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MAINTAINING THE URANIUM RESOURCES DATA SYSTEM AND ASSESSING THE 1989 U.S. URANIUM POTENTIAL RESOURCES

Final Report

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By

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TABLE OF CONTENTS

PAGE

APPENDICES

TABLES

FIGURES

EXECUTIVE SUMMARY

Under the Memorandum of Understanding (MOU) between the EIA, U.S. Department of Energy, and the U.S. Geological Survey (USGS), U.S. Department of the Interior, the USGS develops estimates of uranium endowment for selected geological environments in the United States. New estimates of endowment are used to update the Uranium Resources Assessment Data (URAD) System which, beginning in 1990, is maintained for EIA by the USGS.

For 1989, estimates of U.S. undiscovered resources were generated using revised economic index values (current to December 1989) in the URAD system's cost model. The increase in the estimates for the Estimated Additional Resources (EAR) and Speculative Resources (SR) classes resulted primarily from increases in the estimates of uranium endowment for the solution-collapse, breccia-pipe uranium deposit environment in the Colorado Plateau resource region. The mean values for \$30-, \$50-, and \$100-per-pound U_3O_8 forward-cost categories of EAR increased by about 8, 48, and 32 percent, respectively, as compared to 1988. Estimates of the 1989 undiscovered resources in the SR class also increased in all three forward-cost categories by 10, 5, and 9 percent, respectively.

Because of the difficulties encountered in installing and running the PC-based URAD System using the Oracle RDBMS and in generating the various summary reports, an alternative system that makes use of the dBXL database management system was implemented. The use of dBXL does not involve any change in the Fortran source code of the URAD System; it expedites the generation of summary reports, is easier to use, runs faster, and costs significantly less than the Oracle RDBMS. The two major advantages of dBXL include: a) ease of editing URAD records, and 2) speed of master database creation: 30 seconds with dBXL compared to 25 minutes with Oracle.

The original cost equations in the URAD System were designed to cover drilling costs related to extensive flat-lying tabular ore bodies. The equations do not adequately treat drilling costs for the smaller areas of vertical breccia pipe uranium deposits in the Colorado Plateau resource region. Applying the original cost equations to the breccia pipes data resulted in removing nearly all of the resources from the \$30-per-pound U_3O_8 forward cost category in the 1989 estimates. The development of appropriate cost equations for describing the economics of mining this type of deposit represents a major new task.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is: (1) to describe the work carried out to maintain and update the Uranium Resource Assessment Data (URAD) System, (2) to assess the 1989 U.S. uranium potential resources in various cost categories, and (3) to identify problems and to recommend changes that are needed to improve the URAD System.

1.2 Background on the URAD System

The Energy Information Administration's (EIA) Uranium Resource Assessment Data System contains information on potential resources (undiscovered) of uranium in the United States. The unique mathematical procedures in this system were developed prior to 1983 by Oak Ridge National Laboratory (ORNL) personnel, principally Mr. C.E. Ford and Dr. A.R. McLaren, under the sponsorship of the Grand Junction Area Office of the U.S. Department of Energy (Ford and McLaren, 1980). The URAD System was developed originally on a DEC-10[1] computer. During 1989-1990, the System was converted to operate on IBM-compatible microcomputers by personnel of the Resource Modeling and Technology Economics Group, Energy Division, ORNL, principally Dr. G.L. Chen and Mr. Sujit Das, and by subcontractors, Mr. R. Perubhatla and Mr. R.A. Whitaker, from Coe College and University of Tennessee, respectively (Chen and others, in press; Das and Lee, in press; Das and others, 1988).

The URAD System is used to store subjective geological data on uranium resources for 702 resource areas in the United States. Probabilistic numerical procedures are utilized to compute estimates of resource quantities from these geological data. Estimates are produced for areas that have geological characteristics favorable for the occurrence of uranium deposits. The estimates are classified into categories of Estimated Additional Resources (EAR) and Speculative Resources (SR) and into Forward Cost Categories of $30, $50, and $100 per pound U_3O_8. Although the URAD System is analytically detailed and rigorous, extensive checking, verification, and in some cases revising of URAD output by a knowledgeable geologist is required to assure the quality and reliability of the output data for publication.

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[1]Use of trade names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

Under a Memorandum of Understanding (MOU) between the EIA, U.S. Department of Energy, and the U.S. Geological Survey (USGS), U.S. Department of the Interior, the USGS develops estimates of uranium endowment for selected geological environments in the United States (Finch and McCammon, 1987). The new endowment data are used to update the URAD System files.

Tabulations of U.S. potential resources data are used in the EIA publication _Uranium Industry Annual_ (UIA) and in the EIA's submission for the biennial report _Uranium Resources, Production, and Demand_, which is published jointly by the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency and the International Atomic Energy Agency. The data are also used in preparing the EIA's annual report, _Domestic Uranium Mining and Milling Industry, Viability Assessment_.

1.3 Scope of Work

Under the terms of the present agreement, the USGS is responsible for work on the following Subtasks:

Subtask 1: Cost Escalators - Update 1989 economic indicators for the Cost Factor Generator (CFG) in the URAD System. These indicators are:

a. The Department of Commerce's "Producer Price Index for Industrial Commodities."

b. The "Marshall and Swift Mining-Milling Equipment Cost Index."

c. The "Chemical Engineering Plant Cost Index."

Subtask 2: URAD System Maintenace and Computations. This includes:

a. Manage and maintain the URAD System residing at the USGS computer facility.

b. Provide support in updating system parameters (i.e., reference information, cost-model data, master-file data, etc.) and the potential resources data in the URAD System as requested by the EIA.

c. Provide assistance when requested by the EIA in accessing and running the URAD System concerning uranium potential resources.

d. When requested, review and analyze new mathematical and statistical methods of resource estimation and other modifications that are being considered for use in updating the URAD System with state-of-the-art resource-estimation procedures. Provide the EIA with expert judgements and findings regarding the suitablility of updating the URAD System to incorporate such new procedures. If this task should require a major effort, the contract may be amended to include reimbursable costs

e. Provide results of URAD-computer potential uranium resources for 1989 from the following standard Tasks (reports); 3, 4, 10, 13, 14, 20, 21, 22, and 23 (Appendix I, "Description of Tasks Available" for description of reports).

f. Compile final uranium Estimated Additional Resources (EAR) and Speculative Resources (SR) assessment for the $30, $50, and $100 per pound U3O8 cost categories for 1989. In addition, the contractor shall provide a narrative description in support of the assessments and to compare the results to the assessment from the previous year.

1.4 Deliverables and Due Dates

Description of Deliverables	Due Dates
1. Report on updated cost escalation indicators	April 30, 1990
2. Report of 1989 EAR and SR for various cost categories	June 15, 1990
3. Draft Final Report	November 30, 1990
4. Final report on URAD System maintenance and 1989 potential resources assessment	December 31, 1990

Reports shall be submitted in accordance with Section 11, Scope of Work, and the Reporting Requirements Checklist (DOE Form 1332

2.0 COST ESCALATORS

2.1 Updated 1989 Economic Indicators

Under Subtask 1 of the Scope of Work outlined in Section 1.3, the 1989 updated cost escalation indices are as follows:

Economic Indicators

Yr.	WPI[1]	CEP[2]	M&S[3]
1980	88.0	261.2	659.6
1981	97.4	297.0	721.3
1982	100.0	314.0	745.6
1983	101.1	316.9	760.8
1984	103.3	322.7	780.4
1985	103.7	325.3	789.6
1986	100.0	318.4	797.6
1987	102.6	323.8	813.6
1988	106.3	342.5	852.0
1989	111.6	355.4	895.1

Cost Escalators updated 4/01/90

CEP80 = 355.4/261.2 = 1.3606432
MSI80 = 895.1/659.6 = 1.3570346
MSI82 = 895.1/745.6 = 1.2005096
WPI80 = 111.6/88.0 = 1.2681818
WPI81 = 111.6/97.4 = 1.1457906
WPI82 = 111.6/100.0 = 1.1160000

[1] Producer Price Index (Industrial Commodities), Bureau of Labor Statistics

[2] Chemical Engineering Plant Cost Index, Chemical Engineering, March, 1990

[3] Marshall & Swift Equipment Cost Index, Chemical Enginneering, March, 1990

2.2 Cost Factor Generator (CFG)

The updated cost escalators are used to generate components of capital and operating costs in the Cost Factor Generator, Version 102 Subroutine in the URAD System The values are stored in a file named "CFGPI."

3.0 OVERVIEW OF THE PC-BASED URAD SYSTEM

3.1 General Statement

A demonstration of the PC-based URAD System was given to EIA and the USGS by Dr. G.L. Chen and Mr. Sujit Das of ORNL in Washington, D.C. on January 30, 1990 (Chen and others, in press). The System was implemented using the Professional Oracle Version 5.1B Relational Data Base Management System (ORACLE RDBMS), a product of the Oracle Corporation, Belmont, California. Using the programs provided by ORNL (Appendix 1), EAR and SR for various cost categories were calculated. Several summary reports (IRAREP, AREREP, RLSREP) were also generated as a part of the demonstration. The Professional Oracle version 5.1B replaces the 1022 Database Management System on the DEC-10 computer. The Microsoft Fortran77 language used for the calculations and for generating the summary reports replaces the Fortran66 language. The Pro*Fortran package of the Oracle software is used for transferring the data between the database and the Fortran report writing routines. MS-DOS batch files written for the user interface replaces the macro interpreted command (MIC) language on the DEC-10 computer. The two main datasets (master and cost indices) reside in Oracle; other datasets exist as ASCII files. The ASK.EXE program of the Norton Utilities Advanced Edition Version 4.5 makes the batch files used to generate the various summary reports interactive.

3.2 System Requirements

The PC-based URAD System runs on an IBM-PC or 100-percent compatible microcomputer under MS-DOS version 3.1 or later. The System utilizes the capabilities of the ORACLE RDBMS to store and manipulate the data. Oracle needs 17 megabytes of disk space and 2.5 megabytes of extended memory to install ORACLE RDBMS and some of the essential application tools. The System developed by ORNL contains about 20 different data sets that are in use at any time. They require a total of 1 megabyte of disk storage space. Within a PC environment, approximately 30 minutes is required to select and order the 702 records in the database. Approximately 0.5

minutes/record is required to run the "IRAREP" report and 20-30 minutes/report is required for the other summary reports.

3.3 Installation of the PC-based URAD System on USGS Computers

The necessary hardware to manage and maintain the PC-based URAD System on USGS computers was installed in the early part of 1990. An AST 386/25 and a Dell 310/25 microcomputer was made available for use in Denver and Reston, respectively. The Professional Oracle Version 5.1B RDMBS was installed on both computers making two parallel, identical USGS computer facilities, one in Reston, and one in Denver, in-place and operational in terms of maintaining the PC-based URAD System using the Oracle RDBMS. Using the URAD data records and the PC-based programs provided by ORNL, the updated 1989 economic indicators discussed in Section 3.0 were entered, and the 1989 EAR and SR for the various cost categories were submitted to EIA on June 15, 1990.

4.0 RUNNING THE URAD SYSTEM ON USGS COMPUTERS

4.1 An Alternative to the Oracle RDBMS

Because of the difficulties encountered in installing and running the PC-based URAD System using the Oracle RDBMS and in generating the various summary reports, an alternative system which makes use of the same Fortran77 programs as in the URAD System was implemented. On September 11, 1990, at the EIA/USGS meeting in Denver, an alternative system which uses the dBXL database management software was demonstrated. The use of dBXL does not involve any change in the Fortran source code of the URAD System; it expedites the generation of summary reports, is easier to use, runs faster, and costs significantly less to purchase than the Oracle RDBMS.

In November, 1990, all of the dBXL control programs were run, and the outputs checked against the five available reports generated by the ORNL DEC-10/System 1022 programs. The results of this comparison are given in Appendix III.

4.2 The dBXL Database Management System

The dBXL database management system is available from WordTech Systems, Inc., 21 Altarinda Road, Orinda, California 94563. The cost is under $150. The system runs under PC-DOS and 100-percent IBM-compatible MS-

DOS microcomputers and requires either two floppy disk drives or one hard disk and one floppy disk drive. The system requires only 512K bytes of RAM and DOS version 2.1 or greater. After proper installation, dBXL will also run on most MS-DOS microcomputers that are not 100-percent compatible.

4.3 System Requirements using dBXL

The disk space required by the 702 URAD records in the master database and the dBXL data base manager is approximately 2.3 megabytes. No extended memory is required by dBXL. The PC-based URAD System using dBXL requires only 10 megabytes of disk space, provided that the larger summary reports are deleted after printing.

4.4 Installing dBXL and Running URAD Programs

Installation of dBXL is straightforward in that an "install" program is supplied with the system. Running dBXL is accomplished using commands very similar to those used by dBASE III Plus TM. Listings of all of the dBXL programs used to run the URAD Fortran programs provided to the USGS by ORNL are given in Appendix IV. For example, to generate the "AGEREP" summary report in URAD, one simply types "URADREPT AGEREP" followed by a carriage return. URADREPT is a batch file that calls for directories to be changed as needed, invokes dBXL, and directs dBXL to select and sort records. The AGEREP Fortran program is then invoked to carrry out the necessary calculations and tabulations and directs the output to a print file AGEREP.PRT. Other URAD programs, for instance, CAREP, require other pre-sorting routines prior to calculation and tabulation of results, and this is handled by the specific dBXL program that is used.

4.5 Comparisons with Earlier ORNL Summary Reports

As noted in Appendix III, certain corrections need to be made to 4 out of the 5 Fortran programs supplied by ORNL for which it was possible to compare outputs from earlier ORNL reports. The outputs for the remaining 15 programs could not be checked because the outputs from earlier ORNL reports were not made available to the USGS. For one program in particular, IRAREP, it was found that the first record is always erroneous. The USGS workaround has been to insert a "dummy" record in front of the 702 good records, and by including this record only when IRAREP is run.

5.0. 1989 URANIUM RESOURCE ESTIMATES

5.1. Updating of Undiscovered Uranium Resource Estimates

In accordance with a Memorandum of Understanding (MOU) between the U.S. Geological Survey (USGS) of the U.S. Department of the Interior and the Energy Information Administration (EIA), the USGS will provide updated estimates of uranium endowment for selected geological environments within the United States.

Beginning in 1989, the estimate of undiscovered resources reported in the Uranium Industry Annual for the Colorado Plateau region was derived using the replacement values for uranium endowment supplied by the USGS for deposits associated with the solution-collapse, breccia-pipe environment common to that region. The methodology used is a modification of the NURE methodology by DOE (Finch and McCammon, 1987).

5.2. Estimated Additional Resources (EAR) and Speculative Resources (SR)

The estimates of EAR and SR presented in this section were developed from a database of information on uranium deposits and mining economics compiled during the past three decades of Government and industry activities. The database consists of the extensive data on undiscovered uranium resources compiled during the NURE program concluded in 1983 as well as new data compiled by the U.S. Geological Survey. These data are maintained in the Uranium Resources Assessment Data (URAD) system, which is used to generate current estimates of undiscovered resources of uranium at the forward costs of \$30-, \$50-, and \$100-per-pound U_3O_8.

For 1989, estimates of U.S. undiscovered resources were generated using revised economic index values (current to December 1989) in the URAD system's cost model. The economic indexes are the Wholesale Price Index-Industrial Commodities (WPI), the Marshall and Swift Mining-Milling Equipment Cost Index (MSI), and the Chemical Engineering Plant Cost Index (CEP). The higher 1989 indexes resulted in increased costs, and in slightly lower estimates of the quantities of EAR and SR for most resource regions in 1989 when compared to 1988.

Differences between the estimates of undiscovered resources shown by Table 1 for 1988 and 1989 are small, except for large increases in the \$50 and \$100 per-pound U_3O_8 forward-cost EAR categories. For 1989, the mean values for \$30-, \$50-, and \$100-per-pound U_3O_8 forward-cost categories of EAR were

Table 1. Estimated Additional Resources (EAR) and Speculative Resources (SR) at the End of the year, 1974-1989

[Million Pounds U_3O_8]

Year	Forward-Cost Category in Nominal Dollars[a]									
	$10 per pound		$15 per pound		$30 per pound		$50 per pound		$100 per pound	
	EAR	SR	EAR	SR	EAR	SR	EAR	SR	EAR	SR
1974	900	1,000	1,400	1,700	2,300	3,500	(b)	(b)	(b)	(b)
1975	900	1,100	1,300	1,900	2,100	3,700	(b)	(b)	(b)	(b)
1976	600	400	1,200	1,400	2,200	3,200	2,700	3,900	(b)	(b)
1977	(b)	(b)	1,100	1,300	2,000	3,100	2,800	4,200	(b)	(b)
1978	(b)	(b)	800	600	2,000	2,000	3,000	3,400	(b)	(b)
1979[c]	(b)	(b)	800	600	2,000	2,000	3,000	3,400	(b)	(b)
1980	(b)	(b)	600	300	1,800	1,300	2,900	2,200	4,200	3,400
1981	(b)	(b)	(b)	(b)	1,200	900	2,200	1,800	3,500	2,900
1982	(b)	(b)	(b)	(b)	1,300	900	2,300	1,800	3,800	3,000
1983	(b)	(b)	(b)	(b)	1,300	1,000	2,400	2,000	3,800	3,200
1984	(b)	(b)	(b)	(b)	1,300	1,000	2,300	2,000	3,700	3,200
1985	(b)	(b)	(b)	(b)	1,300	1,000	2,400	1,900	3,800	3,200
1986	(b)	(b)	(b)	(b)	1,300	1,000	2,400	1,900	3,800	3,200
1987	(b)	(b)	(b)	(b)	1,300	1,000	2,300	2,000	3,700	3,200
1988	(b)	(b)	(b)	(b)	1,300	1,000	2,300	2,000	3,800	3,200
1989	(b)	(b)	(b)	(b)	1,400	1,100	3,400	2,100	5,000	3,500

[a] Values shown are the mean values for the distributions of estimates for each forward-cost category, rounded to the nearest 100 million pounds U_3O_8. Resource values in forward-cost categories are cumulative: that is, the quantity at each level of forward cost includes all resources at the lower cost in that category.

[b] Not estimated for the indicated forward-cost category.

[c] No new estimates were released for the end of 1979, since the NURE program was to publish estimates of undiscovered resources by October 1980.

Sources: **1974-1982**--U.S. Department of Energy, Grand Junction Project Office, *Statistical Data of the Uranium Industry* (January 1983). **1983-1989**--Estimates based on uranium resources data developed under the DOE National Uranium Resource Evaluation (NURE) program, 1974-1983, using methodology described in *An assessment Report on Uranium in the United States of America* (October 1980), and in U.S. Department of Energy.*Uranium Industry Seminar* (October 1980) and under the USGS Uranium Resource Assessment project using in part methodology described by Finch and McCammon, 1987.

increased by about 8, 48, and 32 percent, respectively, when compared with the EAR values for 1988 (Table 1). Estimates of undiscovered resources in the SR class also increased in all three forward-cost categories in 1989, being 10, 5, and 9 percent, respectively, in the \$30-, \$50-, and \$100-per-pound forward-cost categories.

The increases in the estimates for the EAR and SR classes resulted from increases in the estimates of uranium endowment for the solution-collapse, breccia-pipe uranium deposit environment in the Colorado Plateau resource region. The revised estimates of endowment were prepared by the U.S. Geological Survey based on subsurface data provided by industry and on results from detailed geological field studies in Northern Arizona and adjacent Utah (Wenrich, 1985).

5.3. Distribution of EAR and SR by Resource Region

Estimates of EAR and SR for the United States are reported for resource regions defined by geologic and physiographic characteristics (see Table 10 in EIA, 1989, 1990). The mean values of EAR and SR are summarized by principal resource region and forward-cost category in Table 2. The Colorado Plateau shows a 133-percent increase in the \$50 per-pound U_3O_8 EAR category when compared to the 1988 value. This marked increase is due mainly to new discoveries and greatly improved knowledge of the distribution of breccia-pipe ores in the Grand Canyon region of Arizona developed in the past 10 years (Wenrich, 1985).

Decreases up to 14 percent in the 1989 quantities of EAR and SR estimated for regions outside the Colorado Plateau resulted from increased values of economic indexes used in the undiscovered-resource cost model for 1989 as compared with 1988. In Table 2, the full extent of these decreases are not apparent because of the rounding of published values to the nearest 10 million pounds of U_3O_8.

5.4. Distribution of Uranium Endowment for EAR and SR by Resource Region

Uranium endowment is the total quantity of estimated resources, irrespective of economic considerations, above 0.01 percent U_3O_8 within geographic areas that have geologic characteristics favorable for uranium deposits. Endowment includes the undiscovered resources (EAR and SR), which are derived by determining economically recoverable portions of the endowment at stipulated maximum forward costs of producing the uranium. The distribution of the mean values of uranium endowment is

Table 2. Estimated Additional Resources (EAR) and Speculative Resources (SR) by Resource Region at the End of 1989

[Million Pounds U_3O_8]

Resource Region[b]	Forward-Cost Category in Nominal Dollars[a]					
	$30 per pound		$50 per pound		$100 per pound	
	EAR	SR	EAR	SR	EAR	SR
Colorado Plateau	500	240	1,960	640	2,590	1,240
Wyoming Basins	170	90	370	170	690	250
Coastal Plain	380	130	500	180	610	230
Northern Rockies	20	80	60	140	180	230
Colorado and Southern Rockies	140	80	180	140	220	190
Basin and Range	60	100	170	180	420	340
Other Regions[c]	120	340	190	630	270	1,010
Total	1,380	1,060	3,430	2,090	4,980	3,500

[a] Values shown are the mean values for the distributions of estimates for each forward-cost category, rounded to the nearest 10 million pounds U_3O_8. Resource values in forward-cost categories are cumulative: that is, the quantity at each level of forward cost includes all resources at the lower cost in that category.

[b] See Figure 6 in EIA, 1990

[c] Includes Appalachian Highlands, Great Plains, Pacific Coast and Sierra Nevada, Central Lowlands, and Columbia Plateau regions and Alaska.

Note: Totals may not equal sum of components because of independent rounding.

Source: Prepared by staff of the U.S. Geological Survey, U.S. Department of the Interior, based on uranium resources data developed under the DOE National Uranium Resource Evaluation (NURE) program and the USGS Uranium Resource Assessment project, using methodology described in *An Assessment Report on Uranium in the United States of America* (October 1980), and in U.S. Department of Energy, *Uranium Industry Seminar (October 1980).*

shown by resource region in Table 3. Endowment values for all regions except the Colorado Plateau are unchanged from 1988 values. The marked increase in the Colorado Plateau uranium endowment is reflected in the totals with EAR and SR resources included in Tables 1, 2, and 3.

5.5. Distribution of EAR and SR by Land Status

The distribution by land status of mean values for \$50-per-pound EAR and SR at the end of 1989 is shown in Table 4. Increases in percentages of EAR and SR over those for 1988 are shown for Bureau of Land Management, Forest Service Lands, National Park Service Lands, Indian Lands, State Lands, and Private Fee Lands.

Table 3. Uranium Endowment by Resource Region at the End of 1989

[Million Pounds U_3O_8]

Resource Region	Endowment Associated with Estimated Additional Resources[b]	Endowment Associated with Speculative Resources[a]
Colorado Plateau	3,950	2,430
Wyoming Basins	1,990	450
Coastal Plain	910	410
Northern Rockies	680	3,860
Colorado and Southern Rockies	320	360
Great Plains	310	950
Basin and Range	1,420	1,080
Central Lowlands	(c)	280
Appalachian Highlands	120	1,140
Other Regions[d]	50	120
Total	9,740	11,070

[a] See Figure 6 in EIA, 1990.

[b] Values shown are the mean values for the distributions of estimates of EAR and SR, rounded to the nearest 10 million pounds U_3O_8.

[c] No uranium endowment in the Estimated Additional Resources category is estimated for this resource region.

[d] Includes endowment associated with Estimated Additional Resources for Pacific Coast region and Alaska and endowment associated with Speculative Resources for Columbia Plateau, Pacific Coast, and Southern Canadian Shield regions and Alaska.

Note: Totals may not equal sum of components because of independent rounding.

Sources: U.S. Department of Energy, Grand Junction Project Office, *Statistical Data of the Uranium Industry*(January 1983). Estimates based on uranium resources data developed under the DOE National Uranium Resource Evaluation (NURE) program, using methodology described in *An Assessment Report on Uranium in the United States of America* (October 1980), and in U.S. Department of Energy, *Uranium Industry Seminar* (October 1980) and under the USGS Uranium Resource Assessment project using in part methodology described by Finch and McCammon, 1987.

Table 4. Estimated Additional Resources (EAR) and Speculative Resources (SR) in the \$50-per Pound Forward-Cost Category by Land Status at the End of 1989

Land Status	Estimated Additional Resources[a]		Speculative Resources[a]	
	Million Pounds U3O8	Percent of Total EAR	Millon Pounds U3O8	Percent of Total SR
Public lands				
Bureau of Land Management and Forest Service Lands	1,000	29.0	330	15.9
Bureau of Reclamation	(b)	(c)	(b)	(c)
Wilderness Areas	20	0.5	20	1.0
National Park Service Lands	110	3.2	10	0.5
Wildlife Refuges	(b)	(c)	(b)	(c)
DOE-Administered	10	0.2	(b)	(c)
Indian Lands	460	13.5	230	11.1
State Lands	200	5.8	140	6.7
Private Fee Lands [d]	1,570	45.8	1,300	62.5
Other (Military Reservations, Waterways, Reclamation Projects, Proposed Withdrawals, etc.)	60	1.9	50	2.4
Total	3,430	100.0	2,090	100.0

[a] Values shown are the mean values for the di: ributions of estimates of EAR and SR, rounded to the nearest 10 million pounds U_3O_8.

[b] Value is less than 5 million pounds U_3O_8.

[c] Value is less than 0.05 percent.

[d] Includes railroad lands and patented claims.

Note: Totals may not equal sum of components because of independent rounding.

Source: Prepared by staff of the U.S. Geological Survey, U.S. Department of the Interior, based on uranium resources data developed under the DOE National Uranium Resource Evaluation (NURE) program and the USGS Uranium Resource Assessment project, using methodology described in *An Assessment Report on Uranium in the United States of America* (October 1980), and in U.S. Department of Energy, *Uranium Industry Seminar* (October 1980).

5.6. Distribution of Potential by Geologic Age of Host Rock and Type of Deposit

The distribution of \$50- and \$100-per-pound U_3O_8 forward cost EAR by geologic age of host rock is shown in Figure 1 and by type of deposit in Figure 3. The distribution of the same cost categories for SR by geologic type is shown in Figure 2 and by type of deposit in Figure 4. The EAR of the \$50 category are concentrated in the Mesozoic and Late Paleozoic rocks and, secondly, in the Early to Late Tertiary rocks. However, if the Tertiary host rocks are totalled, they exceed both Mesozoic and Paleozoic hosts. The \$100 category and the SR have similar distributions. By far the sandstone-type and vein-type deposits contain the most in both EAR and SR classes. The metamorphic class is notably high in the SR class.

5.7. Distribution of Uranium Endowment and Potential in Solution Collapse Breccia Pipes in the Grand Canyon Region

The uranium endowment and potential for the solution-collapse breccia pipe environment in the Grand Canyon region are summarized for the NURE (1989) and the USGS (1990) estimates in Table 5. The endowment for the USGS estimate (column U1END) of 1,210,461 tons U_3O_8 increased nearly 12-fold over the NURE estimate. This increase is due mainly to factors that are related to the new knowledge that has accumulated about the solution-collapse breccia pipe deposits.

Another notable difference is the comparison of potential resource estimates for the \$30-per-pound U_3O_8 Forward Cost category (U130 in Table 5) for the old and new pipes data. In the new estimates, only locality 816003 has material in this category. This is the only locality for which the favorable rock is near the surface. However, ore from the breccia pipes has been mined in 1989 and 1990 from deeper horizons that are analogous to the other areas in the Grand Canyon region that are judged favorable. In the 1989 Uranium Industry Annual (EIA, 1990, table 10), 60 million pounds were added to the Colorado Plateau due to the new breccia pipe estimates. What has happened is that the original cost equations were written to cover drilling costs related to high-tonnage, low-grade, flat-lying, relatively shallow depth, tabular ore bodies. It does not treat drilling costs for the smaller-tonnage, higher-grade, vertical, relatively deep, breccia pipe ore bodies. In particular, the average value of the Factor T (the estimate of the tons of uranium-bearing material per square mile that is used in the cost factor equations) for the new pipes is about 0.00021 times as large than for the old pipes. The result is that nearly all of the resources are removed from the \$30-per-pound U_3O_8 forward cost category. Revising the cost factor model to include the appropriate drilling costs associated with the breccia pipe ore bodies is a task that will require a major new effort.

A listing of the records for the new pipes data is given in Appendix V.

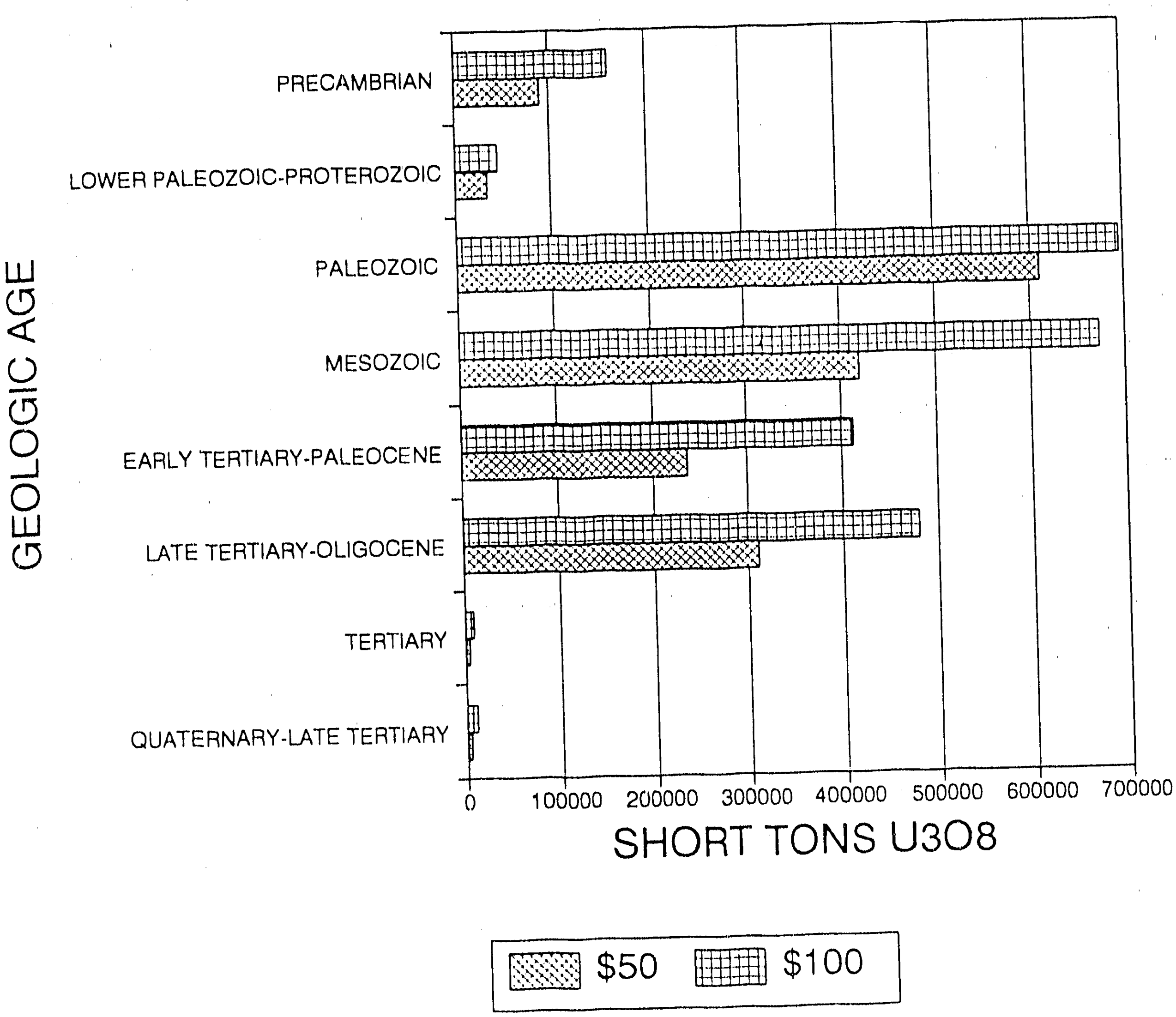

Figure 1. Graph showing the distribution of $50-per-pound and $100-per-pound forward-cost EAR by geologic age of host rock

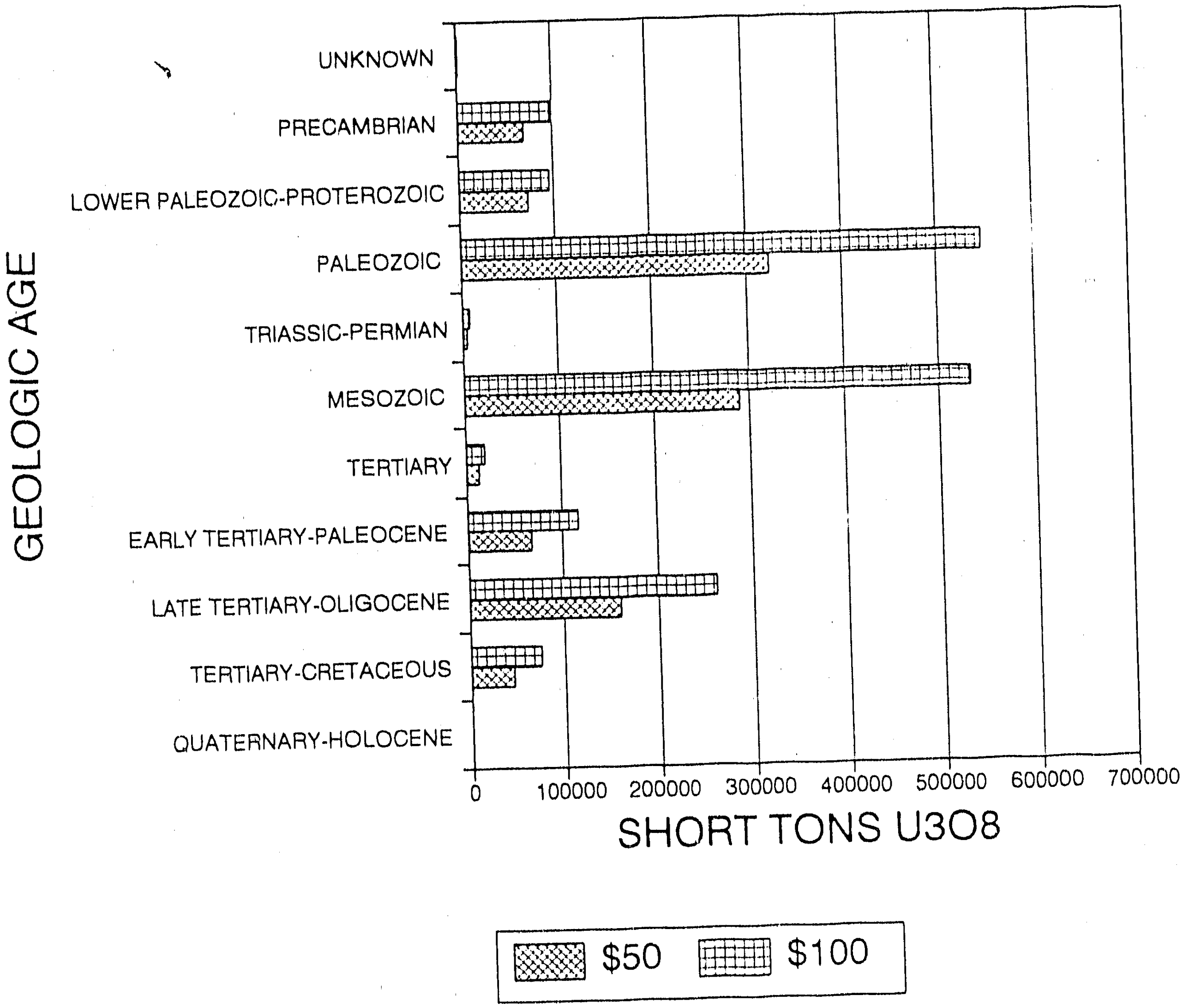

Figure 2. Graph showing the distribution of $50-per-pound and $100-per-pound forward-cost SR by geologic age of host rock.

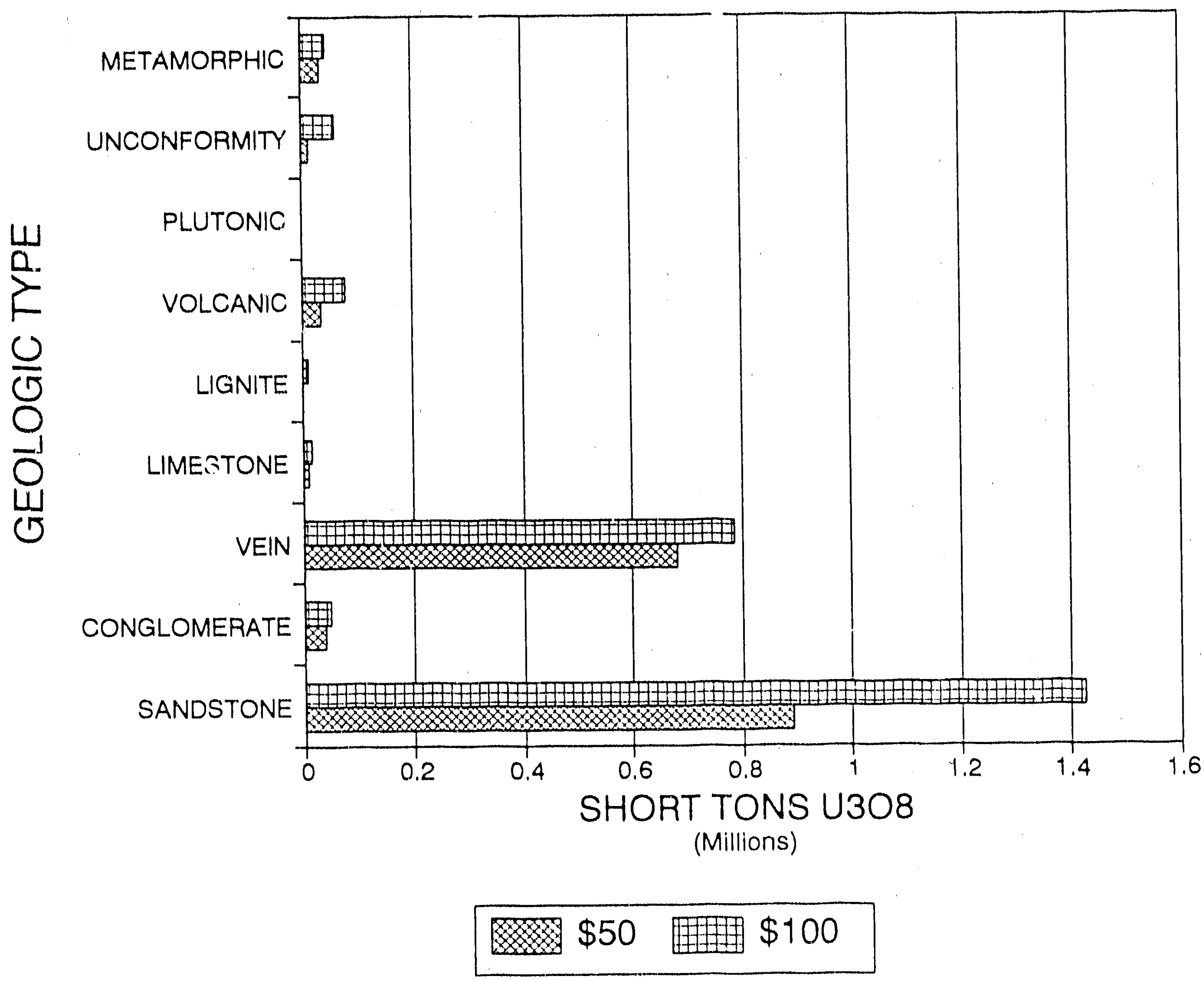

Figure 3. Graph showing the distribution of $50-per-pound and $100-per-pound forward-cost EAR by geologic deposit type.

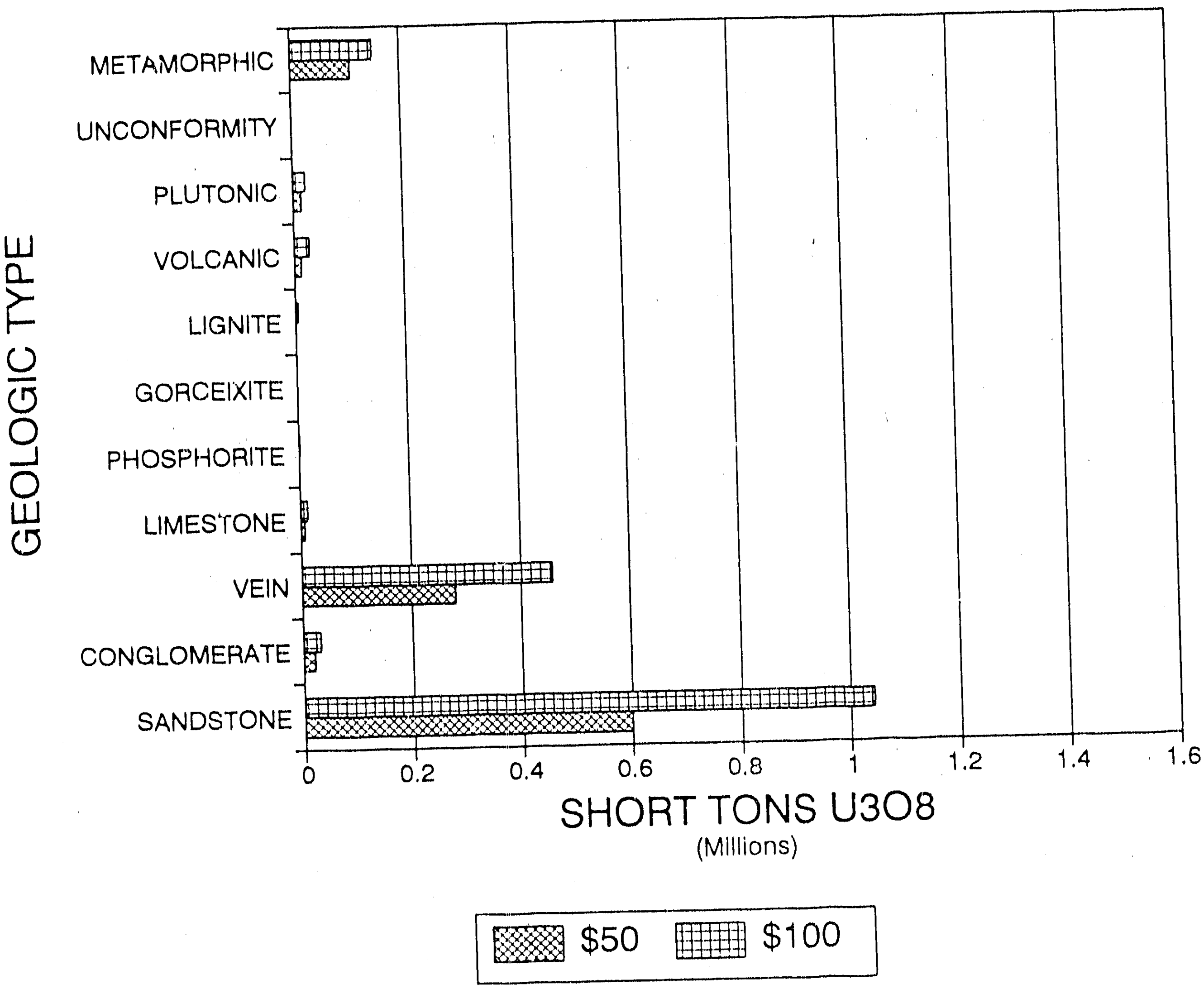

Figure 4. Graph sho^ving the distribution of $50-per-pound ^nd $100-per-pound forward-cost SR by geologic deposit type.

Table 5. NURE (old) and USGS (new) URAD Estimates of Endowment and Potential for Breccia-Pipe Uranium in the Grand Canyon Region

OLD PIPE ESTIMATES (1989) 1988 COSTS

LOCLC	HRU	CLASS	INTL	CA	AREA (sq. mi.)	FMEAN	TMEAN	GMEAN	U1END (short tons U_3O_8)	U130	U150	U1100
8060031	72710	2	MTF	7300M	1463	2.215E-05	2.5620E+08	0.14	11620	4828	7131	8925
8060051	72710	1	HKH	7300M	936	2.215E-05	2.5620E+08	0.20	10630	0	6861	8191
8060051	72710	2	HKH	7300M	3664	2.215E-05	2.5620E+08	0.14	29110	0	16450	21100
8060062	73701	2	RTM	7300M	222	2.215E-05	2.5620E+08	0.14	1764	936	1274	1496
8060063	73701	2	RTM	7300M	89	2.215E-05	2.5620E+08	0.14	707	0	510.6	599.6
8060070	72710	2	KWV	7300M	1394	2.215E-05	2.5620E+08	0.14	11070	5748	7724	9139
8060071	72710	2	KWV	7300M	3055	2.215E-05	2.5620E+08	0.14	24270	9769	14320	18710
8060072	72710	2	JAO	7300M	3258	1.040E-03	1.6110E+06	0.20	10750	0	0	8187
	TOTALS				14081				99921	21281	54271	76348

NEW PIPE ESTIMATES (1990) 1989 COSTS

LOCLC	HRU	CLASS	INTL	CA	AREA	FMEAN	TMEAN	GMEAN	U1END	U130	U150	U1100
8160001	73710	1	CTP	730HP	8100	9.742E-01	5.4330E+04	0.20	841700	0	589300	668500
8160002	73710	2	CTP	730HP	805	9.742E-01	5.4330E+04	0.20	83650	0	55640	65610
8160003	73701	1	CTP	730HP	881	1.280E-01	5.4330E+04	0.20	2030	9441	10800	11410
8160004	73710	2	CTP	730HP	1440	5.662E-01	5.4330E+04	0.20	86970	0	61200	69180
8160005	73710	2	CTP	730HP	2144	5.662E-01	5.4330E+04	0.20	129500	0	0	100700
8160006	73710	2	CTP	730HP	2609	9.716E-02	5.4330E+04	0.20	27040	0	18690	21460
8160007	73710	2	CTP	730HP	488	9.716E-02	5.4330E+04	0.20	5057	0	0	0
8160008	73710	2	CTP	730HP	201	9.742E-01	5.4330E+04	0.20	20890	0	14720	16620
8160009	73710	2	CTP	730HP	60	5.662E-01	5.4330E+04	0.20	3624	0	2560	2885
	TOTALS				16728				1210461	9441	752910	956365

6.0 RECOMMENDATIONS

Based upon the work that was performed by the USGS under the terms in the current Contract, the following specific recommendations are made:

(1) The USGS recommends the use of dBXL for the database management of the PC-based URAD System. The two major advantages of dBXL include: a) ease of editing URAD records, and 2) speed of master database creation: 30 seconds with dBXL, 25 minutes with Oracle.

(2) Boundaries of favorable areas in quadrangles (two-degree sheets) were digitized into plot files as part of the NURE program. Preliminary searching has revealed that the magnetic tapes of these files probably still exist in Grand Junction. These files need to be updated as outlines for new favorable areas are delineated. In particular, updated favorable areas have been delineated for the breccia pipes in the Grand Canyon region and new favorable areas have been delineated for surficial deposits in the state of Washington. It is recommended that these files be sent to the USGS in Denver and that they become a permanent part of the URAD System.

(3) The USGS recommends that new cost equations unique to the geologic environment characteristic of collapse breccia pipe deposits be developed. The equations in the current version of the cost factor generator are not appropriate for describing the economics of mining this type of deposit. Developing appropriate cost equations is a major new task that is beyond the scope of the current URAD tasks being undertaken by the USGS. It is recommended that a separate contract be written to undertake this work.

(4) Several report and graphics generation programs included in the URAD System were found by USGS to have not been converted to PC use by ORNL. The unconverted programs include Sum 22 (cumulative distribution plots), PIREP, PDVREP, and others. None of these programs are currently involved in the generation of data published in EIA's *Uranium Industry Annual*. Because no funds remain for ORNL to convert these programs for PC use, it is recommended that further work involving these programs be deferred indefinitely.

(5) The USGS agrees with EIA that there is a need to check on current state tax codes, to add new state severance/royalty tax equations, and to modify the existing equations where necessary. It is recommended that this work be undertaken as part of next year's Contract.

7.0 REFERENCES

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U.S. Department of Energy, 1980, An assessment report on uranium in the United States of America: U.S. Department of Energy Report GJO 111 (80), U.S. Geological Survey, Denver, Colorado, 150 p., 6 microfiche.

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APPENDIX I

Description of Tasks Available in the URAD System

Listings of executable Fortran programs received by the USGS from ORNL are indicated by an asterisk. At the USGS, dBXL batch files have been written to load URAD records, sort in manner required by the given executable program, and cause the program to execute and to store the output in a print file.

	Task	Description
1	ADDF85	From Form GJ-85 input, create a new 1022 dataset or add records to an existing
2	AGEHRU*	Summary of Host Rock Unit codes broken down by Geologic Age
3	AGEREP*	Summary of potential by geologic age
4	AREREP*	Summary of potential by class, resource region, exploration area, ore reserve area and locality
5	CAREP*	Summary of potential by control areas and class
6	CCREP*	Ranking of potential assessments within cost category and class
7	DEPREP*	Summary of potential by deposit type
8	E50REP*	Descending ranking of assessments by unconditional mean of $50/lb endowments
	FNDREP*	Generates descending ranking of unconditional mean of endowments
9	GEOREP*	Master list of geographic codes
10	GTREP*	Summary of potential resources by geologic type
11	HRUREP	Summary of potential resources by host-rock-unit
12	INDEX*	List of localities with index to endowment and $50/lb ranking
13	IRAREP*	Produce individual Resource Assessment Reports
14	JAPREP*	Produce regional and national uranium resource totals and percentiles
15	LTREP*	Summary of potential resources by years-lead-time

16	PDVREP*	Conditional means and 25th and 75th percentiles for Probable Potential
17	PIREP	Summary of potential resources by P.I./Assessor
18	QDREP	Summary of potential resources by quadrangle
19	REGREP*	Summary of potential resources by class and region
20	RLSREP*	Summary of potential by class, region and land-status-type
21	SLSREP*	Summary of potential by class, state, and land-status-type
22	STAREP*	Summary of potential by state and class
23	SUM22	Produce cumulative distributions of regional and national uranium resources, and files to produce MAPPER graphs
24	YLTREP*	Summary of potential resources by years-lead-time

APPENDIX II

Description of Attributes in the URAD Dataset

No.	Attribute	Abbrev	Description/Remarks
1	LOCLC		8-digit locality code
2	HOST_ROCK_UNIT	HRU	5-digit host-rock-unit code
3	CLASS		1=Probable, 2=Possible, 3=Speculative
4	EFFECTIVE_DATE	EDATE	Effective data of assessment
5	INITIALS	INTL	Initials of principal scientist
6	CONTROL_AREA	CA	
7	PROBABILITY	PO	Probability of occurrence
8	METHOD	MI	1=Linear, 2=Area, 3=Volume
9	FPL		Lower probability level for Fraction (F) estimate
10	TPL		Same for Tonnage (T)
11	GPL		Same for Average Grade (G)
12	FPU		Upper probability level for Fraction (F) estimate
13	TPU		Same for Tonnage (T)
14	GPU		Same for Average Grade (G)
15	AREA		
16	FRACTION_LOWER	FL	Lower percentile for F
17	FRACTION_MODE	FM	Mode for F
18	FRACTION_UPPER	FU	Upper percentile for F
19	TONNAGE_LOWER	TL	Lower percentile for T
20	TONNAGE_MODE	TM	Mode for T
21	TONNAGE_UPPER	TU	Upper percentile for T
22	GRADE_LOWER	GL	Lower percentile for G
23	GRADE_MODE	GM	Mode for G
24	GRADE_UPPER	GU	Upper percentile for G
25	DEPTH_PCT1	DP1	Probability ore is found in depth range 0-100 ft.
26	DEPTH_PCT2	DP2	Same for 101-200 ft.
27	DEPTH_PCT3	DP3	Same for 201-300 ft.
28	DEPTH_PCT4	DP4	Same for 301-400 ft.
29	DEPTH_PCT5	DP5	Same for 401-500 ft.
30	DEPTH_PCT6	DP6	Same for 501-1000 ft.
31	DEPTH_PCT7	DP7	Same for 1001-1500 ft.
32	DEPTH_PCT8	DP8	Same for 1501-2000 ft.

33	DEPTH_PCT9	DP9	Same for 2001-3000 ft.
34	DEPTH_PCT10	DP10	Same for 3001-4000 ft.
35	DEPTH_PCT11	DP11	Same for 4001-5000 ft.
36	AVERAGE_THICKNESS	AVGTH	(feet)
37	MINERAL_TYPE	MINRL	
38	LEAD_TIME	LEAD	(years)
39	MINE_TYPE	MINE	1=Open Pit, 2=Underground, 3=Solution
40	FRACTION_UNEXPLORED	FRUNX	
41	DISCOVERY_RATE	DR	(tons/foot)
42	GEOLOGIC_TYPE1	GT1	
43	GEO_PCT1	GP1	Percentage of deposit(s) on land with geologic type GR1
44	GEOLOGIC_TYPE2	GT2	
45	GEO_PCT2	GP2	Same for geologic type GT2
46	GEOLOGIC_TYPE3	GT3	
47	GEO_PCT3	GP3	Same for geologic type GT3
48	GEOLOGIC_TYPE4	GT4	
49	GEO_PCT4	GP4	Same for geology type GT4
50	STATE_CODE1	ST1	
51	STATE_PCT1	STP1	Percentage of deposit(s) in state ST1
52	STATE_CODE2	ST2	
53	STATE_PCT2	STP2	Same for state STP2
54	STATE_CODE3	ST3	
55	STATE_PCT3	STP3	Same for state STP3
56	STATE_CODE4	ST4	
57	STATE_PCT4	STP4	Same for state STP4
58	STATE_CODE5	ST5	
59	STATE_PCT5	STP5	Same for state STP5
60	QUAD_CODE1	QUAD1	
61	QUAD_PCT1	QP1	Probability deposit(s) are in quad QUAD1
62	QUAD_CODE2	QUAD2	
63	QUAD_PCT2	QP2	Same for quad QUAD2
64	QUAD_CODE3	QUAD3	
65	QUAD_PCT3	QP3	Same for quad QUAD3
66	QUAD_CODE4	QUAD4	
67	QUAD_PCT4	QP4	Same for quad QUAD4
68	QUAD_CODE5	QUAD5	
69	QUAD_PCT5	QP5	Same for quad QUAD5
70	QUAD_CODE6	QUAD6	
71	QUAD_PCT6	QP6	Same for quad QUAD6
72	LAND_TYPE1	LT1	
73	LAND_PCT1	LP1	Probability deposit(s) on land with status LT1
74	LAND_TYPE2	LT2	
75	LAND_PCT2	LP2	Same for land status LT2

76	LAND_TYPE3	LT3	
77	LAND_PCT3	LP3	Same for land status LT3
78	LAND_TYPE4	LT4	
79	LAND_PCT4	LP4	Same for land status LT4
80	LAND_TYPE5	LT5	
81	LAND_PCT5	LP5	Same for land status LT5
82	LAND_TYPE6	LT6	
83	LAND_PCT6	LP6	Same for land status LT6
84	LAND_TYPE7	LT7	
85	LAND_PCT7	LP7	Same for land status LT7
86	LAND_TYPE8	LT8	
87	LAND_PCT8	LP8	Same for land status LT8
88	LAND_TYPE9	LT9	
89	LAND_PCT9	LP9	Same for land status LT9
90	LAND_TYPE10	LT10	
91	LAND_PCT10	LP10	Same for land status LT10
92	LAND_TYPE11	LT11	
93	LAND_PCT11	LP11	Same for land status LT11
94	LAND_TYPE12	LT12	
95	LAND_PCT12	LP12	Same for land status LT12
96	RESOURCE_REGION	REGN	Digits 1-2 of Locality Code
97	EXPLORATION_AREA	EXPLA	Digits 3-4 of Locality Code
98	ORE_RESERVE_AREA	ORA	Digits 5-6 of Locality Code
99	LOCALITY	LOC	Digits 7-8 of Locality Code
100	AGE		Digits 1-2 of HRU
101	FORMATION	FORM	Digits 3-4 of HRU
102	MEMBER	MEM	Digit 5 of HRU
103	DEPOSIT_CODE	DEPST	Characters 1-3 of Control Area Code
104	STATUS_CODE	SCODE	1:OK; otherwise, processing is required
105	DATE_ENTERED	DENTR	
106	DATE_CHANGED	DCHNG	
107	DATE_PROCESSED	DPROC	
108	MEAN_FRACTION	FMEAN	
109	MEAN_TONNAGE	TMEAN	
110	MEAN_GRADE	GMEAN	
111	MEAN_ENDOWMENT	U1END	
112	VARIANCE_ENDOWMENT	U2END	
113	3RD_MOM_ENDOWMENT	U3END	
114	4TH_MOM_ENDOWMENT	U4END	
115	MILL_THRUPUT	MLTHRU	(thousands of tons per day)
116	MINE_LOSS	MLOSS	mining losses (fraction)
117	CAPITAL_COST_15	CC15	Capital cost ($/ton) for $15/lb economic potential
118	OPERATING_COST_15	OP15	Operating cost ($/ton) for $15/lb economic potential

119	MILL_RECOVERY_15	MR15	Mill recovery for $15/lb economic potential
120	CUTOFF_GRADE_15	CG15	Cutoff grade for $15/lb economic potential
121	MIN_AVG_GRADE_15	MG15	Minimum average grade for $15/lb economic potential
122	ASSIGND_AVG_GRADE_15	AG15	Assigned average grade for $15/lb economic potential
123	MEAN_15	U115	Mean for $15/lb economic potential
124	VARIANCE_15	U215	Variance for $15/lb economic potential
125	THIRD_MOM_15	U315	Third moment for $15/lb economic potential
126	FOURTH_MOM_15	U415	Fourth moment for $15/lb economic potential
127	CAPITAL_COST_30	CC30	$30/lb economic potential (see $15/lb descriptions above)
128	OPERATING_COST_30	OP30	
129	MILL_RECOVERY_30	MR30	
130	CUTOFF_GRADE_30	CG30	
131	MIN_AVG_GRADE_30	MG30	
132	ASSIGND_AVG_GRADE_30	AG30	
133	MEAN_30	U130	
134	VARIANCE_30	U230	
135	THIRD_MOM_30	U330	
136	FOURTH_MOM_30	U430	
137	CAPITAL_COST_50	CC50	$50/lb economic potential (see $15/lb descriptions above)
138	OPERATING_COST_50	OP50	
139	MILL_RECOVERY_50	MR50	
140	CUTOFF_GRADE_50	CG50	
141	MIN_AVG_GRADE_50	MG50	
142	ASSIGND_AVG_GRADE_50	AG50	
143	MEAN_50	U150	
144	VARIANCE_50	U250	
145	THIRD_MOM_50	U350	
146	FOURTH_MOM_50	U450	
147	CAPITAL_COST_100	CC100	$100/lb economic potential (see $15/lb descriptions above)
148	OPERATING_COST_100	OP100	
149	MILL_RECOVERY_100	MR100	
150	CUTOFF_GRADE_100	CG100	
151	MIN_AVG_GRADE_100	MG100	
152	ASSIGND_AVG_GRADE_100	AG100	
153	MEAN_100	U1100	
144	VARIANCE_100	U2100	
155	THIRD_MOM_100	U3100	
156	FOURTH_MOM_100	U4100	

APPENDIX III

Comparison of ORNL DEC-10 URAD Reports with USGS dBXL URAD Reports

Comparison is made of available ORNL (DEC-10 SYSTEM 1022) 1989 reports (1988 Cost Factors) with corresponding reports generated in 1990 by USGS (also with 1988 cost factors) using dBXL programs to run PC versions of ORNL Fortran programs provided by Chen, et al, 1990.

REPORTS COMPARED	COMMENTS
AGEREP	1. Title in PC version should be changed from DEPREP to AGEREP. also, " Potential Resources by Deposit " should be changed to read "Potential Resources by Geologic Age".
	2. Subtitle "SPECULATIVE" should read "SPECULATIVE CLASS".
	3. Class totals differ only slightly on the two versions of this report (maximum =0.007%), which would seem to be result only of less precision on the PC version of the program.
AREREP	1. The PC version prints out localities in reverse order for each area, e.g., it lists Sierra Nevada Range after Sonora Pass and Northern Sierra, rather than before.
	2. Tons U_3O_8 differ only because of rounding differences.
	3. The Northern and Central Area does not appear on the PC output.
GTREP	1. EAR in the PC version is mis-titled "SPECULATIVE". Class totals seem correct except for less precision on the PC output.
RLSREP	1. Tons U_3O_8 in the PC version differ only because of rounding differences.
SLSREP	1. Title is incomplete in the PC version. Need to add "STATE & LAND STATUS" to PC version.

2. In the PC version, Alaska appears after Wyoming instead of first of the list for both EAR and SR.

3. Differences noted in the EAR for Arizona were not the result of less precision in the PC version.

Corrections noted above should be made to the URAD Fortran programs. Also, DEC 10 outputs should be checked against PC outputs for the remainder of the URAD programs.

APPENDIX IV

Listings of dBXL Programs used to Automate URAD Report Preparation

URADREPT.BAT

```
echo off
e:
cd /dbxl
echo Retrieving data from Master File
dbxl %1
select
c:
cd/urad
echo %1
%1
```

AGEREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase agerep.ndx
erase select. txt
use uradnew
set filter to loclc > 1
?"    index on age to agerep"
index on age to agerep
?"    creating file SELECT. TXT"
set talk on
copy to select type sdf
quit
```

AGEHRU.PRG

```
set talk off
set compatible off
set odometer to 10
erase agehru.ndx
erase select. txt
use uradnew
set filter to loclc > 1
?"    index on loclc to agehru"
index on loclc to agehru
?"    creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

AREREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase arerep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"    index on loclc to arerep"
index on loclc to arerep
?"    creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

CAREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase carep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"    index on str(class)+ca to carep"
index on str(class)+ca to carep
?"    creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

CCREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase ccrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"    index on
str(class)+str(depst)+str(loclc)+str(hru) to ccrep"
index on str(class)+str(depst)+str(loclc)+str(hru)
  to ccrep
?"    creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

DEPREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase deprep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"    index on str(class)+str(depst) to deprep"
index on str(class)+str(depst) to deprep
?"    creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

E50REP.PRG

```
set talk off
set compatible off
set odometer to 10
erase e50rep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on descend(str(po*val(u150))) to
e50rep"
index on descend(str(po*val(u150))) to e50rep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

ENDREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase endrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on descend(str(po*val(u1end))) to
endrep"
index on descend(str(po*val(u1end))) to endrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

GEOREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase georep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to georep"
index on loclc to georep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

GTREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase gtrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to gtrep"
index on loclc to gtrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

INDEX.PRG

```
set talk off
set compatible off
set odometer to 10
erase index.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to index"
index on loclc to index
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

IRANEW.PRG

```
set talk off
set compatible off
set odometer to 10
erase iranew.ndx
erase selct.txt
use uradnew
set filter to loclc > 0
?"   index on loclc to iranew"
index on loclc to iranew
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

JAPREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase japrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to japrep"
index on loclc to japrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

LTREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase ltrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on str(regn)+str(lead) to ltrep"
index on str(regn)+str(lead) to ltrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

PDVREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase pdvrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to pdvrep"
index on loclc to pdvrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

REGREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase regrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on regn to regrep"
index on regn to regrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

RLSREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase rlsrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to rlsrep"
index on loclc to rlsrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

SLSREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase slsrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to slsrep"
index on loclc to slsrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

STAREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase starep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on loclc to starep"
index on loclc to starep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

YLTREP.PRG

```
set talk off
set compatible off
set odometer to 10
erase yltrep.ndx
erase select.txt
use uradnew
set filter to loclc > 1
?"   index on lead to yltrep"
index on lead to yltrep
?"   creating file SELECT.TXT"
set talk on
copy to select type sdf
quit
```

APPENDIX V

New Records for Breccia-Pipe Favorable Areas in Grand Canyon Region

Listing of Attributes and Values for Records Used for New Pipe Estimates (1990) Listed in Table 5

Attribute	Records								
1 LOCLC	8160001	8160002	8160003	8160004	8160005	8160006	8160007	8160008	8160009
2 HOST_ROCK_UNIT	73710	73710	73701	73710	73710	73710	73710	73710	73710
3 CLASS	1	2	1	2	2	2	2	2	2
4 EFFECTIVE_DATE	1011988	1011988	1011988	1011988	1011988	1011988	1011988	1011988	1011988
5 INITIALS	CTP	CTP	CTP	CTP	CTP	CTP	CTP	CTP	CTP
6 CONTROL_AREA	730HP	730HP	730HP	730HP	730HP	730HP	730HP	730HP	730HP
7 PROBABILITY	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8 METHOD	2	2	2	2	2	2	2	2	2
9 FPL	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
10 TPL	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
11 GPL	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
12 FPU	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
13 TPU	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
14 GPU	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
15 AREA	.8100E+04	.8050E+03	.8810E+03	.1440E+04	.2144E+04	.2609E+04	.4880E+03	.2010E+03	.6000E+02
16 FRACTION_LOWER	.9000E+00	.9000E+00	.1000E+00	.4500E+00	.4500E+00	.1000E-01	.1000E-01	.9000E+00	.4500E+00
17 FRACTION_MODE	.9900E+00	.9900E+00	.1300E+00	.5500E+00	.5500E+00	.1000E+00	.1000E+00	.9900E+00	.5500E+00
18 FRACTION_UPPER	.1000E+01	.1000E+01	.1500E+00	.7500E+00	.7500E+00	.1500E+00	.1500E+00	.1000E+01	.7500E+00
19 TONNAGE_LOWER	.3418E+05	.3418E+05	.3418E+05	.3418E+05	.3418E+05	.3418E+05	.3418E+05	.3418E+05	.3418E+05
20 TONNAGE_MODE	.5576E+05	.5576E+05	.5576E+05	.5576E+05	.5576E+05	.5576E+05	.5576E+05	.5576E+05	.5576E+05
21 TONNAGE_UPPER	.7011E+05	.7011E+05	.7011E+05	.7011E+05	.7011E+05	.7011E+05	.7011E+05	.7011E+05	.7011E+05
22 GRADE_LOWER	.6000E-01	.6000E-01	.6000E-01	.6000E-01	.6000E-01	.6000E-01	.6000E-01	.6000E-01	.6000E-01
23 GRADE_MODE	.1700E+00	.1700E+00	.1700E+00	.1700E+00	.1700E+00	.1700E+00	.1700E+00	.1700E+00	.1700E+00
24 GRADE_UPPER	.4400E+00	.4400E+00	.4400E+00	.4400E+00	.4400E+00	.4400E+00	.4400E+00	.4400E+00	.4400E+00
25 DEPTH_PCT1	0	0	30	0	0	0	0	0	0
26 DEPTH_PCT2	0	0	40	0	0	0	0	0	0
27 DEPTH_PCT3	0	0	20	0	0	0	0	0	0
28 DEPTH_PCT4	0	0	10	0	0	0	0	0	0
29 DEPTH_PCT5	0	0	0	0	0	0	0	0	0
30 DEPTH_PCT6	4	1	0	9	5	20	10	5	7
31 DEPTH_PCT7	81	80	0	81	86	80	90	80	80
32 DEPTH_PCT8	15	19	0	10	9	0	0	15	13
33 DEPTH_PCT9	0	0	0	0	0	0	0	0	0
34 DEPTH_PCT10	0	0	0	0	0	0	0	0	0
35 DEPTH_PCT11	0	0	0	0	0	0	0	0	0
36 AVERAGE_THICKNESS	0	0	0	0	0	0	0	0	0
37 MINERAL_TYPE	4	4	4	4	4	4	4	4	4
38 LEAD_TIME	0	0	0	0	0	0	0	0	0
39 MINE_TYPE	2	2	2	2	2	2	2	2	2
40 FRACTION_UNEXPLORED	0.88	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
41 DISCOVERY_RATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42 GEOLOGIC_TYPE1	30	30	30	30	30	30	30	30	30
43 GEO_PCT1	100	100	100	100	100	100	100	100	100
44 GEOLOGIC_TYPE2	0	0	0	0	0	0	0	0	0
45 GEO_PCT2	0	0	0	0	0	0	0	0	0

46 GEOLOGIC_TYPE3	0	0	0	0	0	0	0	0	0
47 GEO_PCT3	0	0	0	0	0	0	0	0	0
48 GEOLOGIC_TYPE4	0	0	0	0	0	0	0	0	0
49 GEO_PCT4	0	0	0	0	0	0	0	0	0
50 STATE_CODE1	2	2	2	2	2	2	2	2	2
51 STATE_PCT1	97	100	100	100	100	100	100	100	100
52 STATE_CODE2	43	0	0	0	0	0	0	0	0
53 STATE_PCT2	3	0	0	0	0	0	0	0	0
54 STATE_CODE3	0	0	0	0	0	0	0	0	0
55 STATE_PCT3	0	0	0	0	0	0	0	0	0
56 STATE_CODE4	0	0	0	0	0	0	0	0	0
57 STATE_PCT4	0	0	0	0	0	0	0	0	0
58 STATE_CODE5	0	0	0	0	0	0	0	0	0
59 STATE_PCT5	0	0	0	0	0	0	0	0	0
60 QUAD_CODE1	NJ1210	NJ1210	NJ1210	NI1202	NI1202	NI1205	NI1205	NI1201	NI1201
61 QUAD_PCT1	53	49	67	60	51	92	97	100	100
62 QUAD_CODE2	NI1201	NI1201	NI1201	NI1201	NI1201	NI1202	NI1202	0	0
63 QUAD_PCT2	21	29	28	27	35	6	3	0	0
64 QUAD_CODE3	NJ1211	NI1202	NJ1211	NI1205	NI1205	NI1206	0	0	0
65 QUAD_PCT3	13	21	5	12	14	2	0	0	0
66 QUAD_CODE4	NI1202	NJ1211	0	NI1204	0	0	0	0	0
67 QUAD_PCT4	10	1	0	1	0	0	0	0	0
68 QUAD_CODE5	NJ1207	0	0	0	0	0	0	0	0
69 QUAD_PCT5	3	0	0	0	0	0	0	0	0
70 QUAD_CODE6	0	0	0	0	0	0	0	0	0
71 QUAD_PCT6	0	0	0	0	0	0	0	0	0
72 LAND_TYPE1	10	10	14	10	10	10	10	50	50
73 LAND_PCT1	44	40	62	32	70	42	96	66	55
74 LAND_TYPE2	30	40	30	30	40	50	50	30	40
75 LAND_PCT2	27	35	25	25	14	40	3	21	37
76 LAND_TYPE3	40	50	10	50	50	40	40	40	10
77 LAND_PCT3	11	14	13	25	13	17	1	13	8
78 LAND_TYPE4	50	14	0	40	30	30	0	0	0
79 LAND_PCT4	11	7	0	16	3	1	0	0	0
80 LAND_TYPE5	14	30	0	14	0	0	0	0	0
81 LAND_PCT5	7	4	0	2	0	0	0	0	0
82 LAND_TYPE6	0	0	0	0	0	0	0	0	0
83 LAND_PCT6	0	0	0	0	0	0	0	0	0
84 LAND_TYPE7	0	0	0	0	0	0	0	0	0
85 LAND_PCT7	0	0	0	0	0	0	0	0	0
86 LAND_TYPE8	0	0	0	0	0	0	0	0	0
87 LAND_PCT8	0	0	0	0	0	0	0	0	0
88 LAND_TYPE9	0	0	0	0	0	0	0	0	0
89 LAND_PCT9	0	0	0	0	0	0	0	0	0
90 LAND_TYPE10	0	0	0	0	0	0	0	0	0
91 LAND_PCT10	0	0	0	0	0	0	0	0	0
92 LAND_TYPE11	0	0	0	0	0	0	0	0	0
93 LAND_PCT11	0	0	0	0	0	0	0	0	0
94 LAND_TYPE12	0	0	0	0	0	0	0	0	0
95 LAND_PCT12	0	0	0	0	0	0	0	0	0
96 RESOURCE_REGION	8	8	8	8	8	8	8	8	8
97 EXPLORATION_AREA	16	16	16	16	16	16	16	16	16
98 ORE_RESERVE_AREA	0	0	0	0	0	0	0	0	0
99 LOCALITY	1	2	3	4	5	6	7	8	9
100 AGE	73	73	73	73	73	73	73	73	73
101 FORMATION	71	71	70	71	71	71	71	71	71

102 MEMBER	0	0	1	0	0	0	0	0	0
103 DEPOSIT_CODE	730	730	730	730	730	730	730	730	730
104 STATUS_CODE	0	0	0	0	0	0	0	0	0
105 DATE_ENTERED	4041989	4041989	4041989	4041989	4041989	4041989	4041989	4041989	4041989
106 DATE_CHANGED	9271989	9271989	9271989	9271989	9271989	9271989	9271989	9271989	9271989
107 DATE_PROCESSED	9271989	9271989	9271989	9271989	9271989	9271989	9271989	9271989	9271989
108 MEAN_FRACTION	.9742E+00	.9742E+00	.1280E+00	.5662E+00	.5662E+00	.9716E-01	.9716E-01	.9742E+00	.5662E+00
109 MEAN_TONNAGE	.5433E+05	.5433E+05	.5433E+05	.5433E+05	.5433E+05	.5433E+05	.5433E+05	.5433E+05	.5433E+05
110 MEAN_GRADE	.1963E+00	.1963E+00	.1963E+00	.1963E+00	.1963E+00	.1963E+00	.1963E+00	.1963E+00	.1963E+00
111 MEAN_ENDOWMENT	.8417E+06	.8365E+05	.1203E+05	.8697E+05	.1295E+06	.2704E+05	.5057E+04	.2089E+05	.3624E+04
112 VARIANCE_ENDOWMENT	.2917E+12	.2881E+10	.6190E+08	.3356E+10	.7440E+10	.4405E+09	.1541E+08	.1796E+09	.5826E+07
113 THIRD_MOM_ENDOWMENT	.2355E+18	.2311E+15	.7575E+12	.3225E+15	.1064E+16	.1627E+14	.1065E+12	.3598E+13	.2333E+11
114 FOURTH_MOM_ENDOWMENT	.5120E+24	.4995E+20	.2442E+17	.8003E+20	.3933E+21	.1481E+19	.1813E+16	.1941E+18	.2412E+15
115 MILL_THRUPUT	.2500E+01	.2500E+01	.2500E+01	.2500E+01	.2500E+01	.2500E+01	.2500E+01	.2500E+01	.2500E+01
116 MINE_LOSS	.1500E+00	.1500E+00	.3000E-01	.1500E+00	.1500E+00	.1500E+00	.1500E+00	.1500E+00	.1500E+00
117 CAPITAL_COST_15	.1810E+03	.2718E+03	.4231E+02	.1777E+03	.3000E+03	.2213E+03	.3000E+03	.1802E+03	.1831E+03
118 OPERATING_COST_15	.1302E+03	.1253E+03	.8050E+02	.1263E+03	.1287E+03	.1222E+03	.1316E+03	.1221E+03	.1181E+03
119 MILL_RECOVERY_15	.9450E+00	.9448E+00	.9411E+00	.9448E+00	.9449E+00	.9446E+00	.9451E+00	.9446E+00	.9443E+00
120 CUTOFF_GRADE_15	.3000E+00	.3000E+00	.1499E+00	.3000E+00	.3000E+00	.3000E+00	.3000E+00	.3000E+00	.3000E+00
121 MIN_AVG_GRADE_15	.1058E+01	.1058E+01	.4350E+00	.1058E+01	.1058E+01	.1059E+01	.1058E+01	.1059E+01	.1059E+01
122 ASSIGNED_AVG_GRADE_15	.0000E+00	.0000E+00	.7531E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
123 MEAN_15	.0000E+00	.0000E+00	.7364E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
124 VARIANCE_15	.0000E+00	.0000E+00	.4720E+08	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
125 THIRD_MOM_15	.0000E+00	.0000E+00	.5175E+12	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
126 FOURTH_MOM_15	.0000E+00	.0000E+00	.1257E+17	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
127 CAPITAL_COST_30	.1810E+03	.2718E+03	.4231E+02	.1777E+03	.3104E+03	.2213E+03	.6000E+03	.1802E+03	.1831E+03
128 OPERATING_COST_30	.1302E+03	.1253E+03	.8050E+02	.1263E+03	.1287E+03	.1222E+03	.1316E+03	.1221E+03	.1181E+03
129 MILL_RECOVERY_30	.9390E+00	.9386E+00	.9334E+00	.9387E+00	.9389E+00	.9383E+00	.9391E+00	.9383E+00	.9380E+00
130 CUTOFF_GRADE_30	.3000E+00	.3000E+00	.7555E-01	.3000E+00	.3000E+00	.3000E+00	.3000E+00	.3000E+00	.3000E+00
131 MIN_AVG_GRADE_30	.5523E+00	.7051E+00	.2193E+00	.5399E+00	.7794E+00	.6100E+00	.1065E+01	.5370E+00	.5351E+00
132 ASSIGNED_AVG_GRADE_30	.0000E+00	.0000E+00	.4327E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
133 MEAN_30	.0000E+00	.0000E+00	.9441E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
134 VARIANCE_30	.0000E+00	.0000E+00	.5567E+08	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
135 THIRD_MOM_30	.0000E+00	.0000E+00	.5733E+12	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
136 FOURTH_MOM_30	.0000E+00	.0000E+00	.1543E+17	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
137 CAPITAL_COST_50	.1799E+03	.2707E+03	.4113E+02	.1766E+03	.3093E+03	.2202E+03	.9172E+03	.1791E+03	.1819E+03
138 OPERATING_COST_50	.1151E+03	.1129E+03	.6094E+02	.1128E+03	.1141E+03	.1098E+03	.1149E+03	.1113E+03	.1090E+03
139 MILL_RECOVERY_50	.9313E+00	.9311E+00	.9223E+00	.9311E+00	.9312E+00	.9307E+00	.9313E+00	.9309E+00	.9306E+00
140 CUTOFF_GRADE_50	.1931E+00	.2907E+00	.4459E-01	.1897E+00	.3000E+00	.2366E+00	.3000E+00	.1924E+00	.1955E+00
141 MIN_AVG_GRADE_50	.3167E+00	.4120E+00	.1107E+00	.3109E+00	.4546E+00	.3546E+00	.1074E+01	.3119E+00	.3126E+00
142 ASSIGNED_AVG_GRADE_50	.5775E+00	.7190E+00	.2713E+00	.5687E+00	.0000E+00	.6338E+00	.0000E+00	.5703E+00	.5713E+00
143 MEAN_50	.5893E+06	.5564E+05	.1080E+05	.6120E+05	.0000E+00	.1869E+05	.0000E+00	.1472E+05	.2560E+04
144 VARIANCE_50	.2126E+12	.2217E+10	.5651E+08	.2407E+10	.0000E+00	.3055E+09	.0000E+00	.1313E+09	.4208E+07
145 THIRD_MOM_50	.1218E+18	.1311E+15	.5525E+12	.1657E+15	.0000E+00	.8745E+13	.0000E+00	.1860E+13	.1204E+11
146 FOURTH_MOM_50	.2010E+24	.2147E+20	.1535E+17	.3101E+20	.0000E+00	.5814E+18	.0000E+00	.7643E+17	.9421E+14
147 CAPITAL_COST_100	.1793E+03	.2701E+03	.4051E+02	.1761E+03	.3087E+03	.2197E+03	.9167E+03	.1785E+03	.1814E+03
148 OPERATING_COST_100	.1062E+03	.1053E+03	.4882E+02	.1045E+03	.1053E+03	.1021E+03	.1052E+03	.1039E+03	.1027E+03
149 MILL_RECOVERY_100	.9203E+00	.9202E+00	.9175E+00	.9201E+00	.9202E+00	.9198E+00	.9202E+00	.9200E+00	.9198E+00
150 CUTOFF_GRADE_100	.9741E-01	.1468E+00	.2208E-01	.9569E-01	.1678E+00	.1194E+00	.3000E+00	.9703E-01	.9859E-01
151 MIN_AVG_GRADE_100	.1551E+00	.2040E+00	.4868E-01	.1525E+00	.2250E+00	.1749E+00	.5553E+00	.1535E+00	.1544E+00
152 ASSIGNED_AVG_GRADE_100	.3373E+00	.4100E+00	.1792E+00	.3334E+00	.4411E+00	.3668E+00	.0000E+00	.3350E+00	.3363E+00
153 MEAN_100	.6685E+06	.6561E+05	.1141E+05	.6918E+05	.1007E+06	.2146E+05	.0000E+00	.1662E+05	.2885E+04
154 VARIANCE_100	.2063E+12	.2103E+10	.5496E+08	.2358E+10	.5471E+10	.3066E+09	.0000E+00	.1270E+09	.4099E+07
155 THIRD_MOM_100	.1133E+18	.1122E+15	.5330E+12	.1584E+15	.5331E+15	.8315E+13	.0000E+00	.1729E+13	.1145E+11
156 FOURTH_MOM_100	.1892E+24	.1912E+20	.1468E+17	.3001E+20	.1545E+21	.5694E+18	.0000E+00	.7166E+17	.9052E+14

END

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