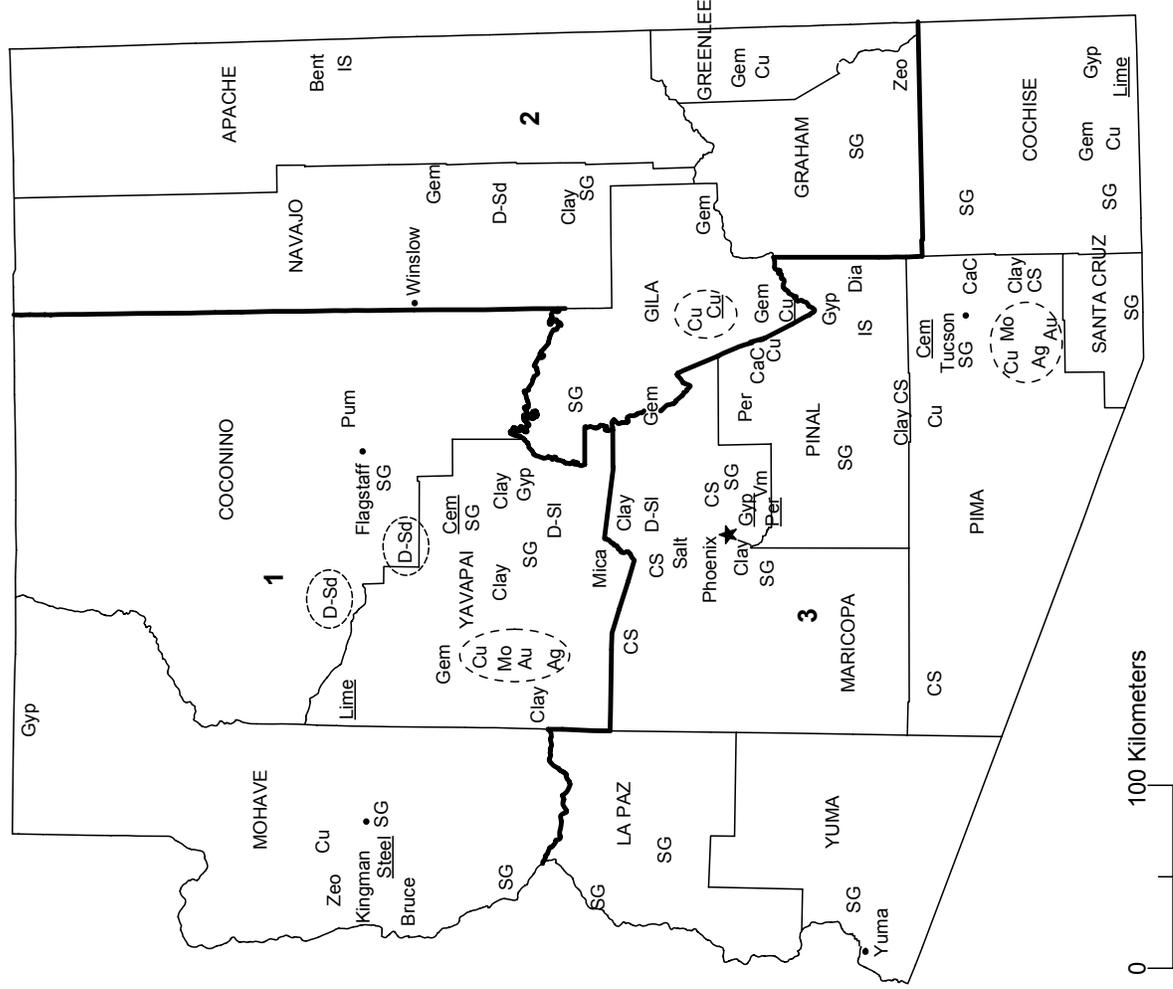


ARIZONA



LEGEND

- County boundary
- ★ Capital
- City
- 1 — Crushed stone/sand and gravel districts

MINERAL SYMBOLS (Major producing areas)

- Ag Silver
- Au Gold
- Bent Bentonite
- Bruce Brucite
- CaC Calcium carbonate
- Cem Cement plant
- Clay Common clay
- CS Crushed stone
- Cu Copper
- Cu Copper plant
- D-Sd Dimension sandstone
- D-Si Dimension slate
- Dia Diatomite
- Gem Gemstones
- Gyp Gypsum
- IS Industrial sand
- Lime Lime plant
- Mica Mica
- Mo Molybdenum
- Per Perlite
- Per Perlite plant
- Pum Pumice and pumicite
- Salt Salt
- SG Construction sand and gravel
- Steel Steel plant
- Vm Vermiculite
- Zeo Zeolites
- (---) Concentration of mineral operations

THE MINERAL INDUSTRY OF ARIZONA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Geological Survey and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.

In 2002, the estimated value¹ of nonfuel mineral production for Arizona was \$1.9 billion, based upon preliminary U.S. Geological Survey (USGS) data. This was about a 12% decrease from the \$2.17 billion of 2001² and followed a 13.5% decrease from 2000 to 2001. Arizona accounted for 5% of total nonfuel mineral production value in the Nation and was fifth in rank (third in 2001).

Arizona continued in 2002 to be the leading copper-producing State, accounting for two-thirds of total U.S. copper mine production and value. Copper was the State's leading nonfuel mineral, also representing about two-thirds of Arizona's total nonfuel mineral production value. Both the quantity and the value of copper production decreased in 2002 because of lower average copper prices and the continued scaling back of some operations. Construction sand and gravel was Arizona's second leading nonfuel mineral, accounting for about 14% of the State's same total value, followed by portland cement, molybdenum concentrates, crushed stone, and lime.

In 2001, copper mine production was down by about 5%, but because of lower average copper prices, the value of production was down almost 18%. The \$320 million decrease in copper's value, a \$16 million decrease in construction sand and gravel, a \$9 million drop in portland cement (although production was up slightly), plus a significant decrease in the production and value of silver accounted for most of the State's drop in value. The largest single increase was in the production and value of molybdenum, up about \$16 million (table 1). All other changes were about \$1 million or less—relatively inconsequential to the State's overall change in value.

Based upon USGS production data in the 50 States during 2002, Arizona remained the leading State in copper and molybdenum (concentrate) output (descending order of value), second in gemstones (by value), fourth in construction sand and gravel and zeolites, and seventh in dimension stone. The State had a significant increase in pumice and pumicite production, rising to 1st from 5th; was tied for 3d in crude perlite; increased to 5th from 6th in silver; and continued to be 10th of 10 gold-producing States. Additionally, Arizona continued to be a significant producer of portland cement, lime, and masonry cement.

The Arizona Department of Mines and Mineral Resources³ (ADMMR) provided the following narrative information. Data presented in ADMMR reports may differ somewhat from data reported by the USGS in table 1.

Commodity Review

Industrial Minerals

Crushed Stone and Sand and Gravel.—In midyear 2002, Rinker Materials Corp. (a subsidiary of CSR Ltd. in Australia) acquired Kiewit Materials Co. for \$540 million. About 80% of Kiewit's operations are in Arizona, including sand and gravel quarries and asphalt and concrete operations that operated statewide under the names San Xavier Rock and Materials, Tanner Companies, and United Metro Materials. Kiewit was the Nation's 16th largest aggregate producer. Its aggregate reserves total more than 730 million metric tons (Mt), or about a 30-year reserve life. The acquisition makes Rinker the fifth largest aggregate producer and the second largest premix concrete producer in the United States. The five largest producers now control about 25% of the Nation's aggregate market.

Dimension Stone.—Growth in the dimension stone mining segment continued. Seventeen companies were active; cut sandstone and split flagstone were the predominate products. Although reported production data was limited, employment totaled 690 workers. ADMMR estimated sandstone-flagstone annual production at 340,000 metric tons per year (t/yr) with an estimated mine value of

¹The terms "nonfuel mineral production" and related "values" encompass variations in meaning, depending upon the minerals or mineral products. Production may be measured by mine shipments, mineral commodity sales, or marketable production (including consumption by producers) as is applicable to the individual mineral commodity.

All 2002 USGS mineral production data published in this chapter are preliminary estimates as of July 2003 and are expected to change. For some mineral commodities, such as construction sand and gravel, crushed stone, and portland cement, estimates are updated periodically. To obtain the most current information, please contact the appropriate USGS mineral commodity specialist. Specialist contact information may be retrieved over the Internet at URL <http://minerals.usgs.gov/minerals/contacts/comdir.html>; alternatively, specialists' names and telephone numbers may be obtained by calling USGS information at (703) 648-4000 or by calling the USGS Earth Science Information Center at 1-888-ASK-USGS (275-8747). All Mineral Industry Surveys—mineral commodity, State, and country—also may be retrieved over the Internet at URL <http://minerals.usgs.gov/minerals>.

²Values, percentage calculations, and rankings for 2001 may differ from the Minerals Yearbook, Area Reports: Domestic 2001, Volume II, owing to the revision of preliminary 2001 to final 2001 data. Data for 2002 are preliminary and are expected to change; related rankings may also change.

³Nyal J. Niemuth, Mining Engineer, authored the text of the State mineral industry information provided by the Arizona Department of Mines and Mineral Resources.

\$51.4 million. New producers included Hammond Wholesale Stone, Howard Grey Stone, Horner Stone, Mortimer Stone, Silver Arrow Stone Co., and Stone World.

Alpha Calcit Arizona Ltd. submitted a mining plan of operations (MPO) to the Coronado National Forest to mine calcium carbonate at the rate of 90,000 t/yr from the Alpha Calcit Marble Mine at the north end of the Dragoon Mountains. The Coronado National Forest had began the National Environmental Policy Act (NEPA) process and projected release of the draft environmental impact statement (EIS) by December 2003 and the final EIS by March 2004. Alpha Calcit plans to supply special additives to the paper and plastics industries.

Gypsum.—In the first quarter of 2002, British Plasterboard, the world's largest manufacturer of gypsum wallboard, bought the three wallboard plants owned by James Hardie Industries and its Western Mining and Minerals gypsum mine near Littlefield, AZ, south of St. George, UT. Current gypsum production at Western Mining and Minerals was about 640,000 t/yr. This is more than the combined total of Arizona's five other producers. Western Mining and Minerals reported plans to double capacity to 1,280,000 t/yr by yearend 2004. Essentially 100% of Western's production is consumed in the Las Vegas area for wallboard manufacture and portland cement production.

Metals

Copper.—Arizona continued to be the number one copper-producing State, accounting for 67% of U.S. production. The U.S. producer cathode price averaged \$0.758 per pound, a fall of only 1.6% from 2001.

Losses continued for Arizona's copper producers in 2002. The economic loss to the State was huge. The estimated value of Arizona's 2002 copper production was \$1.26 billion, a decline of \$210 million. The decline from the 1995 peak of \$3.5 billion was dramatic. In 1995, copper accounted for more than 80% of the State's mineral value compared to about 56% for 2002. As the copper industry has struggled during the past 5 years, approximately 6,000 miners have been laid off.

In midyear 2002, the U.S. Department of Justice temporarily blocked the sale by ASARCO Incorporated (a subsidiary of Grupo Mexico S.A. de C.V.) of its 54% share of Southern Peru Copper Corp. (SPCC) because of concern about the company's financial ability to meet current and pending environmental obligations in the United States. The sale to Grupo Mexico's intermediary, Americas Mining Corp., would strengthen Asarco's financial situation and allow it to repay \$450 million in financing originally due in November 2002. The lenders extended the deadline until early 2003 while talks between Asarco and the U.S. Department of Justice continued. In January 2003, an agreement was reached allowing Asarco to transfer its interest in SPCC, but required \$100 million to be placed in a trust to fund environmental cleanup in Arizona and other States.

Asarco mined high-grade areas of the Ray Mine that averaged as high as 0.85% copper to help cut costs and generate more income. The high-grade material contributed to a record 173,000 metric tons (t) of copper being recovered, 13,000 t more than in 2001. Although leach solvent extraction-electrowin (SX-EW) production was down slightly from last year's record level, copper recovered in concentrate from the two concentrators increased 16% to a record 132,000 t. For a 2-month period at midyear, stripping activity was halted at Ray, resulting in more employee layoffs. Asarco also deferred maintenance and capital purchases to conserve cash.

Unlike Ray, the high-cost Mission Mine suffered cutbacks in production, operating at one-third of mill capacity for the first half of the year. At midyear, stripping activity was halted at Mission, and a possible closure was announced in the fall. The mine cutbacks have affected the Hayden smelter, and it is operating well below capacity. In late December, Asarco announced it would further reduce production at Mission to 15% of capacity, about 23,000 t/yr, rather than close the mine. Asarco also sought a temporary 15% pay cut for employees, but workers rejected the proposal.

The Silver Bell Mine, a 125-employee all-leach operation, produced 20,000 t of copper in 2002. Asarco agreed to remove a pipeline, a power line, and a road from the property that is on Federal lands, now included within the boundaries of Ironwood National Monument.

BHP-Billiton announced it would permanently close the San Manuel open pit and underground mine facility in January 2002. The mine's in situ leach operation, producing about 450 metric tons per month via SX-EW, was also shut down. All underground equipment has been removed and the dewatering pumps have been turned off. Removal of surface equipment, including the access and production headframes and hoists, makes it quite unlikely the underground mine would reopen. The underground mine, shut down since 1999, had hoisted a world record 630 Mt of ore during its operation. The San Manuel smelter, refinery, and rod plant continued to be on care-and-maintenance status and remained for sale.

Recognizing the extensive leach technology and expertise within the company, BHP-Billiton decided to conduct large-scale testing at Pinto Valley. Permits were acquired to test low-cost, enhanced bio-leach recovery of copper from primary sulfide mineralization. If successful, the demonstration project could return the mine to production as a chalcopyrite mine-for-leach facility.

Kennecott Exploration Co. continued the deep drilling program on the Magma Porphyry, also called Resolution Copper. Though multiple drill rigs were on the property for much of the year, no results have been announced. The new discovery was described previously by BHP (Manske and Paul, 2002). Notable characteristics reported by Manske and Paul were large hypogene zones of pyrite–bornite–chalcocite with grades of 1.0% to 2.0% copper. They characterized it as a giant copper system with a metal content greater than most known copper deposits. In a mineral terrain previously thought to be well understood, the deposit was a surprising

and impressive discovery.

Phelps Dodge Corp.'s Morenci Mine increased total copper production by 19,000 t. In the first full year of all-leach operation, 374,000 t of copper was recovered via SX-EW. About 35% of production came from the high-grade crushed leach portion of the operation.

At the Bagdad and Sierrita mines, production cutbacks reduced output by 35% and 37%, respectively, which was less than originally anticipated. Production at Bagdad and Sierrita fell to 76,000 t and 69,000 t, respectively. Phelps Dodge reported the production cutbacks would last as long as market conditions dictate.

At the Bagdad Mine, construction proceeded on a \$40 million concentrate pressure leach plant and EW expansion. Phelps Dodge had two new process technologies under consideration: a high-temperature-pressure oxidation that converts all sulfur to sulfuric acid and a medium-temperature-pressure oxidation where sulfur is converted to elemental sulfur. The first method will be used at Bagdad where an 3.4-meter (m) diameter by 15-m long vessel will operate at 225° C and 475-pounds-per-square-inch pressure. The demonstration plant was anticipated to be complete in the second quarter of 2003 and will process 15% of concentrate output into cathode copper and provide sulfuric acid for conventional heap leaching at the mine.

The final EIS for the Safford leach project (Safford and San Juan deposits) was to be released in the second quarter of 2003, according to U.S. Bureau of Land Management officials. The delay in release was caused by concern by the U.S. Bureau of Indian Affairs and the San Carlos Indians about possible impacts of ground water withdrawals. Predicted impacts were a ground water model's predicted withdrawal of 250,000 cubic meters of water during the 16-year mine life. Efforts for the Safford project began 8 years ago. The proposed project would produce 113,000 t/yr of copper and employ 250 people during its 16-year proposed mine life. Obtaining approval will not mean construction would automatically begin immediately. Phelps Dodge said it would consider the copper market and compare costs to restarting mothballed capacity at other operations.

Gold and Uranium.—American Bonanza Gold Mining Corp. was able to raise funds for exploration at Copperstone in western Arizona. Late in the year, work was underway to extend an adit to allow underground drilling of the "D Zone." Rising gold prices resulted in increased interest among junior companies who announced property acquisitions or had work programs underway in a number of districts across the State.

Low prices have discouraged mining and exploration at uranium mineralized breccia pipes on the Colorado Plateau for a number of years. Taiwan Power Co. and RME Holding Co. put up their mineral holdings for sale. Included were the Sage, Wate, and SBF pipes with proven and potential reserves containing 4,500 t of uranium oxide (U₃O₈) in material grading 0.67% to 0.83%. A fourth pipe also contains drill-indicated high-grade mineralization. Unfortunately, there has been little interest, and some portions of the lands have been relinquished.

Government Programs

The Aggregate Mining Community Notice Act became Arizona law, potentially affecting certain new or major modifications to existing aggregate operations in counties with more than 2 million residents (only Maricopa County at present). Upon petition by at least 100 residents who reside within 0.8 kilometer (km) of an existing aggregate mining operation, the board of supervisors shall designate and establish the boundaries of an aggregate mining operations zoning district. In addition, the board of supervisors may establish districts on initiative of the board. Within these districts, the law requires operators to file a community notice with the State Mine Inspector and with residents within a 0.8 km of the operation and establishes committees to mediate disputes between the public and operators.

The establishment of numerous national monuments in the western States, some of which were in mineralized areas, caused the loss of 800,000 ha of multiple-use lands. The U.S. District Court of Appeals for the District of Columbia affirmed lower court rulings that had dismissed challenges to the constitutionality of their creation. The Mountain States Legal Foundation planned an appeal to the Supreme Court.

The ADMMR acquired data at a high rate. The donation last year by GEOEXploration Co. of geophysical data, maps, and mine files was the largest ever received. Cataloging efforts continue prior to public release of the data.

Reference Cited

Manske, S.L., and Paul, A.H., 2002, Geology of a major new porphyry copper center in the Superior (Pioneer) District, Arizona: *Economic Geology*, v. 97, no. 2, March-April, p. 197-220.

TABLE 1
NONFUEL RAW MINERAL PRODUCTION IN ARIZONA^{1,2}

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2000		2001		2002 ^p	
	Quantity	Value	Quantity	Value	Quantity	Value
Clays, common	W	W	W	W	42 ^e	12 ^e
Copper ³	929	1,810,000	879	1,490,000	760	1,260,000
Gemstones	NA	2,920	NA	1,610	NA	1,640
Gold ³ kilograms	W	W	W	W	129	1,270
Sand and gravel, construction	59,400	304,000	52,900	288,000	49,200	273,000
Silver ³ metric tons	133 ^r	21,400 ^r	W	W	W	W
Stone, crushed	8,030	48,200	8,320	49,600	8,200	49,900
Zeolites metric tons	(4)	NA	(4)	NA	(4)	NA
Combined values of cement, clays (bentonite), gypsum, (crude), iron oxide pigments [crude 2000], lime, mica (2002), molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand and gravel (industrial), stone (dimension sandstone), and values indicated by symbol W	XX	326,000	XX	343,000	XX	321,000
Total	XX	2,510,000	XX	2,170,000	XX	1,900,000

^eEstimated. ^pPreliminary. ^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; values included with "Combined values" data. XX Not applicable.

¹Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Recoverable content of ores, etc.

⁴Withheld to avoid disclosing company proprietary data.

TABLE 2
ARIZONA: CRUSHED STONE SOLD OR USED, BY KIND¹

Kind	2000				2001			
	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value
Limestone	10	4,280	\$21,700	\$5.07	9	4,490	\$23,100	\$5.15
Marble	2	W	W	8.96	1	W	W	5.48
Granite	22	1,870	14,400	7.71	21	2,150	16,200	7.51
Traprock	1	W	W	11.54	1	W	W	5.51
Sandstone and quartzite	2	W	W	5.00	2	W	W	5.25
Volcanic cinder and scoria	7 ^r	186 ^r	901 ^r	4.84 ^r	7	148	769	5.20
Miscellaneous stone	11 ^r	1,450 ^r	8,560 ^r	5.90	8	1,300	8,350	6.40
Total or average	XX	8,030	48,200	6.01	XX	8,320	49,600	5.97

^rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

¹Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

TABLE 3
ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 2001, BY USE¹

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Construction:			
Coarse aggregate (+1 1/2 inch):			
Riprap and jetty stone	W	W	\$8.93
Other coarse aggregates	W	W	3.42
Coarse aggregate, graded, other graded coarse aggregate	W	W	3.63
Fine aggregate (-3/8 inch), other fine aggregate	W	W	3.64
Coarse and fine aggregates:			
Graded road base or subbase	W	W	3.84
Unpaved road surfacing	W	W	3.58
Terrazzo and exposed aggregate	W	W	13.15
Crusher run (select material or fill)	W	W	3.53
Other coarse and fine aggregates	163	\$591	3.63
Other construction materials	173	1,320	7.65
Chemical and metallurgical:			
Cement manufacture	W	W	5.10
Other miscellaneous uses and specified uses not listed	W	W	6.06
Unspecified:²			
Reported	1,770	11,400	6.44
Estimated	2,700	14,000	5.29
Total or average	8,320	49,600	5.97

W Withheld to avoid disclosing company proprietary data; included in "Total."

¹Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

²Reported and estimated production without a breakdown by end use.

TABLE 4
ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 2001, BY USE AND DISTRICT¹

(Thousand metric tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction:						
Coarse aggregate (+1 1/2 inch) ²	W	W	W	W	W	W
Coarse aggregate, graded ³	--	--	--	--	W	W
Fine aggregate (-3/8 inch) ⁴	--	--	--	--	W	W
Coarse and fine aggregate ⁵	W	W	--	--	W	W
Other construction materials	31	386	--	--	142	937
Chemical and metallurgical ⁶	W	W	--	--	W	W
Other miscellaneous uses ⁷	--	--	--	--	W	W
Unspecified: ⁸						
Reported	W	W	W	W	437	2,980
Estimated	830	3,860	290	1,610	1,540	8,560
Total	2,570	15,400	331	1,870	4,420	26,000
	Unspecified districts					
	Quantity	Value				
Construction:						
Coarse aggregate (+1 1/2 inch) ²	--	--				
Coarse aggregate, graded ³	--	--				
Fine aggregate (-3/8 inch) ⁴	--	--				
Coarse and fine aggregate ⁵	--	--				
Other construction materials	--	--				
Chemical and metallurgical ⁶	--	--				
Other miscellaneous uses ⁷	--	--				
Unspecified: ⁸						
Reported	999	6,340				
Estimated	--	--				
Total	999	6,340				

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes riprap and jetty stone and other coarse aggregates.

³Includes other graded coarse aggregates.

⁴Includes other fine aggregates.

⁵Includes crusher run (select material or fill), graded road base or subbase, terrazzo and exposed aggregate, unpaved road surfacing, and other coarse and fine aggregates.

⁶Includes cement manufacture.

⁷Includes other specified uses not listed.

⁸Reported and estimated production without a breakdown by end use.

TABLE 5
ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 2001, BY MAJOR USE CATEGORY¹

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Concrete aggregates (including concrete sand)	10,800	\$61,900	\$5.73
Plaster and gunitite sands	288	2,480	8.61
Concrete products (blocks, bricks, pipe, decorative, etc.)	267	2,040	7.64
Asphalt concrete aggregates and other bituminous mixtures	3,610	22,000	6.09
Road base and coverings	5,010	22,700	4.53
Road stabilization (cement)	246	743	3.02
Fill	332	1,110	3.34
Snow and ice control	1	10	10.00
Other miscellaneous uses ²	181	1,670	9.23
Unspecified: ³			
Reported	23,500	128,000	5.45
Estimated	8,600	45,000	5.23
Total or average	52,900	288,000	5.44

¹Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

²Includes railroad ballast.

³Reported and estimated production without a breakdown by end use.

TABLE 6
ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 2001, BY USE AND DISTRICT¹

(Thousand metric tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand) ²	607	4,840	171	1,260	10,300	58,300
Concrete products (blocks, bricks, pipe, decorative, etc.)	--	--	--	--	267	2,040
Asphaltic concrete aggregates and road base materials ³	1,270	6,190	195	1,030	6,860	36,900
Fill	110	420	30	107	191	585
Snow and ice control.	--	--	1	10	--	--
Other miscellaneous uses	4	19	1	4	176	1,640
Unspecified: ⁴						
Reported	1,620	8,290	71	358	21,600	119,000
Estimated	2,000	11,000	590	2,900	6,000	31,000
Total	5,630	30,300	1,060	5,640	45,400	250,000
	Unspecified districts					
Use	Quantity	Value				
Concrete aggregates (including concrete sand) ²	--	--				
Concrete products (blocks, bricks, pipe, decorative, etc.)	--	--				
Asphaltic concrete aggregates and road base materials ³	533	1,370				
Fill	--	--				
Snow and ice control.	--	--				
Other miscellaneous uses	--	--				
Unspecified: ⁴						
Reported	213	353				
Estimated	--	--				
Total	746	1,720				

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes plaster and gunite sands.

³Includes road and other stabilization (cement).

⁴Reported and estimated production without a breakdown by end use.