necessary. Document interpretations directly on mylar overlays of alternate stereo pairs. Mark each mylar overlay to allow accurate replacement when removed from the photo, and label with the date and name of the geologist conducting the interpretation. The interpreters will review each other's work when completed, then sign and date the overlay. Interpretations not in agreement may be resolved by the interpreters or by the Contract Geologist after completion of the detailed surface geologic mapping activity or may be presented as alternative interpretations in the final report.

HOLD POINT (for review by Contract Geologist of photogeologic interpretations)

4. Develop a composite geologic map on a topographic base for use in the detailed geologic mapping task. Plot on topographic maps and aerial photographs key areas important to the structural and/or stratigraphic interpretation of the area and selected information for field review examination.

4.4.3 Field Inspection

The primary purpose of this task is to familiarize the field geologists with the geomorphologic, lithologic, petrologic, pedologic, and structural features present in the field. In addition, criteria may be established to assist in the correct interpretations of these features during the photogeologic interpretation and the detailed geologic mapping tasks.

This task involves a reconnaissance field inspection of the area of interest. The steps for this task are described in the following paragraphs.

1. Acquire required field clearances and permits. The PI or his designated representative will accomplish this step.

HOLD POINT (for verification by PI that all required permits and clearances have been obtained)

2. Within the area of interest, identify locations of "type localities" and possible key exposures based on literature review and interviews with previous researchers.

3. Within the area of interest, identify potentially significant exposures, lineaments, or areas of structural or stratigraphic significance based on the combined photogeologic and literature analysis.

4. Conduct field inspection of significant features. Maintain a trip log in the field notebooks that includes a record of salient localities visited, photographs, and comments regarding geologic conditions. Document the day's field activities in the Daily Log (Attachment I).

5. Plan detailed surface geologic mapping program. The detailed plan for geologic mapping will be presented in writing by the Contract Geologist and approved by the Contract Manager and PI. The plan will include a schedule of tasks; recommendations for locations of soil pits and exploratory trenches, including sites where significant exposures and lineaments suggest the existence of faults as well as sites where faults are unlikely; and key participants. This information will be used to apply for environmental/archeological permits. Details of the surface geologic mapping program will be included in a revision of this EP, in other EPs (e.g., soil and rock properties), or in separate technical procedures.

HOLD POINT (for review and approval of surface mapping program by PI and Contract Manager)

4.4.4 Detailed Geologic Mapping

This task includes the detailed geologic mapping of the area of interest. The primary purpose of this task is to refine the geologic data obtained thus far. The steps for this task are described in the following paragraphs.

1. Acquire required field clearances and permits. The PI or his designated representative will accomplish this step.

HOLD POINT (for verification by PI that all required permits and clearances have been obtained)

2. Assemble the necessary field instruments and equipment for the geologic mapping task (Table 2).

3. Conduct detailed geologic mapping program according to the plan approved by the PI and Contract Geologist. Survey field locations for soil pits, as specified in the mapping program, and excavate using a backhoe. The survey support contractor will conduct survey work as outlined in the associated LOC (Attachment II) and in accordance with the contractor's procedure for survey work (NNWSI-017). A unique identification for each soil pit will be determined by the PI. Map the soil pits recording geologic information in the field notebooks. Excavate and map exploratory trenches following the appropriate steps in Section 4.5. Develop the site geologic map on a 1:6000 scale topographic base map. Transfer geologic data from aerial photographs to topographic map. Verify by field inspection geology as depicted on both the aerial photographs and topographic map. All field work will be reviewed and approved by the Contract Geologist. Changes to the mapping program will be approved by the Contract Manager and PI. Record geologic information in field notebooks, and maintain the Daily Log.

4. Collect samples for geologic age determination and send them out for analysis. Samples will be collected, handled, and controlled according to Section 4.6 of this EP, DOP 8-1, and applicable USGS procedures. If differences in SNL and USGS procedures arise, the PI and Contract Geologist will address these and determine the most appropriate course of action for the situation. The course of action resulting from the resolution of differences in SNL and USGS procedures will be documented in field notebooks. Analyses of samples will be performed in accordance with the applicable USGS procedures related to specific age-determination techniques and other sample analyses (Table 6).

5. Identify candidate locations for long, supplemental, and additional exploratory trench locations based on results of the mapping program. Mark candidate locations in the field. The locations may include sites where the existence of faults is likely or has been determined by surface geologic mapping as well as sites where faults are unlikely.

TABLE 6

USGS TECHNICAL PROCEDURES FOR AGE DETERMINATION AND OTHER ANALYSES OF GEOLOGIC SAMPLES

Document Number	Title
GCP-01,R1	Radiometric-Age Data Bank
GCP-03,R1	Uranium-Series Dating
GCP-04,R1	Uranium-Trend Dating
GCP-05,R1	Radium-Equivalent Uranium, Thorium, and Potassium Analysis by Gamma-Ray Spectrometry
GCP-06,R1	Potassium-Argon Dating
GCP-08,R1	Fission-Track Dating
GCP-09,R0	Spike Calibration
GCP-10,R0	Field Sampling of Pedogenic Carbonate Rinds for for Radiometric Dating
GCP-11,R0	Laboratory Preparation of Pedogenic Carbonate Rinds for Radiometric Dating

6. Develop recommendations for long and supplemental trench locations as described in Section 4.4.5.

4.4.5 Development of Recommendations for Long and Supplemental Trench Locations

Recommendations for long and supplemental trench locations will be determined using the information obtained from the literature review, photogeologic interpretation, field inspection, and detailed surface mapping. The general steps for this task are described in the following paragraphs.

1. Compile the available geologic and geophysical data and compare these to the results of the geologic mapping task. Geophysical data could include available seismic, gravity, magnetic, and electrical resistivity data, as well as numerous other data types.

2. Should optional geophysical surveys be appropriate, prepare an exploration plan that will include geophysical method, survey location,

cost, and program justification. If deemed appropriate by the PI, an optional geophysical program will be conducted and the results integrated with those from Step 1. Details of this program will be included in a revision of this EP, in other EPs (e.g., soil and rock properties), or in separate technical procedures.

HOLD POINT (for approval of geophysical program by PI, if appropriate)

3. Prepare a written recommendation for possible long and supplemental trench locations after integration of the previous steps with the results from the detailed geologic mapping task. The recommendation will include the rationale for long and supplemental trench locations and the anticipated faults and stratigraphic units expected. Each proposed trench location will be flagged in the field and the proposed orientation, length, width, and depth described. Incorporate recommendations into final contractor report to PI.

HOLD POINT (for review by PI of geotechnical contractor's recommendations for trench locations)

4.4.6 Report Preparation

Prepare geologic report, final geologic map, and related cross sections. The geotechnical contractor will prepare the final contractor report for Activity 1 and transmit it to the PI.

4.5 Procedure for Trench Mapping

The task sequence described below consists of the steps that will be followed for the trench mapping procedure. This task sequence will be conducted for mapping of any exploratory, supplemental, or long trench. Included in the steps are hold points that require signoff by the Contract Geologist, Contract Manager or PI before proceeding to the next task. REECo is responsible for trench excavation and preparation. H&N is responsible for survey support. Pan American World Services is responsible

for photography related to photogrammetry. The geotechnical contractor is responsible for the mapping conducted for this procedure.

4.5.1 Trench Layout and Excavation

This task includes the layout, excavation, and preparation of trenches. The steps for this task are described in the following paragraphs.

1. Acquire required field clearances and permits. The PI or his designated representative will accomplish this step.

HOLD POINT (for verification by PI that all required permits and clearances have been obtained)

2. Verify that trenches identified during surface geologic mapping have been properly located in the field. The survey support contractor will conduct survey work as outlined in the associated LOC (Attachment II) and in accordance with the contractor's procedure for survey work (NNWSI-017) to establish semi-permanent survey markers that will reference USGS survey points and will remain in place for 1-2 yr. The Contract Geologist will check the trench locations to verify that they are as approved by the PI.

3. Develop trench specifications based on the geotechnical contractor's recommendations (Section 4.4.5, Step 3). As part of the trench specifications, a unique trench identification for each trench will be determined by the PI. Locations (coordinates), estimated length, width, and depth of the trench, and an evaluation of the material that will require excavation will be determined by the PI, in cooperation with the excavation contractor. The evaluation may include a visual assessment of the material exposed in the trench to determine the required support equipment and trench layout.

4. Develop an appropriate, safe schedule for excavation. The PI and the excavation contractor will accomplish this step.

5. Excavate trenches according to the trench specifications developed in Step 3. It is anticipated that most trenches will be excavated by bulldozer. However, the excavation contractor will determine the specific method of excavation based on the evaluation of each trench. The PI and/or a geologist from the geotechnical contractor's staff will be present throughout the trench excavation, will monitor the trench excavation, and will inspect the trench during excavation for safe working conditions (e.g., wall stability and structures encountered). Excavation will follow guidelines given in Appendix A (OSHA requirements) and Appendix B (REECo Occupational Safety Code C-2) of Attachment III. Consideration will be given to wildlife during all phases of excavation. Spoil will be placed in locations that will not pose a safety hazard.

6. As soon as possible after excavation, take 35-mm photographs of features that may alter with age (e.g., dessication cracks) or might be obscured or destroyed by subsequent mapping.

7. Rope off all trenches so that they can be easily identified. Attach a metal tag engraved with the trench identification to a permanent marker at one end of the trench.

8. Prepare and clean trench face. These operations will be conducted by the excavation contractor as described in the associated LOC (Attachment II), and directed by the Contract Geologist. After an initial inspection, the Contract Geologist and the PI will select one wall of the trench for mapping, and all exposed surfaces will be cleaned to expose a fresh undisturbed surface. The methods for cleaning will depend on the material present in the trench and should be accomplished to achieve satisfactory exposure. Additional cleaning of selected surfaces, as determined by the Contract Geologist, will be completed before final mapping preparations. If significant additional geologic information about complex geologic structures can be obtained, then both walls as well as the floor of the trench may require mapping.

9. After the initial cleaning, establish a level line and survey control points for photogrammetric survey. The level line will extend from one end of the trench to the other approximately half the distance between the surface and the trench floor. The survey support contractor will conduct survey work as outlined in the associated LOC (Attachment II) and in accordance with the contractor's procedure for survey work (NNWSI-017) to establish survey control points evenly distributed along the trench wall to provide 60% ±5% horizontal overlap of photographic stations. For each photographic station, four survey control points will be established. One end of the trench, to be defined as the first photographic station, will be surveyed to the nearest USGS benchmark.

4.5.2 Reconnaissance Mapping of Trenches

Following the location, excavation, and preparation of trenches, reconnaissance mapping of each trench will be conducted. This task may include an archival photogrammetric survey, mapping of features along one wall of the trench, a geologic photogrammetric survey, and localized mapping of both walls where stratigraphic or structural conditions warrant. The steps included in this task are described in the following paragraphs.

1. As described in Section 4.5.4, conduct the first photogrammetric survey, the archival survey, as soon as possible after the trench face is cleaned.

2. Develop a preliminary understanding of the stratigraphy and structure exposed in the trench. Include in the field notebooks information about geologic features, 35-mm photographs, detailed photo captions, sketches, and interpretations, noting general relationships to the surveyed control points. Maintain the Daily Log.

3. Begin mapping the trench face. Mark geologic contacts, faults, fractures, soil horizons, sample locations, and any other features on the trench face that are to be emphasized. Mark these features on the trench walls with nails and various colors of plastic flagging or spray

paint before the second photogrammetric survey. Note the general relationships of these features to the survey control points, and take measurements of planar features, including offset strike and dip evident in strata and faults. The Geologic Staff will perform this work with supervision from the Contract Geologist.

4. As described in Section 4.5.4 (Steps 7 and 8) conduct the second photogrammetric survey, the geologic survey, to obtain a set of photographs that will record the trench mapping in the field.

5. Use the set of photographs obtained in Step 4 to check how the mapping in the trench corresponds to the mapping recorded by the photographs. Record in field notebooks additional descriptive notes on geologic features, referencing specific photographs. Additional geologic features may be recorded on the prints or by sketches in field notebooks.

6. As mapping progresses, examine the opposite wall for additional significant structural and stratigraphic details. Both trench faces as well as the trench floor will be mapped where appropriate.

7. Mark sample locations on the trench wall with appropriate identification. Record detailed descriptions of each sample location in field notebooks.

8. Collect samples for geologic age determination and send them out for analysis. Samples will be collected, handled, and controlled according to Section 4.6 of this EP, DOP 8-1, and applicable USGS procedures. If differences in SNL and USGS procedures arise, the PI and Contract Geologist will address these and determine the most appropriate course of action for the situation. The course of action resulting from the resolution of differences in SNL and USGS procedures will be documented in field notebooks. Analyses of samples will be performed in accordance with the applicable USGS procedures related to specific age-determination techniques and other sample analyses (Table 3).

HOLD POINT (for review by PI of reconnaissance trench map)

4.5.3 Detailed Trench Mapping

Detailed trench mapping may be performed at selected locations within a trench. If the stratigraphy is simple and no complex structures are evident, detailed trench mapping may not be required. Complex stratigraphic and/or structural relationships, however, may require a more detailed map scale than that used for the reconnaissance mapping. The extent of detailed trench mapping will be determined by the Contract Geologist, approved by the PI, and performed by the geotechnical contractor.

The steps for this task are described in the following paragraphs.

1. Identify the segments, if any, to be mapped in detail.

2. If necessary, perform additional cleaning, preparation, and marking of the area to be mapped in detail, as directed by the Contract Geologist.

3. Conduct the detailed trench mapping, noting features directly onto a set of photographs produced by the photogrammetric survey or onto a single mat 4-5 mil mylar with fade-out blue grid. Detailed trench mapping will be conducted at a scale of nominally 1:10 or larger, based on the judgement of the geologic staff and the complexity of the geologic features being mapped. Plot and label the area mapped in detail on the reconnaissance trench map. Take measurements as described in Section 3.4. Record geologic information, detailed photo captions, and interpretations in the field notebooks.

4. Identify sampling locations on the trench face. Record detailed descriptions for each sample location in the field notebooks.

5. Collect samples for geologic age determination and send them out for analysis. Samples will be collected, handled, and controlled according

to Section 4.6 of this EP, DOP 8-1, and applicable USGS procedures. If differences in SNL and USGS procedures arise, the PI and Contract Geologist will address these and determine the most appropriate course of action for the situation. The course of action resulting from the resolution of differences in SNL and USGS procedures will be documented in field notebooks. Analyses of samples will be performed in accordance with the applicable USGS procedures related to specific age-determination techniques and other sample analyses (Table 3).

6. Take 35-mm photographs of the mapped surface, as appropriate.

7. Prepare reports and maps for detailed geologic mapping. Incorporate information from detailed geologic mapping into contractor report (Section 4.5.5).

4.5.4 Close-Range Photogrammetry

Photogrammetry will be used to provide the necessary planimetric control for all trench mapping activities. This technique has been used by Fairer et al. (1987) to provide accurate, reliable control of sample station locations, structural relationships, and stratigraphic contacts evident within the trench while minimizing the error induced by multiple measurements using a tape and rope grid.

Photogrammetry equipment (Table 2) may include a metric camera, tripod, sliding camera mount, and tripod rail. Equipment currently used by the USGS and Pan American World Services includes a Rollei 6006* metric camera with reseau plate and a Zeiss Distagon* 40-mm lens. If possible, depending on trench conditions, a tripod rail or track will be aligned in the floor of the trench to allow the camera to remain at a fixed distance from the trench wall while moving parallel to the trench axis. The camera will be mounted to a sliding camera mount that can be locked in position at the

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* Use of tradenames is for descriptive purposes only and does not imply endorsement by SNL or the USGS.

various photographic stations. If using the tripod rail and sliding camera mount proves difficult, given the trench conditions, the camera will be mounted on a standard tripod and moved along the floor of the trench from one photographic station to another at a distance parallel and perpendicular to the trench face.

Digitized geologic maps may be generated using an analytical plotter and the appropriate software. Equipment for photogrammetric data reduction and analysis is presently available at the USGS and includes a Kern DRS-11** analytical plotter using DRS-11 software for making an oriented photogrammetric model for stereo pairs and Kork Digital Mapping System** software for digitizing and editing maps. A second unit is available from a private contractor in Boulder, Colorado.

The steps for this task are described in the following paragraphs.

1. Photograph each trench face twice. The first photographic survey, the archival survey, will be done as soon as possible after the trench face has been cleaned. No markings, flags, nails, etc., other than the surveyed control points should appear in these photographs. This survey will serve as an archive of the trench face(s).

2. Before beginning the archival survey, mount the metric camera onto a sturdy tripod or stand. The camera and mount should be located approximately 1.5-2 m from the trench face, depending on the depth of the trench and the field of view of the camera's lens.

3. Begin the photogrammetric survey at one end of the trench. The end of the trench defined as the first photographic station will be accurately surveyed to the nearest USGS benchmark (Section 4.5.1, Step 9).

4. Take photographs on 2.25 x 2.25 in. format film with 60% ±5% horizontal overlap. Each stereo pair will contain at least four surveyed control

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** Use of tradenames is for descriptive purposes only and does not imply endorsement by SNL or the USGS.

points permanently attached to the trench face for aligning or registering the photographs.

5. If necessary to reduce the effects of shadows, take photographs at night or near dusk. A strobe system is required for night photography. The PI and Contract Geologist will determine the photography schedule.

6. Take photographs at each photographic station. After photographs are obtained for a particular station, the next photographic station is defined by measuring the horizontal distance of the trench face covered in the camera's field a view then moving the camera mount 40% of that distance along a trend parallel to the trench face. This will provide coverage of the trench face with a 60% overlap. Once the next photographic station has been defined, move the camera mount to the next station, take photographs for that station, and repeat the process for the length of the trench. Documentation is crucial as photography proceeds; complete the Daily Log for each day of field activity. In addition, record the following information in the field notebooks.

   - the type, model, and serial number of the camera;
   - the model, serial number, and focal length of lens;
   - a sequential photo ID number that includes the trench ID and date photo was taken;
   - the focal length, aperture, and shutter speed settings at the time each photograph was taken;
   - the date and time of day each photograph was taken;
   - the distance of camera from trench face;
   - the distance and direction the camera support was moved from the last photographic station;
   - a brief description of existing weather, particularly how it affects lighting;
   - a description of use of any artificial lighting; and
   - any extenuating circumstances related to the photography.

HOLD POINT (approval of archival survey by Contract Geologist and PI)

7. Proceed with photography of the trench face for the second survey, the geologic survey, as in the archival survey, beginning at the same first photographic station. For the geologic survey, repeat, as closely as possible, the station spacing and camera settings from the archival survey.

HOLD POINT (for approval by Contract Geologist and PI of set of photographs of the trench mapping)

4.5.5 Report Preparation

Prepare geologic report, final geologic map, and related cross sections. Include in the report descriptions of any faults identified in the Midway Valley study area, including displacement rates. Displacement rates are determined from measured offsets of faults observed and identified during the trench mapping and from results of age-determination analyses for samples collected from the associated units. Using this information and the following equation,

$$\text{displacement rate} = \text{offset/age},$$

calculate displacement rates for any faults identified in the study area. The geotechnical contractor will prepare the final contractor report for Activity 2 and transmit it to the PI.

4.6 <u>Procedure for Collection and Control of Samples</u>

The task sequence described below consists of the steps that will be followed for collection and control of samples. Included in the steps are hold points that require approval of the Contract Geologist, Contract Manager, or PI before proceeding to the next step. The PI has overall responsibility for the work described in this procedure. The geotechnical contractor is responsible for performing the work while technical consultants may provide expertise for collecting samples for specific analyses. In addition to the specific steps outlined for this procedure,

the requirements of DOPs 8-1, 8-2, and 13-1 for identification, handling, custody control, shipping, and storage of samples apply to this experiment. Applicable USGS procedures for sample collection also apply. As they arise, differences in SNL and USGS procedures will be resolved by the PI and Contract Geologist who will determine and document an appropriate course of action for each sample collection situation.

4.6.1 Collection and Identification of Samples

This task includes collection and identification of samples from surface exposures, soil pits, and trenches as part of the surface and trench mapping procedures. The steps for this task are described in the following paragraphs.

1. Determine number and locations of samples to be collected and the analysis for which samples will be used. The Contract Geologist, with input from one or more technical consultants, if necessary, will accomplish this step. Document the approach to sample collection in a letter or memo to the PI.

HOLD POINT (for approval by PI of number and locations of samples to be collected)

2. Collect samples determined in Step 1 and place them in appropriate containers that provide protection from damage and contamination. If required, follow USGS technical procedures (Table 6) for special sample collection methods related to specific analysis techniques. Place soil samples in clean, clear glass or plastic jars with screw-on lids. Place rock samples in clean, clear plastic jars with screw-on lids, heavy canvas or plastic bags, or wooden crates. Close sample containers in a manner that will permit determination of unauthorized entry to containers. For most of the containers described, attach a gummed paper seal that must be broken when the container is opened (Section 4.6.3, Step 3). Complete a Soil Sample Description Sheet (Attachment I) for at least one sample from each sample location.

Collect a sample large enough to allow a split for archival storage, unless the amount of available material precludes this. Record sample collection activities in field notebooks.

3. Assign each sample a unique identification number. Samples collected for this experiment will have sample identification numbers in the following format: kkk-mmm-nn-SNL-q-r-s...

where

kkk — is the collection locality, e.g., soil pit or trench number

mmm — is the distance of the sample location from the zero-point of the collection locality. For samples collected from trenches, mmm will be the distance from the surveyed point at one end of the trench. For samples collected from soil pits or other surface exposures, mmm will be the Nevada state plane coordinates to the nearest foot.

nn — is the number of the sample taken from that locality.

SNL — is the organization to which the sample is assigned. For this experiment, all samples will be assigned to SNL.

q — is either AR for the archival sample transmitted to the SNL NWRT Department Samples Library or AN for an analysis sample. All samples collected in the field will have a q designator of AN. If the quantity of a sample allows a split for archive, the archival sample will maintain the original sample ID with the exception of changing the AN to AR.

r — is the designator for the analysis for which the sample will be used. The designators for each type of analysis include, but are not limited to, UT for uranium-trend dating, US for uranium-series dating, KA for potassium-argon dating, FT for

fission-track dating, CA for carbon 14 dating, and RS for rubidium-strontium dating. The Contract Geologist will develop other designators, as required, and record these in the Daily Log and field notebooks.

s-t-u-v.. are sequential designators to be used when subdividing samples, as determined by the PI or his designated representative. The sequence of subdivision is as follows:

s - capital letters in sequence A through Z, and continuing AA through ZZ, if necessary.

t - Arabic numerals in sequence beginning with 1.

u - lower case letters in sequence a through z, and continuing aa through zz, if necessary.

v - Arabic numerals in sequence beginning with 1.

Any subsequent subdivision would begin with capital letters again and follow through the sequence outlined above.

Assignment of designators kkk, mmm, and nn is the combined responsibility of the collector of the sample and PI or his designated representative.

4. Mark the sample identification information in indelible black ink on the outside of the sample container, not on the sample. Exceptions to this step includes the collection of oriented samples for which the orientation of a face of the sample is marked directly on the sample. These samples would be used for fabric analysis, for example, rather than for age determination or geochemical analyses. Collection of oriented samples for this experiment is not foreseen at this time.

5. Make provisions, as necessary, to control sample identification markings for the duration of planned shipping, handling, and storage and to maintain or replace sample identification markings and records.

6. Maintain and update the Sample Number Log (Attachment I), which gives a sequential record of all assigned sample numbers to ensure that sample numbers are not duplicated. The Contract Geologist will assign sample numbers to sample collectors, either a single number or a block of numbers. The initials of the collector assigned the numbers will be placed by the respective numbers in the Log.

4.6.2 Sample Collection Report

This task includes documentation of sample collection by two separate Sample Collection Reports (SCRs), one for the SNL NWRT Department DRMS file and one for the YMP Sample Management Facility (SMF).*** The steps for this task are described in he following paragraphs.

1. Initiate and complete the SNL SCR (Attachment I) for each sample. The information entered on an SCR includes the following:

   - the EP number and revision for which the sample is being collected (EP-0001);
   - the sample identification number;
   - the sample location (including trench or soil pit number, location, and coordinates, if available), depth, and distance from surveyed point at end of trench;
   - the date and time of sampling;

*** The YMP Administrative Procedure (AP-6.3Q) for the Sample Management Facility is still a draft document and has not yet been approved. Initial discussions with those involved with the SMF determined that, for this experiment, only a completed SMF SCR for each sample collected would be required. This EP will be revised, if necessary, to include additional procedural requirements imposed by the final approved AP-6.3Q.

- the type of sample (e.g., rock, soil);
- the purpose for which the sample was collected (e.g., uranium-trend analysis);
- field observations;
- a correlation of the sample to a particular geologic unit or formation;
- references to relevant maps, photographs, or logs; and
- the name and signature of collector.

2. Obtain bar code stickers from the YMP SMF. Complete the second SCR (Attachment I) for the YMP SMF and affix one bar code sticker to the form, where indicated. Affix a second corresponding bar code sticker to the container of the associated sample.

3. Note sample locations and identification numbers on appropriate trench maps or other suitable reference materials and in field notebooks.

4. Take 35-mm photographs of sample location. Record on Sample Photograph Log (Attachment I) sample location photograph, including sample number(s) and film roll and frame number. Reference corresponding photograph on, and attach a print to both SCRs.

HOLD POINT (for review of SCRs by Contract Geologist)

5. Submit the first SCR to the PI for transmittal to the DRMS. Transmit the second SCR to the YMP SMF.

4.6.3 Handling of Samples

This task includes handling of samples, including chain-of-custody control, shipping, and storage. The steps for this task are described in the following paragraphs.

1. When a sample is collected, initiate a Chain-of-Custody form (Attachment I) that will accompany the sample throughout the sample

history, up to and including archive storage and disposal. The sample collector will accomplish this step, indicating on the form the sample identification number, the date, and his name and signature as sample originator.

2. Each time a sample changes location or custody, the sender and receiver sign the Chain-of-Custody form and indicate the time and date of the transfer. After each transfer is made, the receiver will make a copy of the Chain-of-Custody form and submit the copy to the PI for transmittal to the DRMS file. Keep the original form with the sample at all times up to and including archive storage and disposal. If a sample is destroyed for any reason (e.g., as a result of laboratory analysis), the individual responsible for the sample at the time it was destroyed will record this on the Chain-of-Custody form.

3. Each time a sample is removed from its container and then replaced, attach a new seal and mark on the seal "SNL YMP Sample," the sample identification number, the date and time of sealing the container, and the name of the person placing the seal.

4. If the quantity of sample allows, divide the sample for analysis and archival storage. Maintain the original sample ID, changing the AN to AR for the archive sample. Initiate a new Chain-of-Custody form for the archive sample.

5. If a sample is divided (e.g., into different samples for a specific analysis, or into samples for different analyses), retain the original sample identification number as part of the subsample identification number, appending additional unique designators as described in Section 4.6.1. Place subsamples in appropriate containers and mark subsample identification numbers as described in Section 4.6.1. Initiate new Chain-of-Custody forms for all subsamples as described in Step 1 of this section. Retire Chain-of-Custody form for original sample to PI for transmittal to the DRMS file.

The exception to this step is if a sample is divided for an archive sample, in which case, Step 4 applies.

6. During handling and shipping of samples, make provisions to prevent damage to sample containers and samples. When necessary for specific samples, provide and maintain special protective environments, such as specific moisture content or temperature levels. It is expected that special protective environments will not be required for the samples collected during this experiment. If such environments are required, the specifications will be included in a revision of this EP or in a separate technical procedure.

7. Maintain samples in temporary storage at the SNL warehouse in Mercury, Nevada, until shipment to a laboratory for analysis or to the SNL NWRT Department Samples Library for archival storage. The storage facility will provide protection for samples from damage, deterioration, or tampering, including special protective environments, if necessary.

8. When shipping samples, prepare a Sample Shipping List (Attachment I) to accompany the shipment. Indicate on the form the sample identification number of each sample being shipped, the type of analysis to be performed, and any special instructions for analysis or handling.

9. Before shipping samples for analysis, verify that procurement documents for the laboratory performing sample analysis and laboratory procedures for performing the analysis and maintaining quality control are approved and in place. Inspect shipment of samples.

HOLD POINT (for approval of Sample Shipping List by Contract Geologist)

10. After completion of analysis, the laboratory will return all samples, with their respective Chain-of-Custody forms, to the Contract Geologist, signing and dating the Chain-of-Custody form, as required.

11. Transmit all samples to the SNL NWRT Department Samples Library for permanent archival storage.

5.0 QUALITY ASSURANCE LEVEL

Quality Assurance Level I is assigned to the work performed for this experiment.

Quality level assignments for this work were approved in Work Plan No. 123211-86, dated 9/19/86. A revision of this Work Plan, Work Plan 1232122, is currently in review.

6.0 SAFETY

All applicable requirements of the NTS Project Safety Plan will be followed. Details can be found in the O/S Plan (Attachment III) for the study with which this experiment is associated.

Geologic mapping activities include the normal hazards associated with geologic field work. Such hazards may include snake and insect bites. Mapping personnel are required to work in pairs at all times and notify the SNL office in Mercury, Nevada, on a daily basis, of their intended work areas.

The determination of trench stability is a joint responsibility of the PI or his designated representative, and the personnel responsible for trench mapping and excavation. Trench stability will be evaluated before mapping activities begin. For this activity, as a minimum, OSHA standards (DOL, 1988) for safety in excavations and trenches apply. Trenches will be roped off according to NTS safety practices.

7.0 RECORDS CONTROL

7.1 Data Records

The types of data collected during this experiment include, but are not limited to, the following: areal distribution of mappable geological units; attitude of units (e.g., strike, dip, younging direction); description of properties (e.g., weathering, fracturing, composition, gradation); location, orientation, and description of tectonic features (e.g., faults and fractures); samples of units for archiving; samples of units for age determination; and dates on samples.

Other data may include geochemical analyses of datable horizons for correlation purposes; petrographic analyses of datable horizons for correlation purposes; and geophysical measurements across faults. Procedures for collecting these types of data will be included in a revision of this EP, other EPs, applicable USGS technical procedures, or separate SNL technical procedures.

Data are recorded by one or more of the following: in field notebooks, on geologic maps and cross sections at reduced scale, by and/or on photographs, and on various forms. The scale of geologic maps and cross sections will be determined by the detail needed and will be strongly influenced by the complexity of the features in the exposures being mapped. For example, if fault displacements are judged to be absent after a detailed examination of a trench by experienced geologists and geophysicists, then descriptions and photographs will be taken to verify that such a condition exists. On the other hand, if displacements exist, that condition will be thoroughly documented and mapped at a greater level of detail because the amount and recurrence rates of offset are crucial to the placement of the waste-handling facilities.

The records generated from collecting the types of data described above are QA records and will be submitted to the PI for transmittal to the DRMS. These records include, but are not limited to, the following:

- field notebooks,
- data forms (Attachment III)
- photographic media (duplicate prints of all photographs),
- mylar overlays for maps and photos, and
- geologic maps.

Other QA records associated with this experiment include, but are not limited to, the following:

- training records, including personnel familiarization and certification forms,
- deviation reports, if any, and
- related correspondence between participating organizations.

All samples that have not been destroyed during analysis will be transmitted to the SNL NWRT Department Samples Library for permanent archival storage after data collection is completed.

7.2 DRMS Data-Set ID

The DRMS Data Set ID number for this experiment is 55/F12-1/29/87.

7.3 Records Transmittal

Hard copies of the data and information obtained during this experiment will be transmitted by the PI to the DRMS in accordance with DOP 11-3.

8.0 REPORTS

Data gathered during this experiment will be presented in contractor reports for contract activities as specified in the contractor's Statement of Work or LOC (Attachment II). The principal SNL document(s) will be a SAND report(s) that presents interpretations of the data gathered during this experiment.

9.0 PERSONNEL QUALIFICATIONS/TRAINING

Quality Assurance Level I activities require personnel to be qualified in accordance with DOP 2-6. All SNL personnel and other personnel under direct contract to SNL working under this EP will be familiarized and qualified for the YMP in accordance with DOP 2-6 (Section 2.2). In addition, all persons implementing this EP will be trained in its requirements.

10.0 REFERENCES

Compton, R. R., Manual of Field Geology, John Wiley and Sons, New York, 1962.

DOE (U.S. Department of Energy), "Site Characterization Plan," DOE/RW-0198, Office of Civilian Radioactive Waste Management, Washington, DC, 1988.

DOL (U.S. Department of Labor), "Safety and Health Regulations for Construction," Code of Federal Regulations, Title 29, Part 1926, Subpart P, U.S. Government Printing Office, Washington, DC, 1988.

Fairer, G. M., J. W. Whitney, and J. A. Coe, "Neotectonic Trench Studies at Yucca Mountain, Nevada, Using Close-Range Photogrammetry," American Geophysical Union, EOS, v. 68, 1987.

Gibson, J. D., L. E. Shephard, and C. A. Rautman, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM, 1989.

Hatheway, A. W., and F. B. Leighton, "Dating Techniques in Fault Investigations," Geological Society of America, Reviews in Engineering Geology, v. IV, 1979a.

Hatheway, A. W., and F. B. Leighton, "Trenching as an Exploratory Method," in A. W. Hatheway and C. R. McClure, Jr., Geology in the Siting of Nuclear Power Plants, Geological Society of America, Reviews in Engineering Geology, v. IV, pp. 169-195, 1979b.

Holmes & Narver, "Survey Department Work Functions," Procedure NNWSI-017.

Hoover, D. L., W. C. Swadley, and A. J. Gordon, "Correlation Characteristics of Surficial Deposits with a Description of Surficial Stratigraphy in the Nevada Test Site Region," USGS-OFR-81-512, U.S. Geological Survey, Denver, CO, 1981.

Scott, R. B., and J. Bonk, "Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections," USGS-OFR-84-494, U.S. Geological Survey, Denver, CO, 1984.

SNL NWRT Department QA Documents

- DOP 2-6, "Qualification and Certification of Project Personnel"
- DOP 6-1, "Document Control System Procedures"
- DOP 8-1, "Sample Identification and Handling Requirements"
- DOP 11-2, "Requirements for Experiment and Equipment-Test Logbooks"
- DOP 11-3, "Requirements for Interaction with the Data Records Management System"
- DOP 13-1, "Identification, Handling, Shipping, and Storage Procedures for Items and Materials"
- QAP 16-2, "Deviation Reporting"

Swadley, W. C., D. L. Hoover, and J. N. Rosholt, "Preliminary Report on Late Cenozoic Faulting and Stratigraphy in the Vicinity of Yucca Mountain, Nye County, Nevada," USGS-OFR-84-788, U.S. Geological Survey, Denver, CO, 1983.

URS/John A. Blume & Associates, "Ground Motion Evaluations at Yucca Mountain, Nevada with Applications to Repository Conceptual Design and Siting," SAND85-7104, prepared for Sandia National Laboratories, Albuquerque, NM, 1986.

URS/John A. Blume & Associates, "Technical Basis and Parametric Study of Ground Motion and Surface Rupture Hazard Evaluations at Yucca Mountain, Nevada," SAND86-7013, prepared for Sandia National Laboratories, Albuquerque, NM, 1987.

"Use of the Sample Management Facility by Yucca Mountain Project Participants," AP-6.3Q, Yucca Mountain Project Administrative Procedure, Draft Document, 1988.

ATTACHMENT I

DATA FORMS

DAILY LOG

DATE: _____ PRINCIPAL LOCATION: _____ PAGE___OF___

PARTICIPANTS: _____

_____

_____

BEGINNING OF WORK SHIFT (TIME): _____

END OF WORK SHIFT (TIME): _____

WEATHER DURING DAY: _____

OTHER LOCATION(S) OF WORK DURING DAY: _____

APPLICABLE PROCEDURES (EP, TPs, LOCs): _____

FIELD NOTEBOOK PAGE NUMBERS OF DATA COLLECTED BY ALL INDIVIDUALS:

NOTEBOOK # _____ PAGE #s _____

NOTEBOOK # _____ PAGE #s _____

NOTEBOOK # _____ PAGE #s _____

NOTEBOOK # _____ PAGE #s _____

ID #s OF PHOTOGRAPHS USED FOR MAPPING:

_____ _____ _____ _____

_____ _____ _____ _____

IDs OF SKETCHES/FIELD MAPS GENERATED:

_____ _____ _____ _____

_____ _____ _____ _____

ID #s OF SAMPLES COLLECTED:

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

ID #s OF PHOTOGRAPHS TAKEN:

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

DEVIATION FROM EXPERIMENT OR TECHNICAL PROCEDURES: _____

_____

_____

UNUSUAL OCCURRENCES OR UNEXPECTED RESULTS: _____

_____

_____

DISPOSITION OF DEFICIENCY REPORTS FOR DEVIATIONS: _____

_____

DOWNTIME: _____

REMARKS BY PI OR DESIGNATED REPRESENTATIVE: _____

_____

_____

_____

REVIEW, SIGNOFF AT END OF DAY: _____

Signature (PI or designated representative)

SOIL SAMPLE DESCRIPTION

Sample ID number: _____
Sample Collected by: _____ on (Date/Time): _____
Weather: _____
Described by: _____ Date: _____ Time: _____
Soil Series: _____
Taxonomy: _____
Climate: _____
Location: _____
Quadrangle: _____
Geomorphic Surface/Landform: _____
Sampling Method: _____
Estimated Age: _____
Vegetation (natural, present): _____
Provenance: _____
Nature, Texture of Deposit: _____
Surficial Unit: _____ Erosion (type): _____
Elevation: _____ Aspect: _____
Remarks: _____

Photographs: _____

Horizon Bound (cm)	Color dry,moist	Texture	Consistency	Gravel %,size, type	Clay Films	Parent Mat'l	Other--i.e., CO_3, Si, roots

SAMPLE NUMBER LOG

Sequential Sample Numbers	Assigned To (name)	Assigned By (name)	Date

Page___of___

SNL NWRT DEPARTMENT SAMPLE COLLECTION REPORT

Sample Number: _____ Date: _____ Page ____ of ____

Date and Time of Sampling: _____

Sample Type (i.e., rock, soil, etc.): _____

Purpose of Sample: _____

Approximate Weight or Dimensions: _____

_____

Sample Location:

General (e.g., surface facility site): _____

Specific (i.e., coordinates; surface and/or depth): _____

_____

Trench/Soil Pit Number: _____ Coordinates: _____

Other Location Identifiers: _____

_____

Correlation to Particular Geologic Unit or Formation: _____

_____

_____

Field Observations: _____

_____

_____

Reference to Relevant Maps: _____

_____

Photographs: _____

_____

Logs: _____

_____

Comments: _____

_____

_____

_____

Collected By:

_____ _____ _____

Name (printed) Signature Date

YMP SAMPLE MANAGEMENT FACILITY SAMPLE COLLECTION REPORT

YMP	YUCCA MOUNTAIN PROJECT SAMPLE MANAGEMENT FACILITY	
	SAMPLE COLLECTION REPORT	AP6.3Q-5-10/21/88

Date Sample Collected		Page____of____
Sample Collector		
Organization		
Collector's Sample ID		

AFFIX BAR CODE HERE

Type of sample *(circle)*: rock muck soil liquid biota gas
other (*specify*):_____

Type of site *Circle all appropriate entries*

SURFACE:				ESF: Shaft		Drift	
trench	outcrop	borehole	other	borehole	muck pile	in place	other

Collection Location:

SAMPLE: weight_____, volume_____, dimensions_____

FIELD PHOTOS (*circle*): prints slides instant prints video photogrammetry NA

STORAGE REQUIREMENTS:

REMARKS:

SAMPLE TRANSFER TO SMF (*Check one*) ☐ Yes ☐ No

Person Releasing Custody	Date	Person Accepting Custody	Date

SMF USE ONLY

STORAGE LOCATION: Area_____ Unit_____

Date Stored_____ Time Stored_____

Verified By_____ Date_____

SAMPLE PHOTOGRAPH LOG

Sample Number	Roll Number	Frame Number	Date	Photographer

Page____of____

YMP/SNL CHAIN-OF-CUSTODY FORM

Sample Number: _____ Page ____of____ Date _____

Approx. Mass of Sample: _____g Approx. Size of Sample: _____

Sample Originator: _____ _____
Printed Name Signature

Relinquished by:		Received by:	
Signature	Date/Time	Signature	Date/Time
Printed Name	Organization	Printed Name	Organization
Signature	Date/Time	Signature	Date/Time
Printed Name	Organization	Printed Name	Organization
Signature	Date/Time	Signature	Date/Time
Printed Name	Organization	Printed Name	Organization
Signature	Date/Time	Signature	Date/Time
Printed Name	Organization	Printed Name	Organization

CHANGE OF SAMPLE CONTAINER SEAL

Seal Removal		Seal Replacement	
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time
Signature	Date/Time	Signature	Date/Time

If sample is subdivided, numbers of resulting subsamples: _____

SAMPLE SHIPPING LIST

Project Name: YMP Contract Number: _____

Firm: _____ Project Number: _____

Laboratory: _____

Type of Analysis: _____

Sample Number	Return After Analysis	Sample Number	Return After Analysis

Special Instructions: _____

_____

_____

_____

Approval by Contract Geologist:

_____ _____ _____

Name (printed) Signature Date

ATTACHMENT II

LETTERS OF CRITERIA****

Attachment II-A:	Aerial Photography Support and Cartography/ Geographic Information System Support by EG&G for SCP Study 8.3.1.17.4.2
Attachment II-B:	Surveying Support by Holmes & Narver for SCP Study 8.3.1.17.4.2
Attachment II-C:	Photographic Support by Pan Am World Services for SCP Study 8.3.1.17.4.2
Attachment II-D:	Excavation and Trench Preparation Support by REECo for SCP Study 8.3.1.17.4.2

**** The technical content of the LOCs are presented in this EP without their attachments. The LOCs for this experiment have been approved by SNL, but have not been approved by the YMP Office and the Nevada Test Site Operations as required by YMP AP-1.5Q.

ATTACHMENT II-A

LETTER OF CRITERIA

**AERIAL PHOTOGRAPHY SUPPORT AND
CARTOGRAPHY/GEOGRAPHIC INFORMATION SYSTEM SUPPORT
BY EG&G FOR SCP STUDY 8.3.1.17.4.2**

Approved: _____ 3/23/89
Author Date

Approved: _____ 3/29/89
SNL Division Supervisor Date

Approved: _____ 4/13/89
NWRT Department Manager Date

This Letter of Criteria (LOC) provides the specifications for support from EG&G for Sandia National Laboratories in the Yucca Mountain Project under Work Breakdown Structure (WBS) element 1.2.3.2.1.2.2. Funds are requested for EG&G to acquire aerial photographs within Midway Valley, east of Yucca Mountain and west of Fortymile Wash (see Figures 2 and 3 in attached "Safe Operating Procedure for Geotechnical Studies within Midway Valley at the Nevada Test Site") and to provide cartographic and graphics support for this study. Details of the support requested are provided in the descriptions of work that follow. Acquisition of aerial photographs is anticipated to begin on 5/15/89 and should be completed within two weeks. Negatives to be printed will be chosen at that time and should be available within two weeks (by 6/15/89). Cartographic and graphics support will also start on 5/15/89 with the printing of a 1:6000 topographic base map. This map should be available to other participants on the study by June 1. Cartographic support may extend until 6/1/91. As the study develops, helicopter support may be necessary to locate features seen from the air, but difficult to locate on the ground.

The activities under which this work is being conducted have been assigned a Quality Assurance (QA) Level I; relevant Quality Assurance Requirement Assignment and the Quality Assurance Control Specification records are attached (QA Attachment 1). The task outlined in this LOC will be controlled using a graded QA approach to control the activity in a manner commensurate with the Level I assignment of the overall study. Project Administrative Procedures 5.4Q and 5.17Q will be followed to control these tasks. Since the graded QA program is not fully implemented at this time, the existing approved Quality Assurance Level Assignments are included in QA Attachment 2. All necessary equipment will be supplied by EG&G.

The study plan[1] for evaluating the location and recency of faulting near prospective surface facilities (Site Characterization Plan study 8.3.1.17.4.2) will focus on significant Quaternary faults near the proposed surface facilities site within Midway Valley. An SNL experiment procedure[2] is the actual implementation document for the study. If potentially active faults are present, the expected amount of displacement and rate of offset will be calculated. This study will provide much of the information needed in the final selection of the site for the surface facilities as well as design parameters for the waste handling buildings.

Duane Gibson, Org. 6315, Sandia National Laboratories, Albuquerque, NM 87185 (FTS or 505) 844-8823 is the task leader for this WBS element and the primary Sandia contact. Chris Rautman, same address, (FTS or 505) 846-4922, is the principal investigator. Les Shephard (FTS or 505) 844-3604 is an alternate.

---

[1]Gibson, J. D., L. E. Shephard, and C. A. Rautman, in review, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM.

[2]Gibson, J. D., and F. A. Duran, in review, "Geologic Surface and Trench Mapping Near Prospective Surface Facilities," Experiment Procedure EP-0001, Sandia National Laboratories, Albuquerque, NM.

Description of Work for Aerial Photographic Support

Area:	Area covered will include all of the study area as specified in Figure 3 of the attached Safe Operating Procedure. Flight lines as specified in Table 1 will be plotted on existing topographic maps or aerial photographs. These maps or photographs will be used for visual navigation.
Emulsions:	Color (Kodak Aerocolor negative 2445 film, Estar base) Color Infrared (Kodak Aerocolor IR negative 2443 film, Estar base)
Format:	≈9" x 9" (vertical)
Scale:	≈1:6000 (1" = 500 ') (Scale will vary with topography)
Nature of Mission:	One set of both emulsions will be obtained with a high sun angle (30 - 50° above the horizon)). The shadow of the aircraft should not lie within the photographs. Two additional sets of both emulsions will be flown with a low sun angle (15 - 20° above the horizon) to enhance topography. These two additional sets will be flown one in the morning and the other in the afternoon, preferrably on the same day as the high-sun angle photography. In addition, a set of oblique angle color photographs are required for Midway Valley. Views from the north, south, east, and west of as much of the study area (Midway Valley) and its relationship to Yucca Mountain are desired.
Altitude of Mission:	An altitude of 6700 ±10% ft above mean sea level is desired for this work. Assume that the 3700 ft contour is the average elevation of the study area. A flight altitude of 3000 ft above this elevation (6700 ft above mean sea level) results in an approximate 1:6000 scale for the photographic images.
Coverage:	Stereo, 60%±1% forward overlap, 30%±1% side overlap; transparencies plus two each color prints. Additional black and white prints of the color negatives may be requested at a later date. The camera system will be a dual Wild RC-10, 2 each, 153 mm lenses. Flight line spacing will be nominally 3000 ft. All flights lines as specified in Table 1 should be flown in the same direction.

TABLE 1

COORDINATES FOR ENDS OF FLIGHT LINES

Line #	South End	North End	Altitude above M.S.L.
1	36° 49.0'N, 116° 26.3'W	36° 53.0'N, 116° 26.3'W	6700 ft
2	36° 49.0'N, 116° 25.7'W	36° 53.0'N, 116° 25.7'W	6700 ft
3	36° 49.0'N, 116° 25.1'W	36° 53.0'N, 116° 25.1'W	6700 ft
4	36° 49.0'N 116° 24.5'W	36° 53.0'N 116° 24.5'N	6700 ft
5	36° 49.0'N 116° 23.7'W	36° 53.0'N 116° 23.7'W	6700 ft

EG&G will be responsible for acquiring the necessary Operations Permits. This survey is over the northwest corner of NTS Area 25.

Aerial photography will be used as an adjunct to geologic mapping. This purpose of the aerial survey is to delineate Quaternary alluvial units at the surface facility site and to exploit structural/tectonic information, if possible.

Commonly accepted industry standards for aerial photography mapping will be followed during the work specified in this LOC.

Description of Work for Cartography/Geographic Information System Support

Nature of Work: Topographic and geologic maps will be produced as part of the Midway Valley study. These maps are to be prepared at 1:6000, the same scale as newly-acquired aerial photography. A topographic basemap will be needed prior to initiation of field work (prior to June 15, 1989). Most of the 2-m contour interval digital elevation data for Midway Valley has been prepared by the U.S.G.S./Flagstaff, but the final portion needed for a complete map of Midway Valley will not be available until mid-May. When all of the data are available, a suitable contour interval and sampling density of the data will be determined and a topographic map of the study area produced. If more detailed maps are needed as the study continues, maps with a smaller contour interval and closer sampling density may be required. If the following data are available, they should be included on the topographic map: existing roads and tracks, survey reference points, and well locations. The final types of data to be included with the topographic data will be determined when the map is printed. Five copies of this map will be required by June 15, 1989. If copies are available before that date, they should be forwarded to D. Gibson at SNL.

After surface mapping has been completed, EG&G will be responsible for digitizing the soil/rock information and integrating these data into its Geographic Information System (GIS). When this has been completed, a geologic map at 1:6000, similar to the topographic map described above, will be prepared. 10 copies of the geologic map will be needed after the geologic data has been digitized.

Area: Area covered will include all of the study area as specified in Fig. 3 of the attached Safe Operating Procedure.

Scale: ≈1:6000 (1" = 500 ') or as needed (scale will vary with topography)

Commonly accepted industry standards for cartographic mapping will be followed during the work specified in this LOC.

Sandia National Laboratories

Albuquerque, New Mexico 87185

June 2, 1989

WBS: 12525
QA

William T. Hughes
Yucca Mountain Project Office
U.S. Department of Energy
Nevada Operations Office
P.O. Box 98518
Las Vegas, NV 89193-8519

Dear Bill:

Subject: Clarification of Letter of Criteria for EG&G Support for Midway Valley Study

This letter is to provide clarification of accuracies stated in the Letter of Criteria (LOC) for Aerial Photography Support and Cartography/ Geographic Information System Support by EG&G for SCP Study 8.3.1.17.4.2. This LOC was submitted to C. P. Gertz from T. O. Hunter on April 13, 1989.

The accuracy for stereo photo coverage stated on page 3 of the LOC should be as follows: 60%±5% forward overlap and 30%±5% side overlap. These criteria for stereo photo coverage, as stated here, supersede those stated in the LOC.

The accuracy for the coordinates for ends of flight lines stated in Table 1 on page 4 of the LOC is ±500 ft. This accuracy for ends of flight lines, as stated here, supplements the criteria provided in Table 1 of the LOC.

Sincerely,

Duane Gibson

J. Duane Gibson
Geoscience Analysis
Division 6315

FAD:6311:jdg

Copy to:

R. Dyer, DOE/YMPO
R. Meibaum, EG&G
E. Ezra, EG&G
6310 T. O. Hunter
6311 F. A. Duran
6315 L. E. Shephard
6315 J. D. Gibson
6315 C. A. Rautman
6310 55/F12-1/29/87
6310 80/12525/8.3.1.17.4.2/1.2/Q1 XREF
6310 YMP CRF

ATTACHMENT II-B

LETTER OF CRITERIA

**SURVEYING SUPPORT BY HOLMES & HARVER
FOR SCP STUDY 8.3.1.17.4.2**

Approved: _____ Author — 3/23/89 Date

Approved: _____ SNL Division Supervisor — 3/30/89 Date

Approved: _____ NWRT Department Manager — 4/13/89 Date

This Letter of Criteria (LOC) provides the specifications for support from Holmes & Narver (H&N) for Sandia National Laboratories in the Yucca Mountain Project under Work Breakdown Structure (WBS) element 1.2.3.2.1.2.2. Funds are requested for H&N to survey trench and test pit locations within Midway Valley, east of Yucca Mountain and west of Fortymile Wash (see Figures 2 and 3 in attached "Safe Operating Procedure for Geotechnical Studies within Midway Valley at the Nevada Test Site"). Details of the support requested are provided in the descripton of work that follows. Work is anticipated to begin on 6/15/89. This support will be on an as-needed basis through 6/15/91. The activities under which this work is being conducted have been assigned a Quality Assurance (QA) Level I; relevant Quality Assurance Requirements Assignment and Quality Assurance Control Specification records are attached (QA Attachment 1). The tasks outlined in this LOC will be controlled using a graded QA approach to control the activity in a manner commensurate with the Level I assignment of the overall study. Project Administrative Procedures 5.4Q and 5.17Q will be followed to control these tasks. Since the graded QA program is not fully implemented at this time, the existing approved Quality Assurance Level Assignments are included in QA Attachment 2. All necessary equipment will be supplied by H&N.

The study plan[1] for evaluating the location and recency of faulting near prospective surface facilities (Site Characterization Plan study 8.3.1.17.4.2) will focus on significant Quaternary faults near the proposed surface facilities site within Midway Valley. If potentially active faults are present, the expected amount of displacement and rate of offset will be calculated. This study will provide much of the information needed in the final selection of the site for the surface facilities as well as design parameters for the waste handling buildings.

Duane Gibson, Org. 6315, Sandia National Laboratories, Albuquerque, NM 87185 (FTS or 505) 844-8823 is the task leader for this WBS element and the primary Sandia contact. Chris Rautman, same address, (FTS or 505) 846-4922, is the principal investigator. Les Shephard (FTS or 505) 844-3604 is an alternate.

---

[1]Gibson, J. D., L. E. Shephard, and C. A. Rautman, in review, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM.

Description of Work for Surveying Support

Area of Interest:	All trenches and test pits will be located within Midway Valley, immediately east of Yucca Mountain (see maps found within the attached Safe Operating Procedure).
Nature of Surveying:	A third-order survey tied to the nearest U.S. Geological Survey benchmark will be used as the basis for photogrammetric mapping within the trenches. H&N is not responsible for the photogrammetry; photographic support for this work will be supplied by Pan Am World Services. Stakes will be surveyed at the ends of each trench. Additional surveying at similar accuracy will be required to locate test pits. H&N is also responsible for survey support of control points during the photogrammetric survey. The USGS will supply a sliding mount and rail system; Pan Am will provide the necessary photographic equipment and support for the photogrammetric survey. These control points on the trench face(s) will be surveyed to a similar accuracy as the stakes at the ends of the trenches. Each photograph taken as part of the photogrammetric survey will contain at least three control points. Adjacent photographs will overlap approximately 60%.
Location of Trenches:	The exact planned location of trenches and test pits will be determined after preliminary surface mapping and airphoto interpretation have been completed. For fiscal planning purposes, eight trenches (Midway Valley #1a to #1h) of approximately 6 m length are planned for FY89. Two 300-m trenches (Midway Valley #2a and #2b) are planned for FY89 and an additional two 300-m trenches (Midway Valley #2c and #2d) are planned for FY90.

Commonly accepted industry standards for surveying as well as relevant technical procedures found in Experiment Procedure EP-0001[2] will be followed during the work specified in this LOC. Requirements found in the attached Safe Operating Procedure will also be met.

---

[2]Gibson, J. D., and F. A. Duran, in review, "Geologic Surface and Trench Mapping Near Prospective Surface Facilities," Experiment Procedure EP-0001, Sandia National Laboratories, Albuquerque, NM.

ATTACHMENT II-C

LETTER OF CRITERIA

**PHOTOGRAPHIC SUPPORT BY PAN AM WORLD SERVICES
FOR SCP STUDY 8.3.1.17.4.2**

Approved: _____ 3/23/89
Author Date

Approved: _____ 3/20/89
SNL Division Supervisor Date

Approved: _____ 4/8/89
NWRT Department Manager Date

This Letter of Criteria (LOC) provides the specifications for support from Pan Am World Services for Sandia National Laboratories in the Yucca Mountain Project under Work Breakdown Structure (WBS) element 1.2.3.2.1.2.2. Funds are requested for Pan Am to photograph trenches within Midway Valley, east of Yucca Mountain and west of Fortymile Wash (see Figures 2 and 3 in attached "Safe Operating Procedure for Geotechnical Studies within Midway Valley at the Nevada Test Site") as part of photogrammetric surveys. Details of the support requested are provided in the description of work that follows. This work will be similar to previous work performed by Pan Am for the USGS in G-tunnel. A two-man team will be required for the work. This field work is anticipated to begin on 6/15/89; support will be on an as-needed basis through 6/15/91. The activities under which this work is being conducted have been assigned a Quality Assurance (QA) Level I; relevant Quality Assurance Requirements Assignment and Quality Assurance Control Specification records are attached (QA Attachment 1). The tasks outlined in this LOC will be controlled using a graded QA approach to control the activity in a manner commensurate with the Level I assignment of the overall study. Project Administrative Procedures 5.4Q and 5.17Q will be followed to control these tasks. Since the graded QA program is not fully implemented nor approved at this time, the existing approved Quality Assurance Level Assignments are included in QA Attachment 2. All necessary equipment will be supplied by Pan Am.

The study plan[1] for evaluating the location and recency of faulting near prospective surface facilities (Site Characterization Plan study 8.3.1.17.4.2) will focus on significant Quaternary faults near the proposed surface facilities site within Midway Valley. If potentially active faults are present, the expected amount of displacement and rate of offset will be calculated. This study will provide much of the information needed in the final selection of the site for the surface facilities as well as design parameters for the waste handling buildings.

Duane Gibson, Org. 6315, Sandia National Laboratories, Albuquerque, NM 87185 (FTS or 505) 844-8823 is the task leader for this WBS element and the primary Sandia contact. Chris Rautman, same address, (FTS or 505) 846-4922, is the principal investigator. Les Shephard (FTS or 505) 844-3604 is an alternate.

---

[1]Gibson, J. D., L. E. Shephard, and C. A. Rautman, in review, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM.

Description of Work for Photographic Support

Area of Interest:

Photography will be confined to trenches that are located within Midway Valley, immediately east of Yucca Mountain (see maps found within the attached Safe Operating Procedure).

Nature of Photography:

Each trench will be photographed twice[2]. The first photographic survey, the "archival" survey, will be taken as soon as possible after excavation and before any markings are placed on the trench face. Between the first and subsequent "geological" survey, a geotechnical contractor will mark stratigraphic contacts, structural features, and other related geologic features on the trench face(s) with flagging, nails, spray paint, etc. The geological survey will mimic the archival survey as much as possible.

The distance from the trench face to the camera as well as the distance between photographic stations will depend on the dimensions of the trench and the specifications of the camera and lens used. These distances will be determined after each trench is excavated so that at least 60% stereo overlap exists between adjacent photographs. The distance from the trench face to the camera and between photographic stations will be the same for both surveys within a particular trench. Location of photographic stations with a tape measure will provide sufficient surveying accuracy for these two surveys since the control points found on the trench face and shown within photographs will be surveyed independently.

Photography will be done using a 6 cm by 6 cm (2 1/4" by 2 1/4") format camera either mounted on a tripod or on a sliding mount that is attached to a rail. Selection of the type of mount will be based on ease of establishing successive photographic stations. The nature of the trench floor will be an important factor in determining which mount will be used. Color negative film will be used; direct contact color transparencies will be made of selected negatives. These transparencies will be digitized during photogrammetry.

Location of Trenches:	The exact planned location of trenches will be determined after preliminary surface mapping and airphoto interpretation have been completed. Trenches will be restricted to the study area as defined in Fig. 3 of the attached Safe Operating Procedure. For fiscal planning, eight trenches (Midway Valley #1a to #1h) of approximately 6 m length are planned for FY 89. Two 300-m trenches (Midway Valley #2a and #2b) are planned for FY89 and an additional two 300-m trenches (Midway Valley #2c and #2d) are planned for FY90.
Depth of Trenches:	The depth of trenches is assumed to be 3-4 m unless otherwise specified by the SNL Principal Investigator or designated representative. Trenches may need to be extended an additional 1-2 m in depth if sufficiently old strata are not uncovered at 4 m depth or if stratigraphic or structural relationships are unclear. This increased depth may be accomplished by additional bulldozing or by use of a backhoe within the trench.
Length of Trenches:	Exploratory and supplemental trenches are a few meters in length. The long trenches will be up to 200-500 m in length. It is anticipated that two or more of these long trenches will be required.

Commonly accepted industry standards for photography as well as relevant technical procedures found in Experiment Procedure EP-0001[2] will be followed during the work specified in this letter of criteria. Requirements found in the attached Safe Operating Procedure will also be met.

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[2]Gibson, J. D., and F. A. Duran, in review, "Geologic Surface and Trench Mapping Near Prospective Surface Facilities," Experiment Procedure EP-0001, Sandia National Laboratories, Albuquerque, NM.

ATTACHMENT II-D

LETTER OF CRITERIA

EXCAVATION AND TRENCH PREPARATION SUPPORT BY REECO FOR SCP STUDY 8.3.1.17.4.2

Approved: _____ Author — 3/23/89 Date

Approved: _____ SNL Division Supervisor — 3/31/89 Date

Approved: _____ NWRT Department Manager — 4/8/89 Date

This Letter of Criteria (LOC) provides the specifications for support from REECo for Sandia National Laboratories in the Yucca Mountain Project for Work Breakdown Structure (WBS) element 1.2.3.2.1.2.2. Funds are requested for REECo to excavate trenches and smaller soil pits within Midway Valley, east of Yucca Mountain and west of Fortymile Wash (see Figures 2 and 3 in attached "Safe Operating Procedure for Geotechnical Studies within Midway Valley at the Nevada Test Site"). Details of the support requested are provided in the description of work that follows. Additional manpower, approximately one full-time equivalent, may be needed on an as-needed basis to clean the face of trenches prior to geologic mapping. Work is anticipated to begin on 6/15/89; support will be on an as-needed basis through 6/15/91. The activities under which this work is being conducted have been assigned a Quality Assurance (QA) Level I; relevant Quality Assurance Requirements Assignment and Quality Assurance Control Specification records are attached (QA Attachment 1). The tasks outlined in this LOC will be controlled using a graded QA approach to control the activity in a manner commensurate with the Level I assignment of the overall study. Project Administrative Procedures 5.4Q and 5.17Q will be followed to control these tasks. Since the graded QA program is not fully implemented at this time, the existing approved Quality Assurance Level Assignments are included in QA Attachment 2. All necessary equipment will be supplied by REECo.

The study plan[1] for evaluating the location and recency of faulting near prospective surface facilities (Site Characterization Plan study 8.3.1.17.4.2) will focus on significant Quaternary faults near the proposed surface facilities site within Midway Valley. If potentially active faults are present, the expected amount of displacement and rate of offset will be calculated. This study will provide much of the information needed in the final selection of the site for the surface facilities as well as design parameters for the waste handling buildings.

Duane Gibson, Org. 6315, Sandia National Laboratories, Albuquerque, NM 87185 (FTS or 505) 844-8823 is the task leader for this WBS element and the primary Sandia contact. Chris Rautman, same address, (FTS or 505) 846-4922, is the principal investigator. Les Shephard (FTS or 505) 844-3604 is an alternate.

---

[1]Gibson, J. D., L. E. Shephard, and C. A. Rautman, in review, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM.

Description of Work for Excavation Support

Area of Interest: All trenches and soil pits will be located within Midway Valley, immediately east of Yucca Mountain (see maps found within the attached Safe Operating Procedure).

Nature of Excavations: Two different types of excavations are referenced within the study plan and experiment procedure[2] for evaluating the location and recency of faulting near the prospective surface facilities. These include:

1) Soil pit - A narrow manmade excavation made below the surface of the ground by earth removal and producing unsupported earth conditions by reason of the excavation. As used here, soil pits are 1-3 m deep and approximately the width of a backhoe scoop (≈30 in.). It is assumed within this study that most soil pits will be made by backhoes.

2) Trench - A narrow manmade excavation made below the surface of the ground by earth removal and producing unsupported earth conditions by reason of the excavation. In general, the depth is greater than the width, but the width of a trench is generally not more than 15 feet. It is assumed within this study that most trenches will be made by bulldozers. Three different types of trenches are discussed.

   Types of trenches include:

   Exploratory trenches - trenches of a few meters length excavated within Activity 1 of the study. These may be located anywhere within the study area.

   Long trenches - trenches of up to a few 100's of meters length excavated across the proposed site for the surface facilities. Two or more such trenches are planned during Activity 2 of the study.

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[2]Gibson, J. D., and F. A. Duran, in review, Geologic Surface and Trench Mapping Near Prospective Surface Facilities," Experiment Procedure EP-0001, Sandia National Laboratories, Albuquerque, NM.

Supplemental trenches - trenches used to augment the information obtained from the long trenches. These trenches will have the same dimensions as the exploratory trenches but will be excavated during Activity 2.

Location of Trenches: The exact planned location of trenches and soil pits will be determined after preliminary surface mapping and airphoto interpretation have been completed. For fiscal planning, eight trenches (Midway Valley #1a to #1h) of approximately 6 m length are planned for FY89. Two 300-m trenches (Midway Valley #2a and #2b) are planned for FY89 and an additional two 300-m trenches (Midway Valley #2c and #2d) are planned for FY90.

Depth of Trenches: The depth of trenches is assumed to be 3-4 m unless otherwise specified by the SNL Principal Investigator or designated representative. Trenches may need to be extended an additional 1-2 m in depth if sufficiently old strata are not uncovered at 4 m depth or if stratigraphic or structural relationships are unclear. This increased depth may be accomplished by additional bulldozing or by use of a backhoe within the trench.

Length of Trenches: Exploratory and supplemental trenches are a few meters in length. The long trenches will be up to 200-500 m in length. It is anticipated that two or more of these long trenches will be required.

Commonly accepted industry standards for excavation and trenching as well as relevant technical procedures found in Experiment Procedure EP-0001 will be followed during the work specified in this LOC. Fluid spills from machinery involved in excavation will be cleaned up by REECo. A minimum of water will be used during excavation for control of dust and for cleaning of trench faces. Requirements found in the attached Safe Operating Procedure will also be met.

ATTACHMENT III

OPERATIONS AND SAFETY PLAN

SOP Number 10300 8904
Original Issue
Responsible Org. 6315
Effective Date 4/5/89

SAFE OPERATING PROCEDURE FOR GEOTECHNICAL STUDIES WITHIN MIDWAY VALLEY AT THE NEVADA TEST SITE

ABSTRACT

This Safe Operating Procedure presents the Operations and Safety (O/S) Plan for the Yucca Mountain study for evaluating the location and recency of faulting near prospective surface facilities. The study involves geologic mapping and trenching that will be conducted in Midway Valley, which is located in Area 25 along the western margin of the Nevada Test Site. The O/S plan presents the operations and safety requirements for conducting the work for this study.

J. D. Gibson, 6315 Author	2/27/89 Date	L. E. Shephard, 6315 Division Supervisor	3/6/89 Date
for T. O. Hunter, 6310 Department Manager	3/9/89 Date	B. G. Edwards, 7131	3/27/89 Date
M. Olbin, 3216	3-13-89 Date	K. Miles, 3215	3/13/89 Date
D. Rost, 3216	4.4.89 Date	M. M. Carroll, 3215	4/3/89 Date

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6315 C. A. Rautman
7131 B. G. Edwards
K. Fox, USGS (Denver)
R. Shroba, USGS (Denver)
R. Dyer, DOE/YMPO
6310 80/12525/8.3.1.17.4.2/1.2/Q1
6310 YMP CRF

SOP Number 10300 8904
Original Issue
Responsible Org. 6315
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FIGURES

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1.0 Purpose

This Safe Operating Procedure (SOP) presents the Operations and Safety (O/S) Plan for the Yucca Mountain Project (YMP) study for evaluating the location and recency of faulting near prospective surface facilities (Gibson et al., in review). This study involves geologic mapping and trenching activities and will be conducted to evaluate the potential for fault displacement near surface facilities of the proposed high-level nuclear waste repository at Yucca Mountain, Nevada. The activities conducted for the study will focus on gathering geologic data to determine the existence of late Quaternary (<100,000 yr) faults near candidate sites for repository surface facilities. If faults are present, the recurrence intervals and rates of displacement will be determined. The data gathered in this study will support (1) the siting of the repository surface facilities and (2) an assessment of the effect of fault displacement on repository design.

The specific work to be performed for the study is governed by a Sandia National Laboratories (SNL) Experiment Procedure, EP-0001 (Gibson and Duran, in review), which provides step-by-step procedures for implementing the activities for the study. This document will be included, with appendices, as an attachment to EP-0001. All field participants must read the O/S plan and sign Appendix C of the plan. The plan is organized to follow the outline for O/S plans provided by the YMP. The content fulfills the guidelines for both YMP O/S plans and SNL SOPs.

2.0 Schedule

The work for this study will be conducted in two interrelated activities. Figure 1 presents the general sequence of tasks for these two activities. A description of the tasks for these activities is presented in Section 7.0. The schedules for these activities (Tables 1 and 2) are

SOP Number 10300 8904
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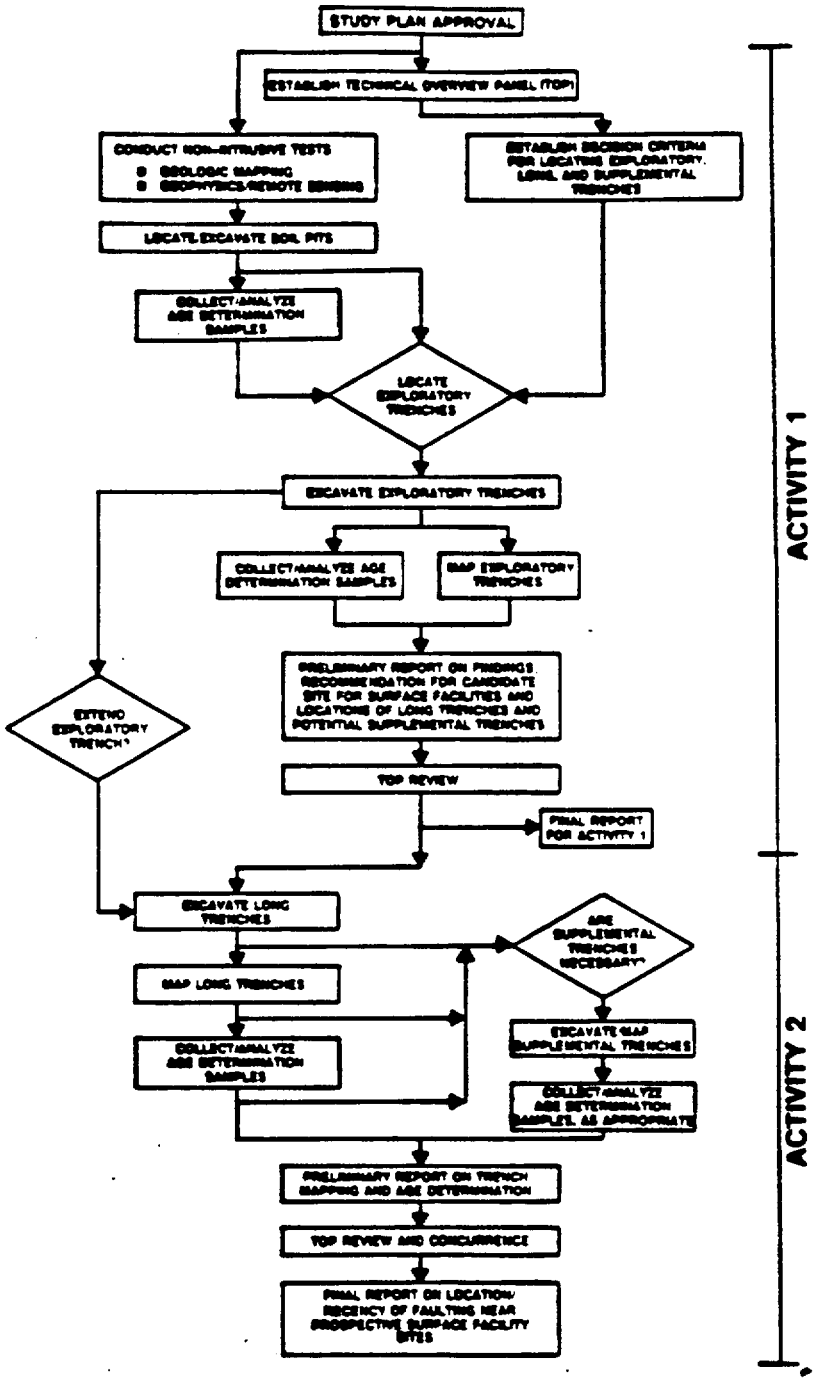

Figure 1. Summary of tasks for Activities 1 and 2 in the study to evaluate the location and displacement history of Quaternary faults in Midway Valley (Gibson et al., in review).

TABLE 1

SCHEDULE FOR ACTIVITY 1
IDENTIFY APPROPRIATE TRENCH LOCATIONS IN MIDWAY VALLEY

Task	Time Before Task Begins After Study Plan Approval (months)	Estimated Duration of Task (months)
Geologic Mapping	+2	+5
Soil Pits	+2	+5
Geophysics/Remote Sensing	+2	+5
Age Determination	+3	+9
Exploratory Trenching	+4	+5.5

TABLE 2

SCHEDULE FOR ACTIVITY 2
CONDUCT TRENCHING IN MIDWAY VALLEY

Task	Time After Study Plan Approval (months)	Estimated Duration (months)
Long Trenching	+7	+14
Supplemental Trenching	+7	+14
Age Determination	+12.5	+9.5

based on approval of the study plan. The current projected date for submittal of the study plan to the U.S. Nuclear Regulatory Commission (NRC) is March 1, 1989. Approval of the study plan by the Department of Energy (DOE) is simultaneous with its submittal to the NRC. Technical work may not begin until at least 3 months after the March 1 submittal date, or June 1. Delays related to the approval of the study plan will have a commensurate effect on the date that planned activities may begin.

3.0 Site Location

Work discussed in this O/S plan will be conducted in Midway Valley along the eastern base of Yucca Mountain (Figures 2 and 3). This site is located within Area 25 on the Nevada Test Site (NTS). Visits outside Midway Valley may be required for geologic correlation and analysis.

4.0 Authorizations

The SNL onsite representative (the principal investigator or his designee) is responsible for coordinating environmental, biological, and archeological permits for both casual use and surface disturbance activities with the Yucca Mountain Project Office and the NTS Support Office. These permits are required before work can begin. EG&G will apply for the air access permits required for acquisition of aerial photographs through the appropriate organizations (NTS and Nellis AFB). Photography permits already exist for Pan Am and SNL personnel. For coordination with other NTS activities, the Operations Coordination Center (OCC), (702) 295-4015, will be contacted on a daily basis. No other special authorizations are required.

5.0 Proposed Organizational Structure/DOE Point of Contact

The activities referenced in this O/S Plan will be accomplished, in part, by outside contractors with oversight, but not direct supervision, by SNL. These contractors include an SNL contractor, to be determined, for geologic mapping and various NTS/DOE contractors: EG&G for acquisition of new aerial photography, Reynolds Electrical and Engineering Co., Inc. (REECo) for excavation and trench face preparation, Holmes and Narver (H&N) for surveying, Pan American World Services (Pan Am) for acquisition of photogrammetric negatives; and the U.S. Geologic Survey (USGS) for photogrammetry equipment and age determination. The principal organizational interfaces and functions are shown in Figure 4. The

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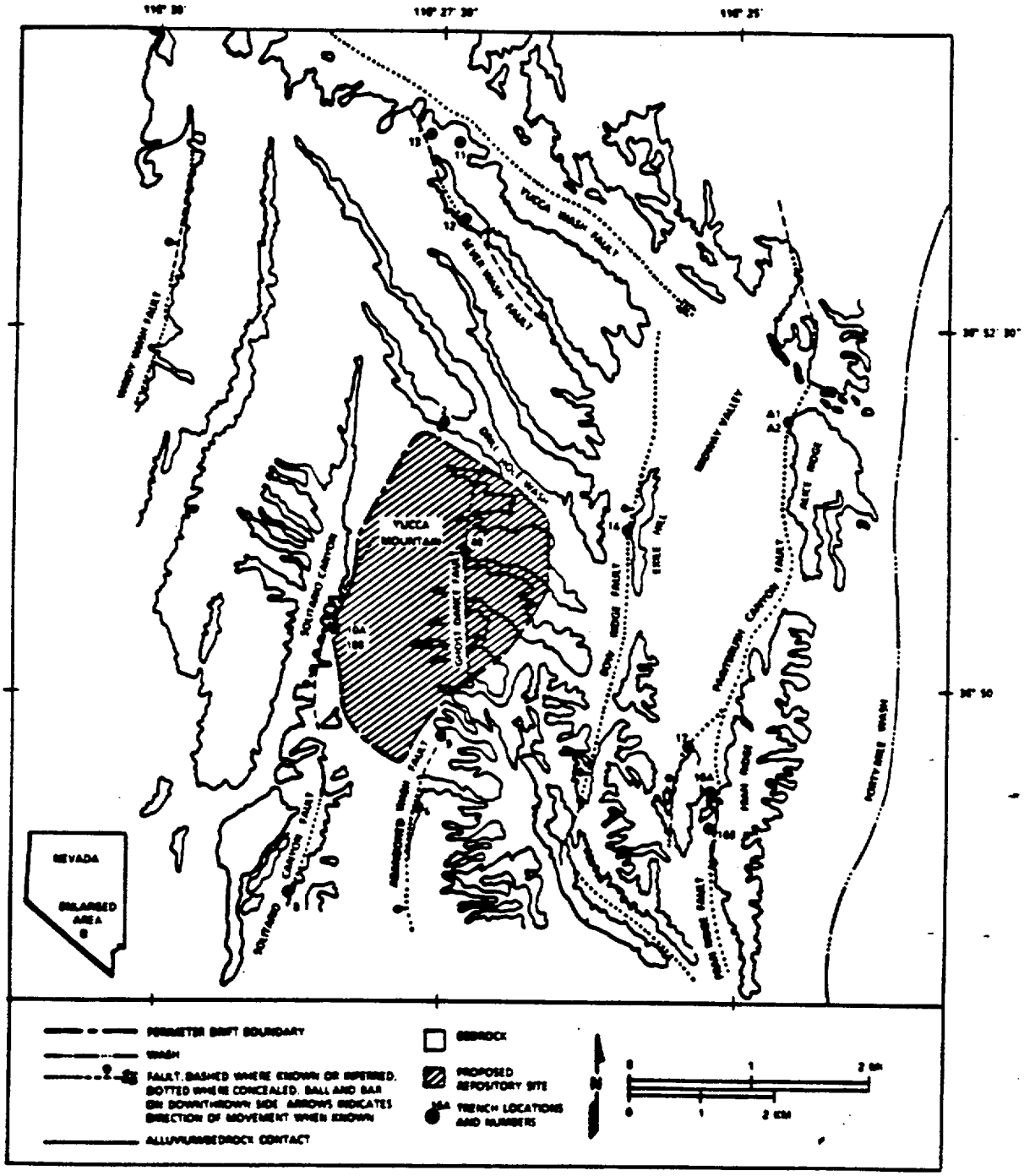

Figure 2. Location of Yucca Mountain and the proposed repository site relative to the surrounding region (modified from SNL, 1987).

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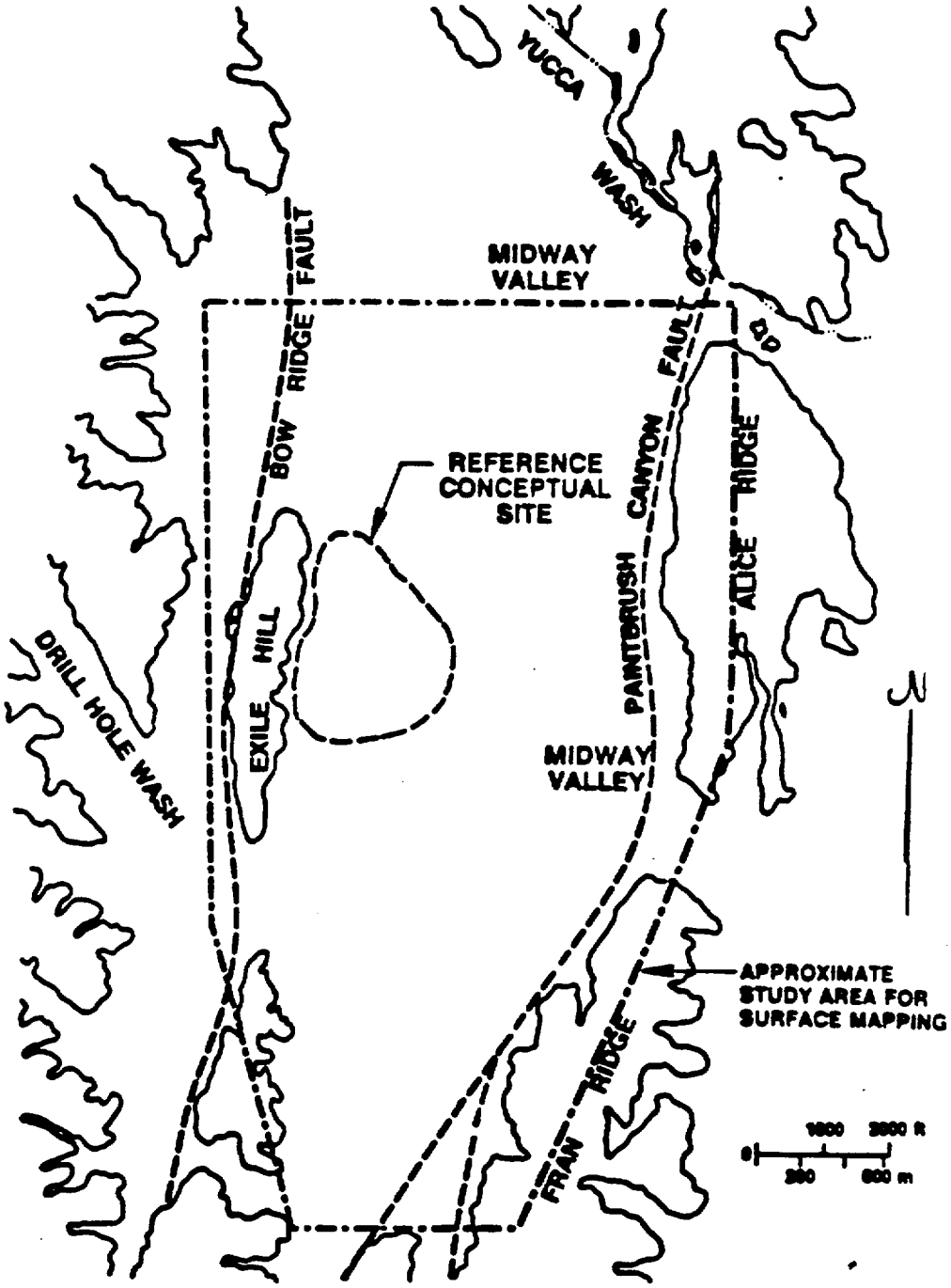

Figure 3. Proposed boundary of the Midway Valley study area. Study area includes the reference conceptual site of Neal (1985).

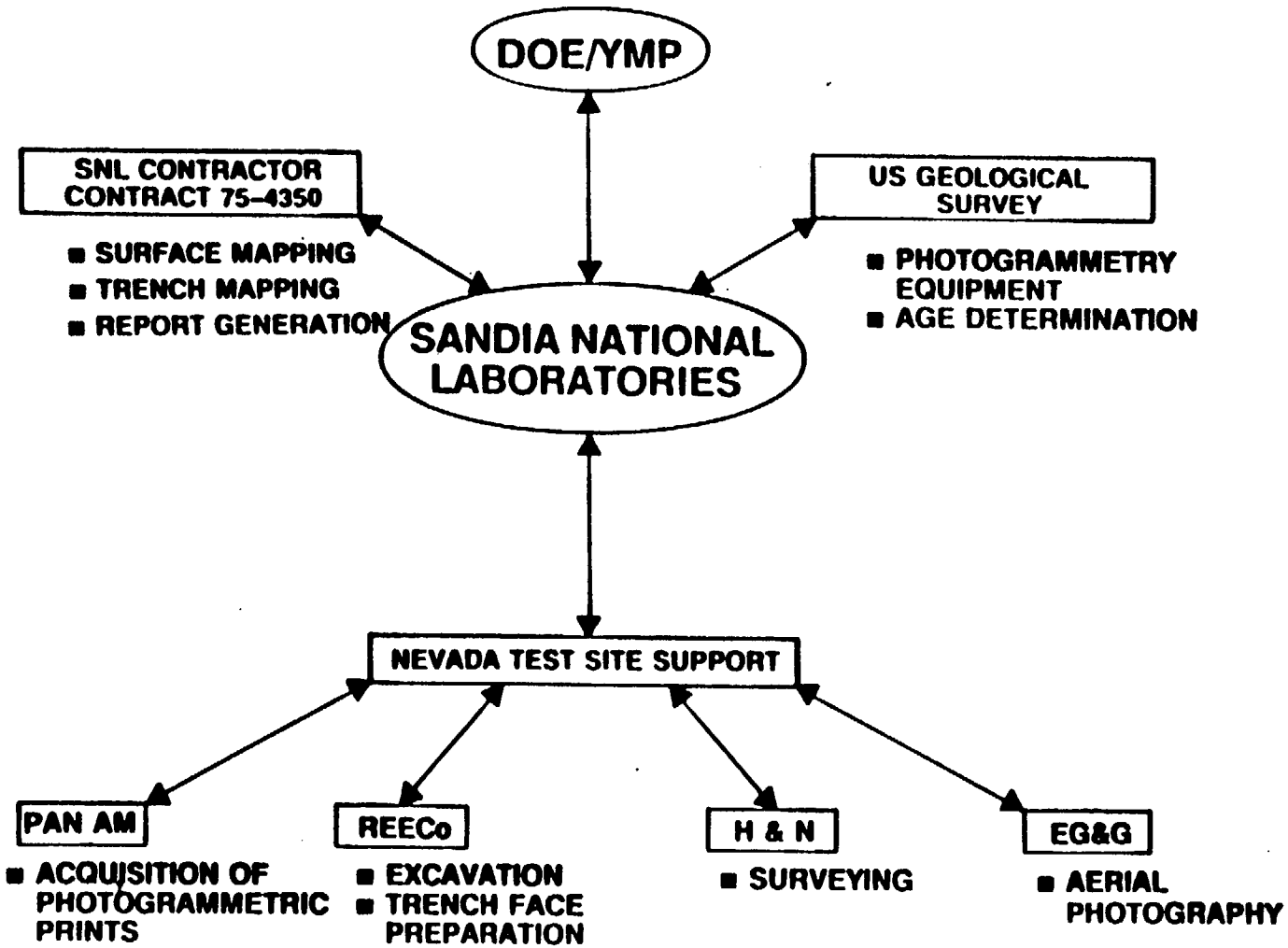

Figure 4. Principal organizational interfaces and functions.

requirements for the specific tasks to be conducted by other organizations will be formally transmitted by the following methods: (1) Statement of Work (for SNL contractors), (2) Letter of Criteria (for NTS/DOE support services), and (3) Interagency Agreement (USGS).

The DOE/YMPO point of contact is Russ Dyer, (FTS) 544-7586.

6.0 Concept of Operations

6.1 Hazardous weather conditions

Poor weather conditions may result in access or mapping problems that could cause minor delays. Heavy precipitation and associated adverse weather can affect the stability of trenches or excavations. In addition, severe weather conditions such as electrical storms, high wind, or snow will result in the suspension of field activities. Field operations will cease when electrical storms approach closer than 2 mi. This will be determined by observing a 10-s delay in thunder following lightning. Information on thunderstorm activity and hazardous weather warnings can be obtained from NOAA/WSNSO at the CP-1, (702) 295-4299, or the Yucca Wx Station, (702) 295-4295.

6.2 Special constraints

Off-road vehicle travel is not allowed, unless special permission has been obtained from the NTS Operations Office.

6.3 Photography

Photography is not allowed without permit. Contractor photography will be arranged through the SNL onsite representative, who will possess an NTS Photographer's Permit. Although no photographic activity is planned in

Area 12 or in areas along the eastern border of the NTS, any photographs taken in these areas will be forwarded to Colonel Charles L. Meyer, USAF/DOE Liaison Office, (702) 295-1147, undeveloped for processing and review before release. The OCC, (702) 295-4015, will be notified as far in advance as possible of the date and times when personnel with cameras will be on site on the NTS.

6.4 Area control, clearance, airspace closure, and emergency support

No special area control, clearance, or emergency support are needed for these activities. A request for an Operations Permit from the NTS Test Operations Office for the aerial survey over Midway Valley, located in Area 25 of the NTS, will be submitted at least one month before planned acquisition of aerial photographs. This request will contain sufficient detail regarding the acquisition of aerial photographs for the DOE/Nevada Operations Office Safeguard and Security Office to process the request for the overflights.

7.0 Sequence of Events

During Activity 1, a detailed map of the surface geology in the study area will be prepared, based on interpretation of new and existing aerial photographs, field mapping, soil pits and exploratory (<30-50 m) trenches, and selected geophysical data. Activity 2 is an extensive trenching program in which long (>100 m) and supplementary (30-50 m) trenches will be excavated and mapped. The specific procedures for this study are governed by SNL Experiment Procedure, EP-0001. The tasks for these activities are initiated sequentially with some overlap. The following paragraphs describe these tasks in the general sequence in which they occur.

Airphoto acquisition will provide a visual record of the area at a scale close to the map scale. Stereoscopic viewing will enable the mapping specialist to observe field features in three dimensions in ways and from a

vantage that are not possible in the field. This viewing enables the geologist to map the distribution of geologic units.

Field mapping involves the correlation of airphoto units and the mappable units that can be identified in the field. Age or lithologic distinctions are commonly manifested in reflectance variations on the airphotos. Usually, but not always, these variations are discernible on the surface during field work.

The process of field mapping involves much judgment and interpretation. Commonly, much time at the outset is spent establishing mappable units. In mapping alluvial units, soil pits may be required to establish continuity of surface units with depth. A conceptual framework of mappable units is formulated that accounts for the distribution of map units in space and time. The actual mapping involves the definition of details and the explanation of nuances. Increased detail in mapping scale commonly produces increased understanding. The process of geologic mapping involves much time and skill on the part of the mapper(s). How closely the resulting map and interpretations reflect reality is largely dependent on the skill and experience of those individuals performing the work.

The selection of trench locations will be based on the relative age of map units and the dating of alluvium, where possible. Much of this involves extrapolation from known ages at other locations and relies on substantial skill on the part of the interpreter. In this respect, procedures for accomplishing these subjective skills cannot be defined precisely because there is no prescribed means for doing so. The requirement to specify trench locations in writing and to approve the locations (also in writing) creates a formal mechanism to create dialogue, if necessary, to document the decision point.

Excavation by support personnel is generally straightforward and will be overseen (but not supervised) by contract technical staff and the SNL onsite representative. Trench excavation will conform with OSHA safety guidelines (DOL, 1988). These safety guidelines are augmented by REECo guidelines as found in REECo's "Occupation Safety Code C-2, Trenches and Excavations." An example of a cross section for a trench that meets all of these guidelines is shown in Figure 5; dimensions on this figure are shown for purposes of illustration only. Specific dimensions for trenches will be determined as work in the field progresses.

Excavation will be accomplished in a manner such that the impact on the environment is minimized. There has been a minimum of environmental impact at Yucca Mountain thus far in the excavation of more than 25 trenches; nonetheless, the oversight function during excavation will be maintained. Any features or artifacts that are uncovered will be examined and preserved, if necessary. The overseer may stop the excavation at any time and for any reason.

Mapping of trenches will begin only after all excavation machinery has stopped and been removed from the trench. The decision regarding trench wall stability is a joint responsibility of the persons doing the mapping and the SNL representative. All must agree regarding stability; otherwise mapping will not begin. The contract personnel conducting geologic mapping and excavation will include persons qualified to determine the safety and stability of the trenches. If any subsequent slumping, sloughing, or caving occurs, mapping will cease and the trench will be re-evaluated with respect to stability and safety.

Trench mapping involves a similar subjective approach as with the surface geologic mapping. Considerable study and reflection is required before the actual placement of symbols on trench logs. The identification of map units may require collaboration by numerous individuals and consultants; agreement by all may not necessarily result. Horizons may be

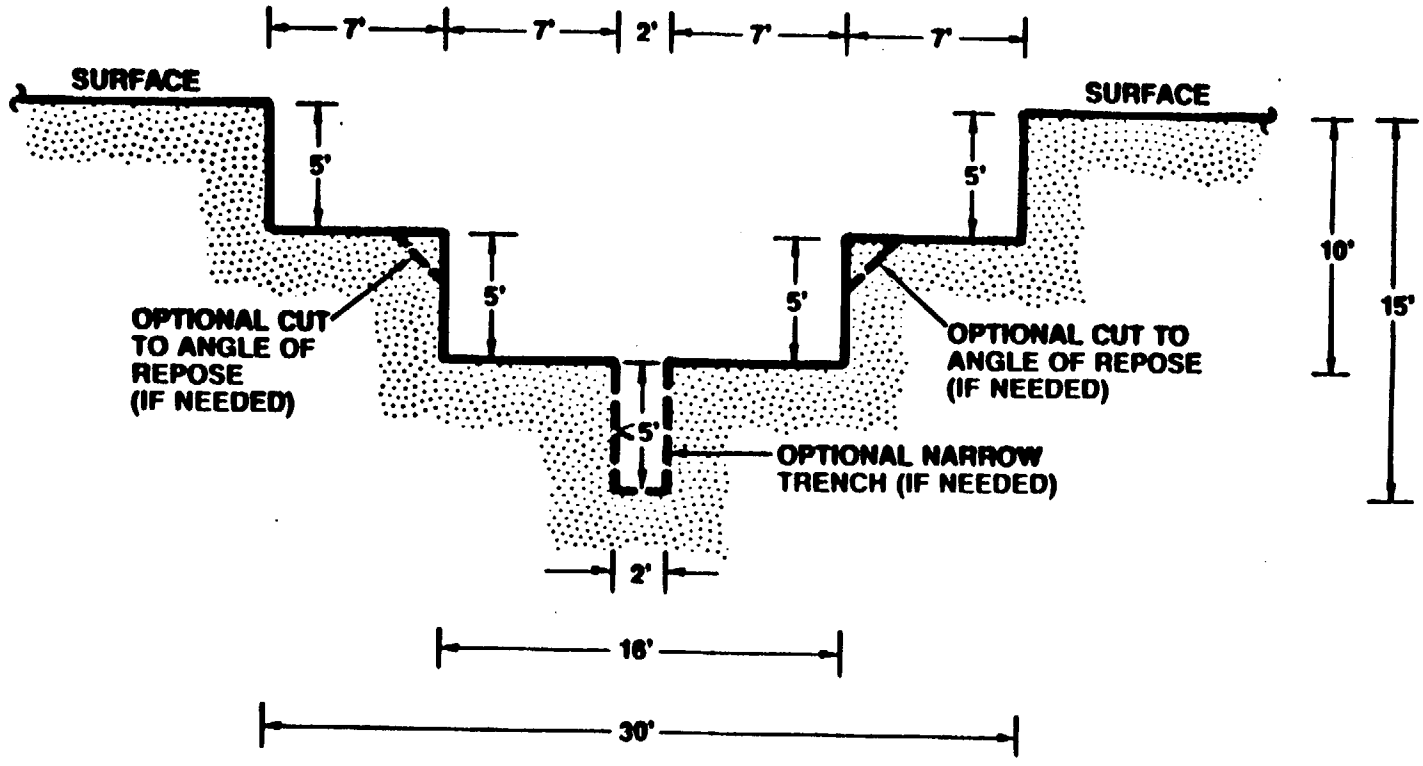

Figure 5. Cross section of a trench in Midway Valley. Dimensions are provided for purposes of illustration only.

sampled for age determination; this may require several weeks or even months before results are available. These dates may then resolve conflict or may require additional collaboration and re-examination. The explanation of trench features is generally evolutionary, and time is needed to reach understanding and consensus.

Sampling is almost never routine and requires individualized attention. Consequently, a sample collection report is required for every sample, and every sample requires specialized work instructions. Each sample requires accountability, i.e., chain-of-custody traceability. These requirements will be documented on appropriate forms.

During mapping, standby for safety, security, or quality assurance reasons may be required; these functions will take precedence over technical work in every instance.

8.0 Occupational Safety, Health, and Fire Protection

8.1 Person-in-charge

Primary responsibility for the conduct of investigations and the execution of the Experiment Procedure rests with the SNL Principal Investigator (PI) or alternate designated by the SNL Division 6315 supervisor. Secondary responsibilities for experiment execution rest with the contractor and support personnel. Supervisory control for REECo, H&N, EG&G, Pan Am, and other contract personnel does not rest with SNL. However, SNL is responsible for the actions of contractor personnel. The direct line of authority is from the SNL PI through the contractor supervisor to the contractor personnel. Changes to work statements are made formally through established procedures for the SNL Purchasing Department and/or the NTS Support Office. Nonconformances are handled by immediate remedial action, where appropriate, and by formal reporting.

Contractor field investigations will be conducted only when an SNL representative or designated alternate is present. No exceptions will be made to this procedure.

8.2 Applicable safety and health standards and regulations

All NTS safety requirements will be followed. Requirements specific to the activities to be conducted for this study include the use of hard hats and safety shoes in trenches or excavations. Safety glasses/goggles are worn when hammering rocks or when sand and dust is being generated from the cleaning of trench walls. As a minimum, safety in excavations and trenches will meet OSHA standards (DOL, 1988) and the REECo Occupational Safety Code C-2 (REECo). These standards are included in Appendices A and B, respectively.

Total field working time, including commuting time, of more than 12 hr per day will not be permitted.

Off-road vehicle travel is not allowed, unless special permission has been obtained from NTS Operations Office. Fire extinguishers will be contained in all field vehicles. First-aid kits will be kept in each field vehicle, and/or in the personal possession of the vehicle operator.

Open excavations and trenches will be roped off according to NTS safety practices.

8.3 Medical treatment for occupational injuries and illnesses

All medical injuries and illnesses will be reported to the SNL onsite representative, who will inform the proper NTS authorities. All personnel will be instructed on the NTS emergency procedures, including first aid and CPR training.

8.4 Personal protective equipment

See Section 8.2.

8.5 Work in remote areas

8.5.1 Buddy system

No work will be conducted alone.

8.5.2 Communications

All vehicles will be equipped with two-way radio communications.

8.5.3 Work hours and daily schedules

Total field working time, including commuting time, of more than 12 hr per day will not be permitted.

8.5.4 Fire fighting and fire fighting equipment

All field vehicles will be equipped with fire extinguishers.

8.5.5 Equipment, supplies

Field supplies normally include standard items used in geologic mapping such as rock hammers, measuring tapes and rulers, mapboards and notebooks, color charts, and marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges). Safety supplies such as hard hats and safety glasses are also required. A more detailed equipment list is presented in Table 3. See also Section 8.2.

8.6 Vehicle operational safety and accident reporting

All accidents with or without injury will be reported to the SNL onsite representative, who will inform the proper NTS authorities. See also Sections 8.2 and 8.3.

TABLE 3

EQUIPMENT LIST

Typical Geologic Field Equipment

hand lens, pick, rock hammer, field notebook, camera, film, camera supplies, shovel, sampling bags, brushes, whisk broom, labeling materials, measuring tapes and rulers, aerial photographs, stereoscope, scale-stable topographic base maps, mapboards, color charts, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), pocket altimeter, Abney level, Jacob's staff, pocket transit (Brunton compass or equivalent), portable mapping grid, safety supplies (first aid kits, hard hats, safety glasses, etc.).

Excavation Equipment

bulldozer, backhoe, field notebook, camera, film, camera supplies, safety supplies (first aid kits, hard hats, safety glasses, etc.).

Surveying Equipment

theodolite, survey rod, measuring tapes and rulers, field notebook, camera, film, camera supplies, calculator, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), safety supplies (first aid kits, hard hats, safety glasses, etc.).

Photogrammetric Equipment

metric camera, sliding camera mount, tripod rail, measuring tapes and rulers, field notebook, camera, film, camera supplies, marking devices (such as nails, flagging, paint, string, pencils, protractors, and straight edges), safety supplies (first aid kits, hard hats, safety glasses, etc.).

8.7 Emergency notifications

All personnel will be instructed on NTS emergency procedures, including first aid and use of radios and telephones. Emergency support may be requested through the SNL onsite representative, e.g. for vehicle repair.

8.8 Sanitation

Portable toilets will be supplied by NTS support services. No additional sanitation requirements will be needed.

8.9 Adverse weather conditions

See Section 6.1.

8.10 Restoration of disturbed areas

Much of the area where trenches are excavated for this study will be reworked during construction of surface facilities, and thus will not require restoration after geologic investigations have been concluded. Any trenches and soil pits outside the actual construction area will be restored, if they pose a safety or environmental threat, as determined by Ken Miles (Org. 3215), SNL Safety Consultant for the NTS.

9.0 Special Transportation, Storage, Handling, and Disposal

No special transportation, storage, handling, or disposal requirements are involved in these activities.

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10.0 Security

All participants will be badged and adhere to all NTS security requirements, including wearing the badge at all times.

11.0 Logistic and Construction Support

Individual participants will make housing and other personal arrangements through the SNL onsite representative. Assistance may be obtained through the SNL field office at Mercury, NV, (702) 295-6200 or FTS 575-7476. Contractor personnel will not be provided with support services. Emergency support may be requested through the SNL onsite representative, e.g. for vehicle repair.

12.0 Radiological Safety

No radioactive materials are involved in these activities. These activities are not near known RADEX areas.

13.0 Special Operations

No special operations are involved in these activities.

14.0 Funding

Funding for FY89 has been requested through DOE/YMP for support services in Letters of Criteria directed to H&N and REECo.

15.0 References

DOL (U.S. Department of Labor), "Safety and Health Regulations for Construction," Code of Federal Regulations, Title 29, Part 1926, Subpart P, U.S. Government Printing Office, July 1988.

Gibson, J. D. and F. A. Duran, "Geologic Surface and Trench Mapping Near Prospective Surface Facilities," Experiment Procedure EP-0001, Sandia National Laboratories, Albuquerque, NM, in review.

Gibson, J. D., L. E. Shephard, and C. Rautman, "Study Plan for Evaluating the Location and Recency of Faulting Near Prospective Surface Facilities," SAND89-0206, Sandia National Laboratories, Albuquerque, NM, in review.

Neal, J. T., "Location Recommendation for Surface Facilities for the Prospective Yucca Mountain Nuclear Waste Repository," SAND84-2015, Sandia National Laboratories, Albuquerque, NM, April 1985.

REECo (Reynolds Electrical and Engineering Co., Inc.), "Occupation Safety Code C-2, Trenches and Excavations."

SNL (Sandia National Laboratories), "Site Characterization Plan Conceptual Design Report," SAND84-2641, compiled by H. R. MacDougall, L. W. Scully, and J. T. Tillerson, Sandia National Laboratories, Albuquerque, NM, September 1987.

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APPENDIX A

OSHA REQUIREMENTS - 29 CFR 1926, SUBPART P

Subpart P—Excavations, Trenching, and Shoring

AUTHORITY: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable.

§ 1926.650 General protection requirements.

(a) Walkways, runways, and sidewalks shall be kept clear of excavated material or other obstructions and no sidewalks shall be undermined unless shored to carry a minimum live load of one hundred and twenty-five (125) pounds per square foot.

(b) If planks are used for raised walkways, runways, or sidewalks, they shall be laid parallel to the length of the walk and fastened together against displacement.

(c) Planks shall be uniform in thickness and all exposed ends shall be provided with beveled cleats to prevent tripping.

(d) Raised walkways, runways, and sidewalks shall be provided with plank steps on strong stringers. Ramps, used in lieu of steps, shall be provided with cleats to insure a safe walking surface.

(e) All employees shall be protected with personal protective equipment for the protection of the head, eyes, respiratory organs, hands, feet, and other parts of the body as set forth in Subpart E of this part.

(f) Employees exposed to vehicular traffic shall be provided with and shall be instructed to wear warning vests marked with or made of reflectorized or high visibility material.

(g) Employees subjected to hazardous dusts, gases, fumes, mists, or atmospheres deficient in oxygen, shall be protected with approved respiratory protection as set forth in Subpart D of this part.

(h) No person shall be permitted under loads handled by power shovels, derricks, or hoists. To avoid any spillage employees shall be required to stand away from any vehicle being loaded.

(i) Daily inspections of excavations shall be made by a competent person. If evidence of possible cave-ins or slides is apparent, all work in the excavation shall cease until the necessary precautions have been taken to safeguard the employees.

§ 1926.651 Specific excavation requirements.

(a) Prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, telephone, water, fuel, electric lines, etc., will be encountered, and if so, where such underground installations are located. When the excavation approaches the estimated location of such an installation, the exact location shall be determined and when it is uncovered, proper supports shall be provided for the existing installation. Utility companies shall be contacted and advised of proposed work prior to the start of actual excavation.

(b) Trees, boulders, and other surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before excavating is begun.

(c) The walls and faces of all excavations in which employees are exposed to danger from moving ground shall be guarded by a shoring system, sloping of the ground, or some other equivalent means.

(d) Excavations shall be inspected by a competent person after every rainstorm or other hazard-increasing occurrence, and the protection against slides and cave-ins shall be increased if necessary.

(e) The determination of the angle of repose and design of the supporting system shall be based on careful evaluation of pertinent factors such as: Depth of cut; possible variation in water content of the material while the excavation is open; anticipated changes in materials from exposure to air, sun, water, or freezing; loading imposed by structures, equipment, overlying material, or stored material; and vibration from equipment, blasting, traffic, or other sources.

(f) Supporting systems; i.e., piling, cribbing, shoring, etc., shall be designed by a qualified person and meet accepted engineering requirements. When tie rods are used to restrain the top of sheeting or other retaining systems, the rods shall be securely anchored well back of the angle of repose. When tight sheeting or sheet piling is used, full loading due to ground water table shall be assumed, unless prevented by weep holes or drains or other means. Additional stringers, ties, and bracing shall be provided to allow for any necessary temporary removal of individual supports.

(g) All slopes shall be excavated to at least the angle of repose except for areas where solid rock allows for line drilling or presplitting.

(h) The angle of repose shall be flattened when an excavation has water conditions, silty materials, loose boulders, and areas where erosion, deep frost action, and slide planes appear.

(i)(1) In excavations which employees may be required to enter, excavated or other material shall be effectively stored and retained at least 2 feet or more from the edge of the excavation.

(2) As an alternative to the clearance prescribed in paragraph (i)(1) of this section, the employer may use effective barriers or other effective retaining devices in lieu thereof in order to prevent excavated or other materials from falling into the excavation.

(j) Sides, slopes, and faces of all excavations shall meet accepted engineering requirements by scaling, benching, barricading, rock bolting, wire meshing, or other equally effective means. Special attention shall be

given to slopes which may be adversely affected by weather or moisture content.

(k) Support systems shall be planned and designed by a qualified person when excavation is in excess of 20 feet in depth, adjacent to structures or improvements, or subject to vibration or ground water.

(l) Materials used for sheeting, sheet piling, cribbing, bracing, shoring, and underpinning shall be in good serviceable condition, and timbers shall be sound, free from large or loose knots, and of proper dimensions.

(m) Special precations shall be taken in sloping or shoring the sides of excavations adjacent to a previously backfilled excavation or a fill, particularly when the separation is less than the depth of the excavation. Particular attention also shall be paid to joints and seams of material comprising a face and the slope of such seams and joints.

(n) Except in hard rock, excavations below the level of the base of footing of any foundation or retaining wall shall not be permitted, unless the wall is underpinned and all other precautions taken to insure the stability of the adjacent walls for the protection of employees involved in excavation work or in the vicinity thereof.

(o) If the stability of adjoining buildings or walls is endangered by excavations, shoring, bracing, or underpinning shall be provided as necessary to insure their safety. Such shoring, bracing, or underpinning shall be inspected daily or more often, as conditions warrant, by a competent person and the protection effectively maintained.

(p) Diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. Water shall not be allowed to accumulate in an excavation.

(q) If it is necessary to place or operate power shovels, derricks, trucks, materials, or other heavy objects on a level above and near an excavation, the side of the excavation shall be sheet-piled, shored, and braced as necessary to resist the extra pressure due to such superimposed loads.

(r) Blasting and the use of explosives shall be performed in accordance with Subpart U of this part.

(s) When mobile equipment is utilized or allowed adjacent to excavations, substantial stop logs or barricades shall be installed. If possible, the grade should be away from the excavation.

(t) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

(u) If possible, dust conditions shall be kept to a minimum by the use of water, salt, calcium chloride, oil, or other means.

(v) In locations where oxygen deficiency or gaseous conditions are possible, air in the excavation shall be tested. Controls, as set forth in Subparts D and E of this part, shall be established to assure acceptable atmospheric conditions. When flammable gases are present, adequate ventilation shall be provided or sources of ignition shall be eliminated. Attended emergency rescue equipment, such as breathing apparatus, a safety harness and line, basket stretcher, etc., shall be readily available where adverse atmospheric conditions may exist or develop in an excavation.

(w) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(x) Where ramps are used for employees or equipment, they shall be designed and constructed by qualified persons in accordance with accepted engineering requirements.

(y) All ladders used on excavation operations shall be in accordance with the requirements of Subpart L of this part.

§ 1926.652 Specific trenching requirements.

(a) Banks more than 5 feet high shall be shored, laid back to a stable slope, or some other equivalent means of protection shall be provided where employees may be exposed to moving

ground or cave-ins. Refer to Table P-1 as a guide in sloping of banks. Trenches less than 5 feet in depth shall also be effectively protected when examination of the ground indicates hazardous ground movement may be expected.

(b) Sides of trenches in unstable or soft material, 5 feet or more in depth, shall be shored, sheeted, braced, sloped, or otherwise supported by means of sufficient strength to protect the employees working within them. See Tables P-1, P-2 (following paragraph (g) of this section).

(c) Sides of trenches in hard or compact soil, including embankments, shall be shored or otherwise supported when the trench is more than 5 feet in depth and 8 feet or more in length. In lieu of shoring, the sides of the trench above the 5-foot level may be sloped to preclude collapse, but shall not be steeper than a 1-foot rise to each ¾-foot horizontal. When the outside diameter of a pipe is greater than 5 feet, a bench of 4-foot minimum shall be provided at the toe of the sloped portion.

(d) Materials used for sheeting and sheet piling, bracing, shoring, and underpinning, shall be in good serviceable condition, and timbers used shall be sound and free from large or loose knots, and shall be designed and installed so as to be effective to the bottom of the excavation.

(e) Additional precautions by way of shoring and bracing shall be taken to prevent slides or cave-ins when excavations or trenches are made in locations adjacent to backfilled excavations, or where excavations are subjected to vibrations from railroad or highway traffic, the operation of machinery, or any other source.

(f) Employees entering bell-bottom pier holes shall be protected by the installation of a removable-type casing of sufficient strength to resist shifting of the surrounding earth. Such temporary protection shall be provided for the full depth of that part of each pier hole which is above the bell. A lifeline, suitable for instant rescue and securely fastened to a shoulder harness, shall be worn by each employee entering the shafts. This lifeline shall be individually manned and separate from any line used to remove materials excavated from the bell footing.

(g)(1) Minimum requirements for trench timbering shall be in accordance with Table P-2.

(2) Braces and diagonal shores in a wood shoring system shall not be subjected to compressive stress in excess of values given by the following formula:

$$S = 1200 - 30L/D$$

Maximum ratio $L/D = 50$

Where:

L = Length, unsupported, in inches.
D = Least side of the timber in inches.
S = Allowable stress in pounds per square inch of cross-section.

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Table P-1

APPROXIMATE ANGLE OF REPOSE
FOR SLOPING OF SIDES OF EXCAVATIONS

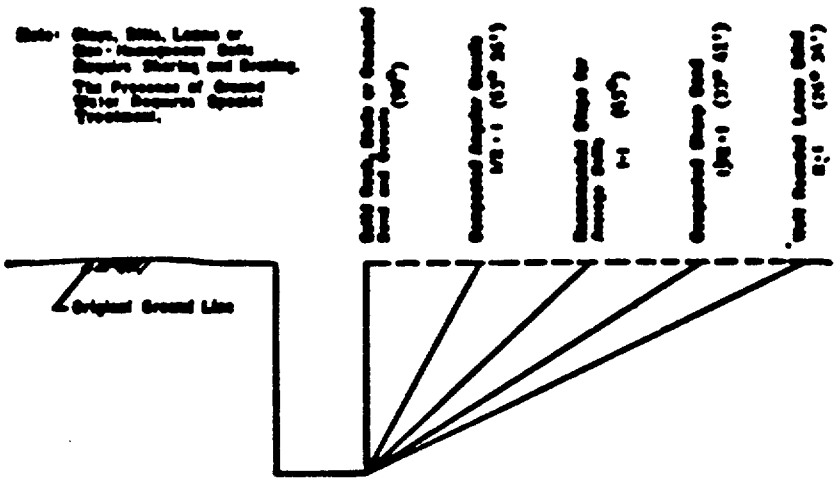

TABLE P-2—TRENCH SHORING—MINIMUM REQUIREMENTS

Depth of trench	Kind or condition of earth	Size and spacing of members										
		Uprights		Stringers		Cross braces[1]; Width of trench				Maximum spacing		
		Minimum dimension	Maximum spacing	Minimum dimension	Maximum spacing	Up to 3 feet	3 to 6 feet	6 to 9 feet	9 to 12 feet	12 to 15 feet	Vertical	Horizontal
Feet		Inches	Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Feet	Feet
5 to 10	Hard, compact	3×4 or 2×6	6			2×6	4×4	4×6	6×6	6×6	4	6
	Likely to crack	3×4 or 2×6	3	4×6	4	2×6	4×4	4×6	6×6	6×6	4	6
	Soft, sandy, or filled	3×4 or 2×6	Close sheeting	4×6	4	4×4	4×6	6×6	6×6	6×6	4	6
	Hydrostatic pressure	3×4 or 2×6	Close sheeting	6×6	4	4×4	4×6	6×6	6×6	6×6	4	6
10 to 15	Hard	3×4 or 2×6	4	4×6	4	4×4	4×6	6×6	6×6	6×6	4	6
	Likely to crack	3×4 or 2×6	2	4×6	4	4×4	4×6	6×6	6×6	6×6		6
	Soft, sandy, or filled	3×4 or 2×6	Close sheeting	4×6	4	4×6	6×6	6×6	6×6	6×10	4	6
	Hydrostatic pressure	3×6	Close sheeting	6×10	4	4×6	6×6	6×6	6×6	6×10	4	6
15 to 20	All kinds or conditions	3×6	Close sheeting	4×12	4	4×12	6×6	6×6	6×10	10×10	4	6
Over 20	All kinds or conditions	3×6	Close sheeting	6×6	4	4×12	6×6	6×10	10×10	10×12	4	6

[1] Trench jacks may be used in lieu of, or in combination with, cross braces.
Shoring is not required in solid rock, hard shale, or hard clay.
Where desirable, steel sheet piling and bracing of equal strength may be substituted for wood.

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(h) When employees are required to be in trenches 4 feet deep or more, an adequate means of exit, such as a ladder or steps, shall be provided and located so as to require no more than 25 feet of lateral travel.

(i) Bracing or shoring of trenches shall be carried along with the excavation.

(j) Cross braces or trench jacks shall be placed in true horizontal position, be spaced vertically, and be secured to prevent sliding, falling, or kickouts.

(k) Portable trench boxes or sliding trench shields may be used for the protection of personnel in lieu of a shoring system or sloping. Where such trench boxes or shields are used, t. ' shall be designed, constructed, and maintained in a manner which will provide protection equal to or greater than the sheeting or shoring required for the trench.

(l) Backfilling and removal of trench supports shall progress together from the bottom of the trench. Jacks or braces shall be released slowly and, in unstable soil, ropes shall be used to pull out the jacks or braces from above after employees have cleared the trench.

§ 1926.651 Definitions applicable to this subpart.

(a) "Accepted engineering requirements (or practices)"—Those requirements or practices which are compatible with standards required by a registered architect, a registered professional engineer, or other duly licensed or recognized authority.

(b) "Angle of repose"—The greatest angle above the horizontal plane at which a material will lie without sliding.

(c) "Bank"—A mass of soil rising above a digging level.

(d) "Belled excavation"—A part of a shaft or footing excavation, usually near the bottom and bell-shaped; i.e., an enlargement of the cross section above.

(e) "Braces (trench)"—The horizontal members of the shoring system whose ends bear against the uprights or stringers.

(f) "Excavation"—Any manmade cavity or depression in the earth's surface, including its sides, walls, or faces, formed by earth removal and producing unsupported earth conditions by reasons of the excavation. If installed forms or similar structures reduce the depth-to-width relationship, an excavation may become a trench.

(g) "Faces"—See paragraph (k) of this section.

(h) "Hard compact soil"—All earth materials not classified as running or unstable.

(i) "Kickouts"—Accidental release or failure of a shore or brace.

(j) "Sheet pile"—A pile, or sheeting, that may form one of a continuous interlocking line, or a row of timber, concrete, or steel piles, driven in close contact to provide a tight wall to resist the lateral pressure of water, adjacent earth, or other materials.

(k) "Sides", "Walls", or "Faces"—The vertical or inclined earth surfaces formed as a result of excavation work.

(l) "Slope"—The angle with the horizontal at which a particular earth material will stand indefinitely without movement.

(m) "Stringers" (wales)—The horizontal members of a shoring system whose sides bear against the uprights or earth.

(n) "Trench"—A narrow excavation made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench is not greater than 15 feet.

(o) "Trench jack"—Screw or hydraulic type jacks used as cross bracing in a trench shoring system.

(p) "Trench shield"—A shoring system composed of steel plates and bracing, welded or bolted together, which support the walls of a trench from the ground level to the trench bottom and which can be moved along as work progresses.

(q) "Unstable soil"—Earth material, other than running that because of its nature or the inf[illegible] of related conditions, cannot be depended upon to remain in place without extra support, such as would be furnished by a system of shoring.

(r) "Uprights"—The vertical members of a shoring system.

(s) "Wales"—See paragraph (m) of this section.

(t) "Walls"—See paragraph (k) of this section.

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APPENDIX B

REECO OCCUPATIONAL SAFETY CODE C-2 TRENCHES AND EXCAVATIONS

OCCUPATIONAL SAFETY CODE

CODE NUMBER	C-2
DATE	03-27-87
REPLACES CODE NO	C-2
DATE	08-31-84

Reynolds Electrical & Engineering Co., Inc.

SUBJECT: TRENCHES AND EXCAVATIONS

[redacted]

1. Before an excavation is started, the responsible supervisor shall coordinate with the following organizations if there are any questions concerning the location of underground service lines:
   a. [redacted] Engineering Department, Survey Section
   b. Power, Electronics & Communications Department
   c. Operations [redacted] Department or Project Manager
   d. Contract-Engineers (REE, RSE)
   e. Central Services System, Battery
2. The area to be excavated shall be surveyed by electronic detection ("potholed") by qualified personnel prior to excavation. When underground services are indicated, the area shall be hand excavated. If electric utilities are known or suspected:
   a. All efforts shall be made to schedule a power outage to deenergize the buried utilities.
   b. If an outage cannot be scheduled on high voltage facilities (over [redacted] volts), qualified electrical workers shall perform the excavation in the immediate area around the cable, utilizing insulated protective gloves.
   c. If an outage cannot be scheduled on low voltage facilities, insulated protective gloves shall be provided and utilized by workers engaged in hand excavation.
   d. Gloves for nonelectrical workers shall be obtained only from the Power Section of Power, Electronics & Communications Department at [redacted], or from the lineman assigned to [redacted] or Systems Construction.
   e. Training shall be provided by qualified personnel to nonelectrical personnel in the proper use of protective gloves prior to use.
3. Boulders or other surface items which could become a hazard during excavation activities shall be removed or made secure.
4. Excavations shall be inspected daily and after heavy events, storms, or other occurrences which could affect the stability of the excavation. Corrective action shall be taken if necessary.
5. Berms, ditches, or other means shall be provided to prevent flooding of excavation. If grading is performed, it should slope away from the excavation.
6. Open edges of excavations shall be marked by barricades, berms, or other barriers. Warning lights or flares shall be installed along barriers during hours of darkness.
7. Ladders, shoring with handrails, ramps, or other adequate exits shall be installed where personnel work in excavations more than four feet deep. Where ladders are used, they shall extend a minimum of three feet above the top of the excavation. No person shall be required to go more than 25 feet laterally to reach ladder exit of an exit ladder or ramp.
8. Bridges, or walkways with standard guardrails, shall be installed where equipment or personnel are permitted or required to cross over excavations.
9. Where personnel are required to enter an excavation, the sides of excavations greater than five feet in depth shall be supported, benched, or sloped to the angle of repose of the least stable material encountered, except where two grades starting in soil meet at a depth. The rock shall be sustained beyond the angle of repose slope. Attachment to this Safety Code details shoring and sloping requirements.
10. Shoring, etc., when required, shall be installed as excavation progresses and shall be removed from the bottom as backfilling is done. Removal shall be performed at surface level unless special measures are taken to protect personnel entering excavation to remove shoring, etc.
11. Materials used for shoring, underpinning, sheeting, etc., shall be in good condition; timber used shall be free of large or loose knots and shall be of proper dimensions. Cross-bracing shall be installed and secured in a horizontal position and be perpendicular to uprights or sheeting.
12. When the passage of traffic, heavy equipment, or other disturbances will occur at ground level near an excavation four feet or more in depth, the vertical side of the trench or excavation shall be shored and braced as necessary to resist such cross loads.
13. No excavation shall be made below the base of the footing of any foundation or retaining wall unless the wall or foundation is underpinned and other necessary precautions are taken against weakening or collapse of the structure.
14. No underpinning shall be performed on excavation walls unless provision is made for protection of personnel and equipment involved in the underpinning or for temporary retaining.
15. Spoilage or other material shall be stored or removed at least two feet from the edge of any vertical excavation.
16. Portable trench boxes or sliding trench shields may be used for protection of personnel in the excavation. These items shall be designed, built, and installed to meet acceptable engineering standards.

Manager, Occupational Safety & Fire Protection

Safety Manager

Attachment
Dist

R518LL/1

AN [redacted] COMPANY

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• Attachment to Safety Code C-6

TRENCH SHORING/SLOPING REQUIREMENTS

TRENCHES NOT MORE THAN 42 INCHES WIDE

Depth of trench in feet (feet)	*Uprights Size (inches)	*Uprights Horizontal spacing (feet)	*Stringers Size (inches)	*Stringers Vertical spacing (feet)	*Cross Bracing Size (inches)	*Cross Bracing Horizontal spacing (feet)	Notes
Stiff, uniform clayey soils, not fissured							
4 to 10	2 x 6	6b-c		None	3-2 x 6 up to 7 feet 3-2 x 6 up to 10 feet	6b-c	
10 to 15	2 x 6	4b-c		None	3-2 x 6 to 13 feet 4-2 x 6 to 15 feet	4b-c	
Over 15	2 x 6	Close tight	4 x 12	4b-c	4 x 12	6b-c	
Fissured clays; poorly cemented sands and gravels							
4 to 10	2 x 6	3b-c	2 x 6	Top and bottom	3-2 x 6 to 7 feet 3-2 x 6 to 10 feet	6b-c	
10 to 15	2 x 6	3b-c	2 x 6	3 in height	3-2 x 6 — 13 feet 4-2 x 6 — 15 feet	6b-c	
Over 15	2 x 6	Close tight	4 x 12	4b-c	4 x 12	6b-c	
Loose sandy or silty soils							
4 to 10	2 x 6	Close tight	4 x 6	2 up to 7 3 up to 10	4 x 6	6b-c	
10 to 15	2 x 6	Close tight	4 x 6	3 up to 13 4 up to 15	4 x 6	6b-c	
Over 15	2 x 6	Close tight	4 x 12	4b-c	4 x 12	6b-c	

TRENCHES MORE THAN 42 INCHES WIDE

Stiff, uniform clayey soils, not fissured							
4 to 10	2 x 6	6b-c	4 x 6	4b-c	4 x 6	6b-c	
10 to 20	2 x 6	Close	6 x 6	4b-c	6 x 6	6b-c	All soils
Over 20	2 x 6	Close	6 x 6	4b-c	6 x 6	6b-c	All soils
Fissured clays; poorly cemented sands and gravels							
4 to 10	2 x 6	3b-c	4 x 6	4b-c	4 x 6	6b-c	
Loose sandy or silty soils							
4 to 10	2 x 6	Close	4 x 6	2 up to 7 3 up to 10	4 x 6	6b-c	

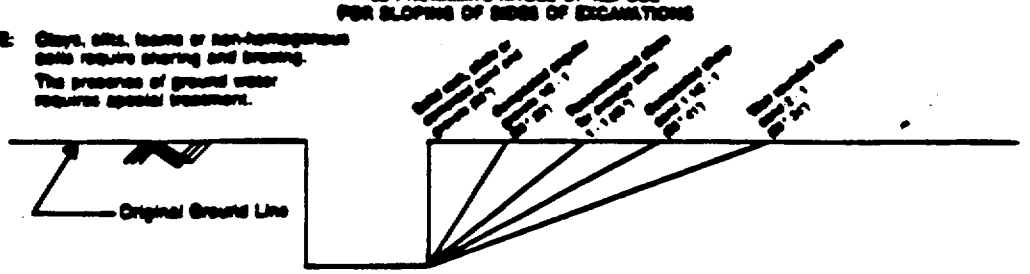
TRENCHES OF ANY WIDTH

Soils having hydrostatic pressure							
Not over 6	3 x 6	T & G Close	6 x 8	4b-c	6 x 8	6b-c	(**)
Over 6	3 x 6	T & G Close	8 x 10	4b-c	6 x 8	6b-c	(**)

* Based on use of nominal sizes of Douglas fir or equivalent.
** Sheet steel piling may be used in place of tongue and groove piling. The greater dimension of the stringers should be at right angle to the sheeting.

APPROXIMATE ANGLE OF REPOSE FOR SLOPING OF SIDES OF EXCAVATIONS

NOTE: Clays, silts, loams or non-homogeneous soils require shoring and bracing.
The presence of ground water requires special treatment.



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APPENDIX C

AUTHORIZED USERS

Name	Org.	Signature	Date