CNWRA PROGRAM MANAGER'S PERIODIC REPORT ON ACTIVITIES OF THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

For The Fiscal Reporting Period

February 19–March 18, 1994

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
1D, 2D, 3D	1-Dimensional, 2-Dimensional, 3-Dimensional
ACF	Alumina (in excess of alkali feldspar), Calcium oxide, Ferromagnesianoxide
ACNW	Advisory Committee on Nuclear Waste
ACRS	Advanced Computer Review System
AECL	Atomic Energy Canada Limited
AES	Atomic Emission Spectrometry
AGU	American Geophysical Union
AML	Arc Macro Language
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASU	Arizona State University
ATDTS	Automated Technical Data Tracking System
CAR	Corrective Action Request
CCDF	Complementary Cumulative Distribution Function
CCL	Commitment Control Log
CCM	Constant Capacitance Model
CDM	Compliance Determination Method
CDROM	Compact Disk Read Only Memory
CDS	Compliance Determination Strategy
CFD	Computational Fluid Dynamics
CM	Configuration Management
CNWRA	Center for Nuclear Waste Regulatory Analyses
COI	Conflict of Interest
COPS	CNWRA Operations
CQAM	CNWRA Quality Assurance Manual
CRWMS	Civilian Radioactive Waste Management System
DAS	Data Acquisition System

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
DBE	Design Basis Event
DCPM	Division of Contracts and Property Management
DECOVALEX	Development of Coupled Models and Their Validation Against Experiments in Nuclear Waste Isolation
DEM	Digital Elevation Model
DFCSS	Division of Fuel Cycle Safety & Safeguards
DHLWM	Division of High-Level Waste Management
DIMNS	Division of Industrial & Medical Nuclear Safety
DLG	Digital Line Graph
DLM	Diffuse Layer Model
DNAG	Decade of North American Geology
DOE	Department of Energy
DRA	Division of Regulatory Applications
EBS	Engineered Barrier System
EBSPAC	Engineered Barrier System Performance Assessment Code
EDO	Office of the Executive Director for Operations
EDS	Energy Dispersive Spectrometry
EDX	Energy Dispersive X-Ray Spectroscopy
EM	Element Manager
EPA	Environmental Protection Agency
EPR	Electrochemical Potentiokinetic Reactivation
EPRI	Electric Power Research Institute
EQA	External Quality Assurance
ESF	Exploratory Studies Facility
FAC	Favorable Condition
FCRG	Format and Content Regulatory Guide
FD&SHA	Fault Displacement and Seismic Hazard Analysis
FEM	Finite Element Method

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
FIN	Financial Identification Number
FTE	Full Time Equivalent
GIS	Geographic Information System
GPS	Global Positioning Satellite
GROA	Geologic Repository Operations Area
GS	Geologic Setting
GWSI	Groundwater System Integration
GWTT	Groundwater Travel Time
HLW	High-Level Waste
HRTEM	High Resolution Transmission Electron Microscopy
ICP-AES	Inductively-Coupled Plasma Atomic Emission Spectrometry
IHLRWM	International High-Level Radioactive Waste Management Conference and Exposition
IM	Intermediate Milestone
IMS	Information Management Systems
INEL	Idaho National Engineering Laboratory
INTRAVAL	International Code Validation
I/O	Input/Output
IPA	Iterative Performance Assessment
IRM	Office of Information Resources Management
IVM	Interactive Volume Modeling
IWPE	Integrated Waste Package Experiments
JC	Job Code
JRC	Joint Roughness Coefficient
KTU	Key Technical Uncertainty
LAN	Local Area Network
LANL	Los Alamos National Laboratories
LARP	License Application Review Plan

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
LSSA	Licensing Support System Administrator
LWR	Light Water Reactor
MH	Mechanical-Hydrological
M&O	Management and Operations
MIT	Massachusetts Institute of Technology
MM	Major Milestone
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
NAS	National Academy of Science
NCR	Nonconformance Reports
NFS	Network File Server
NMSS	Office of Nuclear Material Safety & Safeguards
NOAA	National Oceanographic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NRC-NMSS	Nuclear Regulatory Commission—Office of Nuclear Material Safety & Safeguards
NRC-RES	Nuclear Regulatory Commission—Office of Nuclear Regulatory Research
NRC-RES/WMB	Nuclear Regulatory Commission—Office of Nuclear Regulatory Research, Waste Management Branch
NSRRC	Nuclear Safety Research Review Committee
NTS	Nevada Test Site
NWPA	Nuclear Waste Policy Act, as amended
NWTRB	Nuclear Waste Technical Review Board
OBES	Office of Basic Energy Sciences
OGC	Office of General Counsel
OITS	Open Item Tracking System

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
PA	Performance Assessment
PAAG	Performance Assessment Advisory Group
PAC	Potentially Adverse Condition
PA&HT	Performance Assessment and Hydrologic Transport
PASP	Performance Assessment Strategic Plan
PSHA	Probabilistic Seismic Hazard Analysis
PEM	Program Element Manager
PFD	Probabilistic Fault Displacement
PI	Principal Investigator
PMDA	Program Management Decision Analysis Staff
PMPR	Program Manager's Periodic Report
PNL	Pacific Northwest Laboratory
PRA	Probabilistic Risk Assessment
PSAG	Probabilistic System Assessment Group
QA	Quality Assurance
QAP	Quality Assurance Procedure
RDCO	Repository Design, Construction, and Operations
REE	Rare Earth Element
REECO	Reynolds Electrical & Engineering Company, Inc.
RES	Office of Nuclear Regulatory Research
RFA-ROC	Repository Functional Analysis—Repository Operations Criteria
RIC	Repository Isolation Criteria
RPD	Regulatory Program Database
RRT	Regulatory Requirement Topic
RSRG	Real Space Renormalization Group
SAIC	Science Applications International Corporation
SAR	Synthetic Aperture Radar

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
SCA	Site Characterization Analysis
SCC	Substantially Complete Containment
SCCEX	Substantially Complete Containment Example
SCM	Surface Complexation Models
SCP	Site Characterization Plan
SEM	Scanning Electron Microscopy
SELM	Spectral Element Method
SGML	Standard Generalized Markup Language
SHE	Standard Hydrogen Electrodes
SKI	Swedish Nuclear Power Inspectorate
SLAR	Side Looking Airborne Radar
SNL	Sandia National Laboratories
SOW	Statement of Work
SRA	Systematic Regulatory Analysis
SRBS	Shafts, Ramps, Boreholes, and their Seals
STP	Staff Technical Position
SUFLAT	Stochastic Analyses of Unsaturated Flow and Transport
SwRI	Southwest Research Institute
TBD	To Be Determined
TDAS	Technical Database Access System
TDI	Technical Document Index
TDOCS	Technical Document Reference Database System
TEM	Transmission Electron Microscopy
THMC	Thermal-Hydrologic-Mechanical-Chemical
TLM	Triple Layer Model
TM	Thematic Mapper
TMH	Thermal-Mechanical-Hydrological
TOP	Technical Operating Procedure

LIST OF ABBREVIATIONS (cont'd)

ABBREVIATION	DESCRIPTION
TPA	Total Performance Assessment
TSPA	Total System Performance Assessment
TSw-Chnv	Topopah Spring-Calico Hills
UA	University of Arizona
UDEC	Universal Distinct Element Code
UNM	University of New Mexico
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
UTM	Universal Transverse Mercator
VCS	Version Control System
VF	Vitrification Facility
WAN	Wide Area Network
WIPP	Waste Isolation Pilot Plant
WMB	Waste Management Branch
WP	Waste Package
WSE&I	Waste Systems Engineering and Integration
WSS	Waste Solidification Systems
WVNS	West Valley Nuclear Services
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffractometry
YM	Yucca Mountain
YMP	Yucca Mountain Project
YMPO	Yucca Mountain Project Office
YMR	Yucca Mountain Region

CNWRA PROGRAM MANAGER'S PERIODIC REPORT ON ACTIVITIES OF THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TITLE: Center for Nuclear Waste Regulatory Analyses
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PERIOD OF THIS REPORT: 02/19/94 - 03/18/94

1. TECHNICAL

1.1 *CNWRA Operations (COPS)*

The NRC and the CNWRA management continued coordination meetings and telephone conferences addressing a range of day-to-day and long-term management topics. CNWRA management staff continued its coordination with specific personnel from the PMDA, DHLWM, RES/WMB, and DCPM, responding to *ad hoc* requests for information addressing management issues affecting the conduct of CNWRA work. These issues included: (i) securing SOWs for RES-funded projects in Near-Field Environment and Subregional Hydrology beginning in FY94, (ii) confirming TDOCS/TDI scheduling in connection with RPD development, (iii) scheduling issue-based topical meetings for CNWRA elements, (iv) establishing INEL and LLNL Cray computer support funding, (v) finding opportunities for CNWRA EM staff exchanges, and (vi) reviewing policies for the CNWRA or SwRI conducting work for other U.S. Government agencies.

The CNWRA has participated with the DHLWM in numerous budget-related discussions and meetings; and the CNWRA also has provided cost and resource allocation information in support of such discussions and meetings. P. Justus visited the CNWRA and presented a seminar related to NRC YM activities.

The CNWRA LAN server reliability improved during this period following replacement of the complete hardware system. Alternative approaches for implementing an electronic version of the PMPR remain under consideration, and discussions continue with cognizant PMDA and DHLWM staff on an appropriate recommendation for the introduction of this electronic version.

The current status of CNWRA staffing is indicated in Tables 1 and 2. Recruitment efforts and interviews continued for open positions. There have been no additions to the CNWRA core professional staff this period.

Certain changes to specific element/project plans, including revised cost and resource utilization data, have been conveyed on schedule to the NRC. The PMPR for Period 7 will reflect the revised spending estimates for the remainder of FY94.

The CNWRA QA staff performed routine quality assurance verification and administrative activities, including the following: (i) internal surveillance of laboratory activities, (ii) QA indoctrination of new personnel, (iii) review of QAPs, and (iv) assistance in the revision of TOPs. The CNWRA QA Director participated in COI Management Committee meetings and attended meetings regarding safety of CNWRA personnel. Nonconformances identified in an internal surveillance conducted in a previous period to assess the implementation of TOP-018 (Configuration Management of Scientific and Engineering Computer Codes) were satisfied during this period.

Responding to the NRC request for access to their technical databases, the DOE has authorized such access via Internet to only the ATDTS. The NRC has sent to the DOE a list of DHLWM staff who plan to access these databases within the next 90 days. The CNWRA continued its preparation of the External Database Access Plan (IM 5702-155-406) for Internet access to DOE databases, along with several other external HLW program databases supported by other participants. The CNWRA anticipates delivery of this plan on April 14, 1994.

Further, the CNWRA met with the DHLWM TDOCS Advisory Group on March 3, 1994 to receive feedback on the TDOCS Design Plan. Development efforts continue with the installation schedule for the system hardware and software implementation changed from June 30 to August 15, 1994. The TDOCS User Guide will be delivered on September 30, 1994. Several security issues are being analyzed in connection with the implementation of the TDOCS system. Resolution of these issues should appear in the CNWRA update of its security plan scheduled for delivery on December 1, 1994. Costs related to the preparation of this plan will be included in the FY95 COPS operations plan.

The following activities are expected to occur during the next period. The CNWRA will pursue resolution of management issues from the previous NRC/CNWRA Management Meeting, and another meeting is tentatively scheduled for the first week of Period 8. The CNWRA will continue its participation in budget-related discussions and meetings. Work will proceed on improvements to the CNWRA LAN server.

Recruitment and interviews will continue for CNWRA core staff.

During the next period, the QA staff will: (i) participate in regular COI Management Committee meetings, (ii) conduct QA indoctrinations, (iii) continue CNWRA QA record keeping, and (iv) perform requisite surveillances. In addition, work will continue on the Internal/External QA assignment to re-evaluate QA requirements.

The CNWRA will continue development of the TDOCS and prepare for its second meeting with the TDOCS Advisory Group. Over the next several periods, the CNWRA will provide technical advice and support, as appropriate, on NRC requests for technical data from the DOE or other parties. The CNWRA will pursue preparation of the External Database Access Plan as discussed and will deliver it on schedule.

1.2 *Waste Systems Engineering and Integration (WSE&I)*

There was essentially no activity related to the rulemaking for clarification of siting criteria, and none is expected during the next period. Work so far has been limited to reviewing public comments submitted on the proposed rulemaking to ensure CNWRA staff familiarity with them. Funding for this work has been significantly reduced in the mid-year update to the CNWRA Operations Plans for the DHLWM to reflect the low level of expected tasking.

Essentially no activity related to support for review of the FCRG was undertaken, and none is anticipated in the near future. Funding for this work has been significantly reduced in the mid-year update to the CNWRA Operations Plans for the DHLWM to reflect the low level of expected tasking.

There was essentially no activity undertaken in support of NWPA-mandated actions, and none is expected in the period to come.

Work continued toward completion of CDS revisions, specifically format revisions to references for rationales. This activity will lead to delivery of the CDS Development Report FY93 (MM 5702-221-420), which is due March 31, 1994. With the completion of the LARP manuscript and CDS revisions, CNWRA staff have started CDS integration activities in coordination with NRC staff. This activity will identify inconsistencies among CDSs.

Significant effort continued in work related to CDM development. The CDM for RRT 10.0, Quality Assurance (IM 5702-222-414) was submitted on February 25, 1994. On March 11, 1994 the NRC accepted the Quality Assurance CDM, subject to incorporation of specific modifications. These modifications will be made during the next period, and the CDM will be resubmitted to the NRC. Work continues on the development of the CDM for RRT 1.4, Certification of Safeguards (IM 5702-222-411); the CDM for RRT 1.5, Physical Security Plan (IM 5702-222-412); and the CDM for RRT 2.7, Nuclear Material Control (IM 5702-222-413). NRC staff from the DFCSS have taken primary responsibility for the writing of these CDMs since they should be consistent with other licensing reviews for these topics conducted throughout the NRC. Generic text for CDMs dealing with descriptive review plans and review plans dealing with PACs and FACs was refined and is expected to be ready for NRC and CNWRA technical staff use in the next period. Training on CDM development was conducted for various NRC and CNWRA staff to ensure compliance with QA requirements. Activity continues on development of a Crosswalk of Regulatory/Institutional Uncertainties with Review Plan Topics (IM 5702-

222-451). This will become an appendix to the LARP. Work continued on activities in the LARP Development Plan, including definitions of a findings hierarchy and identification of review plan interfaces.

There was essentially no activity related to WSE&I special projects. Funding for this work has been significantly reduced in the mid-year update to the CNWRA Operations Plans for the DHLWM to reflect the low level of expected tasking.

Work is progressing on the implementation of Phase II of the RPD design to develop a generalized report writer. The development team is finalizing approaches to resolve the remaining technical issues. A parser for the report writer is being prototyped to determine the most effective database input/output formats. This prototype will be completed by April 7, when the related design issues are expected to have been resolved.

The installation of RPD Version 1.0 on the OS/2 platform is continuing. The DOS/Windows and MacIntosh installations are scheduled following completion and testing of the OS/2 port. On March 1, 1994, the NRC concurred in the use of SGML for RPD development.

During the next period, the WSE&I Element will direct effort in the following areas: (i) loading of revised CDSs into the RPD; (ii) production of CDMs; (iii) development of porting software to support the installation of RPD Version 1.0 on various computer platforms; (iv) development of RPD Phase II (Report Writer); (v) initial design of the migration/incorporation of OITS into RPD; (vi) coordination of LARP development activities throughout the CNWRA, including conducting training necessary to support CDM development; (vii) preparation of a Crosswalk of Regulatory/Institutional Uncertainties with Review Plan Topics; (viii) development of an Uncertainty Identification and Resolution Procedure; and (ix) CDS integrating activity.

1.3 *External Quality Assurance (EQA)*

No DOE QA audits occurred during this period, so no NRC observation audits were scheduled. The CNWRA QA Director attended the NRC/DOE Bimonthly QA Meeting at the NRC on February 23, 1994.

Development continued on the special task for re-evaluation of appropriate QA requirements for CNWRA activities. A preliminary report of these activities should be completed during Period 7.

The NRC EQA PEM and the CNWRA QA Director held planning discussions by telephone during this period on anticipated FY94 EQA work, which may include on-site visits, meetings, and observations of the DOE audits and surveillances. Discussions took place between NRC HLW QA and CNWRA QA regarding a modification in the methods used by the NRC in the overview of YM site characterization activities in future years. The CNWRA QA Director will continue to coordinate all upcoming NRC audit/surveillance/meeting team work and other EQA activities with the NRC EQA PEM. The DOE audit schedule has been revised, and one audit was indefinitely postponed. Observation audit activities should increase with the REECO audit currently scheduled for May 2-6, 1994. The CNWRA QA Director has been directed to attend the American Society for Quality Control Energy and Environmental Quality Division Fifth International Environmental and Waste Management Conference April 17-20 due to its applicability to the CNWRA work in the HLW field.

Work will continue on the reevaluation of quality assurance requirements.

1.4 *Geologic Setting (GS)*

Geology and Geophysics

Work continued for GS staff on LARP development. CDS Review Strategies to be published in LARP Rev 0 related to geology and geophysics were reviewed by CNWRA staff to provide input to the NRC as part of the integration review of all CDSs. Work on the CDM for extreme erosion was begun. The CDM for igneous activity was finalized.

The CNWRA evaluation of the DOE topical report on extreme erosion at YM was completed. CNWRA technical review of the document has been completed, and the authors are resolving comments.

During this period, work on issues related to tectonics and structural geology focused on development of a 3D Geological Framework Model of YM (MM 5702-425-403) and production of a technical report on Analysis of Coupled Faulting and Magmatic Dike Intrusion (IM 5702-425-402). Transfer of the 3D model from IVM to EarthVision continued during this period. The original 2D scattered data files were regridded in EarthVision and the solid model partially reconstructed. Work was begun on creation of scattered data files to define fault surfaces for the Bow Ridge, Ghost Dance, and Solitario Canyon faults. Hydrogeologic and rock property data have been compiled for 3D gridding within the Topopah Springs unit of the model. Gridding of these data will proceed after the model geometry is completely reconstructed.

Debugging of the SEISM 1.1 code was essentially completed and a successful computation was made with SEISM 1.1 using published data from the YMR. Incorporation of the results of the computation into the text of the test analysis report is under way. Incorporation of a relationship between fault offset and magnitude to permit calculation of fault offset probabilities is to be completed for this phase of PSHA effort.

R. Hofmann, with C. Connor and B. Hill, attended the Seismic and Volcanic Hazards meeting of the NWTRB in San Francisco, California. The day before the NWTRB meeting, R. Hofmann and A.Ibrahim of the NRC met with LLNL SEISM 1 staff at A. Ibrahim's request. B. Davis of LLNL provided a plotting routine for SEISM 1 attenuation functions and a plot of the eastern U.S. routines in the code provided. These plots indicated maximums of 3000 $cm/sec.^2$ CNWRA analyses provided similar results but were thought likely to be in error. Resolution of this point aided in completion of the successful initial YM computation. J. Savy of LLNL stated that further advice concerning the code could not be provided unless some means of compensating LLNL could be found.

A large number of GIS datasets and map coverages have been acquired during work specifically for the Structural Geology and Tectonics project. Establishment of a GIS library of commonly requested datasets and coverages suitable for read-only access by all projects and tasks with access to the GIS library host system was discussed at an organizational meeting. The major goals are: (i) accommodating these requests for data, (ii) reducing the number of duplicate datasets and coverages stored on the GIS library host, (iii) limiting the labor and overhead necessary to grant access, and (iv) limiting and minimizing the disruption caused by these requests.

A prototype GIS library system has been established. Access has been tested from PC with OS/2, MacIntosh and the MacFinder, and UNIX hosts running ARC/INFO and other software. Some of the long-term issues/goals to be addressed will include, but will not necessarily be limited to: (i) access policy—initially limited to users familiar with the GIS system during the early stages of GIS library development state; this access will be expanded later as required when the GIS library is more robust; (ii) access will be via NFS read-only with a privileged administrator to prevent file corruption; (iii) multiple storage formats to accommodate those users lacking access to ARC/INFO software; (iv) isolation of data from DOE, State of Nevada, CNWRA, and other sources to avoid mixing of potentially incompatible/conflicting datasets; (v) the GIS library primarily constructed from datasets developed during on going task work (no special project to formally build the GIS database), (vi) GIS library version tracking through version assignment and freeze up to read-only media; (vii) minimal, tangential maintenance to minimize cost and manipulation of the data; (viii) online documentation and catalog with ASCII text files for dataset and map coverage descriptions, and PostScript files for image printout of dataset/coverage contents; (ix) documentation guidelines by example in the online catalog; (x) filename limits to accommodate the limitations of MS-DOS and thwart UNIX hard and soft link files (issue and tradeoffs of choice not settled); and (xi) periodic publication to CDROM to facilitate low-cost, wide-audience, machine readable distribution.

Review of the DOE topical report on extreme erosion will be completed within the next period. Work to rebuild the 3D geological framework model in EarthVision will continue, and to include the rock property data. The IM report 5702-425-402 on faulting and dike intrusion will also be completed. The GIS library will continue to be developed with commonly used coverages, and access protocols will be refined. Work will continue on the report on the adaptation of SEISM 1.1 to YM with initiation of a sensitivity study. R. Hofmann will attend the combined meeting of the Seismological Society of America/Earthquake Engineering Research Institute and the Independent Research Institutions for Seismology meetings in Pasadena, California.

Geochemistry, Hydrology, and Climatology

Work continued for GS staff on LARP development. CDS Review Strategies related to geochemistry, hydrology, and climatology were reviewed by CNWRA staff to provide input to the NRC as part of the integration review of all CDSs.

During Period 6, work was begun on CDM 3.2.4.1—Annual Potential Evapotranspiration (IM 5702-424-402). NRC/CNWRA staff tentatively identified information needs.

Procedures and information on calculating and measuring evapotranspiration in arid-to-semi-arid climates is being gathered from the USGS, the NOAA, and the USDA.

Groundwater flow through a saturated/unsaturated medium is being simulated using VTOUGH. This model has properties representative of tuff overlying a carbonate aquifer. The upper 500 m of the 1500-m-thick tuff unit is unsaturated. Difficulties have been encountered in establishing the proper initial and boundary conditions. The model currently exhibits a regional groundwater gradient of about 0.004 (i.e., 50-m-drop over 12,000 m) and a geothermal gradient of 2.5 °C/100 m. Preliminary analyses indicate that thermal effects from the repository extend deep into the saturated portion of the tuff unit for a long period after peak temperatures at the repository have subsided. The tuff and carbonate units are modeled as composite media. GWTT analyses of the tuff geologic scenario and the granite scenario (which incorporates a set of discrete fractures) are ongoing.

The data needs and methods matrices for the hydrology, geochemistry, and climatology/meteorology CDMs were completed and forwarded to the NRC. Electronic copies of mineral chemistry data from LANL reports were obtained and will be evaluated for entry into the ARC/INFO geochemistry database. Utility programs were developed in ARC/INFO programming language that allow for contouring and manipulation of geochemical data entered in the ARC/INFO database. Current plans call for development of a menu structure to allow easier access to the contents of the geochemistry database.

Groundwater modeling will continue using the two scenarios. It is anticipated the modeling results will be finalized and a report prepared. Work continues on the CDM data needs and methods matrix, providing specific data sources for CDM development. Additional geochemical data will be evaluated for entry into the GIS geochemistry database.

1.5 *Engineered Barrier Systems (EBS)*

The development of the authors' draft report of the Field Engineering Experience for Structural Materials (IM 5702-551-430) continued, as all CNWRA input was completed and NRC staff contributions neared completion. Input to the report for sections on data for reliability of nuclear components and corrosion case studies were integrated to the draft as they became available. Collaborative meetings with C. Interrante at the CNWRA advanced further text refinement.

EBS staff participated in the CDS integration review of LARP Rev. 0.

Work continued on development of EBSPAC—Models Development FY94 (IM 5702-523-410), a generalized mass transport model describing corrosion and secondary mineral formation. The code uses an equivalent form of the EQ3/6 database, species-dependent diffusion coefficients, local equilibrium of aqueous complexes, and kinetic reaction of minerals. It will be applicable to a diverse set of problems ranging from spent fuel oxidation to corrosion of a steel canister, as well as precipitation and dissolution of minerals in both isothermal and non-isothermal systems.

As part of IM 5702-523-410, progress continued with consultant J. Walton on evaluation of the dusty gas model to describe transport of water vapor in the near-field of a HLW repository. Incorporating partial pressure boundary conditions in the model gave a more realistic description of such transport than was possible with only specifying mole fraction. However, partial pressure boundary conditions resulted in a more complicated transcendental equation for the evaporation rate.

Modification of the I/O of the VTOUGH code to make it more user friendly was completed with the help of consultant M. Seth. In addition, calculation of the rate of evaporation was added to the code, and more efficient conjugant gradient solvers are currently being evaluated. The code is being tested, and a new users' manual will be created. This activity is partly supported by the PA Element.

Errors were found and subsequently corrected in the values for power generation rates used in the SCCEX code for periods exceeding 4,000 yr. The errors do not impact the recently completed SCCEX report, where the analyses were performed for less than 1,500 yr.

Initial contribution from all four authors for the report, Role of Colloids in the Release of Radionuclides from Vitrified Waste Forms and Spent Fuel (IM 5702-523-415), has been received. Inter-author discussions related to contributions of individual authors are in progress, and the draft report for technical review at CNWRA is expected to be completed in the next reporting period.

G. Cragnolino, H. Manaktala, N. Sridhar, and D. Dunn attended the CORROSION'94 conference in Baltimore, Maryland, February 27–March 4, 1994. A trip report is being prepared. H. Manaktala presented the paper titled, Nuclear Fuel Corrosion Over Millennia Interpreted Using Geological Data, which was co-authored by E. Pearcy of the CNWRA.

In the next period, final NRC contributions to the Field Engineering Experience for Structural Materials Report are expected, and the production and review process will be initiated. Completion of the review process and subsequent issuance is expected to require about 4 weeks. Staffs from CNWRA and NRC will edit the draft to final author form and submit it for CNWRA and editorial review.

In the next period, EBS staff will participate in an MPC kickoff meeting at the NRC, immediately followed by participation in a two-day technical exchange meeting with the NRC on Burnup Credit for the MPC.

1.6 *Repository Design, Construction, and Operations (RDCO)*

In this reporting period, the RDCO Element concentrated on the following activities: (i) development of CDSs, (ii) development of CDM on Shafts and Ramps Design, (iii) evaluation of computer codes for compliance determination and rock joint model development, (iv) prelicensing interactions, and (v) ESF design reviews.

NRC/CNWRA teleconference meetings regarding CDS integration continued. During this period, a general consistency review was made on the 21 CDSs relevant to RDCO. The marked-up copies of these CDSs were transmitted to the NRC RDCO team members for their input.

Work continued on the development of CDM 4.3—Shafts and Ramps Design (IM 5702-622-401). Drafts on the sections for Radiation Protection Performance Objective [60.111(a)], Utility Services [60.131(b)(5)], and Instrumentation and Control Systems [60.131(b)(8)] were prepared for the IM 5702-622-401 and transmitted to the NRC team members for their input. The CDM development on design of SRBS for two other sections, i.e., Protection Against Natural Phenomena and Environmental Conditions [60.131(b)(1)], and Shaft Conveyances Used in Radioactive Waste Handling [60.131(b)(10)] is at various stages of development.

In this period, evaluation of the finite element code ABAQUS continued. ABAQUS modeling for Problem Set 1, comprising the 1D (vertical) infiltration problem with two different sets of material properties (one for Topopah Spring tuff and another for a high permeability medium), has been completed. Analytical solutions for the steady-state conditions have also been obtained for both cases. The results obtained from ABAQUS match quite well with the analytical solutions. These problems were also analyzed for transient conditions using the VTOUGH code. Comparison of results from ABAQUS and VTOUGH is currently under way. Progress was also made in Problem Set 2 where a thick-walled cylinder with an annular crack is heated at the inner wall. The analytical and ABAQUS solutions for the base case, i.e., the thick-walled cylinder without any crack, have been obtained. There appears to be a good parallel between the analytical solution and the ABAQUS results. ABAQUS solutions for the same problem with the annular crack have been obtained for two extreme crack or gap conductances: zero gap conductance (perfectly insulated crack) and gap conductance equal to that of the intact rock. When the gap conductance is equal to that of the intact rock, the solution is the same as the analytical solution with no crack, and the results from ABAQUS confirm this. There is no analytical solution if the gap is perfectly insulated. ABAQUS results for this case show that no heat is flowing across the crack, which is reasonable. These results suggest that the formulation of the interface element in ABAQUS is capable of performing adequately under heat flow.

Development of a constitutive model to simulate the response of a rock joint under cyclic pseudostatic and dynamic loads, as observed in the experimental results of the Seismic Rock Mechanics research project, is currently in progress. Assuming the surface profile a self-affine fractal, the fractal dimensions for the ten standard profiles of Barton have been evaluated by four different methods: modified divider, semi-variogram, power spectral density, and RMS roughness-scale. The results from all these methods are being analyzed.

The SCP Progress Report No. 9 for the period from April 1, 1993 to September 30, 1993 was received during this period. Based on a screening review, the RDCO staff identified a number of technical reports referenced in this progress report that need to be reviewed to facilitate the review of various packages of ESF design and GROA conceptual design. Only very limited interaction between the NRC and CNWRA staffs took place during this period regarding DBE rulemaking.

During the next period, activities within the RDCO Element will include: (i) continued development of the CDM on Shafts and Ramps Design, (ii) integration of CDSs, (iii) development of the rock joint model and evaluation of ABAQUS, (iv) coordination of the DBE rulemaking, (v) participation in prelicensing activities; and (vi) work on ESF Title II Design review.

1.7 *Performance Assessment and Hydrologic Transport (PA&HT)*

The PA&HT Element concentrated on the following activities: (i) revision of the PA&HT section of the Operations Plans for the DHLWM for FY94-95, (ii) preparation of a background report on the use of expert judgment in PA, (iii) participation in LARP team meetings, (iv) discussions with NRC and SKI staff regarding the joint paper on model validation, (v) preparation of the CNWRA contribution to the plan for IPA Phase 3 activities, (vi) auxiliary and detailed analyses for IPA Phase 3, (vii) revision of the draft PASP, (viii) preparation of user guides for selected TPA modules, (ix) implementation of the software configuration management procedure TOP-018, and (x) integration activities.

Revisions of the PA&HT section of the Operations Plans for the DHLWM for FY94-95 were completed. The revisions included the addition of new scope under Subtask 1.1. The new scope consists of review activities associated with: (i) the EPA compliance criteria for the WIPP site, and (ii) EPA draft standard for the YM site. These revisions to the Operations Plans for the DHLWM for FY94-95 are consistent with the NRC technical directive of February 10, 1994.

Work continued on preparation of the background report on the use of expert judgment in PA. The report is being prepared in accordance with the outline approved by N. Eisenberg and J. Park (NRC). An extensive literature search and review is being performed. The literature spans both national and international publications associated with radiation protection and waste management. Preparation of the draft report is ahead of schedule, and a complete draft is expected to be assembled by the end of the next reporting period. The principal contributors to this report are: A. DeWispelare and T. Herren (SwRI), and T. Bonano and R. Clemmon (consultants); R. Winkler (consultant) will serve as technical reviewer. When completed, the report will be submitted to fulfill IM 5702-712-405, Background Report on Use of Expert Judgment in PA. This work is being conducted under the scope described in the PA&HT Element Subtask 1.2 of the Operations Plans for the DHLWM for FY94-95.

R. Bagtzoglou and V. Kapoor continued participation in the LARP team meetings. Integration and consistency reviews were performed of the CDSs with type 1 through 3 review strategies. The teleconference with the NRC focused on discussion of the LARP Chapter 6 review. Discussions were also held with N. Eisenberg. This work was conducted under the scope described in the PA&HT Element Subtask 2.1 of the Operations Plans for the DHLWM for FY94-95.

As a follow up to the previously submitted contribution to the paper entitled, Model Validation from a Regulatory Perspective, B. Sagar and G. Wittmeyer participated in a teleconference with the NRC and SKI staff. Various aspects of the most recent draft of the joint paper were discussed. J. Anderson (SKI) indicated that he was not in full agreement with many parts in section 4 of the paper. Consequently, it was agreed that a copy of the text file would be sent to him so the SKI staff can directly incorporate their changes into the draft. N. Eisenberg and T. McCartin will continue to work on developing an example problem for inclusion in the paper as an appendix. This work was conducted under the scope described in the PA&HT Element Subtask 2.2 of the Operations Plans for the DHLWM for FY94-95.

A letter report was prepared on the CNWRA contribution to the IPA Phase 3 Plan. The report contains the various proposals for TPA module development, auxiliary analyses, detailed analyses of models used in SNL TSPA-91 and -93 reports, and analyses focusing on evaluation of selected KTUs identified in the LARP. The letter report is anticipated to be transmitted to the NRC by March 30, 1994 to fulfill IM 5702-723-420, Contribution to IPA Phase 3 Plan.

Work continued on the auxiliary analysis of infiltration phenomena at YM; S. Stothoff and B. Gureghian, and A. Nedungadi (SwRI), are collaborating on this task. A series of simulations were performed to examine the infiltration as a function of meteorologic conditions. Net recharge was calculated for various cases of temporally averaged precipitation conditions. Work was initiated on a reconnaissance level auxiliary analysis to evaluate seal performance. This auxiliary analysis was initiated in relation to the evaluation of KTUs and is being conducted as a team effort between B. Gureghian, M. Ahola, and G. Ofoegbu; results of this analysis are expected to provide a basis for reclassification of a KTU in the shafts and ramps CDM. Work was initiated on a detailed analysis of the SNL WEEPS and composite-porosity flow models used in TSPA-91/93; this work is being performed by V. Kapoor and will contribute to the detailed review of the SNL TSPAs. Work continued on the auxiliary analysis dealing with flow around the waste package; P. Lichtner, M. Seth (consultant), and J. Walton (consultant) are working on this analysis. Modifications of the VTOUGH code were made to correct a coding error and provide desired outputs. R. Manteufel initiated an analysis to develop an abstracted model of near-field flow. The ORIGEN 2.1 code, which was previously acquired by H. Karimi for other CNWRA work, is being adapted by R. Manteufel for use in generating radionuclide inventories for the IPA analyses; a simple pre-processor program is being developed to make the ORIGEN code easy to use (i) in the calculation of expanded sets of radionuclides for higher burnup fuels and (ii) for demonstrating the use of the Galaxay software (for graphical user interface) and ORACLE software (for a centralized database). G. Stirewalt initiated development of technical specifications for a fault module; these specifications will be used in FY95 to code up a new module for TPA. Discussions were held with R. Baca, R. Manteufel, and W. Murphy, and C. Freitas (SwRI) regarding the auxiliary analysis on C-14 transport. The analyses outlined here were conducted under the scope described in the PA&HT Element Subtask 2.3 of the Operations Plans for the DHLWM for FY94-95. Major products of these analyses will be added in the next revision of the Operations Plan, scheduled for Summer 1994.

Work continued on preparation of the final version of the PASP. As part of the CNWRA internal review process, the draft was reviewed by CNWRA element managers and directors. The draft PASP was modified to incorporate the reviewers comments and suggestions. A copy of this revised draft was provided to J. Buckley for the NRC section leader review. This work was conducted under the scope described in the PA&HT Element Subtask 2.3 of the Operations Plans for the DHLWM for FY94-95.

A report on the DRILLO module was completed and submitted to the NRC on February 25, 1994. The report fulfills IM 5702-723-415, User Guide for DRILLO Module. Preparation of user guides for the SEISMO and AIRCOM modules of TPA continued. Draft user guides for these two modules were completed. These documents are currently in the CNWRA internal review process and are expected to be transmitted to the NRC early in the next reporting period. These user guides will fulfill IMs 5702-723-421, User Guide for SEISMO Module and 5702-723-422, User Guide for AIRCOM Module. Contributing to this activity were R. Janetzke, V. Kapoor, S. Stothoff, R. Baca, and C. Freitas and A. O'Campo (SwRI). This work was conducted under the scope described in the PA&HT Element Subtask 2.3 of the Operations Plans for the DHLWM for FY94-95.

Work continued on placement of appropriate NRC/CNWRA codes under configuration management. To date, a total of 15 computer codes have been placed under the CM procedure TOP-018. T. Ratchford (SwRI), R. Janetzke, and R. Baca are the principal contributors to this activity. This work was conducted under the scope described in PA&HT Element Subtask 2.3 of the Operations Plans for the DHLWM for FY94-95.

A series of meetings is being conducted between the PA&HT Element staff and the PIs of the CNWRA research projects. The purpose of these meetings is to achieve technical and programmatic integration of the research projects with the IPA exercises. These meetings are generally chaired by R. Baca, P. Mackin, and R. Manteufel. In this reporting period, R. Manteufel met with C. Connor of the GS Element to discuss the transfer of developments from the Volcanic Systems Research Project to the IPA. In particular, it was proposed that the VOLCANO module be modified to account for indirect effects of de-gassing and heat transfer.

In the next period, the PA&HT Element will direct its efforts in the following areas: (i) completing the CNWRA contribution to the IPA Phase 3 plan, (ii) continuing the preparation of the background report on use of expert judgment, (iii) completing the user guides for TPA modules SEISMO and AIRCOM, (iv) continuing work on the development of design specifications for the TPA code and modules, (v) continuing to place the major scientific and engineering codes under configuration control, (vi) continuing work on the auxiliary and detailed analyses, and (vii) conducting integration meetings with PIs working on research projects.

1.8 *Research*

Research Project 1 - Overall Research

Modifications to Research Project Plans were completed and submitted as scheduled to the NRC Division of Contracts and Property Management on March 14, 1994. These updates reflect necessary changes in scope, schedule, and/or cost to 13 plans.

The Call for Papers announcement for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment was mailed to more than 130 individuals from the academic, commercial, and international technical communities. By the end of Period 6, response had been received from more than 10 individuals indicating their desire to present papers, participate in panels, and/or attend the workshop. The workshop is scheduled for September 19-20, 1994, at the Holiday Inn Crowne Plaza in Rockville, Maryland.

Planning for the Analogs/Performance Assessment Workshop continued with discussions among CNWRA and NRC Analog and Performance Assessment staff. A meeting has been tentatively scheduled for the week of June 13-17, 1994 in San Antonio, Texas.

Receipt of an SOW for the new Near-Field Research Project is anticipated for the near future; upon receipt of the SOW, work will begin on development of a project plan. Planning for the Analogs/Performance Assessment and the Rock Mechanics Workshops is anticipated to continue.

Research Project 2 - Geochemistry

Work continued on writing the final report for the Geochemistry Research Project. Editorial review is complete and the report is undergoing internal technical review. Three external reviewers have accepted the task to conduct a peer-review of the report. These are J. Apps (LBL), D. Sverjensky (Johns Hopkins University) and J. Walther (Northwestern University). Consulting arrangements are being made with these individuals.

The final report will be completed during the next period. It will be submitted to the NRC as a major milestone and sent to external peer-reviewers.

Research Project 3 - Thermohydrology

During the past reporting period, the technical staff concentrated on work in three areas: (i) preparation of laboratory-scale experiments, (ii) calculation of hydraulic properties of the test media, and (iii) development of analytical and mathematical models of physical mechanisms associated with moisture redistribution in isothermal and non-isothermal media.

Three additional test containers for the Test 6 series of experiments, including those for the gas-gradient experiments, have been prepared using cement mixtures as the test medium. One rectangular container for the Test 6 tests and one cylindrically-shaped container for the gas-gradient tests were filled with a cement paste. A second cylinder was prepared with a cement/clay mixture. A cement mixture was selected to provide a medium with a sufficiently low permeability required for a gas gradient to form. After curing, the two cylindrical containers will be tested to see if internal gas gradients are feasible. Results from the gas-gradient experiments will be used to evaluate theories developed through dimensional analysis of heat and mass transfer in unsaturated fractured rock. This work is being conducted by R. Green and S. Svedeman, L. Bishop and F. Dodge (SwRI).

The hydraulic properties of media used in the laboratory-scale experiments are being characterized. These media include the ceramic to be used in the Test 6 series of experiments, cement mixtures being tested for use in the gas-gradient tests, and alumina powders used in several completed experiments. Preliminary moisture release curve measurements of the ceramic indicate a very low air-entry value. Measurement of the properties of concrete used in several previously prepared cylinders indicated their permeabilities were too large for use in the gas-gradient experiments. These containers were abandoned because of the high permeabilities.

An analysis associated with the completion of the dimensional analyses were continued. This analysis addresses the liquid component of the flow problem whereas the previous analysis only considered the gas phase component. This work is being conducted by F. Dodge (SwRI) and R. Green.

Theoretical analysis of flow mechanisms and identification of simple mathematical models to represent flow in a thermosyphon have continued. Prediction of gas flow through media under the imposition of a heat load has continued. This work is being conducted by R. Manteufel and H. Castellaw.

In the next period, work will continue in five areas: (i) constructing and assessing of test containers and media for use in coupled processes experiments, particularly tests with concrete as the test medium; (ii) conducting of hydraulic property measurement experiments of concrete, ceramic, and alumina; (iii) initiating Test 6/7 series with a ceramic and a concrete medium; and (iv) scoping measurements of the preferential flow experiment.

Research Project 4 - Seismic Rock Mechanics

The Seismic Rock Mechanics Research Project has nine tasks. Among these tasks, the first, Focused Literature Search, and the second, Laboratory Characterization of Jointed Rock, are complete. Task 6, YM Scoping Analysis, has been delayed pending the availability of the data associated with YM. Active tasks in FY94 include: Task 3, Assessment of Analytical Models/Computer Codes; Task 4, Rock Dynamics Laboratory and Field Studies; Task 5, Groundwater Hydrology Field Studies; Task 7, Technical Report; Task 8, Semi-Annual Research Reports; and Task 9, DECOVALEX Modeling and Laboratory Studies. In this reporting period, primary effort was devoted to: (i) the laboratory study of a small-scale jointed rock mass physical model for Task 4; (ii) design of test apparatus for the mechanical-hydrological experimental study for Task 9;

(iii) preparation of test specimens for mechanical properties determination of Lucky Friday Mine rock; and (iv) report preparation for Task 5.

The design and construction activities for small-scale model tests of jointed rock mass using a shaking table continued. Casting of rock mass components that are 2 in. × 2 in. in cross section and 2 ft long was completed during this period. More than 250 full cross section (square), 52 of half cross section (triangular), and 10 of curved cross section (to form a circular excavation in the center of the small-scale model) were made. More than 60 cylindrical specimens of 1-in. diameter were also prepared for mechanical properties determination of rock mass components. Pretest UDEC simulation of the small-scale model test using scaled earthquake velocity signals (calculated from the acceleration response recorded from the Guerrero accelerograph array for the earthquake of September 19, 1985, in Mexico) continued, to develop a preliminary understanding regarding rock mass deformation with an emphasis on the shear displacement and dilation of joints near the excavation. This information is being used to assist in designing the interface between the rock mass components and the steel frame of the small-scale model. Instruments to be used for measurements of joint normal and shear displacements, cable loads, and excavation closure are at various stages of procurement and development. Three linear variable differential transformers (LVDT) for the excavation closure measurements have been received during this period. Fabrication of cantilever beam transducers for joint shear displacement measurements and development of a lifting device for carrying the assembled small-scale model from the floor to the shaking table are well under way.

The activities associated with the coupled MH experiments continued. Work continues in conducting preliminary MH experiments using the modified apparatus. A preliminary test using nitrogen gas has been completed. The test results are being analyzed to determine the appropriateness of the test design. Preparation of detailed specifications for the MH experiment was completed. These specifications were transmitted to the DECOVALEX Secretariat for use in the DECOVALEX Phase III study. Baseline experiments of unsaturated flow through a joint without considering the mechanical effect were conducted and several sets of data were collected. These data are being analyzed.

Preparation of specimens for mechanical properties determination of the rock cores collected from the Lucky Friday Mine, Mullan, Idaho was completed. About 60 cylindrical specimens have been prepared according to ASTM standards for uniaxial and triaxial compressive tests. Forty disk specimens for Brazilian uniaxial tensile tests were also prepared. The preparation of the report Field Site Investigation: Effect of Mine Seismicity on Groundwater (MM 5704-035-094) continued. Also, preparation of the final project report of seismic rock mechanics research project Seismic Rock Mass Behavior Related to High-Level Waste Repository (MM 5704-037-094) was initiated during this period.

A formal announcement for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment was finalized and mailed to more than 130 potential participants. So far, 10 responses have been received showing interest in presenting papers, participating in panel discussion, and/or attending the workshop. A camera-ready copy of the report Laboratory Characterization of Jointed Rock (CNWRA Report 93-

013), which has been accepted by NRC, was sent to NRC for publication as a NUREG/CR report. A camera-ready copy of the report Evaluation of Rock Joint Models and Computer Code UDEC Against Experimental Results (CNWRA Report 93-024), which has been verbally accepted by NRC, is being prepared for publication as a NUREG/CR report.

During the next period, activities within the Seismic Rock Mechanics Research Project will include: (i) developing drive signal for shaking table and initiation of assemblage of rock mass components for the small-scale model; (ii) laboratory work on mechanical properties determination of Lucky Friday Mine rock cores and preparation of the report Field Site Investigation: Effect of Mine Seismicity on Groundwater (MM 5704-035-094); (iii) DECOVALEX modeling and experiments; (iv) preparation of the report Seismic Rock Mass Behavior Related to High-Level Waste Repository (MM 5704-037-094) to document the results obtained from the Seismic Rock Mechanics Research Project and making recommendations on use of these results; and (v) organizing the workshop.

Research Project 5 - Integrated Waste Package Experiments (IWPE)

The long-term tests on alloy 825 in 1000 ppm chloride are continuing. The specimen held at a potential 100 mv below the repassivation potential has not corroded in approximately 7 months. An additional test on alloy 825 in a solution containing 300 ppm chloride was started. Tuff rock from Peña Blanca was received for crushed tuff tests. Six new corrosion cells have been assembled and are ready for conducting long-term tests.

Crevice chemistry control experiments are continuing. Because the change in pH due to acid addition was found to be much faster than that due to hydroxide addition, it was suspected that the bicarbonate conversion to carbon dioxide was creating bubbles in the crevice that block subsequent change in pH due to hydroxide addition. A solution without bicarbonate and purged with inert gas was used, and the changes in pH resulting from acid and hydroxide additions seems to be comparable. However, further tests and computer simulations on the same geometry are being conducted. Once the control runs are completed, experiments on a corroding specimen will be started.

Slow strain rate testing of type 316L stainless steel has continued in this period. To determine if stress corrosion cracking in chloride-containing solutions occurs only above the repassivation potential, tests are being conducted using anodic currents of about 20 to 40 μA under galvanostatic conditions. A crevice-forming device is located on the gauge section of the round tensile specimens to initiate crevice corrosion and create the localized chemistry that can lead to crack initiation. Constant deflection testing of alloy 825 U-bends continued in saturated NaCl solutions at 95 °C. No cracks have been observed in the last inspection of the specimens.

As part of the material stability tests, specimens of variously cold-rolled alloy 825 are being aged at temperatures used previously for solution-annealed specimens. The nitric acid test apparatus for the intergranular corrosion tests has been assembled.

The alternate container materials report is nearing completion. The report examines various issues involved in the life-prediction of alternate DOE waste package design materials including the materials used in the MPC concept.

The database file for EBS sample custody log has been created in the ORACLE database. The format used is almost the same as that used for the Geochemistry group, with minor differences in field notation. The report printing capability has been updated, and access to two individuals through the network has been set up.

G. Cragnolino, D. Dunn, H. Manaktala, and N. Sridhar attended the annual corrosion conference sponsored by NACE International in Baltimore, Maryland, on February 28–March 4, 1994. A trip report is being prepared. The following papers were presented: Effects of Surface Chromium Depletion on the Localized Corrosion of Alloy 825 as a High-Level Waste Container Material by D. Dunn, N. Sridhar, and G. Cragnolino, delivered by D. Dunn, and Effect of Applied Potential on Changes in Solution Chemistry Inside Crevices on Type 304L Stainless Steel and Alloy 825 by N. Sridhar and D. Dunn, delivered by N. Sridhar.

G. Cragnolino attended a Nuclear Waste Technical Review Board meeting on Current and Planned Engineered Barrier System Research in Pleasanton, California, on March 10, 1994. A trip report is being prepared.

The long-term localized corrosion and stress corrosion cracking tests will continue. The circular cell for the crevice chemistry experiments will be used for studying corrosion of metallic specimens. Modeling of chemical transport in this cell will continue and comparisons with experimental results will be made. The specimens for thermal stability will be tested in nitric acid for evaluating intergranular corrosion. The report on the alternate materials will be completed and delivered to the NRC.

Research Project 6 - Stochastic Analysis of Large-Scale Flow and Transport in Unsaturated Fractured Rock (Stochastic)

During this reporting period, the research activities focused on finalizing the technical report (CNWRA 94-007) entitled Effective Hydraulic Property Calculations for Unsaturated, Fractured Rock with Semi-Analytical and Direct Numerical Techniques: Review and Applications. Submission of this report fulfills IM 5704-056-094-003, Application of the Real Space Renormalization Group Method to the Efficient Calculation of Effective Properties for Highly Fractured, Heterogeneous, Unsaturated Media.

This report will undergo external peer review, thus fulfilling IM 5704-054-094-004, Peer Review of Report on Effective Properties. Selection and COI evaluation of the following peer-reviewer candidates are proceeding. The candidates being considered are: A. Journel (Stanford University), P. Kitanidis (Stanford University), A. Gutjahr (New Mexico Tech.), and T. Rasmussen (University of Georgia).

Revisions to the Stochastic Project Plan were made to reflect the new peer-review activity and milestones.

During the next reporting period the activities will concentrate on (i) finalizing the selection of the peer-review group and (ii) continuing the high-resolution flow and transport simulations.

Research Project 7 - Geochemical Analogs

Field research was conducted at the Peña Blanca analog site from February 28 to March 4, 1994. Clearing of a portion of Level +00 was inspected and was found to meet the requirements of the subcontract. Geologic mapping was carried out on selected areas within recently cleared portions of Levels +10 and +00 for qualification of subcontract deliverables; the mapping was determined to be well done. The 1 m × 1 m sampling grid on Level +00 was expanded to include the newly cleared area. A contact gamma survey was conducted on the newly cleared portion of Level +00, and rock and mineral samples were collected using field contouring of the gamma survey to guide sampling. Samples of unaltered Nopal Formation tuff were collected for use in IWPE tuff-container crevice corrosion experiments. Additional samples of vein-filling minerals were collected from the EW fracture at about 13.5 m N on Level +10, and several sets of samples were collected from elsewhere on Level +10 for U-series disequilibria measurements to identify patterns of recent (i.e., within the last 1 Ma) U mobility. A set of electromagnetic measurements was completed spanning the entire Nopal cuesta to search for confirmatory evidence of postulated perched water tables that may have interacted with the Nopal I U deposit. These measurements were conducted using an EM-47 time domain electromagnetic system with a 160 m perimeter transmitter loop; upon reduction of the data, perched water zones (or other conductors) may be detected at depths of up to 150 to 200 m.

Samples collected during the field research at Peña Blanca were entered into the Sample Custody Log (now using the Oracle database on a Sparc 10 workstation). There were 120 new samples added, bringing the total number of samples being tracked within the Geochemical Natural Analog Project to 1,649. Fracture mapping completed during the field research at Peña Blanca was added to the ARC/INFO database for the Nopal I site; the fracture coverages of Levels +10 and +00 now include 11,374 fractures mapped in an area of approximately 1,400 m^2.

X-ray Diffractometry and optical microscopy analyses continued of Nopal I samples to determine mineralogy and phase relations. Polished thin sections were prepared from samples collected during field research at Peña Blanca to measure matrix diffusion perpendicular to the EW fracture at about 13.5 m N on Level +10 of the Nopal I deposit. Additional polished thin sections of fracture filling material were prepared for identification of the minerals upon which or within which U has been retained and the concentrations of U on or in each mineral phase. This information will support interpretation of the relative effectiveness of sorption on and precipitation with various phases as U retardation mechanisms. All of these sections were sent to the Texas A&M University Microprobe Laboratory for analysis.

Gamma spectrometry analyses continued on samples from the Nopal I deposit to measure U concentrations. These analyses allow quantitative assessment of the distribution of U within and around the Nopal I deposit. Tests continued to evaluate the use of the SwRI

Division 01 high-resolution gamma spectrometry system for U-series analysis; duplicate portions of samples previously analyzed by alpha spectrometry are being analyzed for comparison. Measurements continued, in collaboration with the PA Research Project, of saturated hydraulic conductivity and retention curves for tuff matrix samples collected from Nopal I.

Trace metal leaching of samples from the Akrotiri analog site continued. The leaching procedure was modified to recover more leachate for analysis. This modification required that initial samples be releached to produce an internally consistent set of early and later analyses for quantitative comparison.

Preparations were made to give a presentation on the Geochemical Natural Analog Research Project to the ACNW on March 23, 1994. The ACNW requested the presentation to learn more about the programmatic connections of the project, the project structure, and use of research results to support PA and SRA. A dry-run for the presentation was held by teleconference on March 17, 1994. A presentation describing the Geochemical Natural Analog Research Project was given to Dr. K. Sekine, Head of the Environmental Geochemistry Laboratory for the Department of Environmental Safety Research of the Japan Atomic Energy Research Institute on March 17, 1994. Updates to the Geochemical Natural Analog Project Plan were completed and submitted to the NRC. These changes only affect information within Appendix A, and constitute recalculation of cost projections to reflect changes in the SwRI fee structure. An abstract entitled CNWRA Natural Analog Research at Peña Blanca and Santorini was drafted in preparation for an invited presentation at the IHLRWM conference by W. Murphy.

During Period 7, activities within the Geochemical Analog Research Project are anticipated to include: (i) continued gamma spectrometry analyses of Nopal I samples, (ii) continued petrographic study of Nopal I samples, (iii) Auger spectroscopy of fracture-filling iron oxides and jarosite from Nopal I, (iv) continued leachate analyses of the tuff from the Akrotiri site, (v) EMPA analyses of Nopal I sections at Texas A&M University, (vi) a presentation on the Geochemical Natural Analog Project to the ACNW, and (vii) continued writing of the topical report describing U transport at the Nopal I analog site.

Research Project 8 - Sorption Modeling

Experiments on ^{233}U sorption on montmorillonite (initial $\Sigma U = 50$ ppb; solid-mass to solution-volume ratio = 0.01 g to 40 ml) were completed. Aqueous samples were taken for analysis of uranium concentration using a liquid scintillation analyzer.

Characterization and preparation of Wedron silica sand continued. Analysis of grain-mount thin sections revealed that chemical treatments to remove free iron oxides, carbonates, and soluble salts were successful. However, a significant quantity (1-2%) of non-quartz minerals still remain. These minerals include pyrite, rutile, zircon, and others yet unidentified. XRD analysis has failed to identify the presence of any of these minerals. The quartz sand will be processed further using heavy liquid separation.

Characterization of potential experimental containers continued with the inclusion of experiments designed to evaluate the sorption of U on polycarbonate bottles at various pH values. Preliminary results indicate that U sorption onto polycarbonate may be significant at near neutral pH.

Sorption modeling efforts continued with the completion of modeling CNWRA 50 ppb uranium sorption on montmorillonite. DLM simulations were able to reproduce the observed sorption behavior very well. Additional modeling efforts focused on the sorption of carbon-bearing species on iron-oxyhydroxides. Due to a lack of suitable data, these reactions were neglected in previous modeling efforts. Data were taken from the literature and modeled using the DLM with surface acid-base parameters developed at CNWRA. Results indicate that the model assuming formation of the surface complex $>FeOH_2\text{-}CO_3^-$ is adequate to model carbon sorption in the pH range from 4 to 9. Other systems modeled include Np, Th, Am sorption on silica. Results for the Np-Silica system will be useful for the batch and column experiments currently being planned at CNWRA.

A CNWRA perspective (white paper) on the importance of uranium in radionuclide source term and transport studies was completed and is undergoing technical and programmatic reviews.

Uranium sorption experiments on montmorillonite will continue. Additional experiments at initial U concentrations of 5 and 500 ppb will be initiated to determine the concentration dependence of U sorption on montmorillonite. Models developed for the 50 ppb data will be used to predict these results and the results of the solid mass to solution-volume ratio (0.01 g to 40 ml) experiments as a check on model performance and flexibility. Models will also be developed to incorporate CO_3^{2-}-sorption reactions for carbon-bearing systems. Preparation of the Wedron quartz sand to be used in sorption experiments (batch and column) will continue.

Research Project 9 - Performance Assessment (PA)

In this reporting period, the technical staff concentrated on (i) conceptual and mathematical models of flow in fractured permeable media and (ii) analysis of hydraulic properties of the Peña Blanca tuff core samples.

Work on fluid flow in a fracture with imbibition into the matrix continued. A computer code capable of modeling thin film flow in a fracture with imbibition of water into the porous matrix has been developed and tested. Three different imbibition modes can be handled in this code; a first order loss function, Green-Ampt imbibition, and Richards equation based imbibition. The evolution of water pulses introduced into a fracture was numerically simulated. For a first order loss function, similarity solutions to the governing nonlinear advection-imbibition equation have been found in the form of simple analytical expressions. The distinct time-scales associated with fluid flow in the fracture and fluid imbibition into the porous matrix were identified. The relative ease with which a fracture may serve as a conduit for fluid-flow increases with the ratio of these time scales, i.e., imbibition time scale divided by the advection time scale. This nondimensional number may be used to compare the role of different fractures (with distinct apertures, orientations, and lengths, embedded inside different porous medium with different constitutive behavior) in controlling flux of water in unsaturated fractured porous medium. Work continued on documentation of the results of this analysis in a technical report entitled Study of Water Film Flow in a Fracture with Imbibition (IM 5704-191-094-002).

The analysis of the unsaturated hydraulic properties of rock samples collected from the Peña Blanca Natural Analog site continued. Saturated hydraulic conductivity determinations were made for these samples. Difficulties were encountered with the tuff samples exhibiting the presence of clay within the matrix. These difficulties were attributed to the hydraulic influence of clay-filled vugs that tend to provide short water pathways in the rock sample discs. The thin rock sample discs prepared for the permeameter are apparently too thin to allow accurate determination of average matrix properties. Analyses to determine appropriate representative elemental volume for these data are ongoing. This work will be documented in a technical report entitled Analysis of Hydraulic Characteristics of Hydrothermally-Altered Tuff (IM 5704-191-094-004). This work is being conducted under the scope described in Task 1 of the PA Research Project Plan for FY94-95.

No work was performed on model validation activities. As agreed with T. McCartin, (NRC), the major activity on this task will be deferred until the completion of the NRC/SKI model validation paper and PASP by the NRC NMSS staff. This activity was conducted under the scope described in Task 3 of the PA Research Project Plan for FY94-95.

In the next reporting period, work will be directed to: (i) continuing documentation of fracture conceptual/mathematical model and (ii) continuing work on determination of fractured tuff properties

Research Project 10 - Volcanic Systems of the Basin and Range

Data were added to the GIS volcanism database for the San Francisco volcanic field. These data included raster line and DXF files for the stable topographic and geographic base and geologic contacts for the entire volcanic field.

Significant effort was made to improve global access to the ARC/INFO Volcanism GIS during this period. This activity is increasingly important as the database grows, becomes more useful, and numerous individuals at the CNWRA and NRC begin to use the database.

Additional work was done testing the CNWRA near-neighbor nonhomogeneous Poisson model. These tests involved analysis of the model performance through time in the YMR. This was accomplished by calculating a series of probability maps based on the model using volcanoes that formed more than 5, 1.6, 0.5, and 0.1 Ma in the YMR, then determining how well the model predicted the distribution of volcanoes that formed during episodes immediately after these times. The model did better than homogeneous Poisson models at forecasting the locations of the five volcanoes of the Crater Flat alignment and Lathrop Wells, close to the candidate site. The model did not perform as well as the homogeneous Poisson model at forecasting the occurrence of volcanism at

Sleeping Buttes, far from the candidate site, because comparatively few volcanoes have formed in that cluster through time. In addition, a proof was formulated showing that the near-neighbor nonhomogeneous estimate of recurrence rate is identical to the homogeneous Poisson recurrence rate under conditions of complete spatial and temporal randomness in volcano distribution. This proof is important because it shows that the nonhomogeneous model is simply a more general form of the homogeneous model.

Work will continue in data collection and model review. A strong focus will be placed on the critical review and analysis of data tasks in this project during the next period.

Research Project 11 - Tectonic Processes

Work continued to create a 3D volumetric visualization of earthquake hypocenters. Models are being produced for the entire central Basin and Range region, and for the region immediately around the Landers main shock. Animated time sequences have been produced that show the sequence of occurrence of earthquakes coded by magnitude and depth. Time and space clustering that is somewhat evident from quasi-static displays is strikingly distinct in the time-animation. These models will comprise an integral part of regional- and local-scale seismo-tectonic models. Formation contacts and geologic dips were digitized from Scott and Bonk's geologic map along an east-west transect across the southern part of YM. This line will provide the geologic basis for an initial integrated seismo-tectonic section across the YMR.

Compilation of data and planning for cross-section tectonic models of the central Basin and Range and the YMR will continue during the next reporting period. Evaluation of earthquake hypocenters in 3D will also continue. Emphasis during the next period will be on characterization of clustering patterns.

Research Project 12 - Field Volcanism

During this period, work focused on the analysis of samples collected at Parícutin volcano and other basaltic cinder cones. He analyses of 20 soil gas samples from Parícutin were completed. These samples range in He concentration from 10 to 270 ppb above atmospheric. Three samples, collected within 100 m of the highest temperature fumaroles at Parícutin, have clearly anomalous He values (<240 ppb above atmospheric). The remaining samples form a normal distribution with mean He concentration of 90± 20 ppb above atmospheric. For comparative purposes, mean Hg concentrations in hydrothermal areas in the United States are rarely more than 20 ppb in excess of atmospheric He. At Kilauea volcano, mean He concentration around the summit of the volcano is about atmospheric, but is several times atmospheric close to the Sulfur Bank fumaroles. Thus, He concentrations at Parícutin appear too high compared to Kilauea in general, but the highest values, close to the fumaroles, are low compared to those observed at Sulfur Bank fumaroles. One preliminary explanation for the He anomalies at Parícutin is that degassing brings He to the surface from depth. Analysis of CO_2 and Hg and gas condensate samples is still under way. Analysis of temperature data collected at Parícutin indicates that fumarole temperature varied slightly during the sampling period, does not correlate with atmospheric barometric pressure, but does show correlation with atmospheric temperature.

Mineral separates were made of samples collected in the Quaternary Yucca Mountain region during this period. B. Hill visited a laboratory at the Smithsonian to discuss major element analysis and quality assurance procedures and documentation. C. Connor visited the lab at ASU to discuss progress and problems with melt inclusion analyses ongoing at ASU. Hopefully, some volatile content determinations will be forthcoming.

Work continued on preparation of the geophysics major milestone during this period. This work includes analysis of synthetic tomographic surveys in the YMR and elsewhere, and experimental designs in tomography that aid in the resolution of intrusion recognition and mapping. This work was carried out primarily in conjunction with C. Sanders at ASU.

During the next period, activities will focus on the preparation of the geophysics major milestone.

Research Project 13 - Regional Hydrogeologic Processes

As part of Task 1 (Literature Review and Data Collection) of the project, hydraulic and geochemical data are being compiled and sorted according to the State of Nevada hydrographic areas, as defined by Eugene Rush. These hydrographic basin boundaries are being digitized and added as line coverages to the ARC/INFO database. A detailed report was prepared for the regional hydrogeology field trip taken in November, 1993. This trip report includes maps which show the locations of stops during the field trip; the report summarizes the primary observations made at each stop.

Progress has continued in Task 2 (Development of Conceptual Models) on the development of a regional scale hydrostratigraphic model of the Death Valley region. Compilation of data was also continued for cross section tectonic models of the central Basin and Range region and the YMR. Available data were gathered and used in developing interpretations for the pre-Tertiary geologic section, with emphasis on the Paleozoic carbonate aquifer. These data and associated interpretations are from outcrop, seismic reflection profiles, water wells, oil and gas wells, and existing geologic cross sections. D. Ferrill obtained information on the contemporary stress field in the Death Valley region and will attempt to correlate the major and minor stresses with known directions of preferential flow in the Paleozoic carbonate aquifer. G. Wittmeyer is attempting to obtain time-drawdown data from the Amargosa tracer test well field to estimate the hydraulic conductivity tensor for this portion of the Paleozoic carbonate aquifer.

Efforts during Period 7 will be on the compilation of data and planning for cross section tectonic models of the central Basin and Range, Death Valley region, and the YMR and on evaluating the use of contemporary stress data in determining the orientation of preferential flow paths in the carbonate aquifer.

1.9 *Waste Solidification Systems (WSS)*

The CNWRA received a copy of the DOE supporting documentation of the air permit applications for Radionuclide Emissions for the Vitrification Facility from the NRC. This report provides information in support of the review planned under Task 1. Preliminary review of the document indicates that there is a lack of details in the calculations. A site visit to review the calculations is recommended. Three DOE design criteria documents, Vitrification of High-Level Wastes, Sludge Mobilization Waste Removal System, and High-Level Waste Interim Storage System, have been received at the CNWRA. Also included in the DOE transmittal is a report on Hazard Assessment of Vitrification Non-Radiological Integrated Testing. These documents will initiate significant review activity under Tasks 2 and 3.

As part of Task 4, G. Cragnolino attended the sessions dealing with the integrity of carbon steel tanks used in the storage of high-level waste, at the corrosion conference sponsored by NACE International. Papers presented included aspects of monitoring and inspection of these tanks under various DOE programs. The papers are currently under review.

Review of the documents for Tasks 1, 2, 3, and 4 will be initiated. Major review activities are expected for the next several periods as a result of the various documents received this period.

1.10 *Monitored Retrievable Storage (MRS)*

During this period, no work assignment was received from the NRC.

The CNWRA will await further work assignment on MRS from the NRC.

2. MANAGEMENT ISSUES

None.

3. MAJOR PROBLEMS

None.

4. SUMMARY OF SCHEDULE CHANGES

Schedule changes that have become necessary are summarized in Table 3. This table provides formal documentation of: (i) schedule changes for IMs that occurred during the preceding period or are anticipated to occur during the subsequent period, and (ii) schedule changes for MMs that are anticipated to occur during subsequent periods. Each item listed has been discussed with the cognizant NRC PEM and other parties, as appropriate. In the case of MMs, the matter has been discussed with the NRC Contracting Officer and/or the designated representative of DCPM.

5. SUMMARY FINANCIAL STATUS

Table 4 indicates the financial status of the CNWRA in the context of authorized funds established by the NRC. Total commitments of the CNWRA are $273,757. Appendix A displays planned and actual costs to date, without allowance for fee, on both a per-period and a cumulative basis. In addition, these data do not include commitments, and variances are shown on both a dollar and percentage basis. Pertinent information is provided for the CNWRA program as a whole, the DHLWM JC, the RES DRA JC, the DIMNS JC, and the DFCSS JC, as well as for each Program Element and Project. This information is provided in both graphical and tabular form.

The actual cost at the end of the sixth period of FY94 in the HLW JC is 6.8 percent below the estimated cost. All of the elements, except GS, show cost underruns, which are explained in the following paragraphs.

The aggregate underspending of 5.4 percent in the COPS Element reflects the accumulation of both the old and new work breakdown structure account numbers (071-076 and 151-155). For FY94 to date, all subtasks are under projected expenditure levels, including both series of work breakdown structure account numbers, except Management Support and Planning (Subtask 151) and DHLWM Computer Systems Support (Subtask 155). During Periods 5 and 6, spending in Subtask 153 increased to show the costs associated with the mid-year revisions to the operations plans. Subtasks 151 and 155 expenditures should not surpass the revised estimates for the balance of this fiscal year. However, Subtask 154 costs should exceed revised estimates during the preparation for the CNWRA QA audit and conduct of the actual auditing and report writing scheduled for Periods 8 and 9. Subsequently, expenditures for this Subtask should return to the norm for CNWRA QA internal operations.

The WSE&I Element was 8.6 percent underspent at the end of this period. This represents a 9.8 percent increase in spending from the previous period and reflects the increased use of additional SwRI staff for RPD development and uncertainty crosswalk preparation. This increased spending will continue and is expected to result in a temporary overspending condition prior to completion of RPD Phase II in June, 1994. Subsequent to this, use of non-CNWRA labor will be significantly reduced.

Actual costs for the EQA Element are currently 37.3 percent below the estimated spending plan. This underrun in the EQA Element is due to postponement of DOE audits and generally lower costs per activity than originally estimated.

The GS Element is overspent by 12.9 percent. This increase in spending reflects increased activity in CDS integration and CDM development, as well as costs associated with presentations to the NWTRB and ACNW, reviewing the DOE topical report on extreme erosion and efforts to debug the SEISM 1.1 code. Both the erosion review and debugging of SEISM 1.1 are nearing completion. Spending decreased significantly in geology/geophysics during Period 6. Effort will continue to be transferred from geology/geophysics to IPA resulting in continued reduced costs.

The expenditures through Period 6 for the EBS Element are 8.7 percent below the planned costs. Expenditures are expected to increase in the future periods and remain close to planned levels.

Costs incurred to date for the RDCO Element are 3.9 percent below those planned. Costs will increase as the DBE rulemaking, CDS development, and prelicensing activities continue.

Spending in the PA&HT Element is 18.0 percent under the projected amount. The cost variance for Period 6 is less than that of the previous periods. Further decreases in the variance are expected because of the current progress on various auxiliary analyses and the expert judgment study, as well as new tasking on the EPA standard. In addition, new activities are planned to start in the third and fourth quarters.

Costs incurred to date for the Overall Research Project were 13.8 percent above projected costs. An adjustment to the project budget is planned (beginning in Period 7) to accommodate FY93 charges which were costed to Overall Research during Period 3 of FY94. This adjustment is anticipated to bring future project costs close to projected values.

The Geochemistry Research Project is 19.7 percent overspent at the end of Period 6. An increase in the project budget was requested with the recent revision of the project plan. The additional funds will be taken out of the Near-Field Research Project which has not yet been initiated due to delays in the receipt of the statement of work from the NRC.

Actual costs for the Thermohydrology Research Project are close to estimated costs. Actual costs are 0.2 percent over the estimate. This cost variance is about 9 percent smaller than the previous period variance, and reflects efforts to reduce the spending rate. The reduction in actual spending is attributed to requirements by key project personnel on other projects. In addition, a letter was received from the NRC approving an increase in the budget of $70,000 for the remainder of FY94 to ensure the successful and timely completion of this research project.

Seismic Rock Mechanics Research Project costs incurred to date are 1.5 percent less than the planned expenditure. Expenditures are expected to remain close to planned levels.

The IWPE Research Project costs are 7.5 percent less than planned. The underspending was due to the concentration in the SCCEX modeling activities in earlier periods. Activities in the IWPE Research Project have increased in this reporting period and will continue to be close to the project plan in the future periods.

At the end of Period 6, the Stochastic Research Project was 30.6 percent over the projected costs. This excessive rate of spending is associated with the high production cost of reports, which are to undergo peer-review. It is estimated that the production cost for peer-reviewed reports may be as high as $10K per report.

At the end of Period 6, the Geochemical Natural Analog Research Project was 3.7 percent below planned costs. Project costs for the remainder of the fiscal year should approximate planned costs. Occasional short-term cost deviations corresponding largely to field research expenses are anticipated.

The Sorption Research Project is 4.1 percent overspent through Period 6, and is anticipated to continue on this trend for the succeeding periods. This is due to purchase of necessary supplies, e.g., radioactive spikes, and radiation safety related equipment, as well as additional labor costs associated with conducting sorption experiments on plutonium and neptunium. Additional funds were requested with the recent revision of the project plan. These funds will be taken out of the Near-Field Research Project which has not yet been initiated due to delays in the receipt of the statement of work from the NRC.

Costs through Period 6 for the Volcanic Systems of the Basin and Range Research Project were 12.3 percent less than planned levels because of unanticipated reactive work. C. Connor and B. Hill made presentations to the ACNW which required considerable preparation and C. Connor made a presentation to the NWTRB. Anticipated work in the critical review and analysis of data task during the next period should bring spending closer to planned levels.

As of the end of Period 6, the Regional Hydrology Research Project is tracking the projected spending curve as indicated by the small variance of 0.4 percent. This indicates that the actions taken to reduce the spending rate have been successful.

Through Period 6, costs for the Field Volcanism Research Project were 8.8 percent less than planned levels because of unanticipated reactive work. C. Connor and B. Hill made presentations to the ACNW which required considerable preparation and C. Connor made a presentation to the NWTRB. Anticipated work during the next period should bring spending up to anticipated levels

Actual expenditures at the end of this period for the Tectonics Research Project ran over projected costs by 34.4 percent. Most of this overage is accounted for by consulting costs accrued during Periods 4 and 5. These costs will not recur. The variance for Period 7 is expected to be less than 10 percent.

At the end of Period 6, the PA Research Project costs are about 9.8 percent under the projected amount. This variance, like that of the previous period, shows that efforts to control the spending rate have been very successful. However, the spending rate is expected to increase gradually over the next few periods as work is focused on preparation of three major deliverables for Task 1.

The expenditures in the WSS Project are 78.5 percent below the planned level. The nature of the tasks in this program element reflect the dependence on several documents to be received from the DOE. As a result, the expenditures are expected to fluctuate. However, this period, the NRC has received several new documents from the DOE that are to be reviewed under the various tasks. Activities related to the review of the DOE documents will increase in the next few periods. Significant activities will develop in this project once the draft of the Vitrification Safety Analysis Report is made available by the DOE.

In the MRS Project, no work was assigned to the CNWRA by the NRC resulting in a cost underrun of 97.8 percent. E. Shum (NRC) has indicated that the CNWRA may not receive additional work assignments until an MRS site is identified.

TABLE 1. CNWRA CORE STAFF - HIRING PROFILE AND STATUS (03/18/94)

EXPERTISE/EXPERIENCE	FISCAL YEAR (PLANNED)								OPEN THIS YEAR
	FY93								
	1Q	2Q	3Q	4Q	FY94	FY95	FY96	FY97	
ADMINISTRATION	5	5	5	5	5	5	5	5	0
CODE ANALYSIS/DEVELOPMENT	2	2	2	2	2	2	2	2	0
DATABASE MANAGEMENT & DATA PROCESSING	2	2	2	2	2	2	2	2	0
ELECTROCHEMISTRY	1	1	1	1	1	1	1	1	0
ENGINEERING GEOLOGY/GEOLOGICAL ENGNG			1	1	1	1	1	1	0
ENVIRONMENTAL SCIENCES	1	1	1	1	1	1	1	1	0
GEOCHEMISTRY	5	5	5	5	5	5	5	5	0
GEOHYDROLOGY/HYDROGEOLOGY	5	5	5	5	5	5	5	5	0
GEOLOGY	2	2	2	2	2	2	2	2	0
HEALTH PHYSICS	1	1	1	1	1	1	1	1	0
INFORMATION MANAGEMENT SYSTEMS	2	2	2	2	2	2	2	2	0
MATERIAL SCIENCES	4	4	4	4	4	4	4	4	0
MECHANICAL, INCLUDING DESIGN & FABRICATION	1	1	1	1	1	1	1	1	0
MINING ENGINEERING	1	1	1	1	1	1	1	1	0
NUCLEAR ENGINEERING	1	1	1	1	1	1	1	1	0
NUMERICAL MODELING/HP (a)			1	1	1	1	1	1	1
PERFORMANCE ASSESSMENT	4	4	4	4	4	4	4	4	0
QUALITY ASSURANCE	2	2	2	2	2	2	2	2	0
RADIOISOTOPE GEOCHEMISTRY (a)	1	1	1	1	1	1	1	1	1
REGULATORY ANALYSIS	1	1	1	1	1	1	1	1	0
ROCK MECHANICS	3	3	3	3	3	3	3	3	0
SEISMOLOGY	1	1	1	1	1	1	1	1	0
SOURCE-TERM/SPENT FUEL DEGRAD.	1	1	1	1	1	1	1	1	0
STRUCTURAL GEOLOGY/SEISMO-TECTONICS	3	3	3	3	3	3	3	3	0
SYSTEMS ENGINEERING	1	1	1	1	1	1	1	1	0
VOLCANOLOGY/IGNEOUS PROCESSES	1	1	1	2	2	2	2	2	0
TOTAL CORE STAFF PLANNED	51	51	53	54	54	54	54	54	2

Staffing Summary

	Professional	Support	Total
Current	52	16	68
Limited Term	1	0	1
Offers Made	0	0	0
Planned This Date	54	16	70
Planned End of FY94	54	16	70

(a) Interview scheduled next period
(b) Resumes being solicited
(c) Offer made
(d) Offer pending
(e) Offer accepted

TABLE 2. CNWRA CORE STAFF - CURRENT PROFILE (03/18/94)

EXPERTISE/EXPERIENCE	
ADMINISTRATION	J.LATZ, W.PATRICK, H.GARCIA, P.MACKIN, J. RUSSELL, B. SAGAR
CODE ANALYST	R.JANETZKE, R.MARTIN
DATABASE MANAGEMENT AND DATA PROCESS	A.JOHNSON
ELECTROCHEMISTRY	G.CRAGNOLINO
ENGINEERING GEOLOGY/GEOLOGICAL ENGNG	G.OFOEGBU
ENVIRONMENTAL SCIENCES	P.LaPLANTE
GEOCHEMISTRY	W.MURPHY, R.PABALAN, E.PEARCY, J.PRIKRYL, D.TURNER, P.BERTETTI*
GEOHYDROLOGY/HYDROGEOLOGY	A.BAGTZOGLOU, R.GREEN, S.STOTHOFF, G.WITTMEYER, V.KAPOOR, S.MOHANTY
GEOLOGY	L.McKAGUE, M.MIKLAS
HEALTH PHYSICS	J.HAGEMAN
INFORMATION MANAGEMENT SYSTEMS	R.JOHNSON, R.MARSHALL
MATERIAL SCIENCES	P.NAIR, H.MANAKTALA, N.SRIDHAR, D.DUNN
MECHANICAL, INCLUDING DESIGN & FABRICATION	C.TSCHOEPE
MINING ENGINEERING	S-M.HSIUNG
NUCLEAR ENGINEERING	H.KARIMI
NUMERICAL MODELING/SIMULATION	
PERFORMANCE ASSESSMENT	R.BACA, A.B.GURESHIAN, R.MANTEUFEL
QUALITY ASSURANCE	B.MABRITO, R.BRIENT
RADIOISOTOPE GEOCHEMISTRY	
REGULATORY ANALYSIS	S.SPECTOR (law)
ROCK MECHANICS	A.CHOWDHURY, M.AHOLA, A.GHOSH
SEISMOLOGY	R.HOFMANN
SOURCE-TERM/SPENT FUEL DEGRAD	P.LICHTNER
STRUCTURAL GEOLOGY/SEISMO-TECTONICS	G.STIREWALT, S.YOUNG, D.FERRILL
SYSTEMS ENGINEERING	A.DeWISPELARE
VOLCANOLOGY/IGNEOUS PROCESSES	C.CONNOR, B.HILL

*LIMITED TERM

TABLE 3. SUMMARY OF SCHEDULE CHANGES

Milestone Number	Type	Description	Original Date	Revised Date	Rationale for Change
5702-441-431	IM	Review of Erosion Topical Report	3/15/94	3/31/94	Delayed to include field trip comments
5704-094-004	'M	Peer Review of Report on Effective Properties	4/30/94	6/15/94	Delayed to accommodate COI process for reviewers

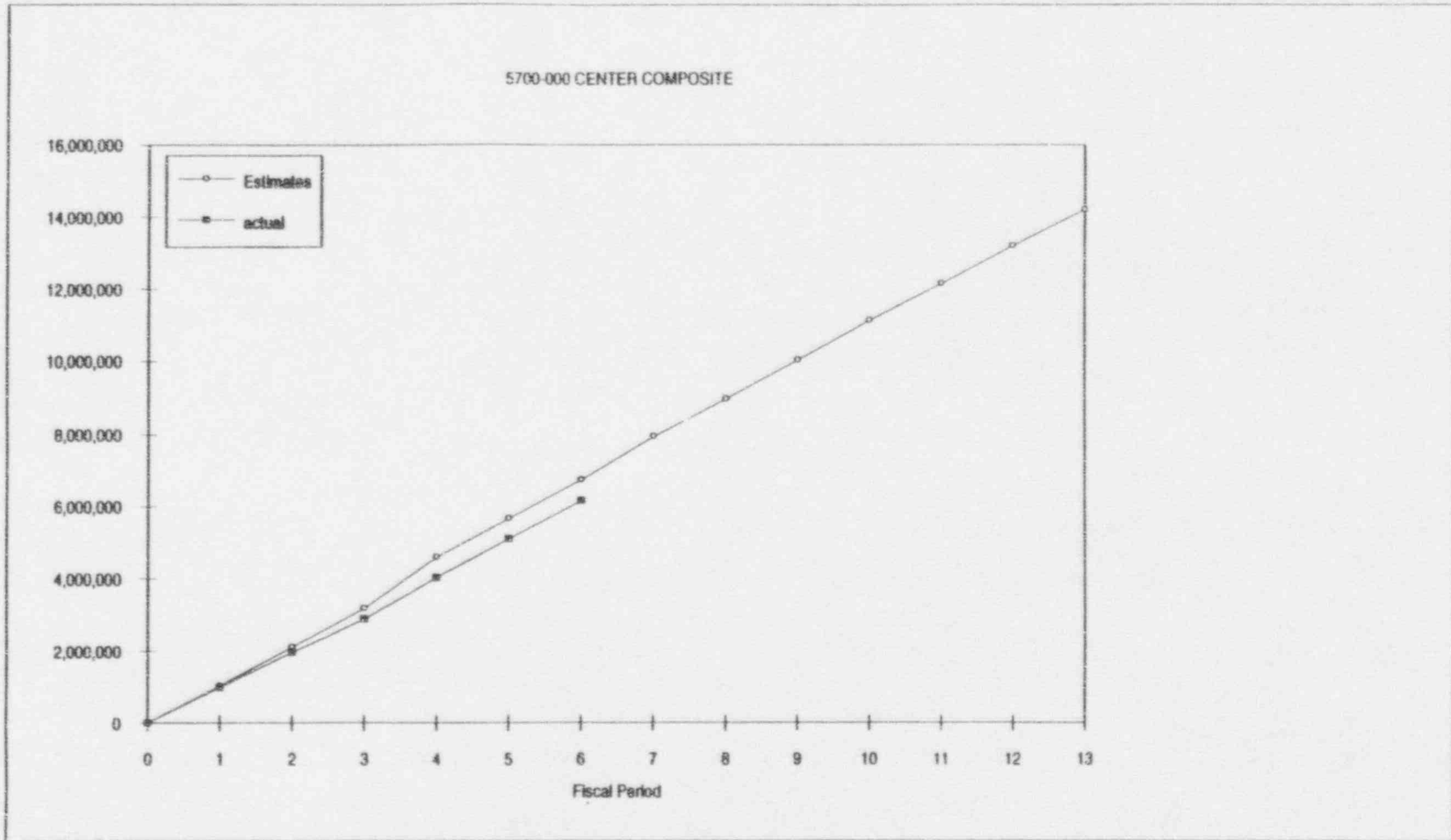
TABLE 4. FINANCIAL STATUS

	Funds Authorized*	Funds Costed to Date**	Funds Uncosted	Commitments
GS	3,567,399	1,802,391.29	1,765,008	13,635
EBS	2,376,992	1,102,371.58	1,274,620	11,489
RDCO	1,206,199	1,451,028.73	(244,830)	14,457
WSEI	2,582,731	1,914,730.19	668,001	15,705
EQA	1,284,454	142,969.50	1,141,485	800
PA	2,480,853	1,971,718.92	509,134	121,909
COPS	4,329,800	3,143,641.35	1,186,159	9,563
HLW	17,828,428	11,528,851.56	6,299,576	187,557
OVERALL	466,856	306,881.35	159,975	3,507
GEOCHEM	388,410	334,622.98	53,787	0
THERMO	924,236	558,951.61	365,284	2,040
SEISMIC	1,208,067	695,773.03	512,294	37,280
IWPE	1,377,499	790,398.81	587,100	4,511
STOCH	510,727	404,620.14	106,107	825
ANALOGS	1,069,663	592,006.18	477,657	13,998
SORPTION	996,066	575,302.44	420,764	533
RES PA	795,113	741,164.10	53,949	11,208
VOLCAN (R)	427,348	405,843.90	21,504	201
VOLCAN (FLD)	774,382	289,096.05	485,286	4,577
REG HYDRO	774,545	179,382.67	595,162	0
TECTONIC	1,236,738	454,486.37	782,252	7,440
RES	10,949,650	6,328,529.63	4,621,120	86,200
WSS	235,392	118,272.77	117,119	0
MRS	56,231	15,469.02	40,762	0
TOTAL	29,069,701	17,991,122.98	11,078,578	273,757

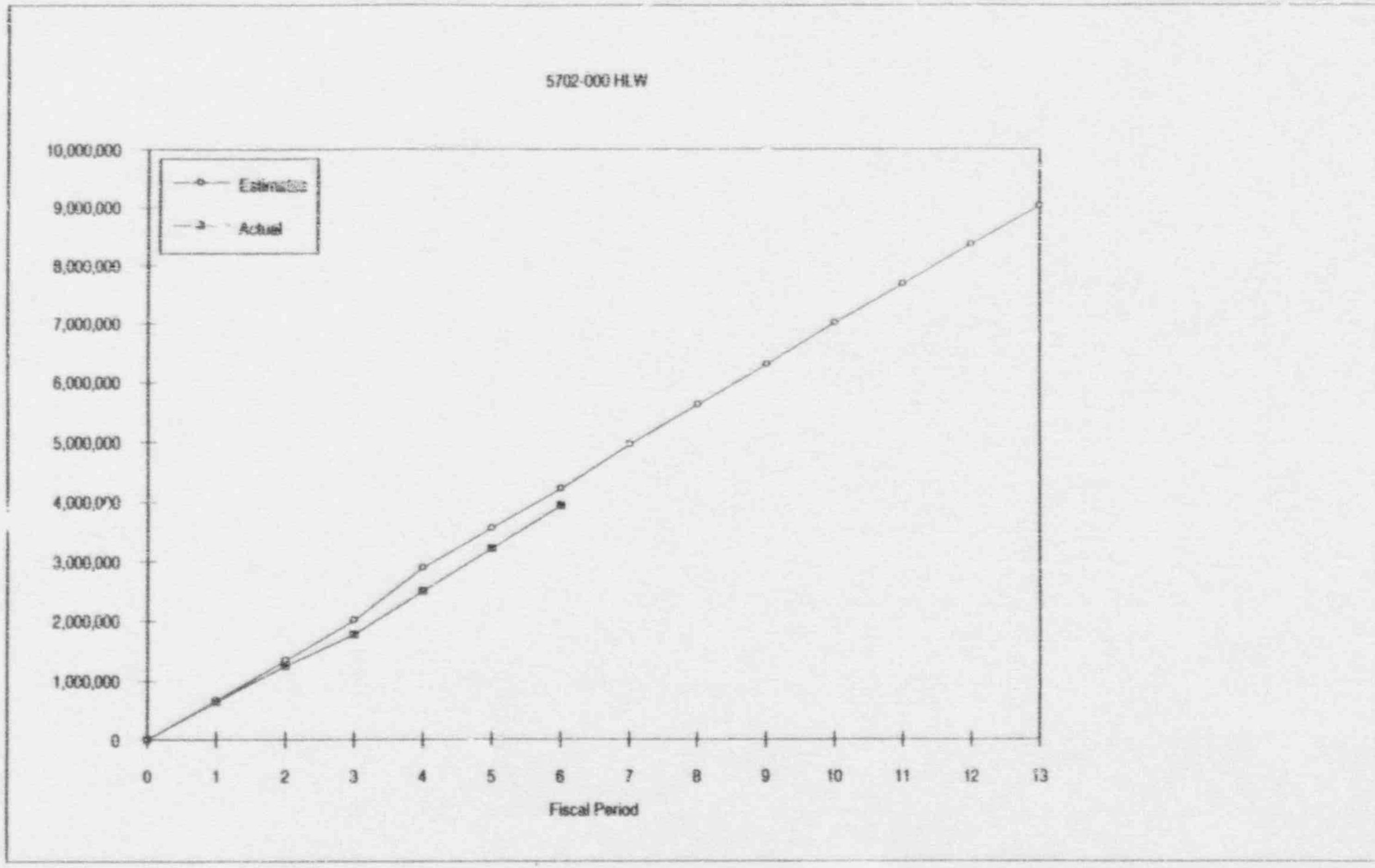
* Additional Authorized Funds of $2,576,788 for HLW and $314,325 for RES have not been allocated.
** Costed to Date includes 3% Base Fee. Additional fee awarded (Award Fee Pool 11) of 4.2% is not included.
Amount authorized includes carryover.

APPENDIX A

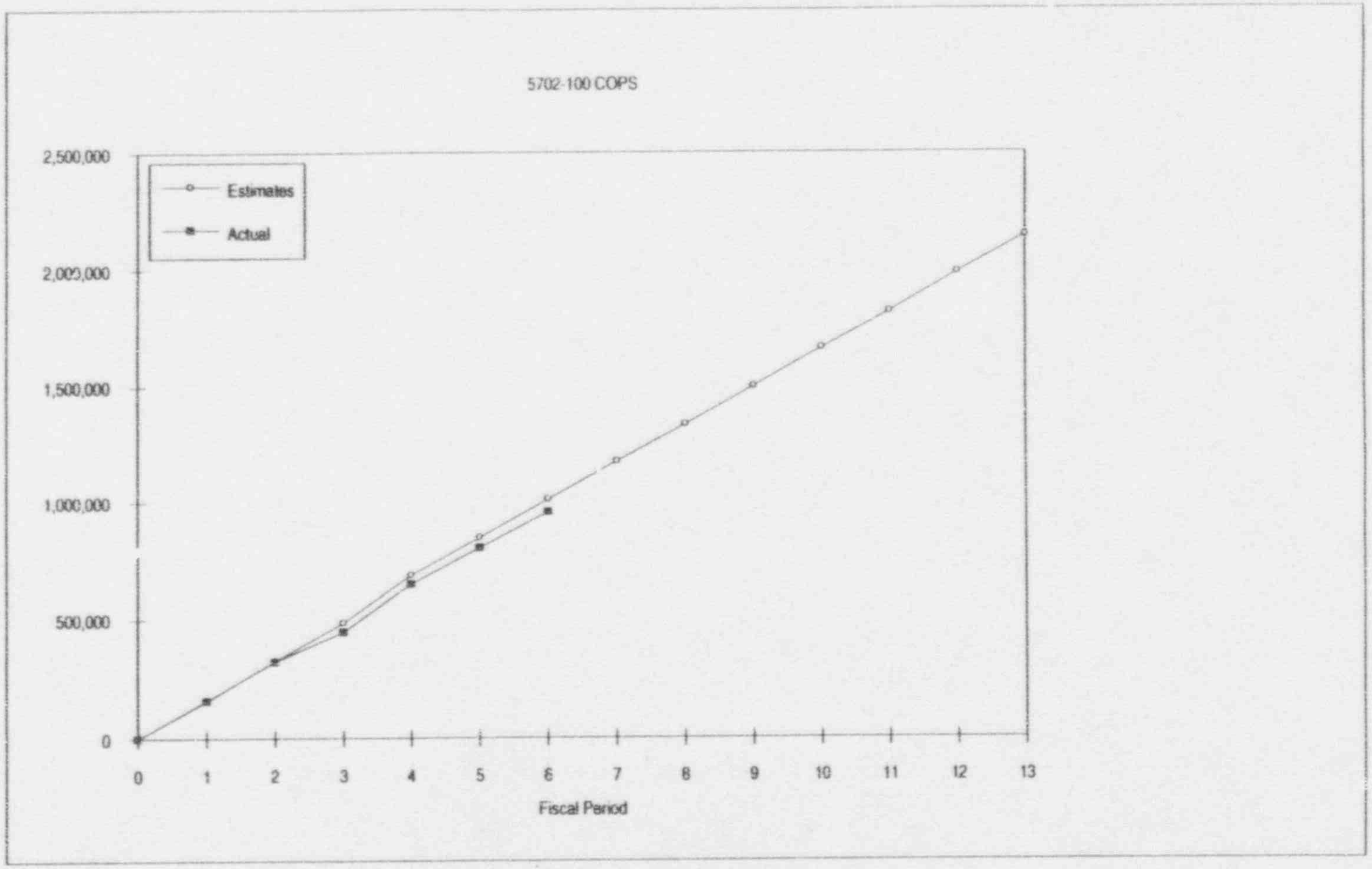
PLANNED AND ACTUAL COSTS, AND COST VARIANCES



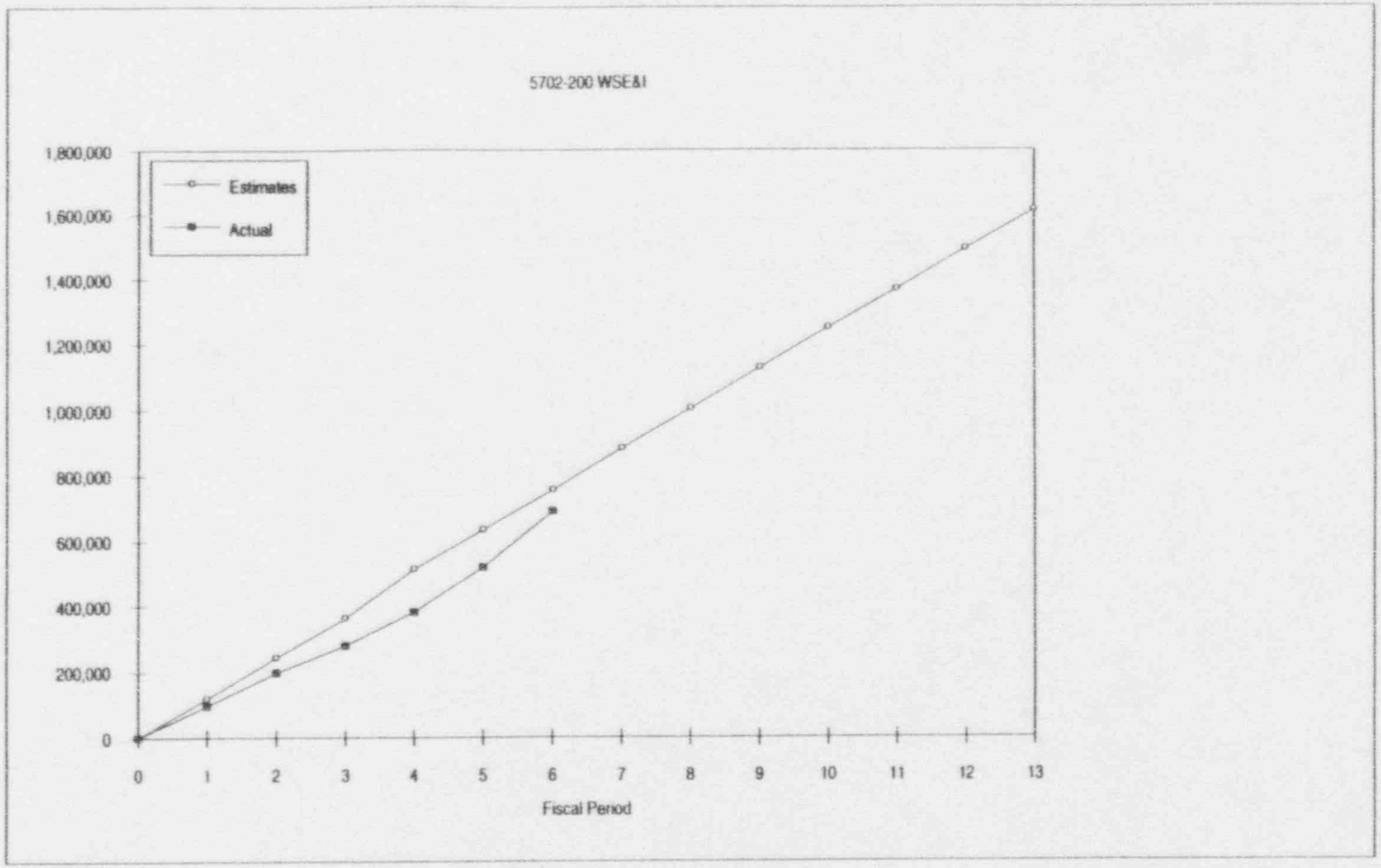
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	1,036,290	1,078,569	1,058,981	1,413,692	1,076,350	1,070,034	1,199,665	1,029,595	1,040,534	1,104,920	1,025,749	1,044,462	1,006,733	6,733,916
ACT. PERIOD COST	988,990	968,936	933,235	1,128,970	1,078,151	1,053,022	0	0	0	0	0	0	0	6,151,304
VARIANCE, $	47,300	109,633	125,746	284,722	(1,801)	17,012	0	0	0	0	0	0	0	582,612
VARIANCE, %	4.6%	10.2%	11.9%	20.1%	-0.2%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.7%
EST. FY CUMUL	1,036,290	2,114,859	3,173,840	4,587,532	5,663,882	6,733,916	7,933,581	8,963,176	10,003,710	11,108,630	12,134,379	13,178,841	14,185,574	
ACTUAL FY CUMUL	988,990	1,957,925	2,891,160	4,020,130	5,098,281	6,151,304	0	0	0	0	0	0	0	
PERCENT COMPLETE	7.0%	13.8%	20.4%	28.3%	35.9%	43.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	47,300	156,934	282,680	567,402	565,601	582,612	0	0	0	0	0	0	0	
VARIANCE, %	4.6%	7.4%	8.9%	12.4%	10.0%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



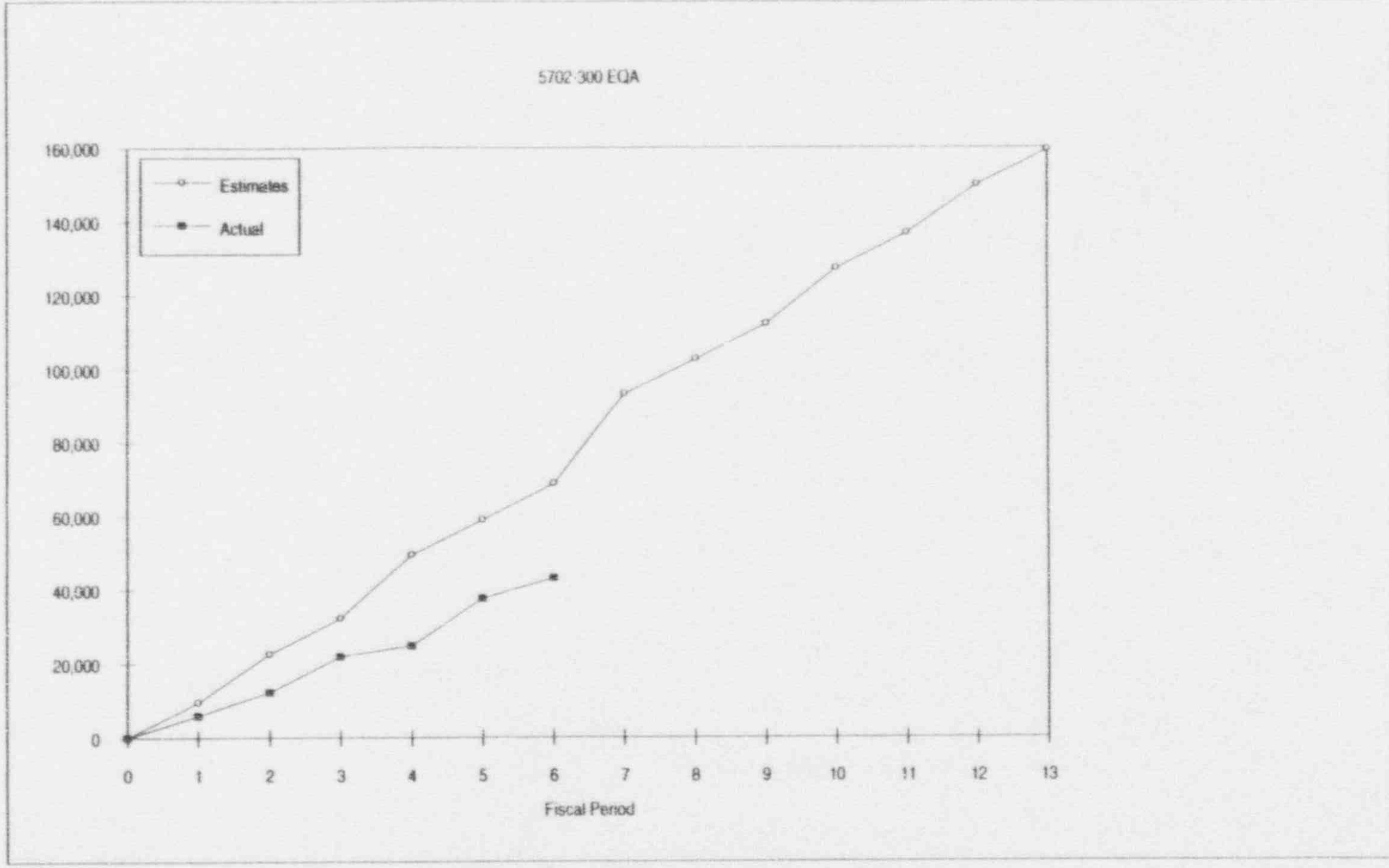
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	657,942	683,096	672,919	876,325	669,674	663,679	732,369	656,577	674,429	714,033	672,919	683,096	662,079	4,223,635
ACT. PERIOD COST	644,178	600,899	531,606	721,653	723,345	715,068	0	0	0	0	0	0	0	3,936,749
VARIANCE, $	13,764	82,197	141,313	154,672	(53,671)	(51,389)	0	0	0	0	0	0	0	286,886
VARIANCE, %	2.1%	12.0%	21.0%	17.7%	-8.0%	-7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.8%
EST. FY CUMUL	657,942	1,341,038	2,013,957	2,890,282	3,559,956	4,223,635	4,956,004	5,612,581	6,287,010	7,001,043	7,673,962	8,357,058	9,019,137	
ACTUAL FY CUMUL	644,178	1,245,077	1,776,683	2,498,336	3,221,681	3,936,749	0	0	0	0	0	0	0	
PERCENT COMPLETE	7.1%	13.8%	19.7%	27.7%	35.7%	43.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	13,764	95,981	237,274	391,946	338,275	286,886	0	0	0	0	0	0	0	
VARIANCE, %	2.1%	7.2%	11.8%	13.6%	9.5%	6.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



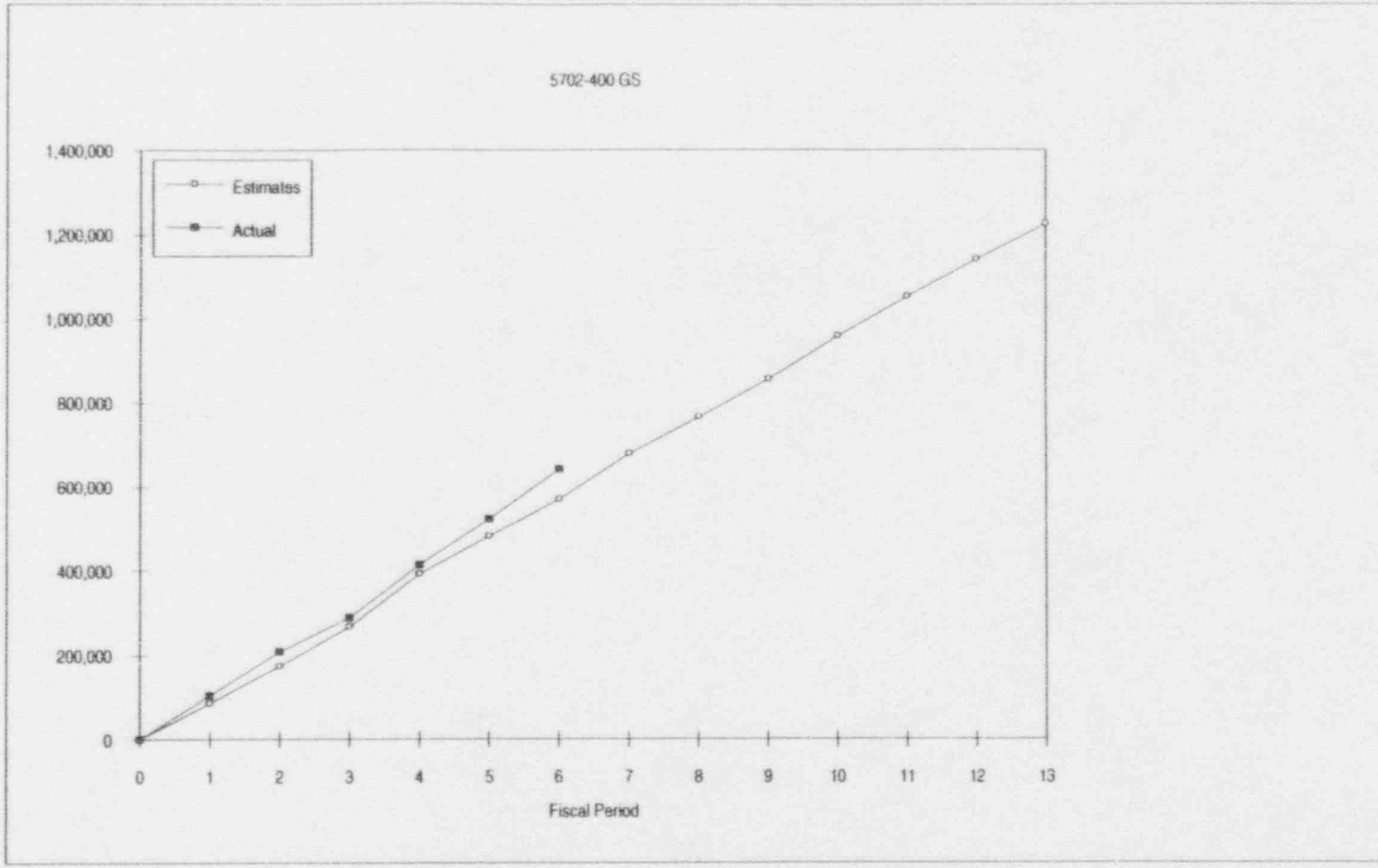
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	158,237	166,818	158,580	204,039	160,927	161,388	162,255	160,473	160,461	164,454	158,580	166,818	158,892	1,009,989
ACT. PERIOD COST	160,035	161,950	125,227	202,472	155,313	150,826	0	0	0	0	0	0	0	955,822
VARIANCE, $	(1,798)	4,868	33,353	1,567	5,614	10,562	0	0	0	0	0	0	0	54,167
VARIANCE, %	-1.1%	2.9%	21.0%	0.8%	3.5%	6.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%
EST. FY CUMUL	158,237	325,055	483,635	687,674	848,601	1,009,989	1,172,244	1,332,717	1,493,178	1,657,632	1,816,212	1,983,030	2,141,922	
ACTUAL FY CUMUL	160,035	321,985	447,211	649,683	804,996	955,822	0	0	0	0	0	0	0	
PERCENT COMPLETE	7.5%	15.0%	20.9%	30.3%	37.6%	44.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(1,798)	3,070	36,424	37,991	43,605	54,167	0	0	0	0	0	0	0	
VARIANCE, %	-1.1%	0.9%	7.5%	5.5%	5.1%	5.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



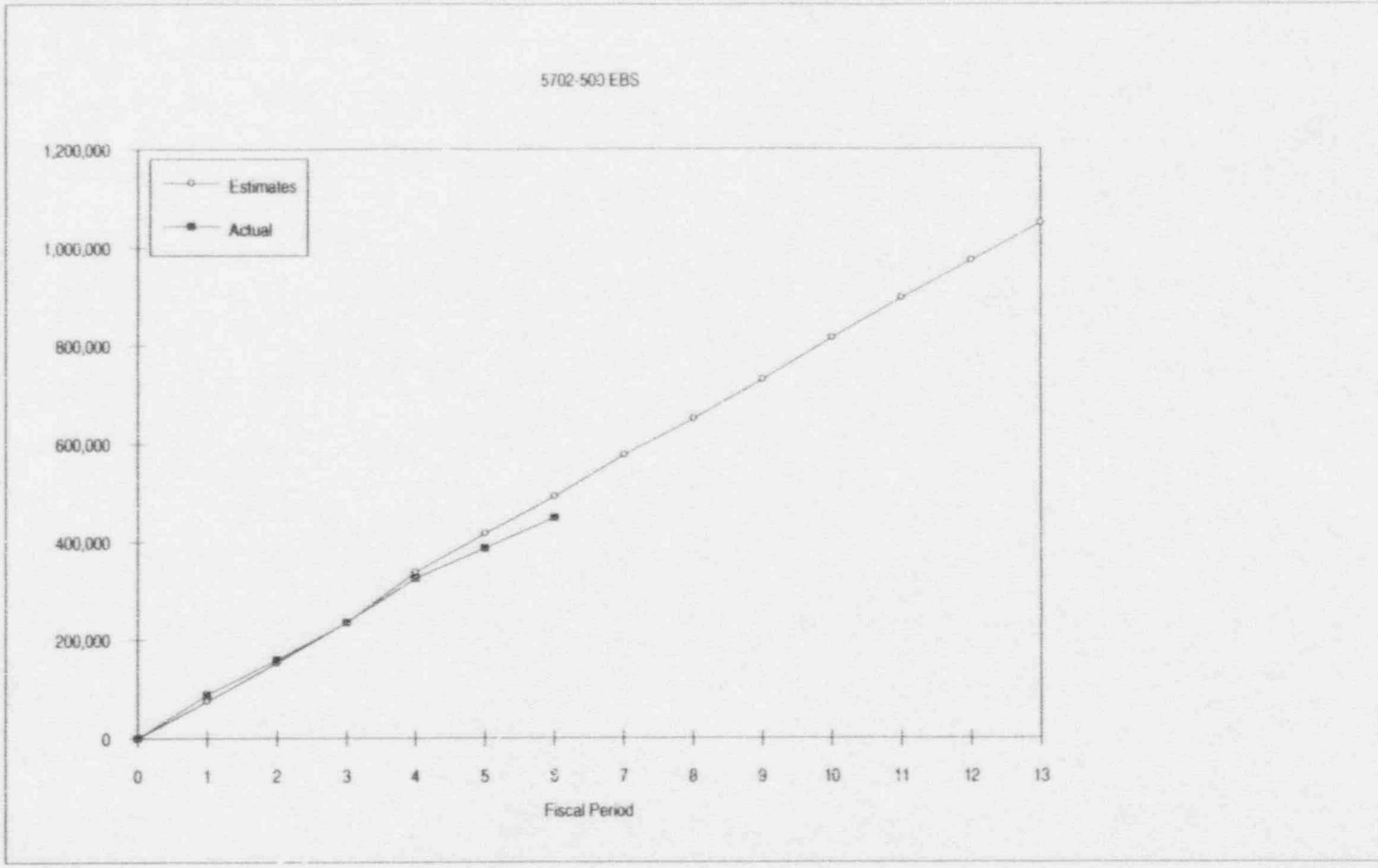
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	119,827	123,640	118,376	151,465	121,502	121,740	124,765	120,536	123,042	122,550	118,376	123,640	120,551	756,550
ACT. PERIOD COST	98,078	98,795	83,026	102,918	135,074	173,506	0	0	0	0	0	0	0	691,397
VARIANCE, $	21,749	24,845	35,350	48,547	(13,572)	(51,766)	0	0	0	0	0	0	0	65,153
VARIANCE, %	18.1%	20.1%	29.9%	32.1%	-11.2%	-42.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.6%
EST. FY CUMUL	119,827	243,467	361,843	513,308	634,810	756,550	881,315	1,001,851	1,124,893	1,247,443	1,365,819	1,489,459	1,610,010	
ACTUAL FY CUMUL	98,078	196,874	279,900	382,818	517,891	691,397	0	0	0	0	0	0	0	
PERCENT COMPLETE	6.1%	12.2%	17.4%	23.8%	32.2%	42.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	21,749	46,593	81,943	130,490	116,919	65,153	0	0	0	0	0	0	0	
VARIANCE, %	18.1%	19.1%	22.6%	25.4%	18.4%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



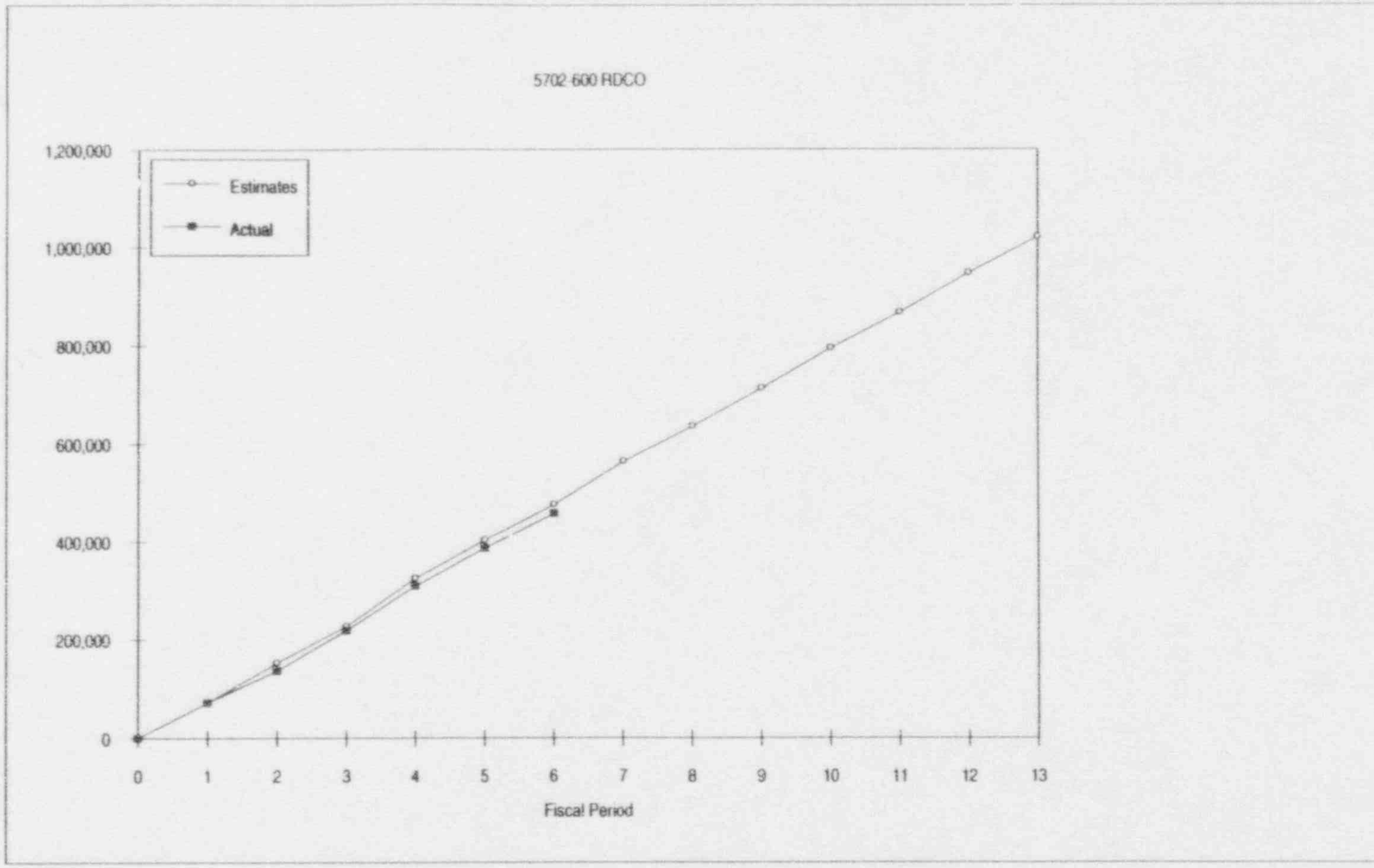
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	9,472	13,130	9,619	17,387	9,419	9,745	24,398	9,543	9,395	15,020	9,619	13,130	9,543	68,772
ACT. PERIOD COST	5,931	6,296	9,795	3,003	12,542	5,524	0	0	0	0	0	0	0	43,091
VARIANCE, $	3,541	6,834	(176)	14,384	(3,123)	4,221	0	0	0	0	0	0	0	25,681
VARIANCE, %	37.4%	52.0%	-1.8%	82.7%	-33.2%	43.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	37.3%
EST. FY CUMUL	9,472	22,602	32,221	49,608	59,027	68,772	93,170	102,713	112,108	127,128	136,747	149,877	159,420	
ACTUAL FY CUMUL	5,931	12,227	22,022	25,025	37,567	43,091	0	0	0	0	0	0	0	
PERCENT COMPLETE	3.7%	7.7%	13.8%	15.7%	23.6%	27.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	3,541	10,375	10,199	24,583	21,460	25,681	0	0	0	0	0	0	0	
VARIANCE, %	37.4%	45.9%	31.7%	49.6%	36.4%	37.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



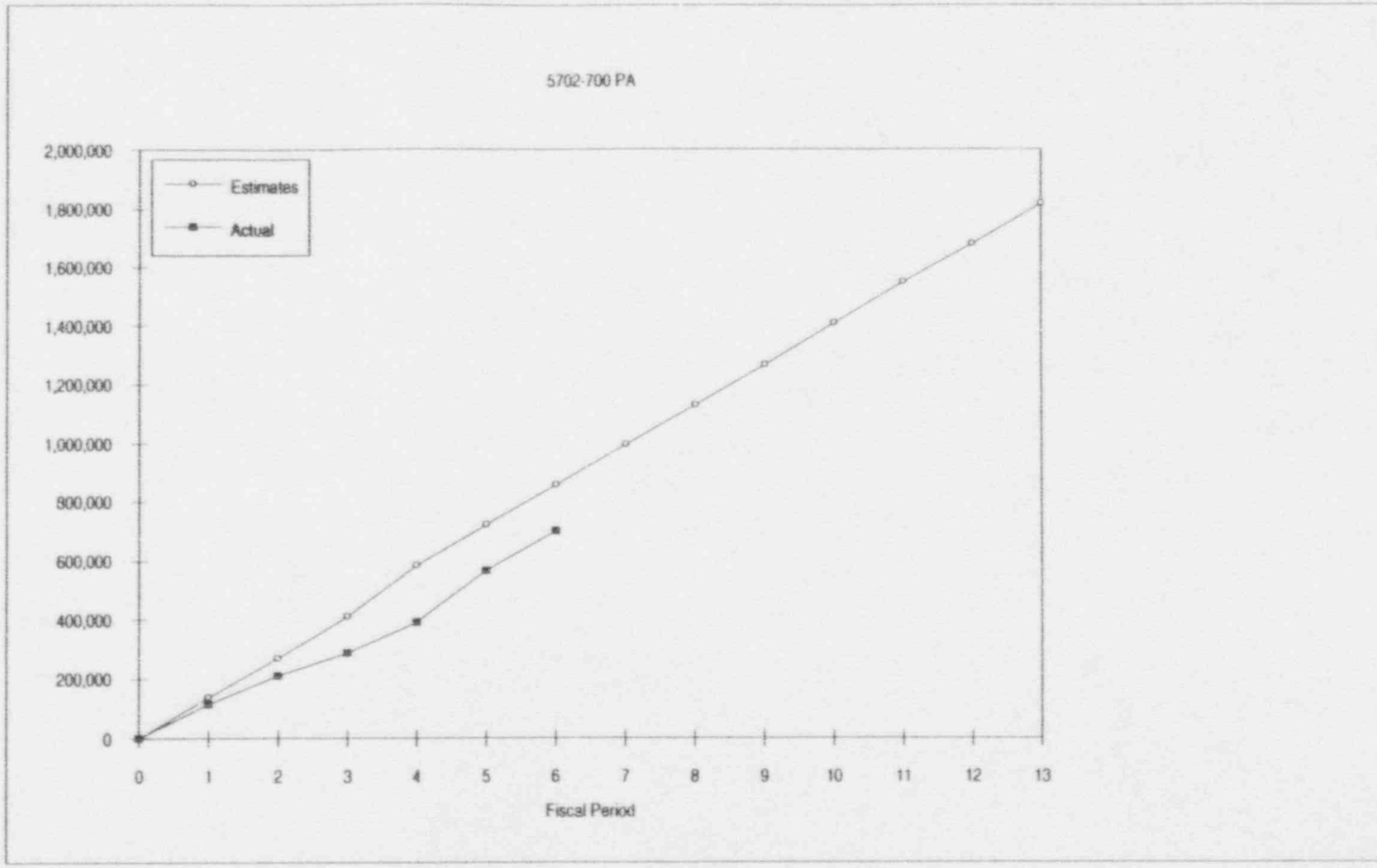
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	85,199	89,533	91,769	124,740	88,111	88,442	110,505	85,654	89,510	103,095	91,769	89,533	86,270	567,794
ACT. PERIOD COST	103,969	104,642	78,620	126,025	107,488	120,307	0	0	0	0	0	0	0	641,052
VARIANCE, $	(18,770)	(15,109)	13,149	(1,285)	(19,377)	(31,865)	0	0	0	0	0	0	0	(73,258)
VARIANCE, %	-22.0%	-16.9%	14.3%	-1.0%	-22.0%	-36.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-12.9%
EST. FY CUMUL	85,199	174,732	266,501	391,241	479,352	567,794	678,299	763,953	853,463	956,558	1,048,327	1,137,860	1,224,130	
ACTUAL FY CUMUL	103,969	208,611	287,232	413,257	520,745	641,052	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.5%	17.0%	23.5%	33.8%	42.5%	52.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(18,770)	(33,879)	(20,731)	(22,016)	(41,393)	(73,258)	0	0	0	0	0	0	0	
VARIANCE, %	-22.0%	-19.4%	-7.8%	-5.6%	-8.6%	-12.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



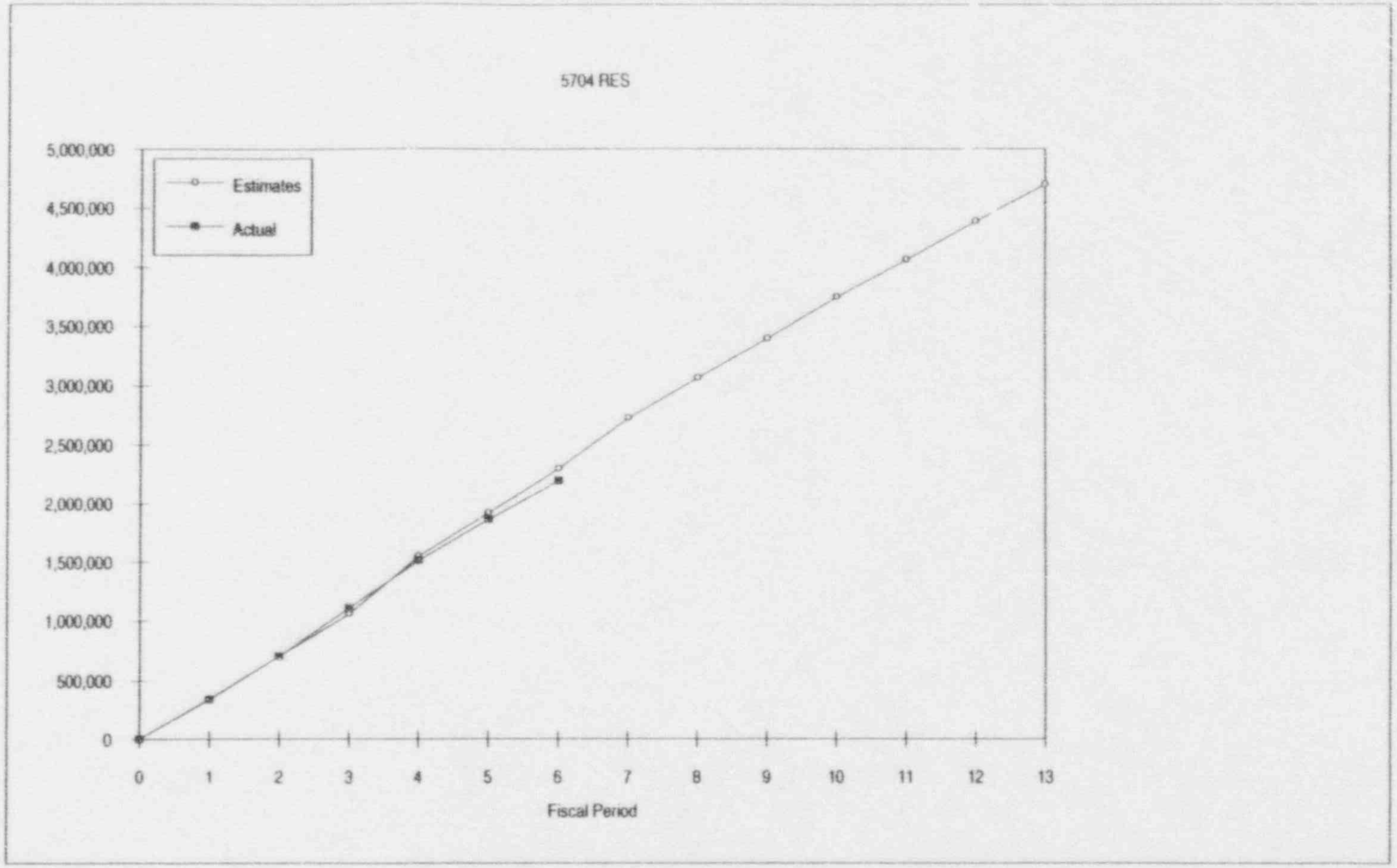
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	76,356	76,588	81,729	103,641	77,970	75,207	84,037	74,775	79,096	84,670	81,729	76,588	76,675	491,491
ACT. PERIOD COST	89,924	68,848	76,194	90,429	62,146	61,174	0	0	0	0	0	0	0	448,716
VARIANCE, $	(13,568)	7,740	5,535	13,212	15,824	14,033	0	0	0	0	0	0	0	42,775
VARIANCE, %	-17.8%	10.1%	6.8%	12.7%	20.3%	18.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.7%
EST. FY CUMUL	76,356	152,944	234,673	338,314	416,284	491,491	575,528	650,303	729,399	814,069	895,798	972,386	1,049,061	
ACTUAL FY CUMUL	89,924	158,773	234,967	325,396	387,542	448,716	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.6%	15.1%	22.4%	31.0%	36.9%	42.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(13,568)	(5,829)	(294)	12,918	28,742	42,775	0	0	0	0	0	0	0	
VARIANCE, %	-17.8%	-3.8%	-0.1%	3.8%	6.9%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



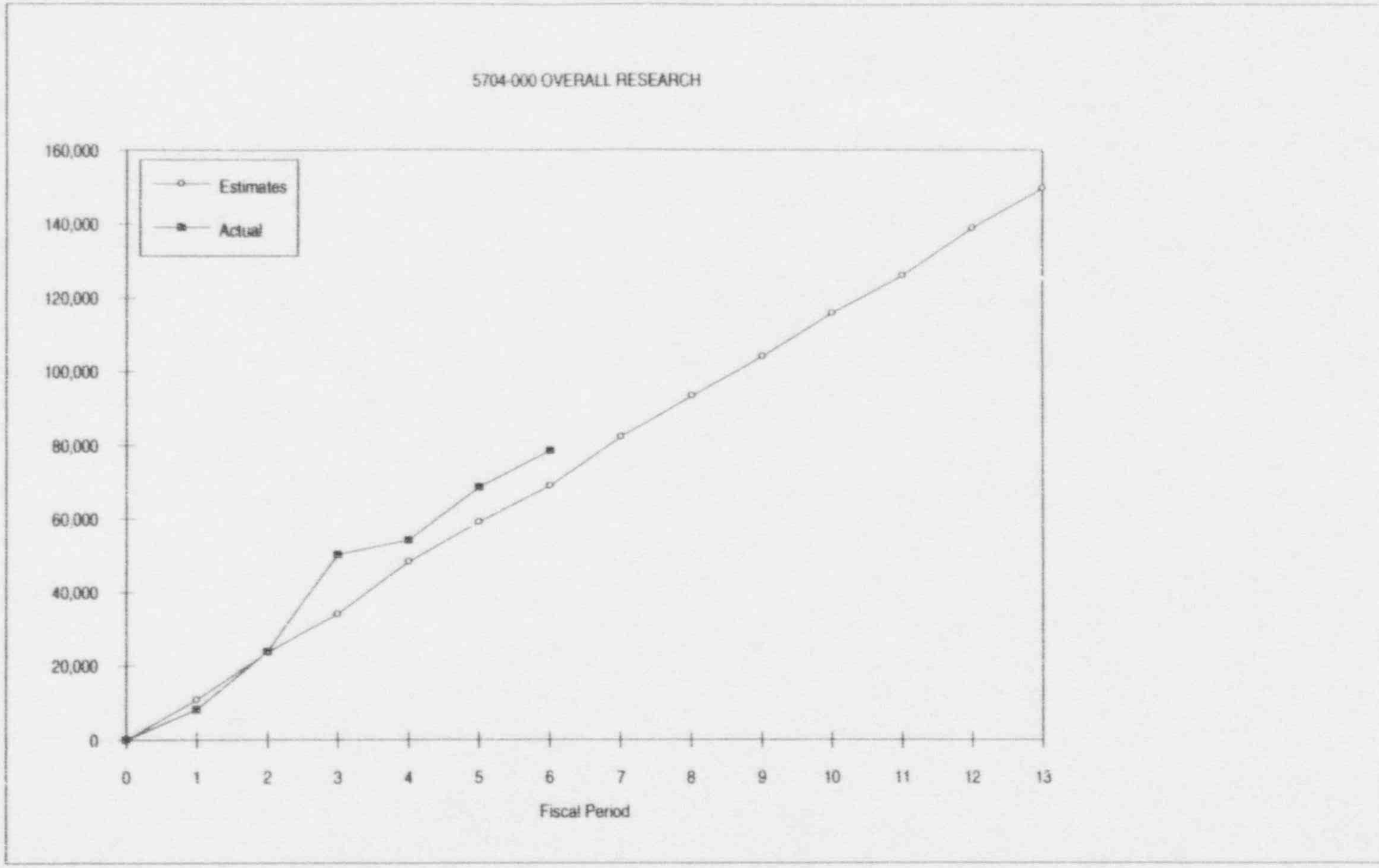
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	72,727	80,430	73,222	99,846	76,147	72,059	88,761	71,569	77,020	81,329	73,222	80,430	73,060	474,431
ACT. PERIOD COST	72,067	64,548	81,312	92,428	76,019	69,791	0	0	0	0	0	0	0	456,165
VARIANCE, $	660	15,882	(8,090)	7,418	128	2,268	0	0	0	0	0	0	0	18,266
VARIANCE, %	0.9%	19.7%	-11.0%	7.4%	0.2%	3.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.9%
EST. FY CUMUL	72,727	153,157	226,379	326,225	402,372	474,431	563,192	634,761	711,781	793,110	866,332	946,762	1,019,822	
ACTUAL FY CUMUL	72,067	136,615	217,927	310,355	386,374	456,165	0	0	0	0	0	0	0	
PERCENT COMPLETE	7.1%	13.4%	21.4%	30.4%	37.9%	44.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	660	16,542	8,452	15,870	15,998	18,266	0	0	0	0	0	0	0	
VARIANCE, %	0.9%	10.8%	3.7%	4.9%	4.0%	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



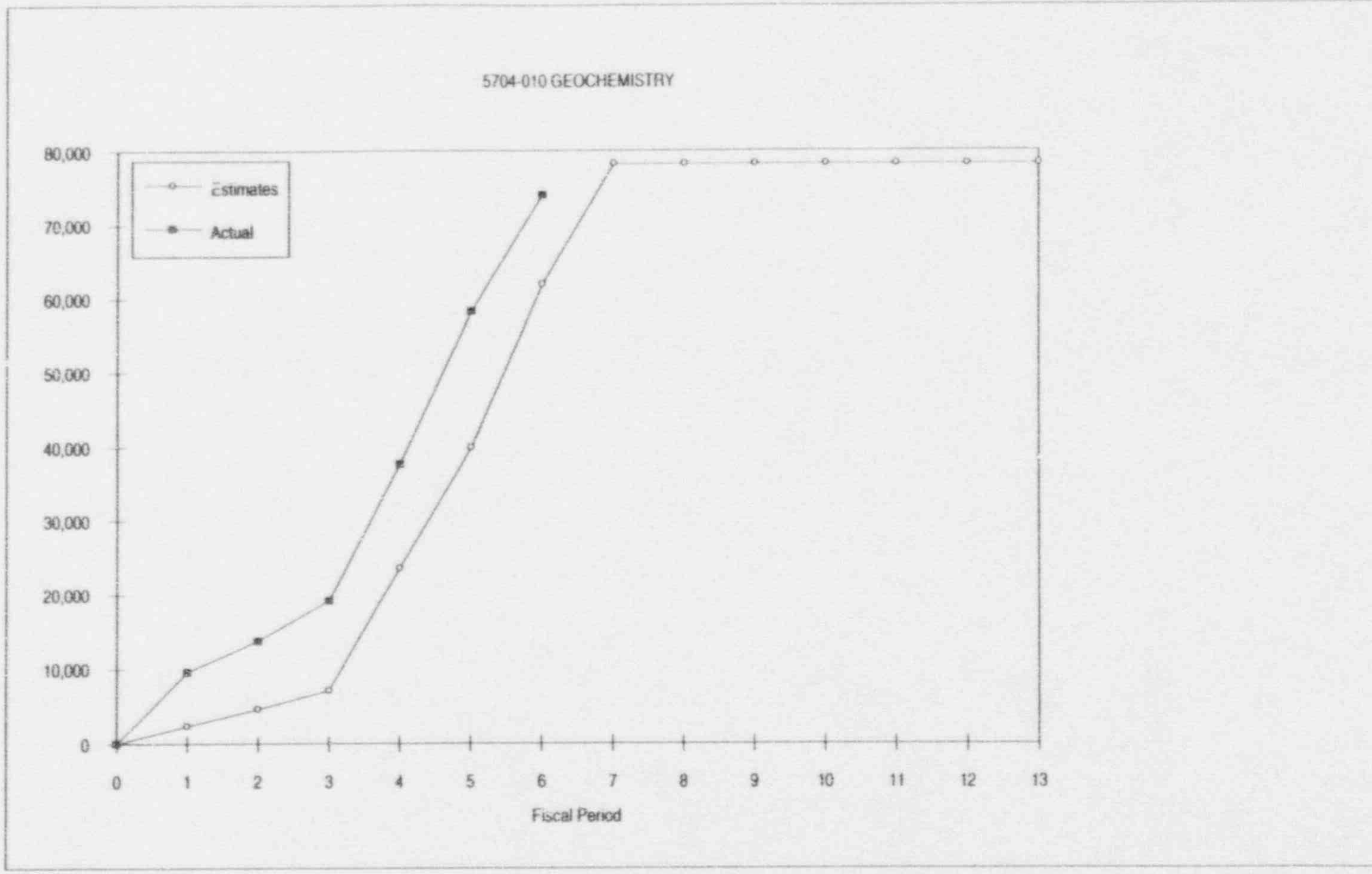
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	136,124	132,957	139,624	175,207	135,598	135,098	137,648	134,027	135,905	142,915	139,624	132,957	137,088	854,608
ACT. PERIOD COST	114,173	95,819	77,432	104,378	174,763	133,941	0	0	0	0	0	0	0	700,505
VARIANCE, $	21,951	37,138	62,192	70,829	(39,165)	1,157	0	0	0	0	0	0	0	154,103
VARIANCE, %	16.1%	27.9%	44.5%	40.4%	-28.9%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18.0%
EST. FY CUMUL	136,124	269,081	408,705	583,912	719,510	854,608	992,256	1,126,283	1,262,188	1,405,103	1,544,727	1,677,684	1,814,772	
ACTUAL FY CUMUL	114,173	209,992	287,424	391,802	566,565	700,505	0	0	0	0	0	0	0	
PERCENT COMPLETE	6.3%	11.6%	15.8%	21.6%	31.2%	38.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	21,951	59,089	121,281	192,110	152,945	154,103	0	0	0	0	0	0	0	
VARIANCE, %	16.1%	22.0%	29.7%	32.9%	21.3%	18.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



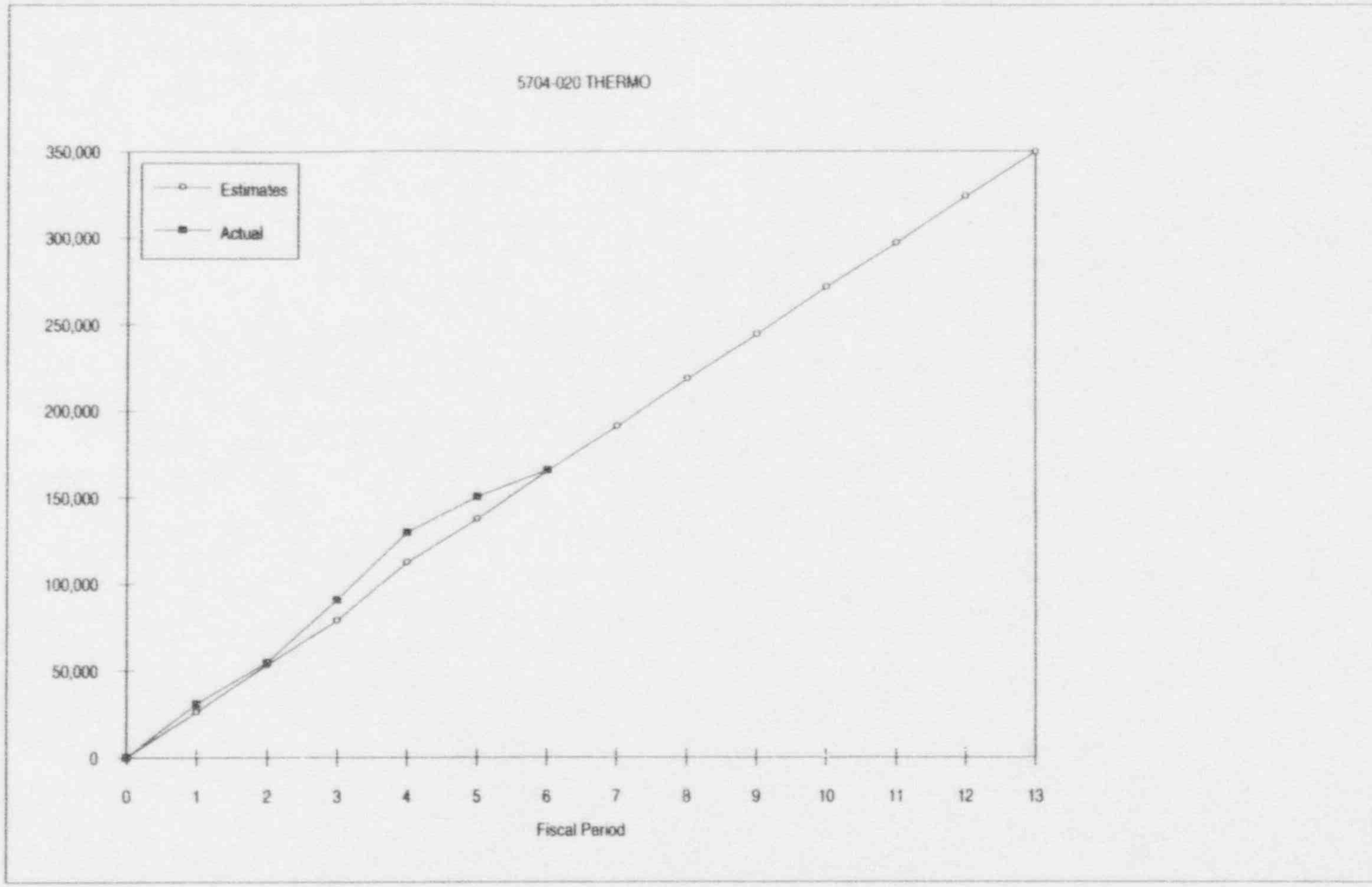
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	345,035	360,635	350,761	489,525	371,772	373,801	426,362	341,618	329,843	351,895	317,529	326,528	311,226	2,291,529
ACT. PERIOD COST	342,323	364,760	399,889	404,182	350,424	330,940	0	0	0	0	0	0	0	2,192,518
VARIANCE, $	2,712	(4,125)	(49,128)	85,343	21,348	42,861	0	0	0	0	0	0	0	99,011
VARIANCE, %	0.8%	-1.1%	-14.0%	17.4%	5.7%	11.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%
EST. FY CUMUL	345,035	705,670	1,056,431	1,545,956	1,917,728	2,291,529	2,717,891	3,059,509	3,389,352	3,741,247	4,058,776	4,385,304	4,696,530	
ACTUAL FY CUMUL	342,323	707,083	1,106,972	1,511,154	1,861,578	2,192,518	0	0	0	0	0	0	0	
PERCENT COMPLETE	7.3%	15.1%	23.6%	32.2%	39.6%	46.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	2,712	(1,413)	(50,541)	34,802	56,150	99,011	0	0	0	0	0	0	0	
VARIANCE, %	0.8%	-0.2%	-4.8%	2.3%	2.9%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



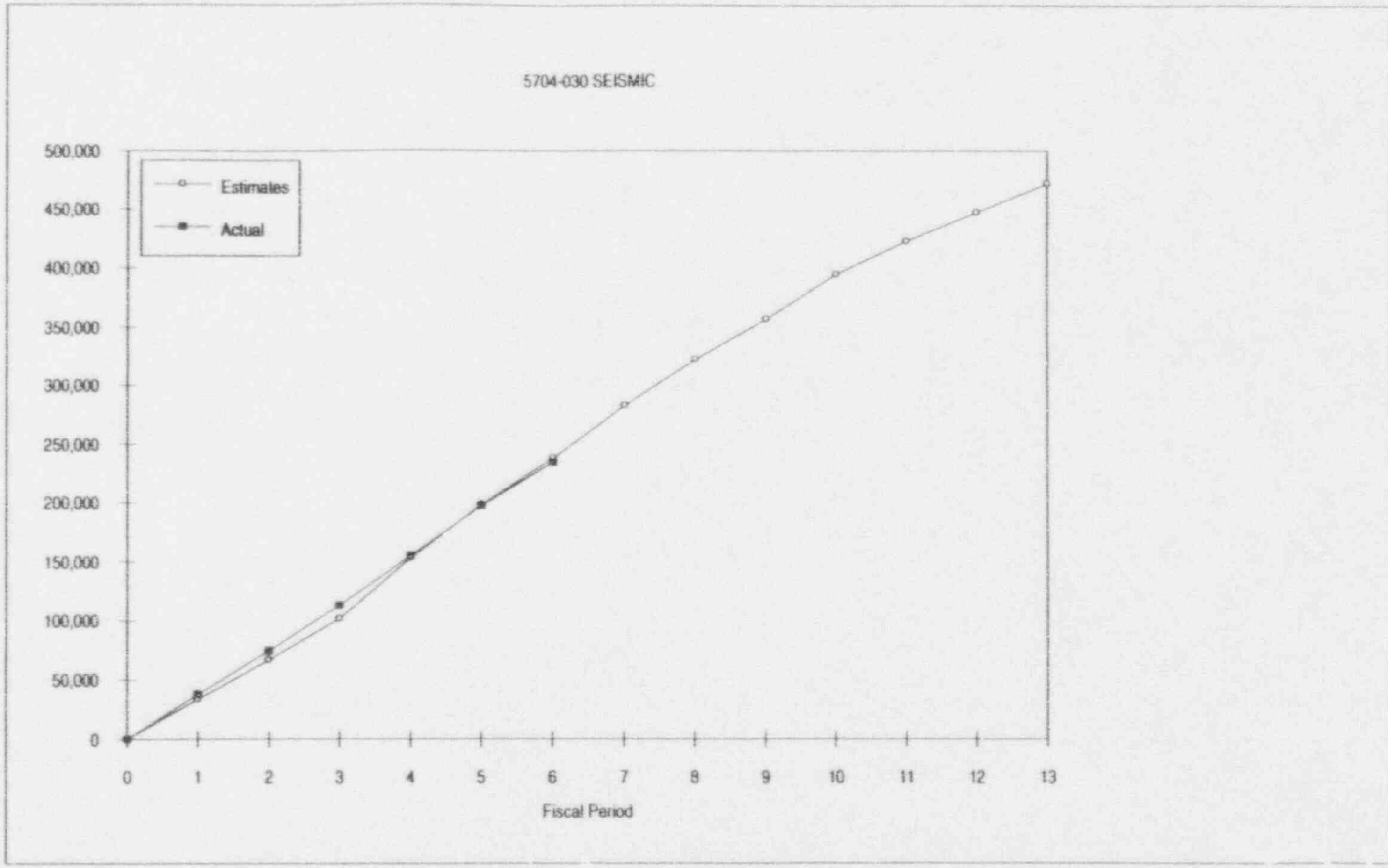
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	10,705	12,830	10,214	14,593	10,754	9,785	13,300	10,935	10,778	11,680	10,214	12,830	10,802	68,881
ACT. PERIOD COST	8,084	15,638	26,636	3,894	14,289	9,817	0	0	0	0	0	0	0	78,358
VARIANCE, $	2,621	(2,808)	(16,422)	10,699	(3,535)	(32)	0	0	0	0	0	0	0	(9,477)
VARIANCE, %	24.5%	-21.9%	-160.8%	73.3%	-32.9%	-0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-13.8%
EST. FY CUMUL	10,705	23,535	33,749	48,342	59,096	68,881	82,181	93,116	103,894	115,574	125,788	138,618	149,420	
ACTUAL FY CUMUL	8,084	23,721	50,357	54,252	68,541	78,358	0	0	0	0	0	0	0	
PERCENT COMPLETE	5.4%	15.9%	33.7%	36.3%	45.9%	52.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	2,621	(186)	(16,608)	(5,910)	(9,445)	(9,477)	0	0	0	0	0	0	0	
VARIANCE, %	24.5%	-0.8%	-49.2%	-12.2%	-16.0%	-13.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



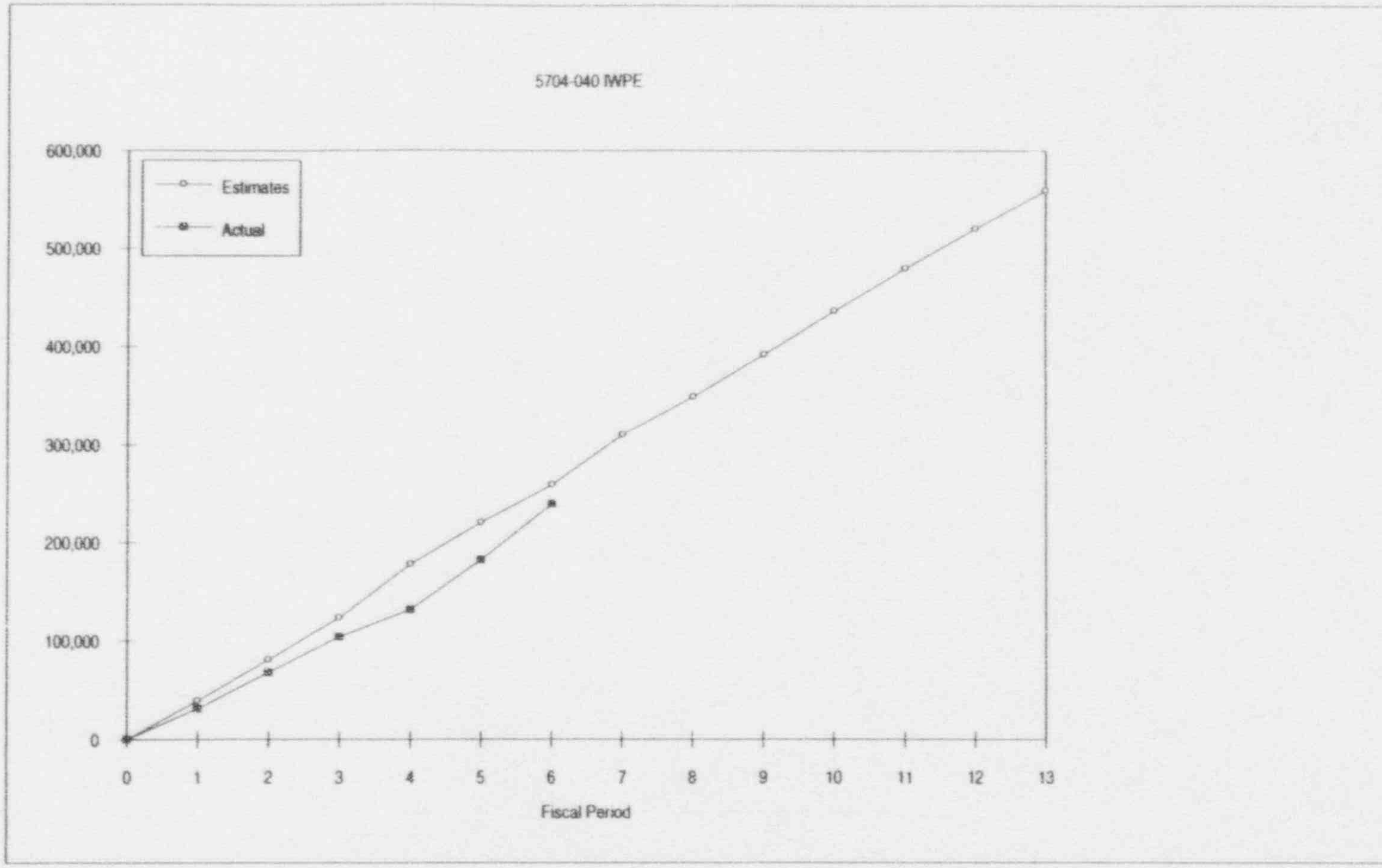
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	2,381	2,292	2,502	16,354	16,354	21,997	16,343	0	0	0	0	0	0	61,880
ACT. PERIOD COST	9,570	4,153	5,451	18,497	20,566	15,808	0	0	0	0	0	0	0	74,045
VARIANCE, $	(7,189)	(1,861)	(2,949)	(2,143)	(4,212)	6,189	0	0	0	0	0	0	0	(12,165)
VARIANCE, %	-301.9%	-81.2%	-117.9%	-13.1%	-25.8%	28.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-19.7%
EST. FY CUMUL	2,381	4,673	7,175	23,529	39,883	61,880	78,223	78,223	78,223	78,223	78,223	78,223	78,223	
ACTUAL FY CUMUL	9,570	13,723	19,174	37,671	58,238	74,045	0	0	0	0	0	0	0	
PERCENT COMPLETE	12.2%	17.5%	24.5%	48.2%	74.5%	94.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(7,189)	(9,050)	(11,999)	(14,142)	(18,355)	(12,165)	0	0	0	0	0	0	0	
VARIANCE, %	-301.9%	-193.7%	-167.2%	-60.1%	-46.0%	-19.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



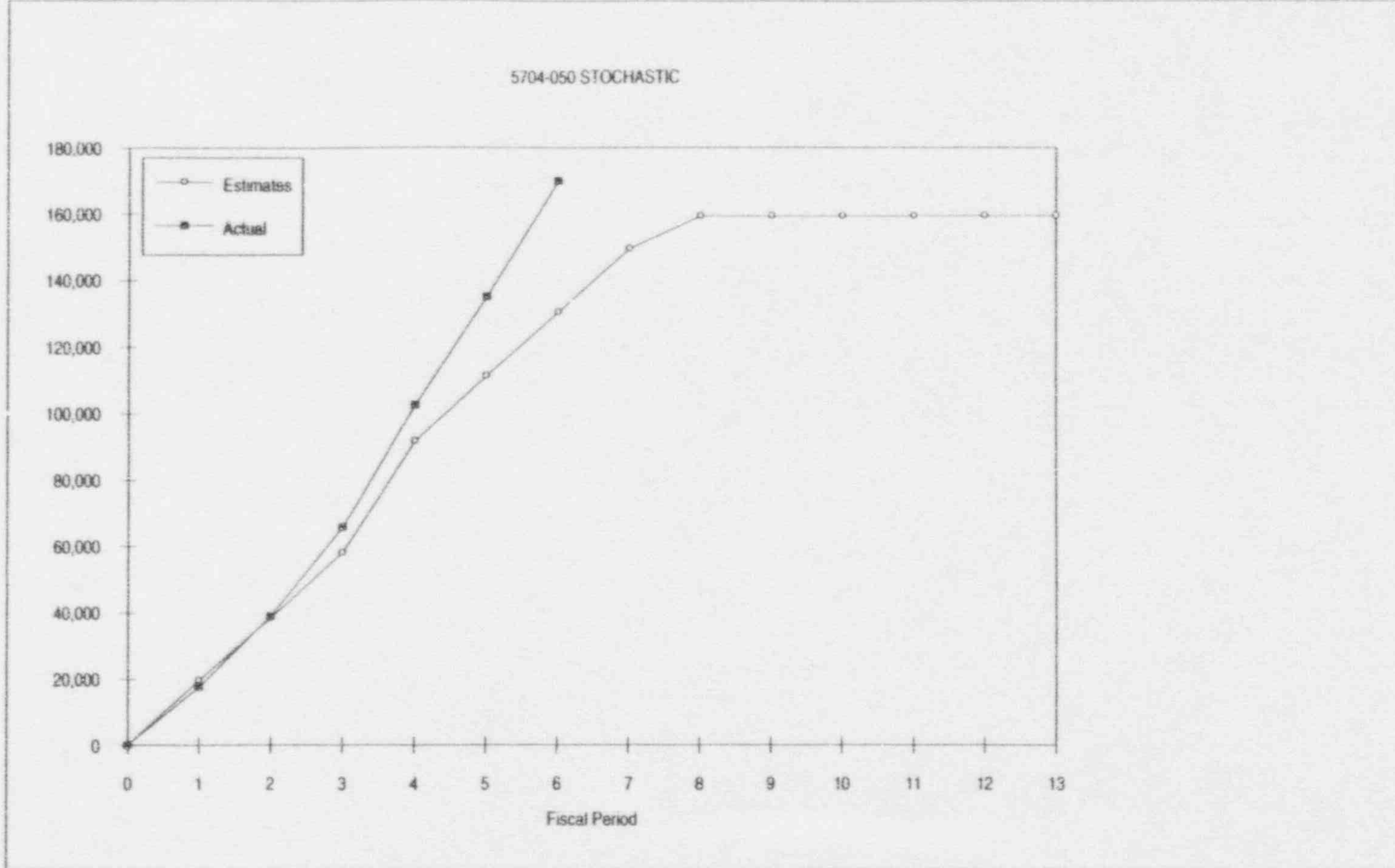
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	25,828	27,200	25,454	33,994	24,997	27,909	25,142	27,512	25,543	27,507	25,454	27,200	25,688	165,382
ACT. PERIOD COST	30,464	24,159	35,990	39,219	20,617	15,183	0	0	0	0	0	0	0	165,632
VARIANCE, $	(4,636)	3,041	(10,536)	(5,225)	4,380	12,726	0	0	0	0	0	0	0	(250)
VARIANCE, %	-18.0%	11.2%	-41.4%	-15.4%	17.5%	45.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%
EST. FY CUMUL	25,828	53,028	78,482	112,476	137,473	165,382	190,524	218,036	243,579	271,086	296,540	323,740	349,428	
ACTUAL FY CUMUL	30,464	54,623	90,613	129,832	150,449	165,632	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.7%	15.6%	25.9%	37.2%	43.1%	47.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(4,636)	(1,595)	(12,131)	(17,356)	(12,976)	(250)	0	0	0	0	0	0	0	
VARIANCE, %	-18.0%	-3.0%	-15.5%	-15.4%	-9.4%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



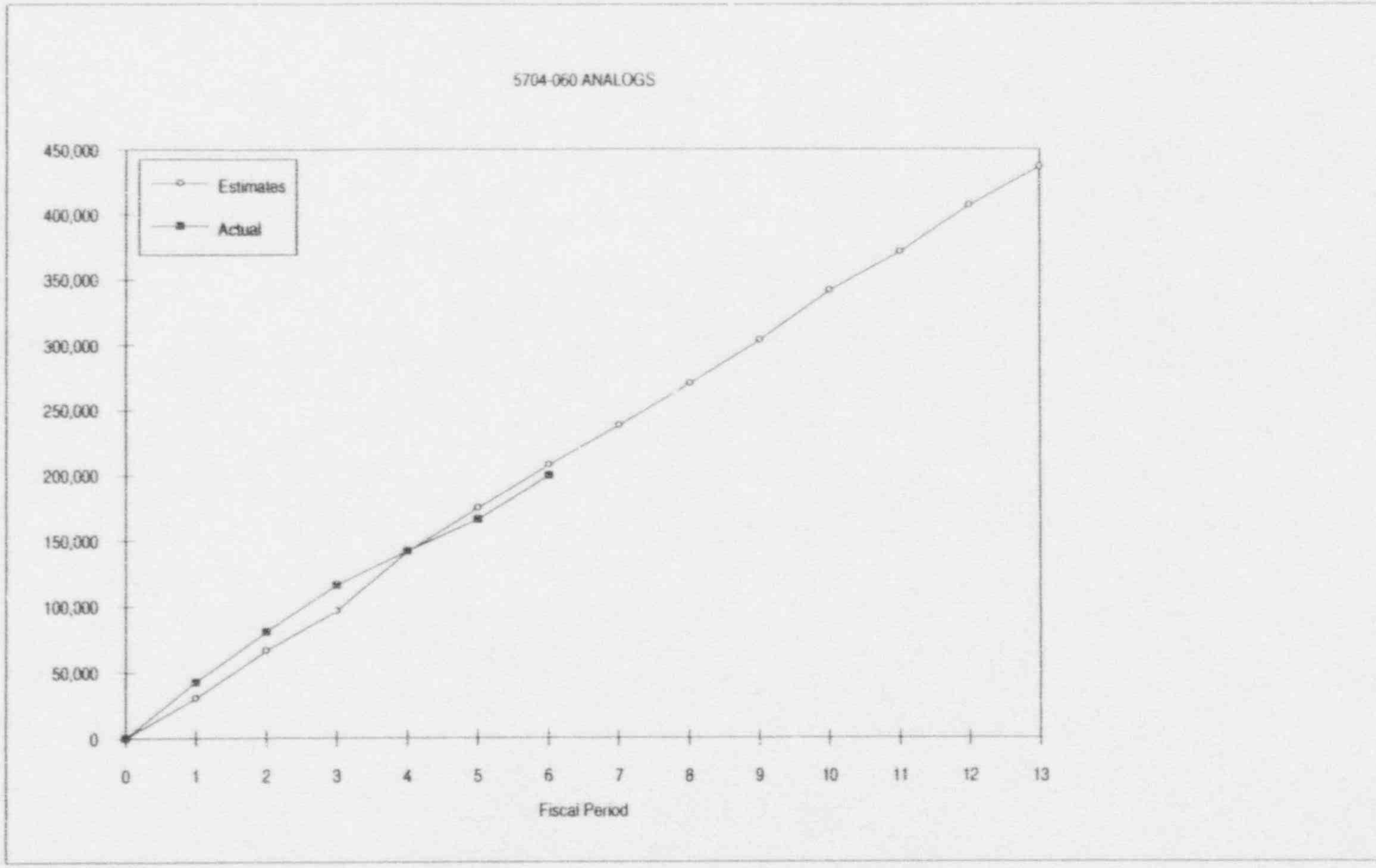
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	33,620	33,071	34,673	51,576	45,221	39,222	45,223	39,024	34,812	37,974	27,879	24,375	24,774	237,383
ACT. PERIOD COST	37,662	36,655	38,201	42,511	42,271	36,476	0	0	0	0	0	0	0	233,776
VARIANCE, $	(4,042)	(3,584)	(3,528)	9,065	2,950	2,746	0	0	0	0	0	0	0	3,607
VARIANCE, %	-12.0%	-10.8%	-10.2%	17.6%	6.5%	7.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%
EST. FY CUMUL	33,620	66,691	101,364	152,940	198,161	237,383	282,606	321,630	356,442	394,416	422,295	446,670	471,444	
ACTUAL FY CUMUL	37,662	74,317	112,518	155,028	197,299	233,776	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.0%	15.8%	23.9%	32.9%	41.8%	49.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(4,042)	(7,626)	(11,154)	(2,088)	862	3,607	0	0	0	0	0	0	0	
VARIANCE, %	-12.0%	-11.4%	-11.0%	-1.4%	0.4%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



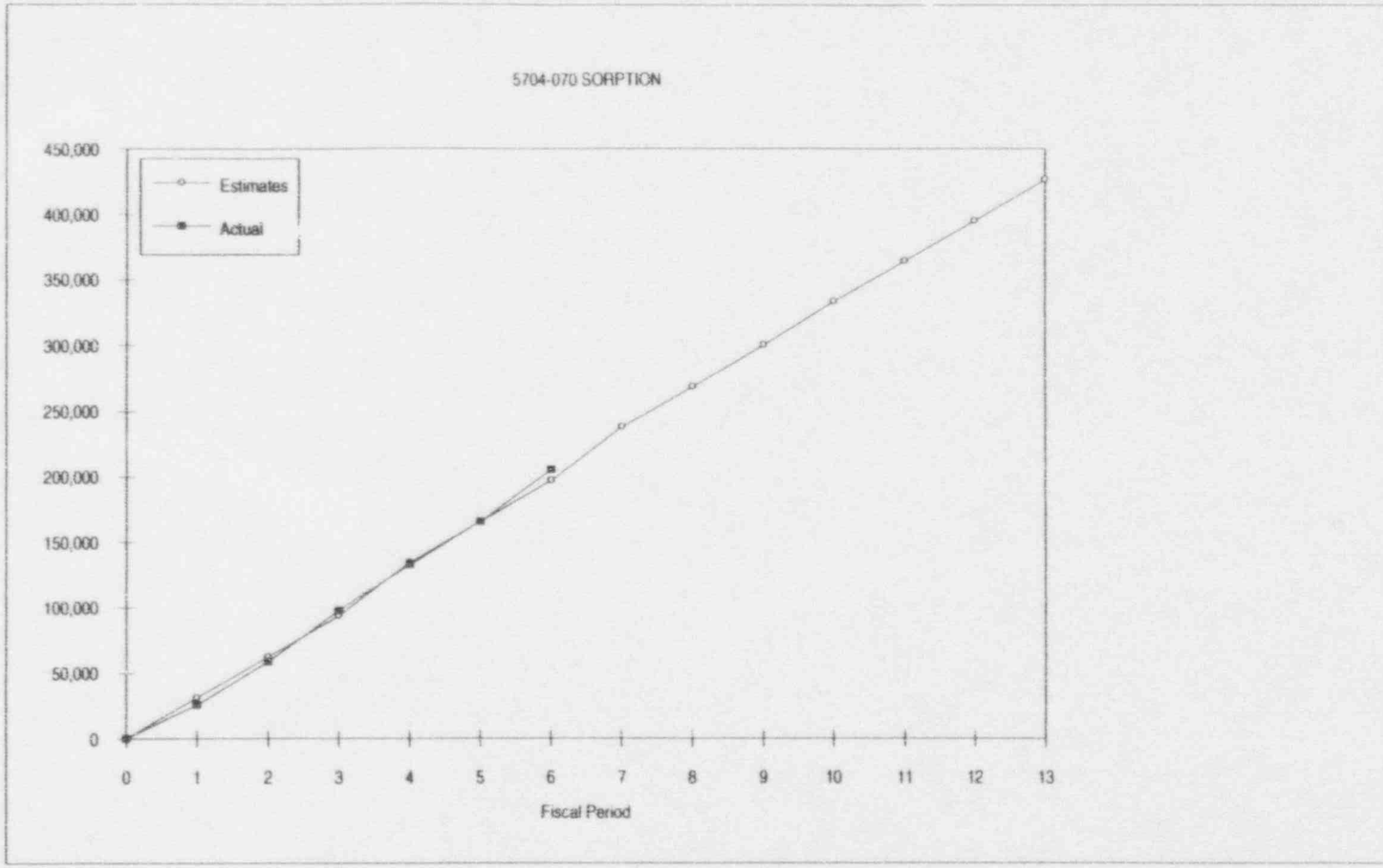
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	39,126	41,310	43,232	54,736	41,652	38,840	50,842	38,848	42,487	44,300	43,232	41,310	39,257	258,896
ACT. PERIOD COST	31,353	36,368	35,843	28,347	50,692	56,819	0	0	0	0	0	0	0	239,422
VARIANCE, $	7,773	4,942	7,389	26,389	(9,040)	(17,979)	0	0	0	0	0	0	0	19,474
VARIANCE, %	19.9%	12.0%	17.1%	48.2%	-21.7%	-46.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.5%
EST. FY CUMUL	39,126	80,436	123,668	178,404	220,056	258,896	309,738	348,586	391,073	435,373	478,605	519,915	559,172	
ACTUAL FY CUMUL	31,353	67,721	103,564	131,911	182,603	239,422	0	0	0	0	0	0	0	
PERCENT COMPLETE	5.6%	12.1%	18.5%	23.6%	32.7%	42.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	7,773	12,715	20,104	46,493	37,453	19,474	0	0	0	0	0	0	0	
VARIANCE, %	19.9%	15.8%	16.3%	26.1%	17.0%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



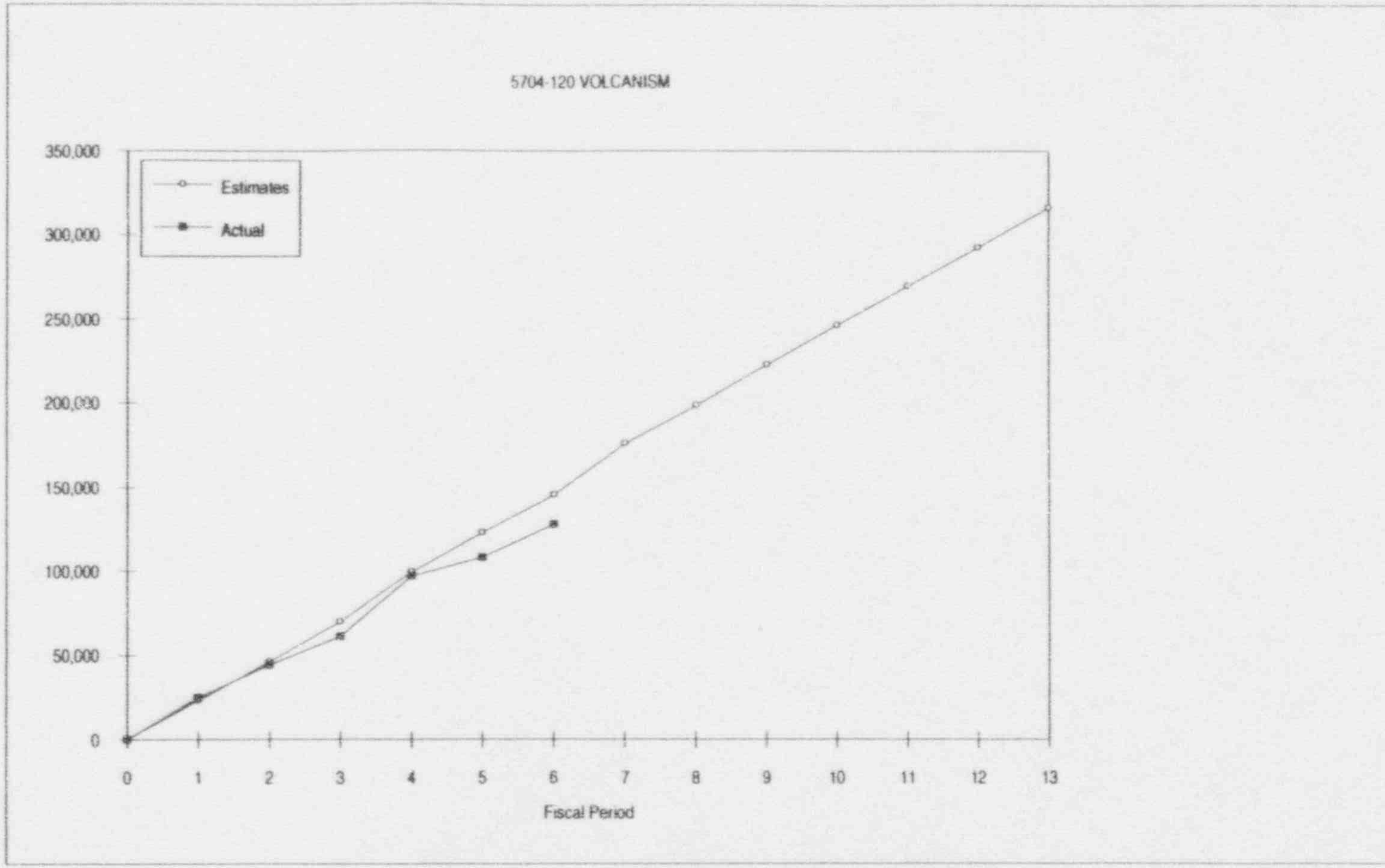
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	19,575	18,792	19,609	33,801	19,404	19,049	19,316	9,823	0	0	0	0	0	130,230
ACT. PERIOD COST	17,707	21,171	26,806	36,731	32,646	34,990	0	0	0	0	0	0	0	170,052
VARIANCE, $	1,868	(2,379)	(7,197)	(2,930)	(13,242)	(15,941)	0	0	0	0	0	0	0	(39,822)
VARIANCE, %	9.5%	-12.7%	-36.7%	-8.7%	-68.2%	-83.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-30.6%
EST. FY CUMUL	19,575	38,367	57,976	91,777	111,181	130,230	149,546	159,369	159,369	159,369	159,369	159,369	159,369	
ACTUAL FY CUMUL	17,707	38,878	65,684	102,415	135,062	170,052	0	0	0	0	0	0	0	
PERCENT COMPLETE	11.1%	24.4%	41.2%	64.3%	84.7%	106.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	1,868	(511)	(7,708)	(10,638)	(23,881)	(39,822)	0	0	0	0	0	0	0	
VARIANCE, %	9.5%	-1.3%	-13.3%	-11.6%	-21.5%	-30.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



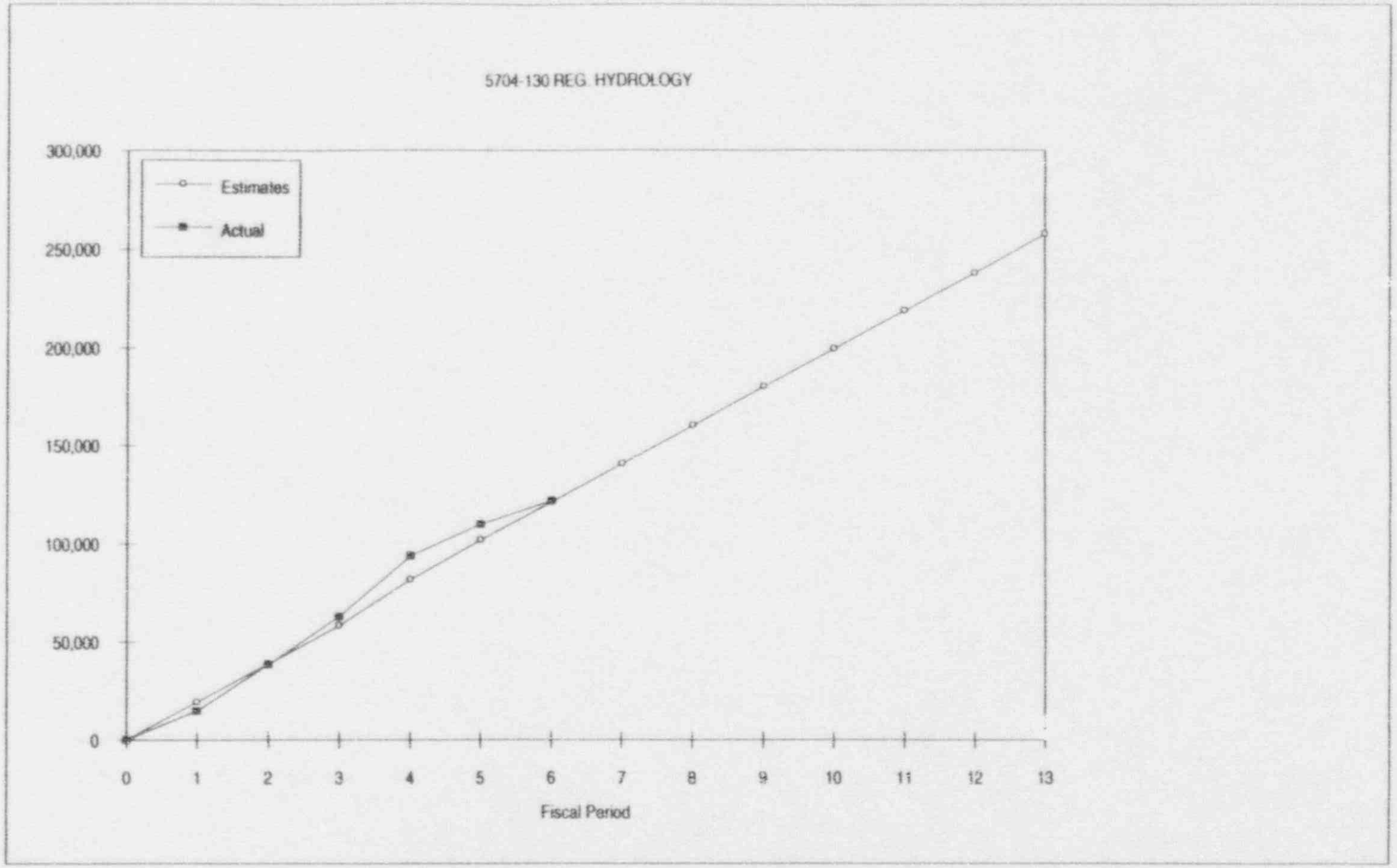
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	30,461	35,818	29,787	45,607	33,067	32,420	30,090	32,352	33,199	38,045	29,787	35,818	29,926	207,160
ACT. PERIOD COST	42,564	37,938	35,406	25,782	24,303	33,431	0	0	0	0	0	0	0	199,424
VARIANCE, $	(12,103)	(2,120)	(5,619)	19,825	8,764	(1,011)	0	0	0	0	0	0	0	7,736
VARIANCE, %	-39.7%	-5.9%	-18.9%	43.5%	26.5%	-3.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.7%
EST. FY CUMUL	30,461	66,279	96,066	141,673	174,740	207,160	237,250	269,602	302,801	340,846	370,633	406,451	436,377	
ACTUAL FY CUMUL	42,564	80,502	115,908	141,690	165,992	199,424	0	0	0	0	0	0	0	
PERCENT COMPLETE	9.8%	18.4%	26.6%	32.5%	38.0%	45.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(12,103)	(14,223)	(19,842)	(17)	8,748	7,736	0	0	0	0	0	0	0	
VARIANCE, %	-39.7%	-21.5%	-20.7%	0.0%	5.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



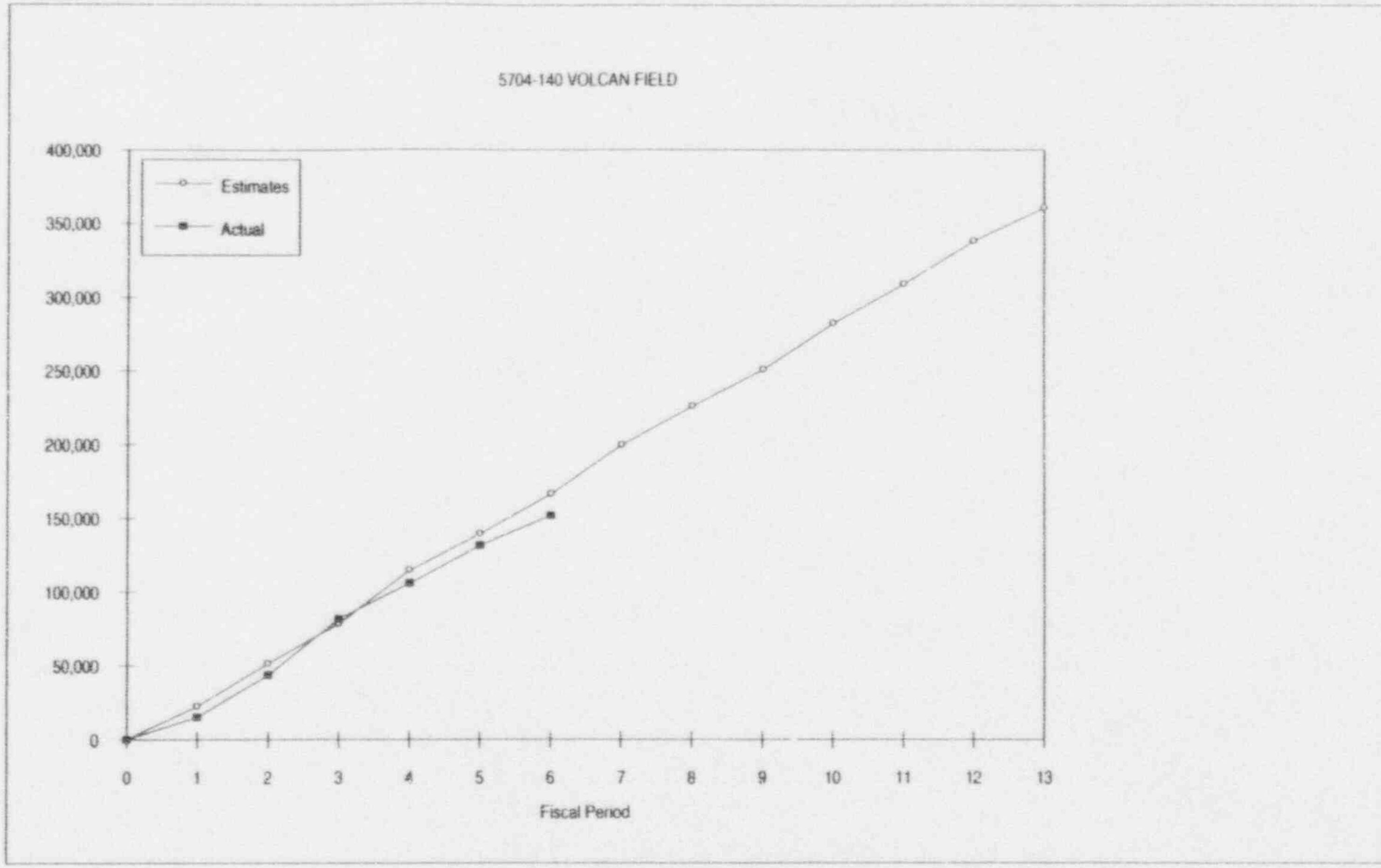
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	31,291	31,043	31,271	41,047	30,992	31,141	40,497	30,861	31,318	33,078	31,271	31,043	31,323	196,785
ACT. PERIOD COST	25,722	33,108	38,493	35,263	33,063	39,302	0	0	0	0	0	0	0	204,951
VARIANCE, $	5,569	(2,065)	(7,222)	5,784	(2,071)	(8,161)	0	0	0	0	0	0	0	(8,166)
VARIANCE, %	17.8%	-6.7%	-23.1%	14.1%	-6.7%	-26.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.1%
EST. FY CUMUL	31,291	62,334	93,605	134,652	165,644	196,785	237,282	268,143	299,461	332,539	363,810	394,853	426,176	
ACTUAL FY CUMUL	25,722	58,830	97,323	132,586	165,649	204,951	0	0	0	0	0	0	0	
PERCENT COMPLETE	6.0%	13.8%	22.8%	31.1%	38.9%	48.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	5,569	3,504	(3,718)	2,066	(5)	(8,166)	0	0	0	0	0	0	0	
VARIANCE, %	17.8%	5.6%	-4.0%	1.5%	0.0%	-4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



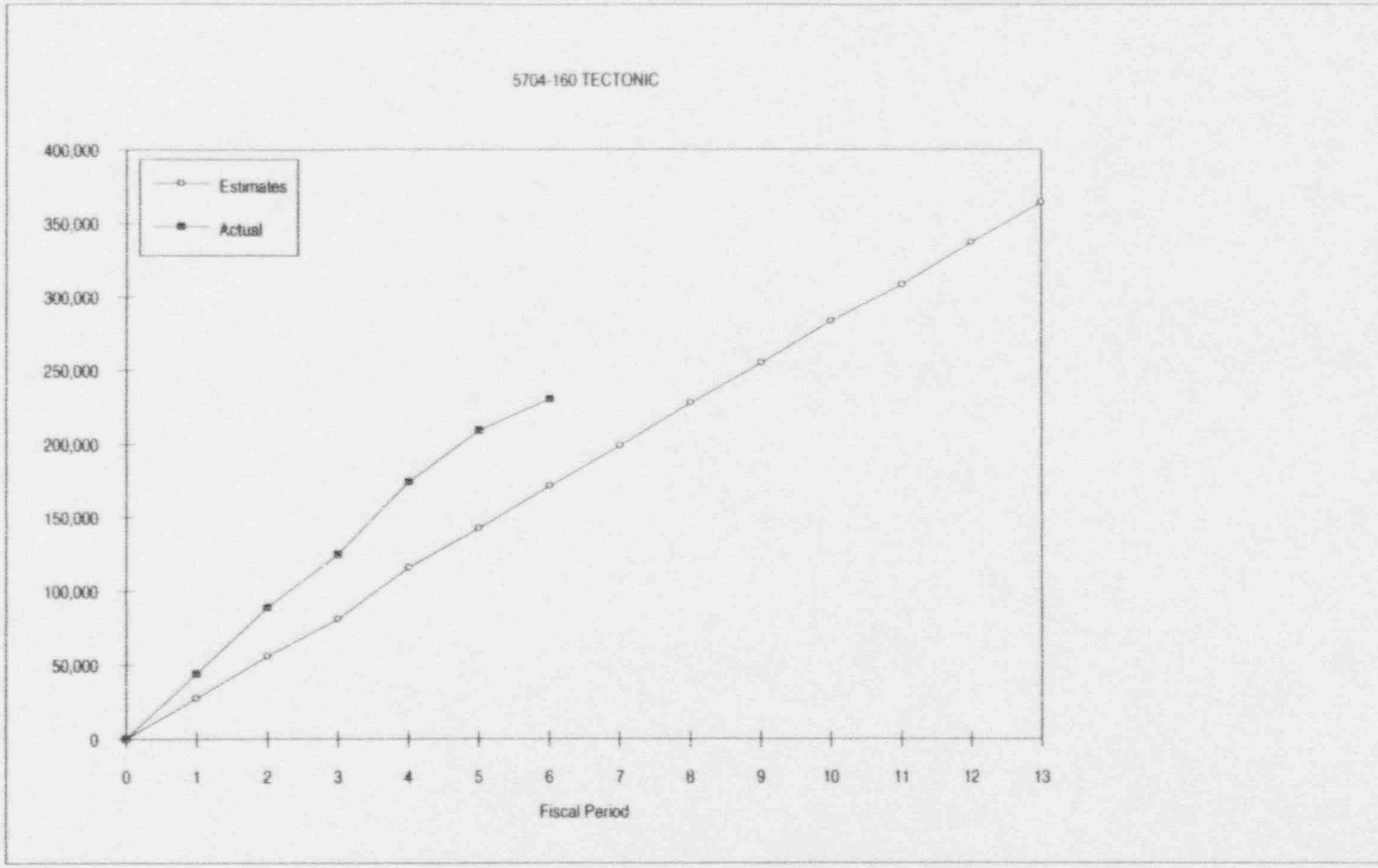
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	23,268	22,781	23,376	29,743	23,388	22,798	30,452	22,477	23,875	23,844	23,376	22,781	23,613	145,354
ACT. PERIOD COST	25,206	19,156	16,566	35,830	11,197	19,485	0	0	0	0	0	0	0	127,440
VARIANCE, $	(1,938)	3,625	6,810	(6,087)	12,191	3,313	0	0	0	0	0	0	0	17,914
VARIANCE, %	-8.3%	15.9%	29.1%	-20.5%	52.1%	14.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.3%
EST. FY CUMUL	23,268	46,049	69,425	99,168	122,556	145,354	175,806	198,283	222,158	246,002	269,378	292,159	315,772	
ACTUAL FY CUMUL	25,206	44,363	60,928	96,758	107,955	127,440	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.0%	14.0%	19.3%	30.6%	34.2%	40.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(1,938)	1,686	8,497	2,410	14,601	17,914	0	0	0	0	0	0	0	
VARIANCE, %	-8.3%	3.7%	12.2%	2.4%	11.9%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



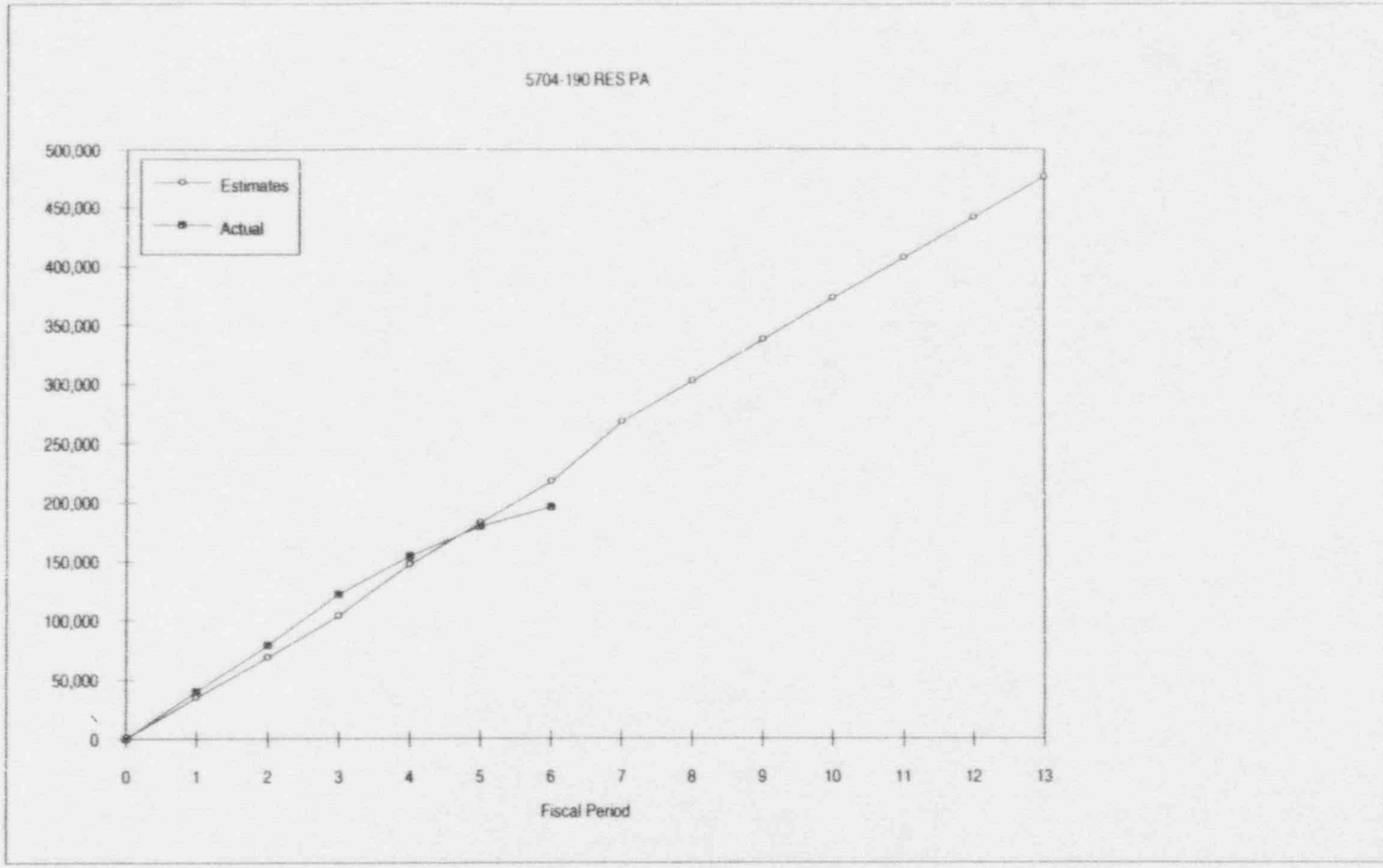
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	19,414	19,303	19,200	23,909	19,954	19,506	19,073	19,405	20,071	19,209	19,200	19,303	19,956	121,286
ACT. PERIOD COST	14,792	23,858	24,066	31,288	15,783	11,944	0	0	0	0	0	0	0	121,731
VARIANCE, $	4,622	(4,555)	(4,866)	(7,379)	4,171	7,562	0	0	0	0	0	0	0	(445)
VARIANCE, %	23.8%	-23.6%	-25.3%	-30.9%	20.9%	38.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%
EST. FY CUMUL	19,414	38,717	57,917	81,826	101,780	121,286	140,359	159,764	179,835	199,044	218,244	237,547	257,503	
ACTUAL FY CUMUL	14,792	38,659	62,716	94,004	109,787	121,731	0	0	0	0	0	0	0	
PERCENT COMPLETE	5.7%	15.0%	24.4%	36.5%	42.6%	47.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	4,622	67	(4,799)	(12,178)	(8,007)	(445)	0	0	0	0	0	0	0	
VARIANCE, %	23.8%	0.2%	-8.3%	-14.9%	-7.9%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



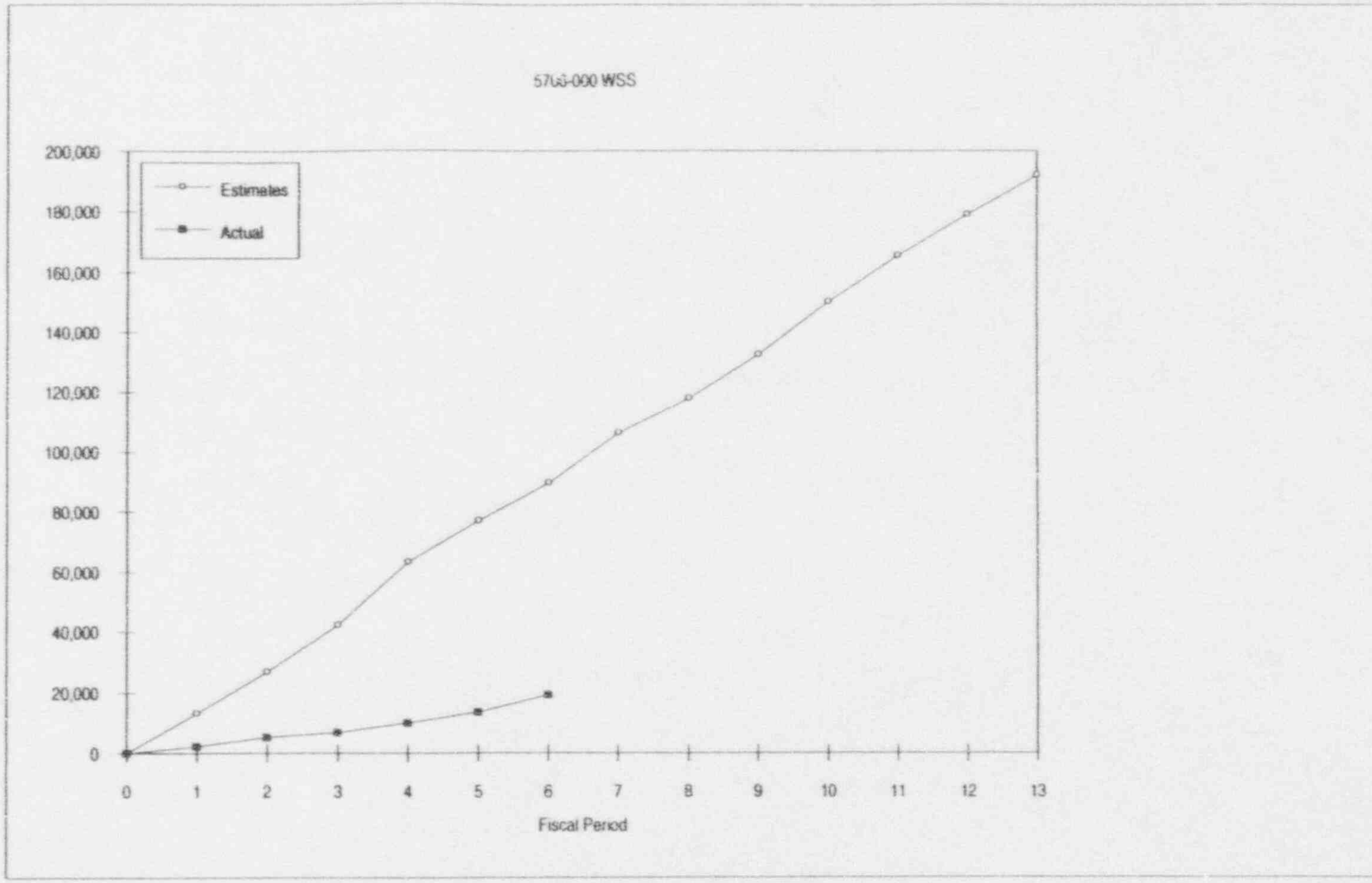
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	22,326	28,954	27,015	36,634	24,212	27,078	33,096	26,536	24,704	31,069	27,015	28,954	22,602	166,219
ACT. PERIOD COST	15,217	28,385	37,962	24,061	25,858	20,159	0	0	0	0	0	0	0	151,643
VARIANCE, $	7,109	569	(10,947)	12,574	(1,646)	6,919	0	0	0	0	0	0	0	14,576
VARIANCE, %	31.8%	2.0%	-40.5%	34.3%	-6.8%	25.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.8%
EST. FY CUMUL	22,326	51,280	78,295	114,929	139,141	166,219	199,315	225,851	250,555	281,624	308,639	337,593	360,195	
ACTUAL FY CUMUL	15,217	43,602	81,564	105,625	131,483	151,643	0	0	0	0	0	0	0	
PERCENT COMPLETE	4.2%	12.1%	22.6%	29.3%	36.5%	42.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	7,109	7,678	(3,269)	9,304	7,658	14,576	0	0	0	0	0	0	0	
VARIANCE, %	31.8%	15.0%	-4.2%	8.1%	5.5%	8.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



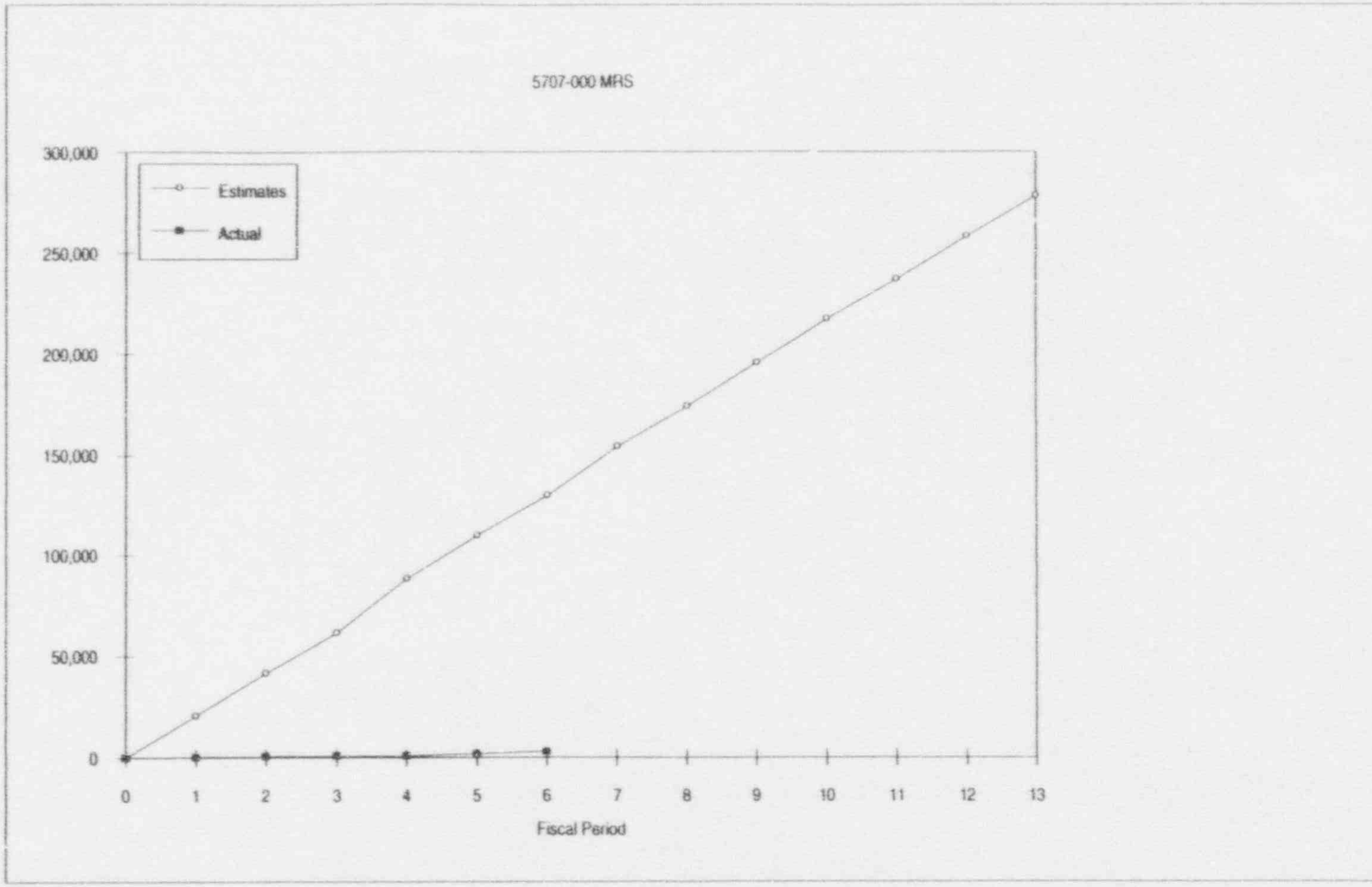
ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	27,357	28,497	24,920	35,059	26,639	28,942	27,238	28,756	27,300	28,372	24,920	28,497	27,417	171,414
ACT. PERIOD COST	44,248	44,712	36,034	49,680	34,211	21,432	0	0	0	0	0	0	0	230,316
VARIANCE, $	(16,891)	(16,215)	(11,114)	(14,621)	(7,572)	7,510	0	0	0	0	0	0	0	(58,902)
VARIANCE, %	-61.7%	-56.9%	-44.6%	-41.7%	-28.4%	25.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-34.4%
EST. FY CUMUL	27,357	55,854	80,774	115,833	142,472	171,414	198,652	227,408	254,708	283,080	308,000	336,497	363,914	
ACTUAL FY CUMUL	44,248	88,960	124,994	174,673	208,884	230,316	0	0	0	0	0	0	0	
PERCENT COMPLETE	12.2%	24.4%	34.3%	48.0%	57.4%	63.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(16,891)	(33,106)	(44,220)	(58,840)	(66,412)	(58,902)	0	0	0	0	0	0	0	
VARIANCE, %	-61.7%	-59.3%	-54.7%	-50.8%	-46.6%	-34.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	34,787	33,902	34,624	44,272	34,767	34,597	50,394	34,514	34,972	35,164	34,624	33,902	35,170	216,949
ACT. PERIOD COST	39,733	39,459	42,436	33,080	24,928	16,094	0	0	0	0	0	0	0	195,729
VARIANCE, $	(4,946)	(5,557)	(7,812)	11,192	9,839	18,503	0	0	0	0	0	0	0	21,220
VARIANCE, %	-14.2%	-16.4%	-22.6%	25.3%	28.3%	53.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%
EST. FY CUMUL	34,787	68,689	103,313	147,585	182,352	216,949	267,343	301,857	336,829	371,993	406,617	440,519	475,689	
ACTUAL FY CUMUL	39,733	79,192	121,627	154,708	179,635	195,729	0	0	0	0	0	0	0	
PERCENT COMPLETE	8.4%	16.6%	25.6%	32.5%	37.8%	41.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	(4,946)	(10,503)	(18,314)	(7,123)	2,717	21,220	0	0	0	0	0	0	0	
VARIANCE, %	-14.2%	-15.3%	-17.7%	-4.8%	1.5%	9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	13,038	13,732	15,343	21,070	13,720	12,282	16,748	11,731	14,498	17,559	15,343	13,732	13,095	89,185
ACT. PERIOD COST	2,192	2,956	1,534	3,099	3,547	5,854	0	0	0	0	0	0	0	19,181
VARIANCE, $	10,846	10,776	13,809	17,971	10,173	6,429	0	0	0	0	0	0	0	70,004
VARIANCE, %	83.2%	78.5%	90.0%	85.3%	74.1%	52.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	78.5%
EST. FY CUMUL	13,038	26,770	42,113	63,183	76,903	89,185	105 933	117,664	132,162	149,721	165,064	178,796	191,891	
ACTUAL FY CUMUL	2,192	5,148	6,682	9,780	13,327	19,181	0	0	0	0	0	0	0	
PERCENT COMPLETE	1.1%	2.7%	3.5%	5.1%	6.9%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	10,846	21,622	35,431	53,403	63,576	70,004	0	0	0	0	0	0	0	
VARIANCE, %	83.2%	80.8%	84.1%	84.5%	82.7%	78.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
EST PERIOD COST	20,275	21,106	19,958	26,772	21,184	20,272	24,186	19,569	21,764	21,433	19,958	21,106	20,333	129,567
ACT. PERIOD COST	297	321	206	37	835	1,160	0	0	0	0	0	0	0	2,856
VARIANCE, $	19,978	20,785	19,752	26,736	20,349	19,112	0	0	0	0	0	0	0	126,711
VARIANCE, %	98.5%	98.5%	99.0%	99.9%	96.1%	94.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.8%
EST. FY CUMUL	20,275	41,381	61,339	88,111	109,295	129,567	153,753	173,422	195,186	216,619	236,577	257,683	278,016	
ACTUAL FY CUMUL	297	618	824	860	1,696	2,856	0	0	0	0	0	0	0	
PERCENT COMPLETE	0.1%	0.2%	0.3%	0.3%	0.6%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
VARIANCE, $	19,978	40,763	60,515	87,251	107,599	126,711	0	0	0	0	0	0	0	
VARIANCE, %	98.5%	98.5%	98.7%	99.0%	38.4%	97.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	