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Uranium Industry Annual 1994

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Preface

The *Uranium Industry Annual 1994* (UIA 1994) provides current statistical data on the U.S. uranium industry's activities relating to uranium raw materials and uranium marketing during that survey year. The UIA 1994 is prepared for use by the Congress, Federal and State agencies, the uranium and nuclear electric utility industries, and the public. It contains data for the 10-year period 1985 through 1994 as collected on the Form EIA-858, "Uranium Industry Annual Survey."

Data collected on the "Uranium Industry Annual Survey" (UIAS) provide a comprehensive statistical characterization of the industry's activities for the survey year and also include some information about industry's plans and commitments for the near-term future. Where aggregate data are presented in the UIA 1994, care has been taken to protect the confidentiality of company-specific information while still conveying accurate and complete statistical data.

A feature article, "Comparison of Uranium Mill Tailings Reclamation in the United States and Canada," is included in the UIA 1994. Data on uranium raw materials activities including exploration activities and expenditures, EIA-estimated resources and reserves, mine production of uranium, production of uranium concentrate, and industry employment are presented in Chapter 1. Data on uranium marketing activities, including purchases of uranium and enrichment services, and uranium inventories, enrichment feed deliveries (actual and projected), and unfilled market requirements are shown in Chapter 2.

The methodology used in the 1994 survey, including data edit and analysis, is described in Appendix A. The history and legal authority, an industry overview, and methodologies for estimation of resources and reserves are described in Appendix B. A list of respondents to the UIAS is provided in Appendix C. The Form EIA-858 for 1994 is shown in Appendix D. For the readers convenience, metric versions of selected tables from Chapters 1 and 2 are presented in Appendix E along with the standard conversion factors used. A glossary of technical terms used in the report is found after Appendix E.

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Beginning in survey year 1984, the Form EIA-858, "Uranium Industry Annual Survey," replaced the following three EIA uranium-industry surveys, and it continued collection of some of the data elements from those surveys.

- "Survey of U.S. Exploration Activity," Form EIA-717
- "Survey of U.S. Uranium Marketing Activity," Form EIA-491
- "U.S. Uranium Industry Financial Survey," Form EIA-854.

The *Uranium Industry Annual* report series (UIA, 1984 through 1994) also supersedes two earlier reports that were based on the three previous EIA surveys. The reports are:

- *Survey of U.S. Uranium Exploration Activity*, DOE/EIA-0402
- *Survey of U.S. Uranium Marketing Activity*, DOE/EIA-0403.

For time series of data for earlier years, the reader is referred to the 1993 UIA report that, in addition to data from the Form EIA-858, also contained historical time series of data compiled from the earlier report series *Statistical Data of the Uranium Industry* (GJO-100, 1966 through 1982) and *Uranium Exploration Expenditures and Plans Survey* (GJO-103, 1971 through 1982).

After acquiring a prospective uranium property or lease, exploratory drilling is often done to obtain rock samples from subsurface strata to test for conditions that are favorable for uranium deposits. Part of an orderly series of exploration activities, drilling is undertaken to test for geological conditions favorable for formation of a minable uranium deposit and, later, to determine the size and nature of a deposit in preparation for possible mine development. Here a crew is setting up a surface drill rig to collect samples from a subsurface target.

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Comparison of Uranium Mill Tailings Reclamation in the United States and Canada

by
Taesin Chung

Introduction

The current low uranium prices, excess world supply, and low expectations for future uranium demand have resulted in the decommissioning of a number of uranium production facilities in North America. Although proper decommissioning is time consuming and expensive, it is essential to protect human health and the environment, both now and in the future.

At conventional production facilities, decommissioning activities include decontamination and dismantling of the mill and associated surface structures, reclamation of mill tailings piles, restoration of groundwater to acceptable conditions, and long-term monitoring of the site.[1] Radiation levels and the health and safety of workers must be monitored, and access to radiation-contaminated areas and equipment must be controlled. Normally, the reclamation of mill tailings is a complex process constituting the largest single component in the overall decommissioning cost.

This article examines tailings reclamation in the United States and in Canada's Elliot Lake area, where numerous production sites have been closed. As the comparison will illustrate, the technical approaches to site remediation in the two areas have substantial differences. Thus, an analysis provides insight on options available to uranium companies in remediating tailings sites that might prove useful to industry and Government agencies in other regions or countries. It presents (1) an overview of the history of the uranium industry, (2) a summary of the regulations that govern the industry, and (3) a comparison of technical approaches to mill tailings reclamation practiced in the two countries. For Canada, the focus is limited to tailings sites in the Elliot Lake area of Ontario, where uranium ore grade is low, similar to the ore grades in the United States. In the Elliot Lake area, older mills are predominant and are under various stages of decommissioning, like mills in the United States.

Overview of the Industry

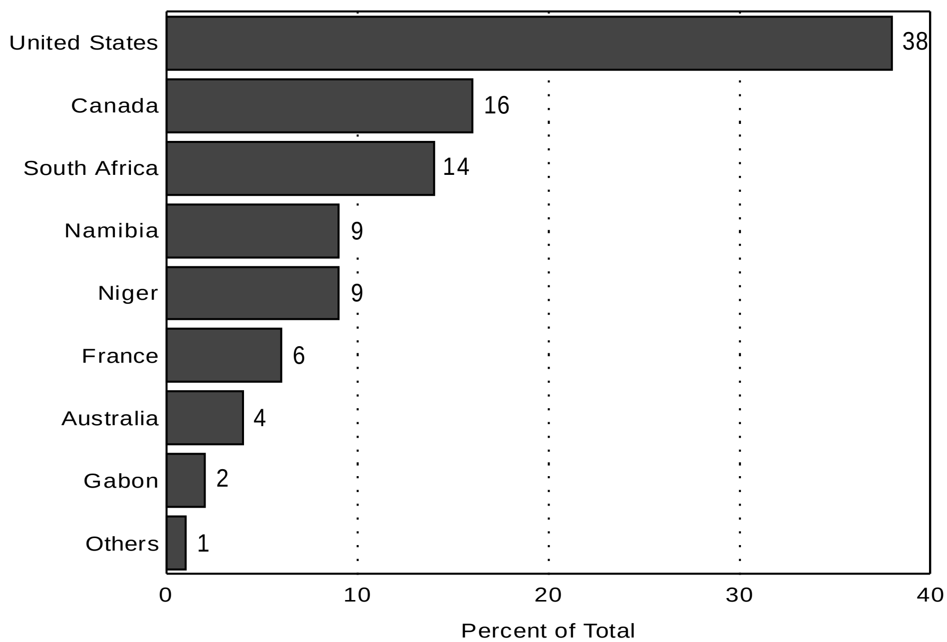
United States

The mining of radioactive ores in the United States began around the turn of century, when research laboratories in Europe were seeking sources of radium, which is found in uranium ore. Uranium's importance substantially increased during World War II because of the Manhattan Project's need for nuclear weapons development. In the postwar years, uranium continued to be essential to the national defense.

The Atomic Energy Act of 1946 (Public Law 83-703, superseded by the Atomic Energy Act of 1954, as amended) created the Atomic Energy Commission (AEC). The AEC launched a uranium procurement program that lasted through 1970 and encouraged new exploration, primarily in the Colorado Plateau region that includes parts of Colorado, Arizona, New Mexico, and Utah. Significant uranium deposits were discovered in these States, as well as in South Dakota, Texas, Washington, and Wyoming. With the development of these deposits, uranium production in the United States reached an all-time high of 22,000 short tons of uranium oxide (U_3O_8) in 1980,[2] accounting for 38 percent of total world production (Figure FE1). The United States was the world's leading uranium producer until 1984, when Canada became

[1]Energy Information Administration, *Decommissioning of U.S. Uranium Production Facilities*, DOE/EIA-0592 (Washington, DC, February 1995). This report surveys the history of the domestic uranium industry and the impact of key Federal regulations. Costs and procedures involved in reclaiming conventional and nonconventional uranium facilities are examined at the site level.
[2]Energy Information Administration, *Uranium Industry Annual 1993*, DOE/EIA-0478(93) (Washington, DC, September 1994), p. 17.

Figure FE1. World Uranium Production by Country, 1980



Notes: Total world production (excluding the Eastern-block countries): 57,000 shorts tons of U_3O_8. Totals may not equal sum of percentages because of independent rounding.
Source: Organization for Economic Cooperation and Development and the International Atomic Energy Agency, *Uranium – Resources, Production and Demand*, 1986, p. 46.

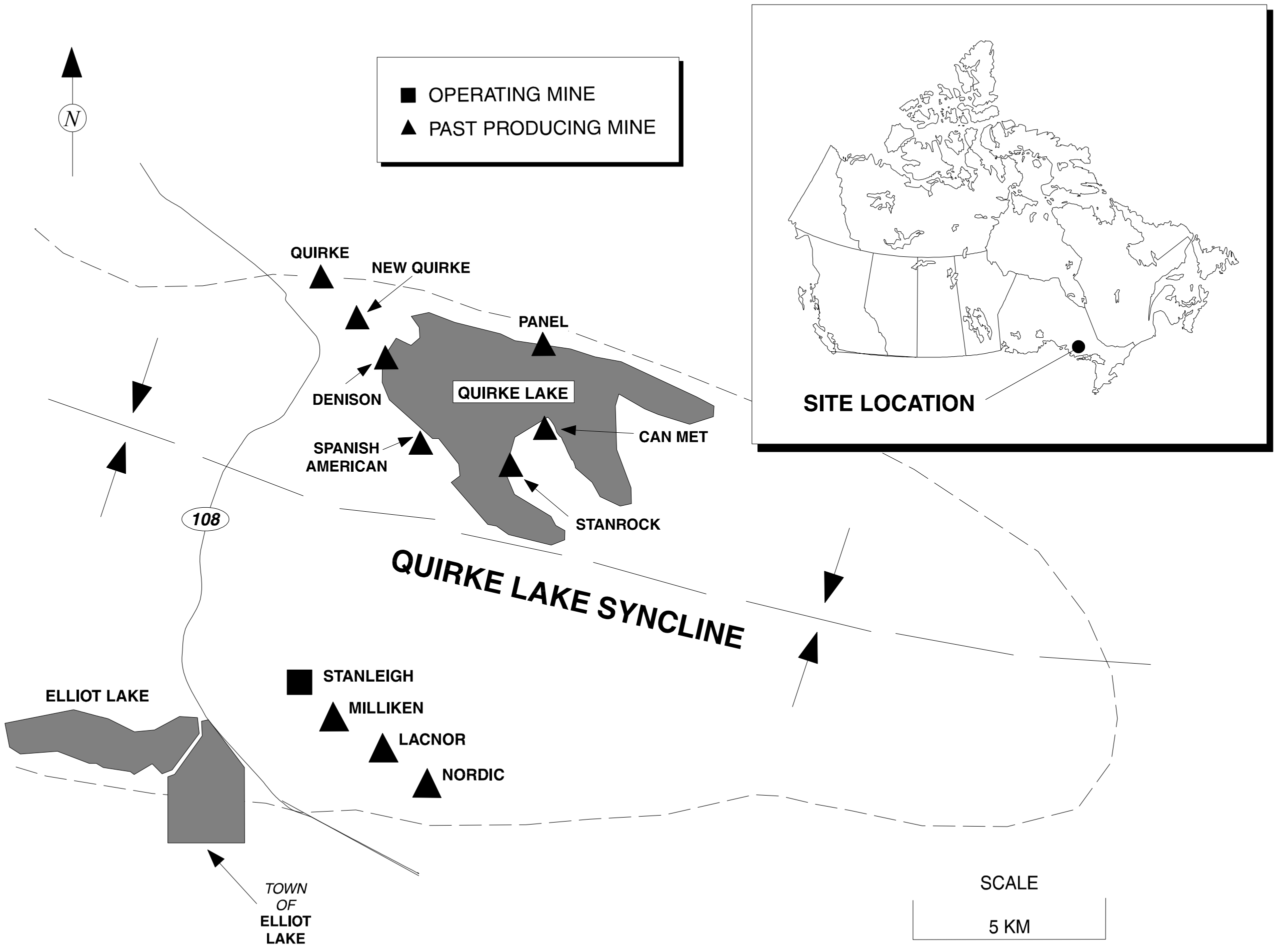
the largest producer. Demand for U.S. uranium declined significantly, causing domestic production to fall to 1,600 short tons in 1993. This decline led to the permanent closing of numerous uranium producing facilities. As of January 1, 1995, none of the 26 U.S. conventional mills was operational. Six of the 26 mills were on standby status, and the rest were undergoing various stages of decommissioning (Figure FE2).

Canada

Uranium mining in Canada started at the Port Radium mine in the Northwest Territories in 1942. The next production phase began in the Beaverlodge area of northern Saskatchewan nearly a decade later in 1953. From 1955 to 1958 numerous uranium mines were developed in the Elliot Lake area of northern Ontario to meet the enormous demand for uranium from the AEC in the United States. As part of its uranium procurement program, the AEC purchased 73,800 short tons[3] of U_3O_8 from the area through 1962. By 1959, however, the AEC decided it would not extend the contract beyond 1962. As a result, most Elliot Lake mines and mills closed down in the early 1960's. Only the Stanrock, Canmet, and Denison facilities of Denison Mines, Ltd., and the Quirke, Panel, Nordic, and Stanleigh facilities of Rio Algom, Ltd. (Figure FE3) remained in production, but at reduced levels. Beginning in 1974, following the Organization of Petroleum Exporting Countries' "oil shock," world demand revived as uranium was sought for nuclear electric power generation. The Provincial electric utility, Ontario Hydro, with its heavy reliance on nuclear power, entered into major, long-term contracts: first with Denison, then with Rio Algom. In the 1980's, however, the demand for uranium for electric power failed to meet predictions made in the previous decade.

[3]U.S. Atomic Energy Commission, *Annual Report to Congress 1970*, p. 104.

Figure FE3. Location and Status of Uranium Production Sites in the Elliot Lake, Ontario, Canada, as of October 1994



Source: National Resources Canada, *Canadian Uranium Industry: An Overview*, October 1994, p. 3.

In addition to the decline in anticipation of future growth of nuclear power in North America, Elliot Lake production suffered from competition with producers of uranium from very large, high-grade deposits that were discovered and developed in the Athabasca Basin of Saskatchewan. These deposits were capable of producing uranium at costs far below those attainable with the low-grade Elliot Lake ores. As a result of all these factors, almost all uranium production facilities in the Elliot Lake area are currently shut down and being decommissioned with the exception of Rio Algom's Stanleigh mine-mill complex, that will continue to operate until its uranium supply contract with Ontario Hydro expires in 1996.

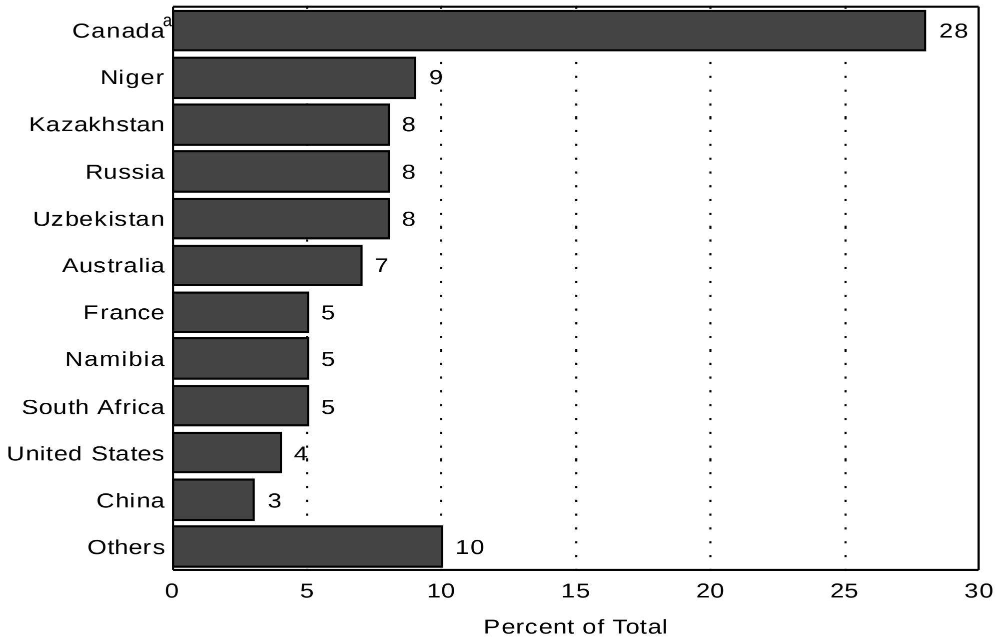
Unlike the decline of uranium production in Ontario, however, the industry in Saskatchewan continues to be the world's leading producer. In 1993, Canada accounted for 28 percent of world uranium production, with 26 percent coming from Saskatchewan, compared with 4 percent for the entire United States (Figure FE4).

Licensing and Regulations

United States

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) governs environmental restoration of uranium production sites including mill tailings. UMTRCA (Public Law 95-604), the basis for present-day control of uranium mill sites in the United States, vests the U.S.

Figure FE4. World Uranium Production by Country, 1993



[a]Saskatchewan accounted for 26 percent and Ontario for 2 percent of world uranium production.

Note: Total world production: 43,000 shorts tons of U_3O_8.

Sources: For U.S. data: Energy Information Administration, *Uranium Industry Annual 1993*. For all other countries: National Resources Canada, *Canadian Uranium Industry: An Overview*, October 1994, p. 9.

Environmental Protection Agency (EPA) with overall responsibility for establishing environmental standards and guidelines under "Health and Environmental Protection Standards for Uranium and Uranium Mill Tailings" (40 CFR Part 192). Regulatory responsibility, however, remains with the U.S. Nuclear Regulatory Commission (NRC), which issues operating licenses under 10 CFR Part 40, "Domestic Licensing of Source Material," and enforces regulations in conformance with UMTRCA.

In the United States, the license for operating a uranium production facility is issued on condition that the operator takes responsibility for decommissioning. To obtain a license, each applicant must present a plan for site reclamation to the NRC or the appropriate "agreement" State[4] for approval. To meet licensing requirements, each applicant must provide a detailed study called the Generic Environmental Impact Statement (GEIS), which reviews all aspects of construction of the uranium production facility and examines various approaches to reclaiming the site, including the mill tailings,[5] and evaluates the potential impact on the environment. The licensee is also required to provide a surety (in the form of cash, tangible assets, or both), that must be kept in place until the responsible agencies have approved a release stating that the licensee has completed restoration and reclamation that satisfy acceptable standards.

Canada

The Federal Atomic Energy Control Act of 1946 (AEC Act), the basis for regulating uranium production facilities in Canada, is administered by the Atomic Energy Control Board of Canada (AECB). The AECB relies on a comprehensive licensing system to regulate the industry and issues separate facility operating and facility decommissioning licenses in conformance with the "Policy on the Decommissioning of Nuclear Facilities, Regulatory Document R-90." Decommissioning regulation is also subject to other Federal and Provincial legislation. For example, in Ontario, applicable regulations are found in the Environmental Protection Act, Environmental Assessment Act, the Ontario Water Resources Act, and the Mining Act - Part IX. In addition, facilities must comply with guidelines issued by the Ministry of the Environment and Energy for the clean-up of industrial sites.

In contrast to the United States, no rigid criteria or detailed regulatory standards comparable to UMTRCA apply to decommissioning uranium facilities in Canada. Instead, the AECB issues broad guidelines and works with other Federal and Provincial agencies, reviewing decommissioning plans on a case by case basis. The Board has the authority to refer to the Federal Environmental Assessment Review Office (FEARO) any proposed plan for tailings remediation. FEARO evaluates the social, economic, and environmental consequences in compliance with the Federal Environmental Assessment Review Process.[6]

Recently, FEARO appointed a three-member environmental assessment panel to conduct an independent review of the decommissioning of uranium production facilities in the Elliot Lake area. The panel, through a series of public hearings, will develop site-specific standards and guidelines to assist licensees in performing an environmental assessment and subsequently submitting an Environmental Impact Statement (EIS).

Technical Approaches

General Considerations

Most of the uranium production in the United States has occurred from the bedded sedimentary deposits in the Colorado Plateau and the Wyoming Basin, located in the semi-arid western regions of the country. Elliot Lake in the Serpent River Basin is located between Sudbury and Sault St. Marie, just north of Lake Huron in northern Ontario, an area known as East Algoma. The uranium deposit in the Elliot Lake area is hosted in a glacially derived pebble conglomerate located in the Huronian sediment of the north and south limbs of the Quirke Lake Syncline (Figure FE3). The Precambrian Shield bedrock in this area, comprised of highly indurated, gently folded metasedimentary rock of the Serpent and Gowganda Formations, is covered with a blanket of glacial debris dotted with numerous lakes, streams and swamps. Currently, 10 out of 11 conventional mills in this region are in various stages of decommissioning. Mill tailings are produced in large amounts over the life of mills. Currently, all 11 Canadian mill sites in the Elliot Lake area contain a total of over 200 million short tons[7] of tailings, as do 26 U.S. mill sites.[8] An average U.S. tailings pile occupies about 180 acres per site compared with about 230 acres per site in Canada.

Tailings contain low concentrations of naturally occurring radioactive materials, including uranium (^{235}U) thorium (^{230}Th), radium (^{226}Ra), and other trace heavy metals such as lead, barium, selenium, molybdenum, and vanadium. Radium (^{226}Ra) decay emits the radioactive gas radon (^{222}Rn) and other daughter products, such as bismuth (^{210}Bi) and polonium (^{218}Po), that are potential health hazards. Because the effects of radiation exposure are cumulative throughout a lifetime, any excess exposure can be harmful to humans, wildlife, and plants. In addition to radon emissions into the atmosphere from uncovered tailings piles, groundwater contamination from radioactive material seeping into groundwater aquifers is a significant environmental concern. Relocation of a tailings pile is sometimes necessary if the tailings pose a

Grants mill tailings reclamation site owned by Rio Algom Mining Corporation in Grants, New Mexico.

threat to inhabitants or the environment, from being situated too close to populated areas, for example, on top of an aquifer, river bank, or other sources of water, or in unstable areas such as flood plains or earthquake faults.

Reclamation of tailings must be geared toward reducing direct gamma radiation from the impoundment area to essentially background levels, reducing the radon emanation from the impoundment area to the surrounding environment, and stabilizing the pile to prevent it from contaminating the groundwater through erosion, seepage, or water runoff. Finally, the tailings remedial action must eliminate or minimize the need for additional work during ongoing monitoring and maintenance program following reclamation.

Tailings site remediation involves covering the pile and stabilizing the embankment. These activities usually account for the largest expenditure in the decommissioning process. Potentially, however, the costs incurred by failure of the tailings cover or destabilization of the embankment can be substantial. Groundwater problems resulting from the exit of contaminated water from an inadequately protected tailings pile are difficult to predict, and very costly to bring under control. Therefore, selection of a cover option and consideration for embankment design based on site characteristics are crucial. Environmental mental, economic, and social factors should be considered in the remediation planning, which includes choosing technical options on cover design and embankment stabilization. The remedial action plan, complete with a checklist, must be documented and reviewed. The checklist will then become part of the quality assurance/quality control documentation for the tailings site reclamation project.

Cover Design—United States

To reduce and control direct gamma and radon emanation, water infiltration, and erosion, tailings piles are typically covered with either solid (soil, rock, clay, plastics, vegetation, etc.) or liquid (water) material. The EPA standards (40 CFR 192) for control of residual radioactive materials from the tailings pile require a cover design that will:

- Be effective for up to 1 thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years

- Provide reasonable assurance that release of radon (^{222}Rn) from residual radioactive material to the atmosphere will not:

  – Exceed an average release rate of 20 picocuries[9] per square meter per second (20 pCi/m^2/sec)

  – Increase the annual average concentration of radon (^{222}Rn) in the air at or above any location outside the disposal site by more than 1/2 picocurie per liter (0.5 pCi/l).

Uranium mill tailings reclamation relies almost exclusively on the solid cover option to control air and groundwater contamination from direct gamma radiation and the radon emanation. Typically, the covering for the containment of a tailings pile is carried out after dehydrating the pile, using impermeable material such as hypalon (synthetic material), clay, shale or equivalent rock or soil. Primarily, the cover acts as a barrier to radon emanation and prevents water infiltration. Radon in water move slower than radon in air, thus the moisture in cover material is desirable for radon attenuation. However, water passing through the cover, into and through the contaminated materials, and ultimately into groundwater is undesirable. The radon attenuation and water infiltration characteristics of cover materials are a function of cover properties, construction methods, and thickness. Cover conditions that provide the best radon attenuation characteristics do not necessarily provide the best water infiltration characteristics. In any case, the cover is designed as a barrier to radon emissions, limiting infiltration into the pile and then into groundwater, protecting against the effects of flooding, and protecting from wind and water erosion.

The thickness of the radon barrier that is required to meet EPA standards (from 6 inches to several feet) varies with the nature of the tailings pile and the cover material. After the pile is settled, the final cover to protect against surface erosion is added. The final erosion cover may include various types of rocks and earth material, depending on what is available near the site. It may be top soil if revegetation is planned, or rock if revegetation is not feasible. This cover must also effectively minimize the potential for misuse or spread of contaminated materials.

Cover Design—Canada (Elliot Lake)

The main problem associated with tailings reclamation in Elliot Lake is acid generation due to the presence of pyrite. The tailings in this region consist of about 5 percent pyrite (iron sulfides). When pyrite is exposed to water and air, oxidation generates significant amounts of acid and soluble iron salts (sludge) that combine with rain and snow to form acid runoff:

$$FeS_2 + 3.75O_2 + 3.5H_2O \rightarrow Fe(OH)_3 + 2H_2SO_4$$

$$(Pyrite + air + water \rightarrow sludge + acid)$$

The relatively high pyrite content in the tailings pile is a potential concern. Since the pH is lowered, leaching of radioactive metals and other trace heavy metals from tailings may be enhanced, especially at abandoned tailings facilities. Potential re-dissolution of radionuclides in sludge ($BaSO_4$), a precipitate removed during the control of radium with barium chloride, may also result from exposure to acid water. Thus, the potential residual acidity releases could elevate levels of radium (^{226}Ra) beyond what is allowable for surface water quality requirements.

Compared with the solid cover practice in the United States, the water cover option offers these Canadian sites an advantage because it prevents acid generation, a major concern in the Elliot Lake area. Reclamation of tailings sites in the Elliot Lake area largely relies on the water cover option to provide a radon barrier, prevent acid generation, and protect against erosion. Solid covers like those used in the United States are not practical for reasons of typical acid generation, climate, surface and subsurface geology, and the relative size of tailings areas.

Denison tailings reclamation site owned by Denison Mines, Ltd. in Elliot Lake area of Ontario, Canada.

The Elliot Lake area is susceptible to permafrost, resulting in extensive frost heave that can disrupt rigid covers. The area also has an average annual precipitation (35 inches) that exceeds the average annual evaporation (28 inches) (Table FE1). These conditions make it ineffective for dehydration of tailings preparatory to covering them with earthen materials.

Elliot Lake is located in a Serpent River subbasin of northern Ontario. This subbasin includes numerous lakes, providing an abundant supply of surface water for tailings cover. Despite the abundant surface water in this region, the massive underlaying Precambrian Shield below the unconformity related ore deposit has little groundwater aquifer. Therefore, use of water covers does not raise the same concern for groundwater contamination as it would in the United States, where water can seep through the sandstone host rock and potentially contaminate groundwater aquifers.

In addition, solid covers, typically used in the United States, are significantly more costly than the water covers typically applied in the Elliot Lake region. Because tailings piles at sites in the Elliot Lake region occupy a much larger average area than the piles at U.S. sites, the cost of covering the Canadian tailings pile with a solid cover would be substantially greater.

Also, because of the comparative remoteness of Elliot Lake sites and a typically higher soil moisture content that tends to attenuate alpha flux, radon emanation control is considered to be less critical compared with the need to control acid generation. Under these unique circumstances, water cover that not only acts as a radon barrier but also cuts off air and catalytic airborne bacteria for acid generation from pyrite, makes it a practical and acceptable cover for tailings remediation work.

Embankment Stabilization—United States

The primary objectives in the design of a stabilized embankment are (1) isolation and stabilization of the tailings and contaminated materials to prevent misuse by humans or dispersion by natural forces such as wind, rain, and flood; (2) reduction of radiation emissions from the tailings pile; and (3) control of contaminant seepage to the extent required to achieve compliance with groundwater protection standards.

Table FE1. Criteria Affecting the Selection of Tailings Cover Options

	United States	Canada (Elliot Lake, Ontario)
Cover Type	soil	water
Average Tailings Area	183 acres[a]	233 acres[b]
Average Annual Precipitation	11 inches[c]	35 inches[d]
Average Annual Evaporation	> 11 inches[e]	28 inches[d]
Host Rock Type	sandstone	pebble conglomerate
Groundwater Aquifer	yes	no
Pyrite Presence	no	yes
Excess Surface Water	no	yes
Soil Moisture	low	high
Permafrost	not susceptible	susceptible

[a]Average of 19 U.S. tailings sites (out of 26 sites), Energy Information Administration, *Decommissioning of U.S. Uranium Production Facilities*, DOE/EIA-0592 (Washington, DC, February 1995).
[b]Average of Quirke, New Quirke, Stanrock, Panel, and Nordic tailings sites, Atomic Energy Control Board, *The Cost of Decommissioning Uranium Mill Tailings*, 1986.
[c]Normal average of Albuquerque, NM, and Cheyenne, WY. *World Almanac*, 1992.
[d]Normal average of Quirke and Panel sites, Rio Algom, Limited. *Environmental Impact Statement for Decommissioning of the Quirke and Panel Waste Management Area*, 1993.
[e]Estimated by Energy Information Administration.

In the United States, embankment slopes must be relatively flat after final stabilization, preferably about 1 vertical to 10 horizontal (10 percent). The maximum design slope for the entire embankment must not exceed 1 vertical to 5 horizontal (20 percent). The minimum design slope for the embankment and cover should be a slope sufficient to promote drainage and prevent ponding. Corners, peaks, and other changes in direction must be contoured and rounded to minimize erosion and present a natural appearance. Drainage in the vicinity must be redirected away from the pile. This may require establishing new drainage routes, moving natural stream beds, and/or putting in diversions such as wing dams. To minimize wind and water erosion, rip-rap[10] may be utilized on the top and slope of the embankment. Additional antierosion measures may include adding topsoil and vegetation to the tailings area and decontaminating waterways and land contaminated by windblown tailings.

All water produced on the site must be collected and treated as required prior to discharge. Some of the existing monitor wells may be preserved to use for monitoring after completion of the reclamation. Existing wells that have to be abandoned should be plugged or capped in compliance with applicable regulations. Upon completion of the reclamation activities, the site is then turned over to DOE or the appropriate State agency for long-term monitoring and perpetual care.

Embankment Stabilization—Canada (Elliot Lake)

Use of a water cover requires leveling the tailings pile to a uniform elevation to eliminate the need for internal dikes, and thus reducing the risk of water release from internal dike failure. Dams must be carefully designed and located, with particular attention to hydraulic gradients and stability to prevent structural failure that may result in loss of a portion of the tailings. Earthfill dams must have foundations that incorporate low permeability seepage barriers, consisting of either compacted glacial till or a clay membrane, and must meet specific static and dynamic design criteria. To protect against erosion of the dam by either wind or surface water (gulleying), locally available cobble stones may be used as rip-rap and laid over the top and slopes of the dam. Use of a water cover requires a treatment facility for seepage collection, tailings spill, and sludge removal. Effluent treatment systems also must efficiently utilize the proper amount of lime (CaO) or calcite ($CaCO_3$) to control acidity (pH), and application of barium chloride ($BaCl_2$) to control radium (^{226}Ra). All culverts and spillways around the treatment facility and the dam should be checked for flow volume, obstruction, overtopping, and erosion.

A long-term care and maintenance program must be carried out through regular inspections to identify potential problems and provide timely maintenance to remedy any adverse conditions that may develop over time. At present, Canadian authorities give no specific guidelines for the longevity of any decommissioning facility or the scope and frequency of long-term inspection and monitoring. The Ontario Ministry of Northern Development and Mines, however, has proposed that closure plans incorporate designs with a life of at least 200 years, as is required in the United States.

[10]Rip-rap is cobblestones or coarsely broken rocks used for protection against erosion of embankment or gully.

Conclusion

The comparison of Elliott Lake and the Western United States illustrates that technical approaches to site remediation can differ substantially, even among sites experiencing similar mining and milling techniques.Water covers, ideally suited to the physical, environmental, and economic conditions in eastern Canada, are impractical in the sites in the western United States where solid covers are exclusively used. There is no such thing as "the best technique" that could apply for all tailings sites.

Technical approaches to cover design and embankment stabilization in tailings reclamation must be site specific and must consider economic, geographic, geomorphic, climatic, hydrologic, engineering, and statutory factors. Many different design combinations could be considered for each unique circumstance. The technical approach must be flexible enough to allow for a proper assessment of risks in order to arrive at a technically acceptable, cost-effective design, optimization of various potential alternatives, and innovative thought. Use of good engineering judgment and adherence to accepted professional procedures are essential. Whatever the technical approach used, tailings remedial action must be designed and implemented so that little active care is required for disposal sites. Remediation action must ensure that future generations are not burdened with a significant, lingering obligation to care for waste generated to produce benefits they receive only indirectly, if at all.

Executive Summary

The *Uranium Industry Annual 1994* contains a statistical profile of the U.S. uranium industry as of December 31, 1994. This summary describes uranium materials and uranium marketing activities and provides selected data in customary units of measurement and in International System of Units (SI) (Table ES1).

Concentrate Production and Shipments. U.S. uranium concentrate production in 1994 totaled 3.4 million pounds U_3O_8, an increase of 9 percent from the 1993 level. Uranium concentrate shipments were 6.3 million pounds, an increase of 87 percent, as producers lowered their stocks of uranium.

Operating Facilities. Seven nonconventional uranium concentrate production facilities were operating at the end of 1994: five in situ leaching and two byproduct recovery plants. Nonconventional facilities in 1994 accounted for 99 percent of the total production, and conventional mills accounted for 1 percent.

Ore Shipments. During 1994, no uranium ore from openpit or underground mining operations was shipped for processing. This was the second consecutive year in which no ore from conventional mines was shipped for processing since 1948 when the U.S. Atomic Energy Commission began recording ore shipments.

Exploration and Development. Total expenditures in 1994 were $3.65 million, a 68-percent decrease from 1993. Foreign participation in U.S. uranium exploration activities in 1994 was $1.9 million, the lowest level reported since 1975.

Reserves. As of the end of 1994, uranium reserves recoverable at a cost of $30 per pound U_3O_8 were 294 million pounds U_3O_8, an increase of 1 percent compared with 1993. Approximately 73 percent of the $30 reserves were located in deposits in New Mexico, Texas, and Wyoming.

Employment. Employment in the raw materials sector of the industry increased during 1994 by 19 percent to 452 person years.

Foreign Purchases (imports). Deliveries of uranium to suppliers and utilities totaled 36.6 million pounds U_3O_8e (equivalent) in 1994. The average price of foreign purchases in 1994 dropped 15 percent from the 1993 level to a record-low level of $8.95 per pound.

Utility Purchases. Foreign and domestic suppliers delivered a total of 38.3 million pounds U_3O_8e to U.S. utilities in 1994. The average price paid by the utilities was $10.40 per pound U_3O_8e. U.S.-origin uranium represented 7.7 million pounds at a average price of $12.08 per pound and foreign-origin uranium was 30.6 million pounds at $9.97 per pound.

Foreign Sales (exports). Deliveries from suppliers and utilities in 1994 were 18.0 million pounds. Most of the 18.0 million pounds was sold after entering the U.S. uranium market earlier in the year as foreign purchases (imports).

Utility Inventories. Uranium inventories held by U.S. utilities continued to decline in 1994 reaching 66.7 million pounds U_3O_8e at the end of the year. This represented a drop of 18 percent from the level of stocks at the end of 1993 and was 58 percent below the record-high level of stocks held by utilities at the end of 1984 (160.2 million pounds).

Fuel Assemblies. Utilities loaded 39.0 million pounds U_3O_8e into U.S. nuclear reactors during 1994, 7.9 million pounds less than in 1993.

Table ES1. Summary Statistics for the U.S. Uranium Industry, 1985-1994

Item	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Uranium Raw Materials Activities										
Exploration and Development										
Surface Drilling (million feet)	1.8	2.1	2.0	3.0	2.2	1.7	1.8	1.1	1.1	0.7
(million meters)	0.5	0.6	0.6	0.9	0.7	0.5	0.6	0.3	0.3	0.2
Land Held for Exploration at End of Year										
(million acres)	2.9	2.6	1.9	1.7	1.5	1.2	1.1	0.8	0.5	0.3
(thousand square kilometers)	11.7	10.7	7.9	6.9	6.2	4.9	4.3	3.2	1.8	1.3
Expenditures[a] (million dollars)	20.1	22.1	19.7	20.1	14.8	17.1	17.8	14.5	11.3	3.7
Reserves at End of Year										
(million pound U_3O_8, $US30 per pound U_3O_8)	345	322	304	289	277	265	304	295	292	294
(thousand metric tons U $US80 per kilogram U)	133	124	117	111	107	102	117	114	112	113
Mine Production of Uranium										
(million pounds U_3O_8)	8.6	8.3	6.0	9.5	9.7	5.9	5.2	1.0	2.0	2.5
(thousand metric tons U)	3.3	3.2	2.3	3.7	3.7	2.3	2.0	0.4	0.8	1.0
Uranium Concentrate Production										
(million pounds U_3O_8)	11.3	13.5	13.0	13.1	13.8	8.9	8.0	5.6	3.1	3.4
(thousand metric tons U)	4.4	5.2	5.0	5.0	5.3	3.4	3.1	2.2	1.2	1.3
Uranium Concentrate Shipments										
(million pounds U_3O_8)	11.8	10.6	11.6	12.8	14.8	13.0	8.4	6.9	3.4	6.3
(thousand metric tons U)	4.5	4.1	4.4	4.9	5.7	4.9	3.2	2.6	1.3	2.4
Employment										
(person-years expended)	2,446	2,120	2,002	2,141	1,583	1,335	1,016	682	[b]380	[b]452
Uranium Marketing Activities										
Deliveries from Suppliers to U.S. Utilities under Domestic Purchases[c]										
(million pounds U_3O_8)	21.7	18.9	20.8	17.6	18.4	20.5	26.8	23.4	15.5	22.7
(thousand metric tons U)	8.3	7.3	8.0	6.8	7.1	7.9	10.3	9.0	6.0	8.7
Average Price of Delivered Uranium[a,d]										
(dollars per pound U_3O_8)	31.43	30.01	27.37	26.15	19.56	15.70	13.66	13.45	13.14	10.30
(dollars per kilogram U)	81.72	78.03	71.16	67.99	50.86	40.82	35.52	34.96	34.17	26.78
Foreign Purchase Contracts (imports) of Delivered Uranium[c,e]										
(million pounds U_3O_8)	11.7	13.5	15.1	15.8	13.1	23.7	16.3	23.3	21.0	36.6
(thousand metric tons U)	4.5	5.2	5.8	6.1	5.0	9.1	6.3	9.0	8.1	14.1
Average Price for Delivered Uranium under Foreign Purchases (imports)[a]										
(dollars per pound U_3O_8)	20.08	20.07	19.14	19.03	16.75	12.55	15.55	11.34	10.53	8.95
(dollars per kilogram U)	52.21	52.18	49.76	49.48	43.55	32.63	40.43	29.48	27.37	23.27
Export sales of Delivered Uranium[c,e]										
(million pounds U_3O_8)	5.3	1.6	1.0	3.3	2.1	2.0	3.5	2.8	3.0	18.0
(thousand metric tons U)	2.0	0.6	0.4	1.3	0.8	0.8	1.3	1.1	1.2	6.9
Commercial Inventories at End of Year[c,e]										
(million pounds U_3O_8)	176.9	171.1	163.2	144.8	138.1	129.1	118.7	117.3	R105.7	86.3
(thousand metric tons U)	68.0	65.8	62.8	55.7	53.1	49.6	45.7	45.1	R40.6	33.2

[a]Expenditures are in nominal U.S. dollars. Prices shown are quantity-weighted averages in nominal U.S. dollars.
[b]Does not include an additional 491 person years expended in reclamation work in 1993 and 528 expended in 1994
[c]Uranium quantities are the aggregate U_3O_8 or U equivalents of values reported on the Form EIA-858.
[d]Based on deliveries from U.S. suppliers to domestic utilities. Imports and interutility transactions are not included.
[e]Includes U.S. utility, supplier, and trader/broker purchases (sales) reported as imports (exports) of uranium materials into (from) the United States. Uranium materials reported on the form as imports (exports) under loan, exchange, and other transactions are excluded. Loan, exchange and other import (export) data are shown on Table 26.
R = Revised data.
Sources: Energy Information Administration: *Uranium Industry Annual 1993* (September 1994); and Form EIA-858, "Uranium Industry Annual Survey" (1994). Specific references for each category of data and year are provided in various detailed text or tables included in the main body of this report.

1. Uranium Raw Materials Activities

Introduction

The development of a uranium-producing industry in the United States began in the late 1940's, following World War II. In the years from 1947 through 1970, the Atomic Energy Commission (AEC) administered the Government's uranium raw materials and procurement programs which fostered the domestic industry.

A large quantity of information about uranium as a producible commodity has been compiled by the Department of Energy (DOE) and its predecessor agencies since the AEC was established in 1946. These historical data were used in making the comparisons, where given in this report, between data and activity levels for 1994 and similar data and activity levels for prior years.

In the United States, only the private sector conducts exploration for new uranium deposits. Companies decide to conduct exploration on a particular uranium property based on information from many sources. Exploration involves the identification of prospective areas with geologically favorable characteristics; development of data on surface and subsurface condi-tions using map-ping, sampling, drilling, and logging; and thorough analysis and reporting of all data developed. If results are favorable, followup drilling is conducted. The aim of these efforts is to develop uranium reserves.

All information developed in a detailed exploration program contributes to determining the feasibility of mining a discovered uranium deposit. The important parameters include accurate data about the deposit's depth and configuration, the distribution of uranium mineralization in the deposit, costs and the determination of cutoff grades, and the metallurgical characteristics of the deposit. If the ore is sufficiently rich in uranium to be recovered profitably, a mining operation might be established at the site.

In the United States in 1994, uranium was mined using in situ leaching methods, which involve leaching uranium from the “in place” host rock without removing the rock from the ground. A leaching solution is circulated through the in-place rock, the uranium-bearing leaching solution is then pumped to the surface, and the uranium is recovered. Leaching solutions commonly employed in solution mining consist of water containing small quantities of oxygen and carbon dioxide or sodium bicarbonate. Uranium is also recovered as a byproduct from the processing of uraniferous phosphate ore. Most of the uranium concentrate produced by the U.S. industry in 1994 was from in situ leach plants and from the manufacture of wet-process phosphoric acid.

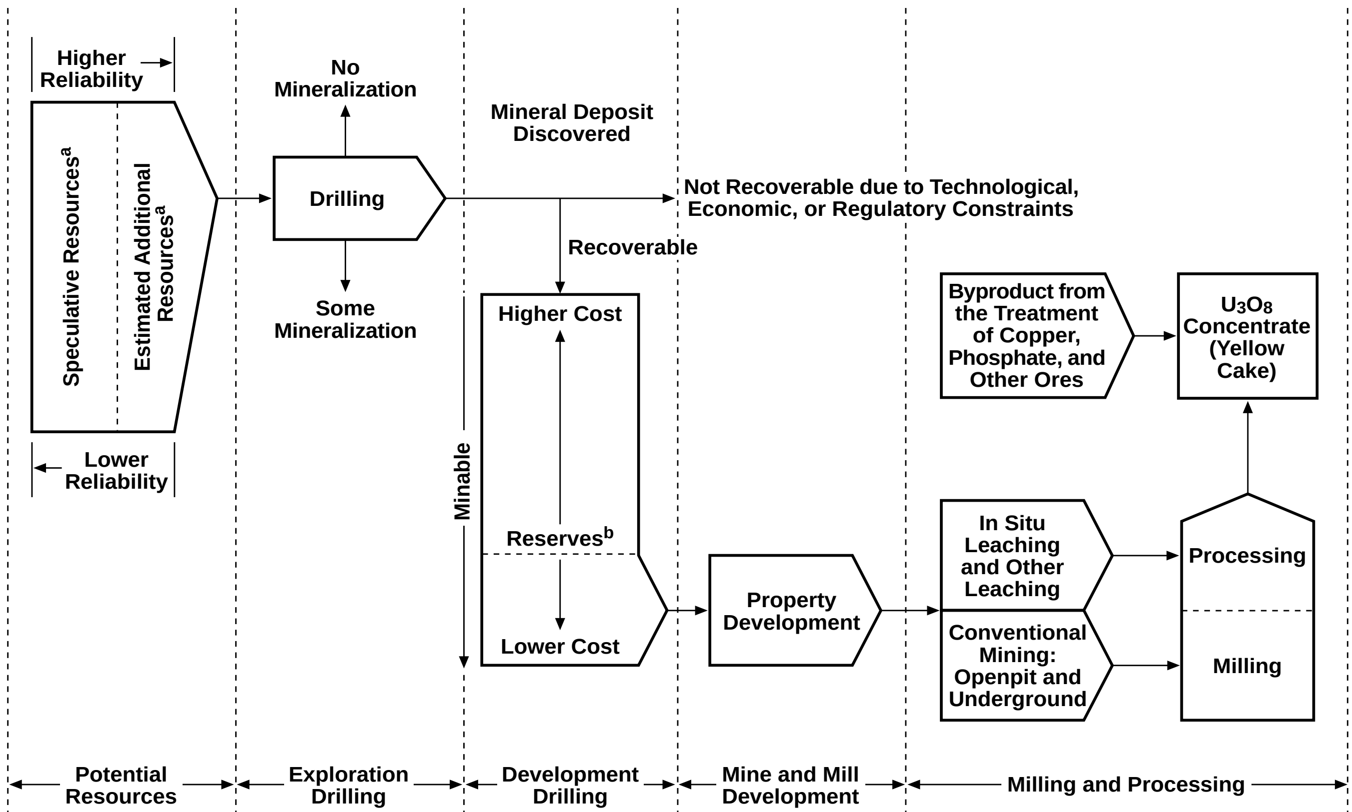
In 1994, no conventional uranium mills, which recover uranium from ores mined from the ground, were operated in the United States.

The production of uranium concentrate consists of several stages (Figure 1). Delineation of exploration targets, exploration and development drilling, evaluation of discovered mineral deposits to determine reserves quantities, and mine and mill development are the major early stages. Mining and milling of uranium ore or processing of uraniferous solutions (including in situ leaching) to recover uranium concentrate complete the uranium concentrate production process.

The Energy Information Administration (EIA), through annual analysis of current and historical information on known uranium deposits, makes estimates of U.S. uranium reserves at specific forward costs. This information includes gamma ray drill hole logs, mining and geologic factors, mine production, and mining and processing practice and costs. Reserves reported in this publication are equivalent to the Reasonably Assured Resources category reported in international publications. Estimates of uranium in both the reserves and potential resources categories are made for selected forward-cost categories that are independent of the market price of uranium.

The EIA also prepares estimates of potential (or undiscovered) uranium resources for various localities, some of which may lack production histories. The estimates incorporate current information provided by the U.S.

Figure 1. Stages in Production of Uranium Concentrate



[a]Estimates of potential resources as Estimated Additional Resources and Speculative Resources are prepared by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels (EIA, CNEAF), and include information provided by the U.S. Geological Survey of the Department of the Interior under a memorandum of understanding.

[b]Estimates of minable (i.e., technically feasible and economically worthwhile) uranium reserves for individual propertiers are made for mine planning and other purposes by private industry firms. Additional data developed by the firms during the mining process, which is dynamic, are used to reassess estimates of remaining minable reserves as necessary throughout the "life" of a mining operation. The EIA, CNEAF, however, prepares all of the estimates of reserves at selected "forward cost" categories as presented in this report using current company-supplied data as available and the estimation methodology described in Appendix B.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Geological Survey (USGS), U.S. Department of the Interior, under a memorandum of understanding between the USGS and EIA. These estimates of potential resources are reported in the international classifications of Estimated Additional Resources (EAR) and Speculative Resources (SR). The methodology for estimating reserves and potential resources is described in Appendix B.

Exploration Activities

Land Holdings and Acquisitions for Uranium Exploration

At the end of 1994, 22 companies involved in domestic uranium exploration held about 0.3 million acres for exploration purposes. This was 29 percent less than the 0.5 million acres held by 25 companies at the end of 1993 (Table 1). The amount of land held for exploration in 1994 represents the lowest level of land held at year end since before 1966.

The amount of land acquired during 1994 was 0.01 million acres, compared with 0.07 million acres acquired in 1993 (Table 1). Types of land held and land acquired each year can include fee land, mineral fee, leases, patented and unpatented claims, and options to purchase mineral fee land.

Land Acquisition Costs

The total cost of land acquired during 1994 was $0.07million, 93 percent less than the reported total cost in 1993 (Table 1). Between 1985 and 1993, annual expenditures for land acquisition have ranged between $1.67 million and $0.25 million. Expenditures for land acquired for exploration purposes in 1994 ranged from just under $1.00 to about $40 per acre. The average cost per acre of land in 1994, $8.05, was 17 percent less than in 1993. Note that this average cost does not include the costs for land acquired under arrangements covering purchases of properties with reserves and/or partially delineated uranium deposits. From 1985 through 1994, the annual average cost (in nominal dollars) per acre of land acquired ranged from $5.34 to $18.12. Five companies acquired land in 1994, compared with ten in 1993.

Table 1. U.S. Land Held and Acquired for Uranium Exploration, 1985-1994

	Land Held for Exploration at End of Year			Land Acquired for Exploration During the Year				
Year(s)	Number of Companies with Holdings	Acres Held (million)	Change from Prior Year in Acres Held (percent)	Number of Companies That Acquired Land	Acquired Acres (million)	Change from Prior Year in Acres Acquired (percent)	Cost[a] (million dollars)	Average Cost (dollars per acre)
1985 . . .	52	2.9	-14.7	9	0.13	-72.9	0.89	6.74
1986 . . .	56	2.6	-8.5	16	0.22	68.1	1.33	6.00
1987 . . .	49	1.9	-26.5	16	[b]0.09	-60.0	0.79	8.96
1988 . . .	54	1.7	-12.6	14	[b]0.09	4.9	1.67	18.12
1989 . . .	53	1.5	-10.1	13	0.03	-69.3	0.39	13.87
1990 . . .	45	1.2	-20.9	7	0.04	25.2	0.40	10.21
1991 . . .	37	1.1	-12.6	7	0.03	-15.7	0.25	5.34
1992 . . .	32	0.8	-25.4	5	0.09	166.5	1.36	[c]8.02
1993 . . .	25	0.5	-42.0	10	0.07	-23.0	1.02	[c]9.76
1994 . . .	22	0.3	-28.6	5	0.01	-86.5	0.07	8.05

[a]Includes costs for land acquisitions and rentals in nominal dollars.
[b]Land acquired in 1987 was 0.088 million acres, in 1988 was 0.092 million acres, and in 1994 was 0.009 million acres.
[c]Average cost does not include land acquired for which a cost was not reported and land acquired under arrangements covering reserves and/or incompletely delineated uranium deposits.
Note: Average cost per acre shown may not equal quotients obtained with independently rounded numerator and denominator.
Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Surface Drilling

Total surface drilling in the United States in 1994 including exploration and development drilling was 0.66 million feet in 996 holes (Table 2). This total footage was 41 percent less than the 1.11 million feet reported by the industry for 1993. During 1994, seven companies conducted surface drilling programs, one fewer than in 1993.

Costs incurred for surface drilling activities include those for ground surveys, road construction and site preparation, drilling, downhole geophysical surveys, sample collection, and geological and other technical support. In 1994, the costs for surface drilling ranged from about $1.00 to nearly $5.00 per foot drilled. The average cost of surface drilling was $1.70 per foot, a decrease of 67 percent from the average cost per foot drilled in 1993 (Table 2). Surface drilling includes both exploration and development drilling. Exploration drilling is done to extend known ore trends or to search for new ore deposits. Six firms reported completing exploration drilling projects in 1994. The 0.34 million feet of exploration drilling completed during 1994 was 53 percent greater than the footage reported for 1993. A total of 519 exploration holes were drilled in 1994, an increase of 46 percent from the 355 holes completed in 1993. The average cost per foot of exploration drilling in 1994 was $2.16, or about one half the average cost per foot reported for 1993. Exploration drilling reported on Form EIA-858 includes assessment drilling completed to meet requirements for holding land under certain lease agreements.

Table 2. Details of U.S. Uranium Surface Drilling, 1985-1994

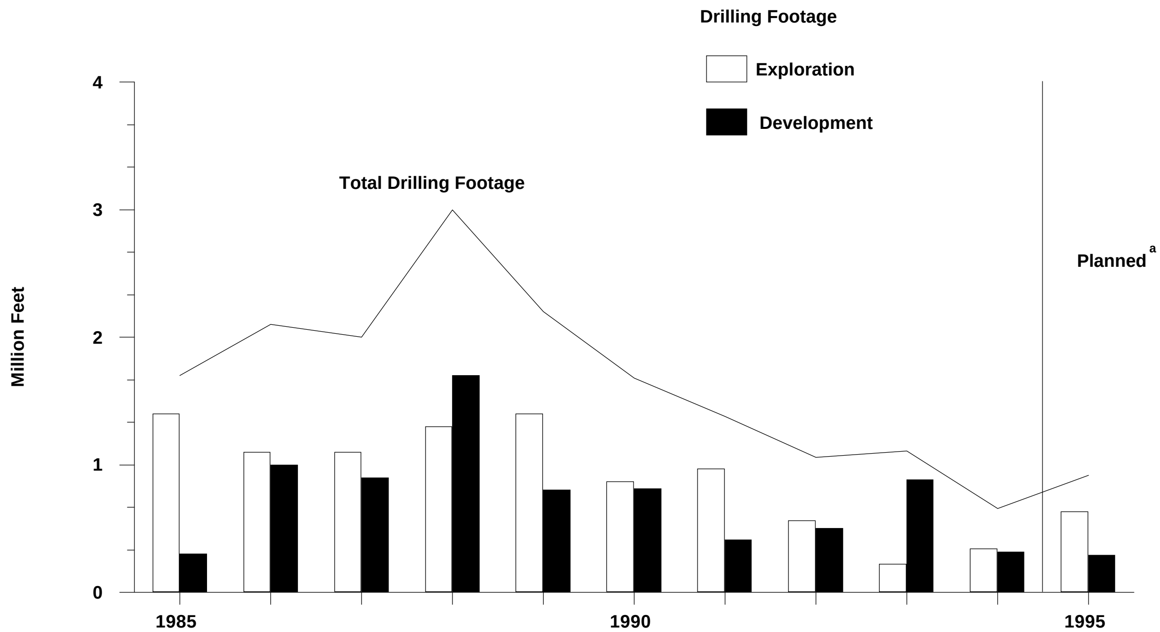
Year(s)	Number of Companies	Holes: Number Drilled	Holes: Change from Prior Year (percent)	Drilling Footage: Total Feet (million)	Drilling Footage: Change from Prior Year (percent)	Cost[a] Total: Dollars (million)	Cost[a] Total: Change from Prior Year (percent)	Cost[a] Average Cost: Per Foot (dollars)	Cost[a] Average Cost: Change from Prior Year (percent)
1985	30	3,649	-33.9	1.76	-30.9	5.53	-53.3	3.14	-32.4
1986	35	3,831	5.0	2.07	17.6	7.74	39.9	3.74	19.0
1987	29	3,814	-0.4	1.96	-5.2	6.96	-10.1	3.55	-5.1
1988	32	5,205	36.5	3.01	53.5	9.70	39.3	3.22	-9.3
1989	27	3,840	-26.2	2.22	-26.2	8.94	-7.8	4.03	25.0
1990	26	3,415	-11.1	1.68	-24.5	9.15	2.3	5.45	35.4
1991	24	3,197	-6.4	1.84	9.7	10.95	19.6	5.94	9.0
1992	16	1,768	-44.7	1.06	-42.2	2.43	-77.8	2.28	-61.6
1993	8	2,020	14.3	1.11	4.1	5.74	136.2	5.18	126.9
1994	7	996	-50.7	0.66	-40.7	1.12	-80.5	1.70	-67.1

[a]Includes costs for exploration and development drilling in nominal dollars.

Notes: Percent change may not equal quotients obtained with independently rounded numerator and denominator. Average cost per foot shown may not equal quotients with independently rounded numerator and denominator.

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994). **1994—**Form EIA-858 “Uranium Industry Annual Survey” (1994).

Figure 2. U.S. Uranium Exploration and Development Drilling Footage, 1985-1995



[a]Planned as of the end of 1994.

Sources: U.S. Department of Energy, Grand Junction Projects Office: **1976-1980—***Uranium Exploration Expenditures in 1980 and Plans for 1981-1982* (May 1981); Energy Information Administration: **1981-1983—***Survey of U.S. Uranium Exploration Activity 1983* (July 1984); **1984-1993—** *Uranium Industry Annual 1993* (September 1994); **1994-1995—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 3. Uranium Surface Drilling by Category, 1985-1994

Year(s)	Exploration[a]				Development[b]			
	Number of Holes	Feet (million)	Cost (million dollars)	Average Cost (dollars per foot)	Number of Holes	Feet (million)	Cost (million dollars)	Average Cost (dollars per foot)
1985	2,877	1.42	5.14	3.63	772	0.34	0.39	1.15
1986	1,985	1.10	6.40	5.83	1,846	0.97	1.35	1.38
1987	1,820	1.11	5.90	5.34	1,994	0.86	1.06	1.24
1988	2,029	1.28	6.44	5.03	3,176	1.73	3.26	1.88
1989	2,087	1.43	5.82	4.09	1,753	0.80	3.12	3.92
1990	1,507	0.87	3.21	3.68	1,908	0.81	5.95	7.37
1991	1,624	0.97	2.83	2.91	1,573	0.87	8.11	9.33
1992	935	0.56	1.27	2.25	833	0.50	1.16	2.31
1993	355	0.22	0.98	4.41	1,665	0.88	4.75	5.37
1994	519	0.34	0.74	2.16	477	0.32	0.38	1.21

[a]Includes assessment drilling and drilling in search of new ore deposits or extensions of known deposits and drilling at the location of a discovery up to the time the company decides sufficient ore reserves are present to justify commercial exploitation.

[b]Includes all drilling of an ore deposit to determine more precisely size, grade, and configuration subsequent to the time that commercial exploitation is deemed feasible.

Note: Average cost per foot shown may not equal quotients obtained with independently rounded numerator and denominator.

Sources: Energy Information Administration: **1984-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 4. Uranium Surface Drilling by State and Type of Drilling, 1994

State	Exploration		Development		Total		Total as a Percent of U.S. Total	
	Number of Holes	Thousand Feet	Number of Holes	Thousand Feet	Number of Holes	Thousand Feet	Number of Holes	Drilling Footage
Wyoming . .	399	253	140	89	539	342	54.1	52.0
Other[a]	120	88	337	227	457	315	45.9	48.0
Total	**519**	**341**	**477**	**316**	**996**	**657**	**100.0**	**100.0**

[a]Includes Arizona, Colorado, Nebraska, and Texas.
Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Development drilling is done to define the size, shape, and grade of known deposits and to provide data needed for mine planning. In 1994, 0.32 million feet of development drilling were completed in 477 holes (Table 3). Three companies reported development drilling for 1994, compared with six in 1993. During the period 1989 through 1994, total annual development drilling has been less than 1 million feet each year. The average cost per foot of development drilling in 1994 was $1.21, or 77 percent less than in 1993.

Uranium Surface Drilling Footage by State

Surface drilling programs were reported by seven companies in 1994. Six firms reported exploration drilling programs and three reported development drilling programs. Compared with the total surface drilling by category for 1993, in 1994 exporation drilling increased in Colorado and Wyoming and exploration and development drilling increased in other States (Table 4).

Total Domestic Uranium Exploration Expenditures

The total expenditures for uranium exploration include all expenditures for land acquired and held, surface exploration and development drilling costs, and other exploration expenditures (Table 5). Total exploration expendi-tures in 1994 were $3.65 million, approximately 68 percent less than the total expenditures in 1993. The 1994 total consisted of $0.07 (2 percent) million for land acquisition, $1.12 (31 percent) million for surface drilling, and $2.46 (67 percent) million for other exploration activities.[1] For 1994, 16 companies incurred costs for exploration activities. Costs for land acquisi-tion, drilling, or work in foreign countries are not included in other exploration expenditures.

Expenditures by the U.S. industry for exploration in foreign countries were reported for 1994, but the total value is not included in this report to prevent disclosure of company-specific infomation.

Table 5. Expenditures for Uranium Exploration and Development, 1985-1994

Year	Surface Drilling		Land Acquisition		Other Exploration Expenditures		Cumulative Expenditures		
	Number of Companies[a]	Cost (million dollars)[b]	Number of Companies[c]	Cost (million dollars)[d]	Number of Companies[e]	Cost (million dollars)[f]	Number of Companies	Cost (million dollars)	Change from Prior Year (percent)
1985 . .	30	5.53	9	0.89	34	13.67	40	20.10	-24.1
1986 . .	35	7.74	16	1.33	34	12.99	50	22.06	9.8
1987 . .	29	6.96	16	0.79	34	11.92	42	19.67	-10.8
1988 . .	32	9.70	14	1.67	31	8.73	44	20.10	2.2
1989 . .	27	8.94	13	0.39	24	5.43	39	14.77	-26.5
1990 . .	26	9.15	7	0.40	31	7.58	40	17.12	15.9
1991 . .	24	10.95	7	0.25	19	6.65	30	17.84	4.2
1992 . .	16	2.43	5	1.36	21	10.72	28	14.51	-18.7
1993 . .	8	5.74	7	1.02	15	4.51	18	11.27	-22.3
1994 . .	7	1.12	5	0.07	12	2.46	16	3.65	-67.6

[a]Number that reported surface drilling, which includes exploration and development drilling.
[b]Includes costs for exploration and development in nominal dollars.
[c]Number that reported land acquisitions and rentals.
[d]Includes costs for land acquisitions and rentals in nominal dollars.
[e]Number that reported other exploration expenditures.
[f]Includes costs, in nominal dollars, for geologic and geophysical investigations and research costs incurred by field personnel during exploration, and overhead and administrative charges specifically associated with supervising and supporting exploration activities.

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

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Foreign Participation in Domestic Uranium Exploration

Contributions from foreign sources to U.S. exporation activities during 1994 were $1.9 million, a 78-percent decrease from the total of $8.5 million from foreign sources in 1993 (Table 6). Foreign participation in 1994 accounted for 51 percent of the total U.S. industry exploration expenditures, down from 76 percent in 1993. The amount of foreign participation in 1994 ($1.9 million) represents the lowest level of such participation reported for the U.S. industry since before 1975 (the first year in which data for this category were collected). Eight companies reported participation in 1994 from foreign sources, one more than in 1993. The dollar amounts contributed from foreign sources are included in all exploration expenditures totals shown in this report.

Planned and Actual Exploration and Development Activities, 1980 Through 1992

A total of eight companies reported on the 1994 survey that they were planning exploration and development drilling programs for 1995. Total surface drilling footage planned for 1995 is projected to be 0.9 million feet, 40 percent greater than the actual drilling footage reported for 1994 (Figure 2). Planned expenditures for total surface drilling for 1995 as reported on the 1994 survey are projected to be $2.8 million, or about 2.5 times greater than actual total surface drilling expenditures reported for 1994.

Table 6. Foreign Participation In Uranium Exploration, 1985-1994

Year	Number of Companies[a]	Expenditures: Total Dollars (million)	Expenditures: Percent of U.S.Total
1985	6	5.6	28
1986	8	12.0	55
1987	11	11.9	60
1988	11	8.9	44
1989	7	6.1	42
1990	9	2.5	15
1991	6	3.5	19
1992	6	8.0	55
1993	7	8.5	76
1994	8	1.9	51

[a]Companies that reported expenditures for foreign participation in U.S. uranium exploration.

Note: Expenditures are in nominal dollars and include expenditures for land acquired and held, surface drilling, and “other exploration expenditures,” which includes geologic and geophysical investigations and research, costs incurred by field personnel during exploration, and overhead and administrative charges specifically associated with supervising and supporting exploration activities.

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 “Uranium Industry Annual Survey” (1994).

U.S. Uranium Resources and Reserves

Potential Uranium Resources

Estimates of potential (undiscovered) uranium resources for the classes of Estimated Additional Resources (EAR) and Speculative Resources (SR) are made at forward-cost categories of $30-, $50-, and $100-per-pound U_3O_8. Within each forward-cost category, the estimates of resources at each cost level are cumulative and include all lower cost resources within that category. Because of limited direct-sample data, the estimation of potential uranium resources is not precise, and the reliability of the estimates is more uncertain than that for estimates of reserves. For 1994 the mean values of EAR and SR for the $30-, $50-, and $100-per-pound U_3O_8 forward-cost categories declined slightly when compared with the 1993 values (Table 7).

Table 7. Potential Uranium Resources by Forward-Cost Category, 1993 and 1994
(Million Pounds U_30_8)

Year	$30 per pound EAR[a]	$30 per pound SR[b]	$50 per pound EAR[a]	$50 per pound SR[b]	$100 per pound EAR[a]	$100 per pound SR[b]
1993	2,200	1,330	3,340	2,250	4,880	3,510
1994	2,180	1,310	3,310	2,230	4,850	3,480

[a]EAR = Estimated Additional Resources.

[b]SR = Speculative Resources.

Notes: Values shown are the mean values for the distribution 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. Estimates of uranium that could be recovered as a byproduct of other commodities are not included.

Sources: Estimates based on uranium data for favorable areas developed under the DOE National Uranium Resources Evaluation (NURE) program, 1974-1983, and, since 1983, updated data on favorable areas become available from the U.S. Geological Survey (USGS). Estimates are updated annually by EIA using revised economic indexes that reflect changes in the U.S. economy.

U.S. Uranium Reserves

Uranium reserves consist of the estimated quantities of uranium (as U_3O_8) occurring in known deposits of such grade, quantity, configuration of mineralized rock, and depth, that, based on mining analyses and engineering calculations, portions of the mineralized deposits can be recovered at specified costs under current regulations using state-of-the art mining and processing. The specified costs, which comprise the forward-cost categories, are not the same as market prices. The category of "uranium reserves" is equivalent to the internationally reported category of Reasonably Assured Resources (RAR). The national estimates of uranium reserves presented in this section use historical data, industry information, and the reserves data and estimating parameters for individual properties reported on the 1994 Form EIA-858. Reserves totals are presented for selected forward-cost categories that cover a broad range of costs for both short-term and long-term planning for the supply and procurement of uranium as well as for planning the development of energy programs by Government and industry. Costs used in deriving the 1994 reserves estimates include capital and operating costs associated with mining, transporting, and processing of the uranium ores. Uranium recovery factors normally encountered in actual mining and milling operations were used in the estimations.

As of the end of 1994, the estimate of uranium reserves in the $30-per-pound category located in 243 properties was 294 million pounds U_3O_8, 1 percent more than in 1993 (Table 8). The estimates for 1994 increased slightly in the $50-per-pound category to 953 million pounds U_3O_8. The 1,501 million pounds in the $100-per-pound category are 1 percent below the correspond-ing estimate at the end of 1993. The changes in reserves were the result of the reevaluation of selected uranium property reserves based on new data and on costs, depletion, and availability of milling facilities within reasonable haulage distance. Three States, New Mexico, Texas, and Wyoming, contain about 73 percent of $30-per-pound U_3O_8 reserves (Table 9 and Figure 3).

Based on reserve data reported on Form EIA-858 and on evaluation of individual uranium-property data, an assessment was made of the distribution of reserves most likely to be extracted by underground, openpit, in situ leaching, or other methods of mining (Table 9 and Figure 4). Conventional underground mining continues to be the dominant method, accounting for about one-half of the total reserves in each cost category. In the $30-per-pound cost category, in situ leaching is the second largest mining method, and in the $50 and $100-per-pound categories, openpit mining is the second largest method.

Table 8. Changes in Uranium Reserves by Forward-Cost Category, 1993 to 1994
(Million Pounds U_30_8)

Year End Reserves and Change	Forward-Cost Category		
	$30 per pound	$50 per pound	$100 per pound
Reserves at the End of 1993	292	952	1,511
Reevaluations of Reserves in 1994			
Additions	8	9	11
Subtractions	(1)	(3)	(13)
Depletion (Production and Erosion) in 1994	(4)	(5)	(8)
Reserves at the End of 1994	294	953	1,501

Notes: Totals may not equal sum of components because of independent rounding. No reserves evaluations for new uranium properties are included in the estimates of U.S. reserves made during 1993. Uranium reserves that could be recovered as a byproduct of phosphate and copper mining are not included in this table. Reserves values in forward-cost categories are cumulative: that is, the quantity at each level of forward cost includes all reserves at the lower costs.

Sources: Estimated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on U.S. Department of Energy, Grand Junction Projects Office data files and Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 9. Uranium Reserves by State, Mining Method, and Forward-Cost Category, 1994

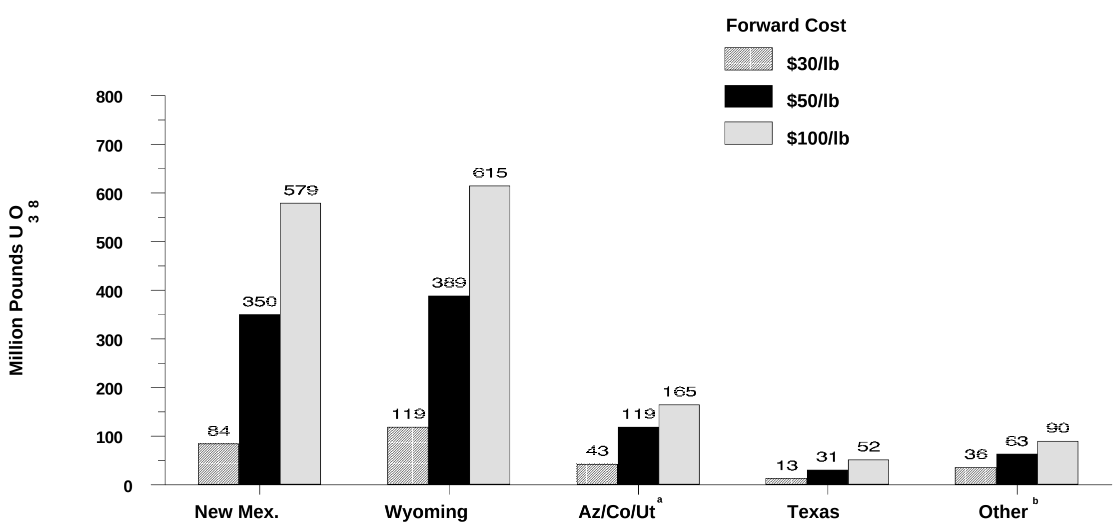
State and Mining Method	$30 per pound			$50 per pound			$100 per pound		
	Ore (million tons)	Grade[a] (percent)	U_3O_8 (million pounds)	Ore (million tons)	Grade[a] (percent)	U_3O_8 (million pounds)	Ore (million tons)	Grade[a] (percent)	U_3O_8 (million pounds)
State									
New Mexico	15	0.277	84	111	0.157	350	296	0.098	579
Wyoming	45	0.131	119	248	0.078	389	618	0.050	615
Arizona, Colorado, Utah . .	7	0.293	43	45	0.133	119	95	0.087	165
Texas	6	0.101	13	23	0.069	31	63	0.041	52
Other[b]	9	0.203	36	28	0.113	63	64	0.070	90
Mining Method									
Underground	25	0.273	139	143	0.163	466	390	0.099	771
Openpit	10	0.139	29	163	0.079	258	433	0.047	410
In Situ Leaching	47	0.133	126	134	0.080	214	290	0.052	299
Other[c]	<1	0.264	<1	15	0.050	15	23	0.044	20
Total	83	0.177	294	455	0.105	953	1,136	0.066	1,501

[a]Weighted average percent U_3O_8 per ton of ore.
[b]Includes California, Idaho, Nebraska, Nevada, North Dakota, Oregon, South Dakota, and Washington.
[c]Includes heap leach, mine water, and low grade stockpiles.

Notes: Uranium reserves that could be recovered as a byproduct of phosphate and copper mining are not included in this table. Reserves values in forward-cost categories are cumulative: that is, the quantity at each level of forward-cost includes all reserves at the lower costs. Totals may not equal sum of components because of independent rounding.

Sources: Estimated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on industry conferences U.S. Department of Energy, Grand Junction Projects Office data files, and Energy Information Administration, Form EIA-858 "Uranium Industry Annual Survey" (1994).

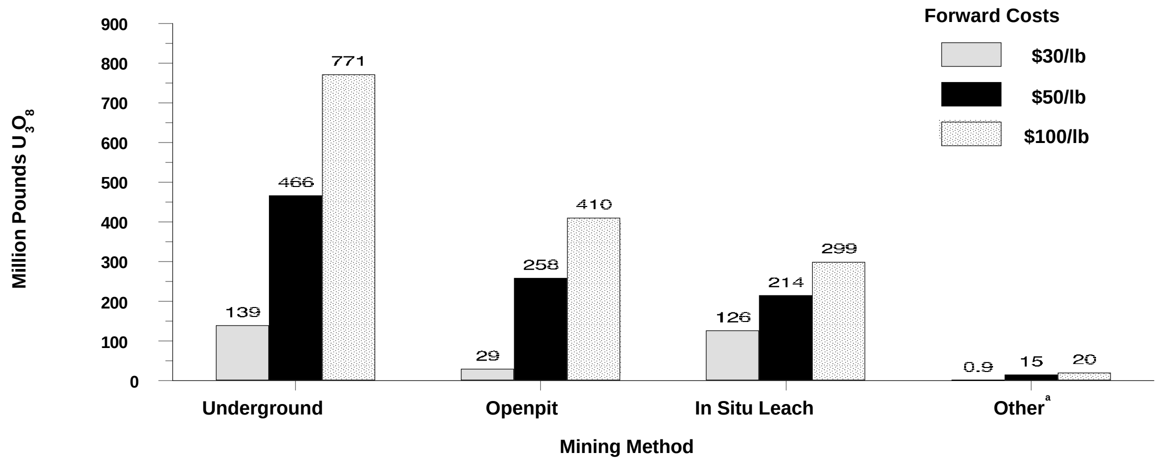
Figure 3. Uranium Reserves by State, 1994



[a]Arizona, Colorado, and Utah.
[b]Includes California, Idaho, Nebraska, Nevada, North Dakota, Oregon, South Dakota, and Washington.

Note: Reserves values in forward-cost categories are cumulative; that is, the quantity at each level of forward cost includeds all resources at the lower costs in that category.

Figure 4. U.S. Reserves by Mining Method at the End of 1994



[a]Includes heap leach, mine water, and low-grade stockpiles.

Note: Reserves values in forward-cost categories are cumulative; that is, the quantity at each level of forward cost includes all rewources at the lower costs in that category.

Sources: Estimated by Energy Information Administration, Office of Coal, Nuclear, and Alternate Fuels, based on industry conferences, U.S. Department of Energy, Grand Jundtion Projects Office data files, and Form EIA-858 "Uranium Industry Annual Survey" (1994).

U.S. Mine Production of Uranium

Production from in situ leach mines and other sources during 1994 totaled 2.5 million pounds U_3O_8, an increase of 23 percent above the 2.0 million pounds produced during 1993 (Table 10 and Figure 5). Commercial-scale in situ leach mining operations located in Nebraska, Texas, and Wyoming accounted for the largest part of total U.S. mine production in 1994 (Table 11). Other sources, such as recovery of uranium from mine water and restoration of mined-out in situ leach well fields accounted for the remainder. The number of sources for mine production of uranium that were operating each year from 1985 through 1994 are shown on Table 12.

Table 10. Uranium Mine Production by Mining Method, 1985-1994
(Million pounds U_3O_8)

Mining Method	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Underground	4.5	6.4	4.9	5.4	5.3	W	W	W	0	0
Percent of Total . .	52.3	77.8	81.7	56.8	54.4	W	W	W	--	--
Openpit	2.0	W	W	W	W	1.9	2.5	W	0	0
Percent of Total . .	23.3	W	W	W	W	32.0	48.8	W	--	--
Other[a]	2.1	1.8	1.1	4.1	4.4	4.0	2.7	1.0	2.0	2.5
Percent of Total . .	24.4	22.2	18.3	43.2	45.6	68.0	51.2	100.0	100.0	100.0
Total	8.6	8.3	6.0	9.5	9.7	5.9	5.2	1.0	2.0	2.5
Percent Change from Prior Year . .	-14.0	-3.5	-27.7	58.3	2.1	-39.2	-11.8	-80.7	105.1	23.2

[a] For 1985 the "Other" includes production from in situ leach, mine water, and water-treatment plant solutions. For 1986 through 1989, the "Other" includes production from openpit, in situ leach, heap leach, mine water, and water-treatment plant solutions. For 1990 and 1991, the "Other" includes production from underground, in situ leach, heap leach (1990), mine water, water treatment plant solutions (1990), and restoration. For 1992, the"Other" includes production from underground, openpit, and in situ leach mines and uranium bearing water from mine workings, tailings ponds, and restoration. For 1993 and 1994, the "Other" includes production from in situ leach mines and uranium bearing water from mine workings and restoration.

-- = Not applicable.

W = Withheld to avoid disclosure of company-specific data. The data are included in the total for "Other."

Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data.

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994). **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 11. Mine Production of Uranium by State, 1985-1994

(Million Pounds U_3O_8)

Year	Texas	Wyoming	Other[a]	Total
1985	2.1	1.6	4.9	8.6
1986	1.5	W	6.8	8.3
1987	0.9	W	5.1	6.0
1988	2.2	2.0	5.3	9.5
1989	2.9	1.4	5.4	9.7
1990	2.0	1.3	2.5	5.9
1991	2.6	1.9	0.7	5.2
1992	0.3	0.2	0.5	1.0
1993	0.3	1.1	0.6	2.0
1994	W	W	W	2.5

[a]Includes, for various years, Alaska, Arizona, Colorado, New Mexico, Nebraska, North Dakota, South Dakota, Texas, Utah, Washington, and Wyoming.

W = Withheld to avoid disclosure of company-specific data. The data are included in the total for "Others."

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

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994**—Form EIA-858 "Uranium Industry Annual Survey" (1994).

Figure 5. Total U.S. Uranium Mine Production, 1985-1994

Sources: **1968-1982—**U.S. Department of Energy, Grand Junction Projects Office, *Statistical Data of the Uranium Industry* (1969-1983). **1983—**Estimated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, from U.S. Department of Energy, Grand Junction Projects Office data files. **1984-1993—**Energy Information Administration, *Uranium Industry Annual 1993* (September 1994). **1994—**Energy Information Administration, Form EIA-858 "Uranium Industry Annual Survey" (1994).

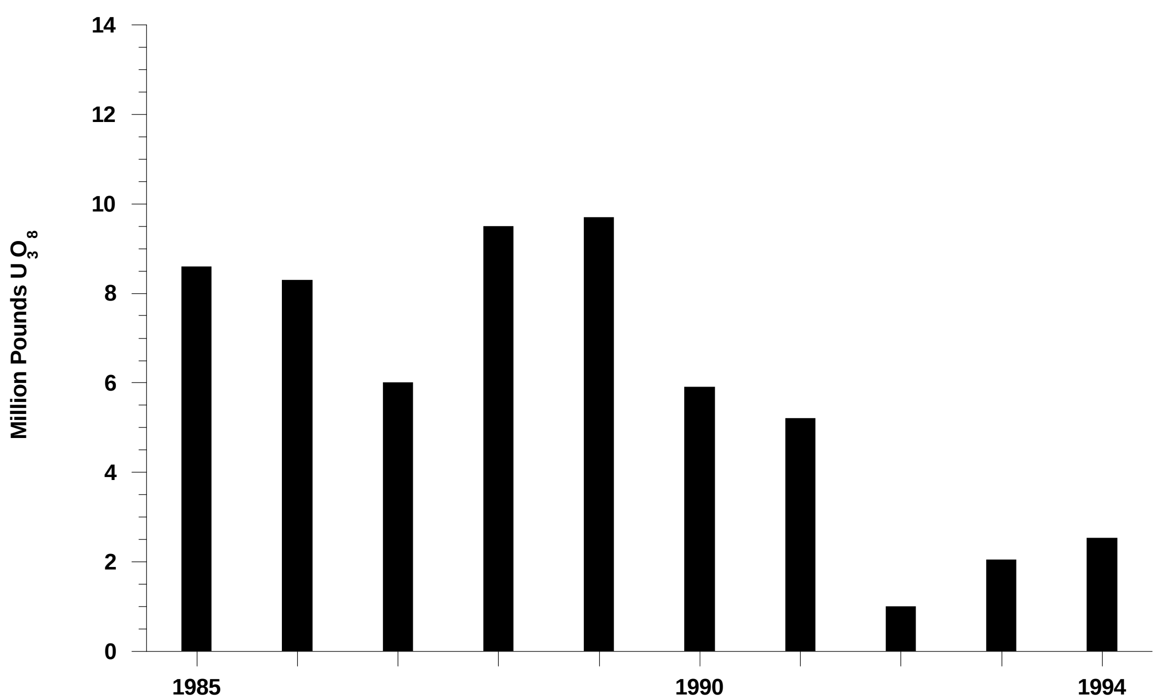


Table 12. Number of U.S. Uranium Mine Operations, 1985-1994

Mine Type	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Underground	13	13	19	17	19	27	6	4	0	0
Openpit	6	4	2	4	2	2	2	1	0	0
In Situ Leaching	10	12	15	11	9	7	6	4	5	5
Other[a]	5	2	1	0	2	3	1	8	7	7
Total	**34**	**31**	**37**	**32**	**32**	**39**	**15**	**17**	**12**	**12**

[a]Includes, in various years, heap leach, mine water, mill site cleanup and mill tailings, well field restoration, and low-grade stockpiles as sources of uranium.
Note: Table does not include byproduct sources.
Sources: Energy Information Administration: **1985-1993—** *Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey (1994).

The quantities of uranium ore produced from openpit and underground mines and received at mills for 1985 through 1994 are shown in Table 13. As in 1993, there were no shipments of uranium ore from mines to uranium mills during 1994. Uranium ore was mined from U.S. deposits in every year from 1947[2] through 1992. The peak year for U.S. mine production of uranium was in 1980 when 40 million pounds U_3O_8 in ore were mined.

Table 13. Uranium Ore Produced at U.S. Mines and Received at U.S. Mills, 1985-1994

	Total Receipts		
Year	Ore (thousand tons)	U_3O_8 (million pounds)	Percent Change from Prior Year
1985	1,506	6.3	-18.2
1986	801	6.7	5.7
1987	642	4.9	-26.9
1988	1,260	7.7	57.1
1989	1,022	7.1	-7.8
1990	722	4.2	-40.8
1991	639	2.5	-40.5
1992	W	W	--
1993	0	0	--
1994	0	0	--

W = Withheld to avoid disclosure of individual company data.
-- = Not applicable.
Note: Mined ore does not include production from mine water, *in situ* leach, heap leach solutions, byproducts, or miscellaneous low-grade ore from old mine dumps.
Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

U.S. Uranium Concentrate Production

Total U.S. uranium concentrate (U_3O_8) production in 1994 was 3.4 million pounds U_3O_8, an increase of 9 percent above the 1993 level . Wyoming again was the leading State in uranium concentrate production in 1994 (Table 14). Louisiana, Nebraska, and Texas also were significant States in uranium concentrate production.

Concentrate production in Texas and Wyoming in 1994 was from in situ leaching operations and restoration of well-field aquifers. In Nebraska concentrate production was from in situ leaching. In New Mexico, production was from processing of mine water. In Louisiana, uranium was recovered as a byproduct of phosphoric acid production. Florida phosphate rock is the raw material used in the production of phosphoric acid.

[2]U.S. Department Energy, *Summary History of Domestic Uranium Procurement Under U.S. Atomic Energy Commission Contracts, Final Report*, GJBX-220(82) (Grand Junction, Colorado, October 1982), pp. 4, 24.

Table 14. Uranium Concentrate Production by State, 1985-1994
(Million Pounds U_3O_8)

Year(s)	State			Total	Cumulative Total
	Texas	Wyoming	Other[a]		
1985	2.167	2.427	5.333	[b]11.314	806.148
1986	2.586	0.633	9.536	[b]13.506	819.654
1987	2.716	0.567	9.008	[b]12.991	832.645
1988	2.805	2.007	8.318	13.130	845.775
1989	2.939	1.607	9.291	13.837	859.612
1990	1.832	1.368	5.685	8.885	868.497
1991	2.343	2.035	3.574	7.952	876.449
1992	1.032	1.589	3.024	5.645	882.094
1993	0.269	1.190	1.603	3.063	885.157
1994	W	W	W	3.352	888.509

[a]Includes, for various years, Arizona, Colorado, Florida, Louisiana, Nebraska, New Mexico, South Dakota, Texas, Utah, and Washington.
[b]Total does not include uranium concentrate production from pilot projects or other research project sources.
Sources: Energy Information Administration: **1985-1993—** *Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

The U.S. uranium concentrate production between 1989 and 1994 has ranged from 13.8 million pounds U_3O_8 (1989) to 3.1 million pounds U_3O_8 (1993) (Table 15 and Figure 6). As in 1993, there was no uranium concentrate production from conventional milling of uranium ore in 1994. A small amount of uranium was recovered, however, from processing (at mills) of mine water and materials recovered from water treatment plants. Production from "Other" sources (other than from mined ore) was 3.3 million pounds in 1994, and it represented 99 percent of total production in 1994. The sources of "Other" production for 1994 include in situ leaching, as a byproduct of phosphate production, and well field restoration.

The byproduct uranium recovery industry began in the United States in 1977, and the annual share of domestic uranium concentrate derived from wet-process phosphoric acid production has been significant.

Table 15. Uranium Processing Operations, 1985-1994

Processing Operations	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Ore Fed to Process[a]										
(thousand tons ore)	1,795	1,308	1,441	1,214	1,235	722	639	256	0	0
(grade)[b]	0.161	0.336	0.284	0.288	0..323	0.293	0.198	0.229	--	--
(million pounds U_3O_8	5.785	8.783	8.191	6.998	7.977	4.227	2.529	1.171	0	0
Other Mill Feed[c]										
(million pounds U_3O_8)	0.750	0.260	0.474	0.507	0.429	0.485	0.179	0.181	0.042	0.078
Total Mill Feed										
(million pounds U_3O_8)	6.535	9.043	8.664	7.505	8.406	4.712	2.708	1.353	0.042	0.078
In-Process Inventory Charge										
(million pounds U_3O_8)	0.206	-0.064	-0.210	0.136	-0.234	-0.244	-0.122	-0.025	0.010	0.024
Concentrate Production										
(million pounds U_3O_8)										
Theoretical Production[d]	6.329	9.107	8.874	7.369	8.640	4.956	2.830	1.377	0.031	0.054
Conventional Milling	6.084	8.853	8.536	7.034	8.175	4.649	2.608	1.359	0.030	0.046
Tailings Less Unaccountables	0.245	0.254	0.338	0.335	0.465	0.309	0.222	0.018	0.001	0.008
Recovery from Mill Feed										
(percent)	96.1	97.2	96.2	95.5	94.6	93.8	92.2	98.7	--	--
Other Processing[e]	5.230	4.653	4.455	6.096	5.662	4.237	5.344	4.286	3.033	3.306
Total Production	[f]11.314	[f]13.506	[f]12.991	13.130	13.837	8.885	7.952	5.645	3.063	3.352
Concentrate Shipments										
(million pounds U_3O_8)	11.760	10.641	11.558	12.791	14.808	12.957	8.437	6.853	3.374	6.319

[a]Uranium ore "fed to process" in any year can include: ore mined and shipped to a mill during the same year, ore that was mined during a prior year and later shipped from mine-site stockpiles, and/or ore obtained from drawdowns of stockpiles maintained at a mill site.

[b]Weighted average percent U_3O_8 per ton of ore.

[c]Includes for various yearsuranium from low-grade ore, mill cleanup, mine water, tailings water, and heap leaching, except as footnoted below.

[d]At 100-percent recovery.

[e]U_3O_8 concentrate production from in situ leaching and as a byproduct of other processing. The totals for 1986 through 1988 include U_3O_8 recovered from reclamation and mine water at some mills that did not report processing of uranium ore for those years.

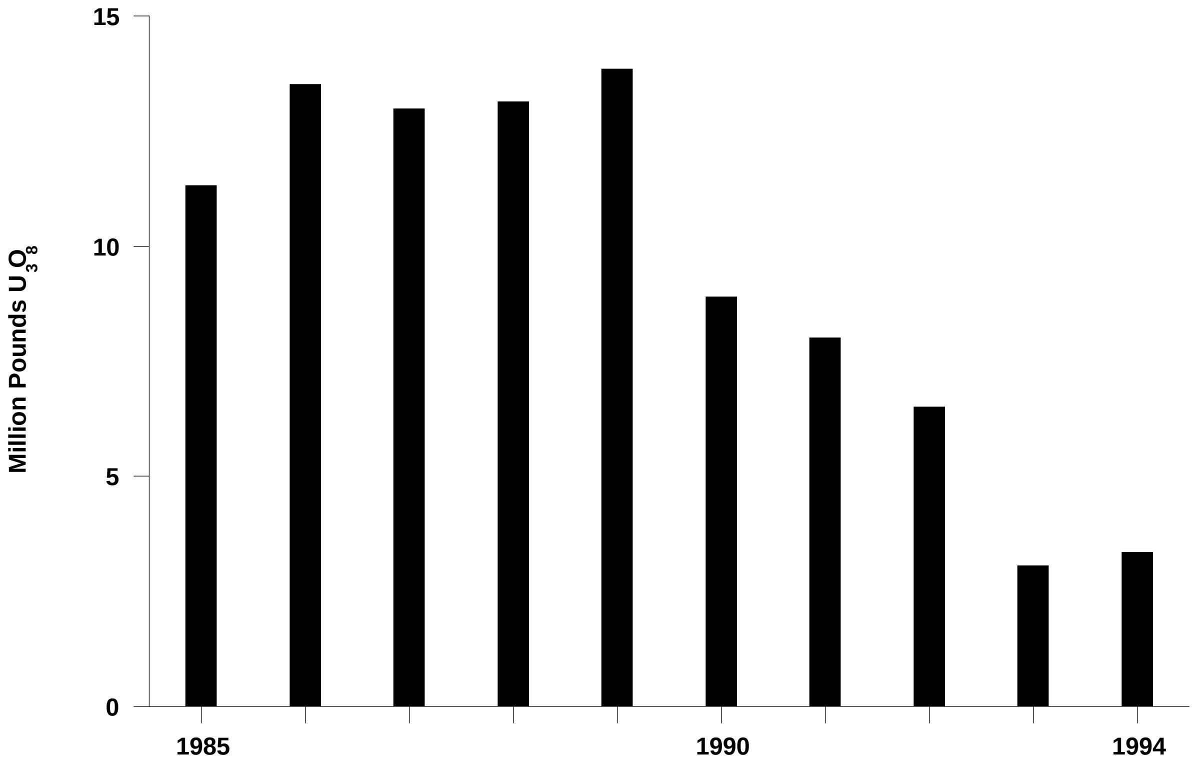
[f]Total does not include uranium concentrate production from pilot projects or other research project sources.

-- = Not applicable

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

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Figure 6. U.S. Production of Uranium Concentrate, 1985-1994



Sources: **1955-1982—**U.S. Department of Energy, Grand Junction Projects Office, *Statistical Data of the Uranium Industry* (January 1983). **1983—**Estimated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, from U.S. Department of Energy, Grand Junction Projects Office data files. **1984-1993—**Energy Information Administration, *Uranium Industry Annual 1993* (September 1994). **1994—**Energy Information Administration, Form EIA-858 "Uranium Industry Annual Survey" (1994).

Shipments of uranium concentrate from domestic production facilities was 6.3 million pounds in 1994 compared with 3.4 million pounds in 1993 (Table 15). Concentrate shipments reported in 1994 by producers were approximately 3.0 million pounds above the total domestic U_3O_8 production for the year.[2] This resulted in an overall decrease in concentrate inventories held at production facilities at the end of 1994. Annual shipments of concentrate from processing plants in 1989 through 1994 exceeded annual concentrate production in those years.

At the end of 1994, two phosphate byproduct and five in situ leaching plants were in operation (Table 16), with a combined rated capacity of 5.8 million pounds U_3O_8 per year. In addition, there were seven inactive plants with a total combined rated production capacity of 5.1 million pounds U_3O_8 per year. At the end of 1994, six inactive U.S. conventional uranium mills that were being maintained on standby mode had a combined rated capacity of 14,650 tons of ore per day (Tables 17 and 18).

[2]Uranium concentrate shipped from domestic production centers is the feed material used in the uranium conversion process, in which the concentrate (generally as U_3O_8) is changed by chemical conversion to uranium hexaflouride (UF_6) for use in the enrichment process. Schedule A of Form EIA-858 does not collect information on the destinations of concentrate shipments from U.S. production centers.

Table 16. Operating Status of Nonconventional Uranium Plants, 1994

Plant Owner	Name and State	Plant Type	Rated Capacity (thousand pounds U_3O_8 per year)	Operating Status at the End of the Year[a]
Converse County Mining Venture	Highland (WY)	In Situ Leach	2,000	O
COGEMA Mining, Inc.	West Cole (TX)	In Situ Leach	200	I
Crow Butte Resources.	Crow Butte (NE)	In Situ Leach	1,000	O
Everest Minerals.	Hobson (TX)	In Situ Leach	1,000	I
IMC-Agrico Company	Sunshine Bridge (LA)	Phosphate Byproduct	420	O
IMC-Agrico Company	Uncle Sam (LA)	Phosphate Byproduct	750	O
IMC-Agrico Company	Plant City (FL)	Phosphate Byproduct	608	I
IMC-Agrico Company	New Wales (FL)	Phosphate Byproduct	750	I
Malapai Resources	Christensen Ranch (WY)	In Situ Leach	650	O
Malapai Resources	Holiday-El Mesquite (TX)	In Situ Leach	600	O
Malapai Resources	Irigaray (WY)	In Situ Leach	350	O
Rio Algom Mining Company	Smith Ranch (WY)	In Situ Leach	250	I
Uranium Resources, Inc.	Kingsville Dome (TX)	In Situ Leach	1,300	I
Uranium Resources, Inc.	Rosita (TX)	In Situ Leach	1,000	I

[a]O = Operating at the end of the year; I = Inactive at the end of the year.
Note: Pathfinder Mines, Inc. has been granted a commercial license for its North Butte-Ruth in situ leach project in Campbell County, Wyoming.
Sources: Energy Information Administration, Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 17. Operating Status of Conventional Uranium Mills, End of the Year, 1990-1994

Mill Owner	Name and State	Milling Capacity[a] (short tons of ore per day)	Operating Status at End of the Year[b]				
			1990	1991	1992	1993	1994
American Nuclear	Gas Hills(WY)	(950)	D	D	D	D	D
Atlas Minerals	Moab (UT)	(1,400)	D	D	D	D	D
Cotter	Canon City (CO)	1,200	I	I	I	I	I
Dawn Mining	Ford (WA)	450	I	I	I	I	I
Energy Fuels Nuclear	White Mesa (UT)	2,000	[c]I	I	I	I	I
Green Mountain Mining Venture	Sweetwater (WY)	3,000	I	I	I	I	I
Homestake Mining	Grants (NM)	(3,400)	I	D	D	D	D
Pathfinder Mines	Lucky Mc (WY)	(2,800)	I	P	D	D	D
Pathfinder Mines	Shirley Basin (WY)	(1,800)	O	O	D	D	D
Rio Algom Mining	Ambrosia Lake (NM)	7,000	I	I	I	I	I
Rio Algom Mining	Lisbon (UT)	(750)	I	I	P	P	P
Rio Grande Resources	Panna Maria (TX)	([d]3,000)	O	O	D	D	D
Umetco Minerals	Gas Hills (WY)	(1,300)	I	D	D	D	D
Umetco Minerals	Uravan (CO)	(1,400)	I	P	P	P	P
U.S. Energy/Plateau Resources	Shootering (UT)	1,000	I	I	I	I	I
Western Nuclear	Split Rock(WY)	(1,700)	D	D	D	D	D
Western Nuclear	Sherwood (WA)	(2,000)	I	P	P	P	P

[a] Milling capacity based on historical data and data reported on Form EIA-858 for 19942. Parentheses indicate mills that have been decommissioned or that were permanently closed as of the end of 1994.
[b]O, Operating throughout the year; I, Inactive at the end of the year; P, Permanently closed as of the end of the year; D, Decommissioning: Restoration begun or completed.
[c]Mill was inactive at the end of the year, but it recovered U_3O_8 from non-ore materials during one or more months of the year.
[d]Capacity for 1990 was reported as 2,500 tons per day.
Sources: Energy Information Administration: **1990-1993**—*Uranium Industry Annual 1993* (September 1994). **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 18. Status of U.S. Conventional Uranium Mills, 1990-1994

Item	1990	1991	1992	1993	1994
Number of Mills					
Operating [a]	2	2	0	0	0
Not Operating	12	7	6	6	6
Total	14	9	6	6	6
Milling Capacity (tons of ore per day)					
Operating	4,300	4,800	0	0	0
Not Operating	26,300	15,400	14,650	14,650	14,650
Total	30,600	20,200	14,650	14,650	14,650
Average Daily Mill Feed (tons of ore per day)[b]	2,060	1,830	730	0	0
Operating Level As Percent of Total Milling Capacity[c]	7	10	5	0	0

[a]Number of mills being operated to process uranium ore at the end of the year.
[b]Rounded value. Based on 350 workdays per year and total ore fed to process during the year shown in Table 15.
[c]Rounded value. Calculated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on ore fed to process (Table 15) during 350 workdays per year.
Sources: Energy Information Administration: **1990-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

The year-end status (active or in-active) of nonconventional plants and conventional mills as of December 31, 1994, and their locations are shown in Figure 7. The map also shows the major uranium reserve areas in the United States.

Employment in the Uranium Raw Materials Industry

Employment in the U.S. uranium raw materials industry in 1994 was reported as 452 person-years expended, an increase of 19 percent from the 1993 total (Table 19 and Figure 8). The employment level for exploration rose by 12 percent, for mining by 18 percent, for milling by 62 percent, and processing by 3 percent. Since 1985, total employment has shown modest increases in 1988 and 1994, although the overall trend in this period has been one of decline (Table 19 and Figure 8).

Colorado, Texas, and Wyoming accounted for 58 percent of employment in the raw materials sector in 1994 (Table 20 and Figure 9). Florida, Louisiana, Nebraska, Utah, and Washington, which are included in the category "Other" in Table 20, also accounted for significant levels of employment in raw-materials-sector activities. In 1994, the total amount of employment reported by the industry as expended in reclamation activities was 528 person-years, which was 17 percent higher than the combined person-years expended in exploration, mining, milling, and processing in 1994.

Table 19. Employment in the U.S. Uranium Industry by Category, 1985-1994
(Person-Years)

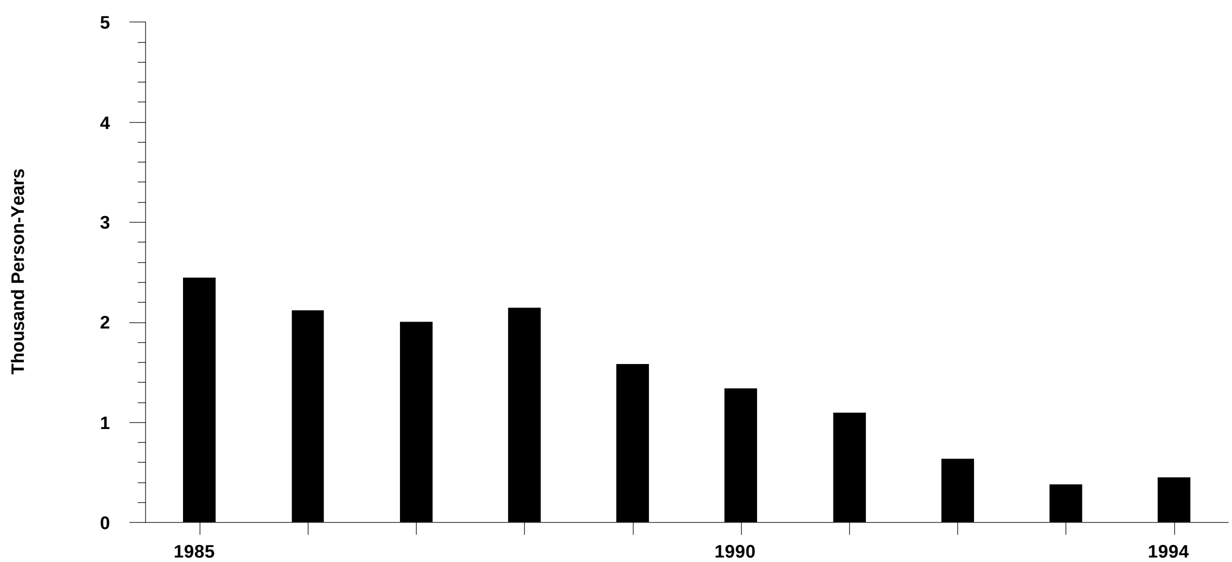
Year	Employment Categories				Total	Percent Change from Prior Year
	Exploration	Mining	Milling	Processing		
1985	163	1,212	514	557	2,446	-32.0
1986	162	954	513	490	2,120	-13.3
1987	183	819	432	568	2,002	-5.6
1988	144	849	572	576	2,141	6.9
1989	86	659	367	471	1,583	-26.1
1990	73	664	304	293	1,335	-15.7
1991	52	411	191	361	1,016	-23.9
1992	51	219	129	283	682	-32.9
1993[a]	36	133	65	145	380	-44.4
1994[a]	41	157	105	149	452	19.0

[a]Does not include 491 person years in 1993 and 528 person years in 1994 for employment in reclamation work relating to exploration, mining, milling, and processing. Data for the reclamation category for years before 1993 were not collected on the "Uranium Industry Annual Survey," (Form EIA-858).

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

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1993); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Figure 8. Employment in the Uranium Industry, 1985-1994



Note: Does not include 491 person years in 1993 and 528 person years in 1994 for employment in reclamation work relating to exploration, mining, milling, and processing. Data for the reclamation category before 1993 were not collected on the Form EIA-858 "Uranium Industry Annual Survey."

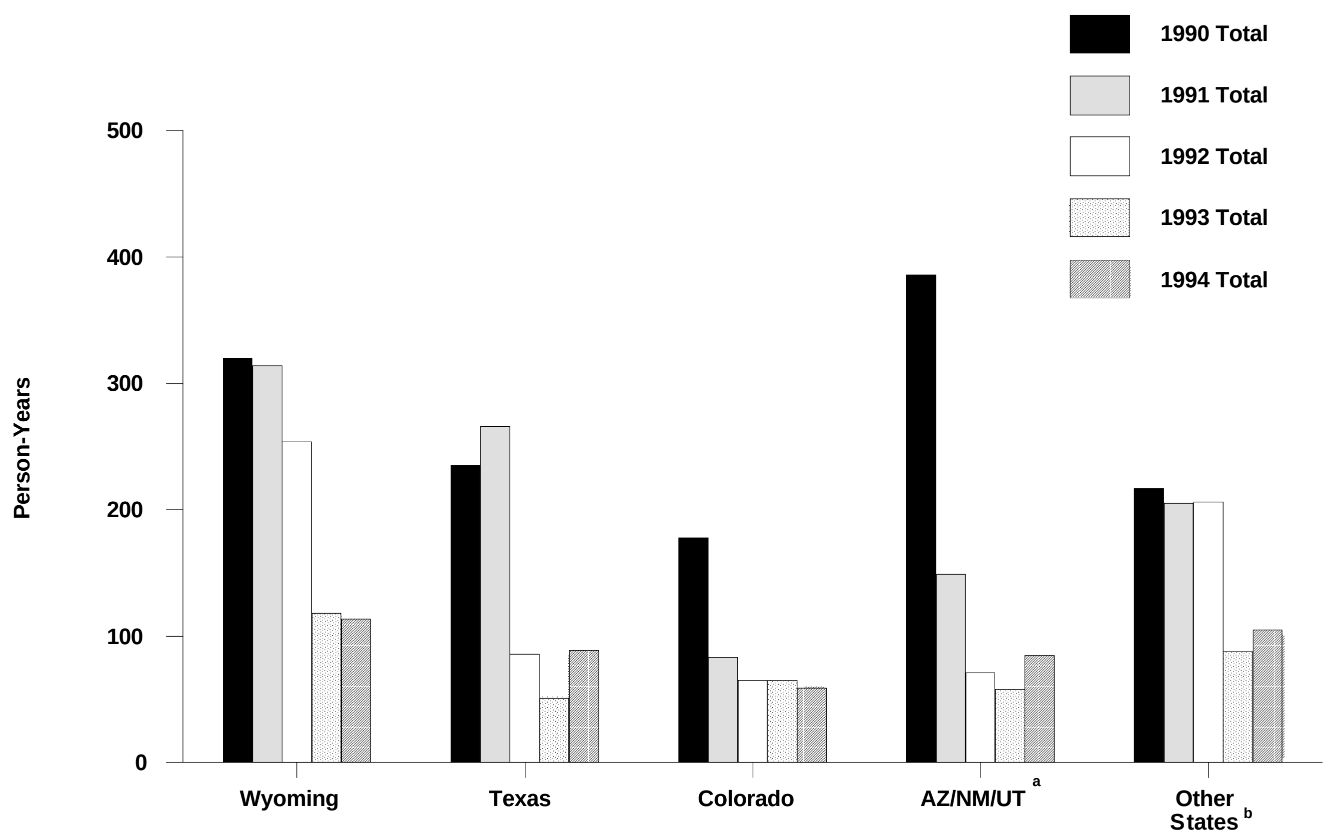
Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858 "Uranium Industry Annual Survey" (1994).

Table 20. Employment in the U.S. Uranium Industry by State, 1994
(Person-Years)

State	Total	Percent of Total
Wyoming	114	25.2
Texas	89	19.6
Colorado	59	13.1
Arizona, New Mexico, Utah	85	18.8
Other[a]	105	23.3
Total[b]	**452**	**100.0**

[a]Includes Florida, Louisiana, Nebraska, Nevada, Washington.
[b]Does not include 528 person years in 1994 for employment in reclamation work relating to exploration, mining, milling, and processing. Data for the reclamation category for years before 1993 were not collected on the "Uranium Industry Annual Survey" (Form EIA-858).
Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Figure 9. Employment in the Uranium Industry by State, 1990-1994



[a]Arizona, New Mexico, and Utah.
[b]**1990—**Florida, Louisiana, Nebraska, Oregon, Virginia and Washington; **1991-1994**—Florida, Louisiana, Nebraska, Nevada, and Washington.
Note: Does not include 491 person years in 1993 and 528 person years in 1994for employment in reclamation work relating toexploration, mining, milling, and processing. Data for the reclamation category for years before 1993 were not collected on the "Uranium Industry Annual Survey" (Form EIA-858).

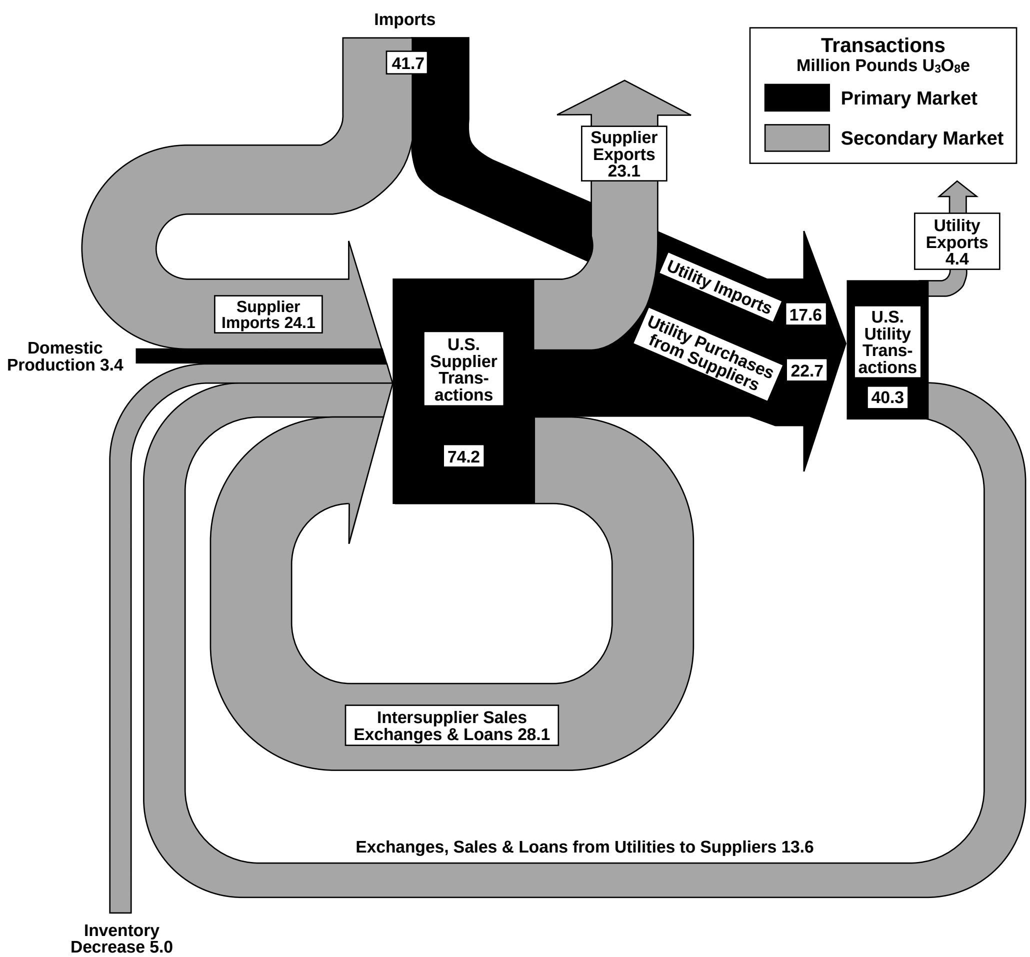
2. Uranium Marketing Activities

Introduction

Movement of both natural and enriched uranium materials in the primary and secondary markets illustrates, for 1994, the normal market mechanisms used by U.S. utilities and suppliers to procure and dispose of uranium (Figure 10). The uranium quantities throughout this chapter that are expressed as U_3O_8 equivalent (U_3O_8e) can consist of natural and enriched uranium. "Suppliers" are U.S. firms or foreign firms that exchange, loan, purchase, or sell uranium and are not U.S. electric utilities. They include uranium brokers, converters, enrichers, fabricators, producers, and traders.

Uranium delivered under purchase contracts in 1994 and expected to be delivered in 1995 and beyond includes deliveries of foreign-origin uranium, some of which was imported during 1994. The remaining uranium was already in the United States. Uranium prices, feed deliveries to domestic and foreign enrichment suppliers, uranium inventories, and secondary market transactions and additional information on domestic uranium marketing activities are provided in this chapter.

Figure 10. Uranium Marketing Activity During 1994



Domestic Purchases by U.S. Utilities

Deliveries of uranium from suppliers to U.S. utilities in 1994 totaled 22.7 million pounds U_3O_8e, 7.4 million pounds more than the expected deliveries for contracts in place at the end of 1993 (Table 21). Projected cumulative deliveries reported for the forward 5-year period 1995 through 1999 increased by 17.7 million pounds U_3O_8e from year-end 1993 to year-end 1994, a 51-percent increase. Firm deliveries increased by 14.8 million pounds U_3O_8e (56 percent) for the 5-year period. Uranium delivery of firm and optional commitments to utilities for 1994 through 2000 and later are displayed in Figure 11.

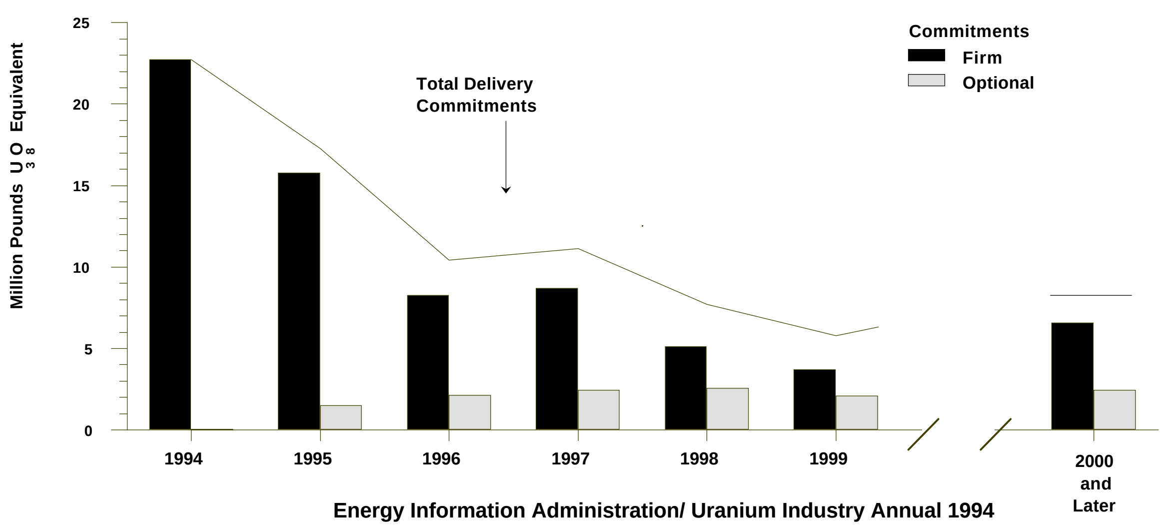
In 1994, 8.8 million pounds U_3O_8e were delivered to utilities under 33 new domestic purchase contracts. In total, utilities signed 58 new purchase contracts. The remaining are foreign purchase contracts with deliveries in 1994 or new purchase contracts with deliveries that started after 1994.

Table 21. Commitments for Delivery of Uranium from Suppliers to U.S. Utilities for Domestic Purchases, 1994-2000 and Later
(Million Pounds U_30_8 Equivalent)

	As of December 31, 1993				As of December 31, 1994				Change in Total from December 31, 1993, to December 31, 1994	
Year of Delivery	Firm	Optional	Total	Cumulative	Firm	Optional	Total	Cumulative	Total	Cumulative
1994	13.8	1.6	15.4	15.4	22.7	0	22.7	22.7	7.4	7.4
1995	10.8	1.9	12.7	28.1	15.8	1.5	17.3	40.0	4.6	11.9
1996	5.8	1.5	7.4	35.4	8.3	2.2	10.4	50.4	3.1	15.0
1997	5.7	1.6	7.3	42.7	8.7	2.4	11.1	61.6	3.9	18.9
1998	2.7	1.7	4.4	47.1	5.1	2.6	7.7	69.3	3.3	22.2
1999	1.7	1.1	2.9	50.0	3.7	2.1	5.8	75.1	2.9	25.1
2000 and Later	4.3	0.8	5.1	55.1	6.6	2.5	9.0	84.1	3.9	29.0
Total	**44.8**	**10.3**	**55.1**	**--**	**70.9**	**13.2**	**84.1**	**--**	**--**	**--**

-- = Not applicable.
Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Figure 11. Commitments for Delivery of Uranium from Suppliers to U.S. Utilities for Domestic Purchases, 1994-2000 and Later, as of December 31, 1994



Note: The data plotted for "2000 and Later" include more than 1 year.
Source: Energy Information Administration, Form EIA-858 "Uranium Industry Annual Survey" (1994).

Of the uranium delivered to U.S. utilities under domestic purchases in 1994, 7.7 million pounds were of U.S. origin and 15.0 million pounds were purchases by suppliers from foreign sources and resold to utilities (Table 22). The top five countries of origin for the 15.0 million pounds U_30_8e of foreign uranium are: Canada (4.6 million pounds); Uzbekistan (3.2 million pounds); China (1.6 million pounds); Australia (1.3 million pounds); and South Africa (1.1 million pounds).

Domestic Purchase Pricing Mechanisms

Three types of pricing mechanisms are recognized: contract specified, market related, and "other." In contract specified procurements, prices and the associated escalation factors (if any) are specified when the contract is signed (11.2 million pounds of U_3O_8e were delivered under this type of contract in 1994, or 49 percent of total deliveries). In market related contracts, the prices are commonly (but not always) determined at or some time before delivery and are based on market prices prevailing at that time. Some of these contracts are related to spot-market prices. Other market-related contracts contain floor (minimum) prices that provide a lower limit on the eventual price. A base floor price and the means of escalation may be specified when the contract is signed (8.4 million pounds U_3O_8 were delivered under this type of contract in 1994, or 37 percent of total deliveries). "Other" pricing mechanisms refer to ones that either fall outside or are a combination of contract specified and market related pricing mechanisms (3.1 million pounds of U_3O_8e, or 14 percent of total deliveries).

For 1994 deliveries under contract specified pricing, 9.2 million pounds U_3O_8 (82 percent) had a fixed price; and 2.0 million pounds (18 percent) had a base price with escalation (Table 23). For all contract specified pricing in place as of December 31, 1994, 51 percent of the quantity to be delivered in all years had a fixed price and the remaining 49 percent were base-price escalated.

For 1994 deliveries under market related pricing, 0.6 million pounds U_3O_8e (7 percent) had a floor price; 7.1 million pounds (84 percent) had no floor as associated with the market price; and 0.7 million pounds U_30_8e (9 percent) had a spot market price (Table 24). For all market related pricing in place as of December 31, 1994, 88 percent of the total quantity to be delivered in all years had a no floor price.

Table 22. Origin of Uranium Committed for Delivery to U.S. Utilities from Suppliers under Domestic Purchases, 1994-2000 and Later, as of December 31, 1994
(Million Pounds U_30_8 Equivalent)

Year of Delivery	Origin of Committed Uranium			Total
	Domestic	Unspecified	Foreign[a]	
1994 [b]	7.7	0	15.0	22.7
1995	1.7	14.7	0.9	17.3
1996	1.1	9.3	0.0	10.4
1997	1.0	9.6	0.5	11.1
1998	0.8	6.3	0.6	7.7
1999	0.6	4.6	0.6	5.8
2000 and Later	1.2	6.0	1.8	9.0

Total	**14.3**	**50.4**	**19.4**	**84.1**

[a]Includes U.S. utility, supplier, and trader/broker purchases reported on Form EIA-858 as imports of foreign-origin uranium materials into the United States. Uranium materials reported as imports under loan and exchange transactions are excluded.
[b]Actual deliveries.
Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 23. Commitments of Uranium under Domestic Purchase-Contracts to U.S. Utilities by Contract-Specified Pricing Mechanisms, 1994-2000 and Later, as of December 31, 1994

Year of Delivery	Fixed Price		Base-Priced Escalated		Annual Total
	Million Pounds U_30_8e	Percent of Annual Total	Million Pounds U_30_8e	Percent of Annual Total	(million pounds U_30_8e)
1994[a]	9.2	82.4	2.0	17.6	11.2
1995	5.2	58.8	3.6	41.2	8.8
1996	1.2	29.2	3.0	70.8	4.3
1997	1.2	18.6	5.3	81.4	6.5
1998	1.1	32.1	2.2	67.9	3.3
1999	0.8	33.0	1.7	67.0	2.5
2000 and Later	2.4	49.5	2.5	50.5	4.9
Total	**21.2**	**51.1**	**20.3**	**48.9**	**41.4**

[a]Actual deliveries.
Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data. Quantities of uranium are U_3O_8 equivalent (U_3O_8e).
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 24. Commitments of Uranium under Domestic-Purchase Contracts to U.S. Utilities by Market-Related Pricing Mechanisms, 1994-2000 and Later, as of December 31, 1994

Year of Delivery	Spot Market Price		Floor Price[a]		No Floor Price[b]		Annual Total
	Million Pounds U_3O_8e	Percent of Annual Total	Million Pounds U_3O_8e	Percent of Annual Total	Million Pounds U_3O_8e	Percent of Annual Total	(million pounds U_3O_8e)
1994[c]	0.7	8.5	0.6	7.2	7.1	84.3	8.4
1995	0.1	1.2	0.7	12.6	4.9	86.2	5.6
1996	0	0	0.6	14.9	3.2	85.1	3.8
1997	0	0	0.2	8.8	1.7	91.2	1.8
1998	0	0	0.1	5.5	1.7	94.5	1.8
1999	0	0	0	0	1.2	100.0	1.2
2000 and Later	0	0	0	0	1.6	100.0	1.6
Total	**0.8**	**3.2**	**2.1**	**8.8**	**21.4**	**88.0**	**24.4**

[a]Refers to contracts with a specific floor price.
[b]Refers to contracts with no floor price provision.
[c]Actual deliveries.
Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data. Quantities of uranium are U_3O_8 equivalent (U_3O_8e).
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Prices of Domestic Purchases by Utilities

The quantity-weighted average price of 22.7 million pounds U_3O_8e delivered by domestic suppliers to utilities in 1994 was $10.30 per pound. The average price for deliveries in 1994 under domestic purchases with contract specified prices was $10.68 per pound U_3O_8e, down 29 percent from the average of $14.96 reported for 1993 (Table 25).

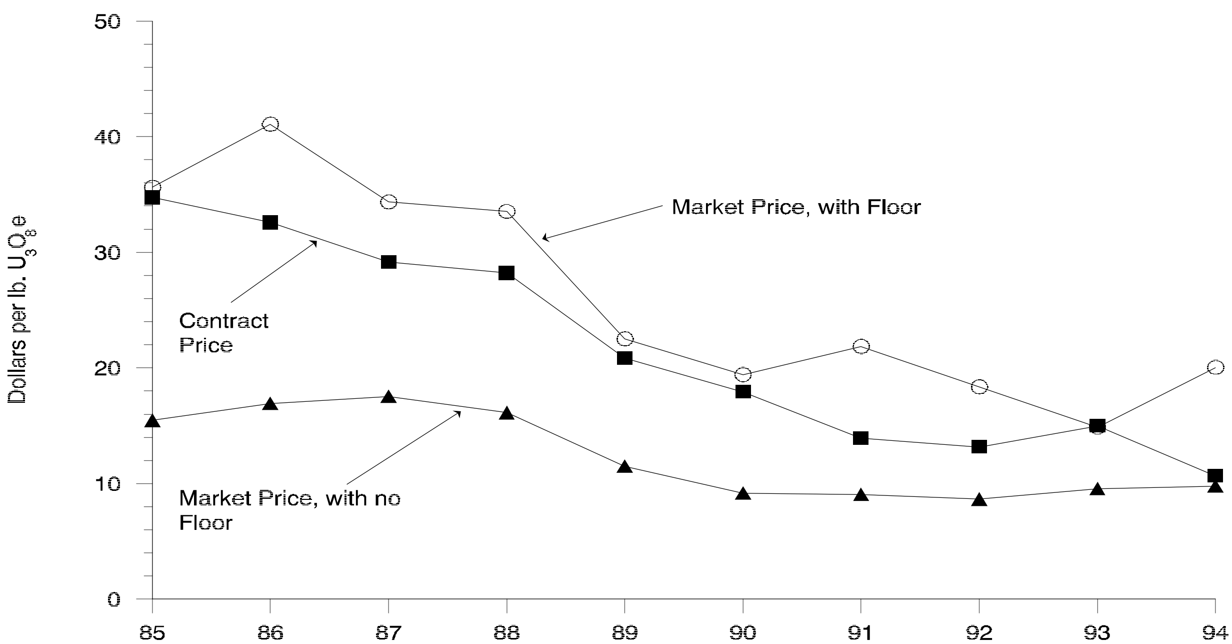
The average price for deliveries in 1994 under market related pricing declined 4 percent from $11.03 in 1993 to $10.57 in 1994. Prices for market related pricing with a floor price rose 35 percent from $14.87 in 1993 to $20.03 in 1994, while the average for no floor price rose 2 percent from $9.57 in 1993 to $9.76 in 1994. The average price for 1994 deliveries under both contact specified and market related pricing (excluding spot market and other pricing mechanisms) was $10.63 per pound U_3O_8e, a 19-percent decrease compared with the 1993 average price of $13.14 per pound.

Table 25. Average of Prices Paid for Domestic Purchases by U.S. Utilities from Suppliers, 1985-1994
(Dollars per Pound U_3O_8 Equivalent, Million Pounds U_3O_8 Equivalent)

Contract Type	Year of Delivery									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Contract-Specified Price										
Average Price	34.74	32.58	29.16	28.20	20.87	17.94	13.94	13.16	14.96	10.68
Quantity with Reported Price	8.9	6.1	10.1	7.4	9.6	12.0	17.3	13.2	8.3	11.2
Market-Related Price										
No Floor										
Average Price	15.46	16.93	17.53	16.12	11.48	9.18	9.04	8.65	9.57	9.76
Quantity with Reported Price	2.9	3.4	2.7	2.3	1.9	5.1	3.5	3.9	5.7	7.1
Floor										
Average Price	35.62	41.06	34.34	33.52	22.50	19.40	21.84	18.35	14.87	20.03
Quantity with Reported Price	4.0	2.6	1.3	1.1	1.1	1.6	1.3	4.6	1.5	0.6
Total Market Related										
Average Price	27.15	27.39	22.85	21.59	15.42	11.65	12.62	13.89	11.03	10.57
Quantity with Reported Price	6.9	6.0	4.0	3.4	3.0	6.7	4.8	8.5	7.2	7.7
Total Contract Specified & Market Related										
Average Price	31.43	30.01	27.37	26.15	19.56	15.70	13.66	13.45	13.14	10.63
Quantity with Reported Price	15.8	12.1	14.1	10.8	12.6	18.7	22.1	21.8	15.5	18.8

Notes: Prices shown are quantity-weighted averages per pound U_3O_8 equivalent in nominal U.S. dollars.
Sources: Energy Information Administration: **1985-1993**—*Uranium Industry Annual 1993* (September 1994); **1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994).

Figure 12. Average of Prices Paid for Domestic Purchases by U.S. Utilities from Suppliers, 1985-1994



Sources: Energy Information Administration: **1985-1993**— *Uranium Industry Annual 1993* (September 1994); **1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994).

Uranium Imports and Exports

Imports include utility, supplier, and trader/broker foreign purchases reported as imports of foreign-origin uranium materials into the United States. Uranium materials reported as imports under loan and exchange transactions, custody/storage arrangements, and the delivery of foreign material for enrichment that is subsequently exported are also included in the "Other" category. U.S. utilities and suppliers imported 36.6 million pounds of uranium under foreign purchase contracts in 1994, 75 percent more than the 21.0 million pounds of like imports in 1993 (Table 26). Almost all of this imported material came from Australia, Canada, China, France, Gabon, Germany, Kazakhstan, Kyrgyzstan, Namibia, Russia, South Africa, Tajikstan, Ukraine, United Kingdom, and Uzbekistan in 1994. From 1985 through 1994, U.S. companies imported a cumulative total of 190.1 million pounds U_3O_8e under purchase contracts. As of December 31, 1994, import-purchase contracts were in place for an additional 124.8 million pounds to be delivered from 1995 through 2000 and later.

Top Five Origin Countries	U_3O_8e (million pounds)
Canada	11.7
Uzbekistan	8.0
Kazakhstan	4.0
Australia	3.5
Kyrgyzstan	2.6

Export sales of uranium by suppliers to foreign countries (some were Canada, France, Germany, Japan, South Korea, United Kingdom) in 1994 totaled 18.0 million pounds, up from the 3.0 million pounds reported for 1993. A majority of these foreign sales in 1994 occurred

Table 26. Deliveries and Commitments of Uranium Imports and Exports by Transaction Type, 1985 to 2000 and Later
(Million Pounds U_3O_8 Equivalent)

Year of Delivery	Imports by Transaction Type[a]					Exports by Transaction Type[a]				
	Purchases	Loans	Exchanges	Other	Total	Sales	Loans	Exchanges	Other	Total
Actual Deliveries										
1985	11.7	0	0	NA	11.7	5.3	0	0	NA	5.3
1986	13.5	0	0.9	NA	14.4	1.6	0	0	NA	1.6
1987	15.1	0.8	0	NA	15.9	1.0	0	0	NA	1.0
1988	15.8	0	1.2	NA	17.0	3.3	0	1.0	NA	4.3
1989	13.1	0.3	0.3	NA	13.7	2.1	0	0.4	NA	2.5
1990	23.7	0.1	2.8	NA	26.6	2.0	0.4	0	NA	2.4
1991	16.3	5.7	1.1	NA	23.1	3.5	0	0	NA	3.5
1992	23.3	2.4	0.8	18.8	45.4	2.8	0	0	18.1	20.9
1993	21.0	W	W	19.6	41.9	3.0	W	W	W	21.3
1994	36.6	W	3.1	W	57.6	18.0	W	2.4	W	46.9
Commitments										
1995	26.0	0	W	W	35.4	8.5	W	W	W	17.6
1996	21.9	0	0	0	21.9	5.4	0	0	0	5.4
1997	19.4	0	0	0	19.4	5.6	0	0	0	5.6
1998	18.0	0	0	0	18.0	4.3	0	0	0	4.3

1999	13.8	0	0	0	13.8	3.6	0	0	0	3.6
2000 and Later	25.8	0	0	0	25.8	8.1	0	0	0	8.1

[a]**1985-1991**—Does not include transactions involving the delivery of uranium materials imported for custody/storage siting, conversion, enrichment, and/or fuel fabrication at U.S. facilities and subsequently exported or uranium materials exported for conversion, fuel fabrication, and/or enrichment at foreign facilities.
1992-1993-"Other" imports include uranium shipped under transactions involving custody/storage siting, conversion, enrichment, and/or fuel fabrication at U.S. facilities. "Other" exports include uranium shipped from conversion, enrichment, and/or fuel fabrication facilities in the United States.

W = Withheld to avoid disclosure of individual company data. NA = Not available. Note: Totals may not equal sum of components because of independent rounding.

Sources: Energy Information Administration: **1985-1993**—*Uranium Industry Annual 1993* (September 1994); **1994**— Form EIA-858, "Uranium Industry Annual Survey" (1994).

after the uranium entered the U.S. market under foreign purchases (imports) of 36.6 million pounds in 1994. Foreign sales (exports) contracts were in place for an additional 35.4 million pounds from 1995 through 2000 and later.

U.S. utilities accounted for 15.5 million pounds U_3O_8e, or roughly 42 percent of the deliveries in 1994 under foreign purchase contracts. For years beyond 1994, utility commitments represent 80 percent of the total quantity under foreign purchase contracts from suppliers (Table 27). Of the 1994 uranium import deliveries under contract specified prices (2.5 million pounds U_3O_8e), 45 percent had a fixed price and the remaining 55 percent had a base price escalated contract (Table 28). For deliveries with market-related prices (12.2 million pounds U_3O_8e), 68 percent was delivered under no floor price contracts, and 32 percent of these contracts included a floor price (Table 29).

For years beyond 1994, most of the uranium for which U.S. utilities have current foreign purchase commitments will be delivered under market related prices, and roughly one-half of the total committed quantity under this type of contract is attributable to contracts which specify a floor price.

Similar data on contracts for imports by suppliers are not presented because the number of contracts is insufficient to avoid disclosure of individual company data.

Table 27. Commitments for Delivery of Uranium Imports to U.S. Utilities and Suppliers Under Foreign Purchases, 1994-2000 and Later, as of December 31, 1994
(Million Pounds U_3O_8 Equivalent)

Year of Delivery	Imports by Utilities[a]				Imports by Suppliers[a]				Combined Imports[a]			
	Firm	Optional	Total	Cumulative	Firm	Optional	Total	Cumulative	Firm	Optional	Total	Cumulative
1994	15.5	0	15.5	15.5	21.1	0	21.1	21.1	36.6	0.	36.6	36.6
1995	16.0	2.6	18.6	34.1	6.8	0.6	7.4	28.5	22.8	3.2	26.0	62.6
1996	13.5	4.7	18.2	52.3	3.1	0.6	3.7	32.2	16.6	5.3	21.9	84.5
1997	11.4	4.5	15.9	68.2	2.9	0.5	3.5	35.7	14.4	5.0	19.4	103.9
1998	10.2	4.7	14.9	83.1	2.3	0.7	3.1	38.7	12.6	5.4	18.0	121.9
1999	7.4	4.1	11.5	94.6	1.8	0.5	2.3	41.1	9.1	4.7	13.8	135.7
2000 and Later	11.8	8.8	20.6	115.2	0.8	4.4	5.2	46.2	12.6	13.1	25.8	161.4

Total	**85.9**	**29.4**	**115.2**	**--**	**38.3**	**7.4**	**46.2**	**--**	**124.7**	**36.7**	**161.4**	**--**

[a]For 1994, includes U.S. utility, supplier, and trader/broker purchases reported as imports of foreign-origin uranium materials into the United States. Uranium materials reported as imports under loan and exchange transactions are excluded. For "1995-2000 and Later," the figure shown equals the amount of import commitments in each year under purchase contracts by utilities, suppliers, and traders/brokers.

-- = Not applicable.

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

Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 28. Commitments of Uranium under Foreign Purchase-Contracts to U.S. Utilities by Contract-Specified Pricing Mechanisms, 1994-2000 and Later, as of December 31, 1994

Year of Delivery	Fixed Price		Base-Priced Escalated		Annual Total (million pounds U_3O_8e)
	Million Pounds U_3O_8e	Percent of Annual Total	Million Pounds U_3O_8e	Percent of Annual Total	
1994[a]	1.1	44.8	1.4	55.2	2.5
1995	0.7	25.9	2.1	74.1	2.8
1996	0	0	1.5	100.0	1.5
1997	0.4	14.0	2.6	86.0	3.0
1998	0.5	15.9	2.4	84.1	2.8
1999	0.5	25.2	1.6	74.8	2.1
2000 and Later	1.0	31.0	2.3	69.0	3.3
Total	**4.3**	**23.7**	**13.8**	**76.3**	**18.1**

[a]Actual deliveries.

Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data. Quantities of uranium are U_3O_8 equivalent (U_3O_8e).

Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 29. Commitments of Uranium under Foreign-Purchase Contracts to U.S. Utilities by Market-Related Pricing Mechanisms, 1994-2000 and Later, as of December 31, 1994

Year of Delivery	Spot Market Price		Floor Price[a]		No Floor Price[b]		Annual Total (million pounds U_3O_8e)
	Million Pounds U_3O_8e	Percent of Annual Total	Million Pounds U_3O_8e	Percent of Annual Total	Million Pounds U_3O_8e	Percent of Annual Total	
1994[c]	0	0.0	3.9	32.0	8.3	68.0	12.2
1995	0	0.0	5.4	44.4	6.8	55.6	12.2
1996	0.1	1.3	5.8	53.7	4.9	45.0	10.8
1997	0.1	1.9	3.2	43.8	4.0	54.3	7.4
1998	0.1	2.1	3.8	55.8	2.9	42.1	6.8
1999	0.1	2.7	3.1	59.4	2.0	38.0	5.2
2000 and Later	0.8	9.9	4.0	47.2	3.6	42.9	8.5
Total	**1.4**	**2.2**	**29.2**	**46.4**	**32.4**	**51.4**	**63.0**

[a]Refers to contracts with a specific floor price.

[b]Refers to contracts with no floor price provision.

[c]Actual deliveries.

Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data. Quantities of uranium are U_3O_8 equivalent (U_3O_8e).

Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Prices for Foreign Purchases of Uranium

The quantity-weighted average of prices paid by suppliers and U.S. utilities for deliveries of uranium under foreign purchase contracts in 1994 was $8.95 per pound U_3O_8e, down 15 percent from the $10.53 for deliveries in 1993 (Table 30). Foreign purchase contracts signed by U.S. utilities in 1994 resulted in deliveries of 2.0 million pounds during the same year, and the quantity-weighted average of the prices paid under these contracts was $9.47 per pound U_3O_8e.

Table 30. Average of Prices Paid for Uranium Delivered to U.S. Utilities and Suppliers under Foreign Purchases, 1985-1994
(Dollars per Pound U_3O_8 Equivalent, Million Pounds U_3O_8 Equivalent)

Item	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
Average Price	20.08	20.07	19.14	19.03	16.75	12.55	15.55	11.34	10.53	8.95	
Quantity with Reported Price . . .	10.7	12.8	12.9	15.2	13.1	23.5	15.9	22.4	21.0	36.6	
Total Quantity Delivered[a]	11.7	13.5	15.1	15.8	13.1	23.7	16.3	23.3	21.0	36.6	
Imports Delivered with Reported Prices (percent)	91	95	85	96	100		99	98	96	100	100

[a]The figure shown includes U.S. utility, supplier, and trader/broker purchases reported as imports of uranium materials into the United States. Uranium materials reported as imports under loan and exchange transactions are excluded.

Notes: Prices shown are quantity-weighted averages per pound U_3O_8 equivalent in nominal U.S. dollars. Material quantities are millions of pounds of U_3O_8 equivalent (U_3O_8e).

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Uranium Purchases by U.S. Utilities

In 1994, 39 U.S. utilities received 38.3 million pounds of U_3O_8e at a weighted average price of $10.40 per pound under purchase contracts. During the previous year, 37 utilities received 31.2 million pounds for $11.97 per pound. Price distributions for 1990 through 1994 show that prices varied from $7.08 to $44.60 per pound of U_3O_8e (Table 31). Of the 38.3 million pounds U_3O_8e delivered to U.S. utilities in 1994 at a weighted average price of $10.40 per pound, 7.7 million pounds (20 percent) were of U.S. origin at a price of $12.08 per pound (Table 32). Non-U.S. origin uranium accounted for 30.6 million pounds (80 percent) of the deliveries at $9.97 per pound. Some of this material was not imported during 1994, as it was already in the United States.

The amount of uranium concentrates delivered to U.S. utilities under all purchase contracts was 28.6 million pounds (Table 33). Deliveries of uranium hexafluoride was 7.1 million pounds, and enriched uranium was 2.6 million pounds.

Of the 38.3 million pounds delivered in 1994, spot contracts accounted for 8.5 million pounds at an average price of $9.01 per pound, short-term contracts 4.5 million pounds at $8.14 per pound, medium-term contracts 9.4 million pounds at $9.84 per pound, and long-term contacts were 15.8 million pounds at $12.13 per pound (Table 33). Some long-term contracts were signed in the 1970's.

Table 31. Price Distributions of Uranium Purchases by U.S. Utilities, 1990-1994

Distributions	1990		1991		1992		1993		1994	
	Quantity (million pounds U_3O_8e)	Average Price ($ per pound U_3O_8e)	Quantity (million pounds U_3O_8e)	Average Price ($ per pound U_3O_8e)	Quantity (million pounds U_3O_8e)	Average Price ($ per pound U_3O_8e)	Quantity (million pounds U_3O_8e)	Average Price ($ per pound U_3O_8e)	Quantity (million pounds U_3O_8e)	Average Price ($ per pound U_3O_8e)
Octile[a]:										
First	3.9	7.70	4.7	7.45	4.1	7.11	3.9	7.80	4.8	7.08
Second . . .	3.9	8.91	4.7	8.52	4.1	7.75	3.9	9.21	4.8	8.86
Third	3.9	9.13	4.7	8.93	4.1	7.98	3.9	9.67	4.8	9.13
Fourth	3.9	9.59	4.7	9.31	4.1	8.56	3.9	9.90	4.8	9.23
Fifth	3.9	10.21	4.7	10.12	4.1	9.75	3.9	9.99	4.8	9.35
Sixth	3.9	14.09	4.7	12.67	4.1	13.54	3.9	10.09	4.8	9.54
Seventh . .	3.9	20.72	4.7	18.66	4.1	18.90	3.9	13.81	4.8	10.89
Eighth	3.9	44.60	4.7	39.10	4.1	37.37	3.9	25.32	4.8	19.08
Total	**31.5**	**15.62**	**37.4**	**14.35**	**32.7**	**13.87**	**31.2**	**11.97**	**38.3**	**10.40**
Quartile[b]:										
First	7.1	8.66	5.7	8.27	7.3	7.58	11.5	9.29	12.0	8.51
Second . . .	7.6	10.09	7.3	9.25	6.5	8.94	6.4	9.85	9.9	9.35
Third	9.3	13.17	14.7	11.83	11.1	13.03	5.5	10.96	7.8	10.29
Fourth	7.5	30.87	9.8	25.43	7.8	25.05	7.8	18.41	8.6	14.31
Total[c]	**31.5**	**15.62**	**37.4**	**14.35**	**32.7**	**13.87**	**31.2**	**11.97**	**38.3**	**10.40**

[a] Octile distribution divides total pounds of uranium delivered (with a price) into eight distributions by price and provides the quantity-weighted average price for each distribution.

Table 32. U.S. Utility Purchases of Uranium and Enrichment Services by Origin, 1994

Origin Country	Deliveries: Uranium Purchases from Suppliers (million pounds U_3O_8 equivalent)	Average Price (dollars per pound U_3O_8 equivalent)	Enrichment Feed (million pounds U_3O_8 equivalent)	Separative Work Units (million SWU)
Australia	2.8	9.88	2.9	--
Brazil	W	--	W	--
Canada	14.6	10.49	14.9	--
China	1.7	9.56	1.4	0.2[a]
France	W	--	W	0.5[b]
Gabon	W	--	W	--
Germany	W	--	W	W[c]
Mongolia	W	--	W	--
Namibia	0.8	9.76	0.8	--
Netherlands	--	--	--	W[d]
NIS[e] Total	8.7	--	6.3	--
Kazakhstan	2.8	8.94	3.5	--
Kyrgyzstan	W	--	W	--
Russia	1.8	8.81	1.8	0.4[f]
Tajikistan	W	--	0	--
Ukraine	W	--	W	--
Uzbekistan	3.5	8.35	0.7	--
South Africa	1.1	9.64	1.2	0[g]
Spain	0	--	W	--
United Kingdom	W	--	W	W[h]
Non-United States	**30.6**	**9.97**	**29.1**	**1.7**
United States	**7.7**	**12.08**	**8.5**	**7.5**[i]
Total	**38.3**	**10.40**	**37.6**	**9.2**

[a] China Nuclear Energy Industry Corp. enrichment plant, Lanzhou Province, Peoples Republic of China.
[b] Eurodif enrichment plant, Georges Besse, France.
[c] Urenco enrichment plant, Gronau, Germany.
[d] Urenco enrichment plant, Almelo, Netherlands.
[e] NIS = Newly Independent States
[f] Techsnabexport (Tenex) enrichment plants located in Angarsk, Russia; Ekaterinburg, Russia; Krasnoyarsk, Russia; and Tomsk, Russia.
[g] Atomic Energy Corporation of South Africa, Ltd. enrichment plant, Valindaba, South Africa.
[h] Urenco enrichment plant, Capenhurst, United Kingdom.
[i] DOE/USEC enrichment plants, Paducah, Kentucky and Portsmouth, Ohio.

W = Withheld to avoid disclosure of individual company data. -- = Not applicable. Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Form EIA-858,“Uranium Industry Annual Survey” (1994).

Table 33. U.S. Utility Uranium Purchases by Contract Type and Material Type, 1994

Material Type	Spot Contract: Quantity (million pounds U_3O_8e)	Spot Contract: Average Price ($ per pound U_3O_8e)	Short-Term Contract: Quantity (million pounds U_3O_8e)	Short-Term Contract: Average Price ($ per pound U_3O_8e)	Medium-Term Contract: Quantity (million pounds U_3O_8e)	Medium-Term Contract: Average Price ($ per pound U_3O_8e)	Long-Term Contract: Quantity (million pounds U_3O_8e)	Long-Term Contract: Average Price ($ per pound U_3O_8e)	Total: Quantity (million pounds U_3O_8e)	Total: Average Price ($ per pound U_3O_8e)
U_3O_8	4.2	9.11	3.6	7.69	8.3	9.82	12.5	12.59	28.6	10.66

Natural UF_6 . .	1.7	8.80	1.0	9.80	1.2	10.00	3.3	10.35	7.1	9.85
Enriched UF_6	2.6	9.00	0.0	--	0	--	0.0	--	2.6	9.00
Total	**8.5**	**9.01**	**4.5**	**8.14**	**9.4**	**9.84**	**15.8**	**12.13**	**38.3**	**10.40**

-- = Not Applicable. Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

U.S. utilities signed 58 new purchase contracts in 1994. The quantity of uranium delivered in 1994 under 40 of the 58 new contracts was 10.7 million pounds U_3O_8e, with an average price of $8.81 per pound. The remaining 18 new purchase contracts begin deliveries to utilities after 1994.

Thirty-one new spot purchases accounted for 5.9 million pounds U_3O_8e in 1994 (Table 34). Projected firm deliveries reported for the 10-year period 1994-2003 total 46.0 million pounds U_3O_8e (Table 35).

Table 34. New Purchases Contracts Signed by U.S. Utilities in 1994 by Contract Type and Deliveries in 1994
(Million Pounds U_3O_8 Equivalent)

Purchase Contract Type	Deliveries (million pounds U_3O_8e)	Number of New Purchase Contracts
Spot	5.9	31
Short-term	W	2
Medium-term	W	3
Long-term	1.3	4
Total	**10.7**	**40**

W = Withheld to avoid disclosure of individual company data. Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858,"Uranium Industry Annual Survey" (1994).

Table 35. Commitments under New U.S. Utility Purchases Contracts Signed in 1994 by Delivery Year, 1994-2003
(Million Pounds U_3O_8 Equivalent)

Delivery Year	Firm	Optional	Total
1994[a]	10.7	0	10.7
1995	5.6	0.2	5.8
1996	4.7	0.8	5.5
1997	5.8	1.1	6.9
1998	5.7	1.1	6.8
1999	5.3	0.9	6.2
2000	4.3	0.7	5.0
2001	2.7	0.7	3.4
2002	1.1	0.4	1.5
2003	0	0	0
Total	**46.0**	**5.9**	**51.8**

[a]Actual deliveries.
Source: Energy Information Administration, Form EIA-858,"Uranium Industry Annual Survey" (1994).

Deliveries to Enrichment Suppliers

In 1994, U.S. utilities delivered 37.6 million pounds of uranium feed to enrichment suppliers (Tables 32 and 36). Of the 37.6 million pounds of uranium feed, 33.5 million pounds were delivered to the United States Enrichment Corporation (USEC) enrichment plants (8.5 million pounds of U.S. origin material and 25.0 million pounds of foreign-origin material). A total of 4.1 million pounds of uranium feed was delivered to foreign enrichment plants in 1994. Enrichment feed deliveries for U.S. enrichment as a percentage of total deliveries was 89 percent in 1994. In 1994, 9.2 million separative work units (SWU) were purchased by U.S. utilities under enrichment service contracts (82 percent from U.S. enrichment and 18 percent from foreign enrichment) (Table 32). Projected feed deliveries for 1995 through 2003 decreased by 15.6 million pounds from those reported in the 1993 survey (Table 37).

Table 36. Deliveries of Uranium Feed by U.S. Utilities to Enrichment Suppliers, 1994
(Million Pounds U_3O_8 Equivalent)

Enrichment Supplier	Domestic Uranium	Foreign Uranium	Total
Domestic (DOE/USEC) Enrichment Plants	8.5	25.0	33.5
Foreign Enrichment Plants	0.1	4.1	4.1
Total	**8.5**	**29.1**	**37.6**

Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 37. Projected Shipments of Uranium by Utilities to Domestic and Foreign Enrichment Suppliers, 1995-2004
(Million Pounds U_3O_8 Equivalent)

Year of Shipment	Amount to be Shipped		Change from 1993 to 1994	
	As of December 31, 1993	As of December 31, 1994	Annual	Cumulative
1995	44.6	46.0	1.4	1.4
1996	44.5	47.4	2.9	4.3
1997	44.7	42.2	-2.6	1.7
1998	45.2	43.5	-1.7	0.0
1999	45.4	43.2	-2.2	-2.2
2000	40.8	40.9	0.1	-2.1
2001	43.3	38.0	-5.3	-7.4
2002	40.7	40.3	-0.4	-7.8
2003	43.4	35.5	-7.9	-15.6
2004	NR	36.0	--	--

NR = Not reported.
-- = Not applicable.
Sources: Energy Information Administration: **1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Uranium Inventories

Total commercial inventories decreased by 19.4 million pounds, from 105.7 million pounds U_3O_8e as of December 31, 1993, to 86.3 million pounds as of December 31, 1994 (Table 38). U.S. utility inventories decreased by 14.4 million pounds from 81.2 million pounds at the end of year 1993, to 66.7 million poundsat the end of 1994. The DOE and United States Enrichment Corp. (USEC) inventories of natural uranium increased from 52.4 million pounds U_3O_8e in 1993 to 53.8 million pounds in 1994 (Table 39). The amount of enriched uranium held in inventory by the DOE and USEC decreased from 26.9 million pounds to 20.5 million pounds.

Table 38. Commercial Uranium Inventories at End of Year, 1990-1994
(Million Pounds U_3O_8 Equivalent)

Type of Uranium Inventory	U.S. Utilities					All U.S. Companies				
	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994
U_3O_8										
Domestic-Origin	17.0	13.8	12.6	10.0	8.2	33.6	27.7	24.4	R22.1	16.1
Foreign-Origin	8.9	11.0	13.4	R15.9	13.2	12.1	13.4	19.9	R20.2	17.6
Total	**25.9**	**24.9**	**26.0**	**R26.0**	**21.4**	**45.7**	**41.1**	**44.3**	**R42.3**	**33.7**
Natural UF_6[a]										
Domestic-Origin	6.1	1.8	1.5	1.5	0.9	6.4	2.2	2.0	R2.2	1.6
Foreign-Origin	2.2	1.9	4.0	R3.3	2.1	2.4	2.0	4.2	4.0	2.4
Total	**8.3**	**3.7**	**5.5**	**R4.8**	**3.1**	**8.8**	**4.2**	**6.2**	**R6.1**	**3.9**
Natural UF_6 under Usage Agreements										
Domestic-Origin	22.6	25.2	18.0	R12.1	7.4	23.9	25.5	18.1	R12.4	7.4
Foreign-Origin	4.7	7.9	8.9	R9.6	3.8	5.1	7.9	8.9	R9.8	4.1
Total	**27.3**	**33.2**	**26.9**	**R21.7**	**11.2**	**29.0**	**33.5**	**27.0**	**R22.2**	**11.6**
Natural UF_6 at Enrichers[b]										
Domestic-Origin	7.4	3.3	1.9	1.0	2.3	7.4	5.0	1.9	1.5	2.5
Foreign-Origin	3.3	5.8	6.3	4.4	4.5	3.3	5.8	6.3	5.0	6.3
Total	**10.7**	**9.1**	**8.2**	**5.4**	**6.9**	**10.7**	**10.7**	**8.2**	**6.5**	**8.8**
Enriched UF_6 at Enrichers										
Domestic-Origin	NR	1.3	1.6	1.6	1.7	NR	1.3	1.6	1.6	1.7
Foreign-Origin	NR	1.0	0.9	0.7	0.2	NR	1.0	0.9	R2.4	0.2
Total	**--**	**2.3**	**2.5**	**2.3**	**1.9**	**--**	**2.3**	**2.5**	**R4.0**	**1.9**
Enriched UF_6										
Domestic-Origin	6.4	4.2	3.2	R2.2	1.5	7.5	5.0	4.4	R3.4	2.7
Foreign-Origin	4.0	4.6	5.8	R6.2	6.6	7.3	5.9	10.7	R8.5	9.4
Total	**10.4**	**8.8**	**9.0**	**R8.3**	**8.1**	**14.8**	**10.8**	**15.1**	**R11.9**	**12.1**
Fabricated Fuel (Enriched UF_6)										
Domestic-Origin	12.3	7.6	8.4	R6.8	4.4	12.3	7.6	8.4	R6.8	4.4
Foreign-Origin	7.7	8.4	5.6	R5.8	9.9	7.7	8.4	5.6	5.1	9.9
Total	**20.0**	**16.0**	**14.0**	**R12.7**	**14.2**	**20.0**	**16.0**	**4.0**	**R12.8**	**14.2**
Total Inventories										
Domestic-Origin	71.8	57.3	47.1	R35.1	26.4	91.1	74.4	60.7	R49.9	36.3
Foreign-Origin	30.9	40.6	45.0	R46.1	40.4	38.0	44.3	56.6	R55.8	49.9

Total	**102.7**	**98.0**	**92.1**	**R81.2**	**66.7**	**129.1**	**118.7**	**117.3**	**R105.7**	**86.3**

[a]UF_6 = Uranium hexafluoride.
[b]Includes both natural and enriched uranium for 1990. Beginning in 1992, natural UF_6 and enriched UF_6 at enrichment suppliers were reported separately.
R = Revised data. NR = Not reported. Note: Totals may not equal sum of components because of independent rounding.
Sources: Energy Information Administration: **1990-1992—***Uranium Industry Annual 1993* (September 1994); **1993-1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table 39. Commercial and U.S. Government Inventories of Natural and Enriched Uranium as of End of Year, 1990-1994
(Million Pounds U_3O_8 Equivalent)

Type of Uranium Inventory	Inventories at the End of the Year				
	1990	1991	1992	1993	1994
Utility Stocks					
Natural Uranium	61.5	70.9	66.5	R57.9	42.5
Enriched Uranium[a]	41.2	27.1	25.5	R23.3	24.2
Domestic Supplier Stocks					
Natural Uranium	22.0	18.7	19.1	R19.1	15.5
Enriched Uranium[a]	4.4	2.0	6.1	R5.4	4.0
Total Commercial Stocks	129.1	118.7	117.3	R105.7	86.3
DOE-Owned and USEC-Held Stocks[b]					
Natural Uranium	59.8	46.8	45.8	R52.4	53.8
Enriched Uranium	32.8	36.7	23.1	26.9	20.5

[a]Includes amounts reported as inventories of UF_6 at Enrichment Suppliers.
[b]Includes amounts reported as inventories by U.S. Department of Energy (DOE) and the United States Enrichment Corporation (USEC) for 1993 and 1994.
R = Revised data.
Note: Totals may not equal sum of components because of independent rounding.
Sources: Energy Information Administration: **1990-1992**—*Uranium Industry Annual 1993* (September 1994); **1993-1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994). **1990-1994, DOE-Owned and USEC-Held Stocks—**Office of Uranium Programs (NE-30), U.S. Department of Energy, and the United States Enrichment Corporation (USEC).

Uranium Used in Fuel Assemblies

The total amount of new uranium fuel loaded into U.S. nuclear reactors during 1994 was 39.0 million pounds U_3O_8e, as reported by utilities and reactor operators. This was 7.9 million pounds U_3O_8e less than in 1993. These quantities do not include any fuel assemblies removed from reactors and later reloaded.

Secondary Market Activities

Secondary market transactions include sales, exchanges, and loans of uranium other than direct sales by suppliers to U.S. utilities or direct imports by U.S. utilities. For 1994, utility exchanges and net loans of uranium with suppliers totaled 8.5 million pounds U_3O_8e. Utility sales to suppliers totaled 5.1 million pounds. Intersupplier transactions totaled 28.1 million pounds U_3O_8e in 1994. Intersupplier sales were 17.9 million pounds; exchanges were 7.2 million pounds; and loans were 3.0 million pounds.

Anticipated Uranium Market Requirements of U.S. Utilities

Unfilled Uranium Requirements

Unfilled requirements are the additional natural uranium that utilities need to purchase after considering their total future enrichment feed delivery requirements, less inventory drawdowns and deliveries under existing procurement contracts. Unfilled requirements also include purchases necessary to maintain a desired level of inventory coverage.

Cumulative unfilled uranium requirements for reactors in operation or under construction for 1995 through 2004 are reported, as of the end of 1994 to be 296.2 million pounds U_3O_8e (Table 40). Unfilled requirements for the period 1995 through 2003 show a decrease, from 261.8 million pounds reported at the end of 1993, to 251.6 million pounds reported at the end of 1994.

Table 40. Unfilled Uranium Requirements of Utilities, 1995-2004
(Million Pounds U_3O_8 Equivalent)

Year	As of December 31, 1992		As of December 31, 1993		As of December 31, 1994		
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	
1995	8.8	8.8		6.5	6.5	2.8	2.8
1996	15.4	24.2	12.4	19.0	12.3	15.1	
1997	22.2	46.4	20.4	39.4	17.4	32.5	
1998	29.8	76.2	25.8	65.2	24.8	57.3	
1999	32.4	108.7	28.3	93.5	34.0	91.3	
2000	38.1	146.7	32.9	126.4	30.2	121.5	
2001	40.8	187.5	46.9	173.3	44.2	165.7	
2002	41.1	228.6	42.0	215.2	45.0	210.7	
2003	--	--	46.5	261.8	41.0	251.6	
2004	--	--	--	--	44.6	296.2	

Note: Totals may not equal sum of components because of independent rounding.
Sources: Energy Information Administration: **1992-1993**—*Uranium Industry Annual 1993* (September 1994); **1994**—"Uranium Industry Annual Survey" (1994).

Uranium Requirements

Data from various parts of this chapter are combined in Table 41 to produce an aggregate picture of selected aspects of U.S. uranium requirements. Anticipated market requirements are computed by summing the quantities of uranium under contract and unfilled requirements. Utility contracts for uranium include firm and optional domestic purchase commitments and imports.

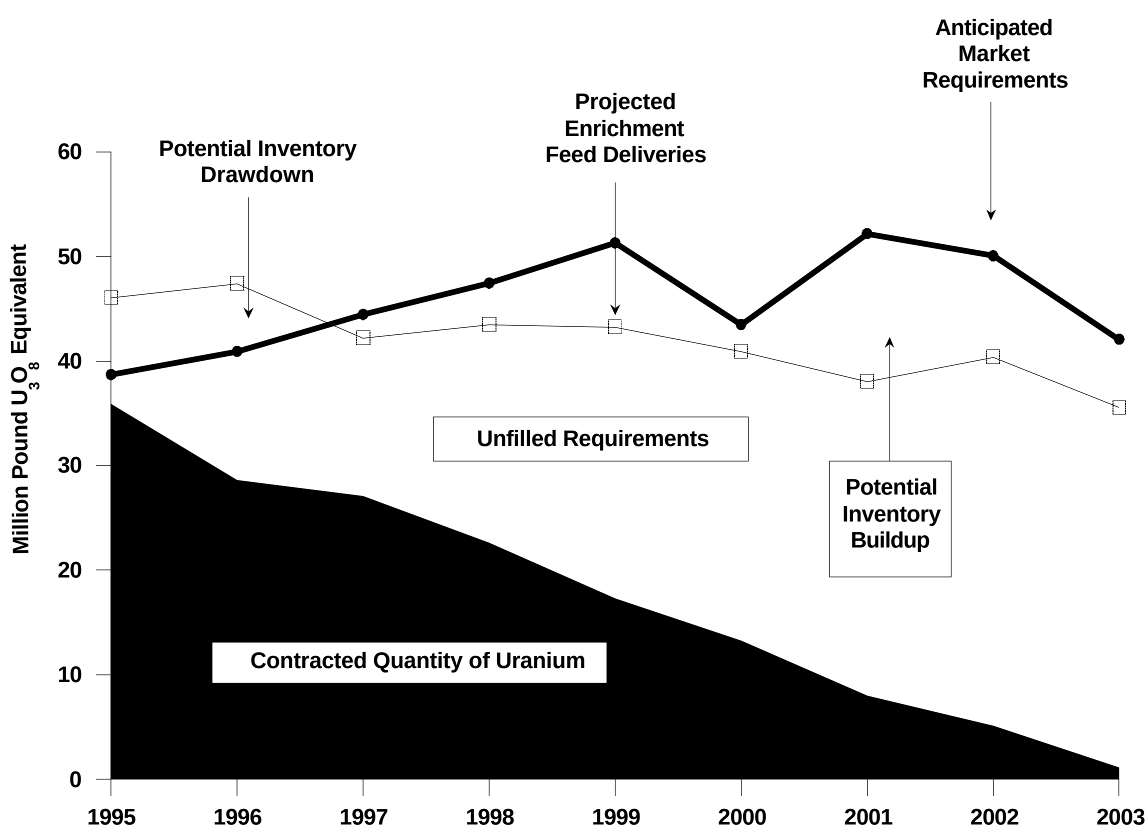
Unfilled requirements constitute a small portion of anticipated market requirements in 1995 (Figure 13). However, they increase to 52 percent of total anticipated requirements by 1998 and to 98 percent by 2003. For the years 1995 through 1996, utilities apparently plan to meet a portion of their enrichment feed deliveries by drawing down uranium inventories. For 1997 through 2003, the utilities' enrichment feed deliveries are less than their anticipated market requirements, indicating a period of uranium inventory build-up by the U.S. utilities.

Table 41. Anticipated Uranium Market Requirements of Utilities, 1995-2003, as of December 31, 1994
(Million Pounds U_3O_8 Equivalent)

Year of Delivery	Quantity of Uranium Under Contract	Unfilled Requirements	Anticipated Market Requirements	Projected Enrichment Feed Deliveries
1995	35.8	2.8	38.7	46.0
1996	28.6	12.3	40.9	47.4
1997	27.1	17.4	44.4	42.2
1998	22.6	24.8	47.4	43.5
1999	17.3	34.0	51.3	43.2
2000	13.2	30.2	43.5	40.9
2001	8.0	44.2	52.2	38.0
2002	5.1	45.0	50.0	40.3
2003	1.1	41.0	42.1	35.5

Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Figure 13. Anticipated Uranium Market Requirements of Utilities, 1995-2003, as of December 31, 1994



Appendix A

Survey Methodology

View of a modern in situ leach uranium processing facility and its nearby well field. In situ leaching, also called solution mining, involves the selective leaching of uranium from a naturally permeable rock (such as sandstone) by continuous injection and recovery of the leaching solution. A dilute chemical solution is pumped through an array of injections wells to dissolve the uranium from mineral grains that fill intergranular spaces in the host rock. The solution, when "pregnant" with dissolved uranium, is recovered through production wells and processed to precipitate the uranium. The barren leaching solution's chemical makeup is then adjusted to desired strength before it is reinjected to continue the leaching process. In the photo, the rows of "black" boxes are all-weather covers for well-head assembly hookups and indicate the regular, repeating pattern of wells in a typical well field.

Appendix A

Survey Methodology

Survey Design

The 11th comprehensive survey of the U.S. uranium industry was conducted in 1995 by the Energy Information Administration (EIA) using the "Uranium Industry Annual Survey," Form EIA-858. EIA collected data from all companies involved in the U.S. uranium industry, mailing the survey form to these firms in January 1995. The data reported in this publication were developed from the 1994 survey and predecessor databases.

EIA asked respondents to the "Uranium Industry Annual Survey" to provide data current to the end of 1994 about the following:

- **Uranium raw materials activities**, including: land holdings, exploration and development activities, uranium-bearing properties and resources, uranium mines, uranium processing facilities, and uranium industry employment in the raw materials sector

- **Uranium marketing activities**, including contracts, contract prices and delivery schedules, uranium inventories, enrichment feed deliveries, unfilled market requirements, uranium used in fuel assemblies, and purchases of enrichment services.

The data collected on Form EIA-858 are subject to various sources of error. These sources are: (1) coverage (the list of respondents might not be complete or, on the other hand, there might be double counting); (2) non-response (all units that are surveyed might not respond or not provide all the information requested); (3) respondents (respondents might commit errors in reporting the data); (4) processing (the data collection agency might omit or incorrectly transcribe a submission); (5) concept (the data collection elements might not measure the items they were intended to measure); and (6) adjustments (errors might be made in estimating values for missing data). Because the "Uranium Industry Annual Survey" is not a sample survey, the estimates shown in this report are not subject to sampling error.[1] Although it is not possible to present estimates of nonsampling error, precautionary steps were taken at each stage of the survey design to minimize the possible occurrence of these errors. The steps are described below, with the error they were designed to minimize shown in parenthesis.

Survey Universe and Frame (Coverage Errors)

The survey universe includes all companies involved in the U.S. uranium industry. The universe includes all firms meeting one or more of the following criteria: (1) are controllers or were controllers during any portion of 1994, or are identified in EIA records as the most recent controllers of uranium properties, mines, mills, or plant; (2) involved as controllers of uranium exploration and development ventures in the United States; (3) incurred uranium exploration expenditures in 1994 or plan such expenditures in 1995; (4) hold uranium reserves; (5) control uranium mining properties; (6) control commercial uranium extraction operations; and (7) purchase, sell, held, or own domestic- or foreign-origin uranium; offered uranium enrichment services; imported or exported uranium; and (utilities only) purchased uranium enrichment services from an enrichment supplier. (See Form EIA-858 in Appendix D for an explanation of these categories.)

The respondent list used for the Form EIA-858 survey was developed from a frame of all establishments known to meet the selection criteria. The frame of potential respondents was compiled from previous surveys and from information in the public domain. The frame was in-tended to cover the following: all utilities owning nuclearfueled generating stations; uranium converters, enrichers, and fuel fabricators; uranium traders and brokers; large and small companies actively engaged in exploration, development, or extraction in the U.S. uranium industry; and companies holding all large properties with uranium reserves. Companies meeting these criteria include: those involved in exploration, development, mining, milling, and trading of uranium; landowners; uranium converters, enrichers, and fabricators; and utilities with whole or partial ownership in operating or planned nuclear electric power plants.

Survey Procedures (Nonresponse)

The survey forms were sent via first class mail to ensure their receipt only by the proper respondent organization. If the U.S. Postal Service was unable to deliver the survey form, the corrected address was obtained where possible. In a few instances, businesses that had reported in earlier surveys were no longer operating. All known companies currently conducting business in the U.S. uranium industry were contacted during this survey.

Form EIA-858, "Uranium Industry Annual Survey," requests data about many areas of company operations. The scope of the questions is necessarily broad, and self-reporting of company-specific data is required.

Cooperation from industry on the 1994 survey was, as in previous years, excellent. About 28 percent of res-pondents replied to the form within the specified deadline. Those that had not responded by the due date (March 1st for Schedules A and B) were telephoned to encourage submission of the forms, and those calls resulted in the submission of most of the remaining forms. In addition, a followup letter was mailed to nonrespondents requesting compliance with the survey by March 31, 1995. Subsequently, telephone calls were made to obtain forms not yet submitted. In a few instances, company data were collected through telephone conversations, followed by submissions of the survey forms.

In order to reduce the burden to the respondents, every effort was made to identify the properties, mines, mills, plants, and long-term contracts that form the bulk of responses to the 1993 survey. Selected data elements for these items that were reported by industry companies on the previous year's forms were preprinted on the 1994 form.

Data Editing, Analysis, and Processing (Respondent and Processing Errors)

The survey forms are logged in and reviewed by agency personnel prior to data entry into the Uranium Industry Annual System, an automated database containing all current and historical data from each company's submissions. The database is maintained on the EIA computer facility in Washington, DC. After entry into the database, a copy of each part of the Form EIA-858 was distributed to the Analysis and Systems Division analyst responsible for that part. The submissions were checked for internal consistency, and the reported data were compared with previous collections of similar data. After reviewing these submissions, the analyst consulted with the reporting company, as needed, to resolve data problems and to confirm any corrections of the data.

Data areas that were reviewed and the corrections that were made differed from company to company. Most represented different interpretations of the data item definitions. No data in the database were changed without first consulting with the reporting company. Computer edits were also used to identify keypunch errors, out-of-range values, and unlikely data combinations. These also were either corrected to represent the data reported on the submissions or were changed only after confirming the corrected values by telephone conversations with company representatives. Data coding and entry errors were eliminated by proofing data after entry. All changes to reported data are documented.

Response Rates

For the 1994 Form EIA-858 survey, Schedule A, "Uranium Raw Materials Activities," was mailed to 61 firms and Schedule B, "Uranium Marketing Activities," was mailed to 91 firms. Response statistics are shown in Table A1. Overall, 87.5 percent of the schedules (A and B combined) that were returned to EIA contained the data as requested for the survey sections as applicable to individual firms. The remainder of the schedules were not applicable for the 1994 survey year.

Missing Data

Some omissions of data were identified during the prescreening and editing of the data. Most omitted data elements fell into two categories: particular data were unknown or inadvertent omissions. EIA contacted respondents to obtain omitted data or to verify that they

Table A1. Response Statistics for the 1994 Uranium Industry Annual Survey

Response Status	Schedule A	Schedule B
Survey Schedules Mailed Out	61	91
Data Provided	51	82
Reported as Not Applicable	10	9

Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

could not be reported. Only confirmed company-reported data are contained in the database and included in this report.

Data Revisions

The Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, has adopted the following policy for review and correction (revision) of data it collects and publishes. The policy covers revisions to prior published data. This new policy was initially implemented with the publication of the *Uranium Industry Annual 1992*.

1. Annual survey data are published either as *preliminary* or *final* when they first appear in a data report. Data released as *preliminary* will be identified as such. When necessary, preliminary data will be revised and declared to be *final* at the next publication of that data.

2. Monthly and quarterly survey data are published initially as *preliminary* data. They will be revised only after the completion of the data collection cycle for the full 12-month survey period. Revisions will not be made to monthly or quarterly data prior to this time.

3. The magnitude of historical data revisions experienced will be included in each data report to inform the reader about the accuracy of the data presented.

4. Revisions to data published as *final* will be made only in the event that newly available information would result in a change to published data of more than than 1 percent at the national level. Revisions for changes of lesser magnitudes will be made at the discretion of the Office Director.

All data, except for uranium inventory data, are published as final. Data on uranium inventories for the survey year are published as preliminary because survey respondents are requested to make changes to their prior year inventory data, if necessary, when reporting inventory data for the current survey year. These revised inventory data are indicated by an "R" in front of the revised table cell.

Changes to the prior year's total uranium inventory figures based on revisions reported on Form EIA-858 have been: for 1993, 1.2 million pounds U_3O_8e (1 percent); 1992, 0.1 million pounds U_3O_8e (<0.1); 1991,-1.3 million pounds U_3O_8e(-1.1);1990, -3.1 million pounds U_3O_8e (-2.3); 1989, 1.0 million pounds U_3O_8e (0.7); 1988, 0.1 million pounds U_3O_8e (<0.1); 1987, 0.3 million pounds U_3O_8e (0.2); and 1986, 0.4 million pounds U_3O_8e (0.2).

Nondisclosure of Data

To protect the confidentiality of individual respondents' data, a policy was implemented to ensure that the reporting of survey data in this publication would not associate those data with a particular company. This is in compliance with EIA Standard No. 88-05-06, "Nondisclosure of Company Identifiable Data in Aggregate Cells." In tables where the nonzero value of a cell is composed of data from fewer than three companies or if a single company dominates a table-cell value so that the publication of the value would lead to identification of a company's data, then the EIA classifies the cell value as "sensitive," and the cell value is withheld ("W") from publication. Within a table with a sensitive cell value, selected values in other cells of the table are also withheld, as necessary, so that the sensitive cell value cannot be computed using the values in published cells. A sensitive table-cell value can be reported, if each company whose data contribute to the sensitivity, gives permission to publish the value and if the company believes that publishing it would not harm the company's competitive position. This is the only exception to the application of EIA Standard No. 88-05-06 in this report.

Appendix B

Technical Notes

A wellhead assembly as used in a typical injection well in an in situ leaching uranium mining operation. The upper half of the wellhead's all-weather cover is removed to show the well hookup. The cup-shaped device on top of the assembly serves to bleed off air gases that might become entrained in the leaching solution during the normal cycle of injection/production pumping at the well field.

Appendix B

Technical Notes

History and Legal Authority

From August 1942 through 1946, the Manhattan Engineer District (MED), under the U.S. Army Corps of Engineers, was responsible for development of nuclear weapons.[1] In that role, it administered U.S. uranium procurement programs as well as its nuclear research and development, engineering, and production operations. The Atomic Energy Act, signed on August 1, 1946, established the Atomic Energy Commission (AEC). By Executive Order 9816, the Government-owned facilities and functions of the Manhattan Engineer District were transferred to the AEC at midnight December 31, 1946. The following is quoted from a 1982 DOE publication.[2]

> *Procurement of uranium concentrates by the AEC spanned the period from 1947 through 1970. During those years, in definable stages, the market for uranium concentrates changed from a monopsony with the Federal Government as the only buyer, to a completely commercial market with no Government purchases. From the viewpoint of the Government as a consumer, the foreseeable supply of uranium increased from desperately short of that which was required for defense needs, to adequate, to surplus. Procurement policies and contracting practices were adopted, implemented, and modified in response to the Government's changing needs and the perceived lack or adequacy of uranium supplies with which to meet them.*
>
> *The AEC procurement policies and practices were not dictated solely by its defense needs, however. The agency was also guided by provisions of the Atomic Energy Acts of 1946 and 1954, which were designed to foster development and utiliza-*

tion of atomic energy for peaceful purposes. Therefore, procurement policies also reflected concern for fostering and maintaining a producing uranium industry which would be able to supply the nation's expected uranium requirements for private nuclear power development.

The Atomic Energy Act of 1954 (Public Law 83-703) eased the Government's control over nonmilitary uses of atomic energy by making lawful the private development and ownership of reactors. The Act stipulated that the fuel to power privately owned reactors could be obtained only from the AEC through lease arrange- ments. By 1963, advances had taken place to further the commercial viability of nuclear power, and many interest groups contended that nuclear fuels should be allowed to compete with other fuels in the marketplace.

Legislation to permit private ownership of nuclear fuels was passed in 1964 in the form of the Private Ownership of Special Nuclear Materials Act (Public Law 88-489). This Act allowed the AEC to provide toll-paid enrichment services for privately owned uranium. It also authorized it to limit the offering of enrichment services for foreign-origin uranium owned by domestic custo- mers to the extent necessary to maintain a viable domes- tic uranium industry. The latter provision has been the authority upon which the AEC and successor agencies have monitored the status of the U.S. uranium industry.

Public Law No. 97-415, the Nuclear Regulatory Commission (NRC) Authorization Act of 1983 enacted on January 4, 1983, further strengthened the Federal Government's role in monitoring the status of the U.S. uran-ium industry. This law amended the Atomic Energy Act of 1954 by adding Section 170B, which required

[1]R.G. Hewlett and O.E. Anderson, Jr., "A History of the United States Atomic Energy Commission," *The New World, 1939-1946*, Volume 1 (University Park, Pennsylvania: The Pennsylvania State University Press, 1962), p. 82.

[2]U.S. Department of Energy, *Summary History of Domestic Uranium Procurement Under U.S. Atomic Energy Commission Contracts*, GJBX-220(82) (Grand Junction, Colorado, October 1982), pp. 3-4.

the Secretary of Energy to determine annually, for the years 1983 through 1992, the viability of the domestic uranium industry.

Determination of the uranium industry's viability requires a continuing review of the industry's status and prospects. Reports on domestic uranium raw materials and marketing activities have been published since 1968, first under the direction of the AEC, later by the Energy Research and Development Administration, then by the Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment in the U.S. Department of Energy (DOE), and more recently by the Energy Information Administration (EIA). The legal authority for Form EIA-858, "Uranium Industry Annual Survey," is stated on the form as follows:

> *Data on this mandatory survey are collected under authority of Section 170B of the Atomic Energy Act of 1954 as amended (42 U.S.C. 790a) and the Federal Energy Administration Act of 1974 (15 U.S.C. 2210b).*

On October 24, 1992, the Congress enacted the Energy Policy Act of 1992 (EPACT 1992), Public Law 102-486. This law provides under Subtitle B, 42 USC § 2296b-4, Sec. 1015, that:

> *. . . the owner or operator of any civilian nuclear power reactor shall report to the Secretary (of Energy), acting through the Administrator of the Energy Information Administration, for activities of the previous fiscal year—*
>
> *(1) the country of origin and the seller of any uranium or enriched uranium purchased or imported into the United States either directly or indirectly by such owner or operator; and*
>
> *(2) the country of origin and the seller of any enrichment services purchased by such owner or operator.*

The information is required to be made available to the Congress annually.

Uranium and the Uranium Industry: A Brief Description

Prior to 1942, uranium for domestic consumption was obtained from ores that were mined primarily for their associated radium and vanadium.[3] The radium was used in medical therapy; the vanadium was used primarily to improve the metallurgical properties of steel, cast iron, and other metals. The uranium was used in manufacturing glass and ceramics to produce yellow-to-brown colors; it was also used in making special alloys of steel, copper, and nickel.

Since passage of the Atomic Energy Act of 1954, uranium has been produced primarily as a fuel for nuclear reactors. Heat produced by the fissioning of ^{235}U in a reactor is used to generate steam, which is then used to generate electricity. One pound of natural uranium can produce as much energy as about 14,000 pounds of coal. Uranium is also used in the production of various radioactive isotopes for medical and other applications and for scientific research.

The average concentration of uranium in the earth's crust is approximately two parts per million. Uranium is more abundant than such "common" elements as mercury, silver, and gold. Many rocks contain minor quantities of uranium, and economically important quantities occur in naturally formed concentrations of minerals such as pitchblende, uraninite, coffinite, and carnotite. Pitchblende, which contains various uranium oxides, is the richest uranium ore mineral.

In the United States, most uranium deposits occur in sandstone host rocks. Significant deposits also occur in mineralized breccia in solution-collapse structures and as veins and fracture fillings in metamorphic and granitic rocks, and, to a lesser extent, in volcanic rocks which host lower-grade deposits. Uranium deposits in sandstones commonly consist of finely divided uranium mineral grains that fill pore spaces, and the uranium can replace some primary mineral grains and cementing materials of the host rock. Other metals associated with uranium in some deposits are vanadium, copper, selenium, molybdenum, beryllium, and chromium.

Exploration for uranium deposits can involve searching for near-surface deposits as well as deposits at depths of several thousand feet. A principal technique in uranium exploration involves the measurement of radioactivity in holes drilled to evaluate a prospective host rock. Systematic logging of boreholes with a variety of geophysical techniques, including gamma-ray, self-potential, resistivity, and other surveys, is a standard practice in uranium exploration. Modern exploration procedures also include detailed geological mapping, geochemical surveys, and analysis of borehole cuttings and cores in the field and laboratory. The principal States in which uranium-bearing ores have been mined, primarily for their uranium content, are Arizona, Colorado, Nebraska, New Mexico, South Dakota, Texas, Utah, Washington, and Wyoming. Both openpit and underground mining methods can be used to produce uranium ores from the ground; these methods are referred to as "conventional" mining. In addition, significant amounts of uranium concentrate are produced by "nonconventional" methods such as solution mining (in situ leaching), and recovery as a byproduct of phosphate, copper, and beryllium production.

At uranium mills, usually located near conventional mines, uranium is extracted from ores by chemical leaching to obtain uranium concentrate. The concentrate from mills, in situ leach plants (including slurry), and byproduct recovery is shipped to conversion facilities, where it is used in the production of uranium hexafluoride (UF_6).

Uranium hexafluoride is the feed material for the uranium enrichment process. Currently two types of enrichment processes are used commercially: gaseous diffusion and centrifuge. In the gaseous diffusion process used in the United States, gaseous UF_6 is passed through a series, or cascade, of porous membrane filters. The UF_6 contains the uranium isotopes ^{235}U (0.7 percent), which is naturally fissionable, and ^{238}U (99.3 percent), which is not naturally fissionable. In the filtering process, UF_6 molecules containing the ^{235}U isotope diffuse through the filters more readily than molecules containing the ^{238}U isotope. Repeated several times in series, the diffusion process eventually results in two product streams of UF_6. Compared with the original feed material, one product stream is relatively enriched in the isotope ^{235}U and the other is relatively depleted in ^{235}U.

In the enrichment process for commercial nuclear fuel, the concentration of ^{235}U is increased from the naturally occurring 0.7 percent to about 3.5 percent. Enrichment is necessary for uranium used as fuel in light-water reactors, because the amount of fissile ^{235}U in natural uranium is too low to sustain a nuclear chain reaction in those reactors. Uranium used as fuel for heavy-water reactors does not require enrichment.

At the fuel fabrication plant, the enriched UF_6 is converted to uranium dioxide (UO_2). The uranium dioxide is compressed into solid, cylinder-shaped pellets that are placed in hollow rods made of a zirconium stainless-steel alloy. These rods are grouped to form fuel-rod assemblies, which, in various configurations, are shipped to nuclear power plants for use as nuclear reactor fuel.

Estimation of Reserves and Potential Resources

This section discusses the methodologies used to estimate the U.S. uranium resources. Three classes of resources are estimated: Reserves, Estimated Additional Resources (EAR), and Speculative Resources (SR). EAR and SR categories have been updated using information provided by the U.S. Geological Survey.

A diagram showing a comparison of nomenclatural schemes used by the EIA and predecessor agencies for reporting estimates of U.S. uranium resources since 1974 is provided in Figure B1.

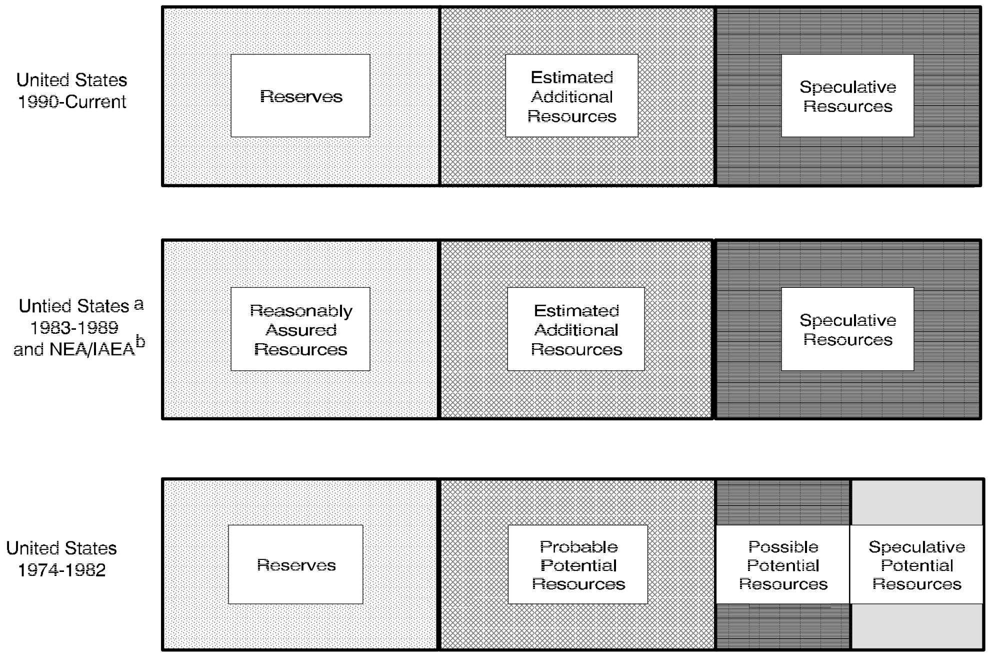
Appraisal of Potential Resources

The appraisal of the Nation's potential resources of uranium, which comprise the EAR and SR categories, is based on extensive data collected under the uranium procurement and resource appraisal programs of DOE, its predecessor agencies, and the USGS. These data include: analyses of company-supplied gamma-ray logs of drill holes; chemical assays of core samples; data from geochemical surveys of groundwater and stream water and sediment; aerial radiometric surveys; limited selective drilling to fill voids in subsurface information; and extensive geological studies of field areas throughout the United States.

An estimate of the uranium endowment is calculated for each geologically favorable setting delineated. The estimate is derived through evaluation and integration of data from field studies, as well as from mathematical and geological models of known uranium deposits (control areas). The uranium endowment, for a given geographical area under study, is an estimate of the quantity of all uranium-bearing material with a grade of at least 0.01 percent U_3O_8 postulated to occur in that setting. This estimate is made before any consideration is given to the economics of exploration and exploitation. It therefore includes undiscovered resources (EAR and SR), as well as associated additional material at or above the 0.01 percent cut-off grade within the area for which the estimate is made.

In the estimation of potential resources, economic factors for discovering, mining, and milling the undiscovered deposits in the favorable area are determined, and the costs are computed considering information about dep-posit location, depth, and other parameters. Computer-based models are used to determine operating costs for mining, hauling, milling, severance and ad valorem taxes, royalty, and capital costs for land acquisition, exploration, development, mining, and milling. All costs are forward costs: that is, costs that have not been incurred. The cost factors are used to calculate average and cut-off grades that are expected to be economic for the \$30-, \$50-, and \$100-per-pound U_3O_8 category in each favorable area. A grade-tonnage relationship, usually derived from the selected control area, is also needed to calculate economic potential resources. The grade-tonnage relationship is used to define a probability distribution for various grades, which in turn is used to develop a probability statement about the quantity of resources likely to meet or exceed the grade criteria.

Figure B1. Comparison of Historical and Current U.S. and NEA/IAEA Classification Nomenclatures for Uranium Resources



[a]This nomenclature was adopted in 1983 by the U.S. Department of Energy and was patterned after the Nuclear Energy Agency/International Atomic Energy Agency Standard.

The classifications shown for the United States prior to and after 1983 and the NEA/IAEA are not strictly comparable, because the criteria used in the individual systems are not identical. Precise correlations are not possible, particularly for the less assured resources. Nonetheless, based on the principal criterion of geological assurance of existence, this figure presents a reasonable approximation of uranium resources classification comparability.

[b]NEA/IAEA: Nuclear Energy Agency/International Atomic Energy Agency.

Note: The NEA/IAEA separates the Estimated Additional Resources (EAR) into Categories I and II based primarily on geological inference. Categories I and II of EAR are not utilized for estimates of resources in the United States.

Source: Prepared by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Estimates of Potential Uranium Resources, 1965 Through 1973

Prior to 1974, estimates of undiscovered uranium resources made by the DOE were assigned to a single resource class, potential uranium resources. The estimates were made for geologically favorable settings in the western United States, primarily in and adjacent to established uranium mining districts. The principles of geological analogy were used to compare geological characteristics favorable for the occurrence of uranium deposits between a “favorable” area and a similar area with known deposits. The methodology yielded point estimates that lacked associated probability distributions. The estimates of potential uranium resources made for 1965 through 1973 are shown in Table B1.

Potential Uranium Resources, 1974-1983

From January 1974 through September 1983, the AEC, the Energy Research and Development Administration (ERDA), and the DOE conducted the National Uranium Resource Evaluation (NURE) program to appraise the uranium resources (including uranium reserves) in favorable geological settings throughout the United States. Estimates of potential resources made during these years were reported for three resource classes to aid in describing the reliability of potential resources across the wide variety of geological environments investigated during the nationwide program. The three classes of resources used during the NURE program were Probable Potential, Possible Potential, and Speculative Potential Resources. The NURE program was terminated in 1983.

Support from the U.S. Geological Survey

In accordance with a Memorandum of Understanding signed in 1984 between EIA and the U.S. Geological Survey (USGS) of the Department of the Interior, the USGS provides support for the annual assessment of the Nation's uranium endowment and its undiscovered uranium resources. Through its ongoing geological programs, the USGS conducts studies of uranium districts and favorable geological environments in selected localities where, because of the availability of new scientific knowledge or industry-developed information relating to uranium resources, opportunities exist for updating the National uranium resource data base, the Uranium Resources Assessment Data (URAD) System, first developed under the NURE program. In this manner, the USGS is continuing the assessment of the Nation's uranium endowment and undiscovered uranium resources begun under the DOE's uranium resource appraisal program. The methodology used by

Table B1. Potential U.S. Uranium Resources at the End of the Year, 1965-1973
(Million Pounds U_3O_8)

Year	Forward-Cost Category			
	$8 per pound	$10 per pound	$15 per pound	$30 per pound
1965	(a)	650	1,050	1,330
1966	(b)	(b)	(b)	(b)
1967	490	700	1,140	2,000
1968	(b)	(b)	(b)	(b)
1969	770	1,200	1,920	3,200
1970	980	1,360	2,080	3,200
1971	920	1,300	2,000	3,200
1972	900	1,400	2,000	3,200
1973	900	1,400	2,000	3,200

[a]Not estimated at this forward cost.
[b]No estimates were made for the end of years 1966 and 1968.
Note: Potential resources at forward costs above $30 per pound U_3O_8 were not estimated prior to 1977.
Source: U.S. Department of Energy, Grand Junction Projects Office, *Statistical Data of the Uranium Industry* (January 1983).

the USGS to develop the U.S. uranium endowment estimates is described in USGS Circular 994 (1987).[4]

In 1989, the EIA's estimate of potential resources reported for the Colorado Plateau region incorporated for the first time values for uranium endowment supplied by the USGS for deposits associated with the solution-collapse, breccia-pipe environment common in the northern Arizona area. The USGS endowment estimates were used in the EIA cost model, along with endowment estimates for other localities to develop estimates of U.S. potential resources.

Uranium Endowment by Resource Region

The distribution of mean values of uranium endowment estimates provided by the USGS for U.S. resource regions for 1994 is shown in Table B2. The distribution of endowment values for all regions are unchanged from 1993 values. These endowment values represent the aggregate totals across all favorable localities within each region of the estimated uranium at a grade of 0.01 percent U_3O_8 and higher grades. Uranium resource regions are defined by geologic and physiographic characteristics and the regions are shown in Figure B2.

Potential Uranium Resources for 1994, EAR and SR

Annual estimates of U.S. potential uranium resources as EAR and SR are prepared from the uranium endowment data. These estimates consist of the portions of the endowment for over 700 favorable localities that could be recoverable at selected forward costs of production based on economic evaluation of anticipated operating and cap-

Table B2. U.S. Uranium Endowment by Resource Region, 1994
(Million Pounds U_3O_8)

Resource Region	Endowment Associated with Estimated Additional Resources[a]	Endowment Associated with Speculative Resources[a]
Colorado Plateau	3,950	2,430
Wyoming Basins	1,990	450
Coastal Plain	910	410
Northern Rockies	680	3,940
Colorado and Southern Rockies	320	360
Great Plains	310	950
Basin and Range	1,420	1,080
Central Lowlands	(b)	280
Appalachian Highlands	120	1,140
Other Regions[b]	50	120
Total	**9,750**	**11,160**

[a]Values shown are the mean values for the distribution of estimates for each forward-cost category, rounded to the nearest 10 million pounds U_3O_8.
[b]No uranium endowment in the Estimated Additional Resources category is estimated for this resource region.
[c]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.
Notes: Estimates of uranium that could be recovered as a byproduct of other commodities are not included. Totals may not equal sum of components because of independent rounding.
Sources: Estimates are based on uranium resources data developed under the DOE National Uranium Resources Evaluation (NURE) program using methodology described in *An Assessment Report on Uranium in the United States of America* (October 1980), in U.S. Department of Energy *Uranium Industry Seminar* (October 1980), and under the USGS Uranium Resource Assessment project using the methodology described in *Uranium Resources Assessment by the Geological Survey:* Methodology and Plan to Update the National Resource Base, U.S. Geological Survey Circular 994 (1987).

[4]W.I. Finch and R.B. McCammon, "*Uranium Resource Assessment by the Geological Survey: Methodology and Plan to Update the National Resource Base*," U.S. Geological Survey Circular 944 (Denver, CO, 1987), p. 31.

Figure B2. Uranium Resource Regions of the United States

Source: U.S. Department of Energy, *An Assessment Report on Uranium in the United States of America*, GJO-111(80) (Grand Junction, Colorado, October 1980).

ital costs, cutoff grade, minimum mining grade, and other factors.

Estimates of U.S. EAR and SR were updated for 1994 by using revised economic index values (current to December 1994) in the URAD System's cost model, the extensive data on potential uranium resources that were compiled during the NURE program, and subsequent data developed by the USGS. The economic indexes are the Wholesale Price Index-Industrial Commodities, the Marshall and Swift Mining-Milling Equipment Cost Index, and the Chemical Engineering Plant Cost Index. For 1990, the URAD System cost model was updated to raise the pre-set threshold value for the average-grade cutoff to reflect the higher range of average grades encountered in deposits in the breccia-pipe environment in northern Arizona. In 1991, the threshold value for the average grade cutoff was removed altogether. This was done in order to reflect more accurately the entire range in grades of the uranium inventory represented by the grade-tonnage curves across all control areas. This change resulted in overall increases in the estimates for the total EAR and SR cost categories with progressively smaller increases with each higher cost category. Estimates for years prior to 1990 would also be affected by this change; however, the changes in the values are not significant and therefore have not been made. Estimates of potential resources in the EAR and SR classes for 1974 through 1994 are shown in Table B3.

For 1994, the mean values for the $30-, $50-, and $100-per-pound U_3O_8 forward-cost categories of EAR and SR declined slightly when compared with the EAR and SR values for 1994.

Distribution of EAR and SR by Resource Region

The mean values of EAR and SR are summarized for principal resource regions and forward-cost categories Table B4. Resource regions are shown on Figure B2. Declines occured in 1994 in the $30-per-pound U_3O_8

Table B3. U.S. Potential Uranium Resources by Forward-Cost Category and Resource Class, 1974-1994

(Million Pounds U_3O_8)

Year	Forward-Cost Category									
	$10 per pound		$15 per pound		$30 per pound		$50 per pound		$100 per pound	
	EAR[a]	SR[b]	EAR[a]	SR[b]	EAR[a]	SR[b]	EAR[a]	SR[b]	EAR[a]	SR[b]
1974	900	1000	1400	1700	2300	3500	(c)	(c)	(c)	(d)
1975	900	1100	1300	1900	2100	3700	(c)	(c)	(c)	(d)
1976	600	400	1200	1400	2,200	3,200	2,700	3,900	(c)	(d)
1977	(c)	(c)	1100	1300	2,000	3,100	2,800	4,200	(c)	(d)
1978	(c)	(c)	800	600	2,000	2,000	3,000	3,400	(c)	(d)
1979[c]	(c)	(c)	800	600	2,000	2,000	3,000	3,400	(c)	(d)
1980	(c)	(c)	600	300	1,800	1,300	2,900	2,200	4,200	3,400
1981	(c)	(c)	(c)	(c)	1,2.00	900	2,200	1,800	3,500	2,900
1982	(c)	(c)	(c)	(c)	1,300	900	2,300	1,800	3,800	3,000
1983	(c)	(c)	(c)	(c)	1,300	1,000	2,400	2,000	3,800	3,200
1984	(c)	(c)	(c)	(c)	1,300	1,000	2,300	2,000	3,700	3,200
1985	(c)	(c)	(c)	(c)	1,300	1,000	2,400	1,900	3,800	3,200
1986	(c)	(c)	(c)	(c)	1,300	1,000	2,400	1,900	3,800	3,200
1987	(c)	(c)	(c)	(c)	1,300	1,000	2,300	2,000	3,700	3,200
1988	(c)	(c)	(c)	(c)	1,300	1,000	2,300	2,000	3,800	3,200
1989	(c)	(c)	(c)	(e)	2,300	1,400	3,400	2,300	5,000	3,500
1990	(c)	(c)	(c)	(e)	2,200	1,300	3,400	2,200	4,900	3,500
1991	(c)	(c)	(c)	(e)	2,200	1,400	3,400	2,300	4,900	3,600
1992	(c)	(c)	(e)	(e)	2,200	1,300	3,400	2,300	4,900	3,500
1993	(c)	(c)	(e)	(e)	2,200	1,330	3,340	2,250	4,880	3,510
1994	(c)	(c)	(e)	(e)	2,180	1,310	3,310	2,230	4,850	3,480

[a]EAR = Estimated Additional Resources.

[b]SR = Speculative Resources.

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

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

[e]Resource values were estimated for the $15 per pound U_3O_8 forward-cost category, but were not included in the table.

Notes: Values shown are the mean values for the distribution of estimates for each forward-cost category: 1974-1992- rounded to the nearest 100 million pounds U_3O_8; 1993- rounded to the nearest 10 million pounds U_3O_8. Estimates of uranium that could be recovered as a byproduct of other commodities are not included. 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.

Sources: **1974-1982**—U.S. Department of Energy, Grand Junction Projects Office, *Statistical Data of the Uranium Industry* (January 1983). **1983-1988**—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) in U.S. Department of Energy, *Uranium Industry Seminar* (October 1980); and under U.S. Geological Survey (USGS) Uranium Resource Assessment Project. **1989-1994—**Estimates based on uranium resources data developed under the NURE program and USGS Uranium Resource Assessment Project using methodology described in *Uranium Resource Assessment by the Geological Survey: Methodology and Plan to Update the National Resource Base*, U.S. Geological Survey Circular 994 (1987). Estimates are updated annually by EIA using revised economic index values which reflect changes in the U.S. economy.

EAR values for the Colorado Plateau and in the SR values for the Wyoming Basins and Basin and Range Regions. Declines also are shown for several regions at the higher forward-cost categories. The declines are a result of assumed higher economic indexes due to escalation of costs in the U.S. economy.

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 1994 is shown in Table B5. Estimates for the quantities of EAR show minor changes compared with 1993.

Table B4. U.S. Potential Uranium Resources by Forward-Cost Category and Resource Region, 1994
(Million Pounds U_3O_8)

Resource Region	Forward-Cost Category					
	$30 per pound		$50 per pound		$100 per pound	
	EAR[a]	SR[b]	EAR[a]	SR[b]	EAR[a]	SR[b]
Colorado Plateau	1,330	480	1,900	770	2,540	1,210
Wyoming Basins	160	80	340	160	660	250
Coastal Plain	370	130	490	180	600	230
Northern Rockies	30	110	60	200	170	300
Colorado and Southern Rockies	140	90	180	140	220	190
Basin and Range	50	90	160	170	390	320
Other Regions[c]	110	330	180	610	270	990
Total	**2,180**	**1,310**	**3,310**	**2,230**	**4,850**	**3,480**

[a]EAR = Estimated Additional Resources
[b]SR = Speculative Resources
[c]Includes Appalachian Highlands, Great Plains, Pacific Coast and Sierra Nevada, Central Lowlands, and Columbia Plateau regions and Alaska.
Notes: Values shown are the mean values for the distribution of estimates for each forward-cost category, rounded to the nearest 10 million pounds U3O8. Estimates of uranium that could be recovered as a byproduct of other commodities are not included. 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. Totals may not equal sum of components because of independent rounding.
Sources: Prepared by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on uranium resources data developed under DOE *National Uranium Resource Evaluation* (NURE) program and the USGS Uranium Resource Assessment project, using methodology described in *Uranium Resource Assessment by the Geological Survey: Methodology and Plan to Update the National Resource Base*, U.S. Geological Survey Circular 994 (1987).

Decreases in the quantities over those for 1993 are shown for both EAR and SR for Bureau of Land Management and Forest Service Lands, and Private Fee Lands.

U.S. Uranium Reserves

Uranium reserves are the estimated quantities of uranium that occur in known deposits of such grade, quantity, configuration, and depth that they can be recovered at or below a specified cost with state-of-the-art mining and processing technology. Estimated reserves are based on direct radiometric and chemical measurements in drill holes and other types of sampling of deposits. Mineral grades and thickness, spatial relationships, depths below the surface, mining and reclamation methods, distances to milling facilities, and amenability of ores to processing are considered in the evaluation. The amounts of uranium in ore that could be exploited within specified forward-cost levels are estimated according to conventional engineering practices, using available engineering, geologic, and economic data. Uranium reserves estimated by the DOE have been adjusted for mining dilution and mill recovery.

The costs used to categorize uranium resources are forward costs (operating and capital costs) in current (year of estimate) dollars that would be incurred in producing the uranium. The costs indirectly cover power and fuel, labor, materials, royalties, payroll, severance and ad valorem taxes, insurance, and applicable general and administrative costs. Previous expenditures (before the time of the estimate) for such items as property acquisition, exploration, mine development, and mill construction are excluded. Also excluded are income taxes, profit, and the cost of money. The forward-cost categories are independent of the market price at which the uranium might be sold. In estimating reserves for developed properties, land acquisition and exploration costs commonly are past expenditures and thus are excluded from the cost estimates.

Procedure for Estimating Reserves, 1964-1983

U.S. uranium reserves from 1964 to 1983 were estimated by the DOE using data voluntarily provided by uranium companies to DOE's Grand Junction Projects Office. Reserves were estimated for each property individually and were based on available data from samples, drill holes,

Table B5. Estimated Additional Resources (EAR) and Speculative Resources (SR) in the $50-per-Pound Forward-Cost Category by Land Status at the End of 1994

Land Status	Estimated Additional Resources		Speculative Resources	
	Million Pounds U_3O_8	Percent of Total	Million Pounds U_3O_8	Percent of Total
Public Lands				
Bureau of Land Management				
and Forest Service Lands	950	28.8	470	21.2
Bureau of Reclamation	(a)	(b)	(a)	0.2
Wilderness Areas	20	0.4	20	0.7
National Park Service Lands	110	3.3	10	0.5
Wildlife Refuges	(a)	(b)	(a)	0.1
DOE-Administered	10	0.2	(a)	(b)
Indian Lands	450	13.6	230	10.1
State Lands	200	5.9	160	7.2
Private Fee Lands[c]	1,520	46.0	1,290	57.8
Other (Military Reservations, Waterways, Reclamation Projects, Proposed Withdrawals, etc.)	60	1.8	50	2.2
Total	**3,310**	**100.0**	**2,230**	**100.0**

[a]Value is less than 5 million pounds U_3O_8.
[b]Value is less than 0.05 percent.
[c]Includes railroad lands and patented claims.
Notes: Values shown are the mean values for the distribution of estimates of EAR and SR, rounded to the nearest 10 million pounds U_3O_8. Estimates of uranium that could be recovered as a byproduct of other commodities are not included. Totals may not equal sum of components because of independent rounding.
Sources: Prepared by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on uranium resources data developed under DOE *National Uranium Resource Evaluation* (NURE) program and the USGS Uranium Resource Assessment project, using methodology described in *Uranium Resource Assessment by the Geological Survey: Methodology and Plan to Update the National Resource Base*, U.S. Geological Survey Circular 994 (1987).

and property maps. The amounts of uranium in ore that could be produced from a property at maximum forward costs of $15-, $30-, $50-, and $100-per-pound U_3O_8 were estimated by the general procedure outlined below. This procedure was applied to the estimates of reserves to be recovered by openpit, underground, and in situ leaching operations.

1. The cut-off grade was determined to define the lowest grade (in percent U_3O_8) of material that could be mined from a property at a given thickness, where the total operating cost per pound of recoverable U_3O_8 in such material would be equal to the chosen cost ($15-, $30-, $50-, or $100-) per-pound. The cut-off grade was determined by the following formula:

$$CG = \frac{(M_n + H + R + M_l)(100)}{(CC)(M_r)(2{,}000)}$$

where:

CG = cut-off grade in percent,
M_n = cost of mining per ton of ore,
H = cost of hauling per ton of ore,
R = royalty costs per ton of ore,
M_l = cost of milling per ton of ore,
CC = chosen cost per pound U_3O_8, and
M_r = mill recovery rate (in percent).

2. The quantity of mineralized material in the deposit that met or exceeded the cut-off grade and thickness criteria was estimated, in tons of material and average grade adjusted for mining recovery and dilution.

3. All forward operating and capital costs not yet incurred were applied to determine the average cost for mining and processing per pound U_3O_8.

4. If the average cost per pound U_3O_8 derived in Step 3 was equal to or less than the chosen cost category, the material was assigned to that cost category.

The procedures described above applied to reserves suitable for conventional mining. The quantities of U_3O_8 estimated to be recoverable from in situ leaching operations are included in reserves totals but were estimated by another method. In situ leaching above a selected minimum thickness were calculated for those properties on which in situ mining was in progress or was planned. The minimum grade-thickness was determined for each property, and the reserves were determined by multiplying the estimated amount of U_3O_8 by a mining recovery factor

Procedure for Estimating Reserves for 1984 to 1989

During 1983, the estimation procedure described above was ended. Estimates for the end of 1984 through 1989 were made by adjusting the estimates made for the end of 1983. For this period, additions to reserves were made for properties not in the NURE database. Deletions from reserves were made during the period for properties reported as mined out. Adjustments were also made to account for production, including "erosion" of higher cost reserves caused by the mining of lower cost reserves.

Beginning in 1984, the EIA, through Form EIA-858, "Uranium Industry Annual Survey," requested that domestic uranium industry companies report their estimates of economic reserves of uranium. Aggregations of U.S. economic reserves quantities were published in the report series *Uranium Industry Annual* beginning in 1985. Domestic uranium companies also were requested, beginning in 1985, to report estimates of their subeconomic uranium reserves. The estimates of economic and subeconomic reserves were derived by the uranium companies based on analyses of all pertinent data acquired in the exploration and development of individual properties and on cost anticipated for the individual mining operations.

Current Procedure for Estimating Reserves

Estimates of reserves as of the end of 1990 through 1994 reflect the phasing in of EIA's new approach to estimation. The previous procedure, in which DOE staff updated estimates on a deposit-by-deposit basis, has been phased out. The basic deposit estimates that were being modified are now thought to be too old to serve as a suitable base for making current reserve estimates. Additional changes have taken place affecting the status of the deposits that cannot be reflected in a modification of the estimates based primarily on adjustment for annual production. These include increased knowledge of the deposits from recent exploration and mining, environmental restriction that impact on the ability of the domestic industry to economically produce uranium, the changing status of industry firms, and changes in mining and processing technology.

The new procedure develops current estimates of reserves producible at selected cost levels using basic information provided by the mining companies. This approach relies on closer cooperation and information exchange with the uranium companies. Direct use of company estimates and information are made to the maximum extent possible. Company reserve estimates are used directly where they conform to EIA definitions and criteria. Modification to company estimates are made as needed to put them in conformity with the EIA standards or use of historical data to develop missing estimates. Where this is not possible. EIA staff members make independent deposit reserve estimates using methods similar to the 1964-1983 procedure.

The costs considered for each cost level includes all forward-cost estimates required to develop and produce the uranium that will be recovered in the mining and processing of ores. This includes capital and operating costs incurred from the nominal date of the estimate.

There are three main components to the new approach;

1. Gathering of Information by Questionnaire, Form EIA-858

   Form EIA-858 was revised for 1990 to lay out EIA objectives and criteria clearly to encourage full reporting of essential reserve data and related information. In addition, the form was simplified and clarified. Some items previously requested, such as company estimates of "economic" and "subeconomic" reserves, were eliminated. The responses to the form provide the basic input from the industry on the status of the properties with uranium resources, exploration and development activities, and the company estimates of reserves under the EIA criteria or under the criteria being used by the companies, together with information on the criteria and procedures used. Review of the information received from the form provides a basis for determining further action by EIA, in conjunction with historical information held by the EIA concerning company estimation procedures.

2. Review of Company Procedures

   Building on information provided by companies in the Form EIA-858 provides a basis for determining whether the company's estimates meet EIA criteria without modification. If EIA criteria are not met, followup meetings are held with company staff. In these meetings a detailed discussion of the company criteria and procedures for reserve estimation is held. Understanding company procedures can provide a basis for reconciling company and EIA estimates. Establishment of such understanding with a company can provide a simplified procedure for the EIA to use in handling data received from the company in the future.

3. Independent EIA Estimates

   Where a review of company procedures indicates it is not feasible to accept company estimates directly or to modify them to conform to EIA criteria, independent EIA estimates of reserves are made using company-provided basic data. In some cases, independent reserve estimation and analysis are done to establish ore deposit parametric relationships that provide a means to modify company estimates to EIA criteria without complete deposit reevaluation. Compilation of the estimates for individual uranium properties gathered at the various steps results in a national uranium reserve estimate at various cost categories. Since a complete cycle of review of industry procedures has not been completed, the currently reported estimates do not completely reflect the results of the new procedure. This will take a few more years to complete. The current reserve estimates are based on a combination of EIA-held historical data, company-reported data, and independent reserve estimates. The 1994 estimates of national uranium reserves are based on current knowledge about domestic deposits and on a consistently applied set of estimating criteria. Current and historical estimates of reserves since 1985 are shown in Table B6. The trends in estimated reserves quantities in each forward-cost category are shown in Figure B3 for the period 1985-1994.

Table B6. U.S. Uranium Reserves, 1985-1994
(Million Pounds U_3O_8)

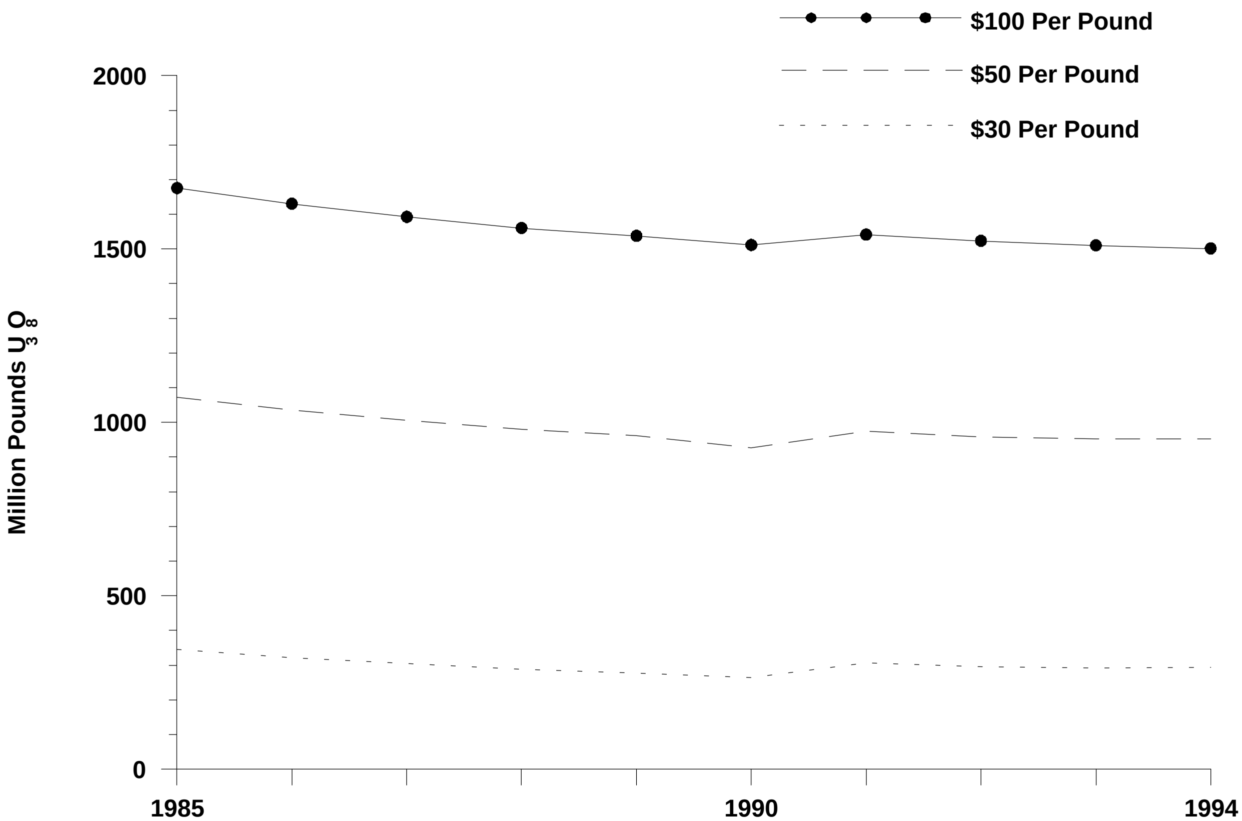
Year	$30 per pound	$50 per pound	$100 per pound
1985	345	1,072	1,675
1986	322	1,036	1,630
1987	304	1,005	1,592
1988	289	981	1,560
1989	277	962	1,537
1990	265	926	1,511
1991	304	975	1,542
1992	295	959	1,523
1993	292	952	1,511

1994	294	953	1,501

Note: Uranium reserves that could be recovered as a byproduct of phosphate and copper mining are not included in these reserves. Reserves values in forward-cost categories are cumulative; that is, the quantity at each level of forward cost includes all reserves at the lower costs.

Sources: Estimated by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on U.S. Department of Energy, Grand Junction Projects Office data files and Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984-1994).

Figure B3. U.S. Reserves by Cumulative Forward-Cost Categories, 1985-1994



Notes: Reserves estimated at the end of the year. Estimates of uranium that could be recovered as a byproduct of other commodities are not included. Forward-cost categories of reserves are cumulative within each year; that is, the quantity at each level of forward cost includes all resources at the lower cost levels.

Sources: **1985-1994--**Estimated by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on U.S. Department of Energy, Grand Junction Projects Office data files and Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985-1994).

Appendix C

Respondents to the Uranium Industry Annual Survey

Ion exchange resin-bead tanks and flow-control pipes at an in situ leach plant. Beds of resin beads in the tanks (background) selectively adsorb uranium-bearing anions from incoming well-field solutions by the process of ion exchange, in which anions are captured on the surface of each resin bead to concentrate uranium values from the relatively dilute well-field solutions. Ion-exchange can provide high uranium recovery and a final uranium product of high purity.

Appendix C

Respondents to the Uranium Industry Annual Survey

Respondents to the Energy Information Administration's (EIA) 1994 Form EIA-858, "Uranium Industry Annual Survey," are listed alphabetically in Table C1. For each respondent, an industry-activity code (or codes) is shown. The activity code (codes) broadly describes the respondent's major industry activity from Form EIA-858 and from publicly available information. Included in the listing are respondents that stated that no part of the Form EIA-858 was applicable to their operations as of the end of the survey year. The footnote at the end of Table C1 provides an explanation for the activity codes.

Table C1. Respondents to the 1994 Uranium Industry Annual Survey

Company Name	Industry Activity Code[a]	Company Name	Industry Activity Code[a]
Alabama Power Co. (Southern Nuclear)	UTL	Cyprus Foote Min. (c/o Cyprus Amax Min. Co.)	- -
Albuquerque Uranium Corporation	UPH, BRO	Dawn Mining Company	MLG
American Electric Power Service Corp.	UTL	DOE, Office of Uranium Programs	ENR
American Nuclear Corporation	UPH	Detroit Edison	UTL
Andrews Mining Company	- -	Duke Power Company	UTL
Arizona Public Service Company	UTL	Duquesne Light Company	UTL
B & W Fuel Company	FAB	Energy Fuels Nuclear Inc.	UPH,MLG,TRA
B. B. Brooks Company	UPH	Enserch Exploration, Inc.	UPH
Baltimore Gas and Electric	UTL	Entergy Operations, Inc.	UTL
BGS Mining Company	UPH	Everest Exploration, Inc.	UPH, MLG
Dave Blake Mining Company	- -	George S. Fender	UPH
Boston Edison Company	UTL	Ferret Exploration Company, Inc	- -
Cameco U.S. Inc.	UPH	Florida Power Corporation	UTL
Cargill Fertilizer, Inc.	UPH	Florida Power and Light	UTL
Carolina Power & Light	UTL	General Electric Company	FAB
Centerior Energy Corporation	UTL	Geomex Minerals, Inc.	UPH,BRO
Cobb Resources Corporation	UPH	Georgia Power Co. (Southern Nuclear)	UTL
Cogema, Inc.	BRO	GPU Nuclear Corporation	UTL
Cogema Mining Inc. (Total Minerals Corp.)	UPH,MLG	Graves and Hudspeth Company	UPH
Combustion Engineering, Inc.	FAB	Green Mountain Mining Venture	UPH,MLG
Commonwealth Edison	UTL	Homestake Mining Company	UPH
Consolidated Edison Co. of NY, Inc.	UTL	Houston Lighting & Power Co.	UTL
Consumers Power Company	UTL	IES Utilities, Inc.	UTL
ConverDyn	CON	Illinois Power Company	UTL
Cotter Corporation	UPH.MLG	IMC Global Operations	MLG

Crow Butte Resources, Inc.	UPH,MLG	Kennecott Corporation	UPH
Cycle Resources Investment Corp.	BRO	Lady Ann Company	- -

C1. Respondents to the 1994 Uranium Industry Annual Survey (Continued)

Company Name	Industry Activity Code[a]	Company Name	Industry Activity Code[a]
Maine Yankee Atomic Power Co.	UTL	Sacramento Municipal Utility Dist.	UTL
Malapai Resources Company	UPH,MLG	San Diego Gas and Electric	UTL
Marquez Development Corporation	UPH	San Rafael Energy, Inc.	UPH
Melvin Staats Company	UPH	Santa Fe Pacific Gold Corporation	UPH
Mesa, Inc.	UPH	Section 2 Joint Venture-Continental Materials	UPH
Mining Unlimited, Inc.	UPH	Sheep Mountain Partners	UPH
Nebraska Public Power District	UTL	Siemens Power Corporation - Nuclear Div.	FAB
New Mexico Arizona Land Company	UPH	Simons Associates	UPH
New York Power Authority	UTL	South Carolina Electric & Gas	UTL
New York Nuclear Corp. /NYNCO Trading	BRO	Southern California Edison Company	UTL
Niagara Mohawk Power Corporation	UTL	Southern Cross Services, Inc.	- -
Noranda Exploration, Inc.	UPH	Taminco, Inc.	- -
North Atlantic Energy Service Corp.	UTL	Noah H. & Diane R. Taylor	UPH
Northeast Utilities Service Co.	UTL	Tennessee Valley Authority	UTL
Northern States Power Company	UTL	Texas Utilities Electric Company	UTL
Nuclear Fuel Services, Inc.	UPH	UG U.S.A., Inc.	TRA
Nuexco Trading Corporation	TRA, BRO	Umetco Minerals Corporation	UPH
Nukem, Inc.	TRA, BRO	Union Electric	UTL
Ohio Edison Co. and Pennsylvania Power Co.	UTL	United Nuclear Corporation	UPH
Omaha Public Power District	UTL	United States Enrichment Corporation	ENR
Pacific Gas and Electric Company	UTL	Uranerz USA, Inc.	UPH, BRO
PACIFICORP	- -	The Uranium Exchange Company	TRA,BRO
Pathfinder Mines Corp. (C/O Cogema Inc.)	UPH	Uranium King Corporation	UPH
PECO Energy Company	UTL	Uranium Resources Incorporated	UPH, MLG, TRA
Pennsylvania Power & Light Company	UTL	USX Corporation	UPH
Petrotomics Company (C/O Texaco, Inc)	UPH	U.S. Energy Corp. (Plateau Resources, Ltd)	UPH,MLG
Power Resources, Inc.	UPH, MLG	Vermont Yankee Nuclear Power Corp.	UTL
Public Service Electric & Gas	UTL	Virginia Electric and Power Co.	UTL
Rajah Ventures, Limited	UPH	Washington Public Power Supply System	UTL
Rhone Poulenc, Inc.	MLG	Western Nuclear, Inc.	UPH
Rio Algom Mining Corp.	UPH, MLG	Westinghouse Electric Corporation	FAB
Rio Grande Resources Corp.	UPH	Wisconsin Electric Power Company	UTL
Riverside Public Utility Dept.	UTL	Wisconsin Public Service Corp.	UTL

RME Partners L. P.	UPH	Wold Nuclear Company (John S. Wold,d,b,a)	UPH
Rochester Gas & Electric Corp.	UTL	Wolf Creek Nuclear Operating Corp.	UTL

[a] - - = Not applicable; BRO = Uranium brokerage company; CON = Uranium conversion service supplier; ENR = Uranium enrichment service supplier; FAB = Uranium fuel fabr ication service supplier; MLG = Uranium milling/processing company (can involve ownership of a uranium property); TRA = Uranium trading company; UPH = Uranium property holder (can include activities related to uranium exploration, reserves, reclamation, and/or mining); UTL = Nuclear electric utility company.

Source: Prepared by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on information reported on the Form EIA-858 "Uranium Industry Annual Survey" (1994).

Appendix D

Form EIA-858: Uranium Industry Annual Survey

The filter-press equipment (background) is used to produce high-quality yellowcake (U_3O_8). After beds of resin beads in ion exchange tanks have become saturated with uranium-bearing anions, washing of the beds with a solvent yields a relatively pure and concentrated uranium solution. This solution is then treated to precipitate its dissolved uranium. The precipitate is recovered in the filter press and is then dried and prepared for shipment.

Appendix E

U.S. Customary Units of Measurement, International System of Units (SI), and Selected Data Tables in SI Metric Units

The Palisades Nuclear Power Plant operated by the Consumers Power Company, located in Covert, Michigan. This plant utilizes pressurized water reactor design and has a Net Summer Capacity of 755 net MWe. The plant first began generating electrical energy in 1971.

Appendix E

U.S. Customary Units of Measurement, International System of Units (SI), and Selected Data Tables in SI Metric Units

Standard Factors for interconversion between U.S. customary units and the International System of Units (SI) are shown in Table E1. These factors are provided as a coherent and consistent set of units for the convenience of the reader in making conversions between U.S. and metric units of measure for data published in this report. Conversion factors are provided only for the U.S. units of measurement quoted in this report.

Table E1. Conversion Factors for U.S. Customary Units and SI Metric Units of Measurement

To convert from:	To:	Multiply by:[a]
	Area	
acre	meter^2 (m^2)	4,046.9*
	Length	
foot (ft)	meter (m)	0.304 801
yard (yd)	meter (m)	0.914 4*
	Mass	
pound—avoirdupois (lb avdp)	kilogram (kg)	0.453 592
pound—avoirdupois U_3O_8[b]	kilogram U	0.384 647
ton, short (2,000 lb)	metric ton (t)	0.907 185

[a]An asterisk after the last digit indicates that the conversion factor is exact and that all subsequent digits are zero. All other conversion factors are rounded to six digits after the decimal.

[b]The factor of 1 pound $U_3O_8 \approx$ 0.848 002 pounds U was used in this conversion.

Source: Table E1 is patterned after Table 3, "Conversion Factors for SI Metric Units and U.S. Customary Units of Measurement," in S.M. Long and A.M. Orellana, "The Metric System," in *Suggestions to Authors of the Reports of the United States Geological Survey*, Sixth Edition, U.S. Government Printing Office (Washington, DC, 1978) pp. 192-196.

Forward Cost and Average Price Conversions

The forward-cost categories of $US80 through $US260 per pound U shown on Table E3 to report uranium reserves quantities were converted from units of "$ per pound U_3O_8" to "$ per kilogram U" by multiplying by the standard factor of 2.6 and rounding the results to the nearest multiple of $US10. The "Averages of Reported Prices" shown on Tables E7 and E9 were derived by applying that same factor to convert to "dollars per kilogram U." These averages were calculated from data reported in Item 1, "Contract," of Schedule B, "Uranium Marketing Activities," Form EIA-858, for the survey year.

Selected Tables Converted to SI Metric Values

Nine principal tables of data from the Uranium Industry Annual 1994 (UIA) converted to equivalent metric values are shown on the following pages. The crosswalk given below shows the correlation between the tables of metric values and their corresponding tables in U.S. customary units in the main body of the UIA.

Appendix E Table Number	UIA Chapter and Table Number
E2	Chapter 1, Table 3
E3	Chapter 1, Table 8
E4	Chapter 1, Table 10
E5	Chapter 1, Table 15
E6	Chapter 2, Table 21
E7	Chapter 2, Table 25
E8	Chapter 2, Table 26
E9	Chapter 2, Table 30
E10	Chapter 2, Table 39

Table E2. Uranium Surface Drilling by Category, 1985-1994

Year(s)	Exploration Drilling[a]				Development Drilling[b]			
	Number of Holes Drilled	Million Meters[c]	Cost (million dollars)[c,d]	Average Cost (dollars per meter)[c]	Number of Holes Drilled	Million Meters[c]	Cost (million dollars)[c,d]	Average Cost (dollars per meter)[c]
1985	2,877	0.43	5.14	11.88	772	0.10	0.39	3.76
1986	1,985	0.34	6.40	19.09	1,846	0.30	1.35	4.57
1987	1,820	0.34	5.90	17.44	1,994	0.26	1.06	4.04
1988	2,029	0.39	6.44	16.51	3,176	0.53	3.26	6.18
1989	2,087	0.44	5.82	13.35	1,753	0.24	3.12	12.80
1990	1,507	0.27	3.21	12.11	1,908	0.25	5.95	24.10
1991	1,624	0.30	2.83	9.57	1,573	0.26	8.11	30.58
1992	935	0.17	1.27	7.44	833	0.15	1.16	7.61
1993	355	0.07	0.98	14.46	1,665	0.27	4.75	17.61
1994	519	0.10	0.74	7.08	477	0.10	0.38	3.99

[a]Includes drilling in search of new ore deposits or extensions of known deposits and drilling at the location of a discovery up to the time the company decides sufficient ore reserves are present to justify commercial exploitation. Costs shown are in nominal U.S. dollars.

[b]Includes all drilling of an ore deposit to determine more precisely the size, grade, and configuration subsequent to the time that commercial exploitation is deemed feasible. Costs shown are in nominal U.S. dollars.

[c]Number of holes for 1981 and prior years and data for meters drilled, total cost, and average cost for 1982 and prior years based on *Statistical Data of the Uranium Industry,* GJO-100(83)(January 1, 1983). Cost shown are in nominal, U.S. dollars.

[d]Does not include the costs for 0.632 million meters of exploration drilling and 0.16 million meters of development drilling for 1966-1971 for which drilling costs were reported as "other exploration expenditures." Does not include costs for 3.038 million meters of exploration and development drilling rep[orted together at a cost of $13.7 million, 1966-1972.

[e]This high value in attributable primarily to the large percentage of total expenditures for development drilling in 1982 attributable to one company.

-- = Not applicable.

Note: Average cost per meter shown here may not equal quotients obtained with independently rounded numerator and denominator.

Sources: Energy information Administration: **1984-1993-***Uranium Industry Annual 1993* (September 1994); **1994-**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E3. Changes in Uranium Reserves by Forward-Cost Category, 1993 to 1994
(Thousand Metric Tons U)

Year End Reserves and Change	Forward-Cost Category $US80 per kilogram U	$US130 per kilogram U	$US260 per kilogram U
Reserves at the End of 1993	112	366	581
Reevaluations of Reserves in 1994			
Additions	3	3	4
Subtractions	(<1)	(1)	(5)
Depletion (Production and Erosion) in 1994	(2)	(2)	(3)
Reserves at the End of 1994	113	366	577

Notes: Totals may not equal sum of components because of independent rounding. No reserves evaluations for new uranium properties are included in the estimates of U.S. reserves made during 1994. Uranium reserves that could be recovered as a byproduct of phosphate and copper mining are not included in this table. Reserves values in forward-cost categories are cumulative: that is, the quantity at each level of forward cost includes all reserves at the lower costs.

Sources: Estimates by staff of the Analysis and Systems Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration (EIA), based on U.S. Department of Energy, Grand Junction Projects Office data files and Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E4. Uranium Mine Production by Mining Method, 1985-1994
(Thousand Metric Tons U)

Mining Method	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Underground	1.7	2.5	1.9	2.1	2.0	W	W	W	0	0
Percent of Total	52.3	77.8	81.7	56.8	54.4	W	W	W	--	--
Openpit Mines	0.8	W	W	W	W	0.7	1.0	W	0	0
Percent of Total	23.3	W	W	W	W	32.0	48.8	W	--	--
Other[b]	0.8	0.7	0.4	1.6	1.7	1.5	1.0	0.4	0.8	1.0
Percent of Total	24.4	22.2	18.3	43.2	45.6	68.0	51.2	100.0	100.0	100.0
Total	3.3	3.2	2.3	3.7	3.7	2.3	2.0	0.4	0.8	1.0
Percent Change from Prior Year	-14.0	-3.5	-27.7	58.3	2.1	-39.2	-11.8	-80.7	105.1	23.2

[a]For 1983, openpit plus underground mine production was 7.2 thousand metric tons U, or 79.1 percent.

[b]For 1985 the "Other" includes production from in situ leach, mine water, and water-treatment plant solutions. For 1986 through 1989, the "Other" includes production from openpit, in situ leach, heap leach, mine water, and water-treatment plant solutions. For 1990 and 1991, the "Other" includes production from underground, in situ leach, heap leach (1990), mine water, water-treatment plant solutions (1990), and restoration. For 1992, the "Other" includes production from underground and in situ leach mines, uranium bearing water from mine workings and tailings ponds, and restoration. For 1993 and 1994, the "Other includes production form in situ leach mines and uranium bearing water from restoration.

-- = Not applicable.

W = Withheld to avoid disclosure of company-specific data. The data are included in the total for "Other."

Notes: Totals may not equal sum of components because of independent rounding. Percentages were calculated using unrounded data.

Sources: Energy Information Administration: **1985-1992—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E5. Uranium Processing Operations, 1985-1994

Processing Operation	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Ore Fed to Process[a]										
(thousand metric tons U)	1,628	1,187	1,307	1,101	1,120	655	580	232	0	0
(grade)[b]	0.161	0.336	0.284	0.288	0.323	0.293	0.198	0.229	--	--
(thousand metric tons U)	2.225	3.378	3.151	2.692	3.068	1.626	0.973	0.450	0	0
Other Mill Feed[c]										
(thousand metric tons U)	0.288	0.100	0.182	0.195	0.165	0.186	0.069	0.070	0.016	0.030
Total Mill Feed										
(thousand metric tons U)	2.514	3.478	3.333	2.887	3.233	1.812	1.042	0.520	0.016	0.030
In Process Inventory Change										
(thousand metric tons U)	0.079	-0.025	-0.081	0.052	-0.090	-0.094	-0.047	0.010	0.004	0.009
Concentrate Production										
(thousand metric tons U)										
Theoretical Production[d]	2.434	3.503	3.413	2.834	3.323	1.906	1.089	0.530	0.012	0.021
Conventional Milling . . .	2.340	3.405	3.283	2.706	3.144	1.788	1.003	0.523	0.012	0.018
Tailings Less										
Unaccountables	0.094	0.098	0.130	0.129	0.179	0.119	0.085	0.007	0.001	0.003
Recovery From Mill Feed										
(percent)	96.1	97.2	96.2	95.5	94.6	93.8	92.2	98.7	--	--
Other Processing[e]	2.012	1.790	1.714	2.345	2.178	1.630	2.056	1.649	1.166	1.272
Total Production	[f]4.352	[f]5.195	[f]4.997	5.050	5.322	3.418	3.059	2.171	1.178	1.289
Concentrate Shipments										
(thousand metric tons U)	4.523	4.093	4.446	4.920	5.696	4.984	3.245	2.636	1.298	2.431

[a]Uranium ore "fed to process" in any year can include: ore mined and shipped to a mill during the same year, ore that was mined during a prior year and later shipped from mine-site stockpiles, and/or ore obtained from drawdowns of stockpiles maintained at a mill site.

[b]Weighted average percent.

[c]Includes uranium from low-grade ore, mine water, tailings water, and heap leaching, except as footnoted below.

[d]At 100-percent recovery.

[e]Uranium concentrate production from in situ leaching and as a byproduct of other processing. The totals for 1986 through 1988 include uranium concentrate recovered from reclamation and mine water at some mills that did not report processing of uranium ore for those years.

[f]Total does not include uranium concentrate production from pilot projects or other research project sources.

-- = Not applicable

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

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E6. Commitments for Delivery of Uranium from Suppliers to U.S. Utilities for Domestic Purchases, 1994-2000 and Later
(Thousand Metric Tons U Equivalent)

Year of Delivery	As of December 31, 1993				As of December 31, 1994				Change in Total from December 31, 1993, to December 31, 1994	
	Firm	Optional	Total	Cumulative	Firm	Optional	Total	Cumulative	Total	Cumulative
1994	5.3	0.6	5.9	5.9	8.7	0	8.7	8.7	2.8	2.8
1995	4.1	0.7	4.9	10.8	6.1	0.6	6.6	15.4	1.8	4.6
1996	2.2	0.6	2.8	13.6	3.2	0.8	4.0	19.4	1.2	5.8
1997	2.2	0.6	2.8	16.4	3.3	0.9	4.3	23.7	1.5	7.3
1998	1.1	0.6	1.7	18.1	2.0	1.0	3.0	26.6	1.3	8.5
1999	0.7	0.4	1.1	19.2	1.4	0.8	2.2	28.9	1.1	9.6
2000 and Later	1.6	0.3	2.0	21.2	2.5	0.9	3.5	32.3	1.5	11.2
Total	**17.2**	**4.0**	**21.2**	**--**	**27.3**	**5.1**	**32.3**	**--**	**--**	**--**

-- = Not applicable.
Note: Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-858, “Uranium Industry Annual Survey” (1994).

Table E7. Average of Prices Paid for Domestic Purchases by U.S. Utilities from Suppliers, 1985-1994
(Dollars per Kilogram U Equivalent, Thousand Metric Tons Equivalent)

Contract Type	Year of Delivery									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Contract-Specified Price										
Average Price	90.32	84.71	75.82	73.32	54.26	46.64	36.24	34.22	38.90	27.77
Quantity with Reported Price	3.4	2.3	3.9	2.8	3.7	4.6	6.7	5.1	3.2	4.3
Market Price Related										
No Floor										
Average Price	40.20	44.02	45.58	41.91	29.85	23.87	23.5	22.49	24.88	25.37
Quantity with Reported Price	1.1	1.3	1.0	0.9	0.7	2.0	1.3	1.5	2.2	2.7
Price and Cost Floor										
Average Price	92.61	106.76	89.28	87.15	58.50	50.44	56.78	47.71	38.65	52.07
Quantity with Reported Price	1.5	1.0	0.5	0.4	0.4	0.6	0.5	1.8	0.6	0.2
Total Market Price Related										
Average Price	70.59	71.21	59.41	56.13	40.09	30.29	32.81	36.10	28.68	27.48
Quantity with Reported Price	2.7	2.3	1.5	1.3	1.2	2.6	1.9	3.3	2.8	3.0
Total Contract Specified & Market Price Related										
Average Price	81.72	78.03	71.16	67.99	50.86	40.82	35.52	34.96	34.17	27.64
Quantity with Reported Price	6.1	4.7	5.4	4.2	4.8	7.2	8.5	8.4	6.0	7.2

Notes: Price excludes uranium delivered under litigation settlements. Prices shown are quantity-weighted averages per kilogram U equivalent in nominal U.S. dollars.
Sources: Energy Information Administration: **1985-1993**—*Uranium Industry Annual 1993* (September 1994); **1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E8. Deliveries and Commitments of Uranium Imports and Exports by Transaction Type, 1985 to 2000 and Later

(Thousand Metric Tons U Equivalent)

Year of Delivery	Imports by Transaction Type[a]					Exports by Transaction Type[a]				
	Purchases[b]	Loans	Exchanges	Other	Total	Sales[c]	Loans	Exchanges	Other	Total
Actual Deliveries										
1985	4.5	0	0	NA	4.5	2.0	0	0	NA	2.0
1986	5.2	0	0.3	NA	5.5	0.6	0	0	NA	0.6
1987	5.8	0.3	0	NA	6.1	0.4	0	0	NA	0.4
1988	6.1	0	0.5	NA	6.5	1.3	0	0.4	NA	1.7
1989	5.0	0.1	0.1	NA	5.3	0.8	0	0.1	NA	1.0
1990	9.1	<0.1	1.1	NA	10.2	0.8	0.1	0	NA	0.9
1991	6.3	2.2	0.4	NA	8.9	1.4	0	0	NA	1.4
1992	9.0	0.9	0.3	7.2	17.5	1.1	0	0	7.0	8.0
1993	8.1	W	W	7.5	16.1	1.2	W	W	W	8.2
1994	14.1	W	1.2	W	22.2	6.9	W	0.9	W	18.0
Commitments										
1995	10.0	0	W	W	10.0	3.3	W	W	W	6.8
1996	8.4	0	0	0	8.4	2.1	0	0	0	2.1
1997	7.5	0	0	0	7.5	2.2	0	0	0	2.2
1998	6.9	0	0	0	6.9	1.6	0	0	0	1.6
1999	5.3	0	0	0	5.3	1.4	0	0	0	1.4
2000 and Later	9.9	0	0	0	9.9	3.1	0	0	0	3.1

[a]**1985-1991**—Does not include transactions involving the delivery of uranium materials imported for custody/storage siting, conversion, enrichment, and/or fuel fabrication at U.S. facilities and subsequently exported or uranium materials exported for conversion, fuel fabrication, and/or enrichment at foreign facilities. **1992-1993**-"Other" imports include uranium shipped under transactions involving custody/storage siting, conversion, enrichment, and/or fuel fabrication at U.S. facilities. "Other" exports include uranium shipped from conversion, enrichment, and/or fuel fabrication facilities in the United States.

W = Withheld to avoid disclosure of individual company data.

NA = Not available.

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

Sources: Energy Information Administration: **1985-1993**—*Uranium Industry Annual 1993* (September 1994); **1994**—Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E9. Average of Prices Paid for Uranium Delivered to U.S. Utilities and Suppliers under Foreign Purchases, 1985-1994

(Dollars per Kilogram U Equivalent, Thousand Metric Tons Equivalent)

Item	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Average Price	52.21	52.18	49.76	49.48	43.55	32.63	40.43	29.48	27.37	23.27
Quantity with Reported Price	4.1	4.9	5.0	5.8	5.0	9.0	6.1	8.6	8.1	14.1
Total Quantity Delivered[a]	4.5	5.2	5.8	6.1	5.0	9.1	6.3	9.0	8.1	14.1
Percentage of Imports Delivered with Reported Prices	91	95	85	96	100	99	98	96	100	100

[a]The figure shown includes U.S. utility, supplier, and trader/broker purchases reported as imports of uranium materials into the United States. Uranium materials reported as imports under loan and exchange transactions are excluded.

Notes: Prices shown are quantity-weighted averages per kilogram U equivalent in nominal U.S. dollars. Material quantities are millions of kilogram U equivalent.

Sources: Energy Information Administration: **1985-1993—***Uranium Industry Annual 1993* (September 1994); **1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994).

Table E10. Commercial and U.S. Government Inventories of Natural and Enriched Uranium as of End of Year, 1990-1994

(Thousand Metric Tons U Equivalent)

	Inventories at the End of the Year				
Type of Uranium Inventory	1990	1991	1992	1993	1994
Utility Stocks					
Natural Uranium	23.7	27.3	25.6	R22.3	16.4
Enriched Uranium[a]	15.8	10.4	R9.8	R8.9	9.3
Domestic Supplier Stocks					
Natural Uranium	8.5	7.2	7.4	R7.3	6.0
Enriched Uranium[a]	1.7	0.8	2.3	R2.1	1.5
Total Commercial Stocks	49.6	45.7	45.1	R40.6	33.2
DOE-Owned and USEC-Held Stocks[b]					
Natural Uranium	23.0	18.0	17.6	R20.1	20.7
Enriched Uranium	12.6	14.1	8.9	10.3	7.9

[a]Includes amounts reported as inventories of UF_6 at Enrichment Suppliers.

[b]Includes amounts reported as inventories by U.S. Department of Energy (DOE) and the United States Enrichment Corporation (USEC) for 1993 and 1994.

R = Revised data.

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

Sources: Energy Information Administration: **1990-1992—***Uranium Industry Annual 1993* (September 1994); **1993-1994—**Form EIA-858, "Uranium Industry Annual Survey" (1994); **1990-1994, DOE-Owned and USEC-Held uranium only—**Office of Uranium Programs (NE-30), U.S. Department of Energy, and the United States Enrichment Corporation (USEC).

Glossary

Used, or "spent," fuel assemblies are removed from the core of a nuclear reactor after three to four years of use in the power plant. After undergoing fission in the core to provide heat energy for electric power generation, a spent fuel assembly is highly radioactive and is stored in a pool of water at the plant site to allow some of the short-lived radioactive fission products to decay. This takes about 120 days and reduces the radioactivity of the spent fuel by over 90 percent.

Glossary

Average delivered price: The weighted average of all contract-price commitments and market-price settlements in a delivery year.

Contract price: The delivery price determined when a contract is signed. It can be a fixed price or a base price escalated according to a given formula.

Conventional mill (uranium): A facility engineered and built principally for processing of uraniferous ore materials mined from the earth and the recovery, by chemical treatment in the mill's circuits, of uranium and/or other valued coproduct components from the processed ore.

Cost model for undiscovered resources: A computerized algorithm that uses the uranium endowment estimated for a given geological area and selected industry economic indexes to develop random variables that describe the undiscovered resources ultimately expected to be discovered in that area at chosen forward-cost categories.

Cutoff grade: The lowest grade, in percent U_3O_8, of uranium ore at a minimum specified thickness that can be mined at specified cost.

Development drilling: Drilling done to determine more precisely size, grade, and configuration of an ore deposit subsequent to the time the determination is made that the deposit can be commercially developed.

Domestic: Domestic means within the 50 States, District of Columbia, Puerto Rico, the Virgin Islands, Guam, and other U.S. possessions. The word "domestic" is used also in conjunction with data and information that are compiled to characterize a particular segment or aspect of the uranium industry in the United States.

Domestic purchase: A uranium purchase from a firm located in the United States.

Domestic sale: A uranium sale to a firm located in the United States.

Domestic uranium industry: Collectively, those businesses (whether U.S. or foreign-based) that operate under the laws and regulations pertaining to the conduct of commerce within the United States and its territories and possessions and that engage in activities within the United States, its territories, and possessions specifically directed toward uranium exploration, development, mining, and milling; marketing of uranium materials; enrichment; fabrication; or acquisition and management of uranium materials for use in commercial nuclear power plants.

Enriched uranium: Uranium in which the ^{235}U isotope concentration has been increased to greater than the 0.711 percent ^{235}U (by weight) present in natural uranium.

Enrichment feed deliveries: Uranium that is shipped under contract to a supplier of enrichment services for use in preparing enriched uranium product to a specified ^{235}U concentration and that ultimately will be used as fuel in a nuclear reactor.

Exploration drilling: Drilling done in search of new mineral deposits, on extensions of known ore deposits, or at the location of a discovery up to the time when the company decides that sufficient ore reserves are present to justify commercial exploitation. Assessment drilling is reported as exploration drilling.

Fabricated fuel: Fuel assemblies composed of an array of fuel rods loaded with pellets of enriched uranium dioxide.

Floor price: A price specified in a market-price contracts as the lowest purchase price of the uranium, even if the market price falls below the specified price. The floor price may be related to the seller's production costs.

Foreign purchase: A uranium purchase of foreign-origin uranium from a firm located outside of the United States.

Foreign sale: A uranium sale to a firm located outside the United States.

Forward cost: The operating and capital costs still to be incurred in the production of uranium from in-place reserves. By using forward costing, estimates of reserves for ore deposits in differing geological settings and status of development can be aggregated and reported for selected cost categories. Included are costs for labor, materials, power and fuel, royalties, payroll taxes, insurance, and applicable general and administrative costs. Excluded from forward cost estimates are prior expenditures, if any, incurred for property acquisition, exploration, mine development, and mill construction, as well as income taxes, profit, and the cost of money. Forward costs are neither the full costs of production nor the market price at which the uranium, when produced, might be sold.

Heap leach solutions: The separation, or dissolving-out, from mined rock of the soluble uranium constituents by the natural action of percolating a prepared chemical solution through mounded (heaped) rock material. The mounded material usually contains low grade mineralized material and/or waste rock produced from openpit or underground mines. The solutions are collected after percolation is completed and processed to recover the valued components.

Heavy water: Water containing a significantly greater proportion of heavy hydrogen (deuterium) atoms to ordinary hydrogen atoms than is found in ordinary (light) water. Heavy water is used as a moderator in some reactors, because it slows neutrons effectively and also has a low cross section for absorbtion of neutrons.

Heavy-water-moderated reactor: A reactor that uses heavy water as its moderator. Heavy water is an excellent moderator and thus permits the use of inexpensive natural (unenriched) uranium as fuel.

In situ leach mining (ISL): The recovery, by chemical leaching, of the valuable components of an orebody without physical extraction of the ore from the ground. Also referred to as "solution mining."

Light water reactor (LWR): A nuclear reactor that uses water as the primary coolant and moderator, with slightly enriched uranium as fuel. There are two types of commercial light-water reactors—the boiling-water reactor (BWR) and the pressurized-water reactor (PWR).

Long-term contract: One or more deliveries to occur after a period of at least 6 years following contract execution (pertains to the 1994 Form EIA-858).

Market price: The prevailing price level in the market at a given time. It generally reflects a published spot price, is mutually agreed upon by the contracting parties, or is independently determined by an unbiased outside arbitrator.

Market-price contract: A contract in which the price of uranium is not specifically determined at the time the contract is signed but is based instead on the prevailing market price at the time of delivery. A market-price contract may include a floor price, that is, a lower limit on the eventual settled price. The floor price and the method of price escalation generally are determined when the contract is signed. The contract may also include a price ceiling or a discount from the agreed-upon market price reference.

Market-price settlement: The price paid for uranium delivery under a market-price contract. The price is commonly (but not always) determined at or sometime before delivery and may be related to a floor price, ceiling price, or discount.

Medium-term contract: One or more deliveries to occur over a period of 3 to 6 years following contract execution (pertains to the 1994 Form EIA-858).

Milling of uranium: The processing of uranium from ore mined by conventional methods, such as underground or openpit methods, to separate the uranium from the undesired material in the ore.

National Uranium Resource Evaluation (NURE): A program begun by the U.S. Atomic Energy Commission (AEC) in 1974 to make a comprehensive evaluation of U.S. uranium resources and continued through 1983 by the AEC's successor agencies, the Energy Research and Development Administration (ERDA) and the Department of Energy (DOE). The NURE program included aerial radiometric and magnetic surveys, hydrogeochemical and stream sediment surveys, geologic drilling in selected areas, geophysical logging of selected boreholes, and geologic studies to identify and evaluate geologic environments favorable for uranium.

Net imports: The uranium imports minus exports in a given delivery period.

Nonconventional plant (uranium): A facility engineered and built principally for processing of uraniferous solutions that are produced during in situ leach mining, from heap leaching, or in the manufacture of other commodities, and the recovery, by chemical treatment in the plant's circuits, of uranium from the processed solutions.

Nuclear reactor: An apparatus in which a nuclear fission reaction, i.e., the splitting of atomic nuclei to release heat energy, can be initiated, controlled, and sustained at a specific rate. A reactor includes fuel (fissionable material), moderating materials to control the rate of fissioning, a heavy-walled pressure vessel to house reactor components, shielding to protect personnel, a system to conduct heat away from the reactor, and instrumentation for monitoring and controlling the reactor's systems.

Optional delivery commitment: A provision to allow the conditional purchase or sale of a specific quantity of material in addition to the firm quantity in the contract.

Processing of uranium: The recovery of uranium from solutions produced by nonconventioanl mining methods, i.e., in situ leach mining (ISL), a byproduct of copper or phosphate mining, or heap leaching.

Purchase-contract imports of uranium: The amount of foreign-origin uranium material that enters the United States during a survey year as reported on the "Uranium Industry Annual Survey" (UIAS), Form EIA-858, as purchases of uranium ore, U_3O_8, natural UF_6, or enriched UF_6. The amount of foreign-origin uranium materials that enter the country during a survey year under other types of contracts, i.e., loans and exchanges, is excluded.

Separative Work Units (SWU): The standard measure of enrichment services. The effort expended in separating a mass F of feed of assay xf into a mass P of product assay xp and waste of mass W and assay xw is expressed in terms of the number of separative work units needed, given by the expression $SWU = WV(x_w) + PV(x_p) - FV(x_f)$, where V(x) is the "value function," defined as $V(x) = (1 - 2x) \ln((1 - x)/x)$.

Short-term contract: One or more deliveries to occur over a period of less than 3 years following contract execution (pertains to the 1994 Form EIA-858).

Spot contract: A one-time delivery of the entire contract to occur within one year of contract execution (pertains to the 1994 Form EIA-858).

Spot market: Buying and selling of uranium for immediate or very near-term delivery. It typically involves transactions for delivery of up to 500,000 pounds U_3O_8 within a year of contract execution.

Spot-market price: A transaction price concluded "on the spot," that is, on a one-time, prompt basis. The transaction usually involves only one specific quantity of product. This contrasts with a term-contract sale price, which obligates the seller to deliver a product at an agreed frequency and price over an extended period.

Unfilled requirements: Requirements not covered by usage of inventory or supply contracts in existence as of January 1 of the survey year.

Uranium: A heavy, naturally radioactive, metallic element (atomic number 92). Its two principally occurring isotopes are ^{235}U and ^{238}U. The isotope ^{235}U is indispensable to the nuclear industry because it is the only isotope existing in nature to any appreciable extent that is fissionable by thermal neutrons. The isotope ^{238}U is also important because it absorbs neutrons to produce a radioactive isotope that subsequently decays to the isotope ^{239}Pu, which also is fissionable by thermal neutrons.

Uranium concentrate: A yellow or brown powder produced from naturally occurring uranium minerals as a result of milling uranium ore or processing uranium-bearing solutions. Synonymous with yellowcake, U_3O_8, or uranium oxide.

Uranium deposit: A discrete concentration of uranium mineralization that is of possible economic interest.

Uranium endowment: The uranium that is estimated to occur in rock with a grade of at least 0.01 percent U_3O_8. The estimate of the uranium endowment is made before consideration of economic availability and any associated uranium resources.

Uranium hexafluoride (UF_6): A white solid obtained by chemical treatment of U_3O_8 and which forms a vapor at temperatures above 56 degrees Centigrade. UF_6 is the form of uranium required for the enrichment process.

Uranium ore: Rock containing uranium mineralization in concentrations that can be mined economically, (typically 1 to 4 pounds of U_3O_8 per ton or 0.05 to 0.20 percent U_3O_8).

Uranium oxide: Uranium concentrate or yellowcake. Abbreviated as U_3O_8.

Uranium property: A specific piece of land with uranium reserves that is held for the ultimate purpose of economically recovering the uranium. The land can be developed for production or undeveloped.

Uranium reserves: Estimated quantities of uranium in known mineral deposits of such size, grade, and configuration that the uranium could be recovered at or below a specified production cost with currently proven mining and processing technology and under current law and regulations. Reserves are based on direct radiometric and chemical measurements of drill holes and other types of sampling of the deposits. Mineral grades and thickness, spatial relationships, depths below the surface, mining and reclamation methods, distances to milling facilities, and amenability of ores to processing are considered in the evaluation. The amount of uranium in ore that could be exploited within the chosen forward-cost levels are estimated in accordance with conventional engineering practices.

Uranium resources categories: Three categories of uranium resources are used to reflect differing levels ofconfidence in the resources reported. Reasonably assured resources (RAR), estimated additional resources (EAR), and speculative resources (SR) are described below.

- **Reasonably assured resources (RAR):** The uranium that occurs in known mineral deposits of such size, grade, and configuration that it could be recovered within the given production cost ranges, with currently proven mining and processing technology. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. RAR correspond to DOE's uranium reserves category.

- **Estimated additional resources (EAR)**: The uranium in addition to RAR that is expected to occur, mostly on the basis of direct geological evidence, in extensions of well-explored deposits, little explored deposits, and undiscovered deposits believed to exist along well-defined geological trends with known deposits, such that the uranium can subsequently be recovered within the given cost ranges. Estimates of tonnage and grade are based on available sampling data and on knowledge of the deposit characteristics, as determined in the best-known parts of the deposit or in similar deposits. EAR correspond to DOE's probable potential resources category.

- **Speculative resources (SR)**: Uranium in addition to EAR that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The locations of deposits in this category can generally be specified only as being somewhere within given regions or geological trends. The estimates in this category are less reliable than estimates of RAR and EAR. The category of SR corresponds to DOE's possible potential resources plus speculative potential resources categories combined.

Usage Agreement: Contracts held by enrichment customers that allow feed material to be stored at the enrichment plant site in advance of need.

Yellowcake: (See uranium oxide).