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PROJECT PLAN FOR SEISMIC/ROCK MECHANICS PROJECT

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PROJECT PLAN FOR SEISMIC/ROCK MECHANICS

The Nuclear Waste Policy Act (NWPAA) of 1982, as amended, establishes the responsibilities of the Department of Energy (the license applicant), the Nuclear Regulatory Commission (NRC) (the license review and license issuing agency), and the Environmental Protection Agency (the promulgator of standards for long-term repository performance).

Siting and licensing of a high-level nuclear waste (HLW) repository requires that sophisticated technology, technical complexities, intense public scrutiny, and rigorous schedule constraints be integrated in one program. This mission has the additional complications associated with a complex multi-party legal and regulatory evaluation and approval process.

In support of its high level waste program under the NWPAA, NRC has established the Center for Nuclear Waste Regulatory Analyses (hereafter referred to as "the Center"). The mission for the Center is to provide a sustained high quality of technical assistance and research in support of NRC's HLW program. Toward accomplishing this mission, the Center is required to establish research activities to aid in identifying and resolving technical and scientific issues associated with the NRC's licensing of a high-level nuclear waste repository.

An important issue, requiring research, concerns the effects of tectonic forces on (a) the design and performance of shaft liners, (b) retrievability of waste in the short-term and (c) long-term performance of the underground repository structures and on the surrounding rock environment for a tuff repository site. An understanding of the critical parameters and an approach to reduce the uncertainty among these parameters are required for resolving this issue before DOE license application can be satisfactorily reviewed and approved. The effects of tectonic forces may influence both the waste package radionuclide containment (i.e., 300 years - 1000 years) and the rate of release of radionuclides to accessible environment (during a 10,000-year time period) as required by 10CFR60 and 40CFR191. In support of developing an adequate understanding of this issue so that timely guidance can be provided to the DOE and a sound basis is available for evaluating the DOE license application, the Seismic/Rock Mechanics research project was identified. This document presents the detailed project plan for the Seismic/Rock Mechanics research project to be conducted under the Center's research program.

1. TECHNICAL OBJECTIVE

1.1 Purpose, Goals, and General Objectives

The purposes and basic objectives of the Seismic/Rock Mechanics Research Project are:

(1) To obtain an understanding of the important parameters associated with the response of the shaft liners and the underground repository structures in tuff due to seismic motion. This objective supports the requirements in 10CFR60 for repository design, safe operations, waste retrievability and integrity of the engineered barriers.

(2) To obtain an understanding of the alterations of the groundwater regime and modification of the permeability and flow patterns by seismic events. This objective supports the waste containment and release rate requirements in 10CFR60. Here the long-term postclosures hydrological conditions in the vicinity of the waste packages are evaluated.

(3) To develop methodologies to evaluate, validate, and reduce uncertainties in the prediction models used in seismic assessment of tuff media. This objective is directed toward decreasing the uncertainties in repository design input conditions.

The goal of this research project is to enable the NRC and the Center to develop the technical capability and the necessary independent experimental data to review DOE submittals to NRC on the seismic effects on the long-term performance of underground repository structures.

1.2 Specific Objectives

The six specific objectives for the Seismic/Rock Mechanics research project have been identified. These are:

- To develop a good understanding of the information currently available on the seismic effects on underground structures.

- To evaluate the extent and nature of instrumented field studies now being conducted in tuff-type materials.

- To critically assess the capabilities and limitations of analytical modelling tools currently in use.

- To demonstrate by experimental model studies the degree of validation for the analytical models used for seismic analysis in a tuff media.

- To identify and assess the key seismic related parameters that are applicable to the Yucca Mountain Site.

- To develop technical data for preparing licensing related positions as they relate to effect of seismic action on the underground repository in a tuff media.

2. TECHNICAL PROGRAM DESCRIPTION

2.1 Technical Approach

There have been many studies conducted on the effect of seismic and shock loading on structures. Most of these studies have concentrated on surface structures, where the effects are severe. Studies on underground structures have indicated that damage can take place due to fault slip, rock burst, and prolonged shaking. Also, field data indicates that groundwater flow conditions and water table levels can be altered by seismic activity. Shock loadings from blasts generate high frequency responses. The data indicate that high frequency spectra often lead to spalling of tunnel liners and create damage on the surface of openings. However, for a given acceleration level, the damage potential of a large-amplitude, low-frequency event is greater than that of a high-frequency event.

The seismic studies performed to date on underground structures have not been subject to an adequate level of experimental investigation. The experimental support for most programs has focused on soils rather than on structurally complex rock formations. There are computer programs currently available to model dynamic events of underground structures in rock formations. However, these programs have not been validated with well-planned and rigorous experimental protocols. Field data evaluations have also been inadequate for direct application to the tuff repository at Yucca Mountain. In order to develop a better understanding of the key parameters affecting the repository under seismic loading, the Center has developed a focused research program approach. The approach involves work to be performed in six tasks. The tasks include:

Task 1 — Focused Literature Search

Task 2 — Instrumentation/Field Studies

Task 3 — Analytical Methods

Task 4 — Model Validation

Task 5 — Yucca Mountain Scoping Analysis

Task 6 — Technical Position Report

A detailed assessment of and the planned activities for each task is presented in Section 2.2.

2.2 Technical Tasks

Six major tasks have been identified for this project and are planned to be completed over a 43-month period. A detailed description of these tasks is given in this section. Activities for the tasks are shown with time sequencing in the Gantt Chart in Section 2.3.

2.2.1 Task 1 — Focused Literature Search

OBJECTIVE

The objectives of this task are to:

(1) Obtain the current state of information relating to:

- Effects of seismic activity on underground structures

- Quantification of forcing functions (seismic and shock) in typical tuff media
- Effect of tectonic forces on hydrological conditions in tuff media.

(2) Define boundary conditions and input parameters required for tasks 3 and 4 of the proposed project.

JUSTIFICATION

This task ensures the proficiency, accuracy, and applicability of proposed laboratory studies and precludes duplication of effort.

This survey and search will focus on significant parameters needed to describe characteristics of field scenarios for a high-level waste repository. These parameters will be used to create analytical and physical models which can be quantitatively compared with each other as well as with conditions at the Yucca Mountain site.

Of particular significance and consequence is the effect of moisture on in-situ conditions in the field over a long period of time. Pore pressure and water table levels may be substantially changed due to tectonic activities. It is the intent of the structured physical and analytical laboratory studies (derived from literature and site information) to model probable events in-so-far-as-possible in order to assess quantitatively the physical disturbances and changes possible at the repository. The probability of such occurrences may be estimated from data documented in literature.

The following delineates areas of concern and parameters that may be used to characterize such areas and derivative events.

2.2.1.1 Computer Search of Data Bases

Data bases to be queried using key words and subject areas identified below include: NTIS, DOE, Geosearch, Rock Mechanics, Lockheed, Dialogue.

Abstracts and summaries from articles documenting field event history, latest technical information and, areas of future study and data correlation will be obtained. From these, the articles of prime interest will be identified and assembled into a reference library for rock mechanics/seismic considerations for the Yucca Mountain repository. Data and observations from these sources will be used to facilitate description of applicable field scenarios, construction of laboratory models, and establishment of the range of values for controllable parameters.

2.2.1.2 Literature Areas and Parameter Identification

It is possible to identify many areas of consequence and interest, but it is expedient to assure that there is a functional correspondence between the topics enumerated and the proposed project activities.

Field data from representative sites similar to that anticipated at Yucca Mountain is required for the project. This data serves as a basis for laboratory analytical and physical models. Parameters representing in-situ conditions at the Yucca Mountain site are of consequence, as are the geologic and tectonic history of the area, including water tables, saturation zones, porosity, permeability, earthquake frequency, fault structure, properties of tuff, etc.

Key words and subject areas to be surveyed include:

Yucca Mountain —
- geology
- hydrology; water tables
- fault structure
- volcanic intrusion
- fracture & blocking tendencies
- stratigraphy
- in-situ rock properties (tuff)
- rock & soil chemistry, pH, solubility
- thermal influence in rock properties
- thermal fluctuations at repository site

Tuff Properties —
- laboratory simulation considerations
- triaxial test values from laboratories
- porosity, permeability tests
- extracted core properties (tuff)
- extracted core properties (Nevada Test Site)

Instrumentation —
- cameras
- displacement, velocity, acceleration
- particle velocity
- triaxial pressure
- porosity, permeability, and saturation
- field deployment
- laboratory use
- earthquake monitoring (long term)
- shock monitoring (short term)
- water table monitoring
- seismic mapping

Tunnels —
- size, length, cross-sectional shape
- intersections
- linings, reinforcing, hardening
- reaction to shock
- reaction to earthquake

Sites —
- earthquake monitoring stations
- data accumulation agencies
- Nevada Test site
- mining operation
- existing earthquake data
- probability of earthquake occurrence

Model Considerations. Model characteristics are discussed in Section 2.2.4. Field data will be the basis for model dimensioning and parameter characterization. The literature search will focus on work reported to date. Items of importance to be scanned are:

Analysis —
- computer programs
- parameters used
- results presented

Parameters —
- shock spectra
- earthquake spectra
- force magnitude/frequency
- saturated/unsaturated rock conditions
- partial saturation
- representation of voids
- dimensionless presentation
- temperature effects

Field Scenario —
- parameters needed to describe characteristics
- relation to analytical model
- relation to physical model
- history to date
- extrapolation for future occurrences

Model Validation —
- geologic models
- tunnel models
- analytical representation
- correlation (analytical w/physical model w/field site data)

Scenario Variations. The totality of undesirable events possible at a high-level waste repository over an extended interval of time encompasses numerous parameters and possibilities. Therefore, it is appropriate to use the following scenario variations to bound the range of conditions and effects anticipated:

- unsaturated w/earthquake vs shock
- saturated w/earthquake vs shock

- geometrical change in voids/intersection geometry
- transition of rock properties due to thermal, chemical, and hydrological considerations

2.2.1.3 Component Characterization

Various topics of possible consequence for developing scenarios relating to undesirable events and processes at a repository due to tectonic occurrences were enumerated in previous sections. Also to be considered are the thermal effects due to heating by radioactive decay, along with possible chemical changes. To construct applicable models, it is necessary to characterize various events by trying to establish the range in values of parameters that are used to describe these events. Information and data from the literature search will be used to characterize:

- seismic vs shock waves
- dynamic properties of rock discontinuities, faults, joints
- seismic/shock effects on underground openings and support systems
- seismic effects on groundwater levels.

2.2.1.4 Identification of Prospective Field Sites

Two types of field sites are considered to exist: 1) those for long range monitoring of earthquakes and 2) those for specific monitoring of underground nuclear detonation effects.

Earthquake Monitoring. One aspect of the literature survey will be directed toward identifying locations at which monitoring instruments have been continually deployed. These instruments may be in mines (subsurfaces) or at surface stations. It may be desirable to add instruments or to take samples to measure saturation characteristics of the material in which subsurface events are monitored. This decision will be made subsequent to the initial investigation in which data sources and monitoring stations are identified. Also, the applicability of the data to the tuff formations at Yucca Mountain will have to be ascertained, since the number of measurements available on tuff from established earthquake monitoring sites is minimal.

Among the agencies that will be contacted for earthquake information are the United States Geological Survey at Menlo Park; Bureau of Reclamation, Denver; Nuclear Monitoring Research Office of the Defense Advance Research Projects Agency. Data and identification of other sources will be requested from these entities. Trips will be scheduled to these agencies and/or their libraries to solicit information and cooperation. Additional sources will be contacted as they are identified.

Blast Monitoring. Blast or shock monitoring differs from earthquake monitoring in that it may be programmed for precise monitoring of a timed event. Shock spectra frequencies are higher than earthquake frequencies. The higher frequencies themselves may be of direct interest, however, in that nuclear detonations occur in the vicinity of the proposed Yucca Mountain site.

Data from these adjacent blasts are of particular interest, but a majority of the data may be classified, since response-distance information can be correlated with yield. It is believed, however, that some information may be available. An attempt will be made to obtain pertinent unclassified data from the various experiments conducted at the Nevada Test Site (NTS). Toward this goal, consulting support from Mr. Glen Roark, Kaman Corporation, who is intimately familiar with the programs at NTS, will be available to this project.

The effort will concentrate on obtaining field data relating to ground shock and tunnel response from detonations at the Nevada Test Site. Some of the data have been obtained in welded and nonwelded tuff sequences similar to those at Yucca Mountain. That data which was not measured in tuff will be correlated so as to give an indication of trends to be expected in tuff. Trips will be scheduled to identified libraries.

2.2.1.5 *Integrated Report*

An interim report will be made to summarize results of the literature survey, enumerate parameters identified, and describe scenarios to be investigated. Earthquake monitoring stations will be listed along with a history of tectonic activities for the region and the effect of these disturbances on groundwater.

Using rock properties (strength, porosity, permeability, density, etc), geologic information (faults, blocks, water tables), frequency spectra (earthquake vs shock), and tunnel geometries (square, round, lined, etc), from the literature studies and site-specific design information for the proposed Yucca Mountain repository, it will be possible to refine the laboratory models used to simulate the conditions at Yucca Mountain. The report will be used as a base document for model enhancement and as a guide to determine areas needing more documentation and study.

A bibliography of data sources (field sites, libraries, and agencies), literature articles, and cognizant personnel will be compiled from the surveys and visits. The usefulness and functionality of the data in deriving laboratory studies will be annotated as a portion of the bibliography, which is intended to provide an enumeration of source information for data, concepts, procedures, and models. The bibliography is not intended as an exhaustive listing of reference documents.

2.2.2 *Task 2 — Investigation/Field Studies*

OBJECTIVE

The objective of this task is to obtain data from the field sources identified in task 1. Aside from documenting:

- the stratigraphy and fault geology
- possible tunnel geometries
- formation and rock properties
- water table and prepressure characteristics

of the targeted repository site at Yucca Mountain, the field studies are designed to obtain on an on-going basis quantitative aspects of:

- earthquake shock spectra (in tuff, if possible)
- underground explosive shock spectra
- effects of these spectra on water table levels and pore pressure

JUSTIFICATION

This task provides the basis for constructing the physical and analytical models and applying realistic loading to the various scenarios which may be scaled into the models.

2.2.2.1 *Field Scenarios*

With reference to scenario variations (2.2.1.2), information will be sought on four particular aspects of dynamic loading and performance of underground excavations. These are:

(1) the identity of sites of underground excavations currently subject to dynamic loading, and the source of the loading;

(2) the intensity of loading to which excavations at the identified sites have been subjected in their recorded history;

(3) the performance of excavations under the combined dynamic and static loads of their operating environments; and

(4) the role and relation between groundwater conditions and dynamic loading and performance with particular emphasis on partial saturation of submerged strata.

In site identification, the scope of dynamic loading conditions will include natural seismic events, rockbursts at hard rock mines, and underground nuclear test events.

Information on the performance of underground excavations will be concerned with surface displacements, localized shear displacements on structural features, induced fracturing in the excavation peripheral rock, and the response of rock support and reinforcement.

In seeking information on groundwater response to dynamic events, particular attention will be paid to deep-level mines subject to rockbursts and to nuclear test sites. At these sites, the relatively short recurrence time for dynamic events and the intensity of instrumentation will provide a more comprehensive data set than for the site subject to episodic natural seismicity.

2.2.2.2 *Scope of Field Studies*

Field studies on underground excavation dynamics will concentrate primarily on hard rock mine sites subject to rockbursts. This emphasis is proposed because, compared with natural seismic events, the recurrence time for rockbursts is comparatively short, and the prospective location of the source of the events is spatially well defined. Also, due to the number of mine sites in North America now subject to rockbursts, it may be possible to select sites where conditions will bound those likely to be relevant to a waste repository in tuff.

The scope of field investigations also includes site characterizations, field measurements of seismic events, and concurrent observation of excavation response and local groundwater conditions with seismic events. The purpose of site characterization is to identify all components of the rock mass and mine structure which determine both the global and local response to seismic activity. This will involve the definition of the geological, geomechanical, and hydrological conditions for a particular mine site, identification of prospective burst locations, and evaluation of the mechanical properties of rock around the periphery of excavations previously subject to dynamic loading.

In the field measurement phase of the work, a prolonged series of observations of mine seismicity will be coupled with detailed examination of the behavior of underground excavations. Most North American mines subject to rockburst activity have installed seismic source location networks. Thus, little effort is anticipated for installation of instrumentation in this phase of the project, provided such data can be obtained in a timely manner. Observation of the performance of excavations may be accomplished by acoustic methods, noting the changes in the resonance characteristics of peripheral rock subsequent to dynamic loading. Prior to selection of the technique, however, an evaluation will be made to ascertain its propriety and functionality.

Changes in groundwater pressure and standing water level during and subsequent to a seismic event are to be determined for a series of events of various magnitudes and for a range of prevailing groundwater conditions. Thus, it is necessary to instrument several mine sites to encounter the range of conditions that may prevail at a waste repository in tuff. Saturated, unsaturated, and dry formation are of interest.

The prospective sites for field studies in North America are the deep-vein mines of the Couer d'Alene mining district of Idaho and the base metal mines of the Sudbury Basin, Canada. At both places, existing seismic monitoring systems and local expertise in seismic techniques provide a basis for development of technically sound programs of field investigation. Trips will be scheduled for site visits if preliminary data evaluation appears to be of consequence for evaluation of possible events of the Yucca Mountain site.

These data do not have to be representative of Yucca Mountain in detail. They are being used to identify pertinent phenomena and important parameters and to guide model development and calibration.

2.2.2.3 Measurement Techniques

Ground Disturbance Spectra Measurements. Earthquakes exert a variety of effects on groundwater. Of these, the most visible is the rapid rise and fall of water in wells or in the output of springs, together with mud and water eruptions from the ground. More frequent are slight fluctuations in well water levels, however, these hydroseisms most commonly occur in wells penetrating confined aquifers. The mechanism is dilatation, i.e., compression and expansion of elastic, confined aquifers through Rayleigh (earthquake) waves travelling at about 200 km/min, fluctuations then appear roughly an hour after the event, even in the case of very distant earthquakes.

Field measurements will primarily consist of long-term monitoring from established earthquake monitoring centers. Standard instrumentation components used to measure acceleration, velocity,or particle displacement at the monitoring site will be considered as acceptable input, as will calculations to identify epicenters. It is to be noted that direct observations of the parameters (acceleration, velocity, or displacement) of interest will be considered desirable, since integrations lead to uncertainties in magnitude assessments. Shock spectra from underground displacements are usually monitored with additional instruments such as stress gages (ytterbium or Manganin). Additional instrumentation other than that provided by the field test-site operator to document spatial distortion of the ground due to an impinging shock spectra will not be requested.

Ground Water Level and Pore Pressure Measurements. The effect of earthquakes on level of groundwater is of interest for creating and evaluating possible scenarios at the proposed repository site at Yucca Mountain. Consequently, the availability of data on general groundwater levels before and after earthquakes will be scrutinized, as will the availability of pore pressure measurements for before and after both earthquakes and underground detonations. If such data is not available at long-term monitoring sites, piezometers will be installed at feasible locations for additional monitoring for earthquakes. A request will be submitted for such measurements to be made at blast-monitoring sites. If water table-level data are not monitored, monitoring devices will be requested and installed in wells close to monitoring sites.

2.2.2.4 *Field Investigations Reports*

A report will be compiled on the initial investigation of possible field monitoring sites. This report will expand on the information assembled in the focused literature search. Sites, instrumentation, calibration techniques, reporting intervals and procedures, geologic description of site, history of data compiled with regard to earthquakes, and key site personnel will be documented in the report.

2.2.3 *Task 3 — Analytical Methods*

Objective

The objective of task 3 is to identify analytical methods which may be useful in explaining and understanding the behavior of tunnels in brittle, jointed, partially saturated rock when the host formations are subjected to displacements, velocities, and accelerations imparted from the impingement of earthquake spectra.

Justification

This task is necessary to provide an effective and efficient means for reducing, in conjunction with the laboratory physical model, the uncertainties associated with predicting the short- and long-term behavior of a repository when it is subjected to earthquake loading.

2.2.3.1 *Analytical Model Identification*

Computer codes are now commercially available which model the mechanics of static and dynamic loading on jointed rock, taking due account of the role of fissure water pressure. These codes have been written specifically to simulate the complex behavior of geologic materials, including slip and separation on joints, and coupling between the solid and any contained fluid. Several such codes have been demonstrated to be valid models of rock dynamics through retrospective analysis of underground nuclear events.

The purpose of code identification activity is to establish the suite of codes which may be applicable to the analysis of dynamic loading of excavations in jointed, brittle, partly saturated rock. This will be done by reviewing codes which have been assessed by groups such as the computer code committees of the International Society of Rock Mechanics and the U.S. National Committee for Rock Mechanics, and by identifying those codes which have been successfully applied in analysis of discontinuous, dynamically loaded media.

Particular codes which are current candidates for assessment are the distinct-element codes UDEC and 3DEC (Cundall)[1], the discrete-element code CICE (Williams, et al)[2], and the finite element code SPECTROM-331 (Key)[3]. All these codes (or suites of codes) can model the large strain, dynamic performance of jointed rock masses, and the interaction of installed support with the rock mass. The particular feature of each code which qualifies it for consideration in this work is the formulation of an interface element on which rigid body slip or separation can occur under static or dynamic loading. The contact logic in the distinct-element and discrete-element schemes is more versatile than that in the finite-element scheme. However, since the scale of displacements anticipated under dynamic load conditions does not involve change in block neighbors in the jointed mass, the finite-element scheme should also present a satisfactory model of a dynamically loaded medium.

The distinct-element codes incorporate logic to model the interaction between rock and contained fluids, which further qualifies them for the analyses required in this project.

A critical aspect of modeling the dynamic performance of a jointed rock mass is the analytical description of joint behavior under dynamic conditions. It is well known that the dynamic shear resistance of joint surfaces is dependent on the sliding velocity and some basic properties of the joint surface. Experimental determination of the stability and resistance to frictional sliding of joint surfaces has been a major concern in engineering seismology and geophysics in the recent past. Work by Rice[4], Ruina[5], and Dietrich[6,7,8] has shown that the general relation between shear resistance and sliding velocity is of the form

$$\tau = \tau_* + A \ln(V/V_*) + \theta \qquad (1)$$

where τ = shear strength,

V_* = ref velocity at which $\tau = \tau_*$,

θ = state function defined by

$$\dot{\theta} = -(V/L)\,[\theta + B \ln(V/V_*)] \qquad (2)$$

where A and B are constants.

The decay of θ with time involves the characteristic length L. From laboratory studies, L is in the range 40-50 μm. The relation between slip velocity and shear resistance is shown graphically in Fig. 2-1.

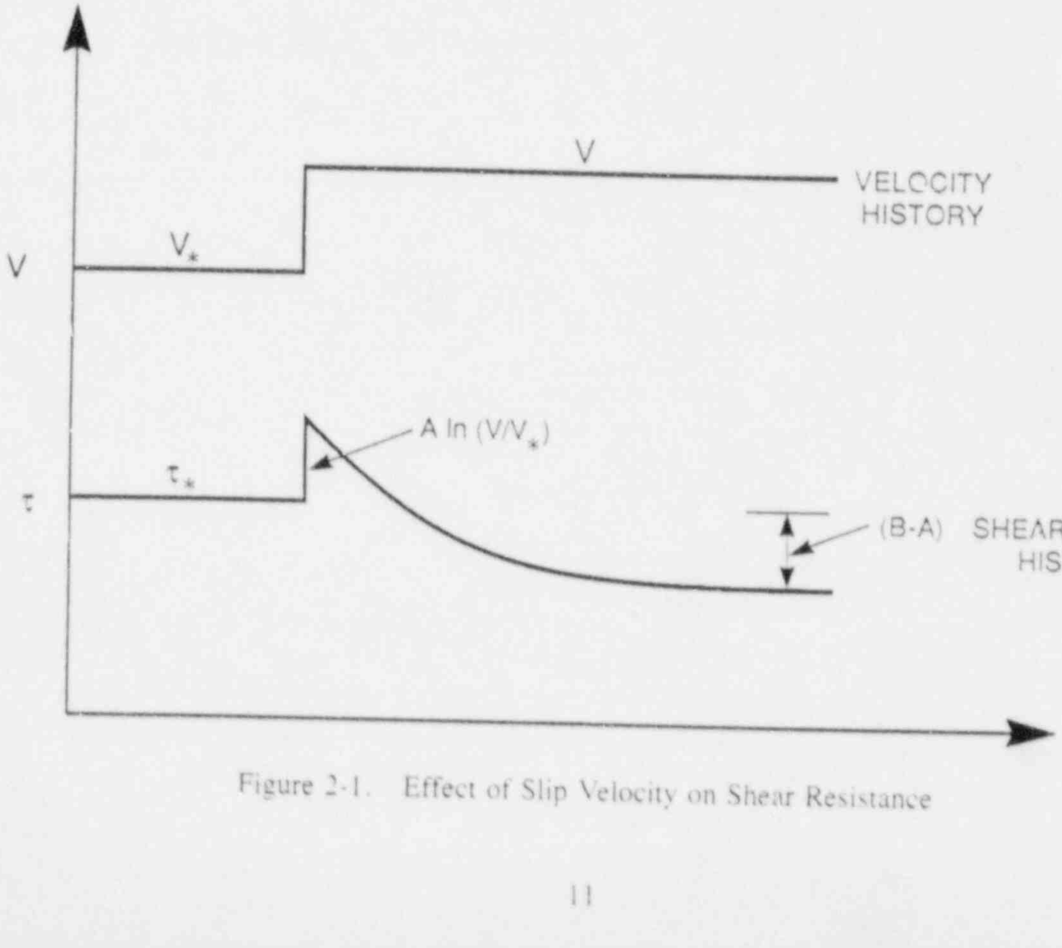

Figure 2-1. Effect of Slip Velocity on Shear Resistance

More recently, Hobbs and Brady[9] have shown that the shear resistance of a joint under impulsive change of normal stress is not simply related to a time-independent coefficient of friction. It appears that a sudden change in normal stress is followed by a time-dependent evolution of the shear resistance. This condition is supported by recent work by Olsson[10].

In the codes selected for validation studies, it is essential that the joint dynamic strength properties of the form described above are implemented. This is a straightforward matter for the distinct-element and discrete-element codes, which are dynamic relaxation schemes. It is not clear how readily the appropriate relations can be incorporated in the finite-element scheme.

2.2.3.2 Comparative Studies/Code Selection

The purpose of comparative studies of code performance is to determine which codes are appropriate and efficient simulators of the behavior of jointed rock under impulsive loading. The studies will be of three types, which together are intended to evaluate the way in which the equations of motion are implemented in the various codes, the constitutive equations employed for modeling rock mass behavior and discontinuities, and the way in which the time history of an event is introduced in the computational scheme.

The first type of study will consist of an evaluation of how each code handles the analysis of a simple, well-controlled laboratory experiment, such as a single block on a surface subject to imposed transient motion. The degree of correspondence between observed motion and predicted motion will be a direct index of the adequacy of a code in modeling elementary rock dynamics processes. Codes which show acceptable performance in this study will qualify for subsequent studies.

In the second type of study, each qualified code will be used to analyze the dynamic response of a physical model of an excavation in a jointed medium subject to controlled loading. In the model studies, particular attention will be paid to the rigid body displacements induced at joints in the course of impulsive loading. The extent to which a code predicts the magnitude of the shear displacement a joint will indicate the adequacy of the constitutive equations for joints, and of the computational solution of the equations of motion.

In the third type of study, rock mass response associated with a well executed field experiment, such as the STARMET experiment, will constitute the subject for analysis. The time history of explosively applied loading will be provided, and each code will be used to predict ground motion at various points in the rock mass. The purpose of analysis of such an experiment is to ensure that the problems of studying a real rock medium under scaled field loading conditions are addressed explicitly. These problems include uncertainties in rock mass conditions, adequate numerical representation of the frequency composition of the dynamic loading, and the capacity to represent the large number of degrees of freedom inherent in an appropriate model of a rock mass.

At the conclusion of these studies, it will be established which codes represent the fundamental rock dynamics satisfactorily and which also simulate the field performance of a dynamically loaded rock mass to an acceptable engineering tolerance. The validity of these code calculations will be checked with both field data and results from the physical model tests described under task 4.

2.2.3.3 Selection Report

A report will describe the assumptions for the physical model used in each candidate code along with a description of the calculating procedure and algorithms necessary for proper functioning of each code. Correlations between analytical results and field data will be made as will correlations between code results and data from the laboratory physical model. Of consequence will be: 1) the loading function (earthquake or shock spectra), 2) block size and fault pattern (rock properties), and 3) moisture condition (saturated vs unsaturated).

The code that is considered to predict most accurately the scenarios documented from field experience will be chosen as the representative code. Predictions from this analytical procedure will be used in conjunction with laboratory experiments with the physical model.

2.2.4 *Task 4 — Model Validation*

OBJECTIVE

The objective of task 4 is to provide validation for the analytical model selected from task 3, using parameters and characteristics in tasks 1 and 2 relating to:

a) earthquake occurrences

b) underground blast impingement

c) water table changes due to these possible events

JUSTIFICATION

Currently, seismic response data for tuff is limited. This task will develop the necessary dynamic/seismic response data that is required for validating available numerical models.

Generally, the approach for task 4 involves a comparison of analytical predictions with experimental data. However, it is complicated by the fact that responses must be predicted for two dissimilar types of excitations (i.e., ground shock and earthquake); little or no data exists for the actual site of concern (Yucca Mountain); and scale model experiments are involved, since earthquake motion cannot be produced at will. Therefore, task 4 will include acquisition of a variety of full scale and scale model experimental data, and integration of this data into a validation plan for the analytical model. The result will be a demonstration that the analytical model predicts the correct responses under a given set of excitations for a system whose appropriate physical properties are known.

The most fundamental description of a dynamic system is shown in Figure 2-2, in terms of the physical system, properties of the excitation, and the resulting response. Analytical representations of each part of such a system have been described in task 3. Herein, we will describe both full scale and

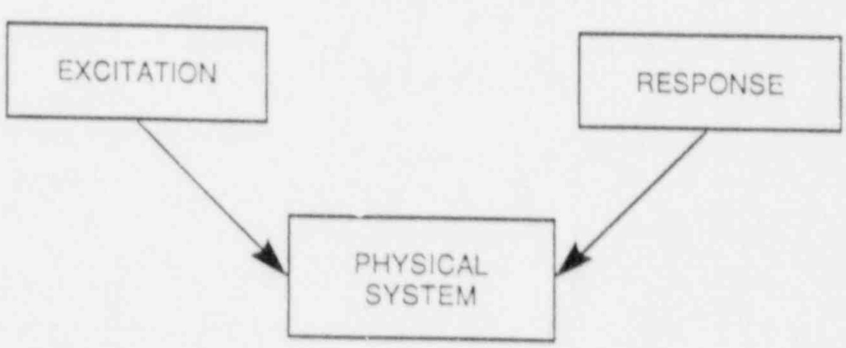

Figure 2-2. Fundamental Dynamic System

scale model experimental representations of each part of such a system, and develop a plan which provides a methodology and basis for evaluating the degree of correspondence between the results and those predicted from the analytical representation.

For purposes of validating the analytical model, the physical system will probably be represented by a segment of rock mass from what will be called the reference site. This rock mass will consist of an aggregate of rock material blocks bound together by fracture joints and subject to at least one overall fault in the rock mass. Thus, as indicated in Figure 2-3, a description of the physical system requires an independent acquisition of data on physical properties of the basic rocks, information on geometry, and on physical processes such as block interface and fault mechanisms. All such data must be gathered from existing sources, where appropriate, or be obtained from additional independent laboratory or field-site tests. Were such data available along with excitation and response measurements at the Yucca Mountain site, validation of the analytical model could be performed *directly* with that information. However, preliminary investigations indicate that such information is not likely to be available for several years, and the validation will have to be performed *indirectly* with data available from the reference site. Furthermore, this indirect validation includes both types of excitation, and provision for use of both full scale and scale model information about the reference site, as will be appropriate. Thus, the computer codes can be validated for a more general application than for site-specific conditions.

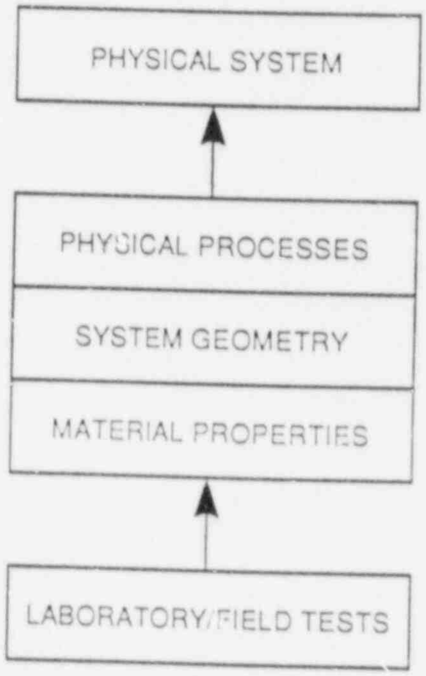

Figure 2-3. System Identification/Material Properties Tests Evaluation

The exact validation plan to be developed must be based on the nature of available data and the amount that must be further acquired. However, a tentative conceptual approach to the plan is shown in Figure 2-4, in which the block numbers correspond to subtasks whose details are subsequently described. The general approach starts with the selection of a reference site which is geologically similar to that for Yucca Mountain and yet has been subject to previous ground shock and/or earthquake experiments. All required information about the reference site probably will not be available. However, at least experimentation with ground shock will have been conducted and the resulting information available. A strong candidate is welded tuff for which data has been reported by Hart, et al[11]. All data on material properties, physical processes, and excitation information must be summarized for the reference site (steps 1 and 2 of Figure 2-4). Additional tests will be performed to provide the lacking information. This leads

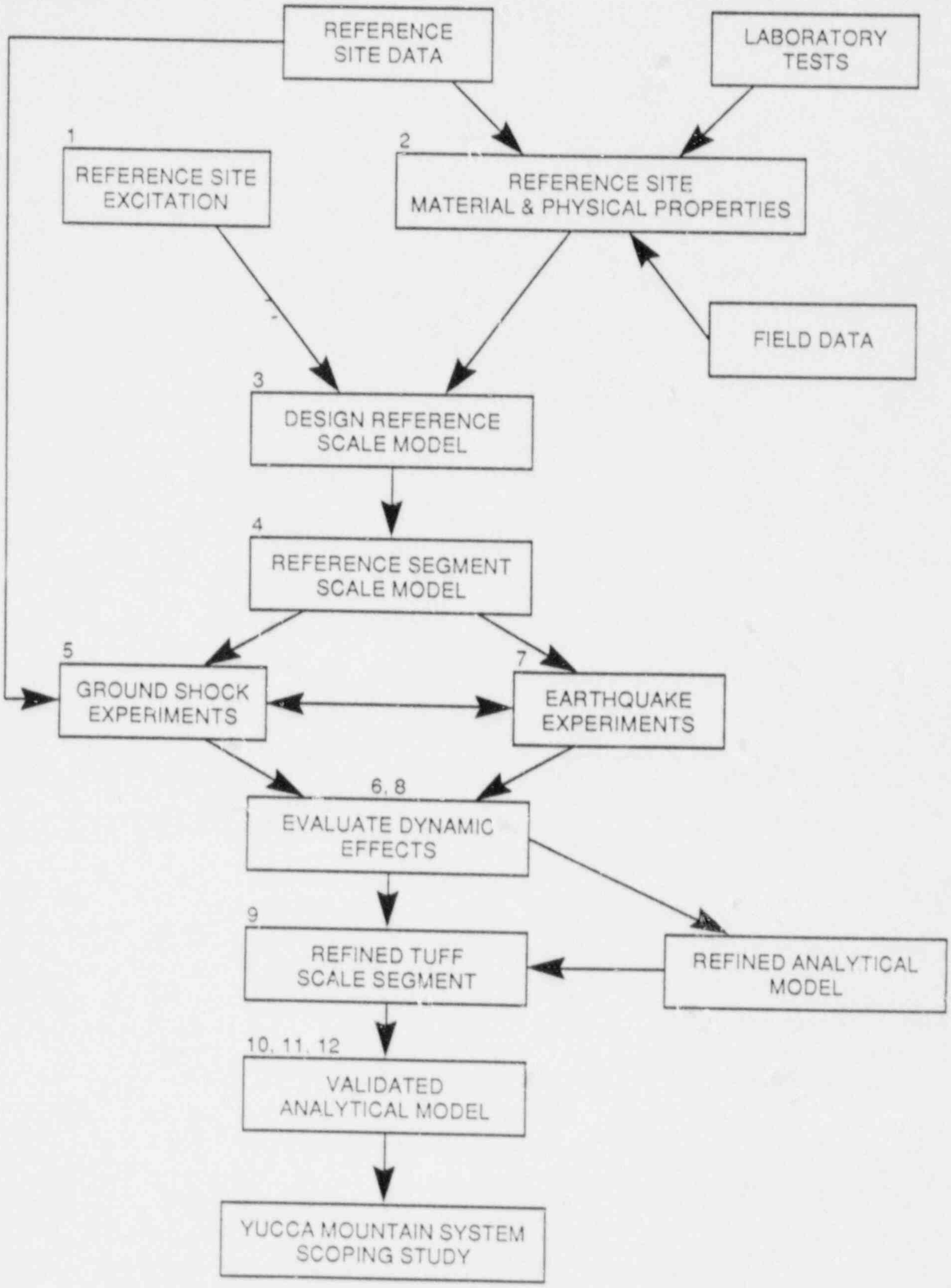

Figure 2-4. Validation Plan for Analytical Model

to (3) the formulation and (4) design of a reference segment scale model. The use of a scale model is deemed necessary since earthquake experiments under controlled conditions are required. Only a segment of an entire system will be used, since size considerations are a practical factor. The scale model will be subjected to both ground shock (5) and simulated earthquake (7) excitations, and the responses observed. This will allow evaluation of frequency effects (6) and (8), and refinement of the corresponding analytical model (9) for the reference segment. Furthermore, the refined model will be reconciled for all data available for the reference site under both dry and saturated conditions (10), (11), (12). Thus, the model will have been validated for the reference site information, and is ready for application to the Yucca Mountain site scoping study.

2.2.4.1 *Develop Reference Excitation*

A description of the reference site excitation must be developed in terms of one or more of the following parameters:

a) Time history

b) Response spectrum

c) Power spectrum

It may be noted that these forms are interchangeable and apply to both ground shock and earthquake motion. They are typically used for both analytical and experimental dynamic models. It is usually more general to specify the excitation as a response (shock) spectrum and develop a time history compatible with it. The resulting time history is not unique, but does possess the appropriate statistical properties and frequency content.

Figure 2-5, which is taken from Vortman[12], shows sample response spectra for both earthquake and ground shock motions. The results are given in terms of pseudorelative velocity, from which relative acceleration and relative displacement also can be derived. In an article by St. John & Zahrah[13], it is shown that the functions represent the peak response of a damped single-degree-of-freedom oscillator whose base is excited by the transient time history. Thus, development of a time history which produces the given response spectrum requires an inverse computation. Computer codes for this purpose are available at SwRI, and have typically been used for computation of both blast and earthquake motions for a variety of applications (Unruh)[14].

It should be emphasized that once a time history has been synthesized, displacement, velocity, and acceleration are present and must be compatible. However, a preference of one over another (i.e., peak velocity) has sometimes been made in the past in developing damage mechanisms in rock material. In the proposed experiments and modeling, this fact will be noted, but any one of the motion parameters may be used as required.

It is seen from Figure 2-5 that the frequency content of earthquake and ground shock motion is significantly different. Furthermore, the time duration of these motions is dramatically different. (A typical earthquake may last 30 seconds, while ground shock occurs over a few milliseconds.) These differences pose significant problems in predicting the responses of a given physical system to the two different types of excitations. This stems from the fact that physical material properties and joint/fault properties are variable with both frequency and time duration. Hence, this behavior must be accounted for in both analytical and physical scale modeling.

The output from this task will be a set of reference spectra and compatible time histories for both ground shock and earthquake motion which has been experienced at the reference site, or could reasonably be expected to occur at the reference site.

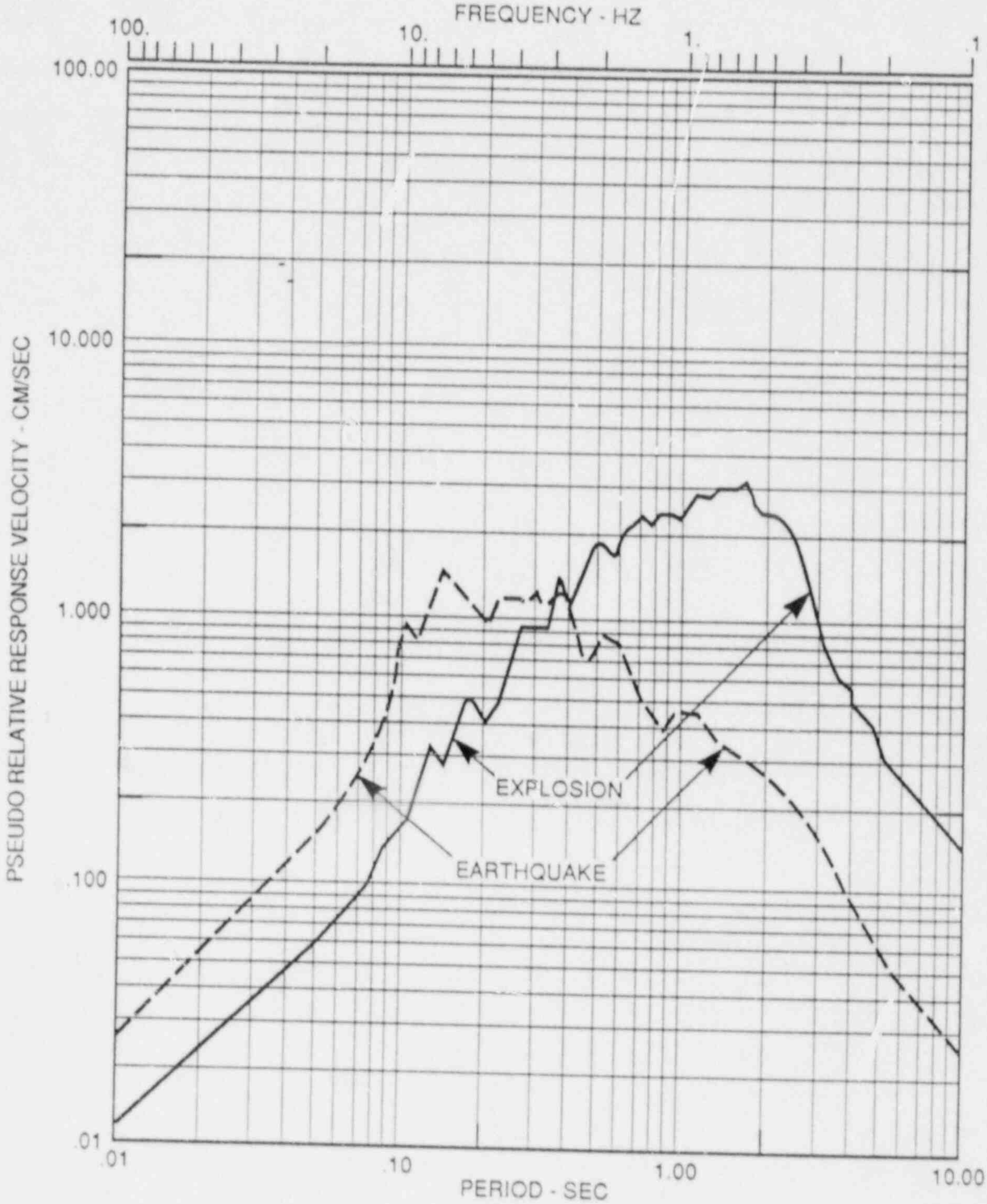

Figure 2-5. Comparison of PSRV's for Horizontal Component for Earthquake and Underground Explosion

2.2.4.2 *Establish Reference Material and Physical Properties*

The objective of this subtask was shown conceptually in Figure 2-3. Thus, by independent laboratory and/or field tests, one must establish the material properties (rock elasticity, geometry, density, homogeneity, etc.), as well as joint force/slip properties and fault force/slip properties. Some of this type of data is already available (Olsson & Jones)[15] from standard soil triaxial tests, and has been used in some finite element dynamic models for ground shock (Hart, et al)[11]. However, it is anticipated that significantly more testing will be necessary to establish the required data for the reference site. Furthermore, procedures for acquisition of site samples and further test methods are given by Sues & Short[16].

Standard compression tests for the reference rock material properties will be conducted in the SwRI material laboratories. A variety of material test machines are available for this purpose. If necessary, use of outside facilities such as those of Sues & Short[16] will be sought. These tests will deal with the properties of the basic unfractured rock material samples acquired at the reference site. The effects of different wetness conditions must be evaluated. It is anticipated that the required site samples will be made available to this program through appropriate arrangements by the NRC.

Another series of tests must be developed and conducted to quantify the force/slip properties at fractures in rock and at faults. The exact nature of these tests is yet to be determined. However, compression/slip tests of the type described by Bakhtar & DiBiona[17] are initially anticipated. The effects of degree of saturation and depth/gravity conditions must be included in the evaluations. Nevertheless, another presently nonstandard preliminary dynamic test will also be included. This is depicted in Figure 2-6 where a typical full-scale faulted block specimen from the reference site will be tested on the SwRI motion simulator. The blocks will be instrumented for response and subjected to an indicated base motion which represents the full-scale earthquake and ground shock excitations developed in task 4.1. Both experiments will be independently analyzed with the analytical model selected in task 3. Rock material properties and force/slip properties will be based on the previously conducted compression-type tests. Correlation of the predicted and measured responses for the preliminary full-scale dynamic tests will be essential before proceeding to the subsequent subtasks which involve scale models.

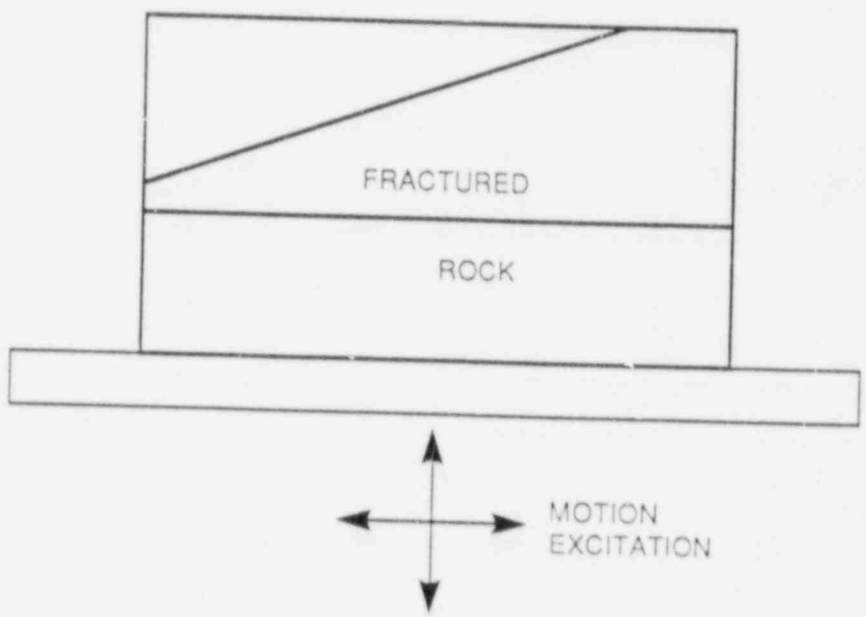

Figure 2-6. Preliminary Experiments with Full-Scale Fractured Rock

2.2.4.3 *Formulate Scale Model Reference Segment for Reference Site*

In this study, a scale model ultimately will be used to determine earthquake response of a large segment of the reference site rock mass. However, scale-model experiments which correspond to the various material and physical property tests for the reference site must also be performed beforehand to assure that a valid modeling of the system properties has been achieved. Procedures for scale-model studies of physical phenomena are based on similitude theory (Baker, et al)[18]. Essentially, the process involves selection of the dimensional variables involved, formation of nondimensional variables, and design of a physical scale model for experiments based on the nondimensional variables. Measurements of dynamic response of these scale models can then be interpreted in terms of responses for the full-scale prototype.

Some of the dimensional variables which will be involved for dynamic response in a faulted rock mass are given in Table 1. These variables are tentatively based on somewhat similar scale model

TABLE 1. TYPICAL SCALING PARAMETERS

Tuff Continuum (Unsaturated/Saturated)

- Elastic Modulus, $E_r(\epsilon)$
- Loss Modulus, $E_i(\epsilon)$
- Density, $\rho(\epsilon)$
- Finite Segment, ---

Nonhomogeneity (Dry/Saturated)

- Block Geometry, d_B
- Block Slip, B_s
- Fault Slip, F_s
- Fault Geometry, d_F
- Gravity/Depth, ---

Earthquake/Ground Shock

- Acceleration, a_s
- Velocity, v_s
- Displacement, x_o
- Frequency, ω
- Time Duration, T_e
- Gravity, g

Structure Properties

- Tunnel Geometry, d_T
- Liner Properties, ---

Response

- Acceleration, a_s
- Velocity, v_s
- Displacement, x_s
- Stress, σ_s
- Strain, ϵ_s

experiments which were conducted at SwRI [19] to determine earthquake response for pile foundations in clay material. More details of variables associated with rock mass material and joint slip properties and their modeling can be obtained from Sues & Short[16] and Bakhtar, et al[17], and other similar sources. Some corresponding sample nondimensional variables are given in Table 2, in which a geometric scale factor λ and a rock density factor α has been assumed. These samples are given to indicate the type of requirements that will result from the complete similitude analysis that will be performed for the reference site segment. In particular, it should be noted that scaling at constant gravity is possible, providing that a synthetic rock material is developed. It is our intent to develop the required model with this approach. Otherwise, centrifuge testing is necessary, and simulation of reasonable earthquake motions is extremely difficult. Furthermore, use of larger geometric scales is possible at one-gravity. Recent similar experiments at SwRI (Boyce, et al)[19] demonstrate that the one-gravity approach has great promise.

TABLE 2. SAMPLE SIMILITUDE REQUIREMENTS

Variable Identification	Variable Ratio	Numerical Ratio
Gravity	g_m/g_p	1.0
Block Geometry	D_m/D_p	$1/\lambda$
Rock Density	ρ_m/ρ_p	$1/\alpha$
Structure Stiffness	$(EI)_m/(EI)_p$	$1/\alpha\lambda^5$
Position Coordinate	y_m/y_p	$1/\lambda$
Response Deflection	x_m/x_p	$1/\lambda$
Structure Mass/Length	M_{pm}/M_{pp}	$1/\alpha\lambda^2$
Rock Elastic Modulus	E_{rm}/E_{rp}	$1/\alpha\lambda$
Rock Loss Modulus	$E_{\ell m}/E_{\ell p}$	$1/\alpha\lambda$
Frequency	ω_m^2/ω_p^2	λ
Time Duration	$T_o^2{}_m/T_o^2{}_p$	$1/\lambda$
Lateral Force Amplitude	F_m/F_p	$1/\alpha\lambda^3$
Ground Acceleration	A_m/A_p	1.0
Ground Velocity	$\upsilon_m^2/\upsilon_p^2$	$1/\lambda$
Ground Displacement	X_{gm}/X_{gp}	$1/\lambda$
Fluid Properties	*(To be determined)*	

A complete similitude analysis will provide the design requirements for the scale model, its material properties, and the force/slip characteristics for fractures and faults. An optimum design must be selected so that the synthetic model can, in fact, be physically fabricated, the excitation be appropriately scaled and produced, and the joint/fault slip properties be physically realizable.

Scaling of earthquake ground motion at constant peak acceleration has been performed for a variety of applications at SwRI (Kana & Scheidt)[20]. The approach essentially amounts to shifting of the response spectra shown in Figure 2-5 along lines of constant peak acceleration. Then, development of a time history to match the scaled spectrum can readily be achieved.

A crucial step in using the scale-model approach for representing the reference site rock mass segment is that all previously conducted full-scale material and physical property tests must also be performed on the synthetic rock material to validate its performance in the scale model. These tests must be performed under scaled parameter conditions that correspond to the scale model. They will be performed on a select basis for economy purposes. However, a scaled test must also be performed to correspond to the preliminary dynamic test described in Section 2.2.4.2. This will verify that the correct joint/fault slip properties have been incorporated at the scale model level to correspond with the independent material and physical properties data for full scale.

2.2.4.4 *Design and Fabricate Scale Model Reference Segment*

All of the experimentation and analysis up to this point have been included to assure that the scale-model approach is valid. The scale model reference segment will now be used as a representation of a significant part of the reference site under controlled excitation conditions. Using the laws of scaling, its response measurements will be interpreted as if they were acquired from experiments on the full scale site segment. Thus, ground shock and earthquake experiments are to be performed on this scale model, and its responses are to be predicted by the analytical model. Correspondence of the measured and predicted results will validate the analytical model for the reference site conditions.

The geometric scale to be selected for the reference site segment is critical in the scale-model design. Obviously, incorporating a large segment of the reference site rock mass, including at least one fault, and some tunnel sections is desirable. On the other hand, for economy, it is also desirable to be able to accommodate the model on the existing SwRI seismic simulator. At this point, it appears that a scale of the order of 1/30 may be feasible. The scale to be used will be determined based on typical joint frequency and fault spacing at Yucca Mountain.

Figure 2-7 shows conceptually what the scale model reference site segment may look like where mounted on the seismic simulator. An important part of the model includes appropriate end boundary conditions which provide the same effect as an infinite medium horizontally. The end impedances must be correctly designed to provide the appropriate compliance. Furthermore, any potential depth/gravity and/or stress/pressure effects on joint/fault slip properties must also be incorporated. This may be done by providing a variable coefficient of friction on the slip surfaces at different depths. With the indicated

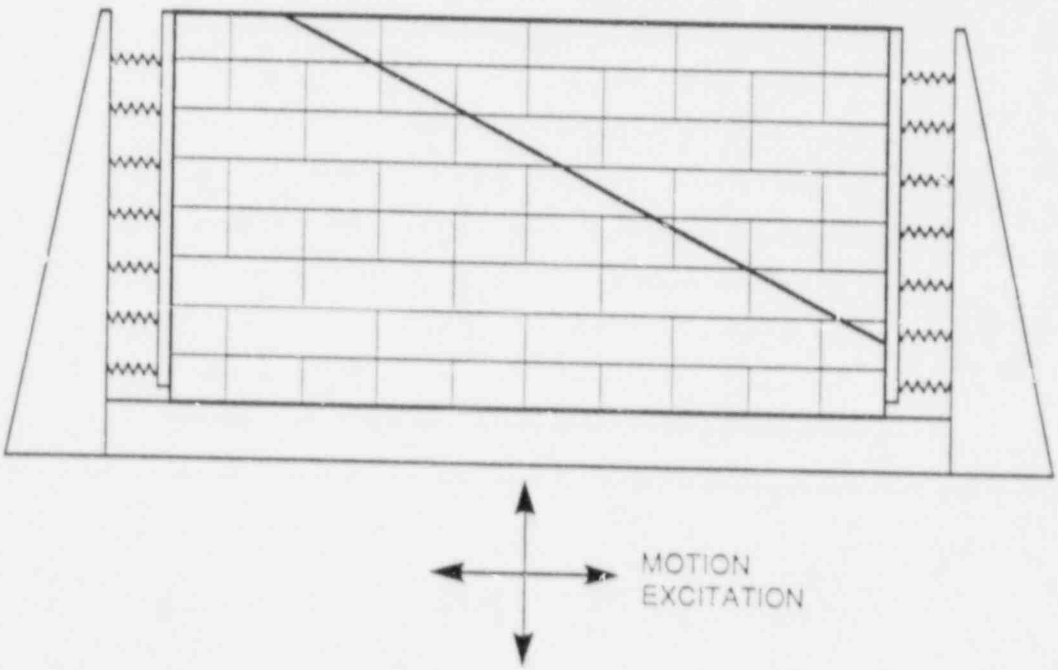

Figure 2-7. Experiments with Scale-Model Faulted Rock Mass Segment

setup, motion will be imparted to the system uniformly along the table surface. In effect, this assumes that the wavelength of the motion is no smaller than the length of the segment itself. At this point, it appears that this approach is realistic.

Production of realistic scaled earthquake excitation with the seismic simulator can readily be achieved. We have performed such experiments for a variety of applications under scales in the vicinity of 1/30 (Kana & Scheidt)[20]. Typically, the motion parameters scale according to the indications in Table 2. Accelerometers are used to measure both excitations and response motions at various locations on the model. However, production of ground shock experiments is not so straightforward.

In the past, ground shock experiments at SwRI and elsewhere typically have been produced by light explosive charges. This approach can be used for the reference site segment model if necessary. However, it would be much more efficient to be able to produce a ground blast simulation by means of an impulsive motion applied directly on the seismic simulator. Even if the correct frequency content were not present, if the motion were more like ground shock than earthquake motion, frequency effects in the response could still be evaluated. Actually, by studying Figure 2-5, it would appear that scaling of a ground shock spectrum and development of a corresponding time history is quite feasible. In that particular case, the dominant ground shock frequency components are actually *lower* than those of the earthquake. The exact nature of the two spectra depend on the depth at which the events occur. Thus, production of the ground shock scaled motion by means of the seismic simulator will be investigated very carefully before embarking on this phase of the experiment.

2.2.4.5 *Scale Model Reference Segment Ground Shock Experiments*

Several test runs under simulated ground shock excitation will be performed on the scaled site segment model. For each run, the excitation and response time histories will be recorded on analog tape. Up to 14 channels can be accommodated on one recorder. A second recorder will be used if more channels are necessary. The exact number will depend on the data available from the full scale reference site. Subsequently, the analog data will be digitized for computer processing. All required data acquisition and reduction equipment are already available in the SwRI Dynamics laboratory.

The exact excitation levels and durations will be scaled to correspond to data available for the test site. However, particular attention must be paid to whether any irreversible (plastic) response occurs in the specimen. If present, the order of the test runs will be especially important. Furthermore, this will determine whether more than one model will be needed to accommodate subsequent earthquake testing.

2.2.4.6 *Correlate Scale and Reference Ground Shock Data*

Various parameters for both excitations and corresponding responses will be developed for both the full scale reference site and the scale model site segment. Corresponding nondimensional parameters should be equal *on a spectral basis*. Note that time histories will not correspond since exact time histories will not be duplicated. In effect, the results will correspond to different events whose spectral properties are equal, but whose exact time histories are not. Validation of the analytical model can still be performed on this basis.

The above results will also be compared to those predicted for the scale-model segment by the analytical model. Material and physical characteristics for this model will be based on tests on the model materials as identified in Section 2.2.4.3. Correspondence of the predicted and measured ground motions will be required for validation of the model for ground shock at the reference site. For this process, the same time history used to excite the scale model may be used to excite the analytical model.

2.2.4.7 *Scale Model Reference Segment Earthquake Experiments*

As previously mentioned, it is probable that little or no earthquake data will be available for the reference site. Therefore, Section 2.2.4.7 will be especially important in the analytical model validation process. Several earthquake test runs will be performed at increasing amplitude levels. Responses will be measured at locations similar to those used for the ground shock experiments. Again, all time histories will be recorded on analog tape and subsequently digitized for further processing.

The test time histories will be based on scaled spectra from the reference site if any are available. If none are available, then the motion will be based on a Standard NRC Regulatory Guide 1.60[21] spectrum. This spectrum is developed from ground motion spectra for many far-field earthquakes. We have used it for a variety of scale-model earthquake experiments in the past.

Response time histories and their associated parameters from the experiments will be compared with those predicted from the analytical model. Material and physical characteristics used in this model will be based on previous results from Section 2.2.4.3. Thus, an evaluation of the analytical model for predicting typical earthquake response at the reference site will be carried out.

2.2.4.8 *Evaluate Dynamic Effects on Reference Segment*

This subtask is included in case there will be significant differences in frequency content of the ground shock data and earthquake data, and the reference site physical properties demonstrate a frequency dependence. A dependence on time duration of the two different types of excitation transients may also exist. At this point, it appears that such dependencies will, in fact, exist. Therefore, the ground shock data and the earthquake data for the scale model reference segment will have to be examined for this behavior. One approach will be to compute transfer functions between the excitation and various response points for both types of transients. This can readily be performed via multi-channel Fast Fourier Transform modal analyzers that are available in the SwRI Dynamics laboratory. Furthermore, algorithms are also available for batch processing of digitized time histories for transfer function parameters. This approach has been used routinely for a variety of applications in the past. Any difference of transfer functions for a given response occurring for the two different types of excitations generally can be attributable to dependence of material physical properties on frequency and/or duration of the event. If differences exist, then assurance must be provided on the validity of the earthquake range data.

2.2.4.9 *Develop Refined Scale Tuff Segment Model*

At this point, a validation of the analytical model will have been achieved for the reference site segment. However, the material and physical characteristics and any present tunnel system details will likely be different for the reference site and the Yucca Mountain site. Furthermore, complete unsaturated and saturated conditions may not be available for the reference site, whereas, both cases need to be considered for the tuff of the Yucca Mountain site. Therefore, the purpose of this subtask is to develop a scale-model segment for the actual Yucca Mountain site for both an unsaturated and a saturated condition. Scale-model earthquakes will be performed for both models so that responses can be measured and compared with those predicted by the analytical model when applied to the scaled segment of the Yucca Mountain site.

In effect, much of the previous effort will have to be repeated to develop the two (one unsaturated, one saturated) models for the Yucca Mountain site. Select material and physical property tests will need to be performed both at full scale and at model scale to provide this data for input to both the analytical and the physical scale models. The amount of such additional tests will depend on the degree of differences between the reference site and the actual Yucca Mountain site.

2.2.4.10 *Reconcile Analytical and Scale Site Segment Models*

The data from Section 2.2.4.9 will be evaluated carefully so that a final validation of the analytical model can be achieved for conditions at the Yucca Mountain site. Both unsaturated and saturated conditions will be included. It is anticipated that the degree of validity may vary depending on the various parameters that affect the response. Thus, any potential limitations on the use of the refined analytical model will be evaluated and carefully documented.

2.2.4.11 *Reconcile Analytical and Field Data*

During the entire progress of task 4, field data measurements will have been acquired for select sites under the progress of task 2 (Instrumentation/Field Studies). In particular, actual earthquake response data at a given site may have been acquired. The refined analytical model will be applied to predict responses at that site, to the extent possible. In this, estimations of the material and physical processes may be required for the site. In any event, the results will be a corresponding prediction for response at the given site and, therefore, a further demonstration of the utility and/or limitations of the refined analytical model.

2.2.4.12 *Report on Model Validation*

This task includes compilation of annual progress reports, as well as a comprehensive final technical report. In view of the overall complexity of task 4, it is probable that the comprehensive report will be compiled into several different volumes, with each covering a different area. The final subjects to be chosen will depend on the nature of the results to be achieved. In any event, the series of reports will be directed toward providing convincing evidence of the extent and range of validity for the resulting analytical model.

2.2.5 *Task 5 — Yucca Mountain Scoping Analysis*

OBJECTIVE

The objective of task 5 is to develop a site specific scenario for predicting and evaluating the effects of possible occurrences of seismic events at Yucca Mountain using inputs from tasks 1, 2, 3, and 4.

JUSTIFICATION

This task will provide direction for decisions affecting repository design, construction, and postclosure performance at Yucca Mountain.

2.2.5.1 *Establishment of Site-Specific Conditions*

In establishing site specific conditions, existing information concerning the Yucca Mountain site will be assembled and reviewed. Particular attention will be paid to assessing the likely range for each parameter. The primary sources of information for geomechanical parameters will include the Reference Information Base (RIB) and Chapter 2 of the CDSCP as well as referenced documents. The Conceptual Design Report and associated references will be the primary sources of information for repository layout and depth, thermal loading, excavation size, shapes, and orientation, etc. Prior to performing the detailed dynamic sensitivity studies, a set of reference pre-emplacement and post-emplacement conditions will be established as the starting point for dynamic analyses.

The detailed scoping study will be performed for the following three scales:

Canister Scale — Studies at the canister scale will focus on the potential for significant discontinuity offset to occur which might cause canisters to be breached or retrieval to be impaired. Both lined long horizontal waste emplacement holes and partially lined short vertical emplacement holes will be studied.

Drift Scale — Studies at the drift scale will focus on the potential for significant shaking to collapse major excavations, such as shafts, ramps, and drifts, as well as their intersections. Collapse of such excavations could significantly affect repository operations and postclosure performance of engineered barriers. The beneficial effects of support, reinforcement, and backfill in mitigating the damaging effects of shaking will be ascertained.

Repository Scale — Studies at the repository scale will consider the topography, groundwater table, and stress state among other things in studying the behavior of major faults in the repository block when subjected to dynamic loading. The primary objective of these studies would be to predict the amount of differential displacement which might occur at various locations as a result of dynamic loading.

For all the analyses, the effects of a broad range of possible problem parameters will be investigated independently. Some specific problem parameters to be investigated include:

(1) the input far field dynamic source, including both compression waves and shear waves;

(2) orientation of excavation axes relative to major discontinuities and far field sources; and

(3) saturation (both fully saturated and unsaturated conditions will be studied).

Near the conclusion of the study, the results will be evaluated and the importance of various problem parameters prioritized. If necessary, some additional analysis may be required to confirm the findings of the study. The final results of the study should be beneficial in evaluating DOE site characterization proposals in the near term, and license application at a later date.

The preceding discussion was concerned with studies of repository near-field response to dynamic loading. With regard to the Yucca Mountain site, it has been suggested that dynamic events and tectonic loading may have substantial far-field effects, both with regard to fault slip and changes in the groundwater table. Some of the codes described previously will have the capacity to model coupled fluid-solid mechanics so that it will be possible to assess, in detail the effect of dynamic loading events on regional groundwater response. These investigations will be conducted as a sensitivity study, assessing the effect of both typical and extreme magnitude events, and various recurrence times for events, on regional response. Tectonic loading, involving pseudo-static loading and deformation, will also be examined in detail, in an appropriately designed parameter study.

The conclusion from the far-field studies will be a realistic and credible assessment of the scope of the computational problem posed by changes in groundwater conditions associated with both pseudostatic tectonic loading and dynamic loading.

2.2.5.2 *Reduction of Uncertainty*

The Yucca Mountain Scoping Analysis consists of a comprehensive sensitivity study aimed at reducing uncertainty regarding the probable dynamic behavior of emplacement holes, drifts, shafts, ramps, and the repository. The damaging effects of both shaking and discontinuity offset will be studied. The scoping analysis will consist of two parts. First, a data base defining the site specific conditions will be established. Secondly, these site specific conditions will then be used as input for performing the numerical analysis. Special attention will be paid during the study to systems, components, and structures which are potentially important to safety, waste isolation, and retrieval.

2.2.6 *Task 6 — Technical Position Report*

Objective

The objective of this task is to develop the technical documents necessary to support NRC's technical issue tracking and resolution process.

Justification

The results of the research conducted on this project must be documented in technical position reports and like documents. The technical position reports will support the development of guidance to DOE, rule changes, or change to Standard Review Plans.

2.2.6.1 *Reports*

Deliverables in the form of draft reports have been identified in tasks 1-5. These draft reports offer technical conclusions on the directed research in the respective technical areas. However, in this task (task 6), reports will be developed that will be directed toward supporting the repository licensing function of the NRC. Two intermediate and major technical position reports are planned for this project. These reports, at a minimum, will include the following:

- Purpose of the report to the licensing process
- Findings/issues addressed
- Summary description of the results of research to date
- Status of uncertainty resolution as a result of the research
- Recommended use of results
- Preliminary outline for the recommended licensing-support documentation and/or staff technical position.

2.3 Schedules, Milestones, and Deliverables

The milestones, with the schedules, for the six tasks are shown in the Gantt chart in Figure 2-8. The deliverables in the form of reports, also shown in Figure 2-8, are listed in Table 2-3. Upon approval, these milestones and activities will be incorporated into the integrated Center Schedule (SEE WSE&I Operations Plan).

Milestone Number	Milestone Type	Deliverable Description	Completion Date
1	Intermediate	Preliminary Draft Integrated Report on computer search of data bases, component characterization and field monitoring sites	9/30/88
2	Major	Draft Integrated Report on the focused literature search	1/30/89
3,4	Intermediate	Preliminary draft Field Investigation Reports	4/20/89 9/30/90
5	Major	Draft Field Investigation Report	8/31/91
6	Intermediate	Draft Analytical Model Identification Report	12/20/89
7,8	Intermediate	Draft Comprehensive Studies/Code Selection Reports	4/20/89 9/30/89
9	Major	Draft Analytical Code Selection Report	12/20/89
10,11,12	Intermediate	Draft Model Validation Reports	12/20/88 9/31/89 8/31/90
13	Major	Draft Model Validation Report	8/31/91
14	Intermediate	Draft Site Specific Condition Report	12/20/90
15	Intermediate	Draft Uncertainty Reduction Evaluation Report	9/30/91
16,17	Intermediate	Draft Technical Position Report	9/15/89 9/15/90
18	Major	Draft Consolidated Technical Position Report	8/30/91
19	Major	Draft Final Project Report	10/30/91

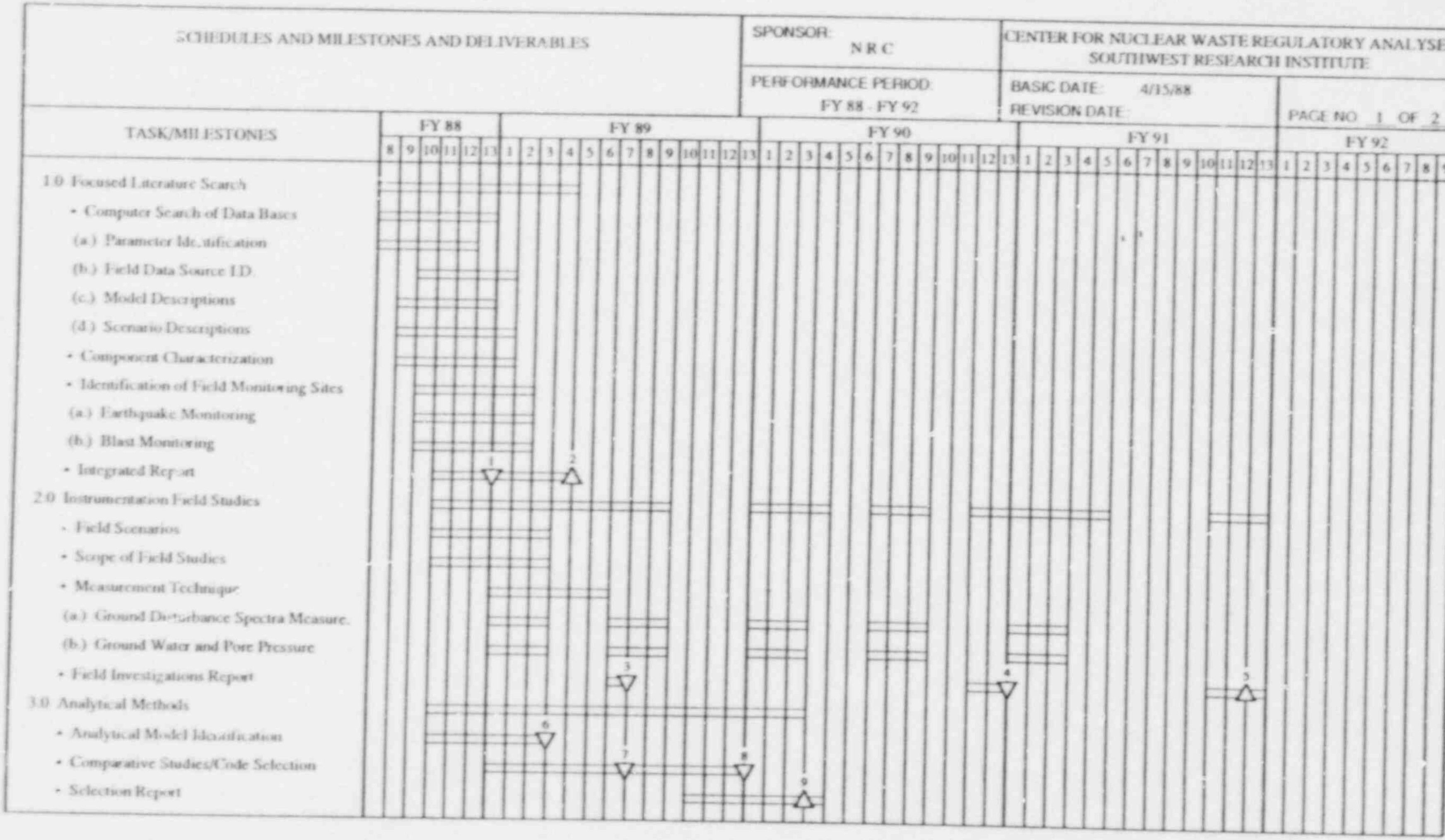

Figure 2-8. Schedule, Milestones, and Deliverables (Gantt Chart)

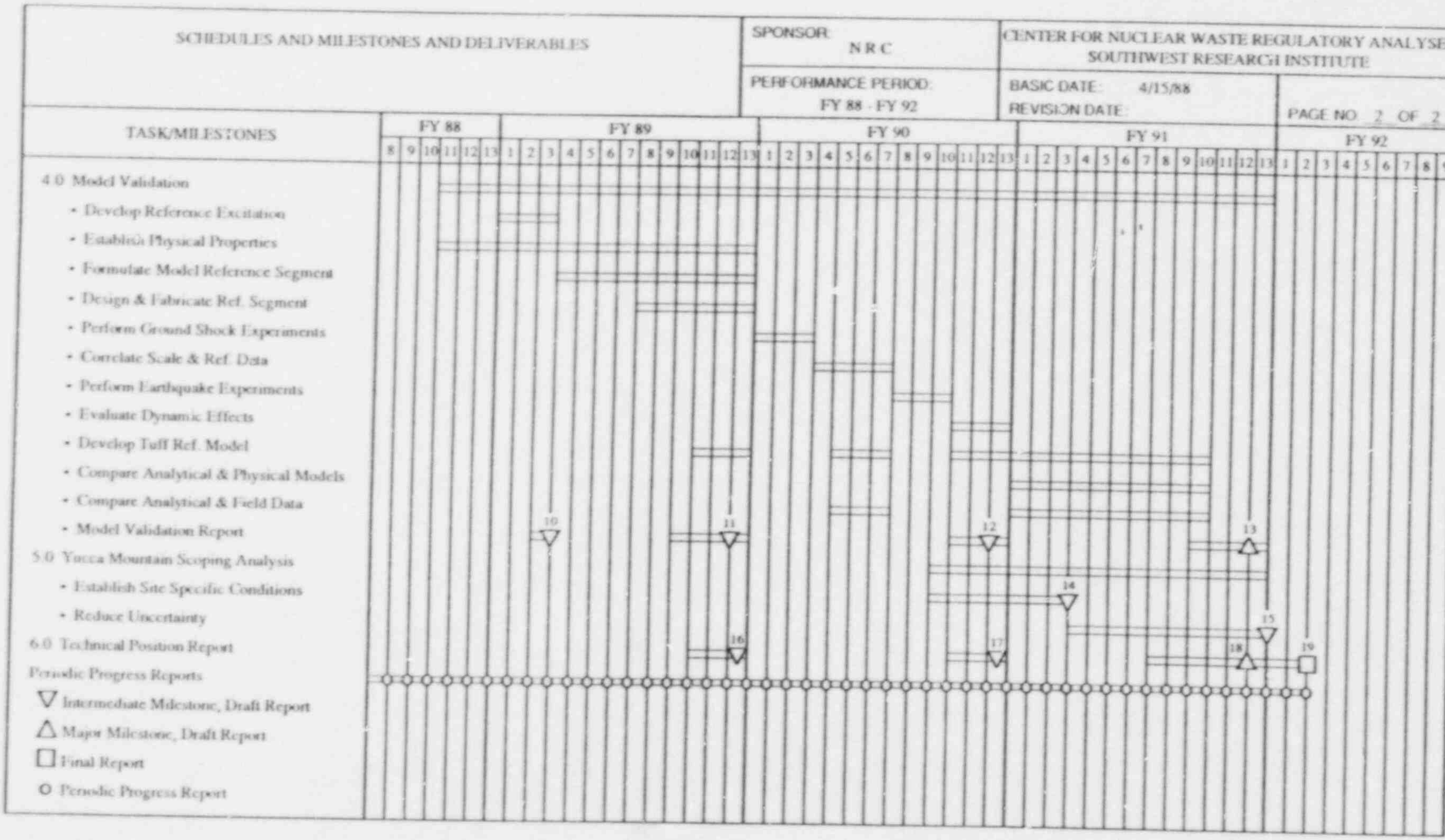

Figure 2-8. Schedule, Milestones, and Deliverables (Gantt Chart) (Cont'd)

2.4 Required Interface With Other Organizations

In the execution of this research project, the Center staff will actively interact with SwRI staff, Center subcontractor ITASCA, Center Consultants, and the NRC staff. The interactions will be by regular telephone communications, scheduled program review meetings, and exchange of draft reports. It is anticipated that there will be an average of four meetings per year with the NRC staff for project review purposes. It is planned that one of these meetings will be held at the NRC offices in Washington and the other three will be in San Antonio at the Center.

3 PROGRAM MANAGEMENT

3.1 Organizational Structure and Responsibility

The organizational structure, responsibilities, and management and control techniques applicable to the Research Element at the Center will be fully described in the Center Management Plan. The Seismic/Rock Mechanics Project will be conducted under the Research Element of the Center's Program. Also, this project directly supports the needs of the Repository Design and Construction Program Element. Dr. Prasad Nair will be the Center Project Manager for this project. The task support, direction, and resource allocation relationships are shown in Figure 3-1.

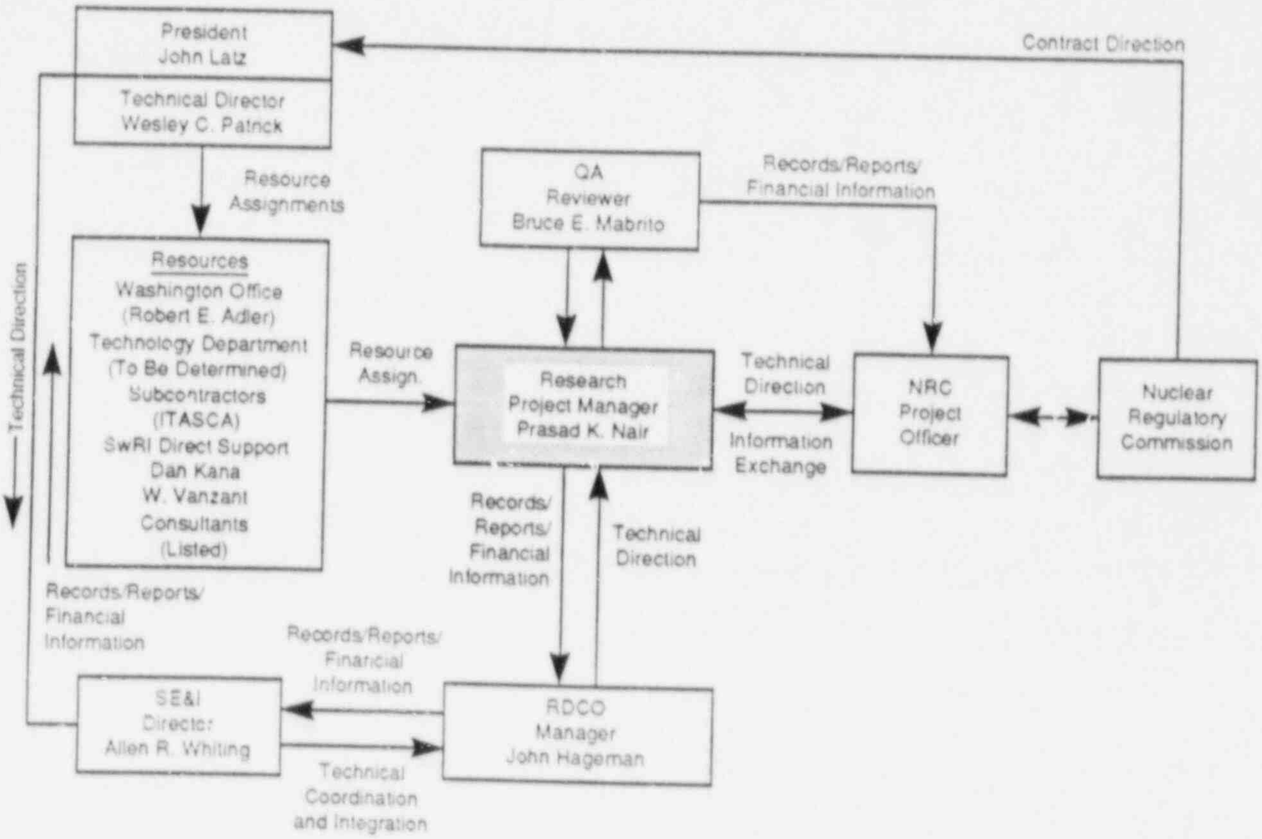

Figure 3-1. Center Management Process for Direction and Control of Research Projects

The project is to be conducted in six tasks over a 43-month period. The project staff support and the project organization is shown in Figure 3-2. As described in Figure 3-2, a Project Advisory Group has been constituted. The purpose of this group is to provide periodic (once a year) critical review and regular consultation assistance to the project. The project has also made allowance for consultants to provide independent review of technical papers and/or technical reports generated by the project.

3.2 Quality Assurance

The resources of SwRI Quality Assurance (QA) are available as necessary for carrying out project work for the Center. The project work includes the requirement to generate and maintain sufficient documentation to assure the reproducibility of the results of the research. Therefore, the methods and tech-

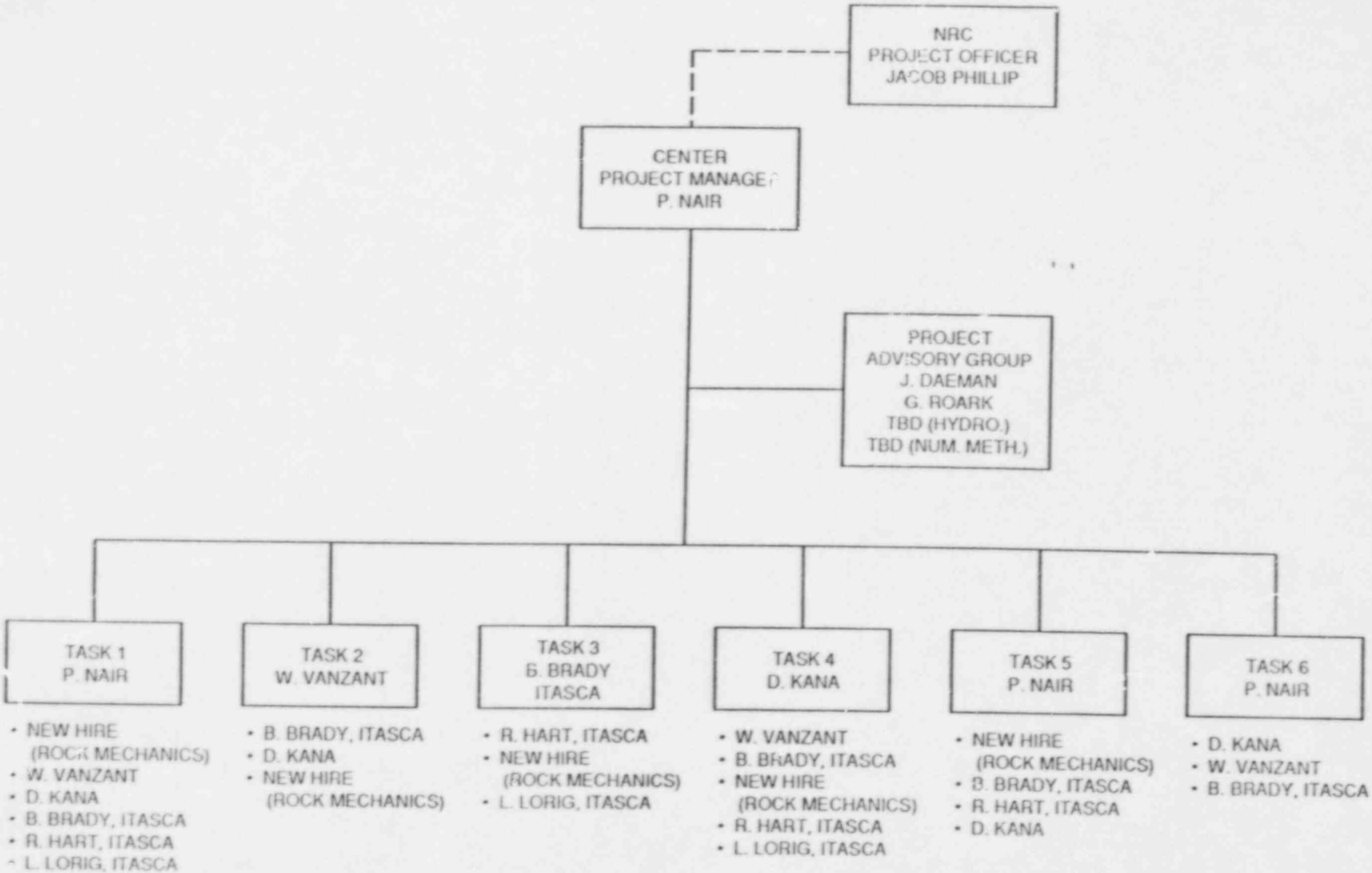

Figure 3-2. Project Staff Support

niques used to collect, reduce, and interpret data shall be sufficiently accurate, traceable, and articulate so that others can duplicate the work done and independently evaluate the results.

3.2.1 Quality Assurance Program

The QA provisions stated herein and selected sections of the SwRI Nuclear Quality Assurance Program Manual (NQAPM) apply to this Center Research Project. These QA requirements also apply to work at the Center (including SwRI) and work by subcontractors and consultants. Because the Center does not have a finalized and approved QA Program, the specifics of this particular Project Plan are more detailed and should not be construed to set a precedent. The referenced sections of the SwRI NQAPM and the QA provisions identified here form the basis of QA until such time that the Center QA Manual is approved.

3.2.2 Project Organization

The QA coverage for this Research Project shall be under the direction of Bruce Mabrito, Center Director of Quality Assurance. QA support personnel are provided by the SwRI QA Department and all QA personnel have lines of reporting responsibility separate from the project activities and report to Management through different authority lines. The organizational structure for this project is shown in Figure 3-2 of this Project Plan.

3.2.3 Project Plan Control

This Project Plan shall be prepared and approved by the cognizant Center Element Manager, Director of QA, and cognizant Technical Director and approved by the NRC. Revisions or changes to the approved document shall be clearly identified and controlled. Prior to the initiation of this Research Project, Center Quality Assurance shall verify that the NRC has, in writing, approved this Project Plan, and any revisions, changes, or deviations thereto.

Three levels of procedures are anticipated to be utilized in the conduct of this project:

- Standardized tests (such as ASTM and IEEE standards).
- Formalized Operating Procedures (such as SwRI Nuclear Project Operating Procedures or Center Technical Operating Procedures).
- Special research experiment guidelines, unique to individual tests, which are purposely written with general criteria so that maximum freedom is allowed the researcher.

All such procedures shall be controlled and the results of such experiments documented.

3.2.4 Analyses Control

On this Research Project, all numerical computations, mathematical equations, and derivations shall be independently reviewed and verified by qualified personnel other than the originator(s).

3.2.5 Test Control

Although this section identifies QA-related activities, the quality of testing, research, and resultant data is a function of the personnel, equipment, and controls established. Assurance of quality is a QA activity. Quality project performance and data accuracy are achieved by application of proper engineering and laboratory practices, not QA work. In the course of project performance, control of quality is a Project activity and assurance of quality is a QA task.

3.2.5.1 Prior to the initiation of this research, QA shall ensure that the various specimens have been identified and stored so that there is no loss of identification.

3.2.5.2 During the course of the Research Project, sample selection, sample population, sampling frequency, and control of samples will be documented. The experimental design and rationale of approach will also be described in this Project Plan and in the Research Project Final Report.

3.2.5.3 This Research Project Plan will reference provisions for sample preparation, selection of sample types, treatment of samples and sample identification.

3.2.5.4 The measurement techniques employed shall be described in procedures and those procedures shall detail the measurement process and provide a description and identification of the equipment used. The calibration methods, including frequency, techniques, reference standards, and traceability, shall also be identified.

3.2.5.4 The measurement techniques employed shall be describe d in procedures and those procedures shall detail the measurement process and provide a description and identification of the equipment used. The calibration methods, including frequency, techniques, reference standards, and traceability, shall also be identified.

3.2.5.5 The data recording techniques, including methods of recording data and identification of person(s) recording and/or certifying data, shall be included in the laboratory data books or on the data recording itself.

3.2.5.6 Data reduction methods and codes, including revisions, modifications, and updates, shall be documented and available for review. Data analysis techniques and methods of data verification shall be confirmed.

3.2.5.7 The identification, location, and retention time of data, various analyses, associated and duplicate data/records shall be specified in procedures.

3.2.5.8 When, in the conduct of the Research Project, statistical evaluation and interpretation of data are made, it shall make reference to the accuracy and precision of results achieved. This is to be documented in the Final Report at the conclusion of the Research Project.

3.2.5.9 Project documentation shall be maintained in a format that is retrievable, with means to identify appropriate personnel performing the research and the dates of activities. If an error is made in documenting entries, a single line shall be drawn through the incorrect entry and the correct information written nearby, with the initials of the person making the correction and the full date of correction shown.

3.2.5.10 QA shall review the codes, standards, and criteria which are referenced in this Project Plan to independently ensure compliance of the work performed.

3.2.6 *Test and Measuring Equipment Control*

Prior to initiation of research on specimens identified for this project, QA shall review the calibration records of the identified test equipment to ensure that it has been calibrated within specified intervals. SwRI NQAPM Section 10-1 shall be applied to T&ME control.

3.2.7 *Audits and Surveillance*

QA audits will be reported in full, and an copy of the audit results will be distributed to appropriate Center personnel. Audit reports will be maintained in a retrievable condition and available for NRC review. Project-specific audits will be performed once per 12 months of project duration and at any time specified by the Center Director of QA, upon request of a Center Director or the Cognizant Element Manager. Audits shall be performed in accordance with NQAPM Sections 15-1, Audits, and 15-2, Qualification and Certification of Quality Assurance Auditors.

QA shall conduct surveillance of research tests periodically during the course of the project or as directed by the Center Director of QA. Formal surveillance reports shall be generated for each QA surveillance activity and distributed to the Center QA Director, Technical Director, cognizant Element Manager, and other appropriate personnel. Surveillance includes, but is not limited to, direct observation of project work to determine procedure compliance.

3.2.8 *Corrective Action and Nonconformance Control*

Any deviations or non conformances noted during audits or surveillance by QA shall be reported in the audit report or surveillance report and shall be controlled by the NQAPM Section 13-1. Corrective actions resulting from a Deviation and Nonconformance Report shall be controlled by NQAPM Section 14-1.

3.2.9 *Reports and Records*

The Research Project Final Report shall be receive an independent technical review and Center Management review which is documented on the submittal to the NRC. The Research Project Final Report shall be issued in draft form to the NRC, but after the final document is submitted, any changes to the report shall be clearly documented stating the date, reason, and scope of the changes.

3.3 Personnel

For the successful execution of an approved project plan, a combination of Center staff, Center subcontractor (ITASCA), SwRI staff, and a selected number of consultants have been identified.

3.3.1 *Key Personnel*

The following personnel have been identified as essential personnel for the successful execution of the work described in Section 2.2 of this Project Plan.

Name	Tasks	Related Section	Expertise	Approx Man-Year Level of Effort (%)
P. Nair	1 5 6	2.2.1 2.2.5 2.2.6	Numerical Modelling Soil/Structural Mechanics Materials Science	10
W. Patrick	1 5	2.2.1 2.2.5	Systems Engineering Rock Mechanics Soil Engineering	3
D. Kana SwRI	1 2 3 4 5 6	2.2.1 2.2.2 2.2.4 2.2.5 2.2.6	Seismic/Earthquake Engineering Dynamic Scale Modelling Soil-Structure Interaction Experimental Mechanics	40
W. Vanzant SwRI	1 2 4 6	2.2.1 2.2.2 2.2.4 2.2.6	Shock & Blast Evaluation Field Instrumentation Experimental Mechanics	40
New Hire Rock Mechanics	1 2 3 4 5	2.2.1 2.2.2 2.2.3 2.2.4 2.2.5	Rock Mechanics Numerical Modelling Underground Structure Evaluations	75
B. Brady ITASCA	1 2 3 4 5 6	2.2.2 2.2.2 2.2.3 2.2.4 2.2.5 2.2.6	Geotechnical Engineering Underground Structure Evaluation Numerical Modelling	10
R. Hart ITASCA	1 3 4 5	2.2.1 2.2.3 2.2.4 2.2.5	Rock Mechanics Civil Engineering	26
L. Lorig ITASCA	1 3 4	2.2.1 2.2.3 2.2.4	Rock Mechanics Numerical Modelling	26
B. Mabrito	All		Quality Assurance	10

3.3.2 Other Personnel

The following personnel have been identified as providing support expertise to the Seismic/Rock Mechanics project.

Name	Tasks	Related Section	Expertise	Man-Year Level of Effort (%)
D. Scheidt SwRI	4	2.2.4	Seismic Testing Data Analysis	40
G. Roark (Kaman Sciences Corporation) Consultant	1 2	2.2.1 2.2.2	Shock Testing (Geologic Media) Data Analysis Field Instrumentation	3
J. Daeman (U of Arizona) Consultant	3 4 5	2.2.3 2.2.4 2.2.5	Dynamic Experimental Analysis Rock Mechanics	3

3.4 Corporate Resources

3.4.1 General Resources

The following resources will be used.

- SwRI library and document retrieval system
- ITASCA — Rock Mechanics Data Base
- SwRI Computer Laboratory
- Computer software packages — 3 DEC. UDEC. CICE. SPECTROM-331
- Library Data Bases — NTIS. DOE. Geosearch. Rock Mechanics
- SwRI Seismic Test Facility
- SwRI Seismic Data Analysis Computer Laboratory
- SwRI Machine/Model Shop
- SwRI Hi-Cap Test Facility
- Other SwRI support resources for drafting, publications services, general administration, etc
- SwRI Quality Assurance

3.4.2 Special Resources

Extensive use of Center, ITASCA and consultants personal computers is planned. The Center has several IBM-XT, -AT, and PS/2 units and related compatibles. It is expected that within the first year of the Center operations, a network computer capability among Center/SwRI, NRC, and ITASCA will be established.

3.5 Travel

The project personnel will incur expenses for travel and associated subsistence while conducting the business of the Center in support of the Seismic/Rock Mechanics Project. The minimum necessary travel anticipated for the project is described below and shown in the attached travel requirements schedule. Essential travel is shown in five groups, generally by destination. Travel necessary to accommodate every mission will be undertaken by the appropriate task personnel.

Technical Interchange Meetings. These meetings are primarily intended for collecting data and information that is specific to past testing at the Nevada Test Site and/or seismic efforts in tuff-like media.

Field Site Visits/Meetings. These visits are designed to take advantage of instrumentation programs currently in place at mines or blast sites or seismic activity areas. If joint participation of field studies can be arranged with other organizations, it will be pursued. Currently, all travel is confined to places within the USA.

Technical and Program Review Meetings. The meetings here are mainly to the Washington NRC offices.

Technical Meetings. Meetings are planned with the subcontractor, in part for coordinating the work and enabling the staff from Center and ITASCA to directly interact.

Conferences/Seminars. These trips are designed to enable the technical staff to present papers and/or participate in technical seminars. This will enable the peer review of the research program results.

TABLE 3. TRAVEL REQUIREMENTS
Seismic/Rock Mechanics

	Purpose/Dest.	FY88		FY89		FY90		FY91	
		No. of Trips	Man Days	No. of Trips	Man Days	No. of Trips	Man Days	No. of Trips	Man Days
	Tech Interchange								
	Santa Barbara	2	8						
1	Denver	1	4						
	Menlo Park	1	2						
	Col. Springs	1	4						
2	Field Sites Tech Interchange *To be determined*			2	8	1	4	1	3
3	Tech Meeting/ Program Review Analyt Washington	3	9	3	9	2	6	3	9
4	Tech Meeting Analyt Minneapolis	2	6	2	6	2	6	2	6
5	Conference Seminar *To be determined*	2	6	3	9	3	9	3	9
	Totals	12	40	10	32	8	25	9	27

4. ESTIMATED COSTS

4.1 Detailed Cost Estimates

Detailed cost estimates are presented at the task level for each of the six tasks. The planned costs are presented for thirteen, four-week periods per year.

Tables 4-1 through 4-4 contain the Year 1 (FY 1988) costs for the project tasks. Table 4-5 is the Year 1 composite cost data.

Tables 4-6 through 4-10 contain the Year 2 (FY 1989) costs for the project tasks. Table 4-11 is the Year 2 composite cost data.

Tables 4-12 through 4-16 contain the Year 3 (FY 1990) costs for the project tasks. Table 4-17 is the Year 3 composite cost data.

Tables 4-18 through 4-21 contain the Year 4 (FY 1991) costs for the project tasks. Table 4-22 is the Year 4 composite cost data.

Table 4-23 is the costs for Year 5 (FY 1992).

For each of these tables, the "Total" column contains the estimated contribution of each cost category for the entire task. Numbers in this column can be compared directly to the task totals shown in the spending plans (see Section 4.2).

4.2 Spending Plan

The spending plan for the various tasks for the five fiscal years are presented in graphical form. Figures 4-1 through 4-23 correspond to the plan costs presented in Tables 4-1 through 4-23.

Table 4.1 - Seismic Yea· 1, Task 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	599	798	798	798	798	798	4,589
PL-3	0	0	0	0	0	0	0	441	3,384	3,384	2,796	2,649	2,649	15,304
PL-2	0	0	0	0	0	0	0	0	0	479	479	240	240	1,438
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	134	134	134	134	90	90	717
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	273	1,003	1,114	977	877	877	5,121
SwRI DIRECT LABOR	0	0	0	0	0	0	0	1,626	5,372	5,372	2,015	1,925	1,296	17,607
SwRI SUPPORT SERVICES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	0	0	0	0	0	0	0	564	2,075	2,305	2,022	1,815	1,815	10,596
CENTER OVERHEAD	0	0	0	0	0	0	0	1,649	6,063	6,737	5,910	5,304	5,304	30,966
SwRI FRINGE	0	0	0	0	0	0	0	634	2,095	2,095	786	751	505	6,867
SwRI OVERHEAD	0	0	0	0	0	0	0	2,621	8,662	8,662	3,249	3,104	2,090	28,389
ADP SUPPORT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA	0	0	0	0	0	0	0	3,493	6,484	7,021	2,300	2,300	1,273	22,871
NWC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS	0	0	0	0	0	0	0	0	4,000	4,000	4,000	4,000	5,000	21,000
TRAVEL	0	0	0	0	0	0	0	0	2,000	2,000	1,000	1,000	0	6,000
EQUIPMENT & MATERIALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	406	1,400	1,466	882	809	715	5,679
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	12,441	43,472	45,570	27,348	25,661	22,651	177,142
FEE (8%)	0	0	0	0	0	0	0	963	3,366	3,528	2,117	1,938	1,755	13,717
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	13,404	46,837	49,098	29,466	27,649	24,405	190,859
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	24.5%	25.7%	15.4%	14.5%	12.8%	
CUMULATIVE COST	0	0	0	0	0	0	0	13,404	60,241	109,339	138,805	166,453	190,859	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	31.6%	57.3%	72.7%	87.2%	100.0%	

Table 4.2 - Seismic Year 1, Task 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	599	599	1,197
PL-3	0	0	0	0	0	0	0	0	0	0	589	736	441	1,766
PL-2	0	0	0	0	0	0	0	0	0	0	0	240	120	360
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	0	45	45	90
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	137	376	280	792
SwRI DIRECT LABOR	0	0	0	0	0	0	0	0	0	0	1,053	1,098	1,173	3,324
SwRI SUPPORT SERVICES	0	0	0	0	0	0	0	0	0	0	0	3,000	2,000	5,000
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	283	778	579	1,640
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	827	2,274	1,692	4,792
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	411	428	457	1,296
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	1,698	1,770	1,891	5,360
ADP SUPPORT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA	0	0	0	0	0	0	0	0	0	0	5,707	5,707	2,132	13,546
NWC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS	0	0	0	0	0	0	0	0	0	0	3,000	3,000	3,000	9,000
TRAVEL	0	0	0	0	0	0	0	0	0	0	0	0	1,000	1,000
EQUIPMENT & MATERIALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	239	388	342	969
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	13,943	20,438	15,750	50,131
FEE (8%)	0	0	0	0	0	0	0	0	0	0	1,096	1,604	1,233	3,933
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	15,039	22,042	16,983	54,064
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.8%	40.8%	31.4%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	15,039	37,081	54,064	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.8%	68.6%	100.0%	

Table 4.3 - Seismic Year 1, Task 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-3	0	0	0	0	0	0	0	0	0	0	0	0	294	294
PL-2	0	0	0	0	0	0	0	0	0	0	0	0	120	120
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	0	0	96	96
SwRI DIRECT LABOR	0	0	0	0	0	0	0	0	0	0	0	0	239	239
SwRI SUPPORT SERVICES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	0	0	199	199
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	0	0	582	582
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	0	0	93	93
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	0	0	386	386
ADP SUPPORT	0	0	0	0	0	0	0	0	0	0	0	0	5,000	5,000
SUBCONTRACTORS														
ITASCA	0	0	0	0	0	0	0	0	0	0	0	0	5,020	5,020
NWC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL	0	0	0	0	0	0	0	0	0	0	0	0	3,000	3,000
EQUIPMENT & MATERIALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	0	0	93	93
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	0	0	15,123	15,123
FEE (8%)	0	0	0	0	0	0	0	0	0	0	0	0	1,202	1,202
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	0	0	16,326	16,326
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	0	0	16,326	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	

Table 4.4 - Seismic Year 1, Task 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SwRI DIRECT LABOR	0	0	0	0	0	0	0	0	0	0	3,686	3,236	3,550	10,472
SwRI SUPPORT SERVICES	0	0	0	0	0	0	0	0	0	0	0	2,000	3,000	5,000
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	1,438	1,262	1,385	4,084
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	5,943	5,217	5,725	16,885
ADP SUPPORT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA	0	0	0	0	0	0	0	0	0	0	4,298	4,544	4,544	13,386
NWC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL	0	0	0	0	0	0	0	0	0	0	0	2,000	1,000	3,000
EQUIPMENT & MATERIALS	0	0	0	0	0	0	0	0	0	0	0	2,000	3,000	5,000
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	552	485	532	1,568
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	15,917	20,743	22,735	59,395
FEE (8%)	0	0	0	0	0	0	0	0	0	0	1,229	1,621	1,776	4,626
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	17,146	22,364	24,512	64,021
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	34.9%	38.3%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	17,146	39,510	64,021	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	61.7%	100.0%	

Table 4.5 - Seismic Year 1 Composite

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	599	798	798	798	1,397	1,397	5,786
PL-3	0	0	0	0	0	0	0	441	3,384	3,384	3,384	3,384	3,384	17,364
PL-2	0	0	0	0	0	0	0	0	0	479	479	479	479	1,916
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	134	134	134	134	134	134	806
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	273	1,003	1,114	1,114	1,253	1,253	6,010
SwRI DIRECT LABOR	0	0	0	0	0	0	0	1,626	5,372	5,372	6,754	6,259	6,259	31,642
SwRI SUPPORT SERVICES	0	0	0	0	0	0	0	0	0	0	0	5,000	5,000	10,000
CENTER FRINGE	0	0	0	0	0	0	0	564	2,075	2,305	2,305	2,593	2,593	12,434
CENTER OVERHEAD	0	0	0	0	0	0	0	1,649	6,063	6,737	6,737	7,577	7,577	36,340
SwRI FRINGE	0	0	0	0	0	0	0	634	2,095	2,095	2,634	2,441	2,441	12,340
SwRI OVERHEAD	0	0	0	0	0	0	0	2,621	8,662	8,662	10,890	10,092	10,092	51,019
ADP SUPPORT	0	0	0	0	0	0	0	0	0	0	0	0	5,000	5,000
SUBCONTRACTORS														
ITASCA	0	0	0	0	0	0	0	3,493	6,484	7,021	12,305	12,551	12,969	54,824
NWC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS	0	0	0	0	0	0	0	0	4,000	4,000	7,000	7,000	8,000	30,000
TRAVEL	0	0	0	0	0	0	0	0	2,000	2,000	1,000	3,000	5,000	13,000
EQUIPMENT & MATERIALS	0	0	0	0	0	0	0	0	0	0	0	2,000	3,000	5,000
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	406	1,400	1,466	1,673	1,682	1,682	8,309
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	12,441	43,472	45,570	57,208	66,841	76,260	301,791
FEE (8%)	0	0	0	0	0	0	0	963	3,366	3,528	4,443	5,213	5,966	23,479
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	13,404	46,837	49,098	61,650	72,054	82,226	325,270
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%	14.4%	15.1%	19.0%	22.2%	25.3%	
CUMULATIVE COST	0	0	0	0	0	0	0	13,404	60,241	109,339	170,990	243,044	325,270	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%	18.5%	33.6%	52.6%	74.7%	100.0%	

Table 4.6 - Seismic Year 2, Task 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	843	843	843	0	0	0	0	0	0	0	0	0	0	2,528
PL-3	2,020	2,020	2,020	0	0	0	0	0	0	0	0	0	0	6,061
PL-2	127	127	127	0	0	0	0	0	0	0	0	0	0	380
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	94	94	94	0	0	0	0	0	0	0	0	0	0	282
CENTER INDIRECT LABOR (MGT)	349	349	349	0	0	0	0	0	0	0	0	0	0	1,047
SwRI DIRECT LABOR $	1,670	2,087	3,454	0	0	0	0	0	0	0	0	0	0	7,211
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	1,339	1,339	1,339	0	0	0	0	0	0	0	0	0	0	4,016
CENTER OVERHEAD	3,068	3,068	3,068	0	0	0	0	0	0	0	0	0	0	9,204
SwRI FRINGE	651	814	1,347	0	0	0	0	0	0	0	0	0	0	2,812
SwRI OVERHEAD	2,693	3,365	5,568	0	0	0	0	0	0	0	0	0	0	11,627
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	5,743	5,743	5,044	0	0	0	0	0	0	0	0	0	0	16,529
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	2,000	4,000	2,000	0	0	0	0	0	0	0	0	0	0	8,000
TRAVEL $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	635	697	902	0	0	0	0	0	0	0	0	0	0	2,233
TOTAL ESTIMATED COST	21,231	24,545	26,153	0	0	0	0	0	0	0	0	0	0	71,929
FEE (8%)	1,648	1,908	2,020	0	0	0	0	0	0	0	0	0	0	5,576
TOTAL COST INCLUDING FEE	22,878	26,453	28,173	0	0	0	0	0	0	0	0	0	0	77,504
% COMPLETION	29.5%	34.1%	36.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
CUMULATIVE COST	22,878	49,331	77,504	77,504	77,504	77,504	77,504	77,504	77,504	77,504	77,504	77,504	77,504	
CUMULATIVE % COMPLETION	29.5%	63.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Table 4.7 - Seismic Year 2, Task 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	632	632	632	632	632	632	0	0	0	0	3,793
PL-3	777	777	777	684	684	684	684	684	684	0	0	0	0	6,434
PL-2	253	253	253	127	127	127	127	127	127	0	0	0	0	1,519
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	47	47	47	47	47	47	0	0	0	0	282
CENTER INDIRECT LABOR (MGT)	117	117	117	169	169	169	169	169	169	0	0	0	0	1,362
SwRI DIRECT LABOR $	675	1,028	506	1,476	1,476	1,223	1,223	1,223	1,223	0	0	0	0	10,053
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	447	447	447	647	647	647	647	647	647	0	0	0	0	5,221
CENTER OVERHEAD	1,025	1,025	1,025	1,482	1,482	1,482	1,482	1,482	1,482	0	0	0	0	11,966
SwRI FRINGE	263	401	197	576	576	477	477	477	477	0	0	0	0	3,921
SwRI OVERHEAD	1,088	1,657	816	2,380	2,380	1,972	1,972	1,972	1,972	0	0	0	0	16,210
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	2,955	2,955	3,654	3,654	3,654	3,654	3,654	3,654	3,654	0	0	0	0	31,489
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	2,000	0	1,000	0	1,000	0	0	0	0	0	0	4,000
TRAVEL $	0	0	0	0	1,000	0	1,000	0	0	0	0	0	0	2,000
EQUIPMENT & MATERIALS $	0	0	0	2,000	0	2,000	0	2,000	0	0	0	0	0	6,000
COST OF FACILITY CAPITAL	229	282	204	407	407	369	369	369	369	0	0	0	0	3,005
TOTAL ESTIMATED COST	7,829	8,942	9,997	14,279	14,279	13,482	13,482	13,482	11,482	0	0	0	0	107,254
FEE (8%)	608	693	783	1,110	1,110	1,049	1,049	1,049	889	0	0	0	0	8,340
TOTAL COST INCLUDING FEE	8,437	9,635	10,780	15,389	15,389	14,531	14,531	14,531	12,371	0	0	0	0	115,594
% COMPLETION	7.3%	8.3%	9.3%	13.3%	13.3%	12.6%	12.6%	12.6%	10.7%	0.0%	0.0%	0.0%	0.0%	
CUMULATIVE COST	8,437	18,072	28,853	44,242	59,631	74,162	88,692	103,223	115,594	115,594	115,594	115,594	115,594	
CUMULATIVE % COMPLETION	7.3%	15.6%	25.0%	38.3%	51.6%	64.2%	76.7%	89.3%	100.0%	100.0%	100.0%	100.0%	100.0%	

Table 4.8 - Seismic Year 2, Task 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	211	211	211	211	211	211	843	632	632	0	3,371
PL-3	777	777	777	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,492	17,249
PL-2	127	127	127	177	177	177	177	177	177	177	177	177	177	2,151
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	47	47	47	47	47	47	47	47	47	94	47	47	47	657
CENTER INDIRECT LABOR (MGT)	108	108	108	218	218	218	218	218	218	295	266	266	194	2,653
SwRI DIRECT LABOR $	253	421	211	384	384	384	384	384	384	421	421	421	211	4,665
SwRI SUPPORT SERVICES $	0	2,000	0	2,000	0	2,000	0	0	2,000	0	0	0	0	8,000
CENTER FRINGE	413	413	413	836	836	836	836	836	836	1,131	1,019	1,019	745	10,172
CENTER OVERHEAD	946	946	946	1,917	1,917	1,917	1,917	1,917	1,917	2,593	2,336	2,336	1,707	23,311
SwRI FRINGE	99	164	82	150	150	150	150	150	150	164	164	164	82	1,819
SwRI OVERHEAD	408	679	340	619	619	619	619	619	619	679	679	679	340	7,522
ADP SUPPORT $	0	3,000	0	3,000	0	3,000	0	3,000	0	3,000	0	0	0	15,000
SUBCONTRACTORS														
ITASCA $	2,256	2,626	2,626	2,888	2,888	2,888	2,888	2,518	2,779	1,920	1,920	523	523	29,243
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	3,000	0	0	0	0	0	0	3,000
TRAVEL $	0	0	0	1,000	0	1,000	0	0	1,000	0	0	0	0	3,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	156	182	150	298	298	298	298	298	298	388	356	356	245	3,620
TOTAL ESTIMATED COST	5,588	11,490	5,825	15,237	9,237	15,237	12,237	11,867	12,129	13,198	9,511	8,113	5,763	135,433
FEE (8%)	435	905	454	1,195	715	1,195	955	926	946	1,025	732	621	441	10,545
TOTAL COST INCLUDING FEE	6,023	12,394	6,279	16,432	9,952	16,432	13,192	12,793	13,075	14,223	10,243	8,734	6,205	145,979
% COMPLETION	4.1%	8.5%	4.3%	11.3%	6.8%	11.3%	9.0%	8.8%	9.0%	9.7%	7.0%	6.0%	4.3%	
CUMULATIVE COST	6,023	18,417	24,697	41,129	51,081	67,513	80,706	93,498	106,574	120,796	131,040	139,774	145,979	
CUMULATIVE % COMPLETION	4.1%	12.6%	16.9%	28.2%	35.0%	46.2%	55.3%	64.0%	73.0%	82.7%	89.8%	95.7%	100.0%	

Table 4.9 Seismic Year 2, Task 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	632	632
PL-3	0	0	0	1,399	1,399	1,399	1,399	1,399	1,399	2,082	995	995	995	13,458
PL-2	0	0	0	202	202	202	202	202	202	329	76	76	76	1,772
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	47	47	47	47	47	47	47	47	47	47	470
CENTER INDIRECT LABOR (MGT)	0	0	0	187	187	187	187	187	187	278	127	127	198	1,849
SwRI DIRECT LABOR $	3,749	2,764	2,191	4,337	4,337	4,590	4,543	4,543	4,543	5,190	5,190	5,190	5,940	57,107
SwRI SUPPORT SERVICES $	0	0	3,000	0	3,000	0	3,000	0	3,000	0	3,000	0	0	15,000
CENTER FRINGE	0	0	0	715	715	715	715	715	715	1,067	485	485	760	7,090
CENTER OVERHEAD	0	0	0	1,640	1,640	1,640	1,640	1,640	1,640	2,446	1,112	1,112	1,741	16,249
SwRI FRINGE	1,462	1,078	854	1,691	1,691	1,790	1,772	1,772	1,772	2,024	2,024	2,024	2,317	22,272
SwRI OVERHEAD	6,045	4,457	3,533	6,993	6,993	7,401	7,326	7,326	7,326	8,368	8,368	8,368	9,577	92,080
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	740	740	740	740	740	740	740	740	740	740	1,868	2,627	2,627	14,520
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	2,000	2,000	0	2,000	0	2,000	0	2,000	0	0	10,000
TRAVEL $	0	0	0	2,000	0	1,000	0	1,000	0	1,000	0	0	0	5,000
EQUIPMENT & MATERIALS $	2,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	38,000
COST OF FACILITY CAPITAL	561	414	328	855	855	893	886	886	886	1,084	916	916	1,108	10,588
TOTAL ESTIMATED COST	14,558	12,452	13,646	25,806	26,806	23,604	27,456	23,456	27,456	27,655	29,207	24,965	29,016	306,085
FEE (8%)	1,120	963	1,065	1,996	2,076	1,817	2,126	1,806	2,126	2,126	2,263	1,924	2,233	23,640
TOTAL COST INCLUDING FEE	15,678	13,415	14,711	27,803	28,883	25,421	29,582	25,262	29,582	29,780	31,470	26,889	31,249	329,725
% COMPLETION	4.8%	4.1%	4.5%	8.4%	8.8%	7.7%	9.0%	7.7%	9.0%	9.0%	9.5%	8.2%	9.5%	
CUMULATIVE COST	15,678	29,093	43,805	71,607	100,490	125,911	155,493	180,755	210,336	240,117	271,586	298,476	329,725	
CUMULATIVE % COMPLETION	4.8%	8.8%	13.3%	21.7%	30.5%	38.2%	47.2%	54.8%	63.8%	72.8%	82.4%	90.5%	100.0%	

Table 4.10 - Seismic Year 2, Task 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	211	211	211	632
PL-3	0	0	0	0	0	0	0	0	0	0	1,088	1,088	1,088	3,263
PL-2	0	0	0	0	0	0	0	0	0	0	127	127	127	380
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	47	47	47	141
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	167	167	167	500
SwRI DIRECT LABOR $	0	0	0	0	0	0	0	0	0	0	540	540	540	1,619
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	639	639	639	1,917
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	1,465	1,465	1,465	4,394
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	210	210	210	631
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	870	870	870	2,610
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	264	264	264	793
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	5,627	5,627	5,627	16,880
FEE (8%)	0	0	0	0	0	0	0	0	0	0	429	429	429	1,287
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	6,056	6,056	6,056	18,167
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	6,056	12,111	18,167	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	66.7%	100.0%	

Table 4.11 - Seismic Year 2 Composite

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	843	843	843	843	843	843	843	843	843	843	843	843	843	10,956
PL-3	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	3,574	46,465
PL-2	506	506	506	506	506	506	506	506	506	506	380	380	380	6,201
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	141	141	141	141	141	141	141	141	141	141	141	141	141	1,831
CENTER INDIRECT LABOR (MGT)	573	573	573	573	573	573	573	573	573	573	559	559	559	7,410
SwRI DIRECT LABOR $	6,347	6,300	6,361	6,198	6,198	6,198	6,151	6,151	6,151	5,611	6,151	6,151	6,690	80,655
SwRI SUPPORT SERVICES $	0	2,000	3,000	2,000	3,000	2,000	3,000	0	5,000	0	3,000	0	0	23,000
CENTER FRINGE	2,199	2,199	2,199	2,199	2,199	2,199	2,199	2,199	2,199	2,199	2,144	2,144	2,144	28,417
CENTER OVERHEAD	5,039	5,039	5,039	5,039	5,039	5,039	5,039	5,039	5,039	5,039	4,913	4,913	4,913	65,123
SwRI FRINGE	2,475	2,457	2,481	2,417	2,417	2,417	2,399	2,399	2,399	2,188	2,399	2,399	2,609	31,456
SwRI OVERHEAD	10,234	10,158	10,257	9,993	9,993	9,993	9,917	9,917	9,917	9,047	9,917	9,917	10,787	130,049
ADP SUPPORT $	0	3,000	0	3,000	0	3,000	0	3,000	0	3,000	0	0	0	15,000
SUBCONTRACTORS														
ITASCA $	11,694	12,064	12,064	7,282	7,282	7,282	7,282	6,912	7,173	2,660	3,788	3,149	3,149	91,780
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	2,000	4,000	4,000	2,000	3,000	0	6,000	0	2,000	0	2,000	0	0	25,000
TRAVEL $	0	0	0	3,000	1,000	2,000	1,000	1,000	1,000	1,000	0	0	0	10,000
EQUIPMENT & MATERIALS $	2,000	3,000	3,000	5,000	3,000	5,000	3,000	5,000	3,000	3,000	3,000	3,000	3,000	44,000
COST OF FACILITY CAPITAL	1,582	1,575	1,584	1,559	1,559	1,559	1,552	1,552	1,552	1,472	1,537	1,537	1,617	20,238
TOTAL ESTIMATED COST	49,207	57,429	55,621	55,323	50,323	52,323	53,175	48,805	51,066	40,853	44,344	38,705	40,406	637,581
FEE (8%)	3,810	4,468	4,323	4,301	3,901	4,061	4,130	3,780	3,961	3,150	3,425	2,974	3,103	49,387
TOTAL COST INCLUDING FEE	53,017	61,897	59,944	59,624	54,224	56,384	57,305	52,585	55,028	44,003	47,769	41,679	43,509	686,968
% COMPLETION	7.7%	9.0%	8.7%	8.7%	7.9%	8.2%	8.3%	7.7%	8.0%	6.4%	7.0%	6.1%	6.3%	
CUMULATIVE COST	53,017	114,914	174,858	234,482	288,706	345,090	402,395	454,980	510,008	554,011	601,780	643,459	686,968	
CUMULATIVE % COMPLETION	7.7%	16.7%	25.5%	34.1%	42.0%	50.2%	58.6%	66.2%	74.2%	80.6%	87.6%	93.7%	100.0%	

Table 4.12 - Seismic Year 3, Task 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-3	724	724	724	0	0	0	724	724	724	0	0	0	0	4,345
PL-2	134	134	134	0	0	0	134	134	134	0	0	0	0	804
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	49	49	49	0	0	0	49	49	49	0	0	0	0	296
CENTER INDIRECT LABOR (MGT)	78	78	78	0	0	0	78	78	78	0	0	0	0	469
SwRI DIRECT LABOR $	1,027	1,027	1,027	0	0	0	491	491	491	0	0	357	0	4,913
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	384	384	384	0	0	0	384	384	384	0	0	0	0	2,307
CENTER OVERHEAD	908	908	908	0	0	0	908	908	908	0	0	0	0	5,451
SwRI FRINGE	401	401	401	0	0	0	192	192	192	0	0	139	0	1,916
SwRI OVERHEAD	1,657	1,657	1,657	0	0	0	792	792	792	0	0	576	0	7,922
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	4,111	4,111	4,111	0	0	0	4,111	4,111	4,111	0	0	0	0	24,665
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	0	1,000	0	0	0	0	0	1,000	0	0	0	0	2,000
EQUIPMENT & MATERIALS $	0	0	2,000	0	0	0	0	3,000	0	0	0	0	0	5,000
COST OF FACILITY CAPITAL	326	326	326	0	0	0	233	233	233	0	0	62	0	1,740
TOTAL ESTIMATED COST	9,800	9,800	12,800	0	0	0	8,097	11,097	9,097	0	0	1,134	0	61,828
FEE (8%)	758	758	998	0	0	0	629	869	709	0	0	86	0	4,807
TOTAL COST INCLUDING FEE	10,558	10,558	13,798	0	0	0	8,726	11,966	9,806	0	0	1,220	0	66,635
% COMPLETION	15.8%	15.8%	20.7%	0.0%	0.0%	0.0%	13.1%	18.0%	14.7%	0.0%	0.0%	1.8%	0.0%	
CUMULATIVE COST	10,558	21,117	34,915	34,915	34,915	34,915	43,642	55,608	65,415	65,415	65,415	66,635	66,635	
CUMULATIVE % COMPLETION	15.8%	31.7%	52.4%	52.4%	52.4%	52.4%	65.5%	83.5%	98.2%	98.2%	98.2%	100.0%	100.0%	

Table 4.13 - Seismic Year 3, Task 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	223	223	223	0	0	0	0	0	0	0	0	0	0	669
PL-3	1,580	1,580	1,580	0	0	0	0	0	0	0	0	0	0	4,740
PL-2	188	188	188	0	0	0	0	0	0	0	0	0	0	563
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	49	49	49	0	0	0	0	0	0	0	0	0	0	148
CENTER INDIRECT LABOR (MGT)	176	176	176	0	0	0	0	0	0	0	0	0	0	527
SwRI DIRECT LABOR $	273	273	844	0	0	0	0	0	0	0	0	0	0	1,389
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	864	864	864	0	0	0	0	0	0	0	0	0	0	2,593
CENTER OVERHEAD	2,042	2,042	2,042	0	0	0	0	0	0	0	0	0	0	6,126
SwRI FRINGE	106	106	329	0	0	0	0	0	0	0	0	0	0	542
SwRI OVERHEAD	439	439	1,360	0	0	0	0	0	0	0	0	0	0	2,239
ADP SUPPORT $	3,000	3,000	2,000	0	0	0	0	0	0	0	0	0	0	8,000
SUBCONTRACTORS														
ITASCA $	6,480	6,480	6,480	0	0	0	0	0	0	0	0	0	0	19,440
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	1,000	0	0	0	0	0	0	0	0	0	0	0	1,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	379	379	479	0	0	0	0	0	0	0	0	0	0	1,237
TOTAL ESTIMATED COST	15,799	16,799	16,614	0	0	0	0	0	0	0	0	0	0	49,213
FEE (8%)	1,234	1,314	1,291	0	0	0	0	0	0	0	0	0	0	3,838
TOTAL COST INCLUDING FEE	17,033	18,113	17,904	0	0	0	0	0	0	0	0	0	0	53,051
% COMPLETION	32.1%	34.1%	33.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
CUMULATIVE COST	17,033	35,146	53,051	53,051	53,051	53,051	53,051	53,051	53,051	53,051	53,051	53,051	53,051	
CUMULATIVE % COMPLETION	32.1%	66.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Table 4.14 - Seismic Year 3, Task 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	669	669	669	892	892	892	892	892	892	892	669	669	669	10,263
PL-3	1,481	1,481	1,811	3,786	3,786	3,720	3,720	3,720	3,720	3,786	2,140	2,140	2,140	37,430
PL-2	214	214	214	402	402	402	402	402	402	536	268	268	268	4,397
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	49	49	49	148	148	148	99	99	99	148	49	49	49	1,186
CENTER INDIRECT LABOR (MGT)	208	208	236	450	450	444	440	440	440	461	269	269	269	4,584
SwRI DIRECT LABOR $	5,213	5,213	4,865	6,513	6,513	6,513	6,022	6,022	6,022	6,513	4,950	4,950	4,950	74,261
SwRI SUPPORT SERVICES $	0	0	3,000	0	3,000	0	3,000	0	3,000	0	3,000	0	0	15,000
CENTER FRINGE	1,023	1,023	1,162	2,215	2,215	2,187	2,166	2,166	2,166	2,271	1,324	1,324	1,324	22,565
CENTER OVERHEAD	2,417	2,417	2,746	5,233	5,233	5,167	5,118	5,118	5,118	5,367	3,129	3,129	3,129	53,321
SwRI FRINGE	2,033	2,033	1,897	2,540	2,540	2,540	2,349	2,349	2,349	2,540	1,931	1,931	1,931	28,962
SwRI OVERHEAD	8,406	8,406	7,845	10,502	10,502	10,502	9,710	9,710	9,710	10,502	7,982	7,982	7,982	119,738
ADP SUPPORT $	0	2,000	2,000	2,000	2,000	2,000	2,000	200	2,000	2,000	0	0	0	16,200
SUBCONTRACTORS														
ITASCA $	1,961	2,236	3,146	4,888	4,888	4,888	3,146	3,420	3,942	3,420	3,817	3,817	796	44,365
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	2,000	0	2,000	0	2,000	0	2,000	0	2,000	0	0	0	10,000
TRAVEL $	0	0	0	2,000	0	2,000	0	0	1,000	0	0	0	0	5,000
EQUIPMENT & MATERIALS $	2,000	2,000	2,000	2,000	2,000	3,000	3,000	3,000	3,000	2,000	2,000	2,000	2,000	30,000
COST OF FACILITY CAPITAL	1,300	1,300	1,293	1,983	1,983	1,973	1,879	1,879	1,879	2,005	1,370	1,370	1,370	21,582
TOTAL ESTIMATED COST	26,975	31,249	32,934	47,552	46,552	48,376	43,942	41,416	45,738	44,443	32,899	29,899	26,878	498,853
FEE (8%)	2,054	2,396	2,531	3,645	3,565	3,712	3,365	3,163	3,509	3,395	2,522	2,282	2,041	38,182
TOTAL COST INCLUDING FEE	29,029	33,645	35,465	51,197	50,117	52,088	47,307	44,579	49,247	47,838	35,421	32,181	28,919	537,035
% COMPLETION	5.4%	6.3%	6.6%	9.5%	9.3%	9.7%	8.8%	8.3%	9.2%	8.9%	6.6%	6.0%	5.4%	
CUMULATIVE COST	29,029	62,674	98,139	149,336	199,454	251,542	298,849	343,428	392,675	440,513	475,935	508,116	537,035	
CUMULATIVE % COMPLETION	5.4%	11.7%	18.3%	27.8%	37.1%	46.8%	55.6%	63.9%	7[illegible].1%	82.0%	88.6%	94.6%	100.0%	

Table 4.15 - Seismic Year 3, Task 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-3	0	0	0	0	0	0	0	0	0	0	823	823	823	2,469
PL-2	0	0	0	0	0	0	0	0	0	0	134	134	134	402
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	49	49	49	148
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	87	87	87	260
SwRI DIRECT LABOR $	0	0	0	0	0	0	0	0	0	0	1,206	848	1,206	3,259
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	426	426	426	1,279
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	1,007	1,007	1,007	3,0[illegible]
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	470	331	470	1,271
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	1,944	1,368	1,944	5,255
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	0	0	0	0	0	0	0	0	0	0	2,748	3,420	0	6,168
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	2,000	2,000
TRAVEL $	0	0	0	0	0	0	0	0	0	0	0	4,000	2,000	6,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	1,000	0	1,000
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	373	311	373	1,058
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	9,267	13,805	10,519	33,592
FEE (8%)	0	0	0	0	0	0	0	0	0	0	712	1,080	812	2,603
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	9,979	14,885	11,331	36,195
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	41.1%	31.3%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	9,979	24,864	36,195	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	68.7%	100.0%	

Table 4.16 - Seismic Year 3, Task 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	223	223	223	669
PL-3	0	0	0	0	0	0	0	0	0	0	823	823	823	2,469
PL-2	0	0	0	0	0	0	0	0	0	0	134	134	134	402
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	0	0	0	49	49	49	148
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	0	0	0	106	106	106	317
SwRI DIRECT LABOR $	0	0	0	0	0	0	0	0	0	0	571	571	571	1,713
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	0	0	0	0	0	0	0	0	0	0	521	521	521	1,562
CENTER OVERHEAD	0	0	0	0	0	0	0	0	0	0	1,231	1,231	1,231	3,692
SwRI FRINGE	0	0	0	0	0	0	0	0	0	0	223	223	223	668
SwRI OVERHEAD	0	0	0	0	0	0	0	0	0	0	921	921	921	2,763
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	0	0	0	0	0	0	0	0	0	0	0	274	673	947
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	0	0	0	299	299	299	898
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	0	0	0	5,101	5,375	5,773	16,250
FEE (8%)	0	0	0	0	0	0	0	0	0	0	384	406	438	1,228
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	0	0	0	5,485	5,781	6,211	17,478
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	31.4%	33.1%	35.5%	
CUMULATIVE COST	0	0	0	0	0	0	0	0	0	0	5,485	11,266	17,478	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	31.4%	64.5%	100.0%	

Table 4.17 - Seismic Year 3 Composite

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	892	892	892	892	892	892	892	892	892	892	892	892	892	11,601
PL-3	3,786	3,786	4,115	3,786	3,786	3,720	4,444	4,444	4,444	3,786	3,786	3,786	3,786	51,454
PL-2	536	536	536	402	402	402	536	536	536	536	536	536	536	6,568
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	148	148	148	148	148	148	148	148	148	148	148	148	148	1,927
CENTER INDIRECT LABOR (MGT)	461	461	490	450	450	444	518	518	518	461	461	461	461	6,156
SwRI DIRECT LABOR $	6,513	6,513	6,736	6,513	6,513	6,513	6,513	6,513	6,513	6,513	6,727	6,727	6,727	85,535
SwRI SUPPORT SERVICES $	0	0	3,000	0	3,000	0	3,000	0	3,000	0	3,000	0	0	15,000
CENTER FRINGE	2,271	2,271	2,411	2,215	2,215	2,187	2,550	2,550	2,550	2,271	2,271	2,271	2,271	30,306
CENTER OVERHEAD	5,367	5,367	5,697	5,233	5,233	5,167	6,026	6,026	6,026	5,367	5,367	5,367	5,367	71,612
SwRI FRINGE	2,540	2,540	2,627	2,540	2,540	2,540	2,540	2,540	2,540	2,540	2,624	2,624	2,624	33,359
SwRI OVERHEAD	10,502	10,502	10,861	10,502	10,502	10,502	10,502	10,502	10,502	10,502	10,847	10,847	10,847	137,917
ADP SUPPORT $	3,000	5,000	4,000	2,000	2,000	2,000	2,000	200	2,000	2,000	0	0	0	24,200
SUBCONTRACTORS														
ITASCA $	12,552	12,826	13,737	4,888	4,888	4,888	7,257	7,531	8,053	3,420	6,565	7,512	1,469	95,584
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	2,000	0	2,000	0	2,000	0	2,000	0	2,000	0	0	2,000	12,000
TRAVEL $	0	1,000	1,000	2,000	0	2,000	0	0	2,000	0	0	4,000	2,000	14,000
EQUIPMENT & MATERIALS $	2,000	2,000	4,000	2,000	2,000	3,000	3,000	6,000	3,000	2,000	2,000	3,000	2,000	36,000
COST OF FACILITY CAPITAL	2,005	2,005	2,097	1,983	1,983	1,973	2,112	2,112	2,112	2,005	2,042	2,042	2,042	26,516
TOTAL ESTIMATED COST	52,575	57,849	62,348	47,552	46,552	48,376	52,039	52,514	54,836	44,443	47,267	50,214	43,171	659,736
FEE (8%)	4,046	4,468	4,820	3,645	3,565	3,712	3,994	4,032	4,218	3,395	3,618	3,854	3,290	50,658
TOTAL COST INCLUDING FEE	56,620	62,317	67,168	51,197	50,117	52,088	56,034	56,546	59,054	47,838	50,885	54,068	46,462	710,393
% COMPLETION	8.0%	8.8%	9.5%	7.2%	7.1%	7.3%	7.9%	8.0%	8.3%	6.7%	7.2%	7.6%	6.5%	
CUMULATIVE COST	56,620	118,937	186,105	237,302	287,420	339,508	395,541	452,087	511,141	558,979	609,864	663,932	710,393	
CUMULATIVE % COMPLETION	8.0%	16.7%	26.2%	33.4%	40.5%	47.8%	55.7%	63.6%	72.0%	78.7%	85.8%	93.5%	100.0%	

Table 4.18 - Seismic Year 4, Task 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PL-3	521	521	521	0	0	0	0	0	0	417	417	417	417	3,233
PL-2	142	142	142	0	0	0	0	0	0	142	142	142	142	991
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	52	52	52	0	0	0	0	0	0	0	0	0	0	156
CENTER INDIRECT LABOR (MGT)	49	49	49	0	0	0	0	0	0	38	38	38	38	301
SwRI DIRECT LABOR $	377	377	377	0	0	0	0	0	0	754	754	377	754	3,772
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	298	298	298	0	0	0	0	0	0	233	233	233	233	1,826
CENTER OVERHEAD	658	658	658	0	0	0	0	0	0	514	514	514	514	4,028
SwRI FRINGE	147	147	147	0	0	0	0	0	0	294	294	147	294	1,471
SwRI OVERHEAD	608	608	608	0	0	0	0	0	0	1,216	1,216	608	1,216	6,081
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	2,785	2,785	2,785	0	0	0	0	0	0	2,785	2,785	3,073	288	17,284
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	0	1,000	0	0	0	0	0	0	0	0	1,000	0	2,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	180	180	180	0	0	0	0	0	0	221	221	155	221	1,357
TOTAL ESTIMATED COST	5,817	5,817	6,817	0	0	0	0	0	0	6,614	6,614	6,704	4,117	42,500
FEE (8%)	451	451	531	0	0	0	0	0	0	511	511	524	312	3,291
TOTAL COST INCLUDING FEE	6,268	6,268	7,348	0	0	0	0	0	0	7,125	7,125	7,228	4,429	45,791
% COMPLETION	13.7%	13.7%	16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.6%	15.6%	15.8%	9.7%	
CUMULATIVE COST	6,268	12,536	19,884	19,884	19,884	19,884	19,884	19,884	19,884	27,009	34,134	41,362	45,791	
CUMULATIVE % COMPLETION	13.7%	27.4%	43.4%	43.4%	43.4%	43.4%	43.4%	43.4%	43.4%	59.0%	74.5%	90.3%	100.0%	

Table 4.19 - Seismic Year 4, Task 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	707	707	707	942	942	942	942	0	0	0	0	0	0	5,890
PL-3	2,607	2,607	2,607	3,128	3,128	3,128	3,128	2,259	2,259	1,842	1,842	1,842	1,842	32,223
PL-2	283	283	283	425	425	425	425	142	142	142	142	142	142	3,397
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	52	52	52	104	104	104	104	52	52	52	52	52	52	887
CENTER INDIRECT LABOR (MGT)	251	251	251	317	317	317	317	169	169	140	140	140	140	2,918
SwRI DIRECT LABOR $	5,227	5,227	5,227	5,083	5,083	5,083	5,083	4,706	4,706	2,768	2,768	3,145	2,415	56,521
SwRI SUPPORT SERVICES $	3,000	0	3,000	0	2,000	0	2,000	0	0	0	0	0	0	10,000
CENTER FRINGE	1,521	1,521	1,521	1,917	1,917	1,917	1,917	1,023	1,023	849	849	849	849	17,673
CENTER OVERHEAD	3,356	3,356	3,356	4,230	4,230	4,230	4,230	2,256	2,256	1,872	1,872	1,872	1,872	38,989
SwRI FRINGE	2,039	2,039	2,039	1,982	1,982	1,982	1,982	1,835	1,835	1,080	1,080	1,227	942	22,043
SwRI OVERHEAD	8,428	8,428	8,428	8,196	8,196	8,196	8,196	7,588	7,588	4,463	4,463	5,071	3,893	91,135
ADP SUPPORT $	0	2,000	0	1,000	0	1,000	0	0	0	0	0	0	0	4,000
SUBCONTRACTORS														
ITASCA $	5,383	3,183	3,183	5,968	5,968	5,968	5,968	5,560	5,968	2,488	2,895	2,488	2,895	57,916
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	0	1,000	0	2,000	0	0	0	2,000	0	0	0	0	0	5,000
EQUIPMENT & MATERIALS $	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	0	0	0	0	18,000
COST OF FACILITY CAPITAL	1,493	1,493	1,493	1,620	1,620	1,620	1,620	1,211	1,211	807	807	873	746	16,618
TOTAL ESTIMATED COST	36,348	34,148	34,148	38,913	37,913	36,913	37,913	30,801	29,209	16,503	16,910	17,701	15,788	383,209
FEE (8%)	2,788	2,612	2,612	2,983	2,903	2,823	2,903	2,367	2,240	1,256	1,288	1,346	1,203	29,327
TOTAL COST INCLUDING FEE	39,136	36,761	36,761	41,897	40,817	39,737	40,817	33,168	31,448	17,758	18,199	19,047	16,991	412,536
% COMPLETION	9.5%	8.9%	8.9%	10.2%	9.9%	9.6%	9.9%	8.0%	7.6%	4.3%	4.4%	4.6%	4.1%	
CUMULATIVE COST	39,136	75,897	112,657	154,554	195,371	235,108	275,925	309,093	340,541	358,299	376,498	395,545	412,536	
CUMULATIVE % COMPLETION	9.5%	18.4%	27.3%	37.5%	47.4%	57.0%	66.9%	74.9%	82.5%	86.9%	91.3%	95.9%	100.0%	

Table 4.20 - Seismic Year 4, Task 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	236	236	236	0	0	0	0	707	707	707	707	0	0	3,534
PL-3	869	869	869	869	869	869	869	869	869	869	869	869	869	11,297
PL-2	142	142	142	142	142	142	142	142	142	142	142	142	142	1,840
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	52	52	52	52	52	52	52	52	52	52	52	52	52	678
CENTER INDIRECT LABOR (MGT)	89	89	89	73	73	73	73	122	122	122	122	73	73	1,194
SWRI DIRECT LABOR $	1,273	1,273	1,273	1,794	1,794	1,794	1,794	1,621	1,621	1,621	1,621	1,273	1,273	20,025
SWRI SUPPORT SERVICES $	0	0	2,000	0	0	0	2,000	0	0	0	0	0	0	4,000
CENTER FRINGE	541	541	541	443	443	443	443	738	738	738	738	443	443	7,232
CENTER OVERHEAD	1,194	1,194	1,194	977	977	977	977	1,627	1,627	1,627	1,627	977	977	15,955
SWRI FRINGE	496	496	496	700	700	700	700	632	632	632	632	496	496	7,810
SWRI OVERHEAD	2,053	2,053	2,053	2,893	2,893	2,893	2,893	2,613	2,613	2,613	2,613	2,053	2,053	32,288
ADP SUPPORT $	2,000	2,000	2,000	2,000	2,000	2,000	2,000	1,000	1,000	1,000	1,000	1,000	0	19,000
SUBCONTRACTORS														
ITASCA $	408	408	1,244	1,652	1,244	1,652	1,244	1,652	408	1,652	1,652	408	408	14,029
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	2,000	0	2,000	0	2,000	0	2,000	0	0	0	0	0	8,000
TRAVEL $	0	1,000	0	0	1,000	0	0	1,000	0	0	0	0	0	3,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	429	429	429	482	482	482	482	565	565	565	565	392	392	6,260
TOTAL ESTIMATED COST	9,782	12,782	12,618	14,077	12,670	14,077	13,670	15,339	11,095	12,339	12,339	8,177	7,177	156,142
FEE (8%)	748	988	975	1,088	975	1,088	1,055	1,182	842	942	942	623	543	11,991
TOTAL COST INCLUDING FEE	10,530	13,770	13,593	15,165	13,645	15,165	14,725	16,520	11,937	13,280	13,280	8,800	7,720	168,133
% COMPLETION	6.3%	8.2%	8.1%	9.0%	8.1%	9.0%	8.8%	9.8%	7.1%	7.9%	7.9%	5.2%	4.6%	
CUMULATIVE COST	10,530	24,300	37,893	53,059	66,703	81,868	96,593	113,114	125,051	138,332	151,612	160,412	168,133	
CUMULATIVE % COMPLETION	6.3%	14.5%	22.5%	31.6%	39.7%	48.7%	57.5%	67.3%	74.4%	82.3%	90.2%	95.4%	100.0%	

Table 4.21 - Seismic Year 4, Task 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	0	0	0	0	0	0	0	236	236	236	236	942	942	2,827
PL-3	0	0	0	0	0	0	0	869	869	869	869	869	869	5,214
PL-2	0	0	0	0	0	0	0	142	142	142	142	142	142	849
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	0	0	0	0	0	0	0	52	52	52	52	52	52	313
CENTER INDIRECT LABOR (MGT)	0	0	0	0	0	0	0	89	89	89	89	138	138	634
SwRI DIRECT LABOR $	0	0	0	0	0	0	0	551	551	1,735	1,735	1,735	1,891	8,197
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	2,000	2,000	0	0	4,000
CENTER FRINGE	0	0	0	0	0	0	0	541	541	541	541	836	836	3,836
CENTER OVERHEAD	0	0	0	0	0	0	0	1,194	1,194	1,194	1,194	1,844	1,844	8,464
SwRI FRINGE	0	0	0	0	0	0	0	215	215	676	676	676	737	3,197
SwRI OVERHEAD	0	0	0	0	0	0	0	888	888	2,797	2,797	2,797	3,049	13,216
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	0	0	0	0	0	0	0	0	0	576	1,820	1,820	2,524	6,740
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	3,000	1,000	0	0	4,000
TRAVEL $	0	0	0	0	0	0	0	0	0	0	0	3,000	0	3,000
EQUIPMENT & MATERIALS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COST OF FACILITY CAPITAL	0	0	0	0	0	0	0	304	304	510	510	623	650	2,899
TOTAL ESTIMATED COST	0	0	0	0	0	0	0	5,081	5,081	14,416	13,660	15,473	13,675	67,385
FEE (8%)	0	0	0	0	0	0	0	382	382	1,113	1,052	1,188	1,042	5,159
TOTAL COST INCLUDING FEE	0	0	0	0	0	0	0	5,463	5,463	15,529	14,712	16,661	14,717	72,544
% COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.5%	7.5%	21.4%	20.3%	23.0%	20.3%	
CUMULATIVE COST	0	0	0	0	0	0	0	5,463	10,926	26,454	41,166	57,827	72,544	
CUMULATIVE % COMPLETION	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.5%	15.1%	36.5%	56.7%	79.7%	100.0%	

Table 4.22 - Seismic Year 4 Composite

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	942	942	942	942	942	942	942	942	942	942	942	942	942	12,251
PL-3	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	51,966
PL-2	566	566	566	566	566	566	566	425	425	566	566	566	566	7,078
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	156	156	156	156	156	156	156	156	156	156	156	156	156	2,034
CENTER INDIRECT LABOR (MGT)	390	390	390	390	390	390	390	380	380	390	390	390	390	5,048
SwRI DIRECT LABOR $	6,877	6,877	6,877	6,877	6,877	6,877	6,877	6,877	6,877	6,877	6,877	6,530	6,333	88,514
SwRI SUPPORT SERVICES $	3,000	0	5,000	0	2,000	0	4,000	0	0	2,000	2,000	0	0	18,000
CENTER FRINGE	2,360	2,360	2,360	2,360	2,360	2,360	2,360	2,301	2,301	2,360	2,360	2,360	2,360	30,567
CENTER OVERHEAD	5,207	5,207	5,207	5,207	5,207	5,207	5,207	5,077	5,077	5,207	5,207	5,207	5,207	67,436
SwRI FRINGE	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,547	2,470	34,520
SwRI OVERHEAD	11,089	11,089	11,089	11,089	11,089	11,089	11,089	11,089	11,089	11,089	11,089	10,529	10,211	142,720
ADP SUPPORT $	2,000	4,000	2,000	3,000	2,000	3,000	2,000	1,000	1,000	1,000	1,000	1,000	0	23,000
SUBCONTRACTORS														
ITASCA $	8,575	6,376	7,212	7,620	7,212	7,620	7,212	7,212	6,376	7,500	9,151	7,788	6,115	95,968
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	2,000	0	2,000	0	2,000	0	2,000	0	3,000	1,000	0	0	12,000
TRAVEL $	0	2,000	1,000	2,000	1,000	0	0	3,000	0	0	0	4,000	0	13,000
EQUIPMENT & MATERIALS $	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	0	0	0	0	18,000
COST OF FACILITY CAPITAL	2,103	2,103	2,103	2,103	2,103	2,103	2,103	2,080	2,080	2,103	2,103	2,042	2,008	27,134
TOTAL ESTIMATED COST	51,947	52,747	53,583	52,991	50,583	50,991	51,583	51,220	45,384	49,871	49,523	48,055	40,757	649,236
FEE (8%)	3,988	4,052	4,118	4,071	3,878	3,911	3,958	3,931	3,464	3,821	3,794	3,681	3,100	49,768
TOTAL COST INCLUDING FEE	55,934	56,799	57,702	57,062	54,462	54,902	55,542	55,151	48,848	53,693	53,316	51,736	43,857	699,004
% COMPLETION	8.0%	8.1%	8.3%	8.2%	7.8%	7.9%	7.9%	7.9%	7.0%	7.7%	7.6%	7.4%	6.3%	
CUMULATIVE COST	55,934	112,733	170,435	227,497	281,959	336,860	392,402	447,553	496,402	550,094	603,411	655,147	699,004	
CUMULATIVE % COMPLETION	8.0%	16.1%	24.4%	32.5%	40.3%	48.2%	56.1%	64.0%	71.0%	78.7%	86.3%	93.7%	100.0%	

Table 4.23 - Seismic Year 5, Task 6 (Composite)

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CENTER DIRECT LABOR (TECH)														
PL-4	996	996	0	0	0	0	0	0	0	0	0	0	0	1,992
PL-3	2,021	2,021	0	0	0	C	0	0	0	0	0	0	0	4,041
PL-2	299	299	0	0	0	0	0	0	0	0	0	0	0	598
PL-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR. TECH.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLERICAL	165	165	0	0	0	0	0	0	0	0	0	0	0	331
CENTER INDIRECT LABOR (MGT)	240	240	0	0	0	0	0	0	0	0	0	0	0	479
SwRI DIRECT LABOR $	908	1,944	0	0	0	0	0	0	0	0	0	0	0	2,851
SwRI SUPPORT SERVICES $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CENTER FRINGE	1,451	1,451	0	0	0	0	0	0	0	0	0	0	0	2,903
CENTER OVERHEAD	3,202	3,202	0	0	0	0	0	0	0	0	0	0	0	6,404
SwRI FRINGE	354	758	0	0	0	0	0	0	0	0	0	0	0	1,112
SwRI OVERHEAD	1,463	3,134	0	0	0	0	0	0	0	0	0	0	0	4,598
ADP SUPPORT $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUBCONTRACTORS														
ITASCA $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NWC $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONSULTANTS $	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAVEL $	1,000	0	0	0	0	0	0	0	0	0	0	0	0	1,000
EQUIPMENT & MATERIALS $	1,000	0	0	0	0	0	0	0	0	0	0	0	0	1,000
COST OF FACILITY CAPITAL	715	895	0	0	0	0	0	0	0	0	0	0	0	1,610
TOTAL ESTIMATED COST	13,814	15,106	0	0	0	0	0	0	0	0	0	0	0	28,920
FEE (8%)	1,048	1,137	0	0	0	0	0	0	0	0	0	0	0	2,185
TOTAL COST INCLUDING FEE	14,862	16,242	0	0	0	0	0	0	0	0	0	0	0	31,105
% COMPLETION	47.8%	52.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
CUMULATIVE COST	14,862	31,105	31,105	31,105	31,105	31,105	31,105	31,105	31,105	31,105	31,105	31,105	31,105	
CUMULATIVE % COMPLETION	47.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

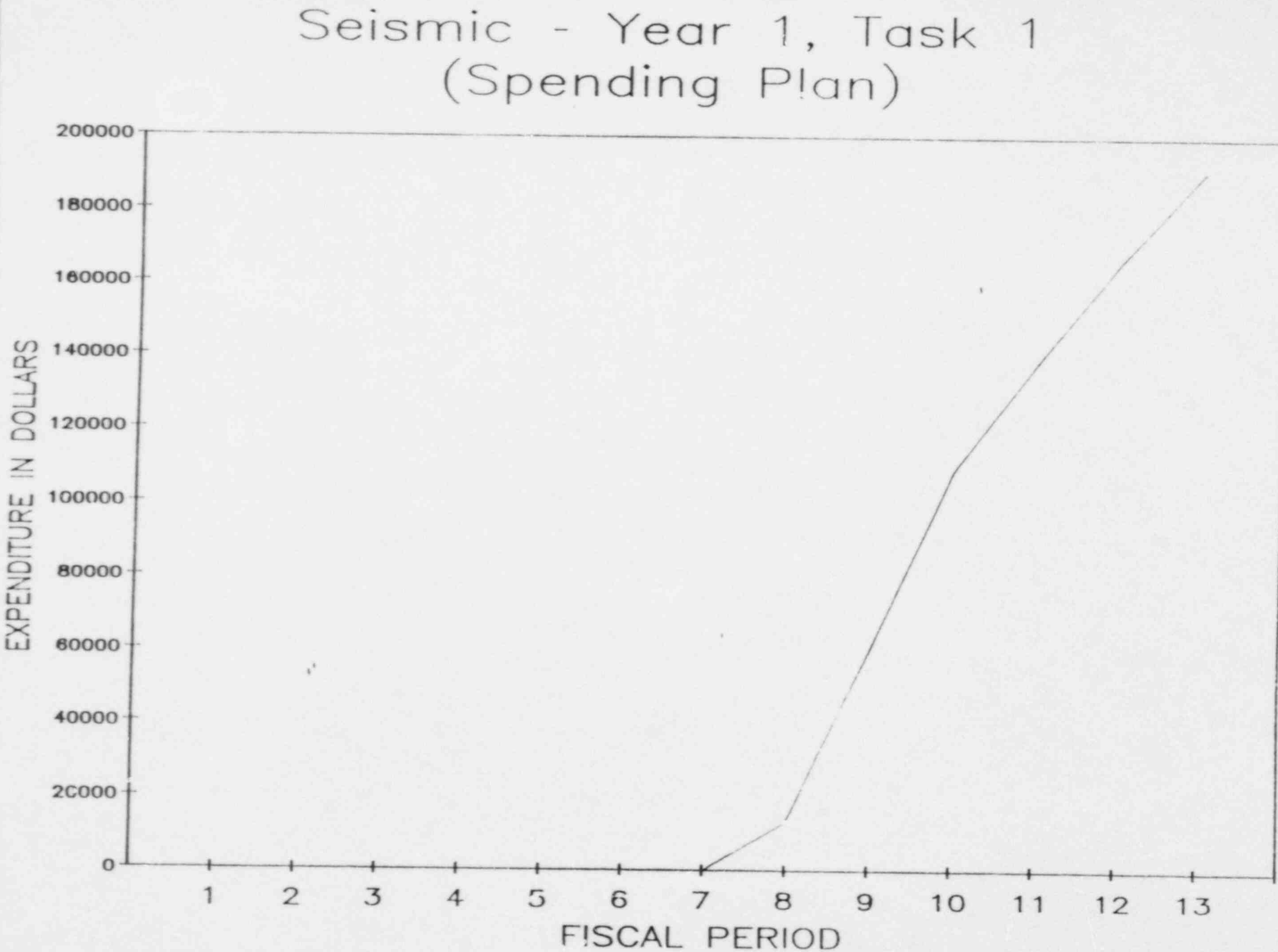

Figure 4.1 - Task 1 Spending Plan, Year 1

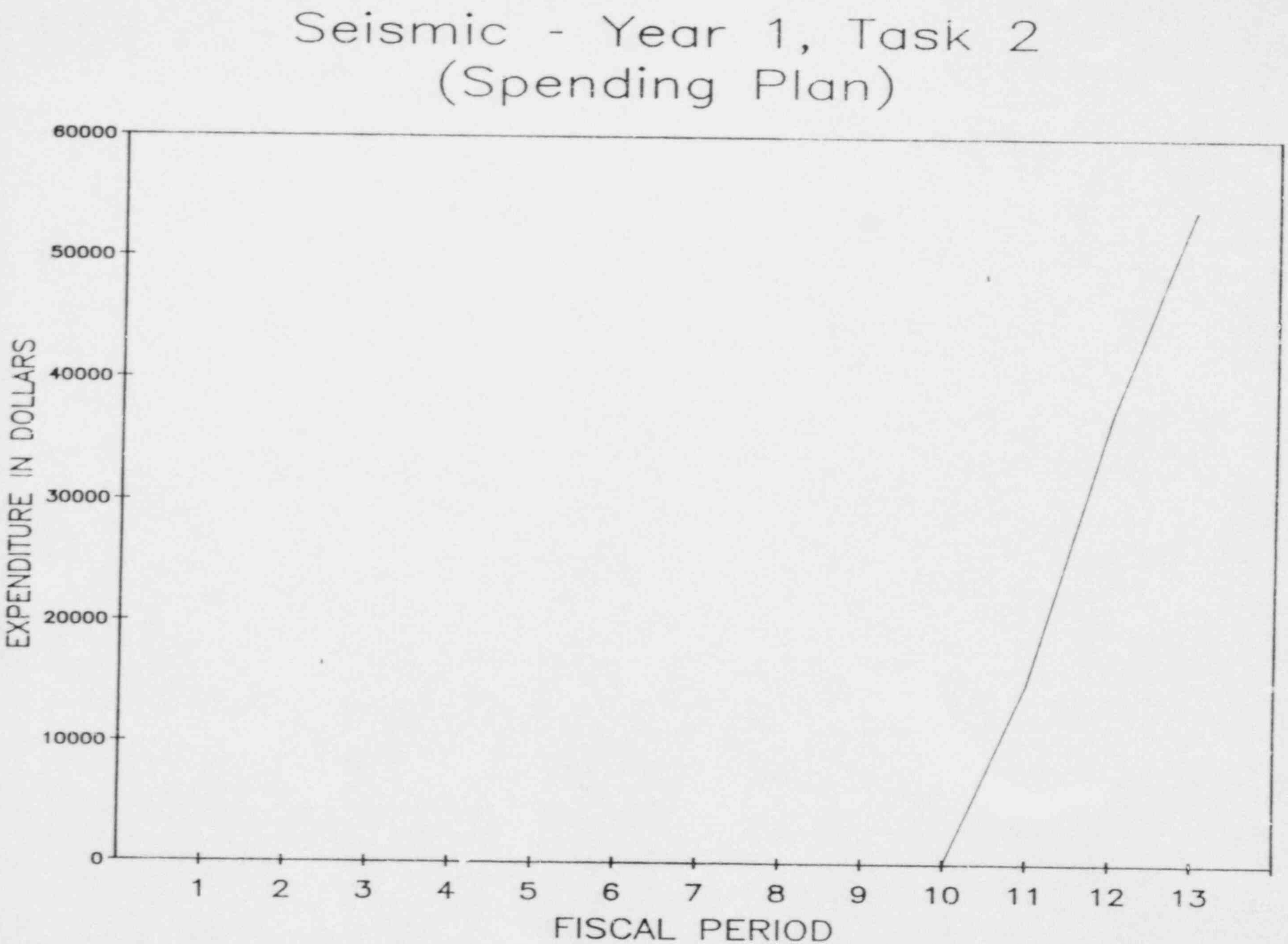

Figure 4.2 -Task 2 Spending Plan, Year 1

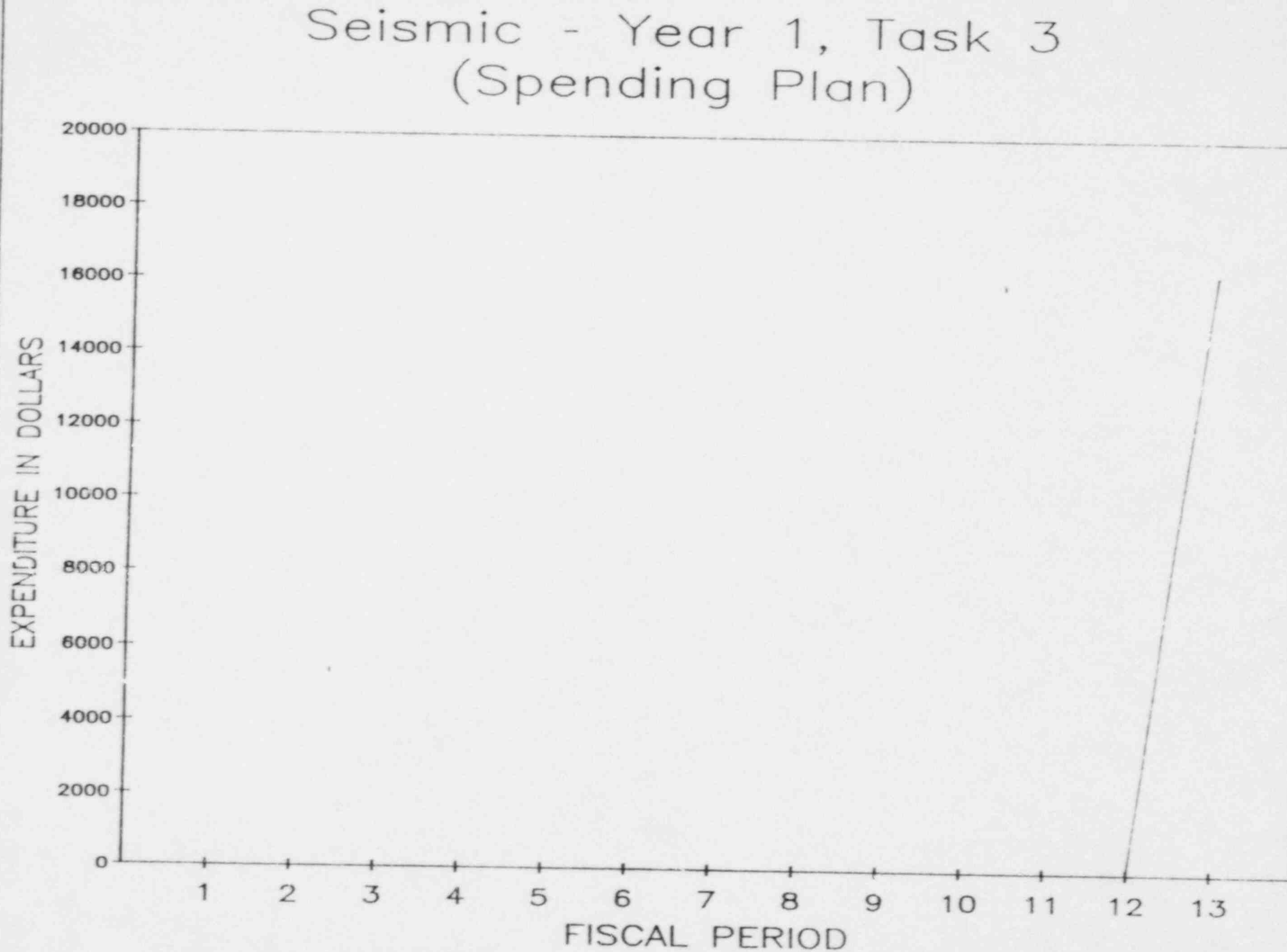

Figure 4.3 -Task 3 Spending Plan, Year 1

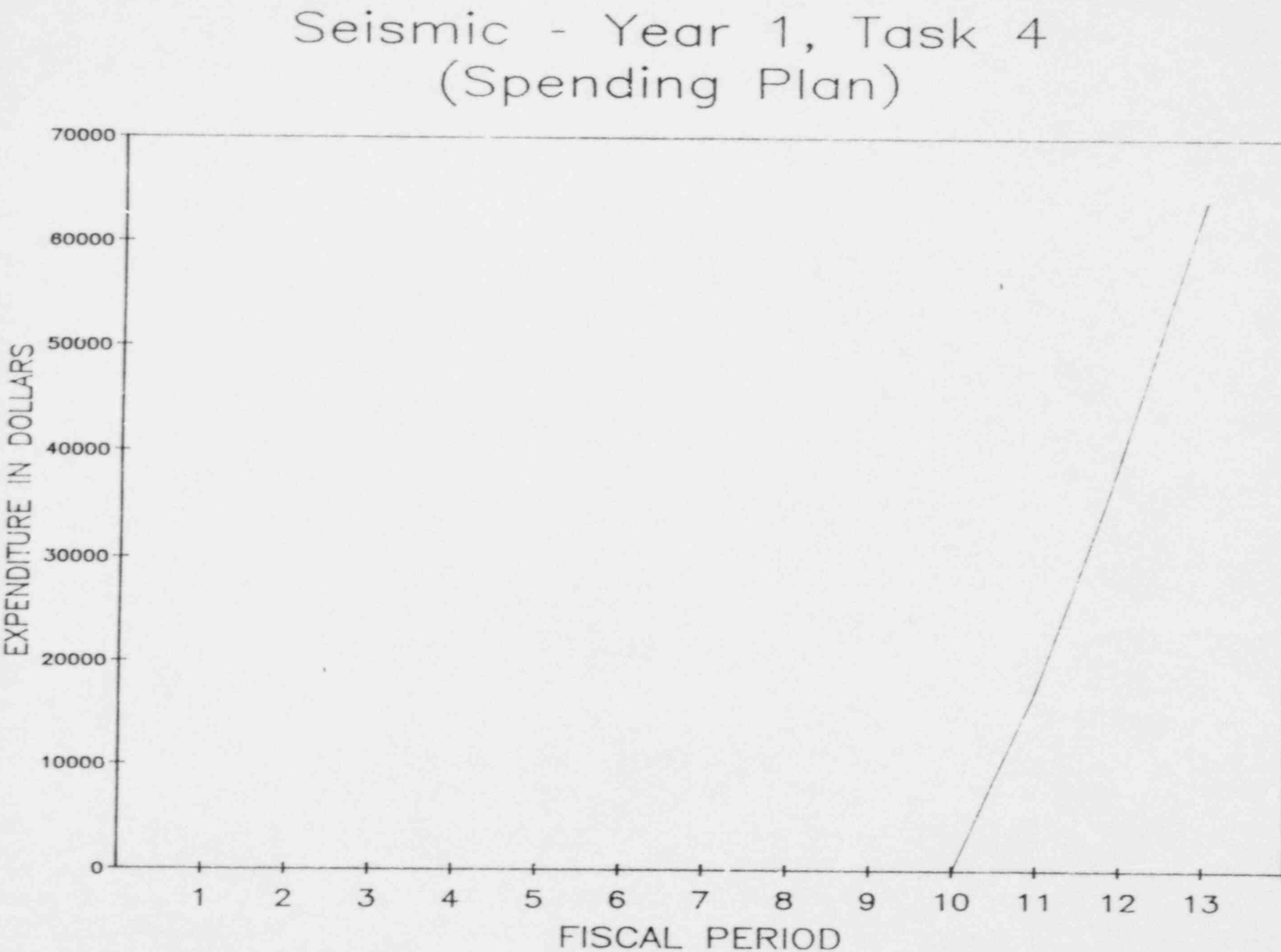

Figure 4.4 -Task 4 Spending Plan, Year 1

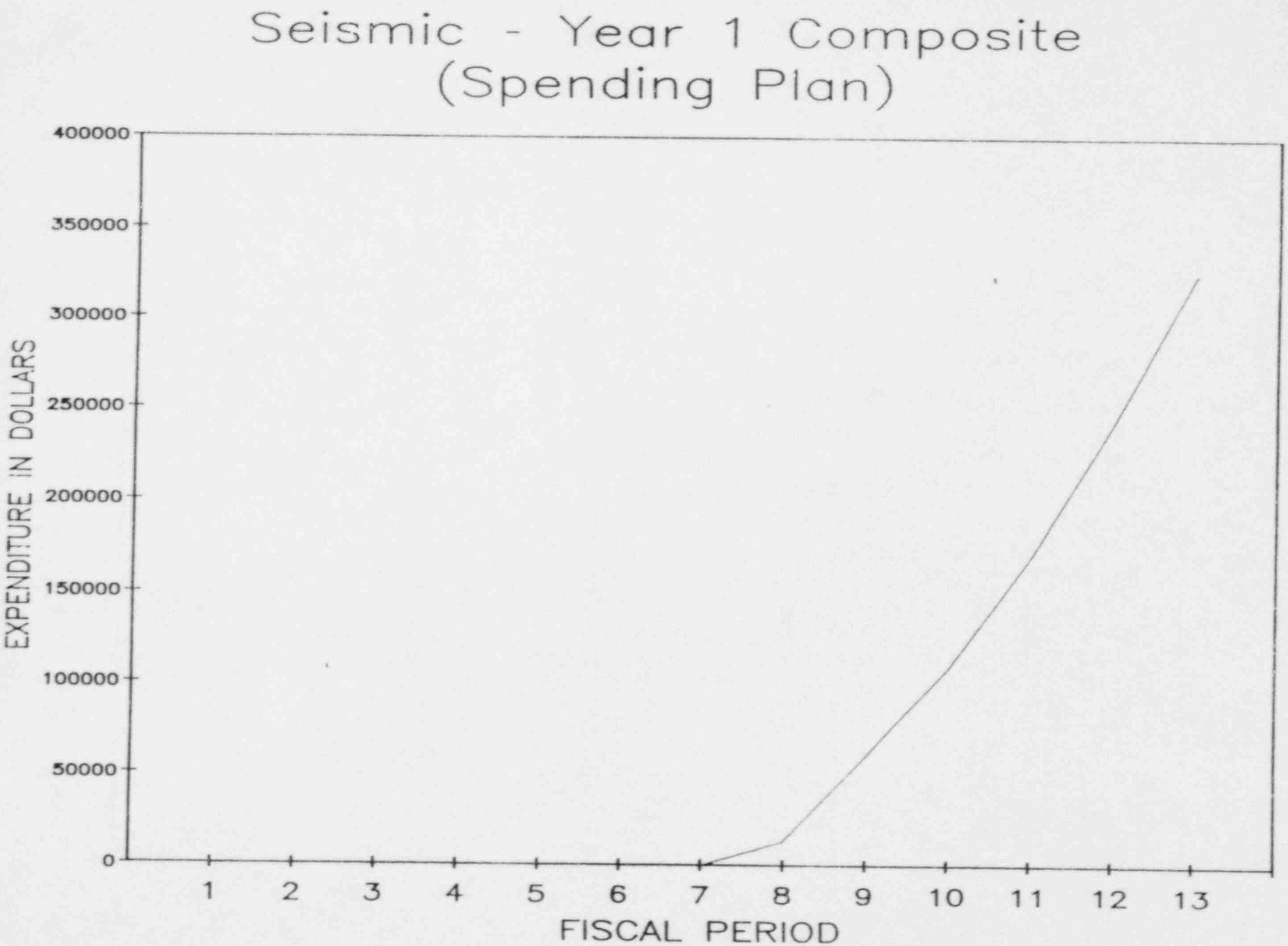

Figure 4.5 - Composite Spending Plan, Year 1

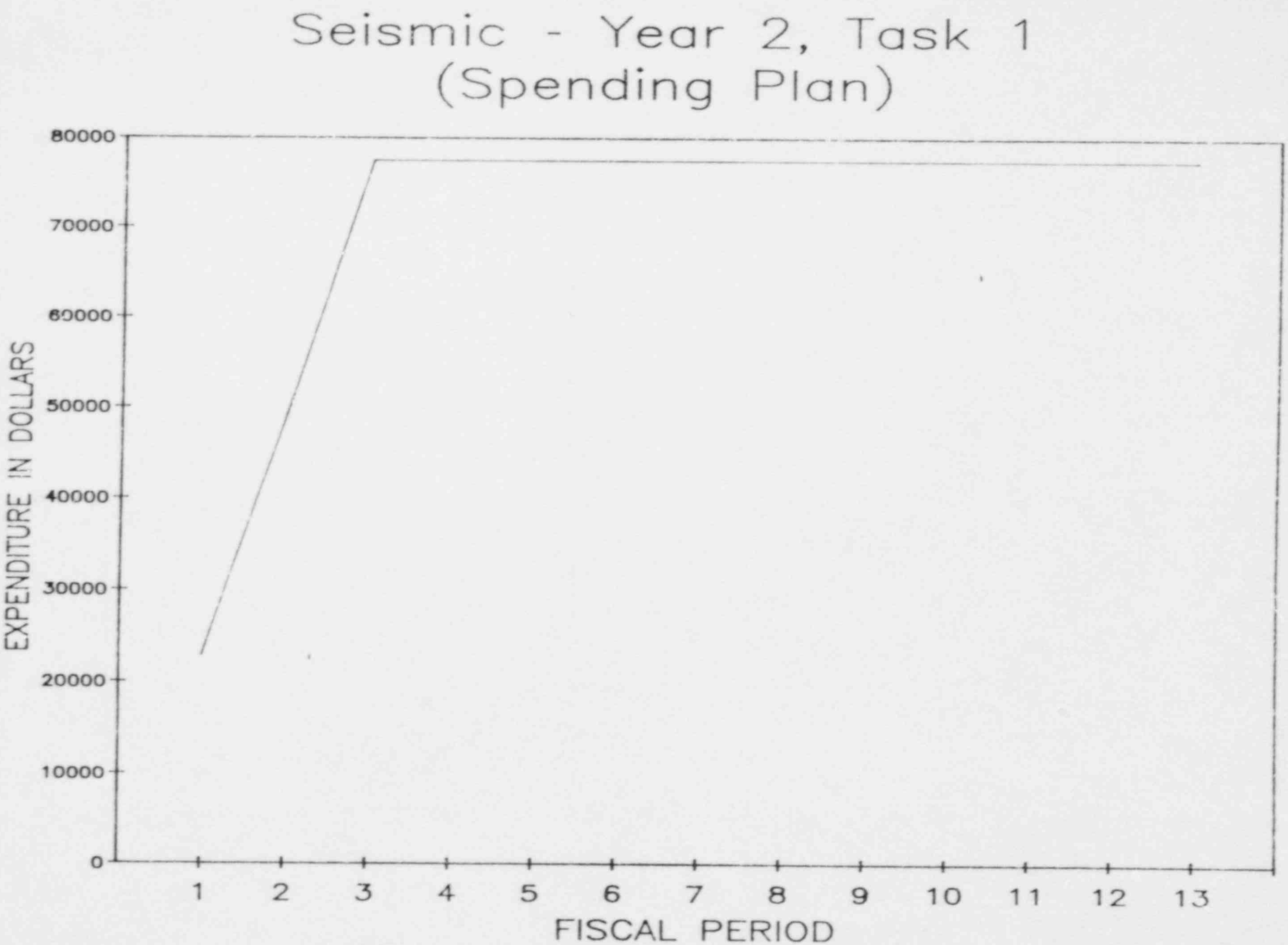

Figure 4.6 -Task 1 Spending Plan, Year 2

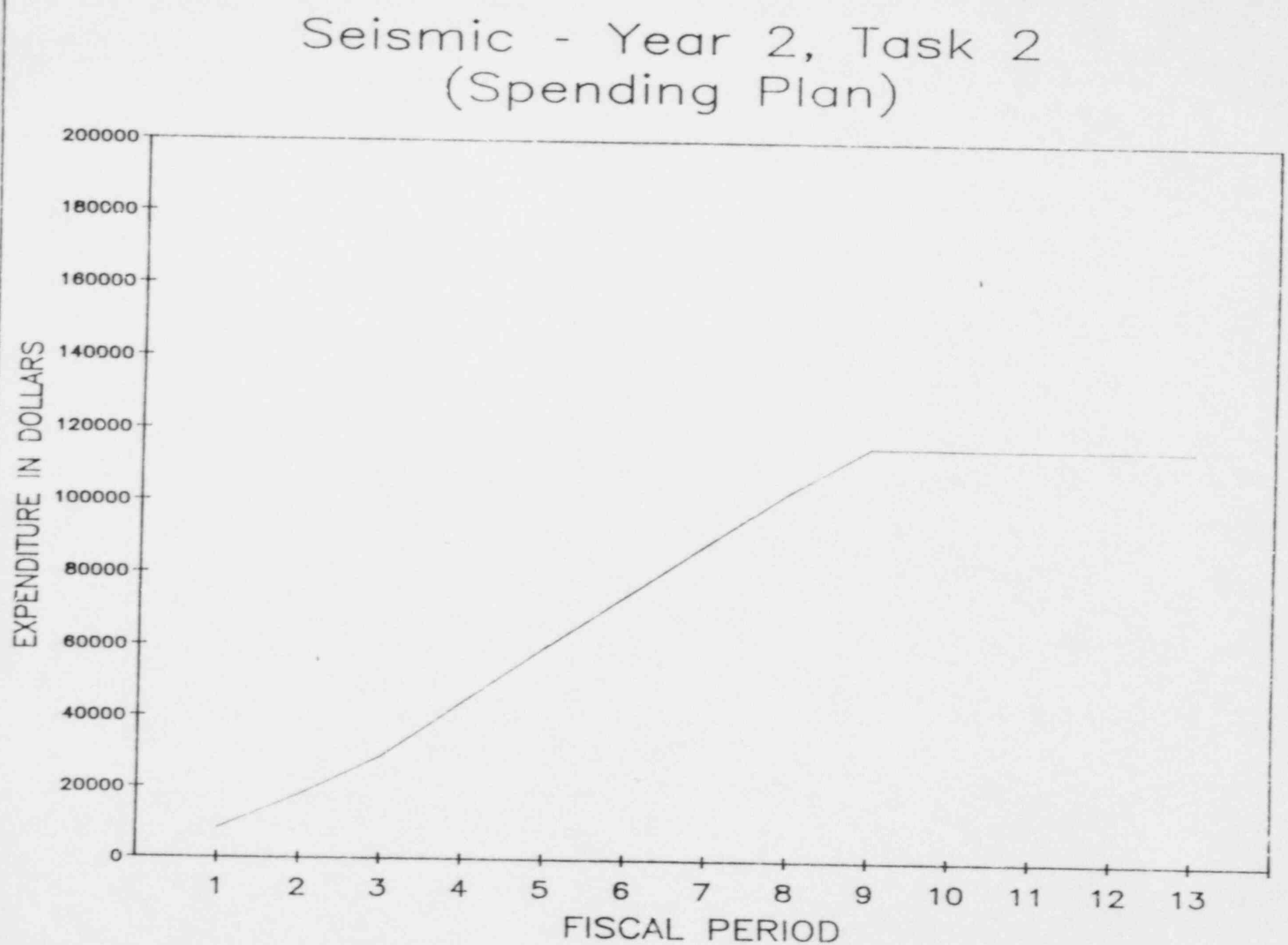

Figure 4.7 -Task 2 Spending Plan, Year 2

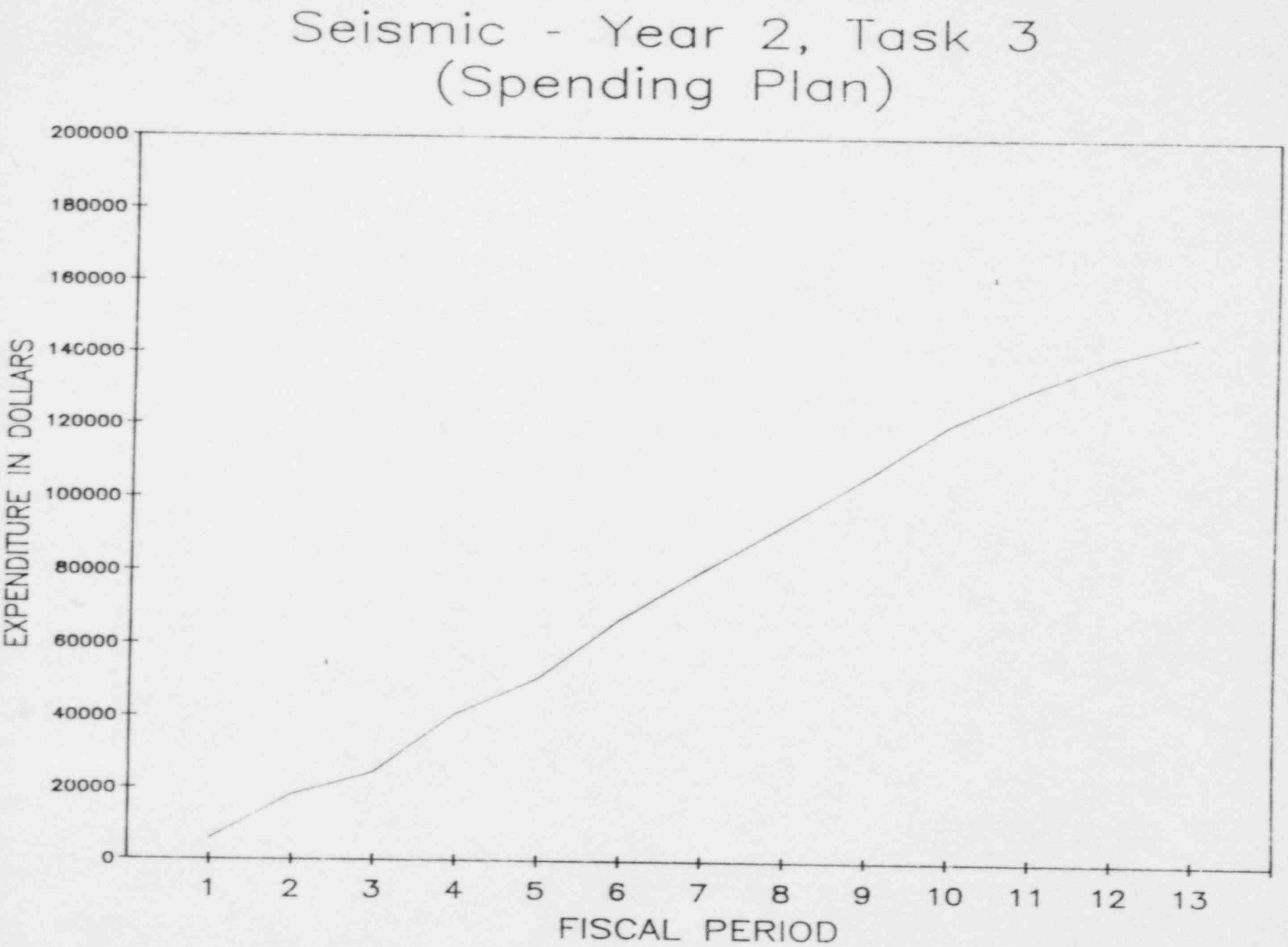

Figure 4.8 - Task 3 Spending Plan, Year 2

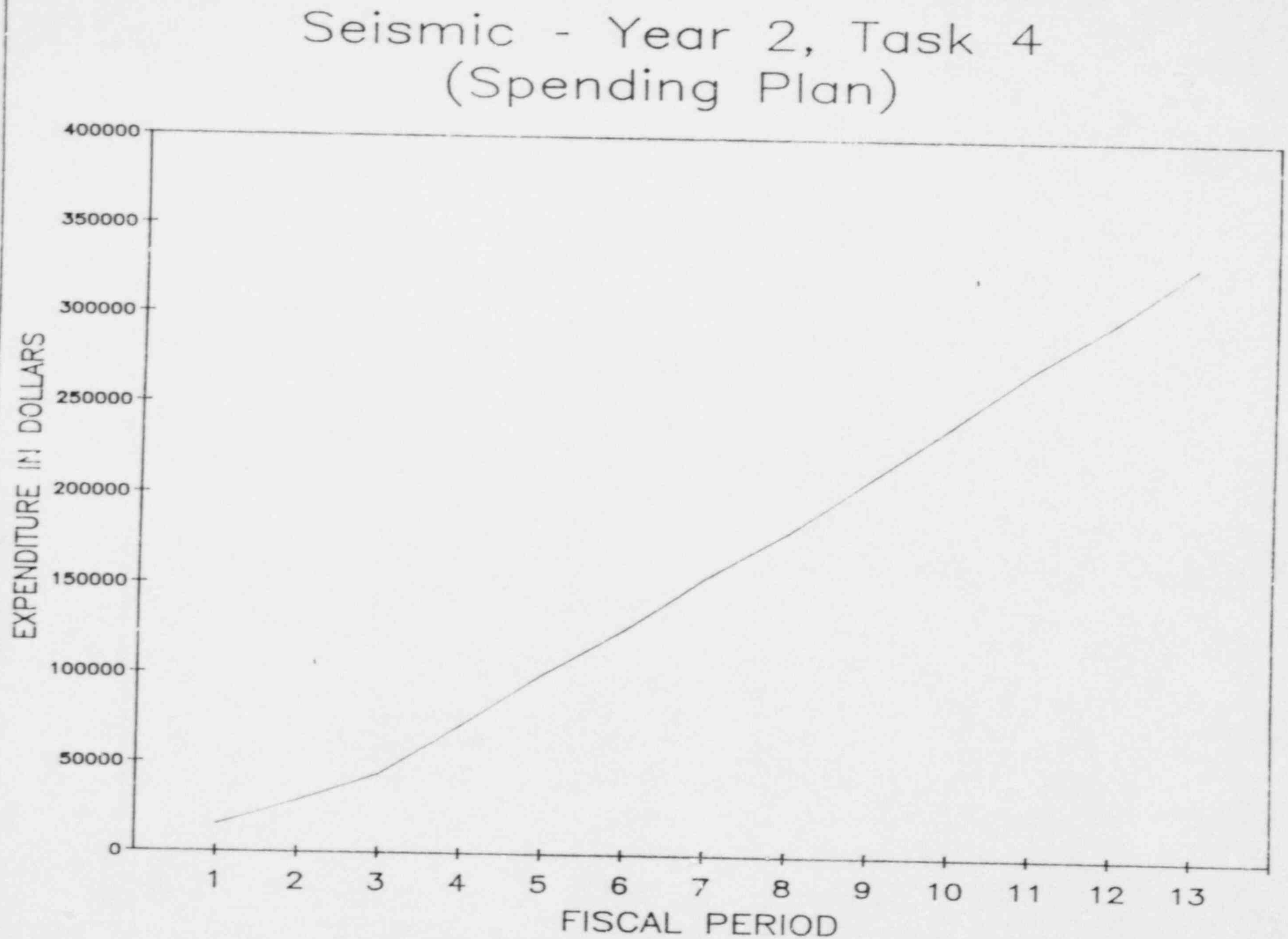

Figure 4.9 - Task 4 Spending Plan, Year 2

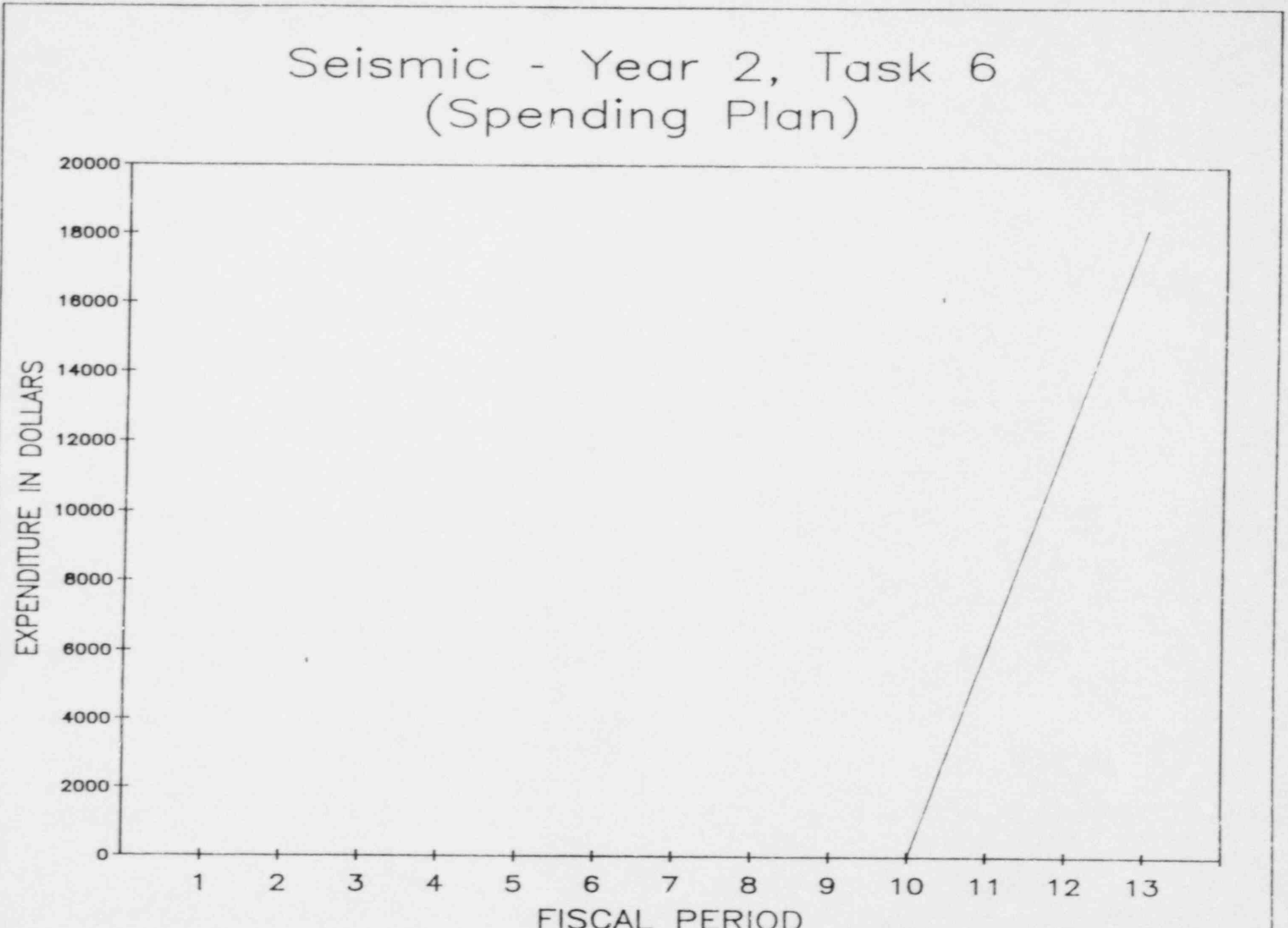

Figure 4.10 - Task 6 Spending Plan, Year 2

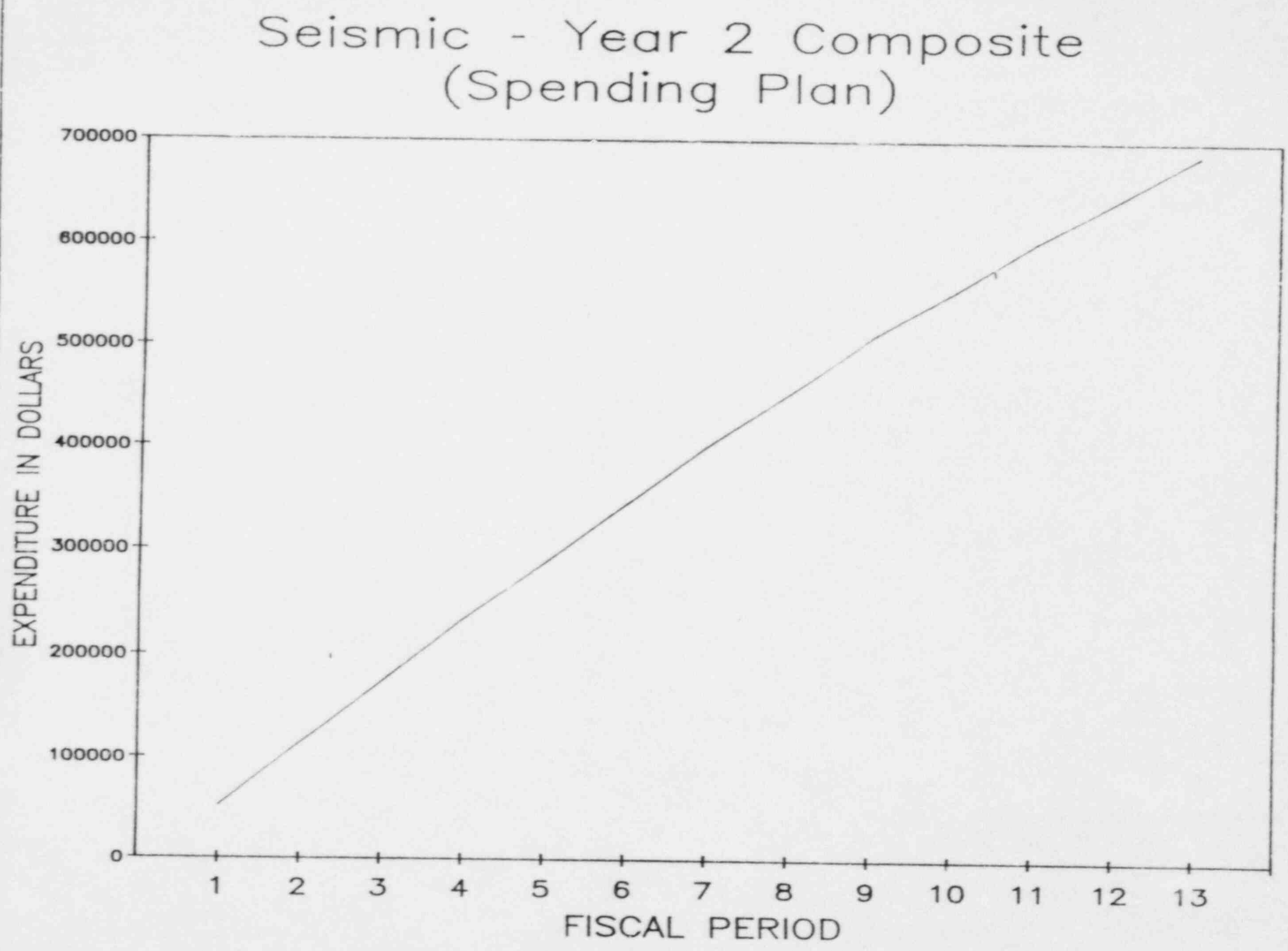

Figure 4.11 - Composite Spending Plan, Year 2

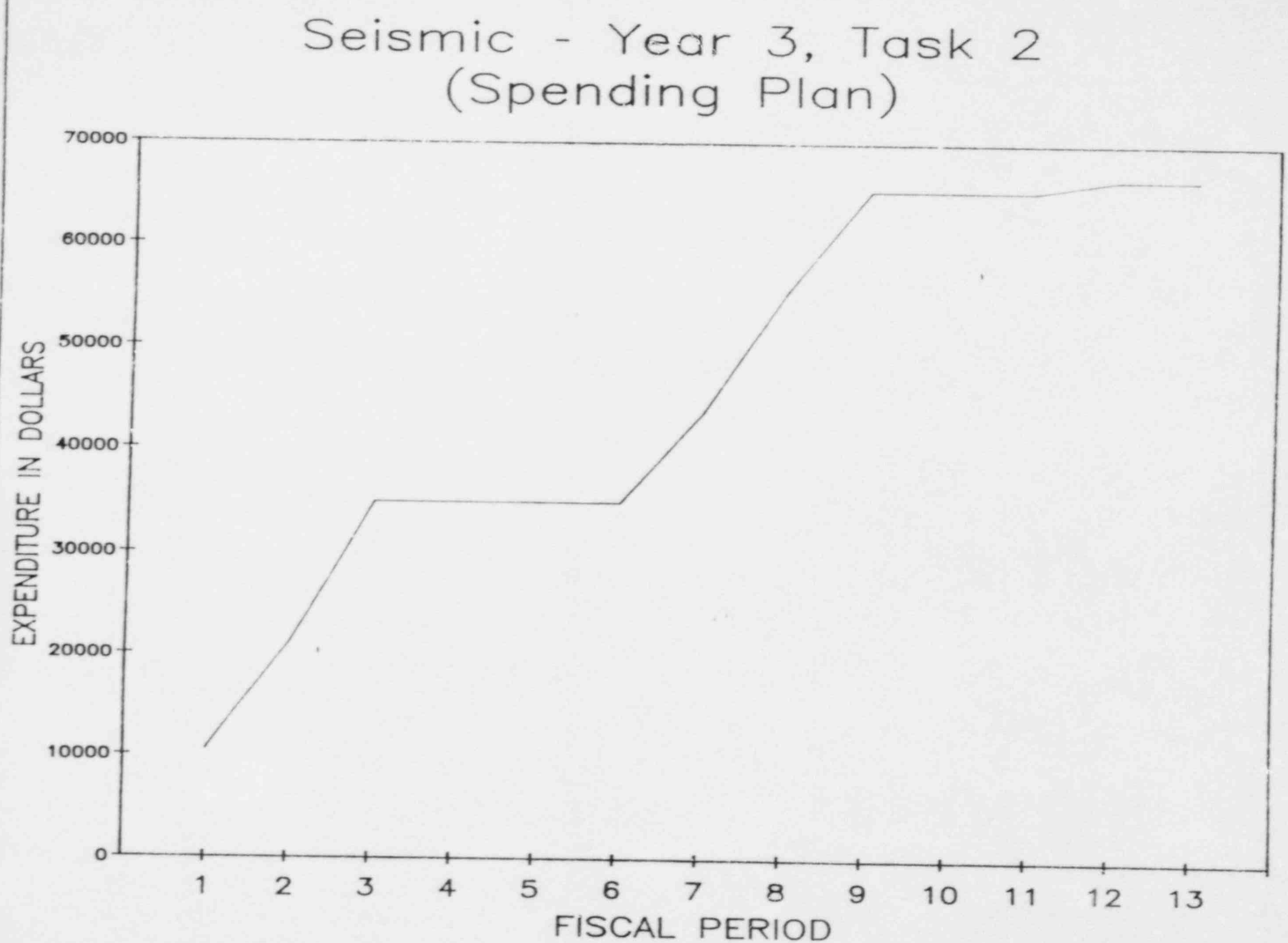

Figure 4.12 - Tcsk 2 Spending Plan, Year 3

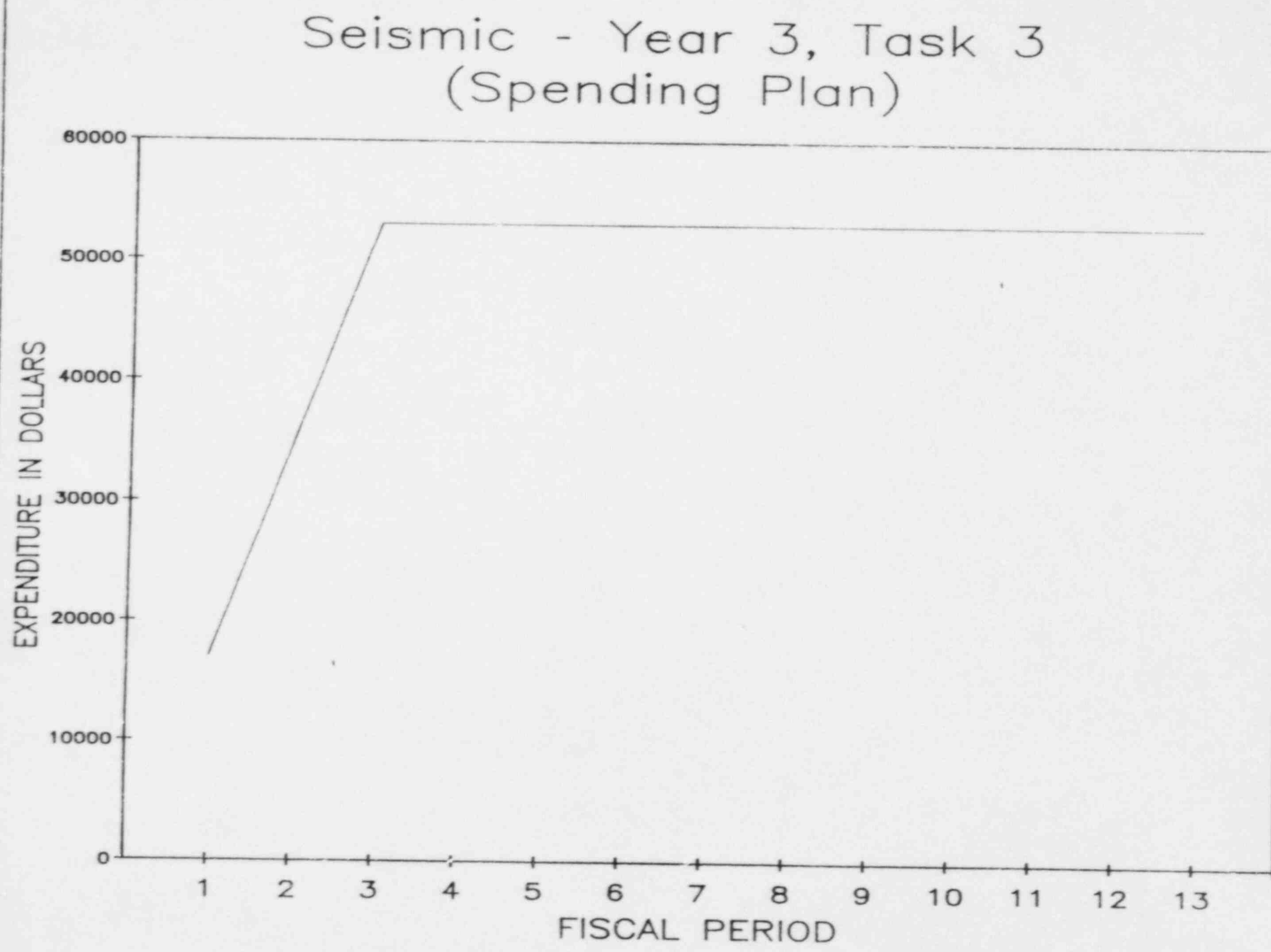

Figure 4.13 - Task 3 Spending Plan, Year 3

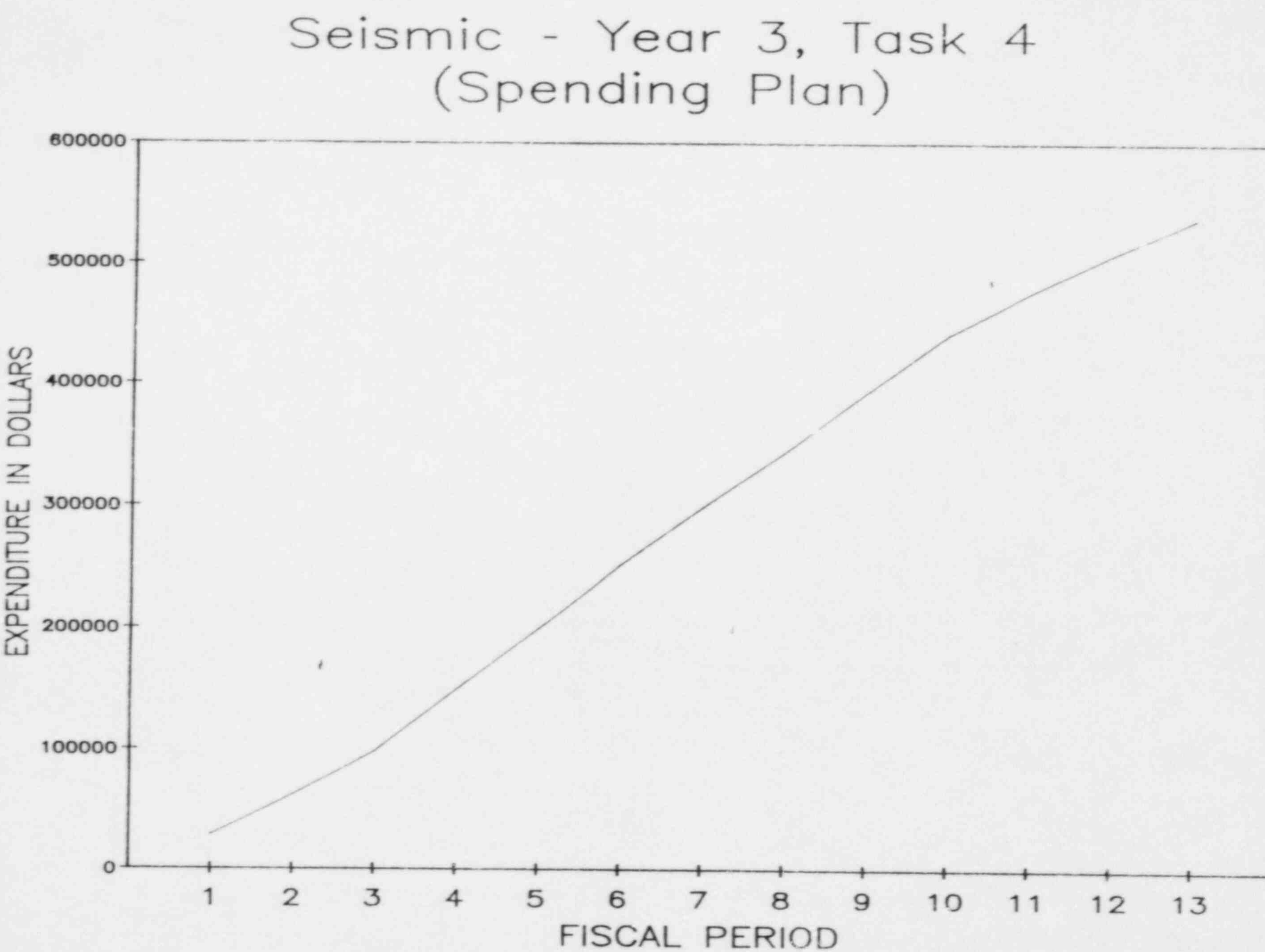

Figure 4.14 - Task 4 Spending Plan, Year 3

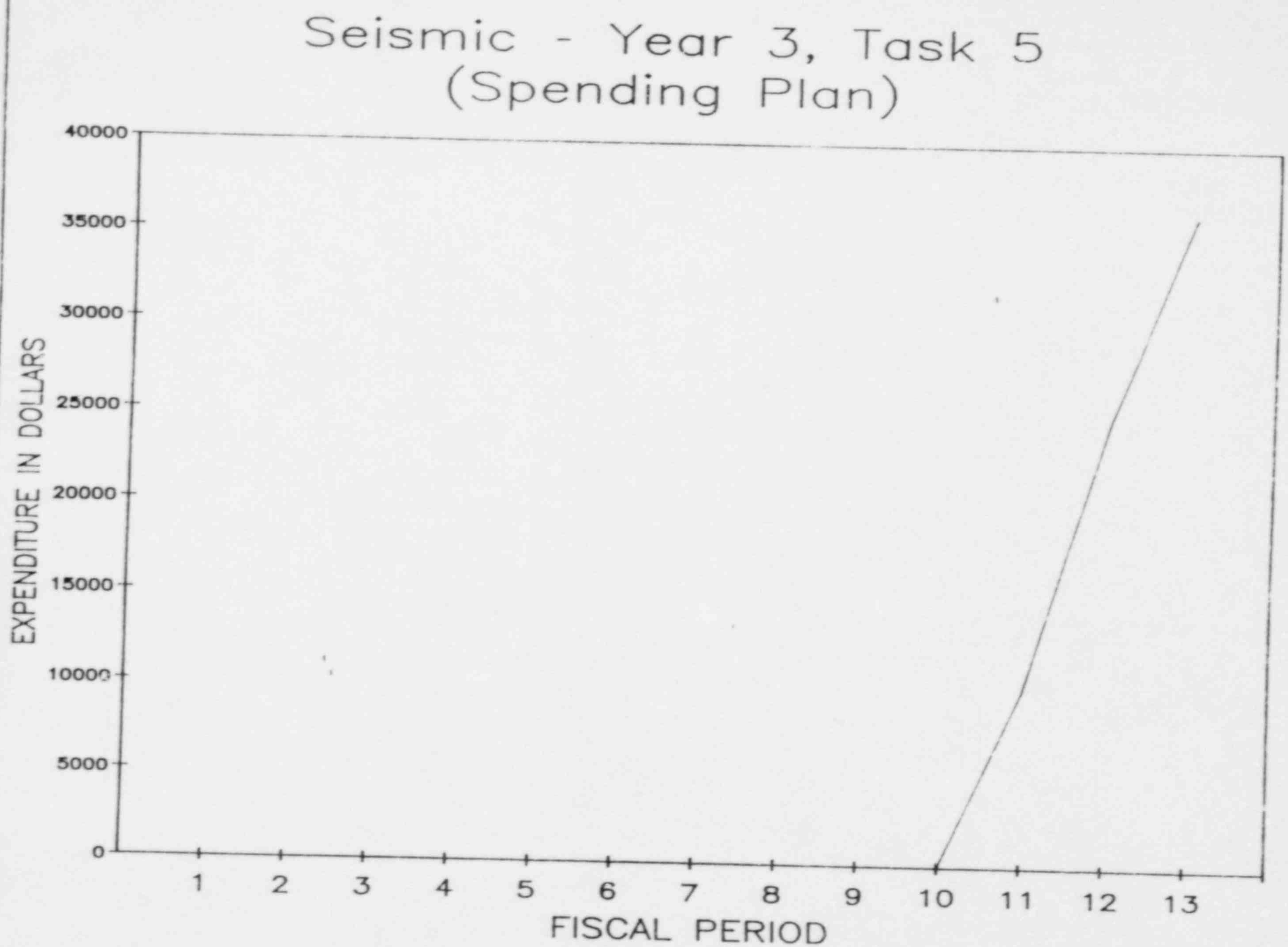

Figure 4.15 - Task 5 Spending Plan, Year 3

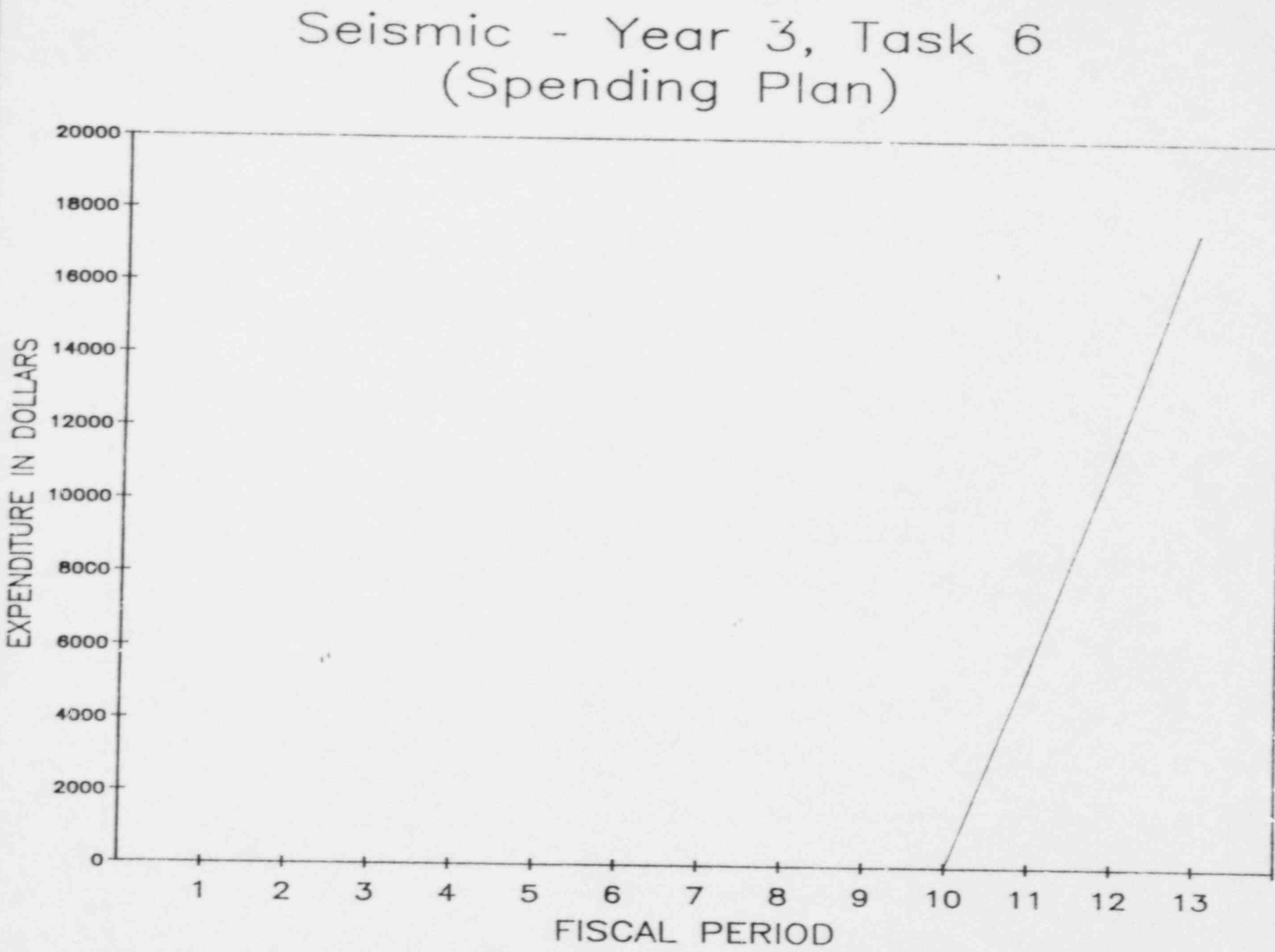

Figure 4.16 - Task 6 Spending Plan, Year 3

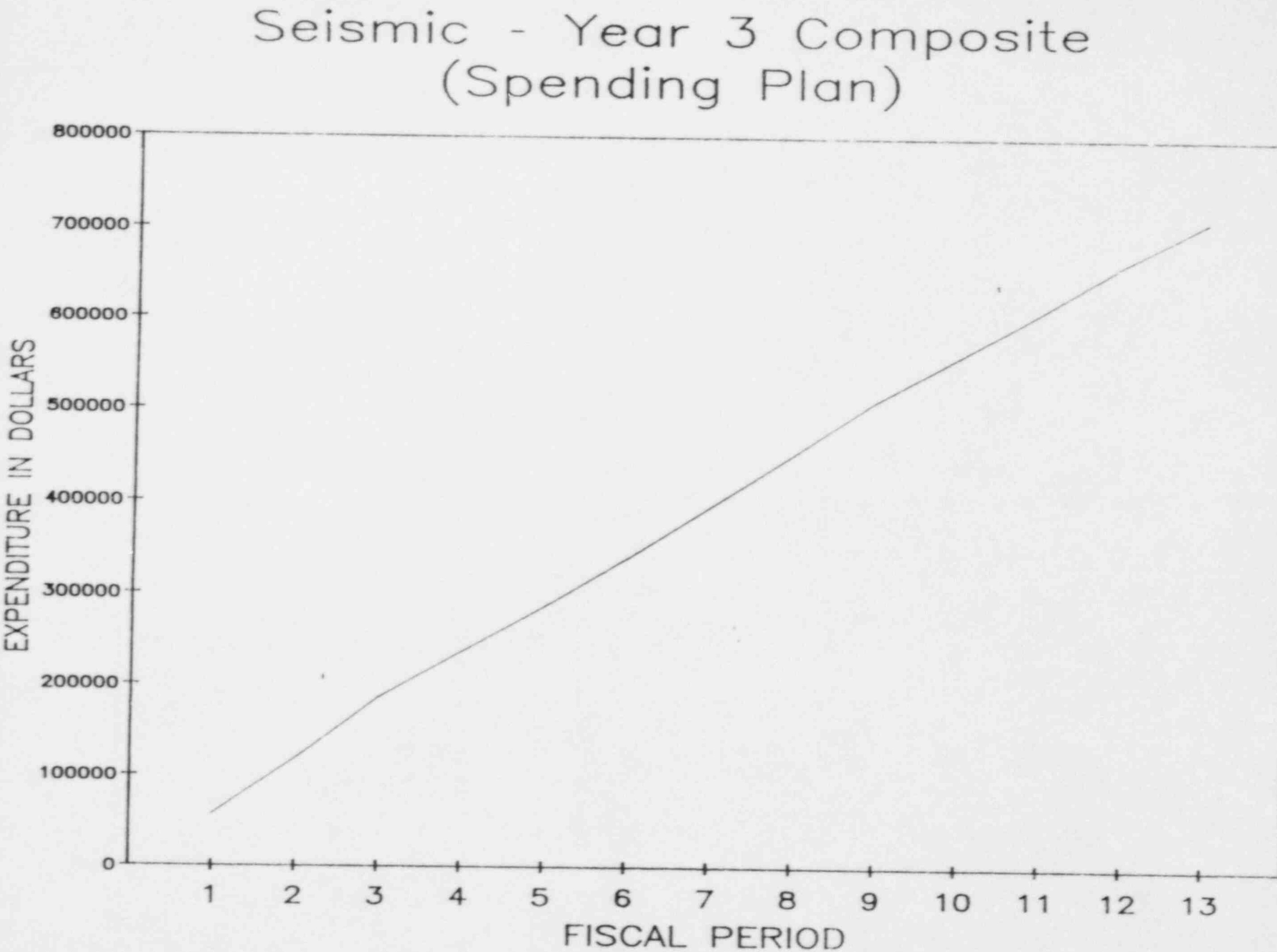

Figure 4.17 - Composite Spending Plan, Year 3

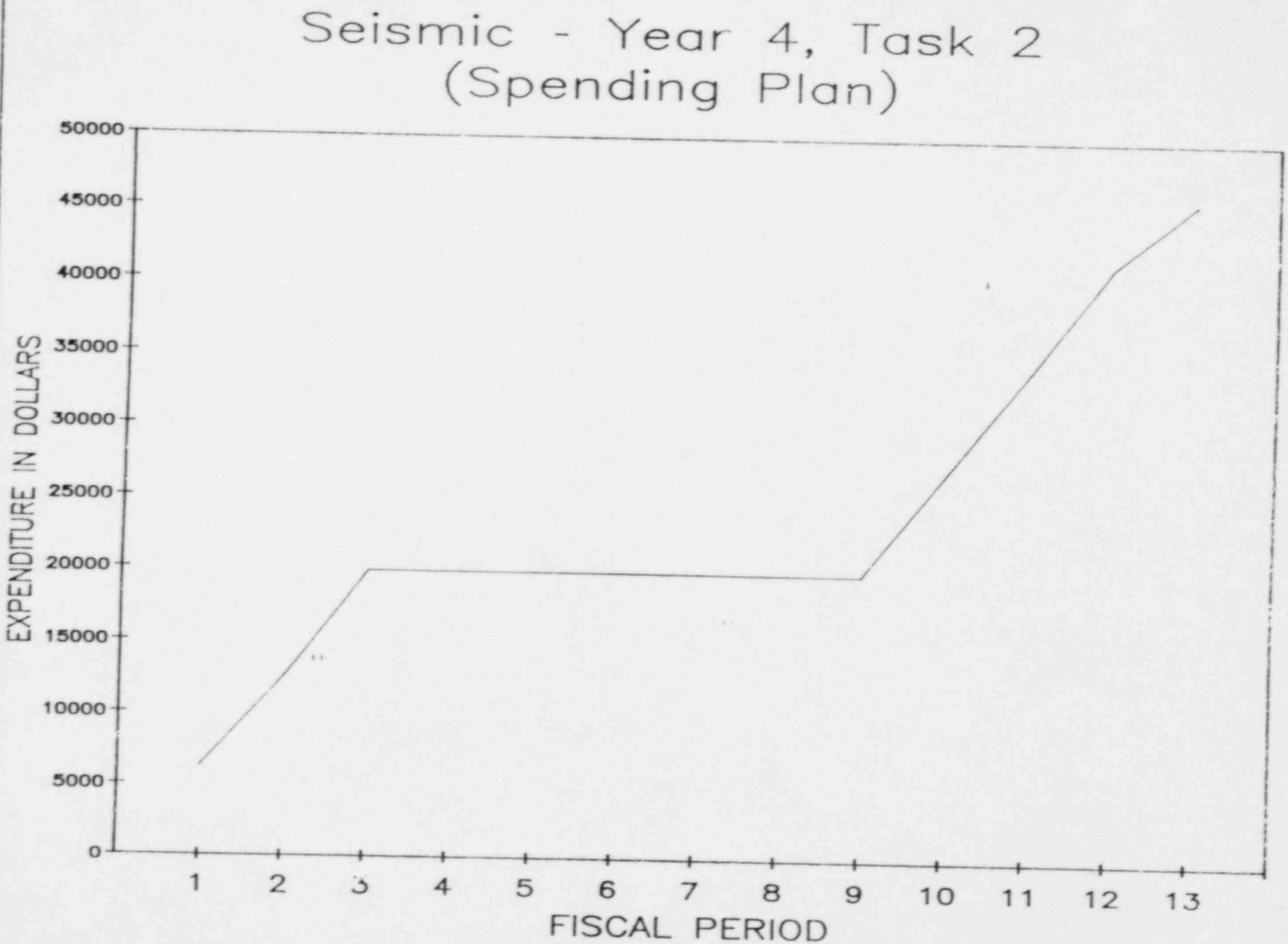

Figure 4.18 - Task 2 Spending Plan, Year 4

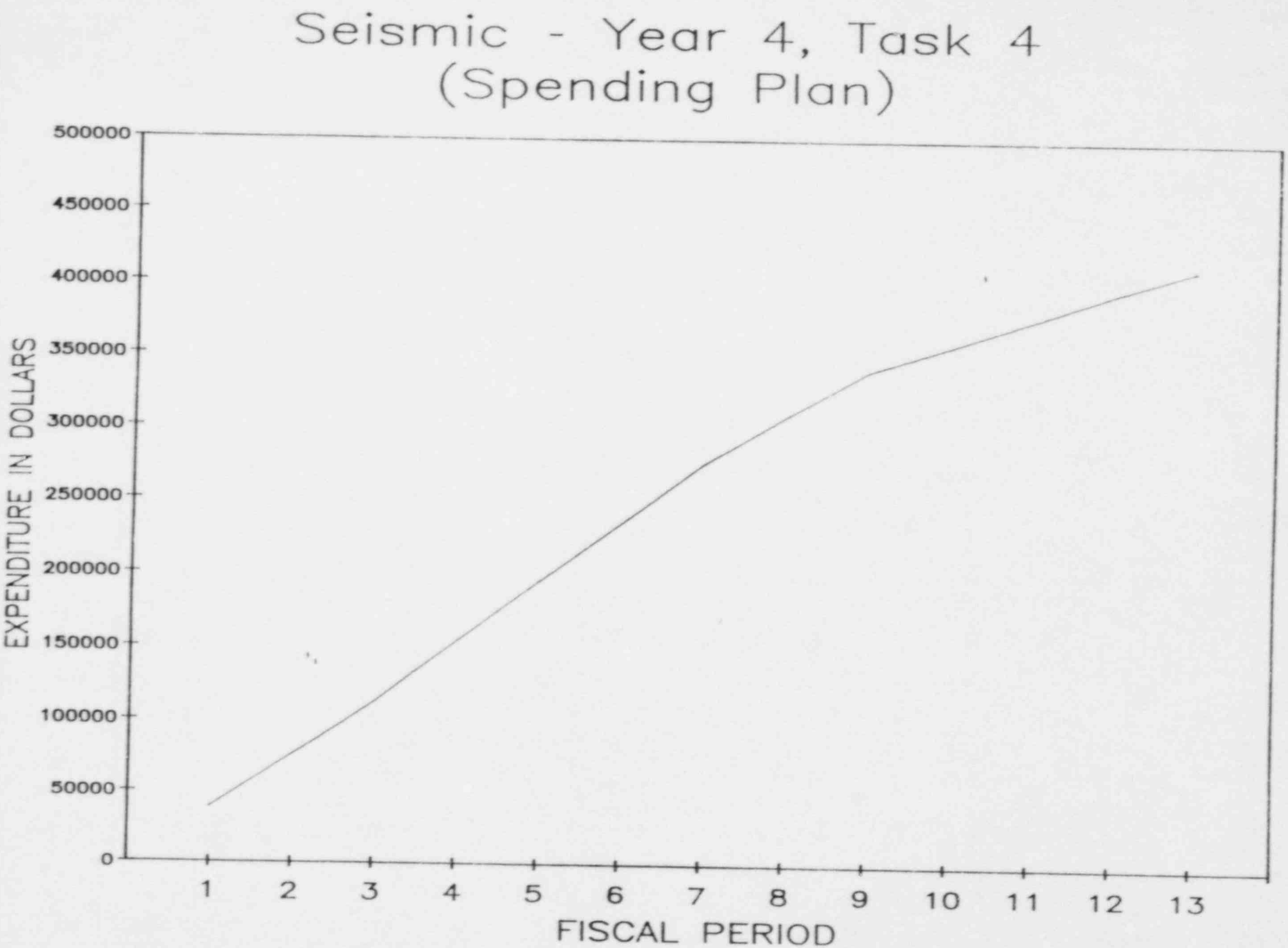

Figure 4.19 - Task 4 Spending Plan, Year 4

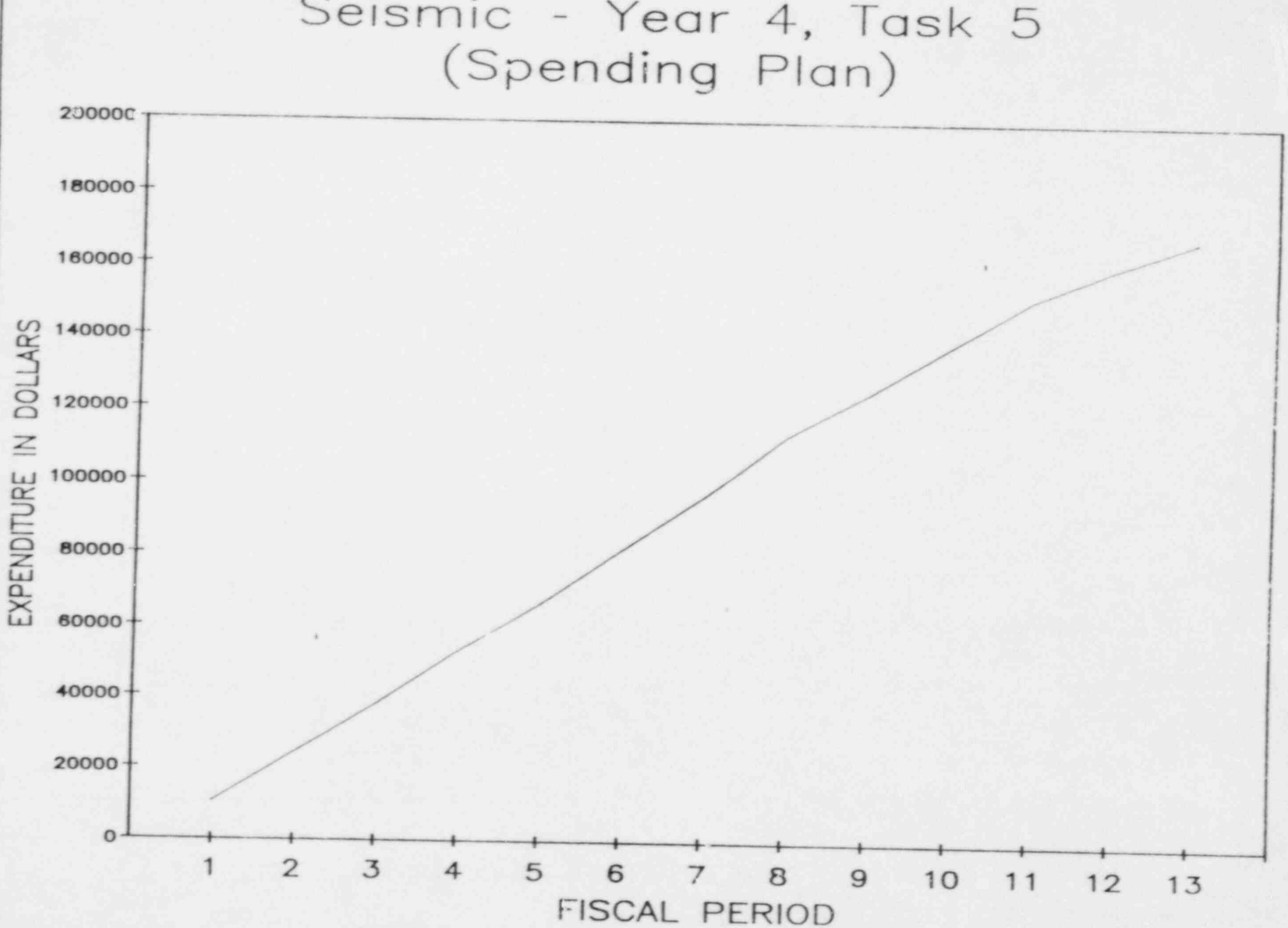

Figure 4.20 - Task 5 Spending Plan, Year 4

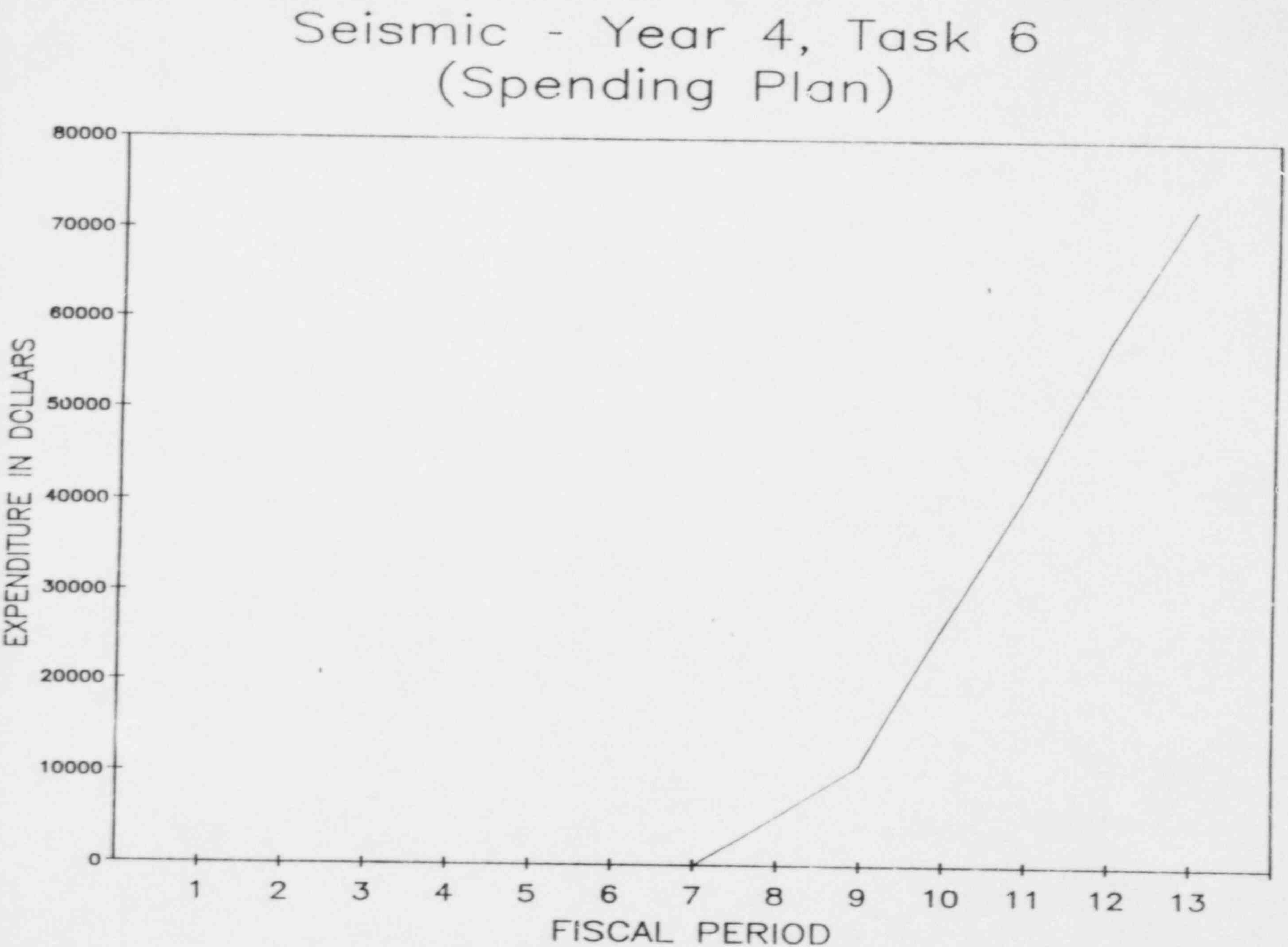

Figure 4.21 - Task 6 Spending Plan, Year 4

Seismic - Year 4 Composite
(Spending Plan)

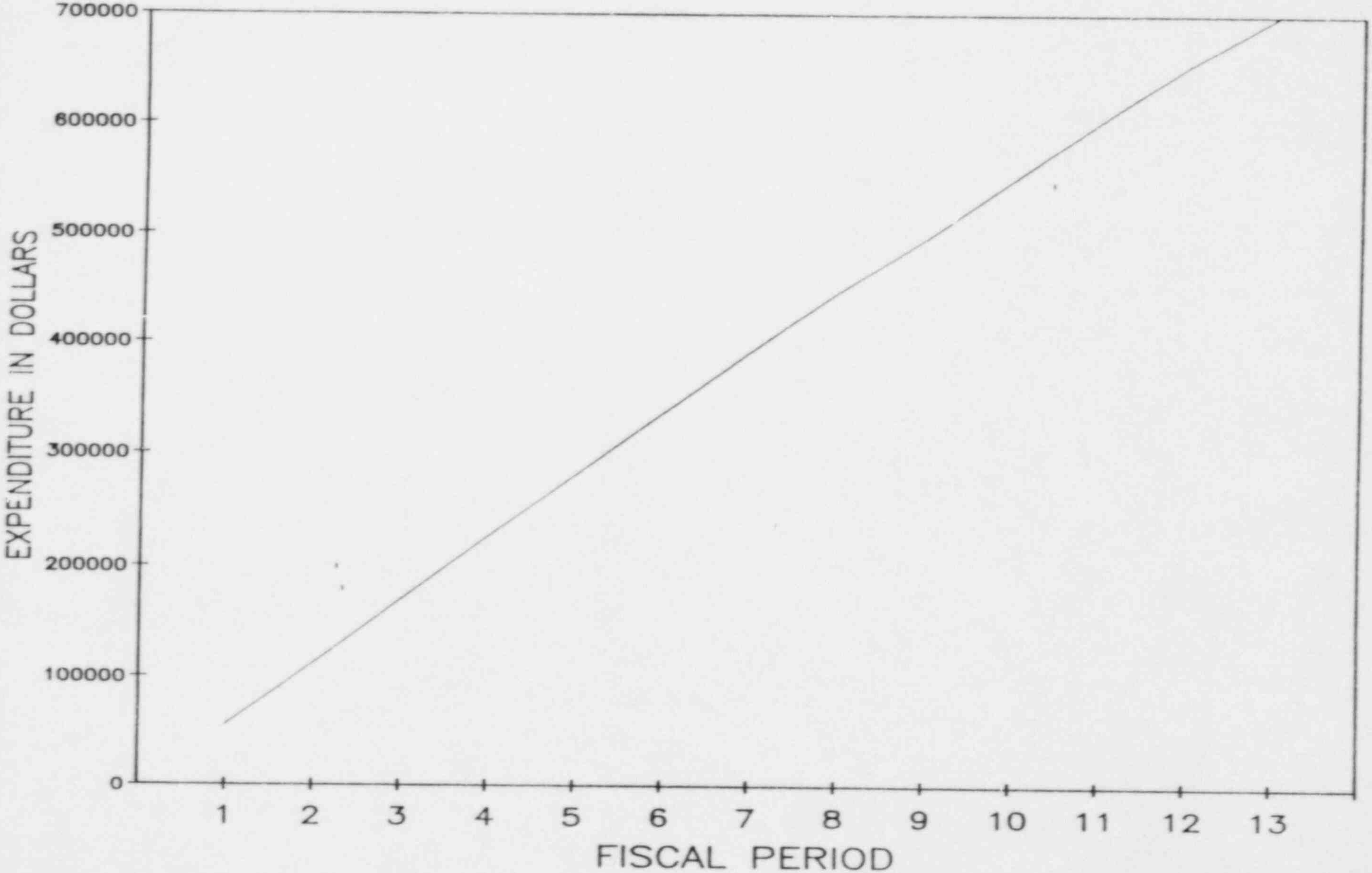

Figure 4.22 - Composite Spending Plan, Year 4

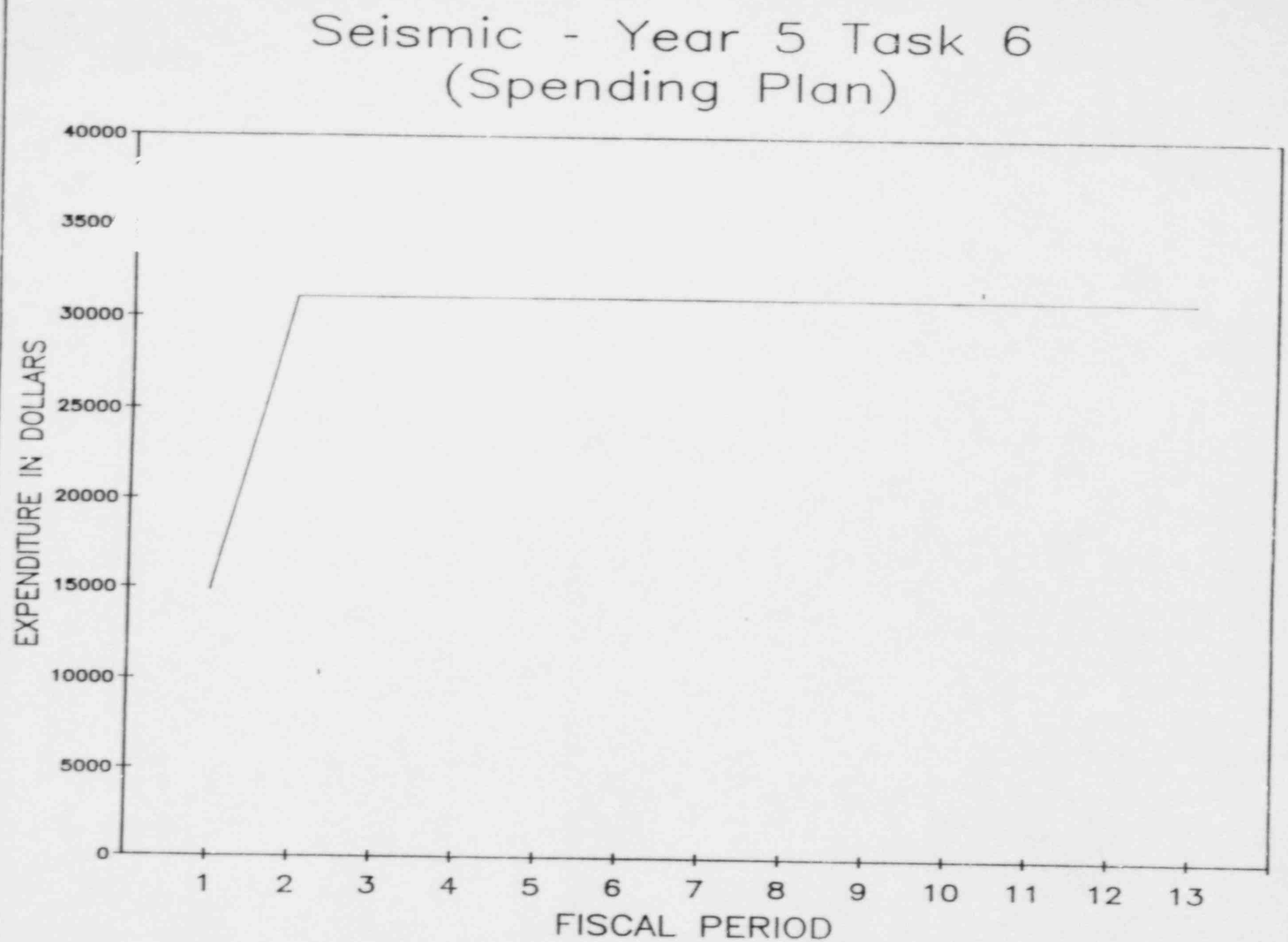

Figure 4.23 -Task 6 Spending Plan, Year 5

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