Ltr'd with ltr dtd - 2/6/95

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

For the Fiscal Reporting Period

December 24, 1994–January 20, 1995

PMPR No. 95-04

February 3, 1995

426.1

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

1D, 2D, 3D	1-Dimensional, 2-Dimensional, 3-Dimensional
AA	Atomic Absorption
ACD	Advanced Conceptual Design
ACF	Alumina (in excess of alkali feldspar), Calcium oxide, Ferromagnesianoxide
ACNW	Advisory Committee on Nuclear Waste
ACRS	Advanced Computer Review System
AI	Administrative Item
AECL	Atomic Energy Canada Limited
AES	Atomic Emission Spectrometry
AGU	American Geophysical Union
AML	Arc Macro Language
AP	Administrative Procedure
ASCE	American Society of Civil Engineers
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
BFD	Basis for Design
CAI	Color Alteration Index
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
CDTS	Commission Decision Tracking System
CEC NAWG	European Community Natural Analog Working Group
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
CRG	Center Review Group
CRWMS	Civilian Radioactive Waste Management System
CSCS	Constrained Stochastic Climate Simulator
DAS	Data Acquisition System
DBE	Design Basis Event
DC	Division of Contracts
DCAA	Defense Contract Audit Agency
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
DIE	Determination of Importance Evaluation
DIMNS	Division of Industrial & Medical Nuclear Safety
DLG	Digital Line Graph
DLM	Diffuse Layer Model
DNAG	Decade of North American Geology
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DRA	Division of Regulatory Applications
DTED	Digital Terrain Elevation Data
DWM	Division of Waste Management
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
EIS	Environmental Impact Statement
EM	Element Manager
EMPA	Electron Microprobe Analysis
EPA	U.S. Environmental Protection Agency
EPR	Electrochemical Potentiokinetic Reactivation
EPRI	Electric Power Research Institute
EQA	External Quality Assurance
EROS	Earth Resource Observation System
ESF	Exploratory Studies Facility
EXAFS	Extended X-Ray Absorption Fine Structure
FAC	Favorable Condition
FCRG	Format and Content Regulatory Guide
FD&SHA	Fault Displacement and Seismic Hazard Analysis
FEM	Finite Element Method
FFT	Fast Fourier Transform
FIN	Financial Identification Number
FTE	Full Time Equivalent
FTP	File Transfer Protocol
FY	Fiscal Year
GEM	General Electrochemical Migration
GERT	General Employee Radiological Training
GET	General Employee Training
GIS	Geographic Information System
GPS	Global Positioning Satellite

LIST OF ABBREVIATIONS (cont'd)

GROA	Geologic Repository Operations Area
GS	Geologic Setting
GSA	Geologic Society of America
GUI	Graphics User Interface
GWSI	Groundwater System Integration
GWTT	Groundwater Travel Time
HLUR	HLW and Uranium Recovery Projects Branch
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
JPL	Jet Propulsion Laboratory
JRC	Joint Roughness Coefficient
KTU	Key Technical Uncertainty
LAN	Local Area Network
LANL	Los Alamos National Laboratories
LARP	License Application Review Plan
LBL	Lawrence Berkeley Laboratory
LHS	Latin Hypercube Sampling
LLNL	Lawrence Livermore National Laboratory
LWR	Light Water Reactor
MGDS	Mined Geologic Disposal System
MH	Mechanical-Hydrological
MIT	Massachusetts Institute of Technology
MM	Major Milestone
M&O	Management and Operations
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
MSS	Multispectral Scanner
NAS	National Academy of Science
NAWG	Natural Analogs Working Group
NCR	Nonconformance Reports
NFS	Network File Server
NMSS	Office of Nuclear Material Safety & Safeguards
NOAA	National Oceanographic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
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
OCRWM	Office of Civilian Radioactive Waste Management
OGC	Office of General Counsel
OITS	Open Item Tracking System
OPS	Operations Plans
ORS	Overall Review Strategy
OWFN	One White Flint North
PA	Performance Assessment
PAAG	Performance Assessment Advisory Group
PAC	Potentially Adverse Condition
PAC/FAC	Potentially Adverse Condition/ Favorable Condition
PA&HT	Performance Assessment and Hydrologic Transport
PASP	Performance Assessment Strategic Plan
PC	Personal Computer
PC/TCP	Personal Computer/Transmission Control Protocol
PCT	Product Consistency Test
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
PO	Project Officer
PPA	Proposed Program Approach
PRA	Probabilistic Risk Assessment
PSAG	Probabilistic System Assessment Group
PSHA	Probabilistic Seismic Hazard Analysis
PTFE	Polytetrafluoroethylene
PVM	Parallel Virtual Machine
QA	Quality Assurance
QAP	Quality Assurance Procedure
RASA	Regional Aquifer-System Analysis
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
ROC	Repository Operations Criteria

LIST OF ABBREVIATIONS (cont'd)

RPD	Regulatory Program Database
RRT	Regulatory Requirement Topic
RSRG	Real Space Renormalization Group
SAIC	Science Applications International Corporation
SAR	Safety Analysis Report
SCA	Site Characterization Analysis
SCC	Substantially Complete Containment
SCCEX	Substantially Complete Containment Example
SCM	Surface Complexation Models
SCP	Site Characterization Plan
SELM	Spectral Element Method
SEM	Scanning Electron Microscopy
SER	Safety Evaluation Report
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
SS	Stainless Steel
STEM	Scanning Transmission Electron Microscopy
STP	Staff Technical Position
SUFLAT	Stochastic Analyses of Unsaturated Flow and Transport
SVF	Springerville Volcanic Field
SwRI	Southwest Research Institute
TBD	To Be Determined
TBM	Tunnel Boring Machine
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-Hydrologic
TMS	The Minerals, Metals, and Materials Society
TOP	Technical Operating Procedure
TP	Technical Position
TPA	Total Performance Assessment
TSPA	Total System Performance Assessment
TSw-Chnv	Topopah Spring-Calico Hills
TWFN	Two White Flint North
UA	University of Arizona
UDEC	Universal Distinct Element Code
UNM	University of New Mexico
U.S.	United States
USDA	U.S. Department of Agriculture
USGS	U.S. Geologic Survey
UTM	Universal Transverse Mercator
VCS	Version Control System
VF	Vitrification Facility
WAN	Wide Area Network
WBS	Work Breakdown Structure
WGB	Western Great Basin
WIPP	Waste Isolation Pilot Plant
WMB	Waste Management Branch
WP	Waste Package
WSE&I	Waste Systems Engineering and Integration
WSS	Waste Solidification Systems
WTSO	Washington Technical Support Office
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffractometry
YM	Yucca Mountain
YMP	Yucca Mountain Project
YMSCO	Yucca Mountain Site Characterization Office
YMR	Yucca Mountain Region

EXECUTIVE SUMMARY — PERIOD 4

In the DWM Job Code, the following outlines the CNWRA key activities and accomplishments:

- The CNWRA gave a detailed technical briefing to the Commissioners regarding CNWRA contributions to the high-level waste repository program.
- The COPS and WSE&I conducted program review briefings at the NRC TWFN offices.
- EQA documented the findings of the observation audit of the M&O administration of technical requirements for document control.
- The WSE&I assisted the NRC in long-range planning for general computer needs related to RPD/OITS system.
- GS and RDCO staff participated in the on-site verification of TBM activities at the YM.
- EBS staff gave presentations on both the technical assistance and research program at the ACNW meeting on the Nuclear Waste Container Materials Research Program.
- The RDCO staff gave a presentation on the technical assistance and rock mechanics research at the ACNW meeting on Rock Mechanics.
- The PA&HT assisted the NRC with development of a presentation on the treatment and effect of climate change on repository PA.

The DWM Job Code year-to-date cost variance is 15.9 percent. This variance reflects a small increase from last period. Reactive work and activities related to site characterization reviews has been limited.

In the RES Job Code, the following outlines the CNWRA key activities and accomplishments:

- The Thermohydrology Research Project final report was completed and submitted to internal review in preparation for submittal next period as an MM.
- The IWPE Project produced a paper on localized corrosion of alloy 825 which was recently accepted for publication in a peer reviewed journal.
- The topical report A Uniform Approach to Surface Complexation Modeling of Radionuclide Sorption was submitted by the Sorption Modeling Project.
- The external peer review of the Subregional Hydrogeologic Flow and Transport Research Project Plan was completed. The peer review panel's comments were forwarded to NRC.
- The PA Research Project produced a paper on a new computational technique for solving the unsaturated flow equation. The paper will be submitted to a peer reviewed journal.

The RES Job Code year-to-date cost variance is 13.1 percent. This variance generally remained about the same as last period even though there were underspending and overspending in some of the research projects.

In the DIMNS Job Code, the following outlines the CNWRA key activities and accomplishments:

- A report was completed containing resolution of comments on the Vitrification SAR.

The DIMNS Job Code year-to-date cost variance of 4.5 percent.

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

TITLE: Center for Nuclear Waste Regulatory Analyses

CONTRACTOR: Southwest Research Institute
6220 Culebra Road, San Antonio, Texas 78238-5166

CONTRACT NO: NRC-02-93-005

JOB CODES: D1035, L1793, B6666

NRC CNWRA PROGRAM MANAGER: John J. Linehan, (301) 415-7780

NRC CNWRA DEPUTY PROGRAM MANAGER: Shirley L. Fortuna, (301) 415-7804

CNWRA PRESIDENT: Wesley C. Patrick, (210) 522-5158

ESTIMATED BUDGET: $89,898,141

PERIOD OF PERFORMANCE: 10/15/92–9/26/97

PERIOD OF THIS REPORT: 12/24/94–1/20/95

1. TECHNICAL

1.1 *CNWRA Operations (COPS)*

The NRC and CNWRA management actively coordinated meetings and telephone conferences to address a wide range of important day-to-day programmatic issues as well as long-term management topics. CNWRA management staff continued its coordination with specific personnel from the PMDA, DWM, RES/DRA, and DC, responding to *ad hoc* requests for information addressing management issues affecting the conduct of CNWRA work. The COPS Program Review was held at TWFN, and the CNWRA briefing to the Commissioners was presented in the same week at OWFN. In addition, an NRC/CNWRA Management Meeting was held during that week. CNWRA staff briefed NRC management on NRC and CNWRA automation systems focusing on text search and document management systems. CNWRA senior management continued further discussions with various NRC staff relative to: (i) current status and proposed timing for implementing the DOE Program Approach; (ii) development of a single point of contact for RPD and TDOCS as well as implementation of TDOCS for FY95; (iii) implementation of the CNWRA Network Security; (iv) status and required actions on KTU integration product; (v) current status of presenting an electronic version of the PMPR; (vi) status of approval of Near Field Processes Project Plan and a statement-of-work on materials research; (vii) evaluation of potential legal concerns regarding split

(U.S. government and non-government) funding of limited-term CNWRA staff positions; (viii) schedule for CNWRA involvement in the DWM FY96 budget development process; and (ix) review of policies for CNWRA or SwRI to conduct work for other U.S. government agencies as well as foreign governments.

The current status of CNWRA staffing is indicated in Table 1. Recruitment efforts and interviews continued for open positions.

A QA staff member made a presentation to the NRC at TWFN on the application of Scientific and Engineering Software QA during this period. This presentation answered many of the questions posed by the NRC regarding scientific and engineering software control at the CNWRA. Other internal QA activities included: (i) QAP-002 verification of review of outgoing CNWRA products, including AI, IM, and MM reports and papers; (ii) coordination of the reviews of the draft TOP-018 Development and Control of Scientific and Engineering Computer Codes procedure; (iii) participation by QA staff in all COI Management Committee meetings; (iv) review of SwRI Requests for Proposal to verify no organizational COI; (v) indoctrination of new staff members to the CNWRA QA program; and (vi) coordination with CNWRA technical staff on the implementation of various operating procedures.

Based on NRC direction, the TDOCS Design Report (IM 5702-156-510) will include a discussion of the major modules that make up TDOCS as well as underlying network architecture that supports the modules. The level of detail will be at the major module (document management server, document processing client, and document search and retrieval client) and module interface level. Required software products and their justification will be developed. A listing of the source code for the prototype will be attached as an appendix. Therefore, this milestone will be delayed until March 3, 1995. The impact of this scope change on other deliverables for FY95 is delineated in the OPS changes to be sent to the NRC in February. Cognizant CNWRA staff continue to participate in discussions with appropriate NRC staff concerning the timing and approach for completing the TDOCS Initial Data Loading Plan.

The FY95 CNWRA Computer Security Plan (IM 5702-157-510) was submitted on schedule. Implementation of the CNWRA Firewall System (IM 5702-157-550), including acquisition of both hardware and software, remains on schedule. In addition, the NFS Mass Storage System has been installed and is functioning in a pilot test mode. Migration of the shared disk drives to the system will follow. The CRAY computer at INEL will shut down effective January 31, 1995, and the CNWRA is actively pursuing other CRAY computer service providers. The new M&O contractor, LITCO, has recommended the use of their CRAY in Denver, and it appears to meet the high-performance computing capability requirements of the CNWRA.

The following activities are expected to occur during the next period.

The CNWRA will pursue resolution of outstanding management issues and continue responding to *ad hoc* requests for information on CNWRA operations. A NRC/CNWRA Management Meeting will be held at TWFN.

Recruitment and interviews will continue for the CNWRA core and limited-term staff.

Change pages to the operations/project plans will be made in response to the NRC letter of January 5, 1995, with the approved extension of the delivery date.

On the following action items, CNWRA QA staff will: (i) work with and make a presentation to the NRC staff to achieve resolution to software QA issues on both CNWRA and NRC scientific and engineering software, (ii) participate in the regular COI Management Committee Meetings, (iii) conduct more QA indoctrinations for new staff, (iv) continue CNWRA QA Records processing and maintenance, (v) perform appropriate surveillances on project and task work, and (vi) respond to any additional NRC questions regarding the Evaluation of Quality Assurance Requirements task which was submitted to the NRC. Following the software QA meeting at TWFN, improvements will be introduced to CNWRA TOP-018—making the procedure more applicable to the specialized needs of the CNWRA and NRC. A restructured and revised version of the TOP-018 procedure was completed. An initial technical review by all EMs has been performed.

The CNWRA will install the TDOCS Prototype (IM 5702-156-520) when the necessary NRC-provided software becomes available. The TDOCS User Guide (IM 5702-156-520) will accompany installation of the prototype server with Windows and UNIX clients.

The CNWRA will continue with the installation, configuration, and testing of the complete CNWRA Firewall System. The CNWRA will await the review and comments of the DWM and IRM on the FY95 CNWRA Computer Security Plan. The CNWRA will continue to support its LAN, and provide design consultation on the DWM ACRS as necessary.

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

No tasking was received for support on NWPA-mandated actions. The CNWRA expects, however, to be tasked later in the FY as the DOE revised program evolves.

In the LARP Development subtask, integration continued with working groups convened to address KTUs associated with structural geology, volcanology, seismic hazards, coupled effects, the EBS, and groundwater flow and radionuclide transport. Discussions were held with HLUR staff to refine the format and content needs for revised KTUs, and examples of such needs were prepared. The results of this effort will be submitted as a Letter Report on Recommended NRC Actions to Address KTUs (IM 5702-221-511) on February 28, 1995. The Crosswalk of Regulatory/Institutional Uncertainties with Review Plan Topics (IM 5702-221-500) was submitted during this period. This crosswalk will become an appendix to the LARP and will be used in CDM development. In response to an action item from the CNWRA Annual Review, preparatory work began on an agenda for a LARP development workshop to be conducted for DWM and CNWRA staffs. The date for this workshop has not yet been determined. As a result of direction received during discussions following the CNWRA Annual Review, the CNWRA submitted a proposal for accelerated development of CDMs (AD 5702-221-580). The

proposal contains a plan for initial completion of all CDMs during FY96, with subsequent annual updates as required.

No tasking for WSE&I special projects was received this period.

RPD and OITS operation and maintenance efforts continued. Testing of the DOS/Windows platform application was completed and it was found to be compatible with a simulated NRC network using OnNet from FTP Software (PC/TCP V3.0). The installation of RPD/OITS at the NRC is being delayed until network security upgrades have been installed. Work on updating the SCA open items continued this period. The open items are being completed based on a prioritization of: (i) SCA open items, (ii) study plan open items, and (iii) other open items. Following NRC approval, the completed open items will be loaded into RPD/OITS. WSE&I staff assisted the NRC in long-range planning for general computer needs as well as the specific needs of the RPD/OITS system.

The WSE&I Program Review was held at TWFN.

In the next period, the WSE&I staff will focus on the following areas: (i) producing CDMs; (ii) developing porting software to support the installation of the RPD on the MacIntosh computer platform; (iii) coordinating LARP development activities throughout the CNWRA, including conducting training necessary to support CDM preparation; (iv) revising the list of CDMs for development in FY95 to address DOE high-level findings for surface processes; (v) continuing KTU integration and briefings to affected NRC staff; (vi) continuing preparation of SCA open items; (vii) finalizing the review plan interrelationships roadmap; and (viii) continuing work on plans for accelerated CDM development and a LARP workshop.

1.3 *External Quality Assurance (EQA)*

During this period, the report for the observation audit of the M&O (Vienna, Virginia) administration of technical requirements document control (IM 5702-331-502) was completed and submitted. In addition, the DOE audit of the M&O implementing procedures (5.0, 15.0, 16.0, and 17.0) in Las Vegas and at the Nevada Test Site (IM 5702-331-503) was observed, and the report was started during this period.

The CNWRA and NRC staffs held numerous discussions concerning the observation audit, meeting, and field verification schedule for FY95. These discussions focused on the NRC field verification activity at the Las Vegas and NTS M&O facilities planned for late February 1995.

As part of the COPS Program Review, presented at NRC headquarters, CNWRA QA staff provided a follow-on to the CNWRA response to NRC questions on the task Evaluation of Quality Assurance Requirements at the CNWRA (AI 5702-331-416). The presentation covered the CNWRA proposed approach to QA, with emphasis on the approach to software control.

The observation report for the DOE audit of the M&O at Las Vegas, Nevada, and at the NTS on implementing the procedures and controls, will be completed during the next period. Although the specific date has not been verified at this time, the NRC field verification team, with CNWRA QA and technical staff participation, will perform work at the M&O in Las Vegas and at the NTS during the next period. A discussion with DWM management concerning software controls is planned for mid-February 1995.

1.4 *Geologic Setting (GS)*

Geology and Geophysics

During this period, tectonic modeling has focused on selecting the model parameters to vary in the finite-element simulations of hangingwall deformation. Reasonable ranges for many of the parameters have been established based on literature review and analyses. Computational tests have been established in order to compare results of the various model calculations.

Integration of the Tectonic/Seismic and Volcanism KTUs continued. The NRC is reviewing the second draft of the CDM on Extreme Erosion and this CDM is expected to be completed in the next period. The CNWRA supported a telephone conference among the NRC/DOE/State of Nevada on the DOE response to the NRC comments on the DOE Topical Report on Extreme Erosion. The DOE is expected to provide approximately 100 pages of comment response.

A draft of the Letter Report on Testing of SEISM 1.1 Sensitivity Analysis (IM 5702-425-501) was prepared and submitted for review. Final calculations indicated no significant increase (and no decrease as reported from the initial calculation) in 50th constant percentile seismic hazard at YM from the addition of five different background zone configurations to the original calculation. For calculations employing a high activity background zone around the Owens Valley and Death Valley–Funeral Mountain faults, an increase in the 85th and 95th constant percentile hazards was noted.

Refinement of the 3D geological framework model continued. The Bullfrog Hills lithologic unit of the Crater Flat Tuff and a nonwelded Crater Flat unit lying between the Bullfrog Hills and the Prow Pass units have been added to the model. The water table (the surface of which has been constructed in EarthVision), surficial geology as portrayed on geologic maps of YM (a first cut at this has been accomplished), and alluvium (data on depths of alluvium are now in the EarthVision database) have been included in the model.

CNWRA personnel participated in the on-site verification of the TBM activities at YM in early January. A trip report for those activities was issued.

Selected GIS library coverages of general interest and static coverages were stored on CD recordable media as distribution version 0.1. The draft version 0.1 of the CD/ROM is undergoing legal, programmatic, and technical review. A letter report has been drafted that describes the GIS library CD/ROM contents and status. The final version is planned to be version 0.12 for initial distribution. Shuttle Imaging Radar (version C) coverages

are available from JPL via anonymous file transport over the Internet. Sample browse imagery has been downloaded for: the Kamchatka region of the Soviet Union; Colima volcano in Mexico; and Stove Pipe Wells across Nevada and California. These images are useful in detecting topographic relief and structural clues for geologic mapping.

Two applicants were interviewed for the open structural geology position. The list of applicants for the limited-term position in volcanology/structural geology was reduced to four candidates. These candidates will be invited to submit full applications, and an interview schedule is being developed.

Modeling of hangingwall deformation during the next period will focus on running the suite of models planned to study the style of deformation above a branching system of normal faults and to test the sensitivity of hangingwall deformation to variations in model parameters. Development of the 3D geological framework model will continue. A Letter Report on Testing of SEISM 1.1 Sensitivity Analysis (IM 5702-425-501) will be completed. Data will continue to be acquired and evaluated for input into the GIS database. The CNWRA anticipates review of the DOE response to NRC comments on the DOE Topical Report on Extreme Erosion during the next period. Work will continue on the integration of KTUs and the development of CDMs.

Geochemistry, Hydrology, and Climatology

Several telephone conferences were held between NRC and CNWRA staffs to determine what, if any, actions should be taken to clarify or re-write the current GWTT rule. A set of briefing notes was prepared for NRC management to outline the intent of the GWTT rule, describe difficulties in implementing the rule, and quantify the effect of various interpretations of the disturbed zone and fastest path concepts on computed travel times. An outline for a staff TP on GWTT is currently under development by NRC and CNWRA technical staff.

CNWRA staff continued to work with the NRC on CDM development. In response to direction by NRC management, CNWRA teams were assigned to CDMs for RRT 3.2.2.10 PAC—Complex Engineering Measures, and RRT 3.2.2.12 PAC—Perched Water Bodies. Combined with the CDM for RRT 3.2.2.5 PAC—Flooding, these will address the DOE HLW findings for FY95. Additional effort will be focused on CDMs for RRT 3.2.3.4 PAC—Groundwater Conditions, and the EBS and RRT 3.2.4.1 FC—Precipitation That Is a Small Percentage of Annual Potential Evapotranspiration.

GS staff also continued to work with the WSE&I Element on KTU integration efforts for the Geochemistry of Retardation. At the direction of the NRC, this work included providing additional information on remaining uncertainties, technical needs, and sensitivity analyses. GS staff were also involved with the EBS Element in KTU integration efforts related to Geochemistry and the Engineered Barrier System.

No tasking was received for reactive work activities.

1.5 *Engineered Barrier Systems (EBS)*

Integration activities for the KTUs in the EBS area continued in conjunction with the WSE&I Element. A multidisciplinary group, representing several CNWRA elements assigned to the EBS KTU Integration Team, met several times to consider various options for integrating 11 EBS KTUs which had been defined during CDS development. The team determined that they could be integrated into three: (i) Uncertainty in Prediction of the Environment Near and Within the EBS, (ii) Uncertainty in Prediction of Effects on the Waste Package During the Containment Period, and (iii) Uncertainty in Prediction of the Effects on the EBS During the Post-Containment Period. Drafts of these three EBS KTUs were distributed to team members for review, and appropriate revisions are being incorporated.

As a benchmarking exercise for the GEM code, modeling of corrosion product formation (during pitting of copper) continued. This month the staff completed a literature search for appropriate input thermodynamic and kinetic parameters. Work began on modifying the GEM code to incorporate the Butler-Volmer rate equation as a boundary condition rather than a volumetric average, which is presently used in the code. As part of the near-field environment modeling effort, work continued on a code named MULTIFLO. This code will sequentially couple two-phase fluid flow with transport and chemical reaction of solutes at elevated temperatures.

The EBS Element supported the RDCO Element in reviewing Chapter 12 of the DOE Initial Summary Report for Repository/Waste Package Advanced Conceptual Design and identified areas of uncertainties not covered by DOE. These areas included the effect of thermomechanical cycles on waste package performance, and the effect of filler material, specifically the zinc-aluminum alloy mentioned as a leading candidate, which may cause the potential embrittlement of austenitic materials.

EBS staff attended and presented both the technical assistance and research program at the ACNW meeting on the Nuclear Waste Container Materials Research Program at TWFN on January 18, 1995. G. Cragnolino has began a 2-week staff exchange at the NRC.

Drafts of the three integrated EBS KTUs will be finalized based on input from EBS KTU Integration Team members. These drafts will incorporate the new sections in the text that provide more information on current DOE and NRC activities, expected residual uncertainties, and delineation of NRC/CNWRA "Draft Technical Support Needs," which include "Technical Assessment Needs" and "Research Needs."

Change pages for the FY95 EBS Operations Plan will be prepared to accommodate additional tasking in the spent-fuel area. Following analysis of the peer review comments on the colloids report, a recommendation for the path forward will be developed.

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

The RDCO Element concentrated on the following activities: (i) developing CDMs and integrating of KTUs; (ii) evaluating computer codes for compliance determination, rock joint model development, and developing a rock properties database; (iii) reviewing prelicensing reports and conducting prelicensing interactions; (iv) conducting TBM excavation field verification; and (v) performing ESF design review and ACD review work.

The NRC and CNWRA management review comments on the revised version of the CDM for RRT 4.3—Shafts and Ramps Design were received during this period. This version of the CDM corresponds to the regulatory requirement 10 CFR 60.134—Design of Seals for Shafts and Boreholes, and it was revised following the guidance provided by NRC management during the NRC/CNWRA meeting held at the NRC on September 28, 1994. A multidisciplinary team involving RDCO, WSE&I, and PA&HT Elements, NRC team members, and a consultant developed this component of the CDM for Shafts and Ramps Design. Emphasis in this revision was given to developing specific acceptance criteria that were possible with the current level of available site-specific and DOE design-specific information. This component of the CDM is being revised further to incorporate the NRC and CNWRA management review comments before revising other components of the CDM on Shafts and Ramps Design. The full CDM development on Shafts and Ramps Design will be documented in a report that will be submitted to the NRC to fulfill the milestone CDM for RRT 4.3—Shafts and Ramps Design (IM 5702-621-501). The integration of TMHC and seals KTUs and the NRC/CNWRA teleconference meetings regarding KTU integration continued during this period. This work was conducted under the scope of RDCO Element Subtask 2.1 of the FY95 OPS.

Computational testing of the ABAQUS finite element code continued. The objectives of this testing are to identify and document the simulation capabilities of the ABAQUS code, with particular attention to problems involving coupled processes. This information will be used to formulate refinements and improvements to this code. Problem Set 1 is designed to evaluate the capability of ABAQUS to model transient fluid flow through unsaturated fractured rock mass with particular attention to how the fracture-matrix interaction affects the flow rate. The ABAQUS simulation of this problem has been completed for a material property set similar to the Topopah Spring Welded tuff. The problem will also be modeled for a material property set representing a higher-permeability material. Problem Set 4 is designed to test the capabilities of ABAQUS in modeling thermally driven fluid flow in both saturated and unsaturated geologic media. The ABAQUS simulation of this problem has been completed. The ABAQUS solutions for these two problem sets will be compared with solutions obtained using PORFLOW and/or V-TOUGH computer codes. The testing of ABAQUS will be documented in a report that will be submitted to the NRC to fulfill the milestone ABAQUS Code Evaluation Final Report (MM 5702-623-503). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

Development of a rock joint constitutive model continued in this period. Characterization of the spatial variations of simulated surfaces with known fractal dimensions and variances continues with particular interest in correlating with the frictional responses

under given normal and shear loads. The objective of this activity is to develop a model for the rock joint responses, under cyclic pseudostatic and dynamic loads that can be incorporated in UDEC, 3DEC, and ABAQUS codes. Final versions of two papers, based on the results from this activity, have been submitted after taking into account the comments made by the reviewers selected by the organizers of the respective conferences. The first paper, titled On Natural Rock Joint Profile Characterization Using Self-Affine Fractal Approach will be presented at the 35th U.S. Symposium on Rock Mechanics at Lake Tahoe in June 1995. The second paper, titled On Characterization of Self-Affine Fractal Profiles will be presented at the 10th ASCE Engineering Mechanics Conference in Boulder in May 1995. A report detailing the progress of this model development activity is near completion and will be submitted to the NRC to fulfill the milestone Seismic Rock Joint Model Development Preliminary Report (IM 5702-623-501). The final report will document the model and the associated development processes and will be submitted to the NRC to fulfill the milestone Seismic Rock Joint Model Development Final Report (IM 5702-623-504). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

Collection of information on the variability of rock material properties at YM continued. Preliminary analyses to model the variability of the uniaxial compressive strength, Young's modulus, and Poisson's ratio of TCw, PTn, TSw1, and TSw2 units at YM using standard statistical distributions have been completed. Data for these analyses came from ESF Title II Design Package 2C for 90 percent review, issued by DOE on May 2, 1994. The preliminary analyses show significant variability of the uniaxial compressive strength, Young's modulus, and Poisson's ratio. The objective of this activity is to create a database for rock mechanics properties to be used for TM and TMH analyses of the near-field region. A progress report documenting the details of this activity will be submitted to the NRC to fulfill the milestone Rock Properties Database—1995 Progress Report (IM 5702-623-505). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

Evaluation of Type 3 CDM codes continued. Work continues on identification of the features of computer codes necessary to carry out a Type 3 review of the ventilation aspects of the DOE proposed repository at YM design. The evaluation of the code RADTRAN IV was completed. RADTRAN IV has been designed to calculate population doses and health effects from routine and accident conditions during the transportation of radioactive materials using a variety of modes (e.g., rail, truck, ship, barge, cargo van, airplane). This code is not suitable for on-site dose modeling in the GROA. The evaluation of the inventory code ORIGEN was initiated during this period. The objective of this activity is to assess the capabilities of several codes, based on reported information, to evaluate their suitability for use during CDM Type 3 reviews. This activity will be documented in a report that will be submitted to the NRC to fulfill the milestone Report on CDM Codes for Type 3 Assessment (IM 5702-623-502). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

RDCO staff collaborated with the GS staff in coordination of the ESF North Ramp Construction Field Surveillance activities. This coordination work was conducted under the scope of RDCO Element Subtask 3.1 of the FY95 OPS.

An overview review of SCP Progress Report No. 10 was conducted to determine if it or any of its references warrant a detailed review. This overview review indicated that the progress report does not need a detailed review, but two references require detailed review. Preparatory activities were conducted during this period to participate at the NRC/DOE Technical Exchange on Seismic Topical Reports I & II that will be held in Washington, DC, on January 26, 1995. This work was conducted under the scope of RDCO Element Subtask 4.1 of the FY95 OPS.

During this period, a review of the Initial Summary Report for Repository/Waste Package ACD dated August 29, 1994, has been completed by a multidisciplinary team involving RDCO, GS, EBS, WSE&I, PA&HT Elements and a consultant. The objective of this activity was to review the DOE Repository ACD to assist the NRC in providing input to the DOE in a timely manner. The scope of ACD review also included the review of the DOE document, FY93 Thermal Loading Systems Study Final Report, Vols. 1 and 2. The review comments will be documented in a report, which is being prepared, that will be submitted to the NRC to fulfill milestone Major Design Report Reviews No. 1 (IM 5702-642-501). The revised version of the ESF Title II Design Package 2C was received at the CNWRA during this period. The review of this Design Package is being done by a multidisciplinary team involving RDCO, GS, PA&HT Elements and a consultant. The objective of this review is to assist the NRC in providing input to the DOE in a timely manner during in-field verification of the TBM excavation of ESF North Ramp. The review comments will be documented in a report to the NRC to fulfill milestone Major Design Report Reviews No. 2 (IM 5702-642-502). This work was conducted under the scope of RDCO Element Subtask 4.2 of the FY95 OPS.

RDCO staff attended the 70th ACNW meeting at TWFN on Rock Mechanics Research and Technical Assistance Program, on January 19, 1995, and made a presentation on Investigation of Issues Related to Technical Assistance in Rock Mechanics.

During the next period, activities within the RDCO Element will include: (i) work on the CDM on Shafts and Ramps Design; (ii) integration of KTUs; (iii) development of the rock-joint model, evaluation of ABAQUS, assessment of Type 3 CDM Codes, and development of rock properties database; (iv) participation in field verification; (v) participation in prelicensing activities; and (vi) work on ESF Title II Design Package 2C Review and Repository Advanced Conceptual Design Review.

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

The PA&HT Element made significant progress on the following activities: (i) preparing a presentation for the WIPP PA Workshop, (ii) preparing a draft technical position on expert judgment, (iii) contributing to the KTU consistency/integration review, (iv) conducting various auxiliary analyses for IPA, (v) initiating IPA Phase 3 planning, and (vi) peer reviewing the Canadian EIS.

Presentation materials for the forthcoming EPA Technical Workshop on WIPP Compliance Issues were prepared. The presentation materials were transmitted to the NRC on January 20, 1995 to fulfill the milestone Presentation for WIPP PA Workshop (AI 5702-723-001). The presentation is scheduled to be given by NRC staff, and is on

the topic of treatment and effect of climate change on repository PA. This work is being conducted under the scope described in the PA&HT Element Subtask 1.1 of the OPS.

The draft TP document on expert judgment was completed. The document describes an appropriate procedure for formal elicitation of expert judgments. The draft TP is currently going through the CNWRA internal review process and will be submitted on or before March 3, 1995, to the NRC to fulfill the milestone Proposed Basis for NRC Technical Position on Elicitation Procedure for Expert Judgment (MM 5702-712-410). This work is being conducted under the scope described in the PA&HT Element Subtask 1.2 of the OPS.

Support to the KTU integration activity continued. A technical team was formed to address integration of the five total-system PA KTU issues. The PA&HT staff held meetings with the WSE&I staff to discuss, plan, and schedule this integration activity. In addition, meetings were held to discuss the preparation of associated CDMs for the total-system PA review plans. This work was conducted under the scope described in the PA&HT Element Subtask 2.1 of the OPS.

Work continued on a shallow infiltration auxiliary analysis. The objective of this work is to develop an improved probability distribution function for infiltration rate. It was noted in the IPA Phase 2 and in the DOE TSPA exercises that infiltration is a key parameter affecting overall performance. Work continued on development of a probabilistic climatic module. In addition, some modifications to the infiltration computer code were made to better describe matrix-fracture interactions. A technical paper on this work will be prepared in the next period and submitted on or before March 30, 1995, to the NRC to fulfill the milestone Paper on Infiltration Study (IM 5702-723-445). This work was conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Limited work was performed on the deep percolation auxiliary analysis for YM. Key CNWRA staff were diverted to work on the Hydrology KTU integration team. The staff is expected to restart work in the next period. This auxiliary analysis is expected to provide improved predictions of flow into the proposed repository. A CNWRA report on this auxiliary analysis is expected to be prepared and submitted on September 9, 1995, to fulfill the milestone Report on Deep Percolation Analysis (MM 5702-723-520). This work is integrated and coordinated with the Subregional Hydrology Project and is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Limited work was performed on the auxiliary analysis of the carbon system at YM. Key SwRI staff were not available to work on this auxiliary analysis. This problem is expected to be resolved in the next reporting period. The results of this work are intended to produce abstracted response surface models that can be used in the TPA code. This work is an integrated activity performed by the PA&HT, GS, and EBS staff. This work is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Significant progress was made on development of the 3D hydrostratigraphic model. Data from the 10 boreholes in the area of the 3D model boundaries have been added to the EarthVision system. Porosity and saturated hydraulic conductivity data have been input into the model on a unit-by-unit basis to distinguish hydrostratigraphic units. This work is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Work on the identification of site-specific dose parameters for the YM site continued. The purpose of this activity is to provide more representative dosimetry information for use in IPA Phase 3 calculations. Estimates for selected dose parameters for the Nevada Test Site were obtained from the literature. A 1990 census-based population grid for the YM region (100 Km radius) was generated from the EPA's GEMS code. Estimates of water use parameters were also calculated from available information. This work is being performed as an integrated activity between PA&HT and WSE&I staff. The preparation of the technical report was initiated. This work is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Limited work was performed on the development of a technical description for a new FAULTING module for IPA Phase 3 because key CNWRA staff were working on the Geology KTU integration team. This situation is expected to be resolved in the next reporting period. The goal of this activity is to develop a new module for the TPA code that accounts for the effects of faulting on waste package failure. When completed, a CNWRA report will be prepared and submitted on or before April 28, 1995, to the NRC to fulfill the milestone Report on Technical Description for Faulting Module (IM 5702-723-505). This work is being performed as an integrated activity between PA&HT and GS staff and is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Work was initiated on an updated assessment of the importance of key radionuclides for PA and compliance determination. The need for periodic assessments in this area arises from the following considerations: (i) shifting importance from a release to a dose standard, (ii) increased time of regulatory interest (potentially up to 1,000,000 yr), and (iii) recent improvements in understanding the release and sorption characteristics of radionuclides. The updated assessment will integrate the results from CNWRA research projects (e.g., Sorption Research Project) as well as utilize the results from IPA Phase 2, the SNL TSPA-93, and other recent studies. This work is being performed as an integrated effort among the GS, EBS, and PA&HT Elements. The result of this work will be documented and submitted to the NRC to fulfill a new milestone Letter Report on Assessment of Key Radionuclides (IM 5702-723-540). This work is being conducted under the scope described in the PA&HT Element Subtask 2.3 of the OPS.

Work continued on an auxiliary analysis of near-field thermally driven flow. The current work is focusing on a single waste package and is being studied using a quasi-steady state analytic model. The model can be used to estimate the thermohydrologic conditions out to approximately 5 m from the waste packages. This work is nearing completion and is being documented in a paper which will be submitted to the NRC to fulfill a new milestone Paper on Near-Field Coupled Liquid, Vapor, and Heat Transport (IM 5702-723-530). Results indicated that in the limiting case of diffusion-controlled vapor flow,

the near-field liquid profile is relatively insensitive to the permeability of the near-field medium. This work is being performed as an integrated effort with the EBS Element, and is in the scope of the PA&HT Element Subtask 2.3 of the OPS.

Work was initiated on the review of the Canadian EIS. B. Sagar attended a review group meeting at the Whiteshell Research Laboratory in Pinawa. The preliminary review comments were presented to the Canadian Ministry of Natural Resources. Contributions to a technical report containing peer review comments are being prepared. This work is being performed under the scope of PA&HT Element Subtask 4.1 of the OPS.

Assistance was provided to the NRC staff in the preparation of the IPA Phase 3 Plan. Reviews of an initial draft plan were conducted and comments provided to the NRC.

In the next period, the PA&HT Element will direct its efforts in the following areas: (i) participating in the KTU integration activity, (ii) finalizing the draft TP on Expert Judgment, (iii) continuing work on the auxiliary analyses (e.g., shallow and deep infiltration studies, carbon balance model, faulting, and volcanism modules), (iv) conducting integration meetings with PIs working on CNWRA research projects and related technical assistance activities, and (v) assisting with the IPA Phase 3 planning.

1.8 *Research*

Research Project 1—Overall Research

Planning for the Evans Workshop was completed. Arrangements for the workshop were developed in concert with UA—Prof. R. Bassett is the primary coordinator at Arizona. The workshop will be held January 31 to February 3, 1995, in Phoenix, Arizona, and conduct of the workshop will fulfill Hydrogeology MM 5704-001-095-005.

Coordination of material developed within individual research projects for inclusion in the CNWRA Semi-Annual Research Report (IM 5704-001-095-003) continued during this period.

A letter was sent to members of the program committee for the 1995 Materials Research Society Symposium on the Scientific Basis for Nuclear Waste Management outlining activities of the committee. A budget to support the symposium is in preparation and fund-raising inquiries have been initiated.

Preparation continued on the proceedings from the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment held in September 1994.

In the next period, the Evans Workshop will be conducted. The CNWRA Semi-Annual Research Report will be coordinated. Activities related to the organization of the 1995 Symposium on the Scientific Basis for Nuclear Waste Management and preparation of the Rock Mechanics Workshop proceedings are expected to continue.

Research Project 2—Thermohydrology

The Thermohydrology Research Project focused activities on two topics: (i) concluding final analyses, and (ii) preparing the final project report.

Final analyses of experimental results and the scaling laws were completed. These results were summarized for inclusion in the final report. The final report Thermally Driven Redistribution of Moisture in Partially Saturated Porous Media (CNWRA 95-005), was prepared and submitted to the CNWRA review process. The report documents the accomplishments, major findings, and recommendations produced by the Thermohydrology Research Project. Recommendations include a proposed field-scale heater experiment designed to test mathematical and conceptual models of thermally driven moisture flow through partially saturated, fractured porous media. The final report will be submitted to the external peer review panel and to the NRC on January 30, 1995, to fulfill the milestone Final Report (MM 5704-027-025-001). The comments and suggestions of the peer review panel will be incorporated in a revision of the final report. This revised report will be formatted for issuance as a NUREG/CR which will be submitted to the NRC on or before March 31, 1995, to fulfill milestone Final Peer Reviewed Report (IM 5704-027-025-002).

In the next period, work will continue in one area: resolving technical comments from the external peer review team and revising the final report as appropriate.

Research Project 3—Rock Mechanics

The Rock Mechanics Research Project focused activity in the following areas: (i) determining mechanical properties for simulated rock of the small-scale model of jointed rock mass and analyzing the experimental results of the small-scale model of jointed rock mass for Task 4, (ii) conducting MH laboratory study, (iii) preparing a report for Task 4 and three chapters for the DECOVALEX manuscript, and (iv) producing the CNWRA Semi-Annual Research Report.

Preparation for triaxial compressive tests on the simulated rock components continued. The results of the triaxial compressive tests will be used to establish the failure criterion of the simulated rock components that are needed for numerical modeling of the small-scale jointed rock mass shaking table experiments. The design and manufacture of a triaxial cell for the tests have begun. Analysis of the experimental results of the small-scale jointed rock mass shaking table tests continued. The objective of the analysis is to obtain a better understanding of the response of a jointed rock mass subjected to repetitive earthquake shaking and to generate a database that can be used for computer code verifications. Draft plots (more than a thousand) of the experimental results for the 21 test runs under various levels of simulated earthquake input signals were prepared. Each test run contains 50 channels of data for measurements of opening closure, shear and normal displacements of simulated joints, cable loads, and accelerations at various locations of the scale model. The results of the analysis and the triaxial compressive tests will be documented in a report that will be submitted to the NRC to fulfill the milestone Report for Scale Model Experiments (IM 5704-034-095-001). Preparation of the report component dealing with the experimental design and procedures continued. This report

component documents design aspects relating to the scale model experiments including test apparatus, rock mass simulants, measuring instruments, instrumentation layouts, earthquake input, assembly, and test procedures. The final version of a peer-reviewed paper entitled "A Scale Model Study on Seismic Response on an Underground Opening in Jointed Rock" has been prepared, taking into consideration the peer review comments, and submitted for presentation at the 35th U.S. Symposium on Rock Mechanics, Lake Tahoe, Nevada, in June 1995.

Preparation of three chapters for a DECOVALEX book, which is titled Mathematical Modeling and Experimental Studies of Coupled Thermo-Hydro-Mechanical (TMH) Processes in Fractured Media, continued. As part of Task 9, Chapter 7 of this book titled Distinct Element Models for Coupled THM Processes (IM 5704-039-095-001) has been completed and was submitted to the NRC on January 19, 1995. This chapter has also been submitted to the DECOVALEX Secretariat. The preparation of Chapter 15 titled Coupled MH of Single Rock Joints (IM 5704-039-095-002) is near completion. The preparation of Chapter 18 titled Dynamic Behavior of Rock Joints (IM 5704-039-095-004) continued. The second set of coupled MH experiments on single-joint specimens continued to study the potential effects of mechanical joint deformations (both normal and shear) on joint hydrological properties under saturated and various unsaturated conditions. Efforts continued towards developing a methodology that can be used for determining representative initial joint aperture, a property that is essential in modeling the MH experiments.

Preparation of the CNWRA Semi-Annual Research Report (IM 5704-038-095-001) continued during this period. The activities for organizing the external peer review of coupled TMH processes were initiated. Preparation of the proceedings for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment continued.

RDCO staff attended the 70th ACNW Meeting on January 19, 1995, to discuss the Rock Mechanics Research and the Technical Assistance Program in the Repository Design, Construction, and Operations Program and gave a presentation on the selected rock mechanics research findings related to the effects of repetitive seismic loads on subsurface facilities and their application to the technical assistance work.

In the next period, activities within the Rock Mechanics Research Project will include: (i) analyzing experimental results of the small-scale model of jointed rock mass; (ii) preparing the proceedings for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment; (iii) preparing the Report for Scale Model Experiments (IM 5704-034-095-001); (iv) preparing the Final Project Report (MM 5704-037-095-001) to summarize research findings relevant to seismic effects on jointed rock mass behavior related to a high-level nuclear waste repository; (v) conducting DECOVALEX MH experimental work; (vi) preparing two chapters for the DECOVALEX manuscript (IM 5704-039-095-002 and IM 5704-039-095-004); (vii) conducting activities associated with the external peer review of coupled TMH processes research; and (viii) preparing the CNWRA Semi-Annual Research Report (IM 5704-038-095-001).

Research Project 4—Integrated Waste Package Experiments (IWPE)

Long-term localized corrosion tests of alloy 825 at potentials above and below the repassivation potential are continuing. No localized corrosion has been observed on specimens held below the repassivation potential. An additional test, using an alloy 825 specimen with crevices on both polished and mill-finished surfaces, was initiated in an aerated 1,000-ppm chloride solution. The open-circuit potential of this specimen will be continuously recorded, and the specimen will be monitored for signs of localized corrosion during 28-day test intervals.

Stress corrosion cracking tests are continuing. A type 316L SS slow strain rate test specimen with a crevice-forming device placed on the gage length in 6.2 M NaCl with the addition of 0.01 M thiosulfate at 100 °C under potentiostatic conditions failed by stress corrosion cracking. An identical test using an alloy 825 specimen is planned. Slow strain rate tests conducted to date have shown that alloy 825 does not undergo significant stress corrosion cracking except in very concentrated (14 molal) chloride solutions. However, tests conducted in this reporting period have shown that even in 40 percent $MgCl_2$ (14 molal Cl^-), the introduction of a crevice decreases the time to failure compared to specimens tested in the same environment without a crevice. U-bend specimens of type 316L SS are presently being tested in both a 1,000-ppm chloride solution at 95 °C and a 1-molar chloride solution also at 95 °C. The specimens are oriented such that the apex of the U-bend is just above the vapor/solution interface. In previous tests in 1,000-ppm chloride with the addition of thiosulfate, severe corrosion and cracking were observed on 316L SS specimens

The analysis of the grain boundary precipitates in sensitized type 304L SS and alloy 825 was found to be affected by the electropolishing procedure prior to electron microscopy. The samples of alloy 825 polished in nitric + methanol mixture showed a relatively low chromium, high nickel (about 29 percent Cr and 39 percent Ni) carbide. On the other hand, electropolishing by perchloric + methanol or sulfuric + methanol mixtures of the same precipitates indicated 70 percent Cr and 10 percent Ni, which compares very well with carbide compositions found in the literature using a carbon replica technique. Similar results were observed for type 304L SS. It is surmised that the nitric acid + methanol mixture selectively dissolved chromium from the precipitates. Hence, analysis of chromium depletion due to sensitization is being carried out using the perchloric + methanol polishing procedure.

The nomination of outside experts for the IWPE Project peer review panel was completed. A list of main candidates and alternates has been prepared after screening for potential COI. This list has been conveyed to the PEM at the NRC. The potential reviewers will be contacted to determine availability and to obtain documentation for evaluating the COI requirements.

A paper entitled Effects of Surface Chromium Depletion on the Localized Corrosion of Alloy 825 as a High-Level Waste Container Material has been accepted for publication in the *Corrosion Journal*. It will be sent to the NRC as an intermediate milestone (IM 5704-041-141). The IWPE chapter for the CNWRA Semi-Annual Research Report (IM 5704-046-100) was completed.

Long-term localized corrosion tests on alloy 825 will continue. Additional slow strain rate tests of alloy 825 and U-bend tests of type 316L SS under crevice conditions in NaCl solutions will be conducted. Electron microscopy of the precipitates in alloy 825 will continue as part of Task 3.

Research Project 5—Geochemical Analogs

Fracture aperture data from 219 fractures on the Level +10 surface of the Nopal I deposit were entered into the ARC/INFO database and compared to contact gamma intensity measurements made on Level +10. This comparison indicated no significant correspondence between fracture aperture and gamma intensity ($r^2 < 0.05$). Gamma intensity at the Nopal I deposit has been shown to be a reliable indicator of uranium concentration, so these results suggest an absence of correlation between fracture aperture and uranium concentration on Level +10. This lack of correspondence may be a function of the transport characteristics of the fracture network, or it may result from the scale of the measurements. The contact gamma measurements were carried out on a 1 m × 1 m grid (1,489 measurements) that may have been too coarse to resolve detailed relationships to fracture aperture variations. Efforts continued to develop a meaningful quantification of the fracture roughness profiles measured from the same fractures on which aperture data were collected.

Interpretation continued of electrical conductivity profiles measured at 17 locations spanning the entire Nopal I formation. These measurements and interpretations are designed to evaluate the possibility of a perched water zone at the Nopal I analog site.

Alpha spectrometry analyses on Nopal I samples continued. Ten additional samples from the 13.5 m N fracture were measured for U/Th isotopes; results showed that $^{234}U/^{238}U$ ratios fit with earlier interpretations suggesting movement away from the deposit. TEM analysis of material from the 13.5 m N fracture also continued. Several samples have been prepared for viewing and EDS analysis. Initial analyses indicate that mineral phases can be identified by their morphology (e.g., goethite has a laminar texture whereas jarosite has a granular texture). Additional work will focus on determining whether U occurs within the iron oxides or as part of discrete phases within the iron oxides. XRD analyses of whole rock samples from Level +00 have been unable to detect the presence of zeolites in or near the deposit. Mineral separation will be required to resolve whether zeolites occur in minor or trace quantities (< 2%) in the vitrophyre.

Information was compiled for the Geochemical Natural Analog Project portion of the CNWRA Semi-Annual Research Report (IM 5704-065-095-002) and the report was written. The subject of the report is a comparison of flow and transport model results for the Akrotiri analog site with data for the nature of the contaminant plume obtained by analyses of field samples. Implications are developed with regard to analog system support for YM repository modeling.

In the next period, the Geochemical Analog Research Project activities are anticipated to include: (i) interpretation of fracture roughness profiles from Nopal I, (ii) continued mineralogic study of Nopal I samples, (iii) continued modeling of flow and transport at

the Akrotiri site, (iv) interpretation of Nopal I formation conductivity measurements, (v) continued hydraulic characterization of Cape Riva and Minoan tuff, (vi) continued alpha and gamma spectrometry measurements of Nopal I samples, and (vii) completion of the Geochemical Natural Analog Project portion of the CNWRA Semi-Annual Research Report.

Research Project 6—Sorption Modeling

Scoping experiments were conducted to evaluate the effects on Np sorption of (i) adjusting solution pH with NaOH instead of $NaHCO_3$, and (ii) closing experimental containers to prevent equilibration of solutions with atmospheric $CO_2(g)$. The experiments used clinoptilolite as the mineral substrate, solution concentration of 1×10^{-6} m Np, and M/V ratio of 4 g/L. These experimental parameters are the same as those used in initial Np sorption experiments on clinoptilolite. Four solutions, adjusted to pH 8, 9, 10, and 10.5, were used. Results of the sorption phase of the experiment indicate that near pH 8, a similar amount of Np sorption occurred (~3 percent), however, above pH 8.5, no desorption edge appeared in the NaOH adjusted solutions in contrast to what had been observed in solutions adjusted with $NaHCO_3$. The maximum Np sorption observed was about 8 percent at pH 10.5. This is more than twice the maximum sorption observed in the experiments with added carbonate.

Based on the results of the above scoping experiment, additional experiments that will investigate sorption of Np on quartz and clinoptilolite over a pH range of 4–11 have been initiated. Experimental solutions will be capped immediately after adjustment of pH to prevent equilibration with atmospheric $CO_2(g)$. To facilitate comparison, Np concentration and M/V ratios will be the same as previous experiments where pH was adjusted using $NaHCO_3$.

Experiments were completed to determine if clinoptilolite can be loaded with sufficient U for studies using EXAFS spectroscopy, which requires a minimum of 5000 ppm U on the solid to generate well-resolved spectra. The EXAFS work will be used to derive structural and chemical information on sorbed uranium and will be conducted using the Stanford synchrotron light source. Two sorption mechanisms are of interest in this study, namely, ion-exchange and surface-adsorption; experimental conditions were optimized in order to load clinoptilolite with these two different mechanisms. U ion-exchange was conducted at low pH where the uranyl ion UO_2^{2+} is the predominant aqueous species, whereas U surface-adsorption was done at pH between 6 and 6.5, which is the pH-range in which surface-adsorption reaches a maximum. Analysis of U concentrations desorbed from the solid indicated that one ion-exchanged clinoptilolite was loaded with about 13,000 ppm U and one surface-adsorbed clinoptilolite was loaded with about 3,800 ppm U. These samples will be loaded onto EXAFS sample cells and will be analyzed sometime during the next two report periods.

Preliminary work has begun for experiments on plutonium sorption. Activities included literature work, procurement of supplies, calculations, planning, and initial solution preparation. The possibility of conducting, in collaboration with another lab, measurements of Pu speciation in our experimental solutions is being investigated.

The topical report A Uniform Approach to Surface Complexation Modeling of Radionuclide Sorption (IM 5704-074-183) was completed and submitted to the NRC for programmatic review. Input into the CNWRA Semi-Annual Research Report (IM 5704-074-182) was completed. An extended summary entitled Uniform Surface Complexation Approaches to Radionuclide Sorption Modeling was revised and accepted for presentation at the 1995 IHLRWM Conference to be held May 1-5, 1995, in Las Vegas, Nevada. Camera-ready mats are being prepared for publication in the proceedings volume. Preparation of a peer-reviewed paper Experimental and Modeling Study of Uranium(6+) Sorption on Quartz (IM 5704-074-184) continued.

During the upcoming period, work will focus on completing the peer-reviewed paper on uranium-quartz sorption experiments and continuing experiments on Np sorption on quartz and clinoptilolite. Experiments on Np sorption on montmorillonite will also be initiated. Evaluation of analytical and experimental techniques for Pu sorption experiments will also continue.

Research Project 7—Volcanic Systems of the Basin and Range

Work during this period focused on completion of reports reviewing the CNWRA Volcanism Geographic Information System (GIS) database (MM 5704-123-020) and the expert-panel review of CNWRA Volcanism Research (IM 5704-125-050). Preparation of the CNWRA Semi-Annual Research Report (IM 5704-125-040-002) also continued during this period.

Data contained in the CNWRA Volcanism GIS are sufficient to test some volcanism probability models, if reasonable bounding assumptions are placed on the geochronological data. The development and testing of many magmato-tectonic models is limited by the low resolution of mapping and the absence of critical geochronologic and tectonic data for most volcanic fields in the WGB. CNWRA research on probability and magmato-tectonic models for the YMR will need to account for these significant uncertainties in the available data.

During the next period, work will continue on the CNWRA Semi-Annual Research Report (IM 5704-125-040-002) and preparation for the Geomatrix volcanism probability modeling meetings which will be held next month in Phoenix, Arizona.

Research Project 8—Regional Hydrogeologic Processes

The Regional Hydrogeologic Processes Research Project made progress on preparation of a report summarizing activities conducted in Task 1 (Collect and Analyze Data and Existing Models), in Task 2 (Conceptual Model Development), and in Task 3 (Computational Model Development).

Preparation of the letter report describing the GIS database continued. This database will include data describing the hydrogeologic regime of the greater Death Valley region. The report will be submitted to the NRC to fulfill the milestone Letter Report on Collected Data and GIS System (IM 5704-131-401), which has been rescheduled to mid-

April. In addition, review of newly released data and literature continued. This work was conducted under Task 1 of the Regional Hydrogeologic Processes Project Plan.

The recently constructed steady-state potentiometric surface map has been undergoing continuous revisions based on information gleaned from detailed investigation of each of the thousands of boreholes at which measured water levels were obtained. Where measurements of the elevation of the tops of the lithologic units penetrated by a borehole are available, hydrostratigraphic columns have been constructed. The hydrostratigraphic columns are being used to determine whether the inferred steady-state water level represents hydraulic conditions in the upper aquifer, which is composed of both the Tertiary Tuff and Valley-Fill aquifers, or in the lower aquifer composed primarily of Paleozoic units. This work was conducted under the scope of Task 2 of the Regional Hydrogeologic Processes Project Plan.

The methodology developed for estimating the spatial distribution of average annual precipitation in the Death Valley region based on a combination of kriging with an external drift and non-intrinsic kriging with a spatial trend surface has been refined. Attempts to use cross-validation statistics to select the semivariogram model produced results that made little physical sense, consequently, this method was abandoned. Ultimately, model semivariogram parameters were determined by fitting the models to the sample semivariograms using simple nonlinear least squares. Two methods were used to estimate the external drift models defining the altitude dependence of average annual precipitation: (i) ordinary least squares, and (ii) generalized or weighted least squares. Because the variance of the measured average annual precipitation is greater for high altitude precipitation stations, the generalized least squares model tends to significantly underpredict precipitation in the mountains. Recharge was determined from the areal precipitation estimates using the empirical Maxey-Eakin formula. This work was conducted under the scope of Task 3 of the Regional Hydrogeologic Processes Project Plan.

Work will continue on summarizing existing data and literature from the Death Valley Region for the GIS letter report. Future activities will continue to focus on evaluating the relationship between contemporary regional stress and the anisotropy of fractured rock hydraulic properties, and developing alternative conceptual models of local and regional flow systems. During the next two periods, work will commence on developing geologic cross-sections and constructing a 3D hydrostratigraphic model of the region.

Research Project 9—Field Volcanism

Preparation of the CNWRA Semi-Annual Research Report (IM 5704-145-002) and completion of the Expert-Panel Review Report (IM 5704-125-050-000) were the main activities during this reporting period. Work also continued on developing process models for cinder-cone cooling, using data from Tolbachik Volcano collected in the summer of 1994. Compilation and documentation of the field studies at the Tolbachik volcanoes continued at a low level through this period.

Models were developed for heat and mass transfer processes around cooling dikes during this period. These models include a simple 1D time-transient heat conduction model

(analytical), a 1D time-transient finite difference model which handles various interfaces and changes in rock thermo-physical properties, and modification of the VTOUGH code to handle the higher temperature conditions associated with dike emplacement. Preliminary models indicate that dry-out zones develop extremely rapidly around intruding dikes and these zones extend outward for 10–30 m from the dike. Beyond these dry-out zones, water vapor content in the unsaturated rock increases dramatically. One preliminary interpretation of field data, based on these model results, remains that significant alteration is difficult or impossible to develop close to dikes because of the dry-out effect, even though high temperatures can persist for a long time. In addition to this modeling effort, a literature review was initiated to investigate the thermo-physical properties of rock as a function of water content in the vapor phase in pore spaces, porosity, permeability and related rock properties, and rock temperature. One early but important conclusion is that the bulk thermal conductivity of basaltic scoria or tuff gravel decreases by more than one order of magnitude with increasing porosity. This increases the cooling time required for dikes tremendously in porous and permeable media. Data collected at Tolbachik cinder cone and at dikes near Tolbachik can be modeled using these lower thermal conductivities and additional heat sources from depth are not required.

Detailed petrographic studies on Tolbachik and YMR scoria as well as development and testing of thermal models will continue. Emphasis in model development will be placed on determining the field data and tests that will most successfully constrain models, in anticipation of additional field work at Tolbachik in the summer of 1995.

Research Project 10—Tectonic Processes

Slip- and dilation-tendency analyses continued, and work has begun to evaluate potential affects of fluid pressure on slip and dilation tendency. Slip- and dilation-tendency analyses will be used to refine tectonic models, to assess risk of slip on mapped faults and the susceptibility of faults and fractures for magma intrusion and groundwater flow. Slip- and dilation-tendency analyses are the primary topics of the CNWRA Semi-Annual Research Report (IM 5704-167-005) that has been completed. Those analyses will be incorporated in the critical review of compiled tectonic data that will be reported in Critical Data Review NUREG/CR (MM 5704-167-004).

Fission track analyses of apatite grains from the first five fission-track samples are yielding preliminary results. Cutting of samples from Bare Mountain, collected for paleomagnetic analyses, was continued in preparation for paleomagnetic analyses which will be performed at the University of Michigan in February. Field studies at Bare Mountain (including fission-track, paleomagnetic, and microstructural analyses) are being performed to constrain the 3D movement of Bare Mountain. This is critical to understanding faulting at YM, because of the possible linkage of the Bare Mountain fault and YM faults at depth. The Bare Mountain fault may be able to support large earthquakes and trigger slip and aftershocks on the YM faults.

Design of the analog modeling apparatus to perform 3D structural analog modeling was completed. Tectonics research staff have been acquiring necessary equipment and materials for the analog modeling lab. Review of literature on analog modeling

(especially materials and scaling properties), strike-slip faulting, and strike-slip releasing bends (e.g. Death Valley and possibly Crater Flat Valley) continued. Analog modeling will be used to evaluate patterns of 3D faulting in strike-slip releasing bends in order to constrain tectonic models of the Death Valley region and the YM-Crater Flat region.

Review of the CNWRA Semi-Annual Research Report (IM 5704-167-005) will be completed during the next period. Compilation of data to constrain detailed cross sections through Bare Mountain and analysis of internal deformation of extensional fault blocks will continue. Preparation of samples for paleomagnetic analysis will continue, and the samples will be transported to the University of Michigan for paleomagnetic analyses. Counting of apatite fission tracks is planned to continue. Literature review and planning of the first round of analog models will continue. Field work is planned at Bare Mountain to study field relationships of faults, layering, and mesoscopic structures, and to collect samples for analyses of microstructures within fault blocks and adjacent to normal faults. Preparation of previously collected samples for microstructural analyses is expected to begin during the next period. The microstructural analyses are intended to determine the deformation mechanisms that were active during faulting, which can be used to interpret the conditions (e.g. temperature, pressure, depth) during deformation.

Research Project 11—Subregional Hydrogeologic Flow and Transport Processes

The project plan has undergone peer-review by Dr. M.Th. van Genuchten. In general, the reviewer had very favorable comments to offer. His comments will be submitted to the NRC staff by January 31, 1995. This will satisfy the milestone Project Plan Peer Review (IM 5704-171-094-001). This work is being conducted under the scope described in Task 1 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Work continued on enhancing the CNWRA hydrogeologic model. The Bullfrog unit has now been included in the model. After procurement of the geostatistical package ISATIS software, it will be used for geostatistical analyses of hydraulic parameter data and subsequent lithologic horizon generation and/or refinement. An extended summary entitled Evaluation of Uncertainty in Geological Framework Models at Yucca Mountain was accepted for presentation at the 1995 IHLRWM Conference to be held May 1-5, 1995 in Las Vegas, Nevada. Camera-ready mats are being prepared and will be submitted for publication in the proceedings volume. This work is being conducted under the scope described in Task 3 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Identification of potential focused recharge zones at YM using the ARC/INFO GIS continued. Modifications to a DEM shading application called GEOVIEW have been implemented. The new shading option will be tested against a similar ARC/INFO option. The modified numerical tool produced by this activity will be used in estimating evapotranspiration rates at the surface of YM. The ARC/INFO GIS database management package was investigated under Subtask 4.1. A DEM, accurate to within 1 m on a 30-m by 30-m grid, is available at the CNWRA in ARC/INFO format. Using this DEM grid, all of the ARC/INFO functions required to generate the elevation-related recharge indices described in Subtask 4.1 were tested; all but the WATERSHED

function worked properly. A literature review is currently being conducted to identify methods and associated public domain software that is capable of calculating run-on potential using DEM information. Under Subtask 4.2, the CSCS, a synthetic weather generator with associated parameter estimation programs developed at MIT, was scanned from the listing in the documentation. As the scanning process is not perfect, a number of typographical errors accumulated; several compilers were used to identify errors. Development of a test input set started, based on 10 yr of hourly weather readings from the National Weather Service station at Desert Rock, Nevada. An extended summary entitled Estimation of Spatial Distribution of Recharge Factors at Yucca Mountain, Nevada was accepted for presentation at the 1995 IHLRWM Conference to be held May 1-5, 1995 in Las Vegas, Nevada. Camera-ready mats are being prepared and will be submitted for publication in the proceedings volume. This work is being conducted under the scope described in Task 4 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Borehole mineralogy and isotope chemistry data have been entered into spreadsheets, and ASCII files have been developed for boreholes that are currently available in the 3D hydrogeological framework model. Data on borehole mineralogy from LANL reports have been added to the 3D hydrogeological framework model for boreholes G-1, G-2, G-3/GU-3, and G-4. Additional data will be imported during the next period. An extended summary entitled Characterization of the Potential for Perched Water Development at Yucca Mountain, Nevada was accepted for presentation at the 1995 IHLRWM Conference to be held May 1-5, 1995 in Las Vegas, Nevada. Camera-ready mats are being prepared and will be submitted for publication in the proceedings volume. This work is being conducted under the scope described in Task 5 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Work continued in modifying GEM to incorporate partially saturated porous media flow conditions. The model will be initially applied to deposition of calcite in the near-surface environment. Work was started on incorporating enhancements to the numerical code CTOUGH. These code upgrades were found to be imperative so that large-scale flow and transport simulations can be conducted. At present, the CTOUGH code is not capable of handling: (i) rugged topographic relief, (ii) a large number of computational blocks, (iii) heterogeneous soil properties, (iv) time-varying boundary conditions, and (v) gravity drainage boundary conditions. This work is being conducted under the scope described in Task 6 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

CNWRA staff travelled to Tucson and Superior, Arizona, in order to interact with the NRC PO and the UA group and visit the Apache Leap Tuff Site. Deliberations between the two groups went well and a tentative first plan of collaboration was agreed upon. This work is being conducted under the scope described in Task 7 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Work in the next period will involve the continuation of all activities.

Research Project 12—Performance Assessment (PA)

The PA Research project made significant progress on the following activities: (i) revision of the technical report on the BREATH computer code, (ii) benchmarking NRC/CNWRA and DOE PA codes, (iii) implementing PVM technology in the TPA code, and (iv) documenting progress in the semi-annual research report.

Revision of the technical report entitled BREATH Version 1.0—Coupled Flow and Energy Transport in Porous Media, Simulator Description and User Guide (CNWRA 94-020) was completed. The revised report addresses the comments of the NRC Project Officer and was formatted for issuance as a NUREG/CR. Delivery of the revised report will be designated as an AI. This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

Benchmark testing of the DOE two-phase flow codes continued. This work is being conducted to determine the capabilities and limitations of the DOE codes used to evaluate the extended-dry concept. This information will be beneficial to future reviews of DOE PAs. The DOE two-phase flow codes V-TOUGH, TOUGH2, and FEHMN are being compared against the CNWRA codes PORFLOW and CTOUGH (an extension of V-TOUGH). All five codes were set up and run on three test problems. Results from two of the test problems showed good to excellent agreement among the codes. The third test case, which was more challenging, posed difficulty for the PORFLOW and FEHMN codes. This testing led to discovering an error in the FEHMN code. This work will be documented in a technical report that will be designated as a new milestone. This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

To evaluate the effectiveness of parallel computation methodology in PA, the IPA total-system code, TPA, is being modified to run in heterogeneous computing applications on a number of SUN workstations. Under the control of the PVM software, the various workstations will execute separate realizations that will be combined by an executive program. The original TPA code is designed to execute subprocesses by spawning separate programs; this spawning process will be put under the control of the PVM software. Although the spawned programs correctly execute, a system error results upon the completion of the subprogram execution. The error was reported to SUN for clarification and resolution. In the interim, the latest version of the PVM software was obtained and installed. Significant aspects of this activity will be documented and submitted to fulfill the milestone Topical Report on Evaluation of Parallel Virtual Machine Computing (IM 5704-192-500). This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

A draft technical paper was written on a new computational technique for solving the nonlinear Richards' equation for unsaturated flow. The paper will be submitted for journal publication. The objective of the research presented in the paper was to develop numerical techniques that are more robust, accurate, and computationally efficient. Selected results of this paper will be presented at the Third SIAM conference on Mathematical and Computational Issues in the Geosciences. The key aspects of this and other planned work will be documented in a technical report that will be submitted to

fulfill the milestone Topical Report on Advanced Computational Methods in PA (MM 5704-192-505). This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

Preparation for the Semi-Annual Research Report (IM 5704-194-500) was completed. The chapter summarizes work conducted on conceptual model development (Task 1) and model evaluation (Task 3). This work is being conducted under the scope described in Task 4 of the PA Research Project Plan for FY94–95.

In the next reporting period, research activities will include: (i) continuing benchmark testing of the DOE two-phase flow codes, (iii) continuing evaluation of PVM technology for use in IPA, and (iv) finalizing the NUREG/CR version of the report on the BREATH code.

1.9 *Waste Solidification Systems (WSS)*

The meeting report was completed for the December follow-up meeting to discuss resolution of comments on the Vitrification SAR (WVNS SAR-003, Rev 2, Draft C) with WVDP personnel, December 6–8, 1994, at Buffalo, New York. In addition, a meeting with the DNFSB and NRC was attended by CNWRA and SwRI staff for the purpose of discussing the ongoing review of the SAR-003 on the Vitrification Operation and High-Level Waste Interim Storage.

Initial activities associated with development of the SER on the SAR-003 were begun upon receipt of Draft D, dated December 30, 1994. Additional supporting information on the SAR-003 review was received from WVDP in the form of a December 28, 1994, letter, which included enclosures detailing WVDP responses to comments, which had not been transmitted to the Joint Review Group during the previous SAR-003 review. A telephone meeting with NRC was held to discuss the tentative schedule for production of the SER. Revisions were made to the WSS Operations Plans to reflect the anticipated schedule for production of the SER.

CNWRA and SwRI staff plan to meet with NRC and WVDP staff to discuss technical issues and resolution of outstanding comments at the WVDP facility during the week of February 13, 1995. An intermediate milestone Comment Resolution with WVDP (IM 5706-002-525) has been identified for completion by February 28, 1995. The completion date for the Draft SER on the Vitrification Process is set for April 17, 1995.

2. MANAGEMENT ISSUES

None.

3. MAJOR PROBLEMS

None.

4. SUMMARY OF SCHEDULE CHANGES

Table 2 provides formal documentation of schedule changes for IMs that occurred during the preceding period or are anticipated to occur during the subsequent period. Each item listed has been discussed with the cognizant NRC PEM and other parties, as appropriate.

5. SUMMARY OF FINANCIAL STATUS

Table 3 summarizes the CNWRA financial status in the context of authorized funds established by the NRC. Total commitments of the CNWRA are $356,198. Appendix A lists planned and actual costs to date, without allowance for fee, on both a per-period and a cumulative basis. Furthermore, 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 DWM JC, the RES DRA JC, and the DIMNS JC, as well as for each Program Element and Project. This information is provided in both graphical and tabular form.

CNWRA Program

The CNWRA Composite Period 4 cost variance between estimated and actual spending is 14.7 percent. This variance shows a slightly larger net underspending for the entire program. The CNWRA still remains committed to meet or slightly exceed the 54 FTE staffing level during the first half of this fiscal year. Spending on consultant labor, especially in the RES JC, and spending on SwRI labor, especially in the DWM JC, has been generally moderate. Work and associated spending on the Near-Field Processes Project awaits approval of the plan by NRC. Historically, Period 4 and, to some extent, Period 5 have experienced a greater difference between estimated and actual spending because of CNWRA staff time related to holidays and vacations. Notwithstanding over/under spending in individual elements/projects, both the DWM and RES DRA JCs are operating at comparable levels of underspending.

DWM JC

The DWM JC cumulative cost variance for Period 4 has increased over the previous two periods.

Reactive work is proceeding at a reasonable pace, and LARP-related activity for CDM development has remained constant and strong for the last three periods, showing an approximately 20 percent overrun to date. Accelerated activity in field verification activities has accounted for increased spending in the QA area—essentially a 100 percent increase from last period, although it remains underspent. Spending for activities related to site characterization reviews, although greater than last period, shows an almost constant variance for the last two periods. The greatest underrun is in the NWPA Regulatory Requirements and Technical Guidance Task, which accounts for more than a third of the total DWM cost variance. Spending declined in the SRA and CNWRA Operations Task as the result of reduced expenditures for RPD/OITS development, maintenance, and operation, as well as TDOCS software applications, and relatively constant spending on the CNWRA LAN and firewall security system management and implementation.

The DWM JC cumulative cost variance is 15.9 percent.

The COPS Element cost variance is 5.6 percent. Spending in this element was expected to be less than planned because this period encompasses several holidays, and some staff use this period for taking vacations.

The WSE&I Element cost variance is 8.6 percent. This trend in slight underspending is expected to continue for the next two periods due to current scheduling conflicts.

The EQA Element cost variance is 41.7 percent. This is due postponements of several early DOE audits and concentration by the NRC on the M&O organization audits. The underspent condition is also due to the regular DOE schedule of audits which typically are weighted in number toward the last half of the FY. There has been no NRC-directed work in the Field Verification Subtask as of this date.

The GS Element cost variance is 27.0 percent. This reflects a 23.4 percent underrun in Geology and Geophysics and a 29.1 percent underrun in Hydrology, Geochemistry, and Climatology. It is anticipated that these underruns will be reduced as a result of the increased effort going into the integration of the KTUs and development of the CDMs addressing surface processes.

The EBS Element cost variance is 5.4 percent. The scope of activities and the expenditures are expected to continue to track close to planned spending. The EBSPAC development activities increased, and activities in the prelicensing interactions area continued at a moderate level. Accelerated work performed earlier in the glass compendium report review slowed during this period.

The RDCO Element cost variance is 14.2 percent. This variance largely reflects underspending in Subtasks 1.1 and 1.2, due to a lack of tasking in DBE Rulemaking and NWPA Mandated Actions, and a delay in processing of travel expenses and consultant billings for In-Field Verification (Subtask 3.1) and Major Design Report Reviews (Subtask 4.2).

The PA&HT Element cost variance is 29.2 percent. This variance largely reflects underspending in IPA (Subtask 2.3), Model Validation Strategy (Subtask 1.3), and LARP Development for PA (Subtask 2.1). Underspending in IPA has occurred because of the unavailability of key CNWRA staff and delays in completing IPA Phase 3 planning. Underspending in the other subtasks occurred because of: (i) no tasking for Model Validation, and (ii) delays in the KTU integration/consolidation and CDM preparation activities. Progress and associated spending for these subtasks is expected to improve in the next few months. Consultants will be used to accelerate progress and compensate for the current lack of staff. In addition, efforts to fill the open PA position will be pursued more aggressively.

RES DRA JC

Several factors have contributed to the cost variance for the RES JC. These include: (i) delayed authorization/funding for the High-Level Waste Near-Field Processes and Variations research project, (ii) unachieved staffing level of 54 FTE, (iii) inclusion of budget but lack of statement-of-work for a follow-on materials research project, and (iv) net underspending among certain research projects, especially Overall Research, Rock Mechanics, IWPE, Field Volcanism, Regional Hydrology, and Tectonic Processes.

Actual expenditures are expected to remain generally consistent with estimates for at least the next two periods.

The RES DRA JC Period 4 cumulative cost variance is 13.1 percent.

The cost variance for the Overall Research Project is 22.9 percent. Costs associated with the Evans Workshop are anticipated to reduce this variance in coming period. Future costs may continue somewhat below estimated values, however, until activity occurs on the anticipated Hydrogeology Research Project and the planned Geology Workshop.

Cost variance for the Thermohydrology Research Project is currently 18.4 percent. This high cost variance is expected to be eliminated in the next reporting period as a result of the large team used to accelerate completion of the deliverable for the MM. Final core-staff costs and consultant fees are expected to bring the actual budget close to the projected budget. Sufficient funds remain in the current budget to ensure a timely and successful completion of the Thermohydrology Project.

The Rock Mechanics Research Project cost variance is 24.5 percent. This variance is due to the current low level of effort on prelicensing activities, organizing the external peer review of coupled TMH processes research (Task 6), and preparation of the Final Technical Report (Task 7). These activities are expected to increase during the next few periods to increase the spending levels.

The IWPE Research Project cost variance is 29.8 percent. The variance reflects the continued delay in retaining a microbiologist and, hence, the spending rate in Task 4 is lower than anticipated. However, the spending in Task 3 has been higher than anticipated due to the increased effort in testing and analysis. It is anticipated that the costs in this project will be less than planned for the next two reporting periods.

The Geochemical Natural Analog Research Project cost variance is 1.8 percent.

The Sorption Research Project cost variance is −17.5 percent. The level of spending is expected to approach the planned level in coming periods as work is conducted in the Near Field Processes Project and in other CNWRA tasks.

Volcanic Systems of the Basin and Range Research Project cost variance is −60.8 percent. This is due to a large effort to prepare and/or submit three deliverables and one peer-reviewed paper in Period 4. The spending rate is expected to decrease over the next few periods.

The Regional Hydrogeologic Processes Project cost variance is 33.1 percent. This large cost variance is due to: (i) the PI being temporarily assigned to completion of other research, KTU integration and GWTT activities, and (ii) the need for additional hydrogeologist support. Although the cost variance for this period is lower than the previous period, the spending rate for the project is not expected to increase markedly until the new hydrogeologist is hired.

The Field Volcanism Project cost variance is 37.7 percent. Underspending was due to staff being occupied in activities related to NRC-DWM technical support and preparation of reports for the

Volcanic Systems of the Basin and Range Research Project. Underspending will continue until fieldwork is started in the spring.

The Tectonics Research Project cost variance is 22.6 percent. This reflects continued deliberate underspending in anticipation of an increased level of activity early in 1995 with the initiation of analog modeling, increased field work, paleomagnetic and fission track data collection, and computer modeling activities.

The cost variance for the Subregional Research Project is 5.8 percent. The spending rate has increased as a result of activities being initiated in various tasks of the Project.

The PA Research Project cost variance −0.9 percent. This small cost variance reflects the continued efforts to maintain effective cost control.

DIMNS JC

At the end of the fourth period, WSS expenditures for FY95 are 4.5 percent below planned levels. Significant activities in Task 2 are currently under way. These involve interactions with the DOE on the Vitrification SAR. Also, the NRC is scheduled to issue the SER for the Vitrification SAR during the second and third quarter of FY95. The expenditures will be above the planned levels for the next three reporting periods.

Table 1. CNWRA Core Staff—Current Profile and Hiring Plan* (01/20/95)

EXPERTISE/EXPERIENCE	CURRENT NO.	PROFESSIONAL STAFF	POSITIONS OPEN FY95
ADMINISTRATION	5	W.PATRICK, H.GARCIA, P.MACKIN, J.RUSSELL, B.SAGAR	
CODE ANALYST	2	R.JANETZKE, R.MARTIN	
DATABASE MANAGEMENT AND DATA PROCESS	2	A.JOHNSON, A.JACOB	
ELECTROCHEMISTRY	1	G.CRAGNOLINO	
ENGINEERING GEOLOGY/GEOLOGICAL ENGNG	1	G.OFOEGBU	1
ENVIRONMENTAL SCIENCES	1	P.LaPLANTE	
GEOCHEMISTRY	5 (1)†	W.MURPHY, R.PABALAN, E.PEARCY, J.PRIKRYL, D.TURNER, P.BERTETTI†	
GEOHYDROLOGY/HYDROGEOLOGY	5	A.BAGTZOGLOU, R.GREEN, A.B.GUREGHIAN, S.STOTHOFF, G.WITTMEYER	1‡
GEOLOGY	2	L.McKAGUE, M.MIKLAS	
INFORMATION MANAGEMENT SYSTEMS	2	R.JOHNSON, R.MARSHALL	
MATERIAL SCIENCES	4(1)**	P.NAIR, H.MANAKTALA, M.SRIDHAR, D.DUNN, J. Song**	
MECHANICAL, INCLUDING DESIGN & FABRICATION	1	C.TSCHOEPE	
MINING ENGINEERING	1	S-M.HSIUNG	
NUCLEAR ENGINEERING	1	H.KARINI	
NUMERICAL MODELING/SIMULATION	1	M. JARZEMBA	
PERFORMANCE ASSESSMENT	3	R.BACA, R.MANTEUFEL, S.MOHANTY	1
QUALITY ASSURANCE	2	B.MABRITO, R.BRIENT	
RADIOISOTOPE GEOCHEMISTRY	1	D.PICKETT	
REGULATORY ANALYSIS	1	S.SPECTOR (law)	
ROCK MECHANICS	3	A.CHOWDHURY, M.AHOLA, A.GHOSH	
SEISMOLOGY	1	R.HOFMANN	
SOURCE-TERM/SPENT FUEL DEGRAD	1	P.LICHTNER	
STRUCTURAL GEOLOGY/SEISMO-TECTONICS	2	G.STIREWALT, D.FERRILL	1
SYSTEMS ENGINEERING	1	A.DeWISPELARE	
VOLCANOLOGY/IGNEOUS PROCESSES	2	C.CONNOR, B.HILL	
TOTAL	51 (2)		3 (1)‡

* SEE STAFFING PLAN FOR DETAILS
† LIMITED TERM
‡ ADDITIONAL POSITION TO IMPLEMENT AGGRESSIVE HIRING PLAN
** VISITING SCIENTIST, LIMITED TERM

Table 2. Summary of Schedule Changes

Milestone Number	Type	Description	Original Date	Revised Date	Rationale for Change
5702-156-510	IM	TDOCS Design Report	01/30/95	03/03/95	Per NRC direction, this report requires additional information. Change of scope is being negotiated and in approval process.
5702-221-511	IM	Letter Report on Recommended NRC Actions to Address KTUs	01/30/95	02/28/95	Competing staff priorities is the cause for the delay.
5702-421-502	IM	CDM for RRT 3.2.1.5 — Structural Deformation	05/01/95	TBD FY96	Rescheduled to accommodate surface processes CDMs.
5702-421-504	IM	CDM for RRT 3.4 — Natural Barriers	07/03/95	TBD FY96	Deleted to accommodate surface processes CDMs.
5702-421-506	IM	CDM for RRT 3.2.1.1 — Nature and Rates of Physical Processes	09/30/95		Added to address high level finding for surface processes.
5702-421-507	IM	CDM for RRT 3.2.1.2 — Minimum Waste Emplacement Depth	09/30/95		Added to address high level finding for surface processes.
5702-421-508	IM	CDM for RRT 3.1.1. — Geologic Systems Description	09/30/95		Added to address high level finding for surface processes.
5702-423-501	IM	CDM for RRT 3.2.2.5 — Flooding	01/08/95	02/23/95	Date changed at NRC request during CCL meeting of 01/19/95.
5702-423-504	IM	CDM for RRT 3.2.2.11 — Potential for Water Table Rise	TBD FY95	TBD FY96	Deleted to accommodate surface processes CDMs.

Table 2. Summary of Schedule Changes (Cont'd)

Milestone Number	Type	Description	Original Date	Revised Date	Rationale for Change
5702-423-505	IM	CDM for RRT 3.2.2.12 — Perched Water Bodies	09/30/95		Added to address high level finding for surface processes.
5702-423-506	IM	CDM for RRT 3.2.2.10 — Complex Engineering Measures	09/30/95		Added to address high level finding for surface processes.
5702-425-502	IM	Letter Report on Status of GIS Database	01/30/95	02/28/95	In order to perform a more comprehensive review of data on CD-ROM disk.
5702-425-504	IM	Assessment of Coupled Faulting and Magmatic Dike Intrusion Process	06/30/95	09/29/95	To allow sufficient time for calculational effort.
5702-425-506	IM	Near Surface Geometries Beneath Quaternary Cinder Cones	07/31/95	10/31/95	Need to hire for limited term position and plan field work.
5704-039-095	IM	Report on DECOVALEX MH Experiments Modeling	02/24/95	08/31/95	As directed by the NRC to accommodate Prelicensing Activities (Reviews of ACD, ESF Package 2C, Thermal Load Document; and Support at NRC M&O Independent Verification Meeting), and IPA Phase 3 Activities.
5704-074-185	IM	Peer-Reviewed Journal Paper on Molecular Dynamics Simulation Processes Change to Uranium Adsorption on Montmorillonite	03/15/95	06/30/95	Molecular dynamics activities moved to IR&D.

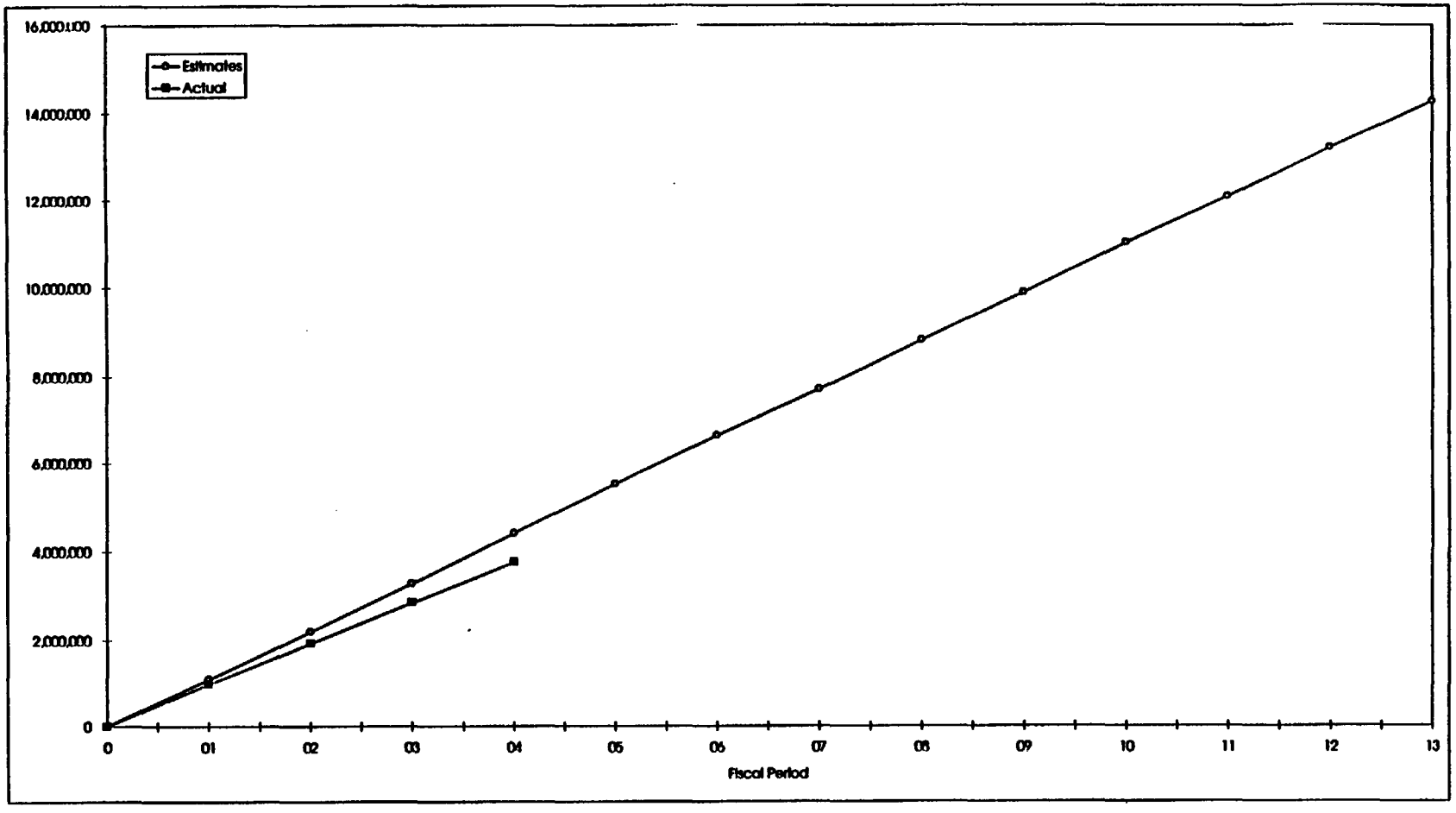
Table 3. Financial Status

	Funds Authorized	Funds Costed to Date	Funds Uncosted	Commitments
GS	3,204,908	2,789,189	415,720	4,735
EBS	1,964,425	1,802,242	162,183	33,963
RDCO	2,500,328	2,222,633	277,696	30,746
WSEI	3,330,073	3,057,105	272,968	9,020
EQA	347,520	282,342	65,178	1,200
PA	3,540,271	3,109,425	430,845	161,050
COPS	5,199,564	4,769,076	430,488	9,030
DWM COSTS	20,087,089	18,032,011	2,055,078	
DWM AWARD FEE	1,032,768	356,391	676,377	
DWM BASE FEE	691,428	674,891	16,537	
TOTAL DWM	21,811,285	19,063,293	2,747,992	249,743
OVERALL	508,127	434,897	73,230	18,494
GEOCHEM	396,353	396,353	0	0
THERMO	970,347	847,347	123,000	508
SEISMIC	1,211,618	1,073,848	137,770	10,828
IWPE	1,414,051	1,212,424	201,627	2,274
STOCH	474,407	474,407	0	0
ANALOGS	1,034,278	938,910	95,368	5,677
SORPTION	1,063,491	993,818	69,673	1,324
RES PA	1,177,585	1,074,958	102,627	19,269
VOLCAN (R)	705,427	699,705	5,721	29,445
VOLCAN (FLD)	669,221	553,179	116,042	7,970
REG HYDRO	434,001	334,837	99,164	0
NEAR FIELD	29,011	0	29,011	0
TECTONIC	1,002,461	830,808	171,653	7,975
SUB-REG HYDRO	142,417	94,081	48,336	1,590
RES COSTS	11,232,796	9,959,572	1,273,224	
RES AWARD FEE	581,964	207,371	374,593	
RES BASE FEE	381,664	360,143	21,521	
TOTAL RES	12,196,424	10,527,085	1,669,339	105,355
WSS COSTS	311,093	271,602	39,492	1,100
WSS AWARD FEE	12,808	7,330	5,478	
WSS BASE FEE	11,490	11,090	400	
TOTAL WSS	335,392	290,022	45,370	
TOTAL	34,343,101	29,880,400	4,462,701	356,198

Note: Additional Authorized Funds of $3,111,633 for DWM, and $2,067,551 for RES have not been allocated. Amount authorized includes carryover.

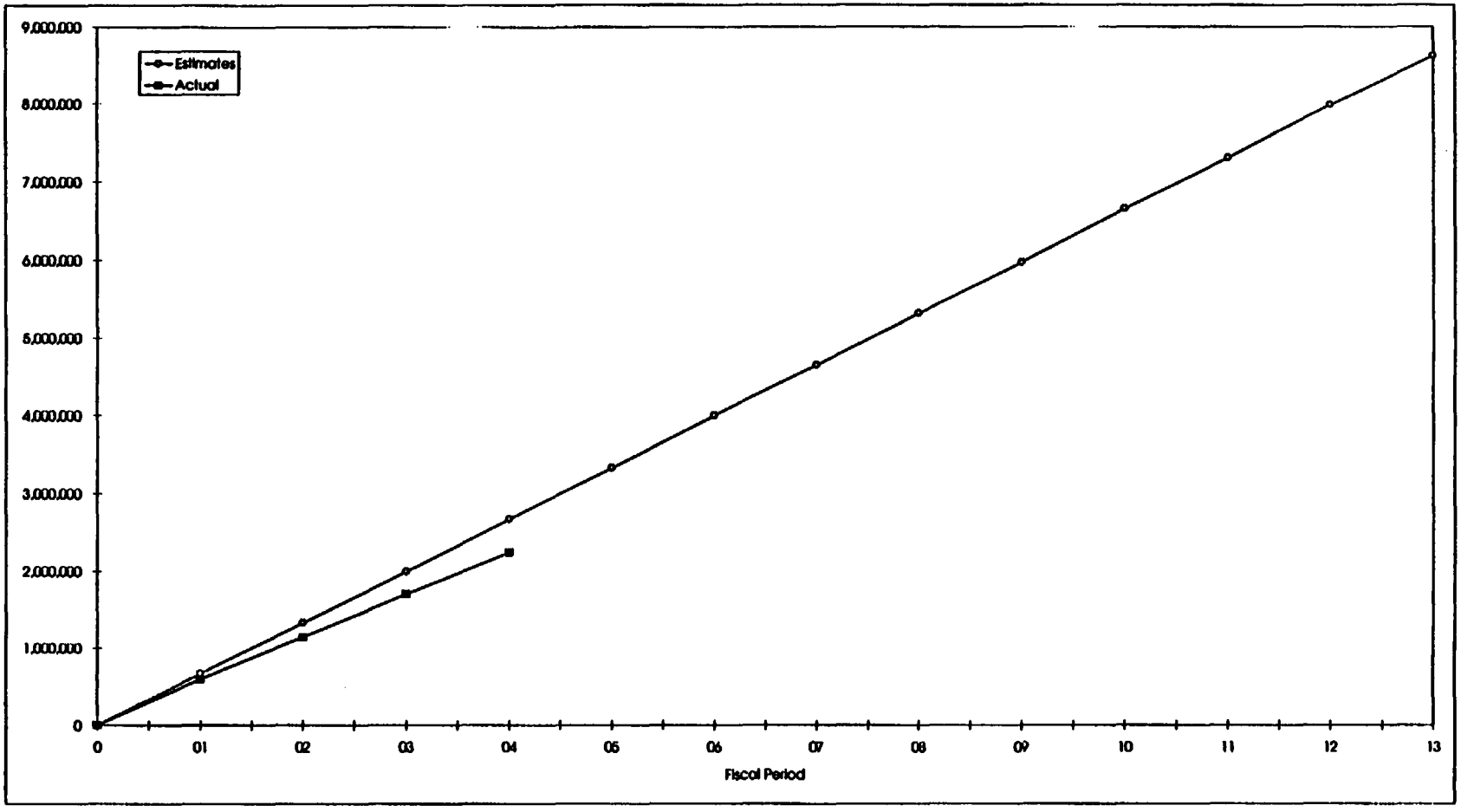
APPENDIX A

PLANNED AND ACTUAL COSTS, AND COST VARIANCES



CENTER COMPOSITE
5700-000

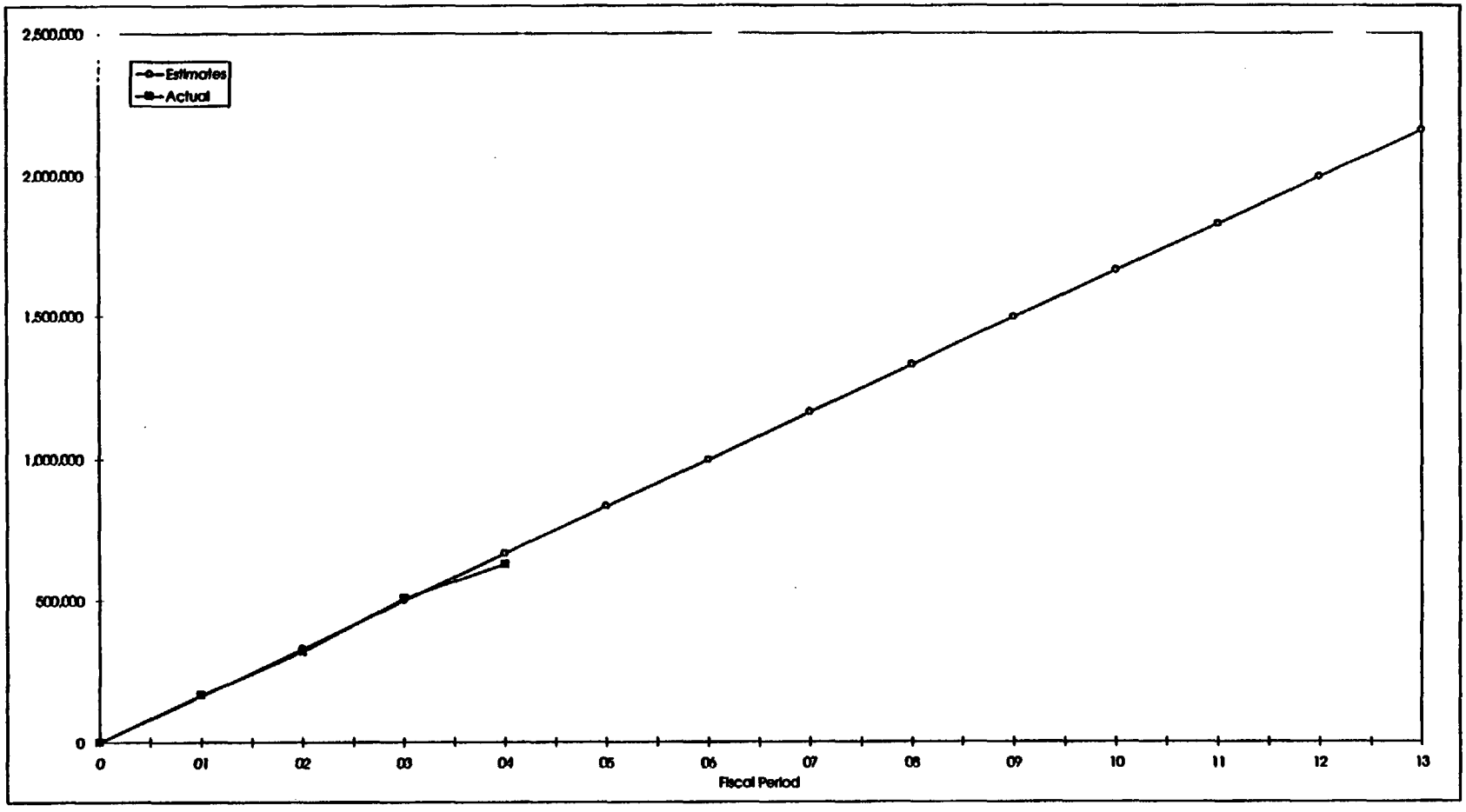
ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	1,092,281	1,094,802	1,086,330	1,129,254	1,101,906	1,129,770	1,071,541	1,116,665	1,064,632	1,121,580	1,059,994	1,130,551	1,055,018	4,402,667
Actual Pd Cost	981,172	939,506	913,138	921,919	0	0	0	0	0	0	0	0	0	3,755,735
Variance, $	111,109	155,296	173,192	207,335	0	0	0	0	0	0	0	0	0	646,932
Variance, %	10.2%	14.2%	15.9%	18.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.7%
Est FY Cumul	1,092,281	2,187,083	3,273,413	4,402,667	5,504,574	6,634,344	7,705,885	8,822,550	9,887,182	11,008,762	12,068,755	13,199,306	14,254,324	
Actual FY Cumul	981,172	1,920,678	2,833,816	3,755,735	0	0	0	0	0	0	0	0	0	
Percent Complete	6.9%	13.5%	19.9%	26.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	111,109	266,405	439,597	646,932	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	10.2%	12.2%	13.4%	14.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



DIVISION OF WASTE MANAGEMENT

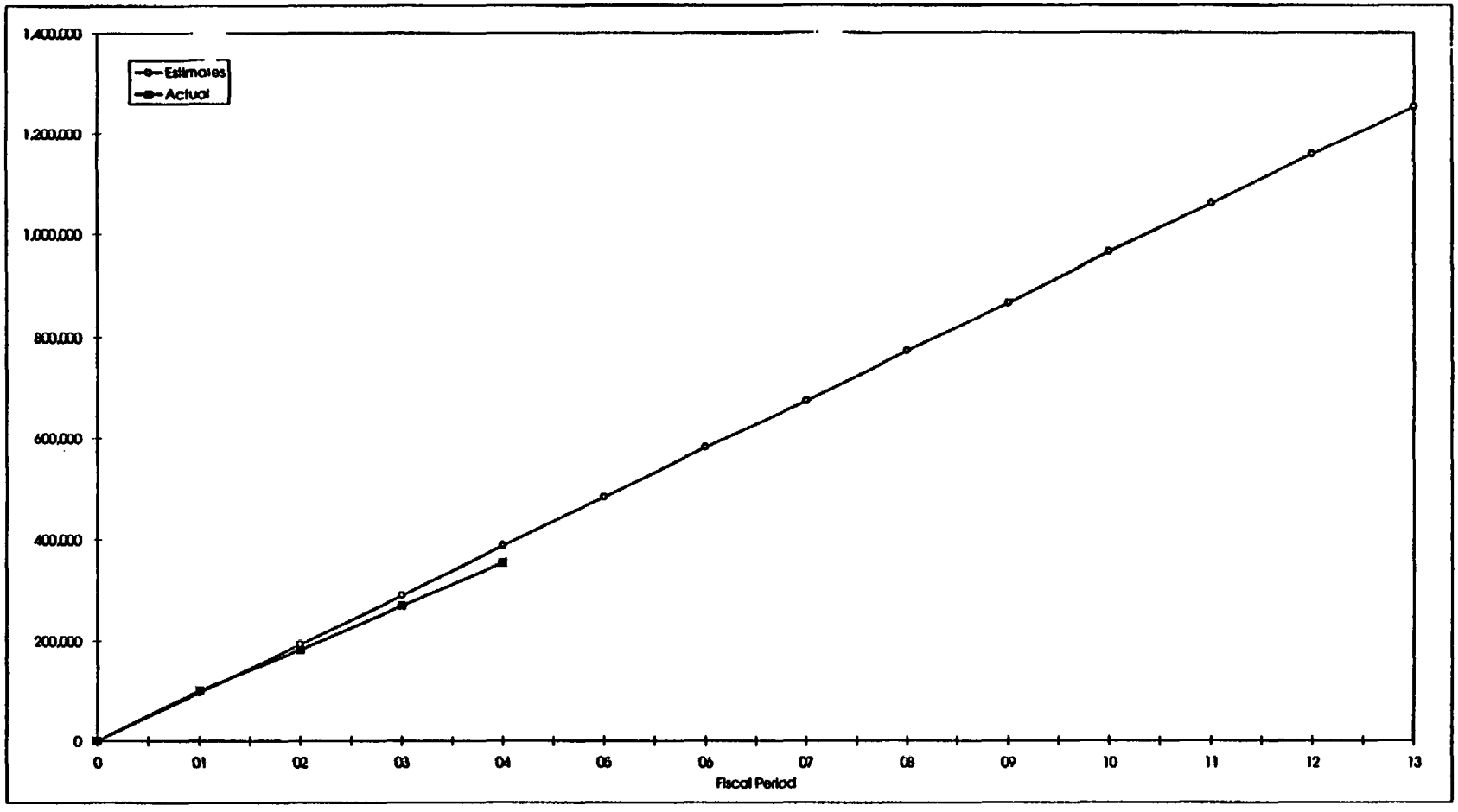
5702-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	665,318	666,554	662,409	670,160	658,613	671,950	653,277	674,411	649,769	677,785	647,785	683,541	643,837	2,664,441
Actual Pd Cost	593,353	548,852	564,074	534,037	0	0	0	0	0	0	0	0	0	2,240,315
Variance, $	71,966	117,702	98,335	136,124	0	0	0	0	0	0	0	0	0	424,126
Variance, %	10.8%	17.7%	14.8%	20.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.9%
Est FY Cumul	665,318	1,331,872	1,994,281	2,664,441	3,323,055	3,995,004	4,648,281	5,322,692	5,972,462	6,650,246	7,298,031	7,981,572	8,625,409	
Actual FY Cumul	593,353	1,142,204	1,706,278	2,240,315	0	0	0	0	0	0	0	0	0	
Percent Complete	6.9%	13.2%	19.8%	26.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	71,966	189,668	288,003	424,126	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	10.8%	14.2%	14.4%	15.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



CNWRA OPERATIONS
5702-100

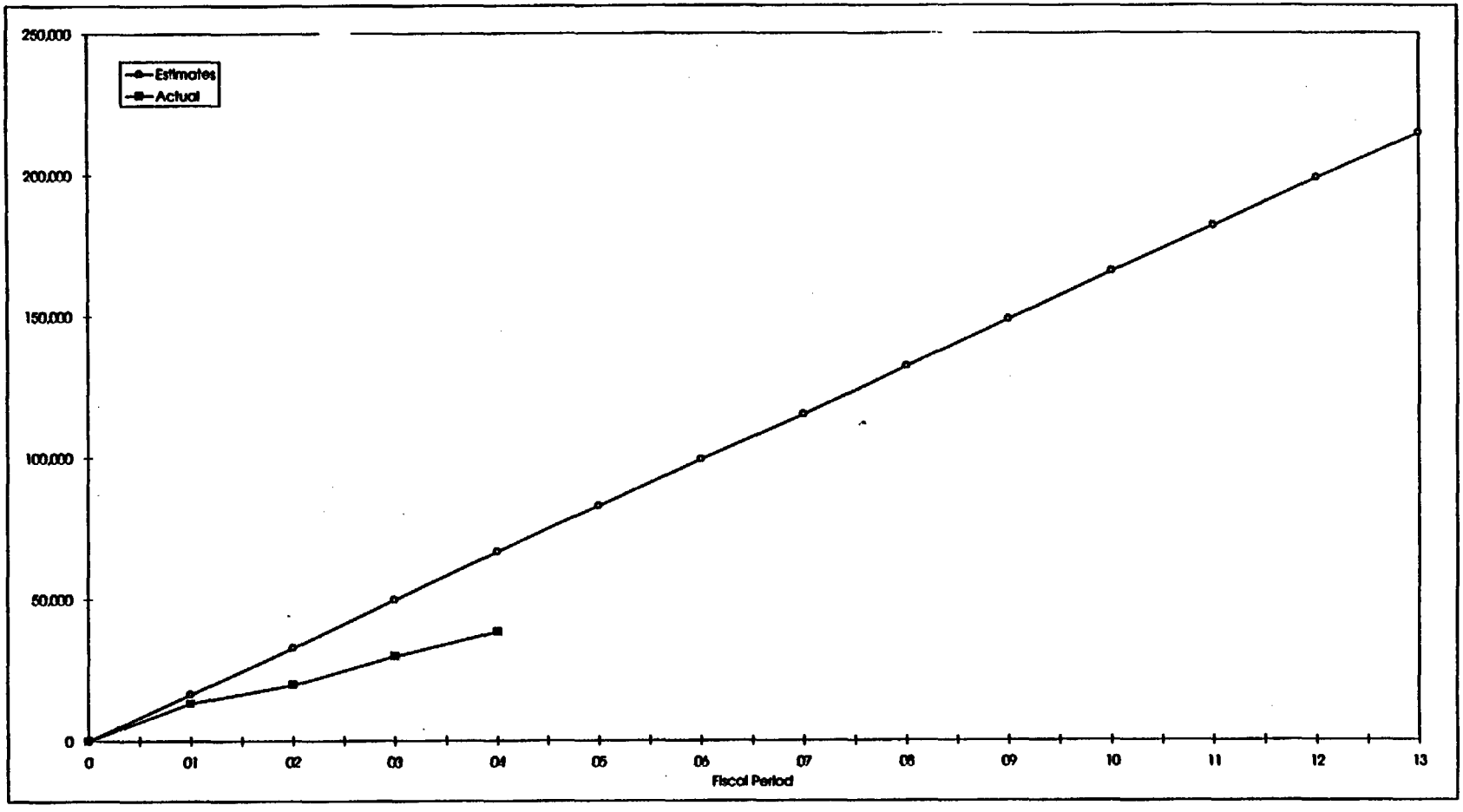
ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	165,866	166,160	165,572	166,565	165,291	166,913	165,003	167,073	164,663	167,814	164,451	169,179	163,221	664,163
Actual Pd Cost	169,759	151,910	183,445	121,645	0	0	0	0	0	0	0	0	0	626,759
Variance, $	(3,892)	14,249	(17,873)	44,920	0	0	0	0	0	0	0	0	0	37,404
Variance, %	-2.3%	8.6%	-10.8%	27.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.6%
Est FY Cumul	165,866	332,026	497,598	664,163	829,454	996,367	1,161,369	1,328,442	1,493,106	1,660,920	1,825,370	1,994,549	2,157,770	
Actual FY Cumul	169,759	321,669	505,114	626,759	0	0	0	0	0	0	0	0	0	
Percent Complete	7.9%	14.9%	23.4%	29.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(3,892)	10,357	(7,516)	37,404	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-2.3%	3.1%	-1.5%	5.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



WASTE SYSTEMS ENGINEERING AND INTEGRATION

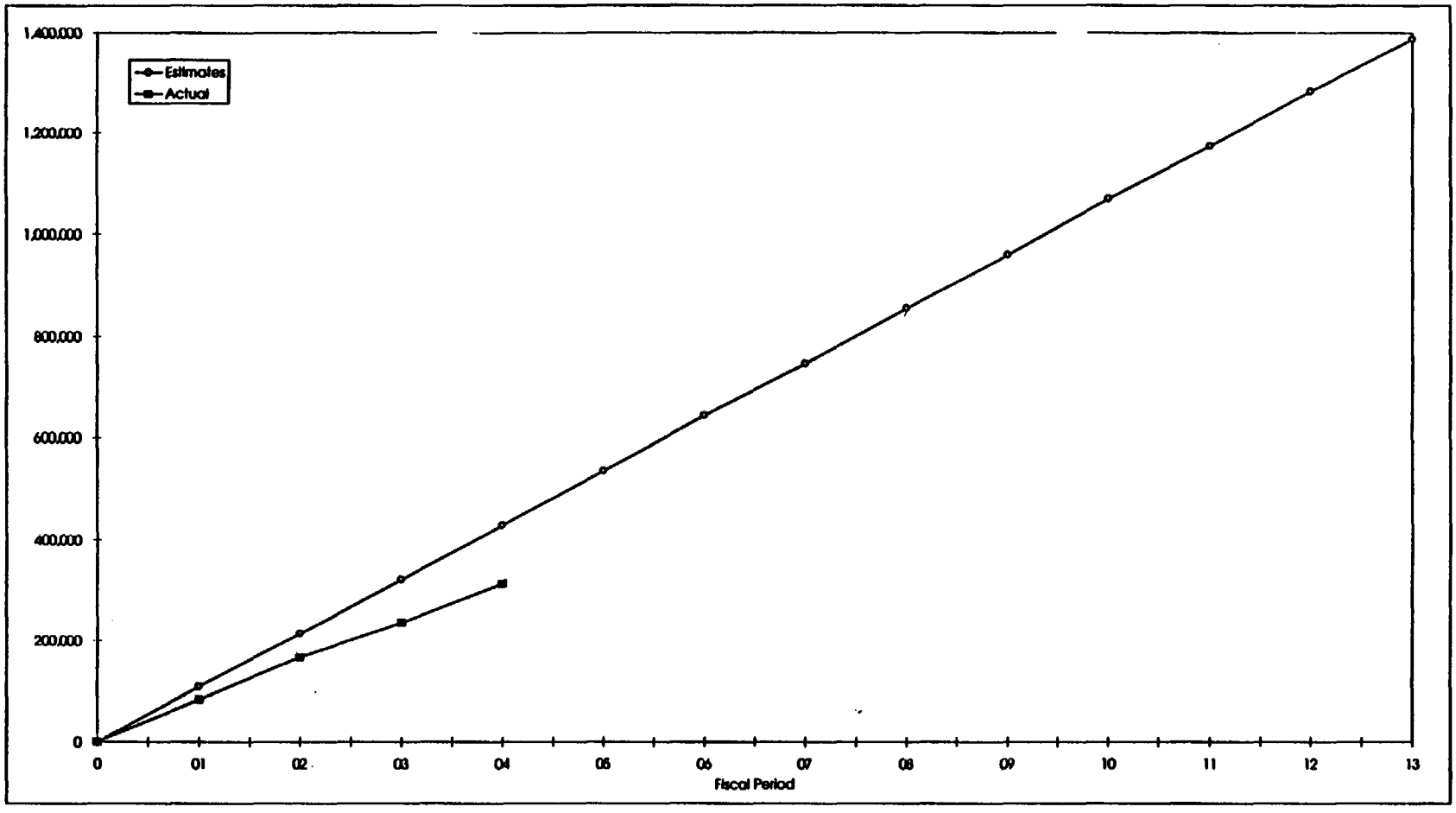
5702-200

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	96,747	96,775	96,151	97,527	95,831	97,614	94,763	98,031	94,073	98,188	93,759	98,640	93,594	387,200
Actual Pd Cost	100,394	82,672	86,606	84,352	0	0	0	0	0	0	0	0	0	354,024
Variance, $	(3,647)	14,103	9,546	13,174	0	0	0	0	0	0	0	0	0	33,176
Variance, %	-3.8%	14.6%	9.9%	13.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.6%
Est FY Cumul	96,747	193,522	289,673	387,200	483,031	580,645	675,408	773,439	867,511	965,700	1,059,458	1,158,098	1,251,692	
Actual FY Cumul	100,394	183,066	269,671	354,024	0	0	0	0	0	0	0	0	0	
Percent Complete	8.0%	14.6%	21.5%	28.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(3,647)	10,456	20,002	33,176	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-3.8%	5.4%	6.9%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



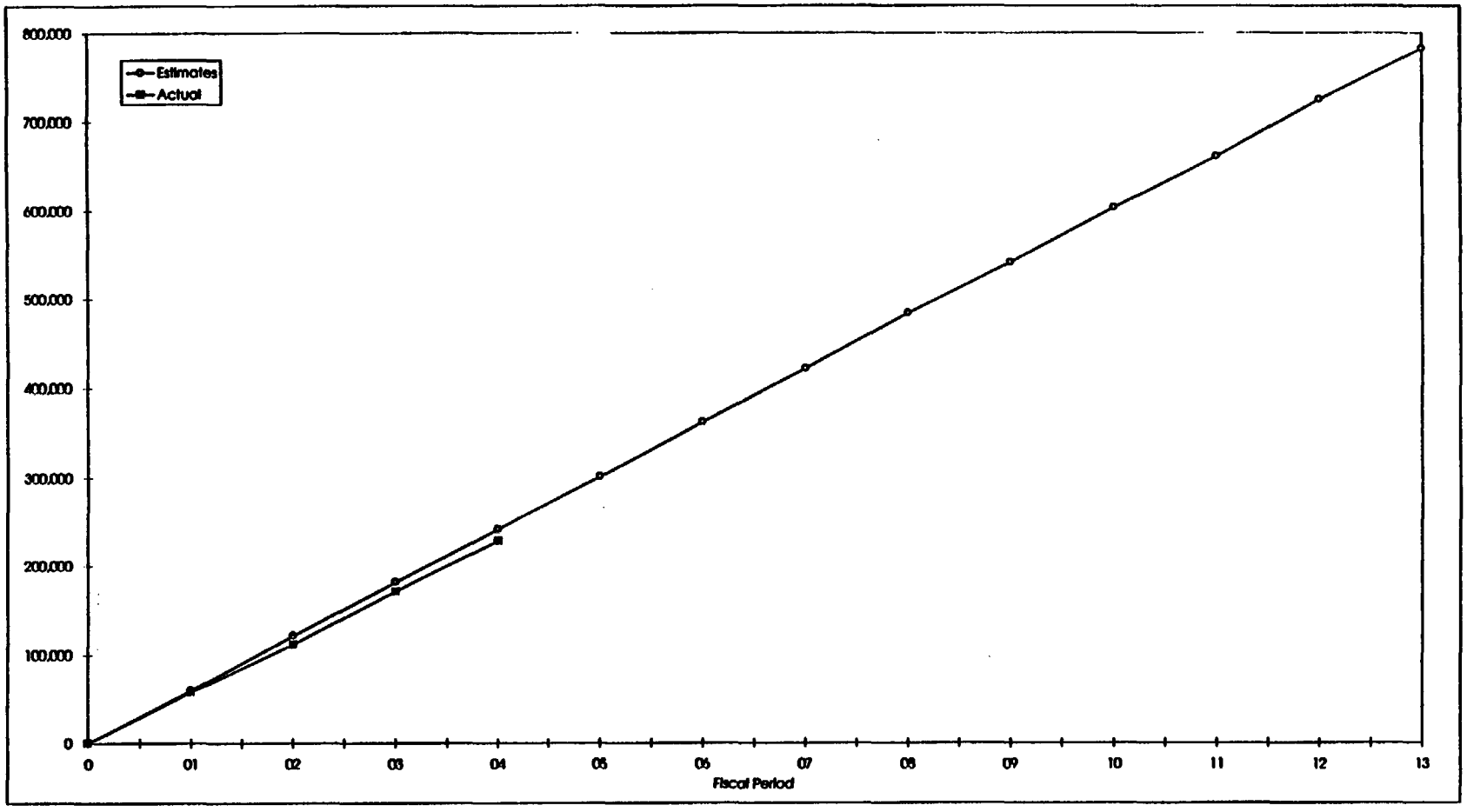
QUALITY ASSURANCE
5702-300

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,530	16,532	16,450	16,663	16,318	16,742	16,187	16,952	16,185	16,953	16,184	16,954	15,936	66,175
Actual Pd Cost	13,456	6,488	10,158	8,449	0	0	0	0	0	0	0	0	0	38,551
Variance, $	3,074	10,044	6,292	8,214	0	0	0	0	0	0	0	0	0	27,624
Variance, %	18.6%	60.8%	38.3%	49.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	41.7%
Est FY Cumul	16,530	33,062	49,512	66,175	82,494	99,236	115,423	132,374	148,559	165,512	181,696	198,649	214,585	
Actual FY Cumul	13,456	19,944	30,102	38,551	0	0	0	0	0	0	0	0	0	
Percent Complete	6.3%	9.3%	14.0%	18.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	3,074	13,118	19,410	27,624	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	18.6%	39.7%	39.2%	41.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



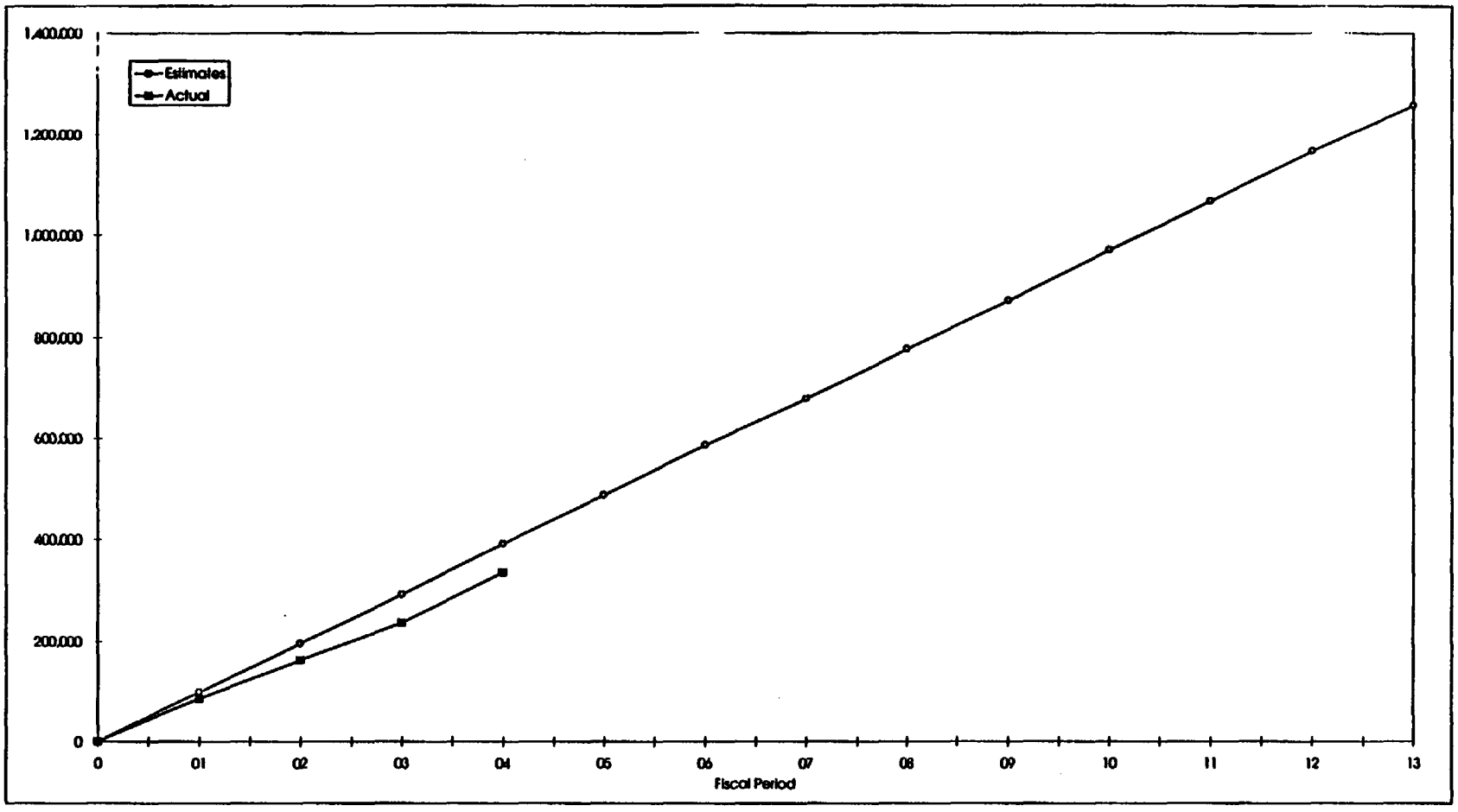
GEOLOGIC SETTING
5702-400

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	106,960	107,400	106,215	108,209	105,542	108,590	104,329	109,441	103,677	109,990	102,983	110,964	102,349	428,784
Actual Pd Cost	82,121	84,265	70,267	76,292	0	0	0	0	0	0	0	0	0	312,946
Variance, $	24,839	23,134	35,947	31,917	0	0	0	0	0	0	0	0	0	115,838
Variance, %	23.2%	21.5%	33.8%	29.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.0%
Est FY Cumul	106,960	214,360	320,575	428,784	534,325	642,916	747,244	856,686	960,363	1,070,353	1,173,336	1,284,300	1,386,649	
Actual FY Cumul	82,121	166,387	236,654	312,946	0	0	0	0	0	0	0	0	0	
Percent Complete	5.9%	12.0%	17.1%	22.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	24,839	47,973	83,921	115,838	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	23.2%	22.4%	26.2%	27.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



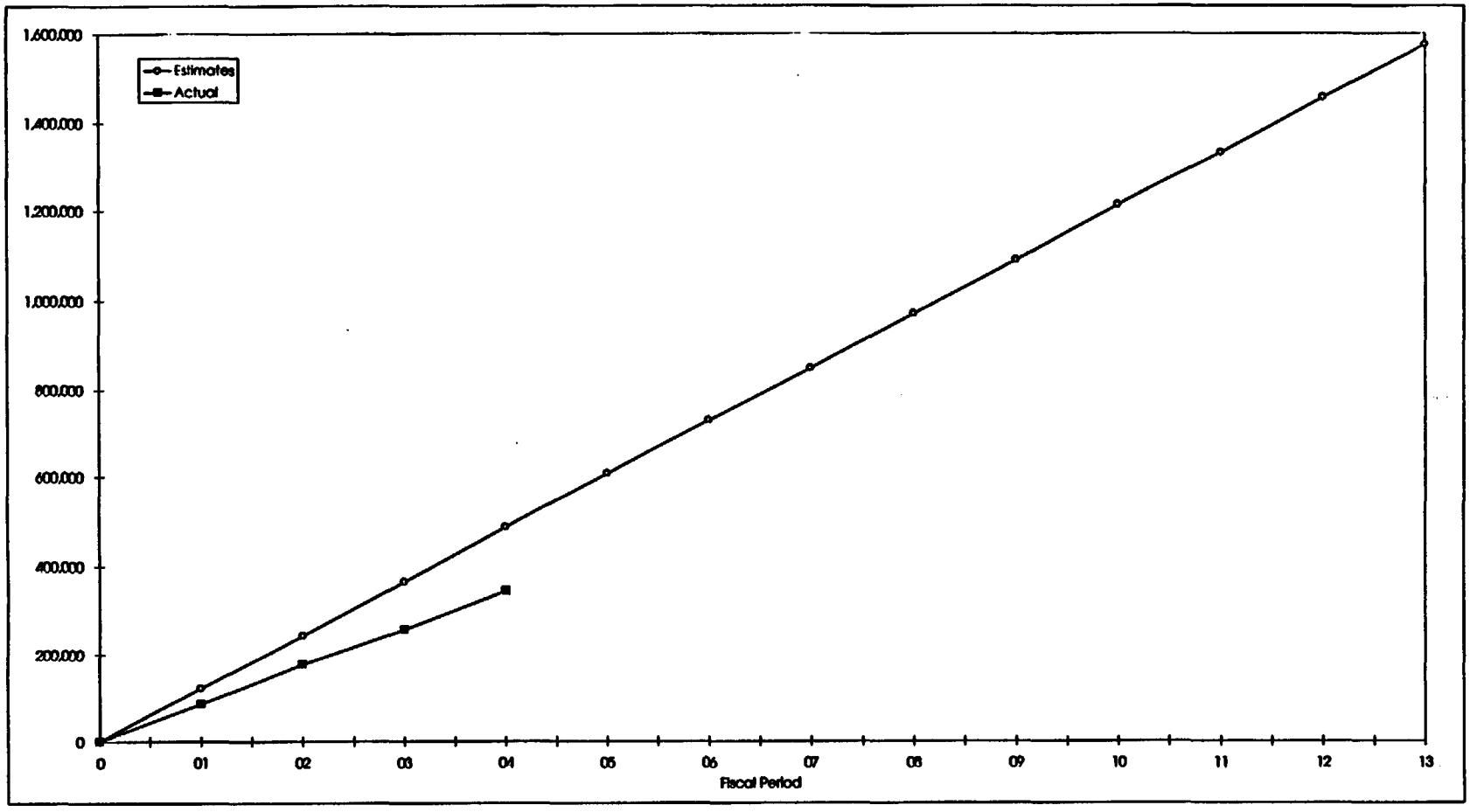
ENGINEERED BARRIER SYSTEM
5702-500

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	60,340	60,421	60,079	60,786	59,629	61,156	59,058	61,633	58,537	61,948	58,193	62,245	57,802	241,626
Actual Pd Cost	58,485	52,588	59,988	57,553	0	0	0	0	0	0	0	0	0	228,614
Variance, $	1,856	7,832	91	3,233	0	0	0	0	0	0	0	0	0	13,012
Variance, %	3.1%	13.0%	0.2%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%
Est FY Cumul	60,340	120,761	180,839	241,626	301,254	362,410	421,468	483,101	541,638	603,587	661,780	724,025	781,827	
Actual FY Cumul	58,485	111,073	171,060	228,614	0	0	0	0	0	0	0	0	0	
Percent Complete	7.5%	14.2%	21.9%	29.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	1,856	9,688	9,779	13,012	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	3.1%	8.0%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



REPOSITORY DESIGN, CONSTRUCTION, AND OPERATIONS
5702-600

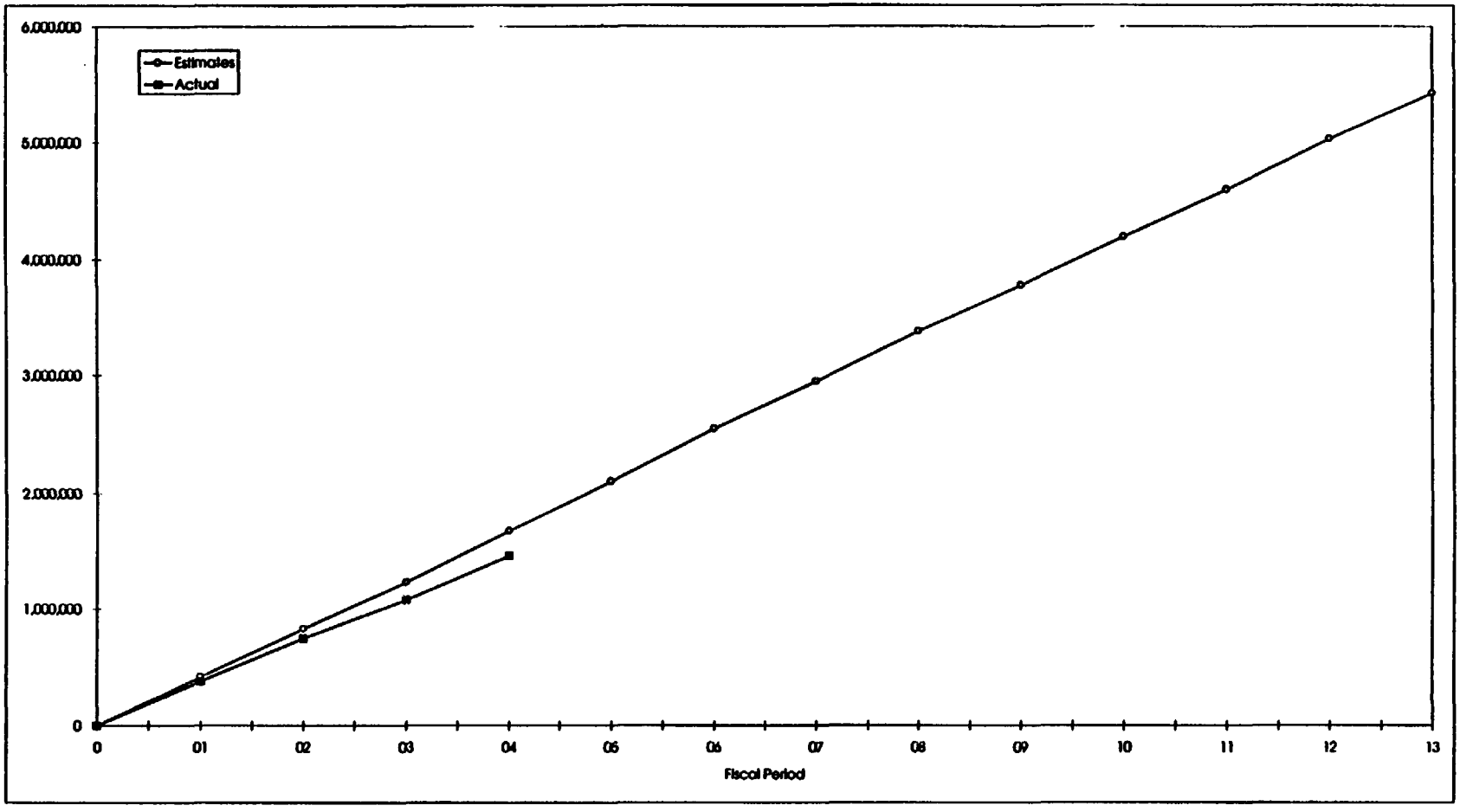
ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	97,544	97,876	96,849	98,265	95,719	98,668	94,861	98,753	93,798	99,581	93,519	100,252	92,710	390,535
Actual Pd Cost	84,365	78,602	73,996	98,297	0	0	0	0	0	0	0	0	0	335,260
Variance, $	13,179	19,275	22,853	(32)	0	0	0	0	0	0	0	0	0	55,275
Variance, %	13.5%	19.7%	23.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.2%
Est FY Cumul	97,544	195,420	292,269	390,535	486,254	584,922	679,783	778,536	872,334	971,916	1,065,434	1,165,686	1,258,396	
Actual FY Cumul	84,365	162,967	236,963	335,260	0	0	0	0	0	0	0	0	0	
Percent Complete	6.7%	13.0%	18.8%	26.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	13,179	32,453	55,307	55,275	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	13.5%	16.6%	18.9%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



PERFORMANCE ASSESSMENT AND HYDROLOGIC TRANSPORT

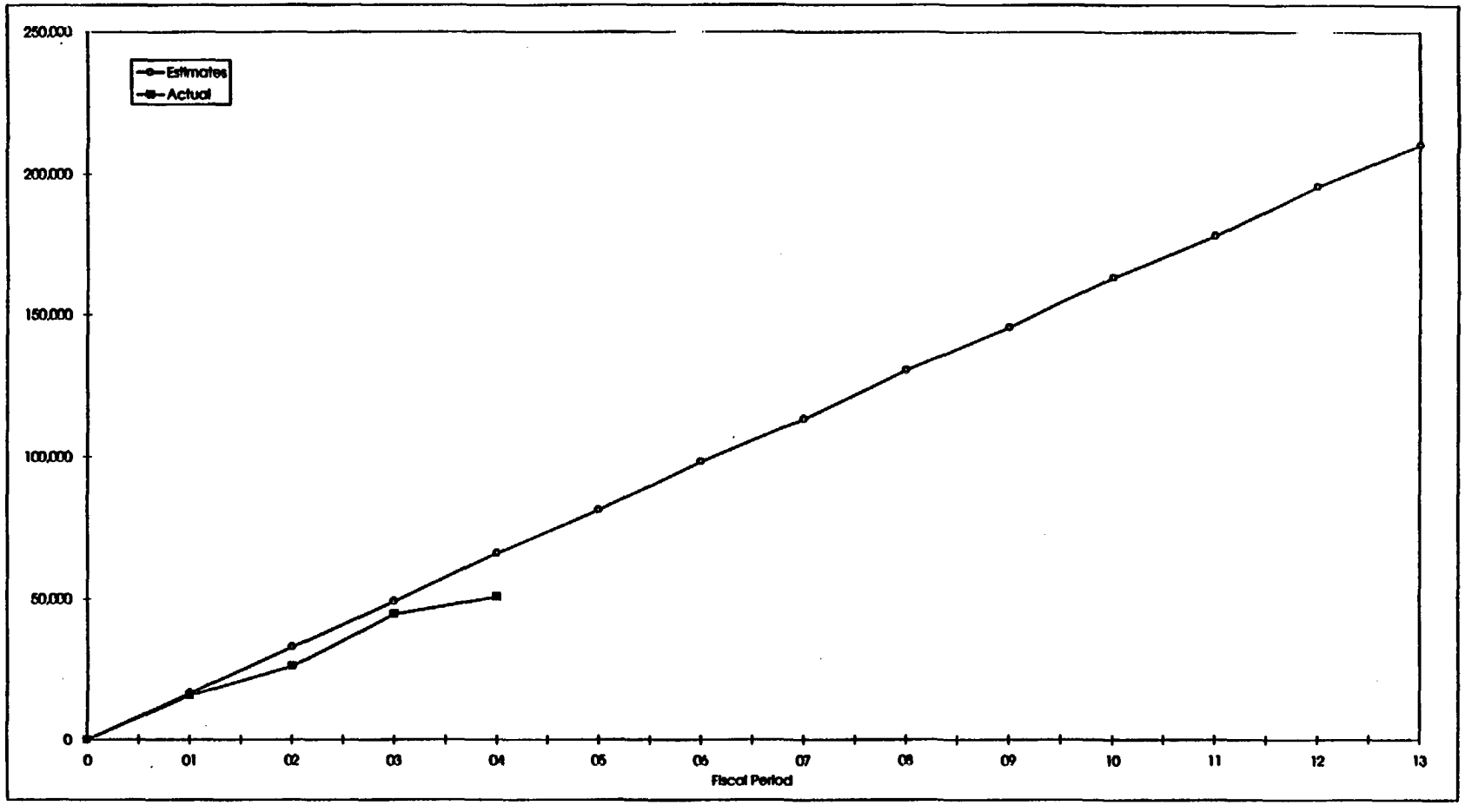
5702-700

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	121,331	121,390	121,094	122,145	120,283	122,266	119,077	122,528	118,836	123,310	118,697	125,307	118,227	485,960
Actual Pd Cost	84,773	92,326	79,615	87,448	0	0	0	0	0	0	0	0	0	344,163
Variance, $	36,558	29,064	41,478	34,697	0	0	0	0	0	0	0	0	0	141,797
Variance, %	30.1%	23.9%	34.3%	28.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.2%
Est FY Cumul	121,331	242,721	363,815	485,960	606,243	728,509	847,585	970,114	1,088,950	1,212,260	1,330,957	1,456,264	1,574,491	
Actual FY Cumul	84,773	177,099	256,715	344,163	0	0	0	0	0	0	0	0	0	
Percent Complete	5.4%	11.2%	16.3%	21.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	36,558	65,622	107,101	141,797	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	30.1%	27.0%	29.4%	29.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



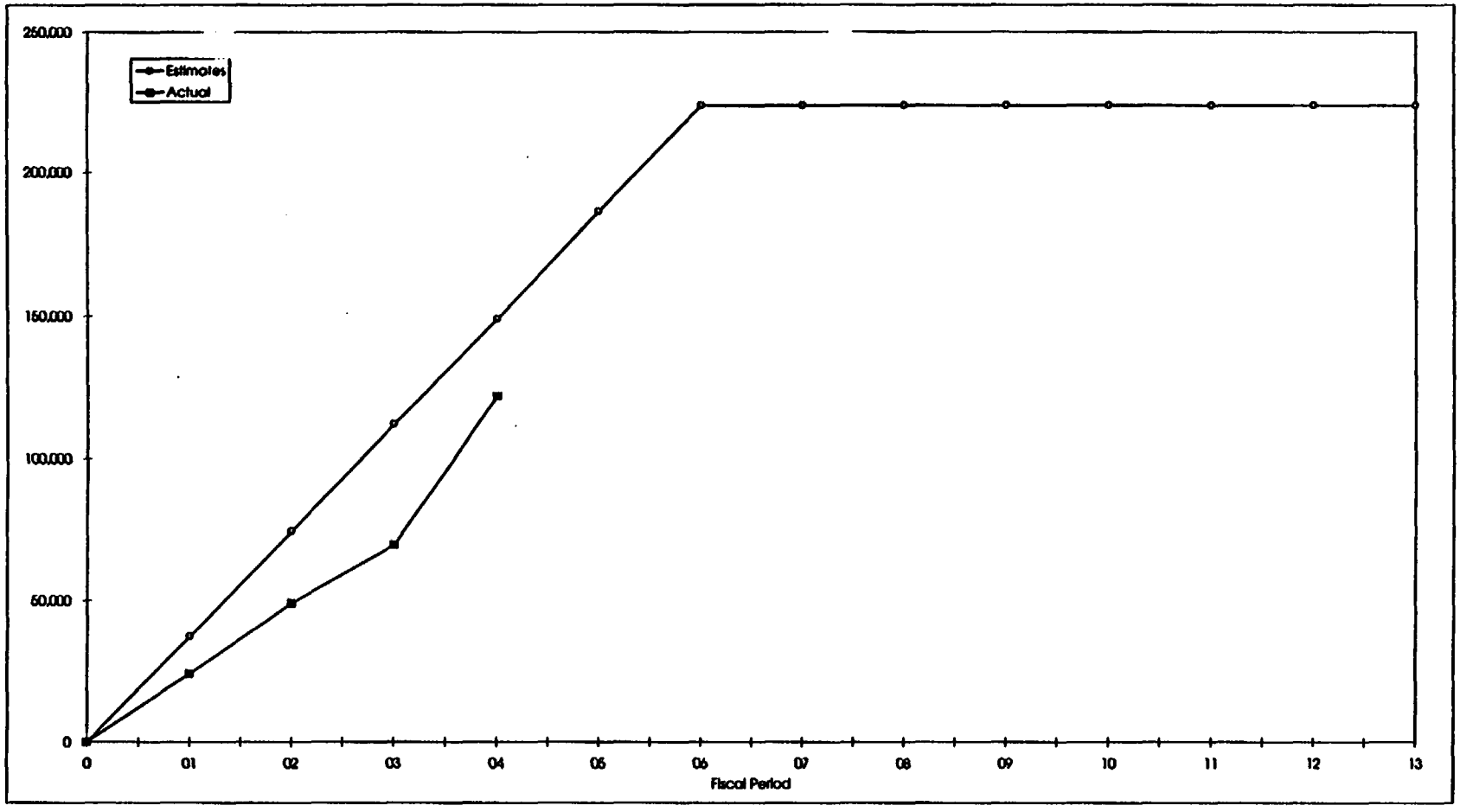
RESEARCH
5704-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	410,802	412,086	408,045	442,569	427,783	441,296	403,116	425,673	399,946	427,084	397,615	430,218	396,667	1,673,501
Actual Pd Cost	371,839	370,797	334,063	376,939	0	0	0	0	0	0	0	0	0	1,453,638
Variance, $	38,963	41,288	73,982	65,630	0	0	0	0	0	0	0	0	0	219,864
Variance, %	9.5%	10.0%	18.1%	14.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.1%
Est FY Cumul	410,802	822,887	1,230,932	1,673,501	2,101,285	2,542,580	2,945,696	3,371,369	3,771,315	4,198,399	4,596,014	5,026,232	5,422,900	
Actual FY Cumul	371,839	742,636	1,076,699	1,453,638	0	0	0	0	0	0	0	0	0	
Percent Complete	6.9%	13.7%	19.9%	26.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	38,963	80,251	154,234	219,864	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	9.5%	9.8%	12.5%	13.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



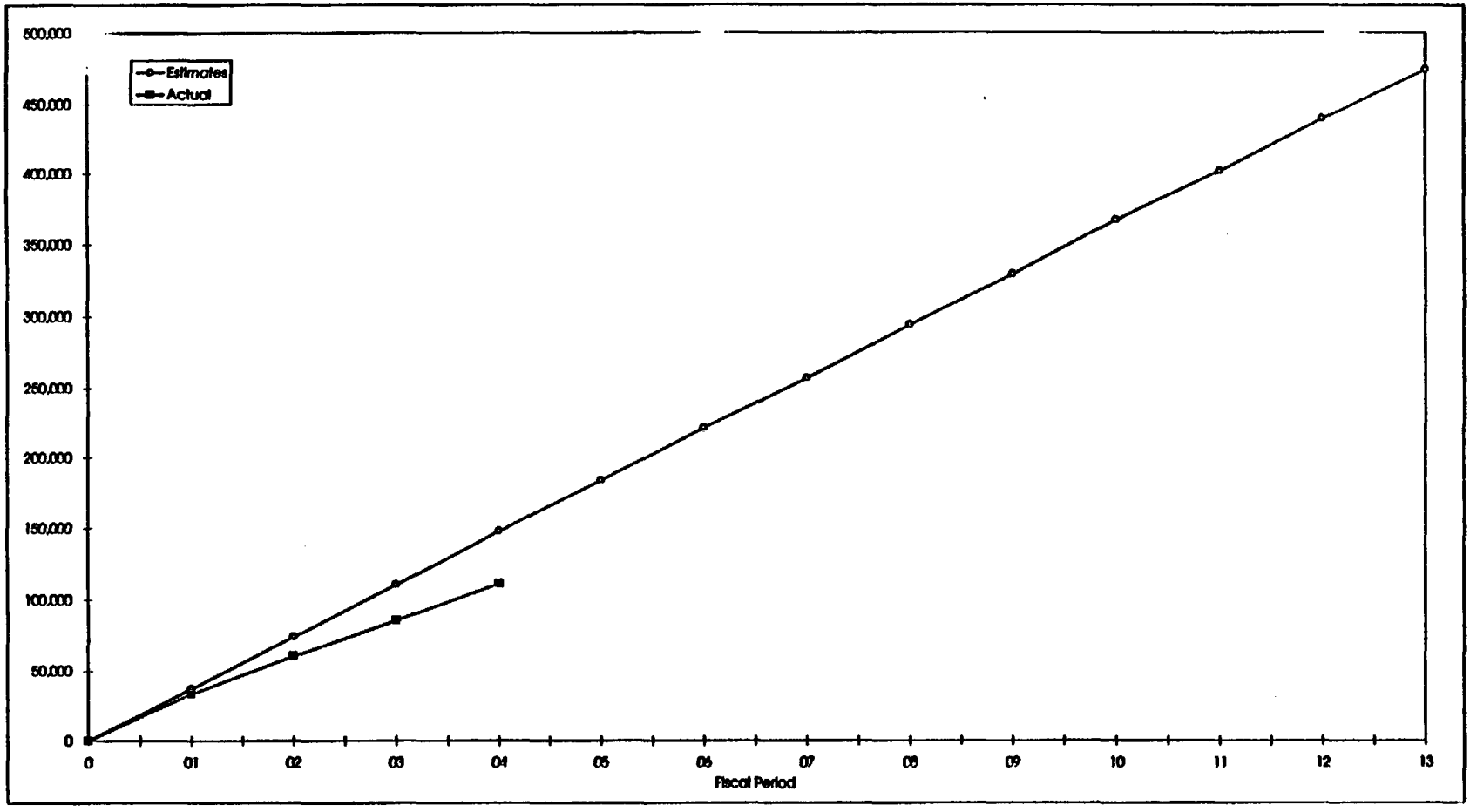
Overall Research
5704-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,542	16,570	15,873	16,649	15,197	17,378	15,195	17,481	14,686	17,481	14,658	17,831	14,657	65,634
Actual Pd Cost	15,715	10,482	18,467	5,949	0	0	0	0	0	0	0	0	0	50,612
Variance, $	827	6,088	(2,593)	10,700	0	0	0	0	0	0	0	0	0	15,022
Variance, %	5.0%	36.7%	-16.3%	64.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.9%
Est FY Cumul	16,542	33,112	48,985	65,634	80,831	98,209	113,405	130,885	145,571	163,052	177,709	195,540	210,196	
Actual FY Cumul	15,715	26,197	44,663	50,612	0	0	0	0	0	0	0	0	0	
Percent Complete	7.5%	12.5%	21.2%	24.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	827	6,915	4,322	15,022	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	5.0%	20.9%	8.8%	22.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



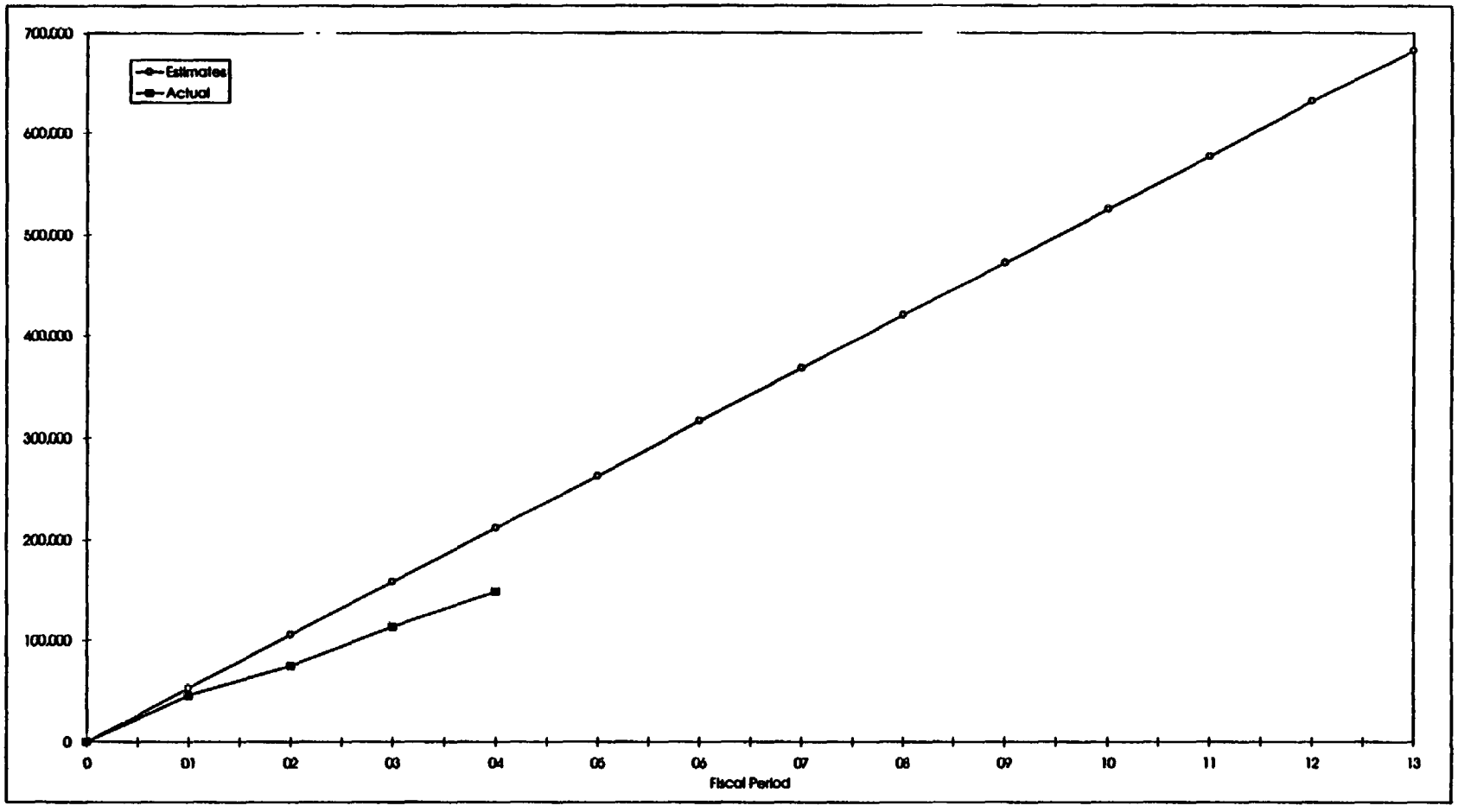
THERMOHYDROLOGY
5704-020

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	37,221	37,193	37,469	37,105	37,469	37,105	0	0	0	0	0	0	0	148,989
Actual Pd Cost	24,001	24,932	20,806	51,910	0	0	0	0	0	0	0	0	0	121,648
Variance, $	13,221	12,262	16,663	(14,805)	0	0	0	0	0	0	0	0	0	27,341
Variance, %	35.5%	33.0%	44.5%	-39.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18.4%
Est FY Cumul	37,221	74,415	111,884	148,989	186,458	223,563	223,563	223,563	223,563	223,563	223,563	223,563	223,563	
Actual FY Cumul	24,001	48,932	69,739	121,648	0	0	0	0	0	0	0	0	0	
Percent Complete	10.7%	21.9%	31.2%	54.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	13,221	25,482	42,145	27,341	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	35.5%	34.2%	37.7%	18.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



ROCK MECHANICS
5704-030

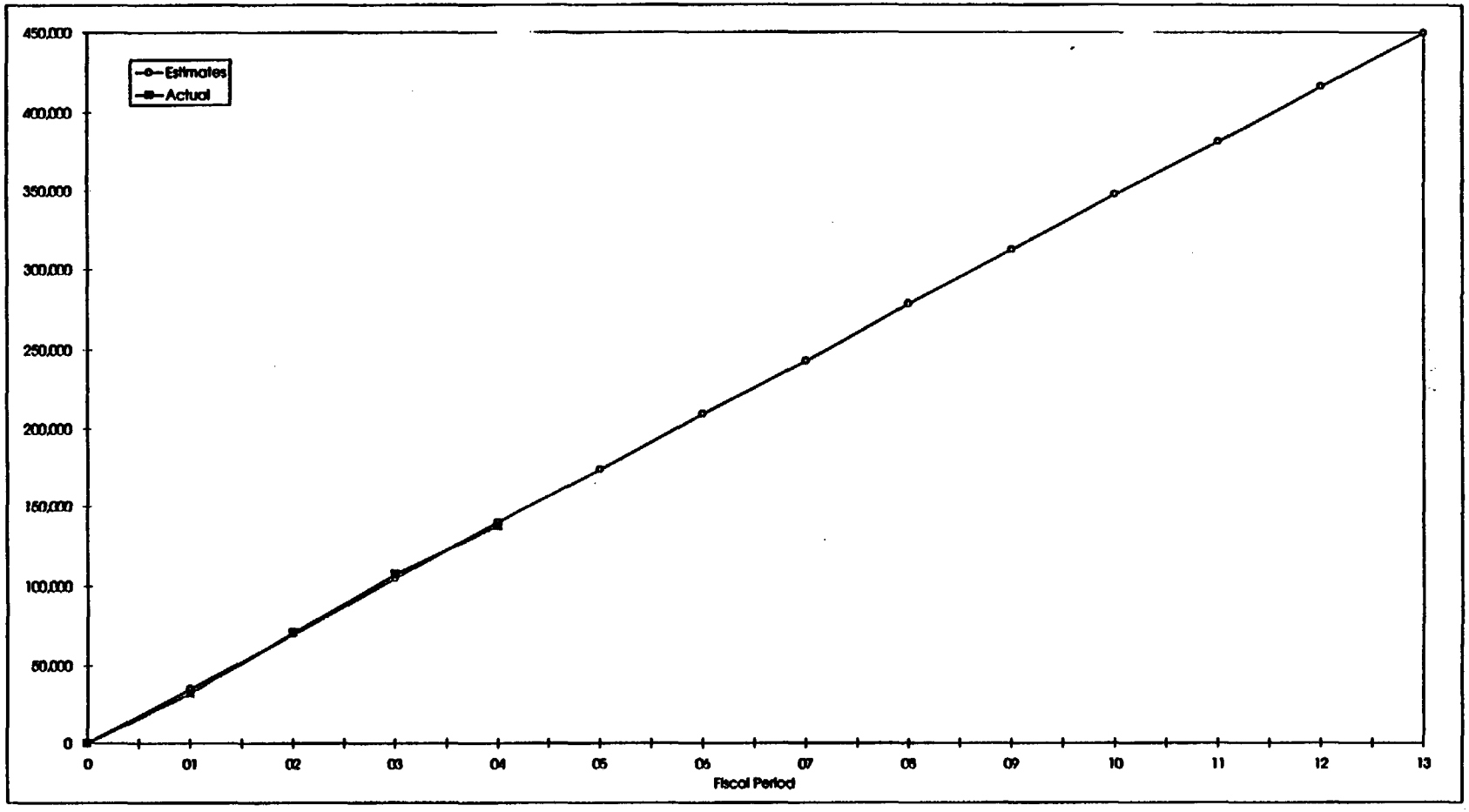
ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	36,700	37,174	36,257	37,210	36,074	37,549	35,496	37,665	34,688	37,690	34,553	38,224	34,391	147,341
Actual Pd Cost	33,373	26,555	25,408	25,877	0	0	0	0	0	0	0	0	0	111,213
Variance, $	3,327	10,619	10,850	11,332	0	0	0	0	0	0	0	0	0	36,128
Variance, %	9.1%	28.6%	29.9%	30.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	24.5%
Est FY Cumul	36,700	73,874	110,132	147,341	183,415	220,963	256,460	294,124	328,813	366,503	401,056	439,280	473,672	
Actual FY Cumul	33,373	59,928	85,336	111,213	0	0	0	0	0	0	0	0	0	
Percent Complete	7.0%	12.7%	18.0%	23.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	3,327	13,946	24,796	36,128	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	9.1%	18.9%	22.5%	24.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



INTEGRATED WASTE PACKAGE EXPERIMENTS

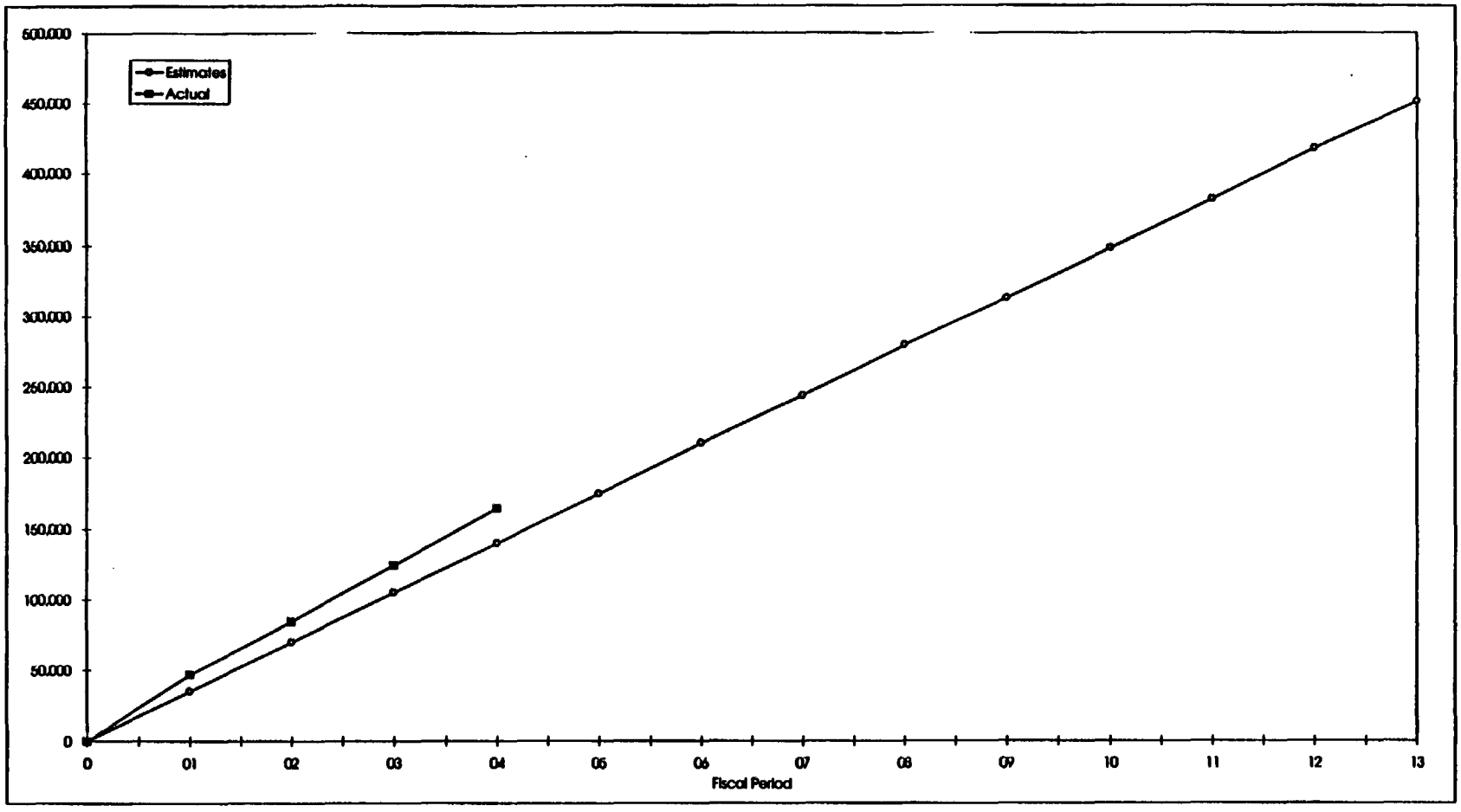
5704-040

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	52,705	52,762	52,575	53,350	51,795	53,353	50,857	53,898	50,689	53,958	50,607	54,396	50,578	211,392
Actual Pd Cost	45,642	29,027	38,800	34,931	0	0	0	0	0	0	0	0	0	148,400
Variance, $	7,063	23,735	13,775	18,419	0	0	0	0	0	0	0	0	0	62,993
Variance, %	13.4%	45.0%	26.2%	34.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.8%
Est FY Cumul	52,705	105,467	158,042	211,392	263,187	316,541	367,398	421,296	471,985	525,943	576,551	630,946	681,525	
Actual FY Cumul	45,642	74,669	113,469	148,400	0	0	0	0	0	0	0	0	0	
Percent Complete	6.7%	11.0%	16.6%	21.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	7,063	30,798	44,573	62,993	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	13.4%	29.2%	28.2%	29.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



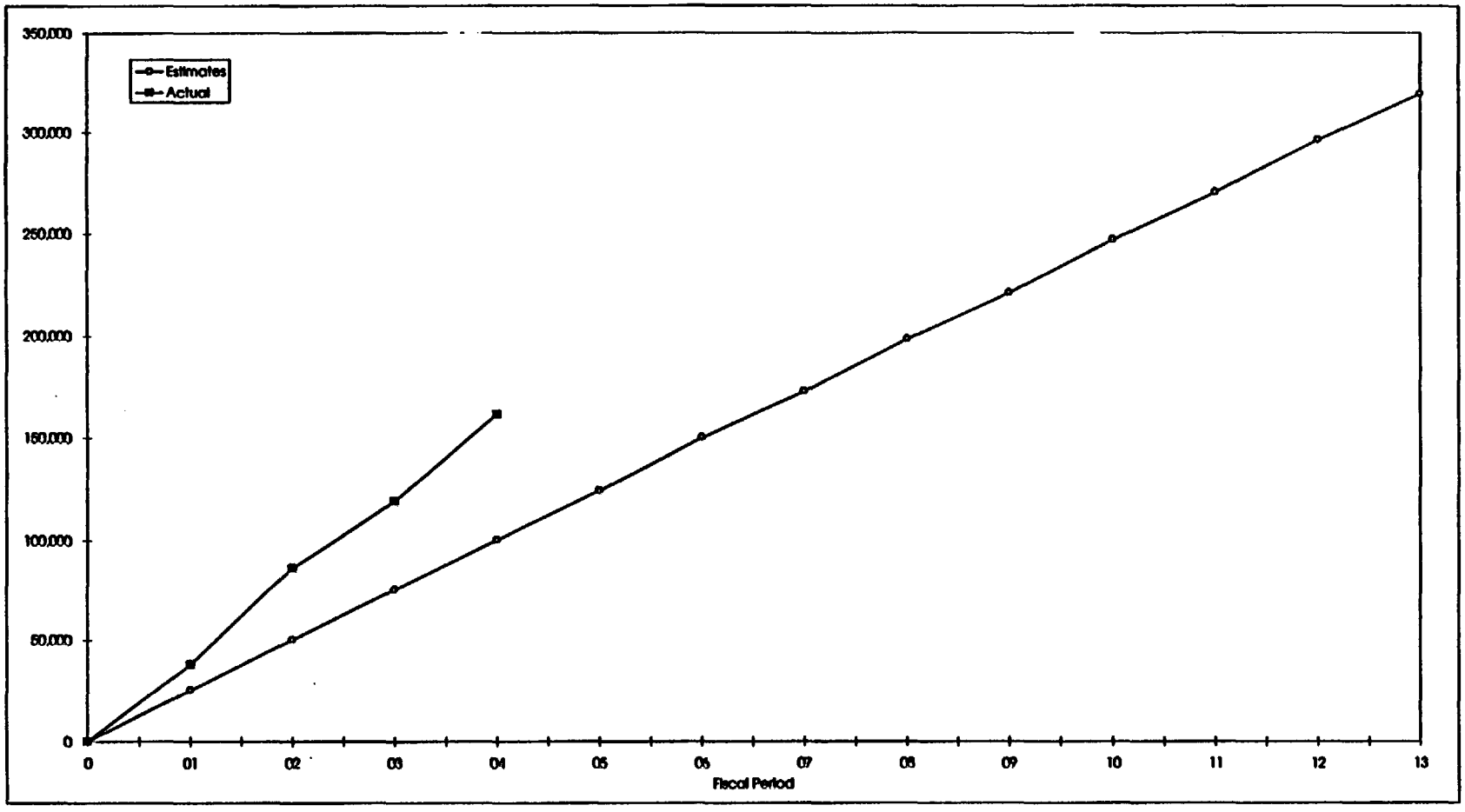
GEOCHEMICAL ANALOG
5704-060

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	34,871	35,053	34,758	35,157	34,276	35,158	33,729	35,187	33,726	35,244	33,493	35,324	33,464	139,839
Actual Pd Cost	32,054	39,004	36,029	30,206	0	0	0	0	0	0	0	0	0	137,293
Variance, $	2,817	(3,951)	(1,271)	4,951	0	0	0	0	0	0	0	0	0	2,547
Variance, %	8.1%	-11.3%	-3.7%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%
Est FY Cumul	34,871	69,924	104,683	139,839	174,115	209,273	243,002	278,189	311,916	347,160	380,653	415,977	449,442	
Actual FY Cumul	32,054	71,058	107,087	137,293	0	0	0	0	0	0	0	0	0	
Percent Complete	7.1%	15.8%	23.8%	30.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	2,817	(1,134)	(2,405)	2,547	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	8.1%	-1.6%	-2.3%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



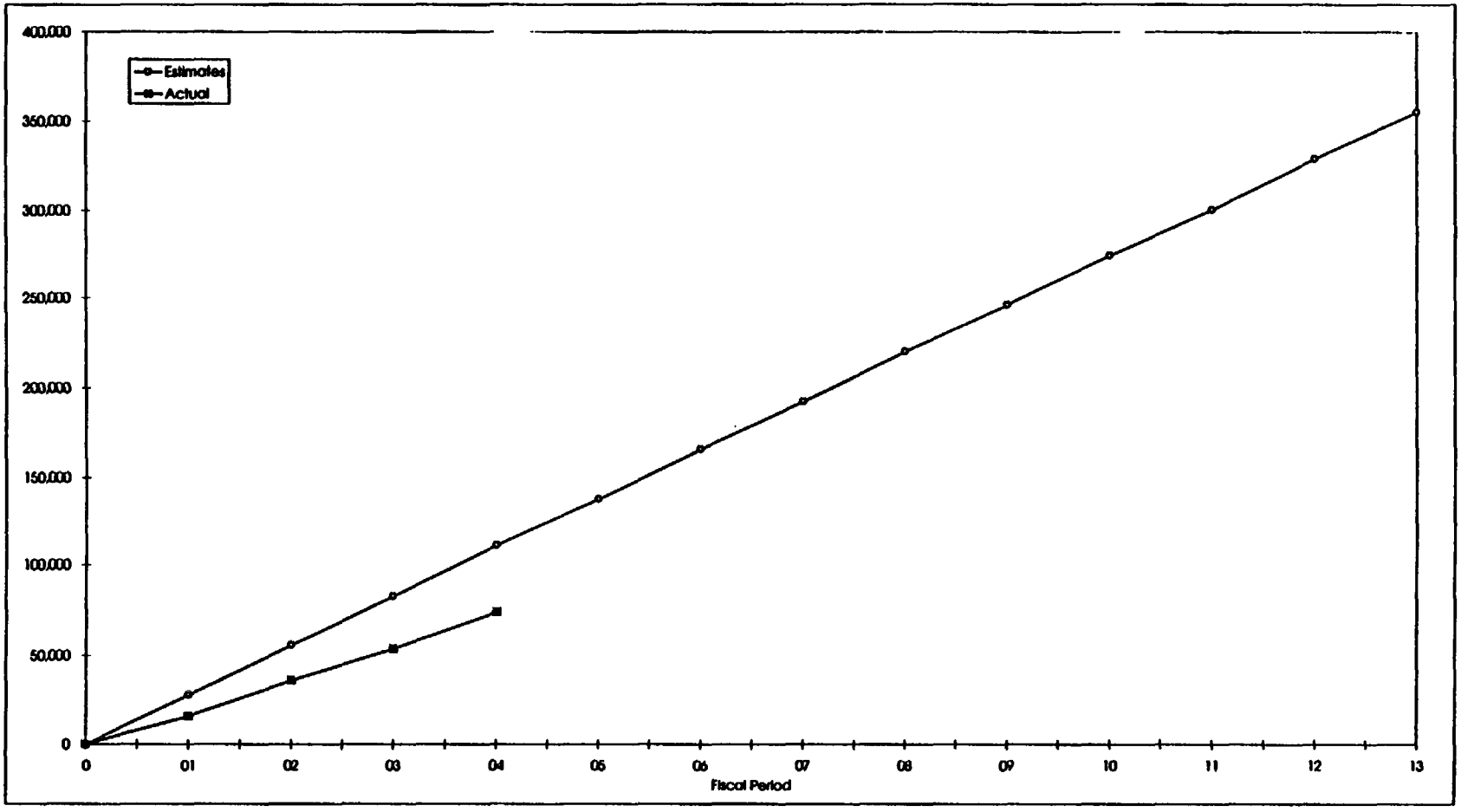
SORPTION MODELING
5704-070

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	34,922	34,923	34,897	34,952	34,507	35,379	33,902	35,380	33,708	35,380	33,600	35,381	33,599	139,694
Actual Pd Cost	46,671	37,967	39,640	39,793	0	0	0	0	0	0	0	0	0	164,071
Variance, $	(11,749)	(3,044)	(4,744)	(4,840)	0	0	0	0	0	0	0	0	0	(24,377)
Variance, %	-33.6%	-8.7%	-13.6%	-13.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-17.5%
Est FY Cumul	34,922	69,845	104,742	139,694	174,201	209,580	243,482	278,862	312,570	347,951	381,550	416,932	450,530	
Actual FY Cumul	46,671	84,638	124,278	164,071	0	0	0	0	0	0	0	0	0	
Percent Complete	10.4%	18.8%	27.6%	36.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(11,749)	(14,793)	(19,536)	(24,377)	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-33.6%	-21.2%	-18.7%	-17.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



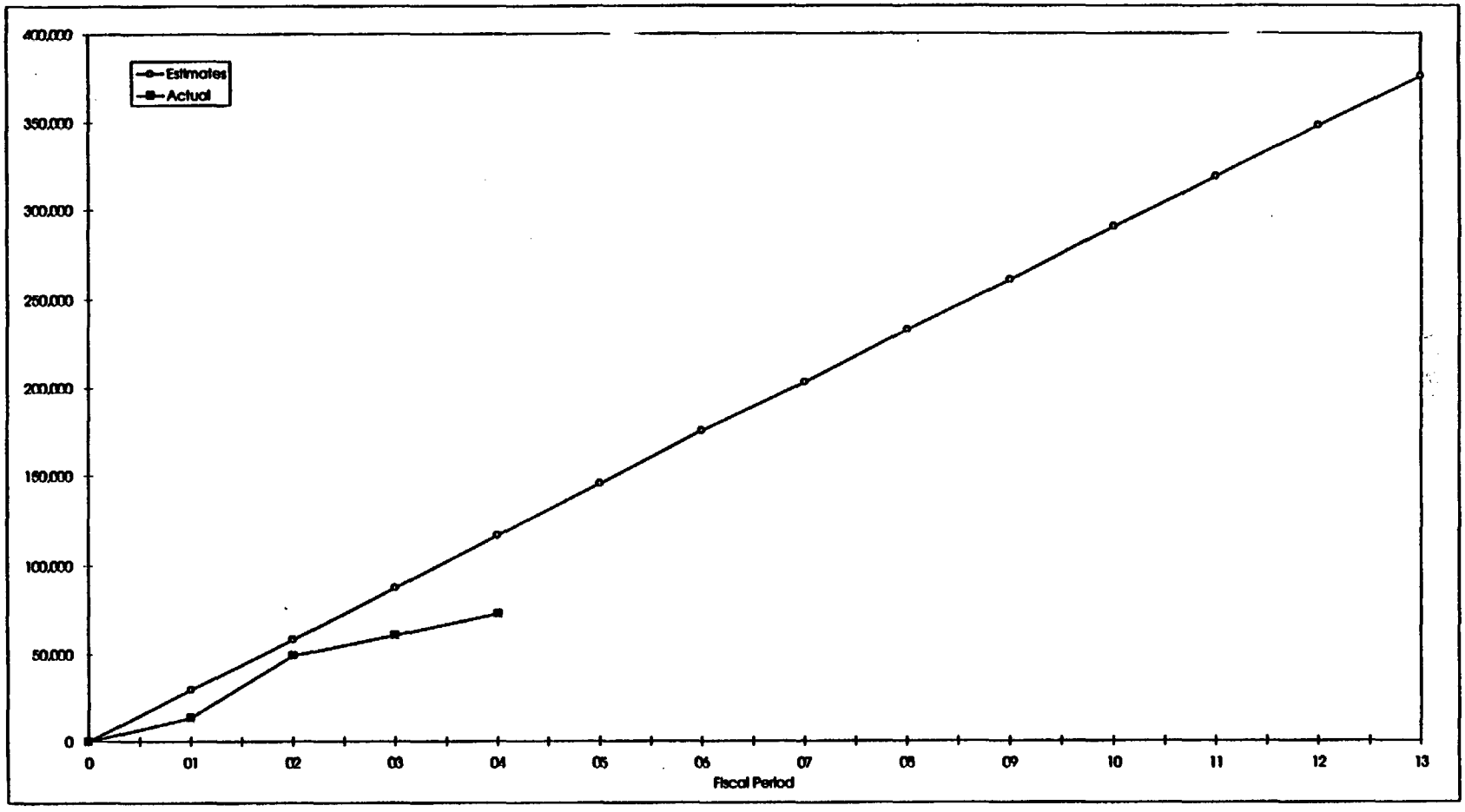
VOLCAN SYSTEMS
5704-120

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	24,981	25,183	24,845	25,263	24,008	25,542	22,934	25,685	22,907	25,798	22,802	26,070	22,715	100,272
Actual Pd Cost	37,758	48,413	32,846	42,216	0	0	0	0	0	0	0	0	0	161,234
Variance, $	(12,777)	(23,230)	(8,001)	(16,955)	0	0	0	0	0	0	0	0	0	(60,962)
Variance, %	-51.1%	-92.2%	-32.2%	-67.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-60.8%
Est FY Cumul	24,981	50,164	75,009	100,272	124,280	149,823	172,757	198,441	221,349	247,146	269,949	296,018	318,733	
Actual FY Cumul	37,758	86,170	119,017	161,234	0	0	0	0	0	0	0	0	0	
Percent Complete	11.8%	27.0%	37.3%	50.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(12,777)	(36,006)	(44,008)	(60,962)	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-51.1%	-71.8%	-58.7%	-60.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



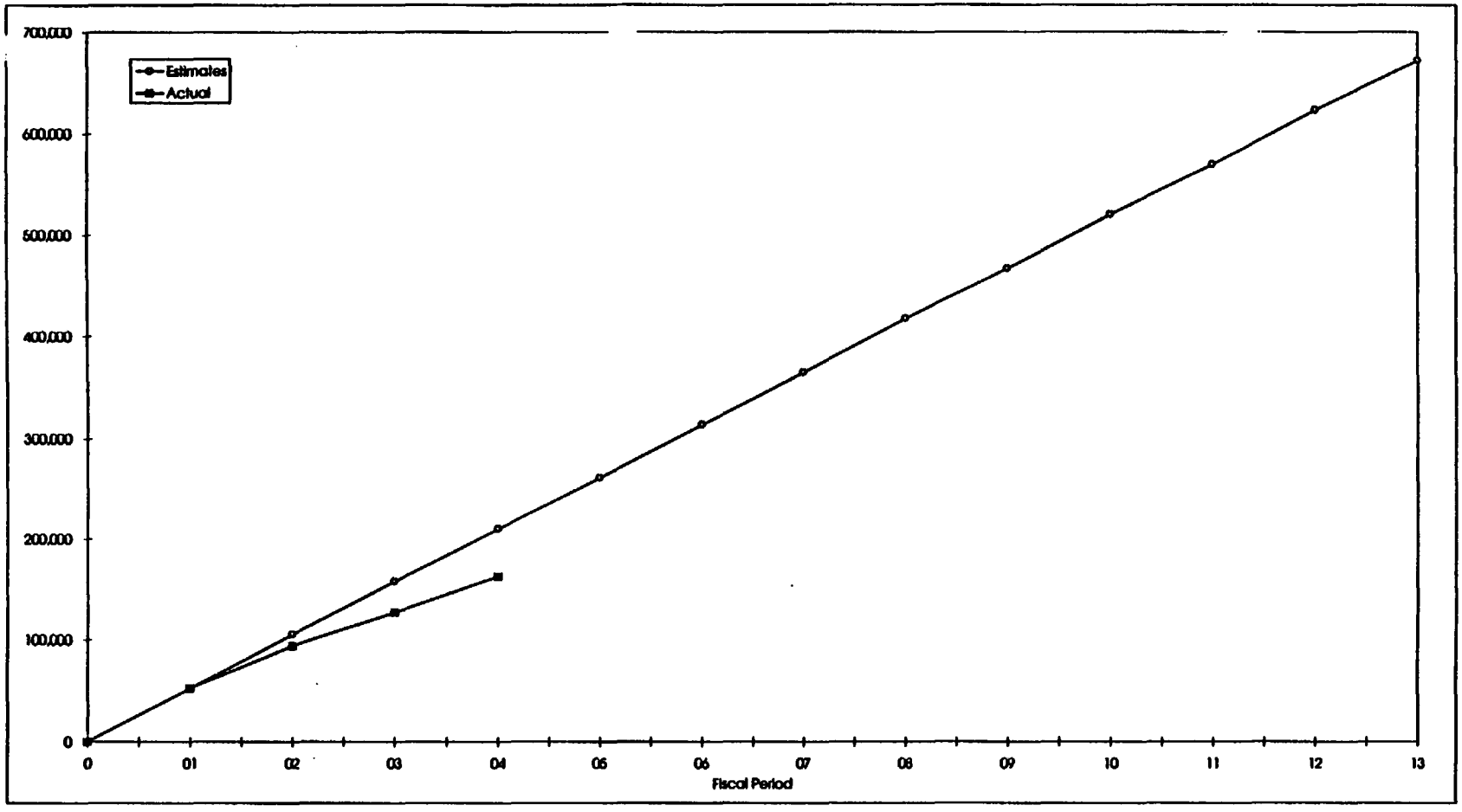
REGIONAL HYDROGEOLOGIC PROCESS
5704-130

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	27,820	27,822	27,042	27,903	26,984	27,992	26,578	27,993	26,058	28,382	26,002	28,642	25,894	110,587
Actual Pd Cost	15,817	20,203	17,856	20,126	0	0	0	0	0	0	0	0	0	74,003
Variance, $	12,003	7,619	9,186	7,777	0	0	0	0	0	0	0	0	0	36,584
Variance, %	43.1%	27.4%	34.0%	27.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.1%
Est FY Cumul	27,820	55,642	82,684	110,587	137,570	165,563	192,141	220,134	246,192	274,574	300,576	329,218	355,112	
Actual FY Cumul	15,817	36,021	53,877	74,003	0	0	0	0	0	0	0	0	0	
Percent Complete	4.5%	10.1%	15.2%	20.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	12,003	19,621	28,807	36,584	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	43.1%	35.3%	34.8%	33.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



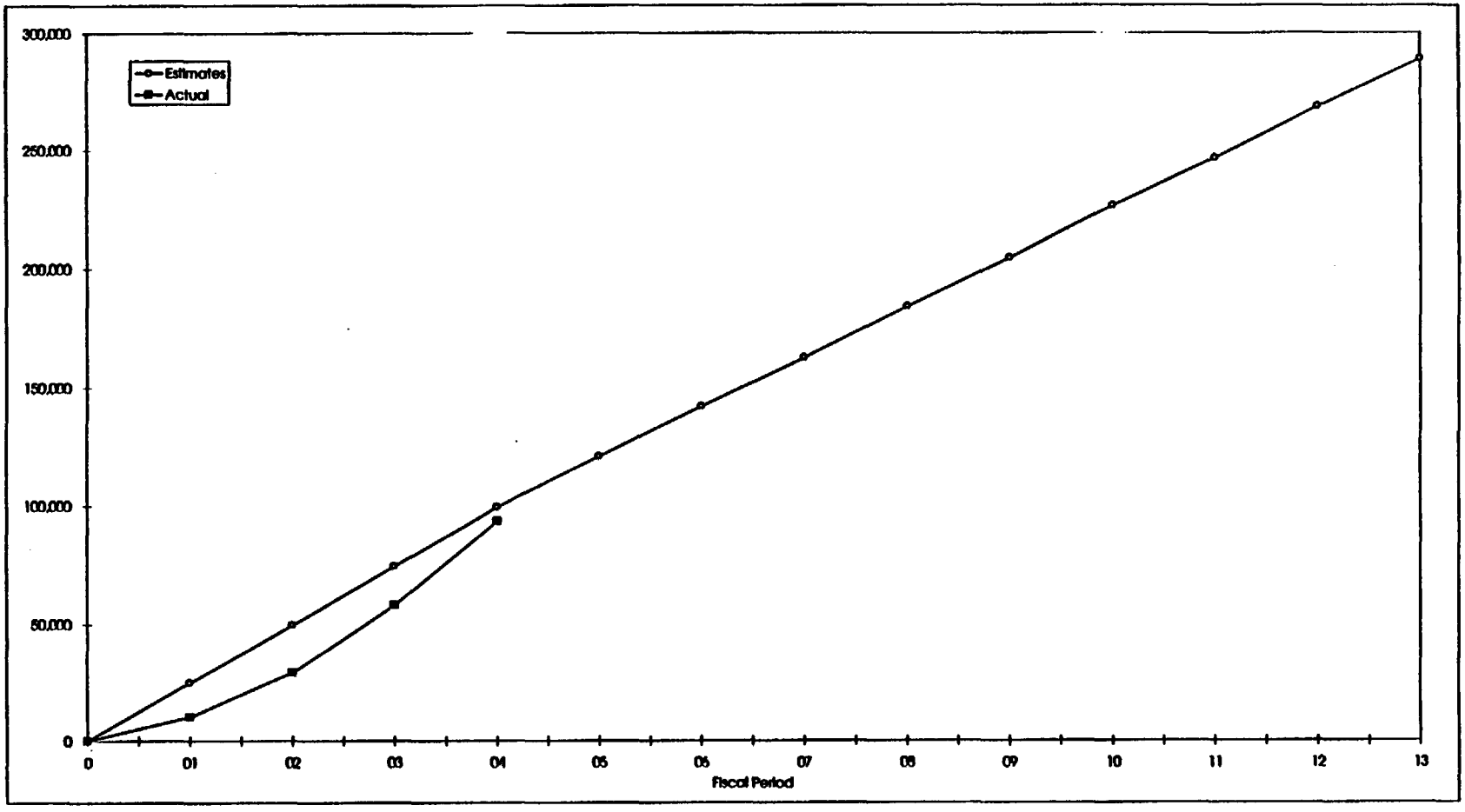
FIELD VOLCANISM
5704-140

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	29,074	29,155	28,944	29,393	28,525	29,504	28,133	29,588	28,130	29,617	27,921	29,617	27,842	116,566
Actual Pd Cost	13,396	35,694	11,724	11,816	0	0	0	0	0	0	0	0	0	72,630
Variance, $	15,678	(6,539)	17,220	17,577	0	0	0	0	0	0	0	0	0	43,936
Variance, %	53.9%	-22.4%	59.5%	59.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	37.7%
Est FY Cumul	29,074	58,229	87,173	116,566	145,091	174,595	202,728	232,316	260,446	290,062	317,983	347,600	375,442	
Actual FY Cumul	13,396	49,090	60,814	72,630	0	0	0	0	0	0	0	0	0	
Percent Complete	3.6%	13.1%	16.2%	19.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	15,678	9,139	26,359	43,936	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	53.9%	15.7%	30.2%	37.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



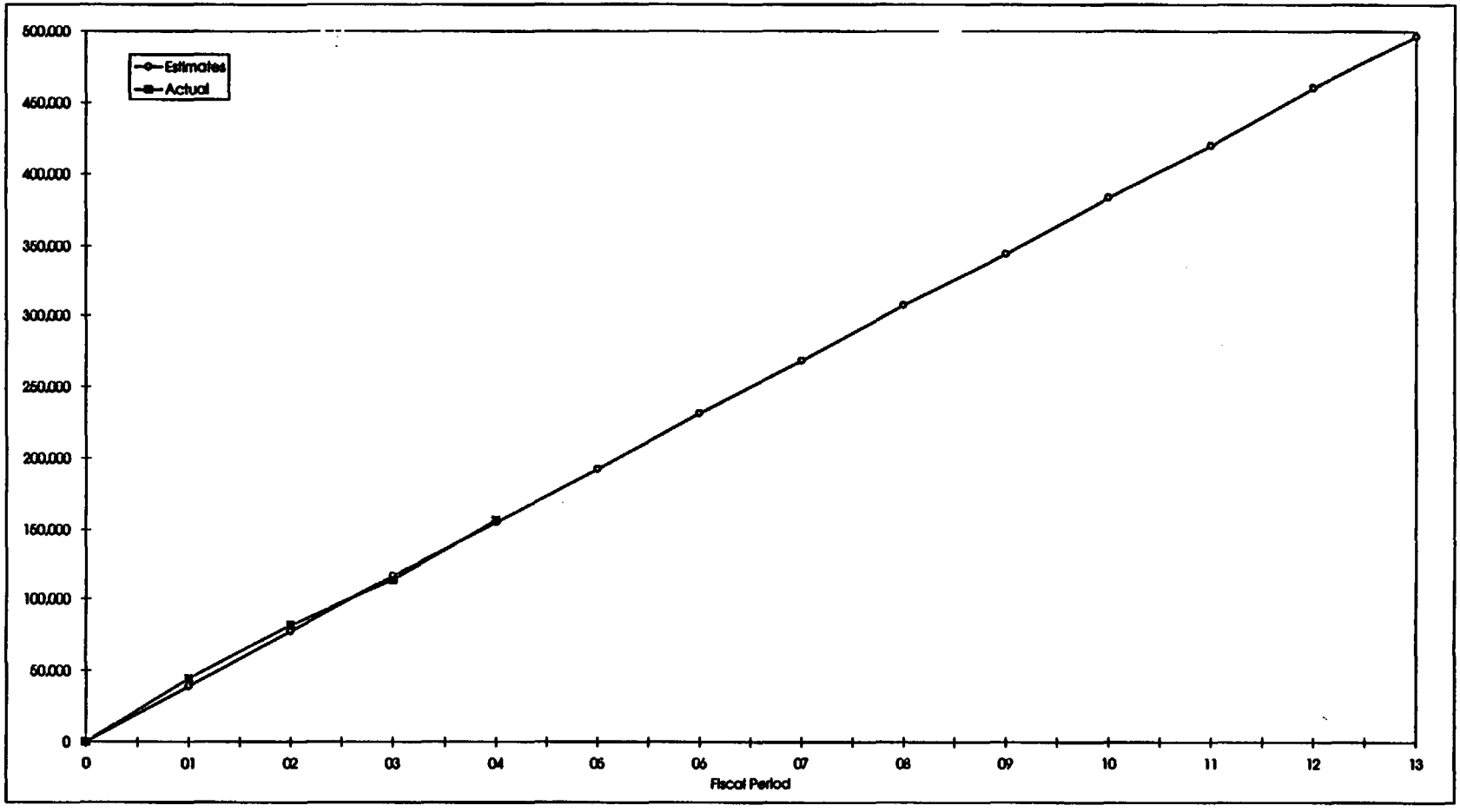
TECTONIC PROCESS
5704-160

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	52,326	52,554	52,268	52,556	51,346	52,730	50,697	52,815	49,849	52,951	49,161	53,037	49,100	209,705
Actual Pd Cost	52,603	41,680	32,578	35,399	0	0	0	0	0	0	0	0	0	162,259
Variance, $	(277)	10,875	19,691	17,157	0	0	0	0	0	0	0	0	0	47,446
Variance, %	-0.5%	20.7%	37.7%	32.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.6%
Est FY Cumul	52,326	104,880	157,148	209,705	261,051	313,782	364,479	417,294	467,143	520,095	569,256	622,293	671,393	
Actual FY Cumul	52,603	94,282	126,860	162,259	0	0	0	0	0	0	0	0	0	
Percent Complete	7.6%	14.0%	18.9%	24.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(277)	10,598	30,288	47,446	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-0.5%	10.1%	19.3%	22.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



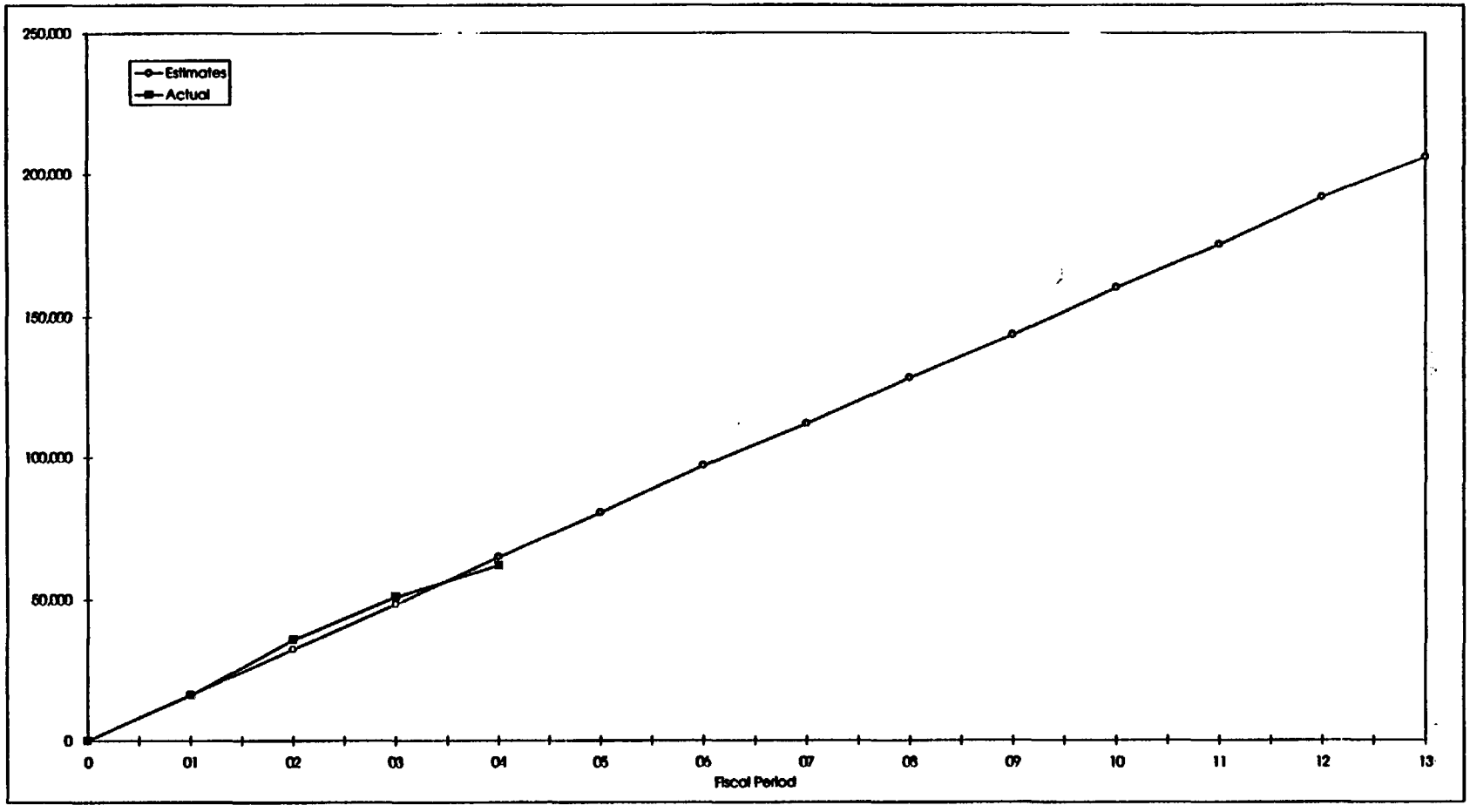
SUB-REGIONAL HYDROGEOLOGIC FLOW AND TRANSPORT PROCESSES
5704-170

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	24,839	24,839	24,737	24,944	21,071	21,437	20,446	21,607	20,389	21,798	20,287	22,130	20,287	99,359
Actual Pd Cost	10,309	19,193	28,282	35,769	0	0	0	0	0	0	0	0	0	93,552
Variance, $	14,530	5,646	(3,545)	(10,824)	0	0	0	0	0	0	0	0	0	5,808
Variance, %	58.5%	22.7%	-14.3%	-43.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.8%
Est FY Cumul	24,839	49,678	74,415	99,359	120,430	141,868	162,313	183,920	204,309	226,108	246,395	268,525	288,813	
Actual FY Cumul	10,309	29,501	57,783	93,552	0	0	0	0	0	0	0	0	0	
Percent Complete	3.6%	10.2%	20.0%	32.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	14,530	20,177	16,632	5,808	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	58.5%	40.6%	22.4%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



PERFORMANCE ASSESSMENT RESEARCH
5704-190

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	38,800	38,857	38,379	39,076	37,520	39,077	36,570	39,270	36,568	39,486	36,147	40,209	36,146	155,112
Actual Pd Cost	44,288	37,646	31,629	42,946	0	0	0	0	0	0	0	0	0	156,510
Variance, $	(5,488)	1,211	6,750	(3,871)	0	0	0	0	0	0	0	0	0	(1,398)
Variance, %	-14.1%	3.1%	17.6%	-9.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.9%
Est FY Cumul	38,800	77,657	116,036	155,112	192,632	231,709	268,279	307,549	344,117	383,603	419,750	459,959	496,104	
Actual FY Cumul	44,288	81,934	113,563	156,510	0	0	0	0	0	0	0	0	0	
Percent Complete	8.9%	16.5%	22.9%	31.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(5,488)	(4,277)	2,473	(1,398)	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	-14.1%	-5.5%	2.1%	-0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	



WASTE SOLIDIFICATION SYSTEMS
5706-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,162	16,163	15,876	16,525	15,510	16,525	15,148	16,581	14,917	16,711	14,594	16,792	14,514	64,725
Actual Pd Cost	15,981	19,857	15,001	10,944	0	0	0	0	0	0	0	0	0	61,783
Variance, $	181	(3,695)	875	5,581	0	0	0	0	0	0	0	0	0	2,942
Variance, %	1.1%	-22.9%	5.5%	33.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%
Est FY Cumul	16,162	32,324	48,200	64,725	80,234	96,759	111,908	128,489	143,406	160,116	174,710	191,502	206,015	
Actual FY Cumul	15,981	35,838	50,838	61,783	0	0	0	0	0	0	0	0	0	
Percent Complete	7.8%	17.4%	24.7%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	181	(3,514)	(2,639)	2,942	0	0	0	0	0	0	0	0	0	
Cumul Variance, %	1.1%	-10.9%	-5.5%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	