Duncan G

NNWSI PROJECT

USGS SCIENTIFIC INVESTIGATION PLAN

SEISMIC REFLECTION AND REFRACTION SURVEYS

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1.0 INTRODUCTION

1.1 Purpose and Scope

The seismic reflection and refraction surveys will provide detailed information on the subsurface geologic framework at and near the NTS.

Lateral discontinuities in the seismic reflection and refraction profiles will be evaluated to (1) define the crustal structure within and adjacent to the Walker Lane in the vicinity of NTS, and if one or more throughgoing wrench faults are found, to establish their location with respect to the NTS, and their geographic and genetic relationships to detachment faults and listric-normal faults; (2) characterize the crustal velocity structure and define lateral inhomogeneities in that structure in the NTS region; and (3) trace the 5- and 10-seconds events found on Death Valley COCORP profiles through the NTS region, and if possible, to trace reflections from the upper and lower carbonate aquifers, the Precambrian-Cambrian Pahrump Group and Noonday dolomite, and the Proterozoic basement through the area of the projected continuation in the subsurface of the Las Vegas Valley shear zone.

Potential reflectors include the mid-crustal, ductile-brittle transition zone, found at about 5 seconds depth (two-way sonic travel time) in Death Valley (DeVoogd and others, 1986), the mylonitic detachment-bounded upper surface of the Precambrian, exposed in the northern Amargosa Desert, the upper and lower carbonate aquifers with the Paleozoic (Winograd and Thordarson, 1975), and the Miocene-Paleozoic contact in the Yucca Mountain region. Deep reflection seismology, supplemented by gravity and magnetic surveys, should define the lateral extent, continuity, and depth of these features, thus constraining the location and character of the Walker Lane geologic boundary. Using Vibroseis (trademark of Conoco, Inc.) methods, the deep seismic reflection survey will follow primary and secondary roads and extend from Stovepipe Wells, California to Indian Springs, Nevada. Shorter cross-profiles will be included, either to provide three-dimensional control, or to examine specific structural features.

Significant velocity contrasts may be associated with lateral discontinuities caused by faulting and tectonism. Crustal velocity structure will be established using seismic refraction methods. The seismic refraction survey will include an east-west profile, coincident with the seismic reflection survey spanning a transect from Stovepipe Wells, California on the west to the Sheep Range of Nevada on the east, and three cross-profiles designed to provide information on the north-south dimension.

Shallow seismic surveys, both reflection (Mini-Sosie or equivalent) and refraction (Bison-type or equivalent) will be conducted to establish continuity in the subsurface of fault segments observed at the surface of Yucca Mountain and vicinity, and to determine the depth of alluvium in canyons and/or portions of canyons not covered by boreholes.

1.2 Application of Results

The location and definition of all Quaternary faults and fault systems, at or proximal to the proposed repository at Yucca Mountain, is a primary objective of the shallow seismic reflection and refraction surveys. The objectives of the deep seismic refraction and reflection investigations are to characterize the subsurface geologic framework of the entire crust and upper mantle in the vicinity of Yucca Mountain. Seismic profiles along with data acquired from gravity and magnetic surveys (Gravity and Magnetics, WBS 1.2.3.2.2.1), magneto-telluric surveys (Electro and Electromagnetic Methods, WBS 1.2.3.2.2.6), and remote sensing surveys (Remote Sensing, WBS 1.2.3.2.2.5) will establish a subsurface geologic framework required for studies conducted under tectonics and volcanism (Tectonics and Volcanism, WBS 1.2.3.2.3.1). Shallow seismic surveys described in Sections 3.4 and 3.5 will be conducted to determine the depth of alluvium in canyons (Infiltration and Shallow UZ Hydrology, WBS 1.2.3.3.4.2).

Characterization of the stratigraphic sequence within the site area (Site Geology, WBS 1.2.3.2.1.1) will also draw information from seismic investigations. Seismic refraction surveys have been used in the Yucca Wash area to determine significant velocity contrasts that may be associated with differing lithologies in the Paleozoic section, or with abrupt lateral changes in lithologies caused by strike-slip faults in the vicinity of the steep gradient in the potentiometric surface north of USW G-1. Seismic reflection surveys will be useful in studying structures that may be used to trace individual faults by studying the lateral continuity of any well-defined reflecting horizons.

The application of these results will be used in satisfying, in part, a specific information need of the SCP issues hierarchy, namely Information Need 1.19.2 concerned with whether data collected in order to describe future tectonic processses or events provide the information required by the design and performance issues. As illustrated in Table 1-1 this information need supports the resolution of Issue 1.19 concerned with the regional tectonics necessary for the design assessment analysis. This information need also supports the resolution of Issue 1.13 concerned with characterizing the unsaturated zone hydrologic system.

The results of the seismic investigations will be used in analyses of repository design. Table 1-2 lists the SCP design and characterization information needs that will directly use the information developed by this investigation. The investigations will provide geophysical information to evaluate the tectonic setting and structure and potential for fault movements in the vicinity of Yucca Mountain necessary for the design of the repository. The investigations will also provide information on the configuration of alluvial cover for the purposes of hydrology infiltration studies.

Table 1-1. Study Location within the SCP Issues Hierarchy, July 10, 1986.

Issue 1.19. Do the data collected in order to describe future tectonic processes or events provide the information required by the design and performance issues?

Information Need 1.19.2 - Nature and Rates of Tectonic Processes, Including Faulting, Folding, Uplift and Subsidence, and Seismic Activity

Study 1.19.2.1 - Investigation of Wrench Faulting Along Geologic Province Boundary (Walker Lane)

Activity 1.19.2.1.1 - Evaluation of the Nature of Geologic Boundary and Location with Respect to NTS

Deep Seismic Refraction Survey (Death Valley-Beatty Junction-Sheep Range)

Deep Seismic Reflection Survey (Stovepipe Wells-Beatty-Crater Flat-Yucca Mountain-Mercury-Indian Springs)

Deep Seismic Reflection Test (Amargosa Desert)

Study 1.19.2.2 - Investigation of Left-Lateral Strike-Slip Faulting on Northeast-Trending Systems

Activity 1.19.2.2.1 - Evaluation of the Rock Valley Fault System

Shallow Seismic Refraction Survey (Bison-type or equivalent)

Shallow Seismic Reflection Survey (Mini-Sosie or equivalent)

Study 1.19.2.4 - Investigation of Normal and Strike-Slip Faulting on North- to Northwest-Trending Systems

Activity 1.19.2.4.3 - Evaluation of Subsurface Geometry and Concealed Extensions of North-Trending Systems

Shallow Seismic Reflection Survey (Mini-Sosie or equivalent)

Information Need 1.13.2 - Description of the Unsaturated Zone Hydrologic System at the Site

Table 1-1 continued. Study Location within the SCP Issues Hierarchy, July 10, 1986.

Study 1.13.2.1 - Characterization of Unsaturated Zone Infiltration

Activity 1.13.2.1.2 - Natural Infiltration Monitoring

Shallow Seismic Reflection Survey (Mini-Sosie or equivalent)

Table 1-2. SCP Information Needs which use the Study Results in Design and Performance Assessment Analyses, July 10, 1986.

Design Information Needs	
1.11.1	Site characterization information needed for design.
4.4.1	Site and performance assessment information needed for design.
4.4.6	Potential impacts of tectonic activity on design.
Characterization Information Needs	
1.13.2	Description of the unsaturated zone hydrologic system at the site.
1.15.1	Stratigraphy and structure necessary to locate the underground facility.
1.19.2	Nature and rates of tectonic processes, including faulting, folding, uplift and subsidence, and seismic activity.
4.7.1	Stratigraphy and structure necessary to locate the underground facility.
4.9.2	Potential fault movements at the site.

2.0 RATIONALE FOR THE STUDY

2.1 General Approach

The overall supporting geophysical investigations can be divided into six principal studies: (1) gravity and magnetics; (2) seismic investigations (the subject of this study); (3) rock properties; (4) heat flow; (5) remote sensing; and (6) electric and electromagnetic methods. These studies will supplement information needs for both the hydrologic and geologic characterizations.

This study plan describes seismic reflection and refraction activities conducted under Geology, WBS 1.2.3.2, according to the structure presented in Figure 2.1. Descriptions of the geophysical investigations can be found in the following: (1) SIP-3221G-01, Gravity and Magnetic Surveys ; (2) SIP-3222G-01, Seismic Reflection and Refraction Surveys (the subject of this study); (3) SIP-3223G-01, Geophysical Rock Properties Testing; (3) SIP-3224G-01, Characterization of Site Ambient Thermal Conditions; (4) SIP-3225G-01, Remote Sensing; and (5) SIP-3226G-01, Electric and Electromagnetic Methods.

Activities planned for this survey and included in this scientific investigation plan will be the acquisition, processing, and interpretation of seismic reflection and refraction data. Deep seismic reflection and refraction surveys will be conducted on an east-west transect from Stovepipe Wells, California to the Sheep Range of Nevada. Additional north-south profiles will be run to provide information on the north-south dimension. A short test program of the deep seismic reflection method will be performed to evaluate the ability of the method to trace subsurface reflectors in the vicinity of Yucca Mountain. If this test is successful, then a deep seismic reflection survey will be conducted at a later time as described in Section 3.3. Shallow seismic reflection (Mini-Sosie or equivalent) and refraction (Bison-type or equivalent) surveys will be conducted on specific faults and/or fault zones and to determine the depth of alluvium. The structure for this study is presented in Figure 2.2.

Maps are included within this Scientific Investigation Plan as illustrations for planning purposes; specific sampling sites shown on these maps and discussed in the text may be modified in the future without formal revision of this document.

2.2 Quality Assurance Levels

One requirement for participation in the NNWSI Project is that a Quality Assurance Program Plan (QAPP) will be prepared to describe how the participant will satisfy the quality assurance requirements of the project and to recognize the importance of both radiological and non-radiological health and safety related activities. The QAPP brings together an assimilation of Quality Assurance Management Procedures (QMP) that are in compliance with the NNWSI

Figure 2-1. Geology Work Breakdown Structure Indicating Placement of the Seismic Reflection and Refraction Surveys to the NNWSI Work Breakdown Structure.

SEISMIC REFLECTION & REFRACTION SURVEYS

USGS–NNWSI PROJECT

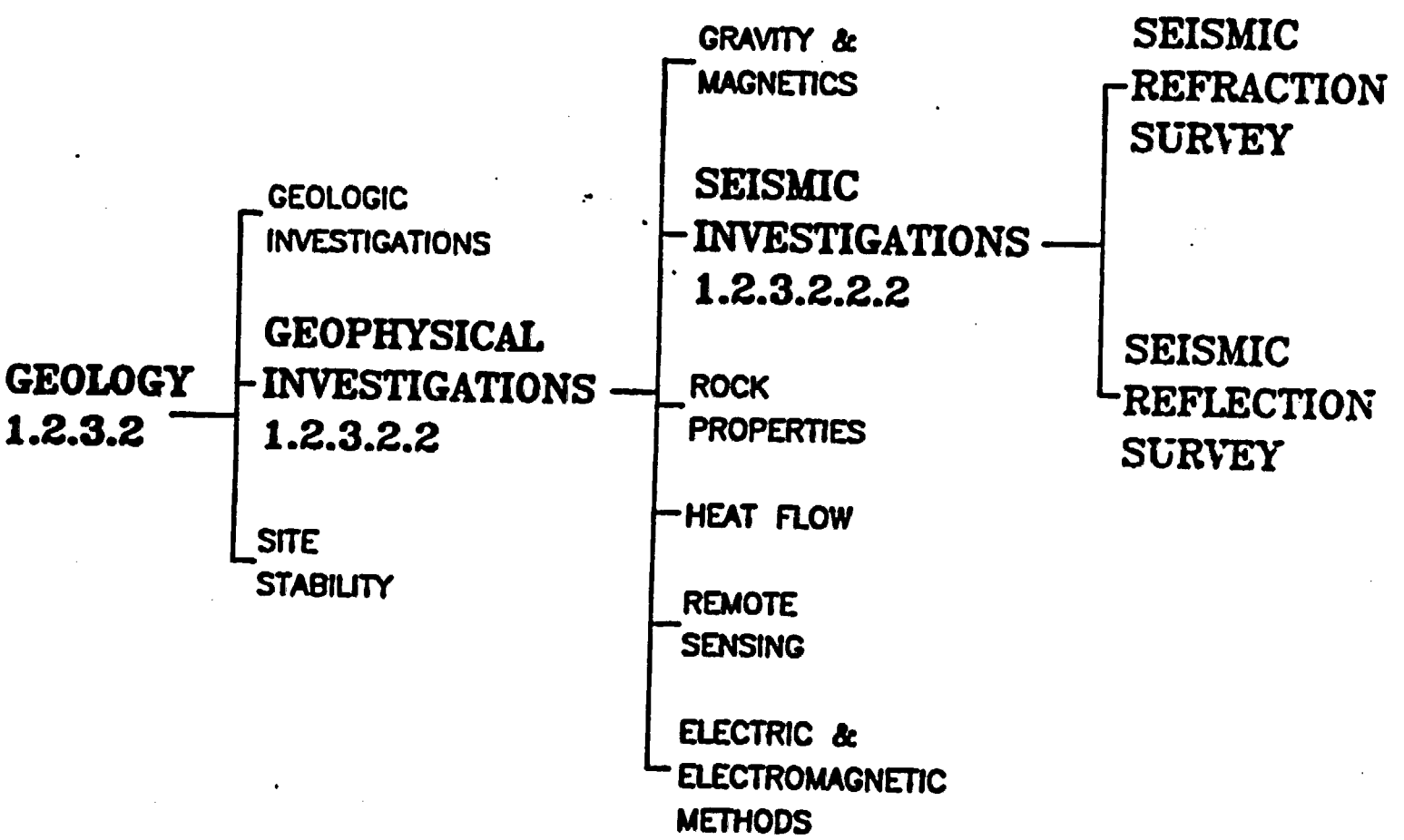
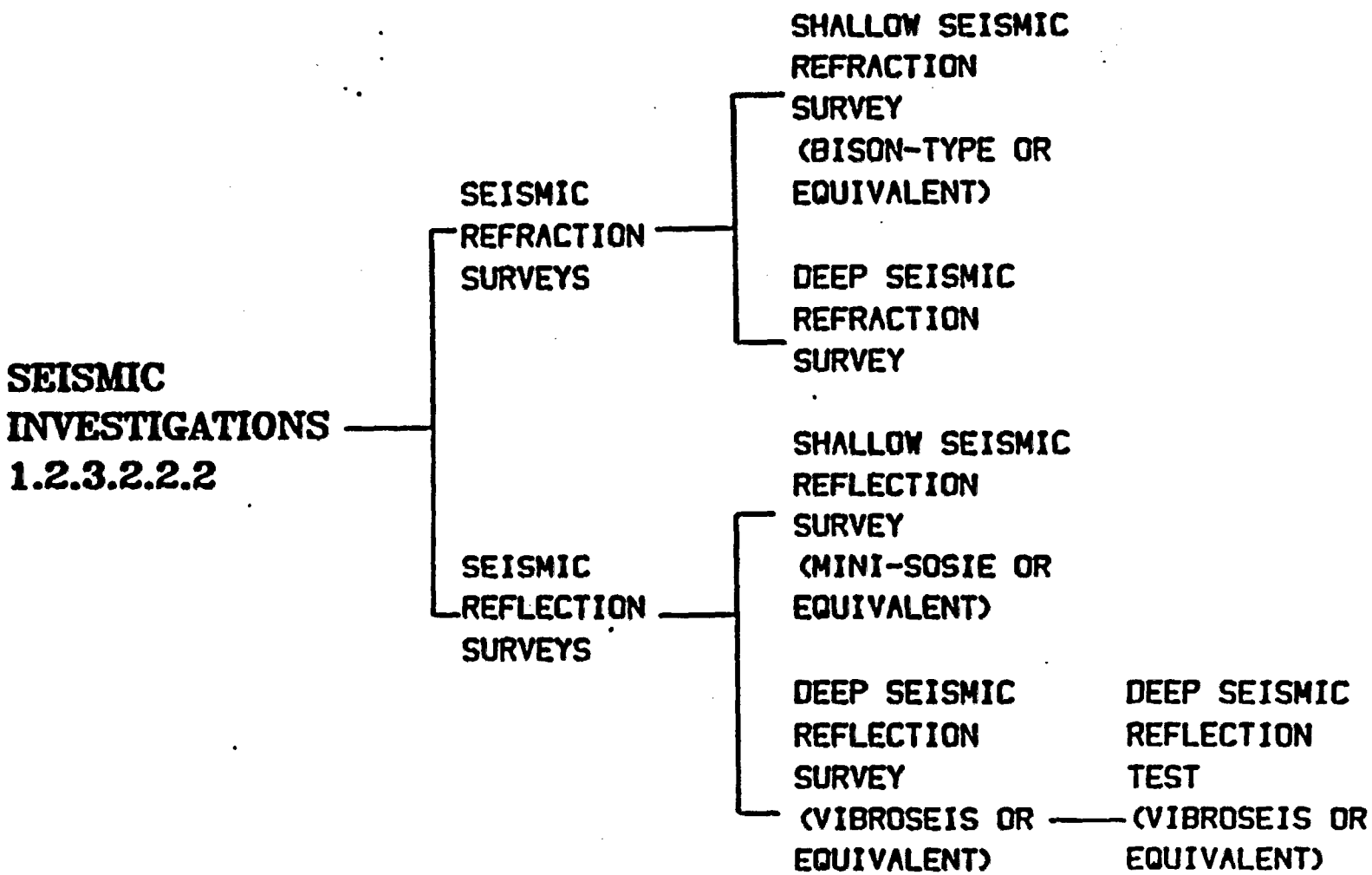


Figure 2-2 Work Breakdown Structure for Seismic Reflection and Refraction Surveys.

SEISMIC REFLECTION & REFRACTION SURVEYS

USGS–NNWSI PROJECT



Project QA Plan, NVO-196-17. The Plan includes preliminary organizational and explanatory elements followed by the procedures for its implementation.

The USGS QA Program identifies the systems, structures, components, and activities to be covered by the USGS QA Program Plan. It also identifies the major organizations participating in the project and the designated functions of these organizations. The USGS QA Program Plan provides control over activities that affect the quality of the identified structures, systems, and components to an extent consistent with their importance to safety. The activities that affect quality are accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment; suitable environmental conditions for accomplishing the activity; and assurance that all prerequisites for the given activity have been satisfied. The USGS QA Program also takes into account the need for special controls, processes, test equipment, instruments and skills to attain the required quality, and the need for verification of quality by inspection, test, and/or peer review. The USGS QA Program provides for indoctrination and as necessary, training of personnel performing activities that affect quality to assure that suitable proficiency is achieved and maintained. The Waste Management Project Office (WMPO) will regularly assess the status and adequacy of the QAPPs of the U.S. Geological Survey and Support Contractors by means of surveillance and audit activities. The USGS and Support Contractors' management shall assess the adequacy and implementation of their QA Program Plans on an annual basis.

The provisions of a QAPP and its implementing documents apply to all nuclear waste management activities performed by USGS participants and by contractors to the USGS who do not have a qualifying QAPP. It is the responsibility of the Assistant Director for Engineering Geology of the USGS, or his delegate, to assure compliance of the USGS with the requirements of this QAPP. The Chief, Branch of NNWSI, shall be responsible for enforcing and assuring the preparation and implementation of thhe Quality Assurance Program. The Manager of the Quality Assurance Office is responsible for preparation of the QAPP and its associated Quality Management Procedures and for tracking and verifying their implementation. The participating investigators are assigned responsibility for preparation of their technical procedures and for becoming familiar with and implementing appropriate parts of the QAPP under the guidance of the Quality Assurance Office. All support contractors and suppliers shall be responsible for compliance with pertinent sections of this QAPP.

In conformance with the NNWSI QA Plan (NVO-196-17) as specified in NNWSI-USGS-QMP-3.02, the USGS shall use a graded approach to quality assurance based on the differences between items and activities that affect radiological health and safety and those that do not. This approach assigns QA requirements at a level consistent with the activity's or item's potential impact and/or importance in terms of radiological health and safety, non-radiological health and safety, the Nuclear Regulatory Commission (NRC) licensing process, costs, and schedules. The requirements shall be:

For Level I & II - Compliance with all 18 Criteria of 10CFR50, Appendix B, as described in NQA-1 and incorporated in the USGS QA Manual, is required unless omission of a specific criteria is noted and thoroughly justified according to Para. 6.3.6 of QMP-3.02; and

For Level III - Existing USGS good scientific practice requirements shall apply.

2.3 Other Applicable Information

The selected bibliography at the end of this plan provides a tabulation of technical reports and publications that are used as a basis of existing information pertinent to the objectives of this study. Reports and publications of work sponsored by the NNWSI Project are listed, including those produced by the USGS and and other project participants. Data, samples, interpretations, and conclusions pertinent to the crustal structure in the Yucca Mountain Site area are described in these documents.

Data compiled or produced throughout this study, which will be used for site characterization will be input to or obtained from the NNWSI Project data base in accordance with WMPO procedures.

Data or data interpretation developed prior to August, 1980, the implementation date of the NNWSI Quality Assurance Plan, will be handled according to procedures outlined in the USGS Quality Assurance Plan, NNWSI-USGS QMP-17.02 (Acceptance of Data Not Developed Under the NNWSI QA Plan). QMP-17.02 is not intended to cover data or data interpretations that were generated by the NNWSI participants after August 1980. Data or data interpretations developed after August 1980 will be handled according to procedures outlined in NNWSI-USGS QMP-3.04 (Technical Review of NNWSI-USGS Publications). Data or data interpretations generated after August 1980 where the NNWSI QA Plan was not implemented shall be processed in accordance with NNWSI-USGS QMP-15.01 (Control of Nonconforming Items).

2.4 Program Interfaces

This study summarizes the activities to be continued under Seismic Investigations, WBS 1.2.3.2.2.2. Permits, required to conduct field activities, will be coordinated through Environmental Compliance, WBS 1.2.5.3. Thicknesses of alluvium, determined from shallow seismic reflection surveys, supplement the lithostratigraphic data bases; Site Geology, WBS 1.2.3.2.1.1 important to site infiltration studies; these surveys aid the identification of subsurface structures supporting Site Geology, WBS 1.2.3.2.1.1 and Tectonics and Volcanism, WBS 1.2.3.2.3.1. Gravity and Magnetics, WBS 1.2.3.2.2.1 provides data to assist the interpretation of the shallow portion of the reflection records. Velocity contrasts, determined from seismic refraction surveys, aid the identification of differing lithologies; Site Geology, WBS 1.2.3.2.1.1; or abrupt changes in lithology caused by faulting; Tectonics and Volcanism, WBS 1.2.3.2.3.1. Combined with magneto-telluric surveys; Electro

and Electromagnetic Methods; refraction surveys provide gross characterizations of crustal structures. Data base management for site characterization activities is coordinated through the NNWSI-Project data bases developed under Technical Data Base Management, WBS 1.2.1.3.

3.0 DESCRIPTION OF ACTIVITIES

3.1 Deep Seismic Refraction Survey (Death Valley-Beatty Junction-Sheep Range)

3.1.1 Introduction

The objectives of the deep seismic refraction investigations are to characterize the subsurface geologic framework of the crust and uppermost mantle in the vicinity of Yucca Mountain. In particular, deep seismic refraction surveys, running east and west just south of Yucca Mountain, are used to investigate the preTertiary subvolcanic basement rock, by mapping the lateral continuity of refracting horizons.

Four seismic refraction profiles are planned (Figure 3.1). A 195-kilometer (121-mile) long east-west profile running just south of the NTS will consist of two 80-kilometer (50-mile) deployments, each utilizing 120 instruments spaced at 0.7 to 1.0 kilometers (0.4 to 0.6 miles) and recording seven 900 to 1800 kilogram (2000 to 4000 pound) shots spaced at 8 to 20 kilometers (5.0 to 12.4 miles). Three cross-profiles, including an 80-kilometer (50-mile) profile extending southward from the northern end of Crater Flat, a 110-kilometer (68-mile) profile extending southwestward from the northern end of Crater Flat, and a 70-kilometer (43-mile) northwest-southeast profile centered on Stovepipe Wells, will consist of one to two deployments of 120 instruments recording two to three 900 to 1800 kilogram (2000 to 4000 pound) shots per deployment. Specific ranges in acquisition parameters are estimates only, actual parameters used in the field may vary.

3.1.2 Supporting Activities

Interpretation of the deep seismic refraction data will be performed in conjunction with, as appropriate, results obtained from the deep seismic reflection profiling, magneto-telluric (MT) sounding traverses, gravity and magnetic surveys, field mapping, and from sonic velocity measurements in wells drilled in the vicinity of Yucca Mountain.

Deep seismic reflection studies will be performed as described in Section 3.3 to attempt to map near-surface faults to depth by studying the lateral continuity of any well-defined reflecting horizons.

The crustal conductivity structure within the transect will be established using magneto-telluric (MT) sounding methods. The MT survey will include a

Figure 3-1. Location of Proposed Deep Seismic Refraction Lines in the Vicinity of Yucca Mountain.

detailed net with station spacings of 3 to 5 kilometers (1.9 to 3.1 miles), and a reconnaissance net with stations spaced at 8 to 10 kilometers (5.0 to 6.2 miles). The rock conductivities obtained from these studies will be correlated to the inferred seismic velocities to constrain interpretations of the crustal structure and its physical properties.

Gravity and magnetic studies to be performed in the vicinity of Yucca Mountain may be used to establish continuity in the subsurface of fault segments observed at the surface of Yucca Mountain and vicinity.

Field mapping at a scale of 1:100,000 may provide the ability to correlate rock velocities with lithologies.

Sonic and bulk density measurements in wells at or in the vicinity of Yucca Mountain may also provide greater ability to correlate rock velocities with rock lithologies. These correlations may provide important constraints on the interpretation of the upper crustal structure.

3.1.3 Equipment

Equipment required to conduct this activity is identified in the technical procedures. No additional major equipment is required for this activity. Maintenance and repair of existing equipment, however may be necessary.

3.1.4 Methods, Procedures, and Quality Assurance

Specific investigative methods used in the deep seismic refraction surveys are listed in Table 3-1. Identified in the table are supporting technical procedures used to assure the quality and traceability of the activity, data collection, and interpretation; the applicable QALA numbers; and software requirements.

Approved procedures are identified with a USGS number, title, and effective date. Procedures that require preparation before implementing elements of this plan are identified as being needed. Work shall not proceed on these activities until the applicable technical procedure have been prepared, reviewed, and approved in accordance with NNWSI-USGS-QMP-5.01. Appendix A of this plan contains completed Quality Assurance Level Assignments (QALA) for each method identified including criteria exception justifications for each method identified.

Table 3-1. Methods and Technical Procedures for Deep Seismic Refraction Survey (Death Valley-Beatty Junction-Sheep Range).
* refers to other USGS Scientific Investigation Plans

Method	Technical Procedure: Number (NWM-USGS-)	Technical Procedure: Title	Technical Procedure: Date	QA Level Assignment Sheet (QALAS) Number (NNWSI-QALA-)	Softwa Refere
Deep Seismic Refraction Profiling	SP-08	Seismic Study of the Tectonic Environment	06/06/83	3222G-01-01, RO	USGS OFR 82-1
Deep Seismic Refraction Profiling	SP-09	Calibration of Seismic Refraction Equipment	02/20/86	3222G-01-01, RO	

3.2 Deep Seismic Reflection Test (Armagosa Desert)

3.2.1 Introduction

The objectives of the deep seismic reflection test in Amargosa Desert are to determine whether the subsurface geologic framework of the crust and uppermost mantle in the vicinity of Yucca Mountain can be mapped using the seismic reflection technique.

If reflecting horizons can be successfully mapped, deep seismic reflection surveys, east and west of Yucca Mountain, will be used to investigate the preTertiary subvolcanic basement rock as described in Section 3.3.

Field tests of acquisition parameters will be conducted at two different locations within the northern Amargosa Desert (Figure 3-2). At the conclusion of these tests a reconnaissance line totaling 24 kilometers (15 miles) in length will be acquired at the location of the second test in the northern Amargosa Desert. The tests and survey will utilize 10-kilometer (6.2-mile) spreads, 24 geophones per group, 25-meter (82-foot) group interval, 480 groups per spread, Vibroseis energy source, 100-meter (328-foot) vibrator interval, 72,000 kilogram (160,000 pounds) minimum peak vibrator force, and 480 channel floating-point digital recording. Specific ranges in acquisition parameters are estimates only, actual parameters used in the field may vary.

3.2.2 Supporting Activities

This activity stands alone, requiring no additional supporting activities.

3.2.3 Equipment

Equipment required to conduct this activity is identified in the technical procedures. No additional major equipment is required for this activity. Maintenance and repair of existing equipment, however, may be necessary.

3.2.4 Methods, Procedures, and Quality Assurance

Specific investigative methods used in the deep seismic reflection test are listed in Table 3-2. Identified in the table are supporting technical procedures used to assure the quality and traceability of the activity, data collection, and interpretation; the applicable QALA numbers; and software requirements.

Approved procedures are identified with a USGS number, title, and effective date. Procedures that require preparation before implementing elements of this plan are identified as being needed. Work shall not proceed on these activities until the applicable technical procedures have been prepared, reviewed, and approved in accordance with NNWSI-USGS-QMP-5.01. Appendix A of this plan contains completed Quality Assurance Level Assignments (QALA) for each method identified including criteria exception justifications for each method identified.

Figure 3-2. Locations of Proposed Deep Seismic Reflection Test in the Amargosa Desert.

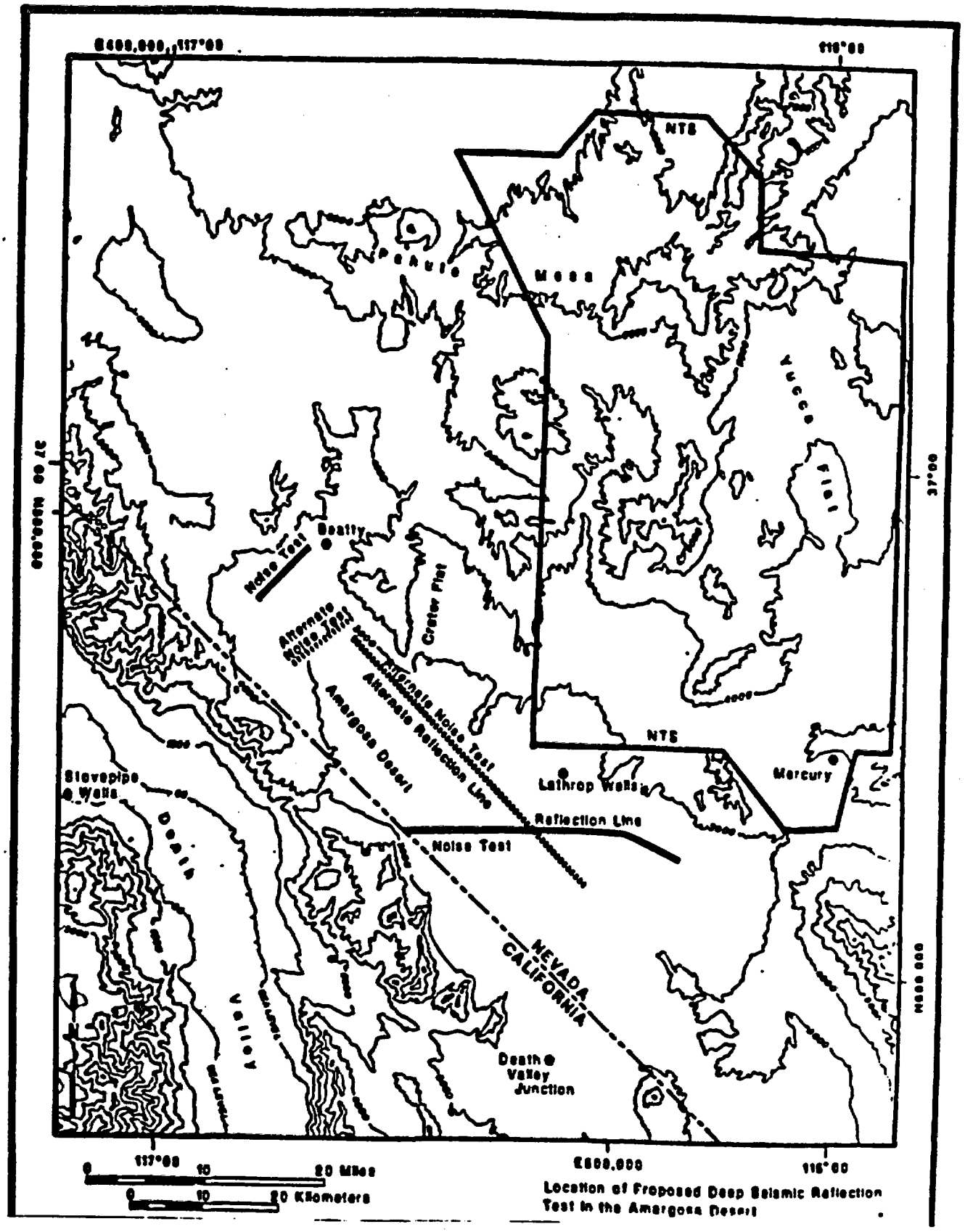


Table 3-2. Methods and Technical Procedures for Deep Seismic Reflection Test (Amargosa Desert).
[a] refers to other USGS Scientific Investigation Plans

Method	Technical Procedure: Number (NWM-USGS-)	Technical Procedure: Title	Technical Procedure: Date	QA Level Assignment Sheet (QALAS) Number (NNWSI-QALA-)	Software Reference
Deep Seismic Reflection Noise Test	SP-10 In Progress	Deep Seismic Reflection Study of the Tectonic Environment		3222C-01-02, RO	TBD

3.3 Deep Seismic Reflection Survey (Stovepipe Wells-Beatty-Crater Flat-Yucca Mountain-Mercury-Indian Springs)

3.3.1 Introduction

The objectives of the deep seismic reflection investigations are to characterize the subsurface geologic framework of the crust and uppermost mantle in the vicinity of Yucca Mountain. In particular, deep seismic reflection surveys, east and west of Yucca Mountain, are used to investigate the preTertiary subvolcanic basement rock by mapping the lateral continuity of reflecting horizons.

The deep seismic reflection survey (Figure 3-3) will be conducted along a 220-kilometer (136-mile) long east-west profile extending from Stovepipe Wells, California to the junction of Kyle Canyon and Highway 95, 22 kilometers (14 miles) east of Indian Springs, Nevada. This line will follow primary and secondary roads through Beatty, Crater Flat, southern Yucca Mountain, and Jackass Flat. Four north-south cross-profiles are also planned, including a 27-kilometer (17-mile) line in Death Valley, an 88-kilometer (55-mile) line from Death Valley Junction northward to the narrows of Forty Mile Wash, a 37-kilometer (23-mile) line following the Mercury Highway northward to the northern end of Yucca Flat, and a 37-kilometer (23-mile) crossing Highway 95 at Kyle Canyon. The survey will utilize 10-kilometer (6.2-mile) spreads, 24 geophones per group, 25-meter (82-foot) group interval, 480 groups per spread, Vibroseis energy source, 100-meter (328-foot) vibrator interval, 72,000 kilogram (160,000 pounds) minimum peak vibrator force, and 480 channel floating-point digital recording. Specific ranges in acquisition parameters are estimates only, actual parameters used in the field may vary.

3.3.2 Supporting Activities

Interpretation of the deep seismic reflection data will be performed in conjunction with, as appropriate, results obtained from the deep seismic refraction profiling, magneto-telluric (MT) sounding traverses, gravity and magnetic surveys, field mapping, and from sonic velocity measurements in wells drilled in the vicinity of Yucca Mountain.

Deep seismic refraction studies will be performed as described in Section 3.1 to attempt to map crustal structure by studying the lateral continuity of any well-defined refracting horizons.

The crustal conductivity structure within the transect will be established using magneto-telluric (MT) sounding methods. The MT survey will include a detailed net with station spacings of 3 to 5 kilometers (1.9 to 3.1 miles), and a reconnaissance net wtih stations spaced at 8 to 10 kilometers (5.0 to 6.2 miles). The rock conductivity models obtained from these studies will be correlated to the inferred crustal structure to constrain interpretations of the crustal structure and its physical properties.

Figure 3-3. Locations of Proposed Deep Seismic Reflection Surveys in the Vicinity of Yucca Mountain.

Gravity surveys at a grid spacing of 100 m will be performed in Yucca Wash and in the vicinity of the proposed core hole tentatively located south of Busted Butte (USW G-7), and in other locations. Gravity variations will be used to map vertical relief on major stratigraphic horizons as well as to map the lateral variations in densities corresponding to facies changes.

Ground magnetic studies at a grid spacing of 50 m to be performed in the vicinity of Yucca Mountain will be used to map lateral variations in the magnetizations of surficial rocks.

Field mapping at a scale of 1:100,000 will provide the ability to correlate reflecting horizons with mapped lithologies.

Sonic and bulk density measurements in wells at or in the vicinity of Yucca Mountain will also provide greater ability to correlate reflecting horizons with the stratigraphy near Yucca Mountain. These correlations will provide important constraints on the interpretation of the upper crustal structure.

3.3.3 Equipment

Equipment required to conduct this activity is identified in the technical procedures. No additional major equipment is required for this activity. Maintenance and repair of existing equipment, however, may be necessary.

3.3.4 Methods, Procedures, and Quality Assurance

Specific investigative methods used in the deep seismic reflection studies are listed in Table 3-3. Identified in the table are supporting technical procedures used to assure the quality and traceability of the activity, data collection, and interpretation; the applicable QALA numbers; and software requirements.

Approved procedures are identified with a USGS number, title, and effective date. Procedures that require preparation before implementing elements of this plan are identified as being needed. Work shall not proceed on these activities until the applicable technical procedures have been prepared, reviewed, and approved in accordance with NNWSI-USGS-QMP-5.01. Appendix A of this plan contains completed Quality Assurance Level Assignments (QALA) for each method identified including criteria exception justifications for each method identified.

Table 3-3. Methods and Technical Procedures for Deep Seismic Reflection Survey (Stovepipe Wells-Beatty-Crater Flat-Yucca Mountain-Mercury-Indian Springs). * refers to other USGS Scientific Investigation Plans

Method	Technical Procedure			QA Level Assignment Sheet (QALAS) Number (NNWSI-QALA-)
	Number (NNM-USGS-)	Title	Date	
Deep Seismic Reflection Profiling	SP-10 In Progress	Deep Seismic Reflection Study of the Tectonic Environment		3222C-01-03, R0

3.4 Shallow Seismic Refraction (Bison-type or equivalent)

3.4.1 Introduction

The objectives of the shallow seismic refraction investigations are to characterize the subsurface geologic framework of the volcanic and Paleozoic rock, and site of the proposed surface facility in the vicinity of Yucca Mountain. In particular, the location and definition of Quaternary faults and fault systems, at or proximal to the proposed repository at Yucca Mountain, is a primary objective of the shallow seismic refraction surveys.

Velocity profiles, within very shallow (to depth of 100 meters; 328 feet) deposits, will be established along selected traverses (Figure 3-4) crossing known and suspected fault traces, using a portable (Bison-type or equivalent) seismic refraction apparatus. These surveys will also be used to determine the depth of alluvium in canyons and/or portions of canyons not covered by boreholes.

3.4.2 Supporting Activities

The locations of the shallow seismic refraction lines are chosen based on the results of study of detailed air photographs and field studies of fault scarps showing the locations of potential Quaternary faults.

3.4.3 Equipment

Equipment required to conduct this activity is identified in the technical procedures. No additional major equipment is required for this activity. Maintenance and repair of existing equipment, however, may be necessary.

3.4.4 Methods, Procedures, and Quality Assurance

Specific investigative methods used in the shallow seismic refraction studies are listed in Table 3-4. Identified in the table are supporting technical procedures used to assure the quality and traceability of the activity, data collection, and interpretation; the applicable QALA numbers; and software requirements.

Approved procedures are identified with a USGS number, title, and effective date. Procedures that require preparation before implementing elements of this plan are identified as being needed. Work shall not proceed on these activities until the applicable technical procedures have been prepared, reviewed, and approved in accordance with NNWSI-USGS-QMP-5.01. Appendix A of this plan contains completed Quality Assurance Level Assignments (QALA) for each method identified including criteria exception justifications for each method identified.

Figure 3-4. Locations of Proposed Shallow Seismic Refraction Surveys in the Vicinity of Yucca Mountain.

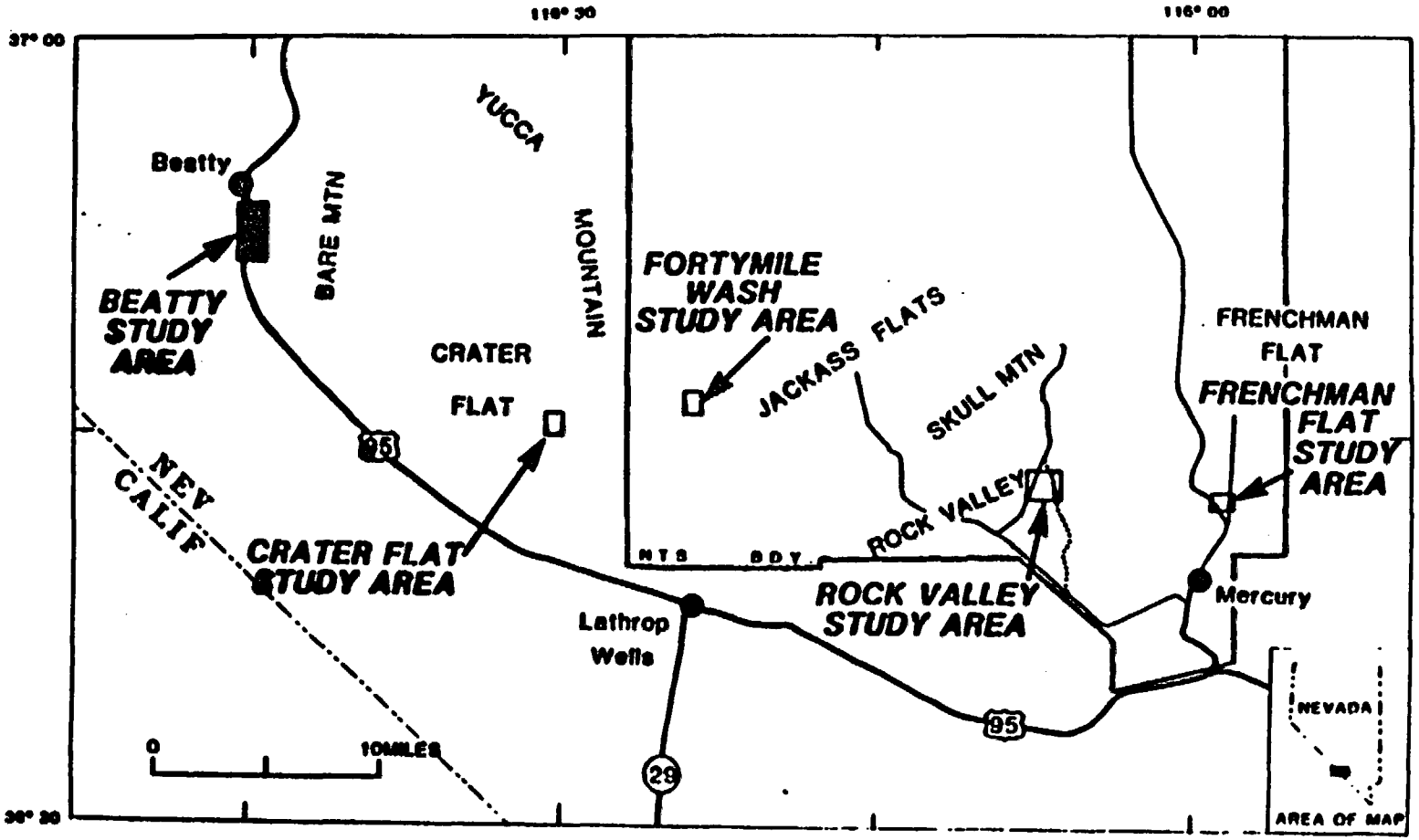


Table 3-4. Methods and Technical Procedures for Shallow Seismic Refraction Survey (Bison-type or equivalent).
[a] refers to other USGS Scientific Investigation Plans

Method	Technical Procedure			QA Level Assignment Sheet (QALAS) Number (NNWSI-QALA-)	Software Reference
	Number (NNM-USGS-)	Title	Date		
Shallow Seismic Refraction Profiling	In Progress			3222C-01-04, RO	TBD

3.5 Shallow Seismic Reflection (Mini-Sosie or equivalent)

3.5.1 Introduction

The objectives of the shallow seismic reflection investigations are to characterize the subsurface geologic framework of shallow volcanic and Paleozoic rock, and site of the proposed surface facility in the vicinity of Yucca Mountain. In particular, the location and definition of Quaternary faults and fault systems, at or proximal to the proposed repository at Yucca Mountain, is a primary objective of the shallow seismic reflection surveys.

Shallow seismic reflection surveys (Mini-Sosie or equivalent) (Figure 3-5) will be conducted in short (1- to 5- kilometer; 0.6 to 3.1-mile) traverses surveyed at locations to be defined. Three lines are planned, two of which will be in Crater Flat, and the third in Rock Valley. Six to seven lines aggregating 30 linear kilometers (18.6 miles) are planned at Yucca Mountain. All lines will use 9.1-meter (30-foot) source point, data stacked at common midpoints every 4.6 meters (15 feet) at 12-fold, or every 9.1 meters (30 feet) at 24 fold; 12 geophones per group. These surveys will also be used to determine the depth of alluvium in canyons and/or portions of canyons not covered by boreholes. Specific ranges in acquisition parameters are estimates only, actual parameters used in the field may vary.

3.5.2 Supporting Activities

Locations for the shallow reflection lines are chosen on the basis of field mapping of potential faults, and on the results of gravity and magnetic surveys indicating the presence of large vertical faults.

Sonic and bulk density measurements in wells at or in the vicinity of Yucca Mountain may also provide greater ability to correlate reflecting horizons with the stratigraphy at Yucca Mountain. These correlations may provide important constraints on the interpretation of the upper crustal structure.

3.5.3 Equipment

Equipment required to conduct this activity is identified in the technical procedures. No additional major equipment is required for this activity. Maintenance and repair of existing equipment, however, may be necessary.

3.5.4 Methods, Procedures, and Quality Assurance

Specific investigative methods used in the shallow seismic reflection studies are listed in Table 3-5. Identified in the table are supporting technical procedures used to assure the quality and traceability of the activity, data collection, and interpretation; the applicable QALA numbers; and software requirements.

Figure 3-5. Locations of Proposed Shallow Seismic Reflection Surveys at Yucca Mountain.

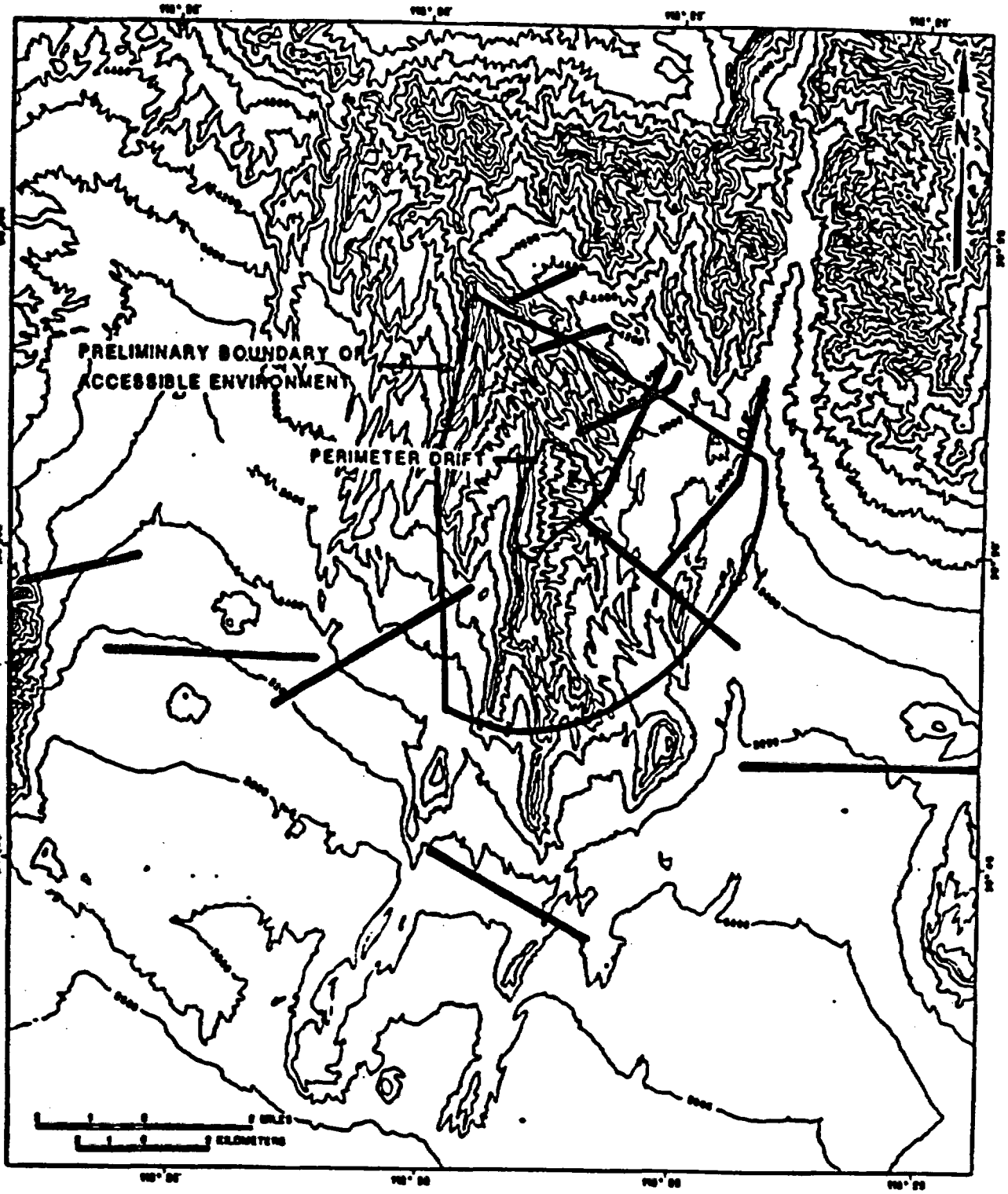


Table 3-5. Methods and Technical Procedures for Shallow Seismic Reflection Survey (Mini-Sosie or equivalent).
* refers to other USGS Scientific Investigation Plans

Method	Technical Procedure			QA Level Assignment Sheet (QALAS) Number (NNWSI-QALA-)	Softw Refer
	Number (NNM-USGS-)	Title	Date		
Shallow Seismic Reflection Profiling)	In Progress			3222C-01-05, RO	TBD

Approved procedures are identified with a USGS number, title, and effective date. Procedures that require preparation before implementing elements of this plan are identified as being needed. Work shall not proceed on these activities until the applicable technical procedures have been prepared, reviewed, and approved in accordance with NNWSI-USGS-QMP-5.01. Appendix A of this plan contains completed Quality Assurance Level Assignments (QALA) for each method identified including criteria exception justifications for each method identified.

4.0 SCHEDULE AND MILESTONES

An essential component of the quality assurance level assignments includes the identification of technical procedures required of quality level one activities. Preparation of these procedures constitutes a prerequisite for initiating this study. The schedule presented in Figure 4-1 summarizes a sequence of events associated with the preparation of the technical procedures and the activities for this study. A more detailed outline of activities is included and illustrated in the Gantt chart of Figure 4-2. These diagrams are referenced to the start of a fiscal year but are dependent on completion of technical procedures. A more detailed schedule of events is incorporated into the Site Geology schedule, 1G232.FIX, on file in the USGS area of the PMS system.

A list of reports resulting from this study is included in Table 4-1.

SEISMIC INVESTIGATIONS

DATE: 9-18-87

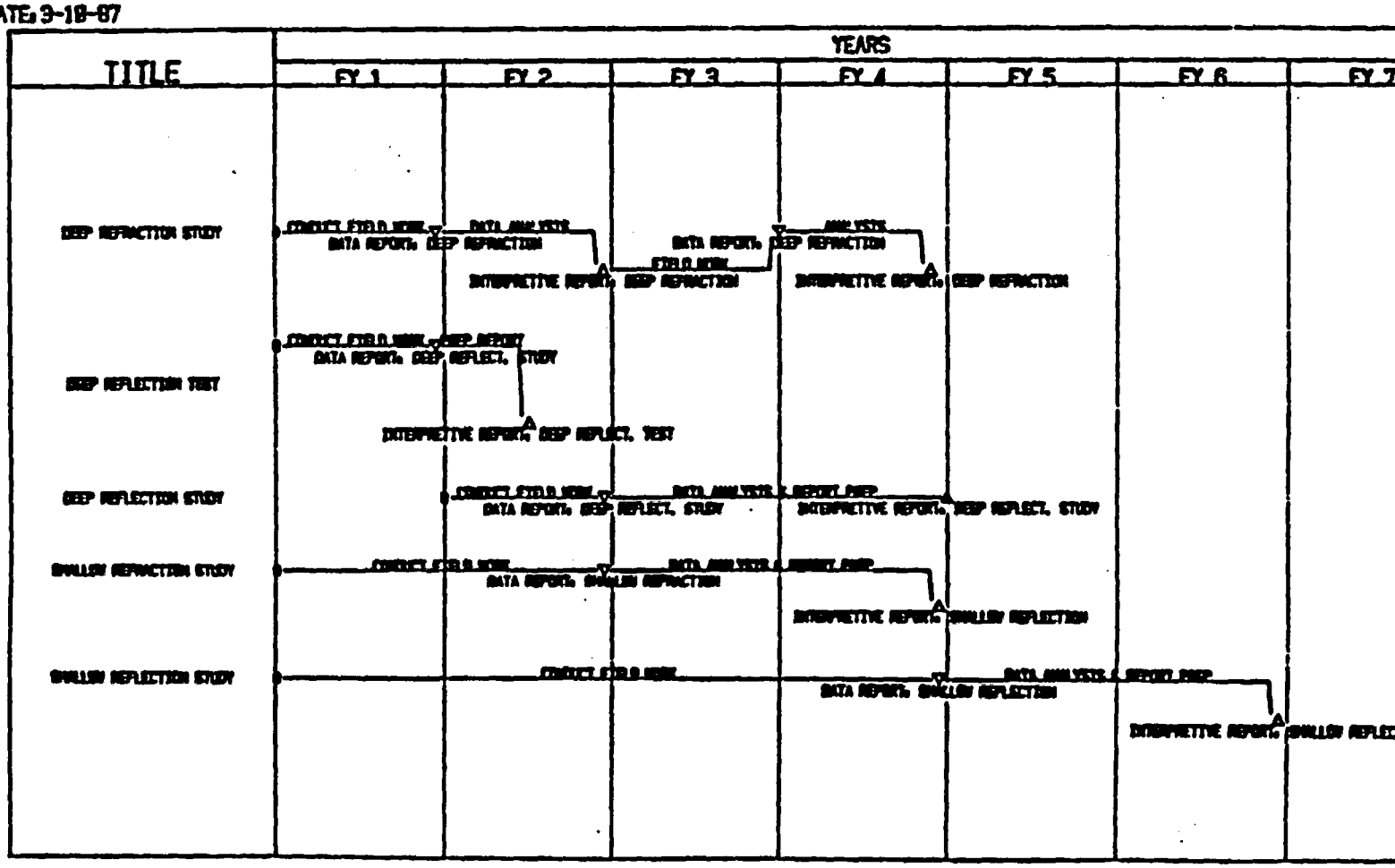


Figure 4-2. Gantt Chart Summary of Activities Associated with the Seismic Reflection and Refraction Surveys.

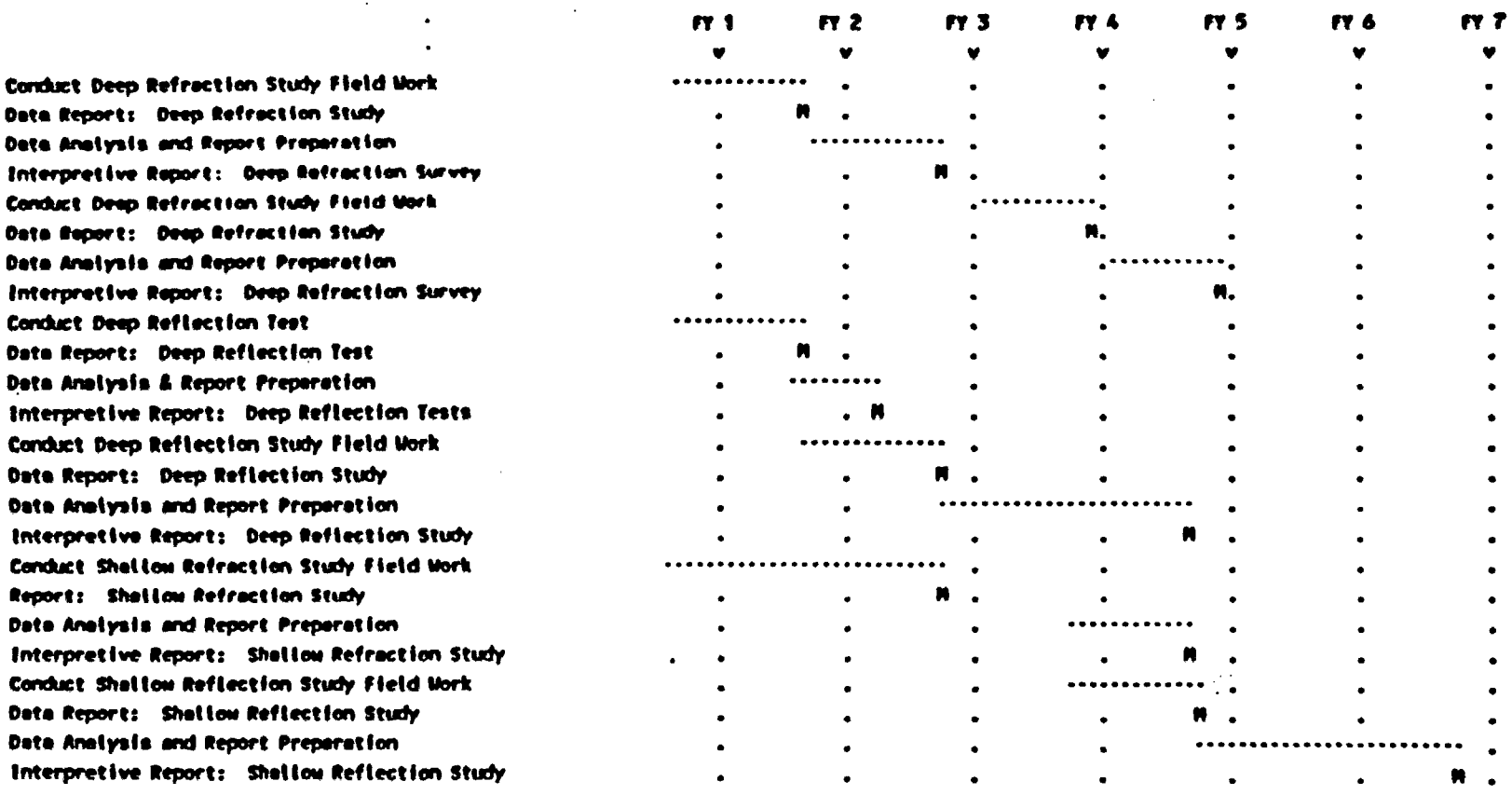


Table 4-1. List of Reports Identified for the Seismic Reflection and Refraction Surveys

Node	Description
P797	Interim Report: Regional Seismic Refraction Field Studies
P798	Interim Report: Seismic Reflection Field Test Studies
	Interim Report: Seismic Reflection Field Studies
P825	Report: Preliminary Interpretation of Regional Seismic Profiles
	Interim Report: Regional Seismic Refraction Field Studies
	Report: Preliminary Interpretation of Regional Seismic Profiles
P799	Final Report: Completion of Regional Seismic Refraction Field Studies
P822	Final Report: Completion of Regional Seismic Reflection Field Studies
P718	Issue Report: Regional Crustal Structure via Deep Seismic
P826	Report: Final Interpretation of Regional Seismic Profiles
	Interim Report: Shallow Refraction Field Studies
	Interim Report: Shallow Reflection Field Studies
	Final Report: Completion of Shallow Refraction Field Studies
	Final Report: Completion of Shallow Reflection Field Studies
	Report: Final Interpretation of Shallow Refraction Lines
	Report: Final Interpretation of Shallow Reflection Lines

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USGS, NNWSI Project USGS Scientific Investigation Plan, Characterization of Site Structural Features, U.S. Geological Survey Scientific Investigation Plan 3211G-02, RO, In preparation.

USGS, NNWSI Project USGS Scientific Investigation Plan, Borehole Geophysical Studies, U.S. Geological Survey Scientific Investigation Plan 3223G-03, RO, In preparation.

USGS, NNWSI Project USGS Scientific Investigation Plan, Characterization of Site Structural Features, U.S. Geological Survey Scientific Investigation Plan 3211G-02, RO, In preparation.

Appendix A - Quality Assurance Level Assignments (QALA Sheets)

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Deep Seismic Refraction Survey (Death Valley-Beatty Junction-Sheep Range)
Method - Deep Seismic Refraction Profiling

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements[a]	Justification of Level and QA Criteria Exceptions
Select potential shotpoints from published topographic maps A	III	N/A	Reconnaissance work and planning, does not meet any attributes of Level I or II. All criteria are excluded since they are required for Level I or II only.
Visit potential shotpoint locations in the field to determine the suitability of the sites	III	Same as above.	Same as above.
Drill and case shotholes C	III	Same as above.	Meets none of the attributes of Level I or II; if hole is lost prior to casing it can be redrilled at minimal cost. All criteria are excluded since they are required for Level I or II only.

[a]LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION
2 QA PROGRAM
3 DESIGN AND SITE INVESTIGATION CONTROL
4 PROCUREMENT DOCUMENT CONTROL
5 INSTRUCTIONS, PROCEDURES AND DRAWINGS
6 DOCUMENT CONTROL
7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES
8 ID AND CONTROL OF MATERIALS, PARTS AND SUPPLIES
9 CONTROL OF SPECIAL PROCESSES
10 INSPECTION (SURVEILLANCE)
11 TEST AND EXPERIMENT/RESEARCH CONTROL
12 CONTROL OF MEASURING AND TEST EQUIPMENT
13 HANDLING, STORAGE AND SHIPPING
14 INSPECTION, TEST, AND OP. STATUS
15 CONTROL OF NONCONFORMING ITEMS
16 CORRECTIVE ACTION
17 QA RECORDS
18 AUDITS

APPROVALS

Walter D Mooney	2/26/87	Wellmon	3/9/87	for Chief, Branch of NNWSI	3/10/87
Originator	Date	Quality Assurance Manager	Date		Date
James Blanford	4/22/87	Maxwell Blanford	5-13-87		
NNPO Quality Assurance	Date	NNPO Technical	Date		Effective Date

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements	Justification of Level and QA Criteria Exceptions
Load explosives in shotholes	III	N/A	Meets none of the attributes of Level I or II; if hole is lost prior to loading it can be redrilled at minimal cost. All criteria are excluded since they are required for Level I or II only.
Survey locations of shotholes and seismic receivers	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the locations are incorrectly surveyed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Deploy seismic receivers at surveyed locations	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the receivers are incorrectly deployed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Detonate explosive sound sources (shotholes)	III	N/A	Meets none of the attributes of Level I or II; if explosive does not detonate the data from only this shothole are effected. All criteria are excluded since they are required for Level I or II only.
Measure origin times	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the origin times are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Retrieve seismic receivers	III	N/A	Meets none of the attributes of Level I or II; if receiver is not retrieved the data from only a single receiver is lost. All criteria are exluded since they are required for Level I or II only.
Calibrate clock drift rates	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the clock drift rates are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Digitize cassette tapes	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the cassette tapes are incorrectly digitized, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements	Justification of Level and QA Criteria Exceptions
Correct and merge time and range data into seismic data headings	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the data are incorrectly merged into the headers, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Plot seismic record sections on a computer plotter	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the seismic records are incorrectly plotted, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Digitize arrival travel times, invert times for models, fit times with forward models; finalize velocity models	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the arrival travel times and and amplitudes are incorrectly interpreted, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Deep Seismic Reflection Test (Amargosa Desert)
Method - Deep Seismic Reflection Noise Test

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Page 1 of 2

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
Select locations of potential reflection lines from published topographic maps	III	N/A	Reconnaissance work and planning, does not meet any attributes of Level I or II. All criteria are excluded since they are required for Level I or II only.
Visit locations of potential lines in the field to determine the suitability of the lines	III	Same as above.	Same as above.
Deploy seismic receivers and cables.	III	N/A	Meets none of the attributes of Level I or II; if instruments are improperly deployed, they can be redeployed at minimal cost prior to data acquisition. All criteria are excluded since they are are required for Level I or II only.

LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION
2 QA PROGRAM
3 DESIGN AND SITE INVESTIGATION CONTROL
4 PROCUREMENT DOCUMENT CONTROL
5 INSTRUCTIONS, PROCEDURES AND DRAWINGS
6 DOCUMENT CONTROL
7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES
8 ID AND CONTROL OF MATERIALS, PARTS AND SUPPLIES
9 CONTROL OF SPECIAL PROCESSES
10 INSPECTION (SURVEILLANCE)
11 TEST AND EXPERIMENT/RESEARCH CONTROL
12 CONTROL OF MEASURING AND TEST EQUIPMENT
13 HANDLING, STORAGE AND SHIPPING
14 INSPECTION, TEST, AND OP. STATUS
15 CONTROL OF NONCONFORMING ITEMS
16 CORRECTIVE ACTION
17 QA RECORDS
18 AUDITS

APPROVALS

Thomas Mark Brocher	2/26/87	[illegible]	3/9/87	[illegible] for	3/10/87
Originator	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI	Date
James Blaylock	4/30/87	Maxwell Blanford	5-13-87		
NPO Quality Assurance	Date	NNPO Technical	Date		Effective Date

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
Calibration of equipment D	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the instruments are improperly tested, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process; 11-no tests or research involved; 14-not part of USGS QA Program.
Test the large-aperture seismic reflection technique to determine its usefulness Amargosa Desert near Yucca Mountain E	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the acquisition parameter testing is improperly performed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process; 11-no tests or research involved; 14-not part of USGS QA Program.
Acquire a 15 mile long test line in Amargosa Desert near Yucca Mountain F	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 4 of the QA Level Checklist wherein this item is a step in providing site characterization data that has a significant impact on the data base that supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Survey location of sources and receivers along test line G	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the locations are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Process seismic reflection test data using commercially available software H	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the data are incorrectly processed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Interpret the seismic reflection profile I	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the reflectors are interpreted, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

NSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
tivity - Deep Seismic Reflection Survey (Stovepipe Wells-Beatty-Crater Flat-Tucca Mountain-Mercury-Indian Springs)
thod - Deep Seismic Reflection Profiling

NNWSI-QALA-32220-01-03, R0

thod/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
lect locations of tential reflection lines on published topographic ps	III	N/A	Reconnaissance work and planning, does not meet any attributes of Level I or II. All criteria are excluded since they are required for Level I or II only.
sit locations of potential ses in the field to termine the suitability the lines	III	Same as above.	Same as above.
ploy seismic receivers i cables	III	N/A	Meets none of the attributes of Level I or II; if instruments are improperly deployed, they can be redeployed at minimal cost prior to data acquisition. All criteria are excluded since they are required for Level I or II only.

CEND OF 18 QA CRITERIA OF NQA-1

ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE AND SHIPPING
QA PROGRAM	8 ID AND CONTROL OF MATERIALS, PARTS AND SUPPLIES	14 INSPECTION, TEST, AND OP. STATUS
DESIGN AND SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
INSTRUCTIONS, PROCEDURES AND DRAWINGS	11 TEST AND EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
DOCUMENT CONTROL	12 CONTROL OF MEASURING AND TEST EQUIPMENT	18 AUDITS

PROVALS

James Mark Brocher	2/26/87	J R Williamson	3/9/87	R H Handy for	3/10/87
ginator	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI	Date
James Blanchard	4/30/87	Maxwell Blanchard	5-13-87		
O Quality Assurance	Date	NNPO Technical	Date	Effective Date	

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements	Justification of Level and QA Criteria Exceptions
Calibration of equipment D	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the instruments are improperly tested, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process; 11-no tests or research involved; 14-not part of USGS QA Program.
Test the large-aperture seismic reflection technique to determine its usefulness Amargosa Desert in and near Tucca Mountain E	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the acquisition parameter testing is improperly performed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process; 11-no tests or research involved; 14-not part of USGS QA Program.
Acquire a set of regional seismic reflection lines to map subsurface reflectors F	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 4 of the QA Level Checklist wherein this item is a step in providing site characterization data that has a significant impact on the data base that supports the final repository design and assessment of the repository performance. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Survey location of sources and receivers along regional reflection lines G	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the locations are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Process seismic reflection test data using commercially available software H	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the data are incorrectly processed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Correlate reflectors between profiles and interpret the seismic reflection lines I	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the reflectors are incorrectly correlated, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria exluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Shallow Seismic Refraction Survey (Bison-type or equivalent)
Method - Shallow Seismic Refraction Profiling

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
Select locations of potential refraction lines from published topographic maps A	III	N/A	Reconnaissance work and planning, does not meet any attributes of Level I or II. All criteria are excluded since they are required for Level I or II only.
Visit locations of potential lines in the field to determine the suitability of the lines B	III	Same as above.	Same as above.
Deploy seismic receivers, cables, trigger, source, and recorder C	III	N/A	Meets none of the attributes of Level I or II; if instruments are improperly deployed, they can be redeployed at minimal cost prior to data acquisition. All criteria are excluded since they are required for Level I or II only.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION
2 QA PROGRAM
3 DESIGN AND SITE INVESTIGATION CONTROL
4 PROCUREMENT DOCUMENT CONTROL
5 INSTRUCTIONS, PROCEDURES AND DRAWINGS
6 DOCUMENT CONTROL
7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES
8 ID AND CONTROL OF MATERIALS, PARTS AND SUPPLIES
9 CONTROL OF SPECIAL PROCESSES
10 INSPECTION (SURVEILLANCE)
11 TEST AND EXPERIMENT/RESEARCH CONTROL
12 CONTROL OF MEASURING AND TEST EQUIPMENT
13 HANDLING, STORAGE AND SHIPPING
14 INSPECTION, TEST, AND OP. STATUS
15 CONTROL OF NONCONFORMING ITEMS
16 CORRECTIVE ACTION
17 QA RECORDS
18 AUDITS

APPROVALS

Thomas Mark Brocher Originator	2/26/87 Date	J. W. Williams Quality Assurance Manager	3/9/87 Date	A. H. Handy for Chief, Branch of NNWSI	3/10/87 Date
James Blanford WHPO Quality Assurance	4/30/87 Date	Maxwell Blanford WHPO Technical	5-13-87 Date		Effective Date

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements[a]	Justification of Level and QA Criteria Exceptions
Check the geophone sensors, cables, trigger, source, and recorder D	I	1,2,3,4,5,6,7,8, 10,12,13,15 16,17,18	Meets step No. 5 of the QA Level Checklist wherein if the instruments are improperly checked, incorrect or misleading conclusions can be drawn from the data and the supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Survey the location of the seismic line E	I	1,2,3,4,5,6,7,8, 10,12,13,15 16,17,18	Meets step No. 5 of the QA Level Checklist wherein if the line locations are improperly surveyed, incorrect or misleading conclusions can be drawn from the data and the supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Acquire shallow refraction travel-time data F	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 4 of the QA Level Checklist wherein this item is a step in providing site characterization data that has a significant impact on the data base that supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Interpret shallow refraction travel-time data G	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the traveltimes are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Shallow Seismic Reflection Survey (Mini-Sosie or equivalent)
Method - Shallow Seismic Reflection Profiling

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
Select locations of potential reflection lines from published topographic maps A	III	N/A	Reconnaissance work and planning, does not meet any attributes of Level I or II. All criteria are excluded since they are required for Level I or II only.
Visit locations of potential lines in the field to determine the suitability of the lines B	III	Same as above.	Same as above.
Survey location of sources and receivers along reflection lines C	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the locations are incorrectly measured, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION
2 QA PROGRAM
3 DESIGN AND SITE INVESTIGATION CONTROL
4 PROCUREMENT DOCUMENT CONTROL
5 INSTRUCTIONS, PROCEDURES AND DRAWINGS
6 DOCUMENT CONTROL
7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES
8 ID AND CONTROL OF MATERIALS, PARTS AND SUPPLIES
9 CONTROL OF SPECIAL PROCESSES
10 INSPECTION (SURVEILLANCE)
11 TEST AND EXPERIMENT/RESEARCH CONTROL
12 CONTROL OF MEASURING AND TEST EQUIPMENT
13 HANDLING, STORAGE AND SHIPPING
14 INSPECTION, TEST, AND OP. STATUS
15 CONTROL OF NONCONFORMING ITEMS
16 CORRECTIVE ACTION
17 QA RECORDS
18 AUDITS

APPROVALS

Thomas Mark Brocher Originator	2/26/87 Date	[illegible] Quality Assurance Manager	3/9/87 Date	[illegible] for Chief, Branch of NNWSI	3/10/87 Date
James Blanford NNPO Quality Assurance	4/30/87 Date	Maxwell Blanchard NNPO Technical	5-13-87 Date		Effective Date

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level and QA Criteria Exceptions
Perform monthly tests of geophones and recording equipment D	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the instruments are improperly tested, incorrect or misleading conclusions can be drawn from the data and the supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Deploy the geophone sensors, cables, sources, and recording equipment E	III	N/A	Meets none of the requirements for Levels I or II; if equipment is improperly deployed, instruments can be redeployed at minimal expense prior to data acquisition. All criteria are excluded since they are required for Level I or II only.
Check that the geophone sensors, cables, sources, and recording equipment are properly deployed and functioning F	I	1,2,3,4,5,6,7,8, 10,12,13,15 16,17,18	Meets step No. 5 of the QA Level Checklist wherein if the instruments are improperly checked, incorrect or misleading conclusions can be drawn from the data and the supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Acquire shallow reflection data G	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 4 of the QA Level Checklist wherein this item is a step in providing site characterization data that has a significant impact on the data base that supports the final repository design and assessment of the repository performance. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Process seismic reflection data using commercially available software H	I	Same as above.	Meets step No. 5 of the QA Level Checklist wherein if the data are incorrectly processed, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.
Interpret shallow reflection data I	I	1,2,3,4,5,6,7,8, 10,12,13,15,16, 17,18	Meets step No. 5 of the QA Level Checklist wherein if the data are incorrectly interpreted, incorrect or misleading conclusions can be drawn from the data and the item can impact this and other Level I activities. Criteria excluded: 9-not a special process, 11-no tests or research involved; 14-not part of USGS QA Program.