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The Class V Underground Injection Control Study

Volume 12

Solution Mining Wells

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SOLUTION MINING WELLS

The U.S. Environmental Protection Agency (USEPA) conducted a study of Class V underground injection wells to develop background information the Agency can use to evaluate the risk that these wells pose to underground sources of drinking water (USDWs) and to determine whether additional federal regulation is warranted. The final report for this study, which is called the Class V Underground Injection Control (UIC) Study, consists of 23 volumes and five supporting appendices. Volume 1 provides an overview of the study methods, the USEPA UIC Program, and general findings. Volumes 2 through 23 present information summaries for each of the 23 categories of wells that were studied (Volume 21 covers 2 well categories). This volume, which is Volume 12, covers Class V solution mining wells.

1. SUMMARY

Solution mining wells are used to inject a fluid (lixiviant) into underground mines to dissolve mineral values from the ore. The resulting "pregnant" solution is then brought to the surface, through separate wells, for subsequent recovery of the dissolved mineral being produced. Solution mining wells that are currently regulated under the federal definition of Class V injection wells are used in the recovery of copper, uranium, and potentially other minerals, from mines that have already been conventionally mined, through the injection of solutions of sodium bicarbonate or sulfuric acid in ground water or recirculated mine water. When solution mining techniques are used to extract minerals from ore bodies that have not been conventionally mined, the injection wells are classified as Class III injection wells under USEPA regulations.

The characteristics of the injected solution are highly dependent on those of the ore body being mined because a variety of metals present in the ore body are incorporated into the solution as it goes through repeated cycles of injection, extraction, and reinjection. Data on the composition of solution mining fluids indicate that the concentrations of sulfate, molybdenum, radium, selenium, arsenic, lead, and uranium exceed primary drinking water maximum contaminant levels (MCLs) or health advisory levels (HALs). Concentrations of total dissolved solids (TDS), chloride, manganese, aluminum, iron, sulfate, and zinc have been measured above the secondary MCLs. Site-specific factors determine which constituents exceed one or more of the standards.

In many cases, the hydrogeology of the injection zone, or mined ore body, has already been altered by ground water pumping as well as previous mining. In uranium mining, for example, the formation is a water-bearing sandstone. As part of solution mining operations, ground water flow is normally modified to create a drawdown, or zone of depression, so that the injected lixiviant is retained in the leaching zone for subsequent recovery.

No ground water contamination incidents have been identified that are directly attributable to Class V solution mining injection wells. However, the fluids injected into these wells inherently contain a variety of metals at concentrations above MCLs or HALs, and contamination resulting from a

combination of mining-related activities has been reported at several sites. Elevated concentrations of metals have been observed in ground water in the vicinity of solution mining operations, but complex hydrogeology and other mining and mining-related activities make it difficult to attribute the cause to a specific activity, such as solution mining injection wells. At sites where solution mining injection wells are used, the likelihood that ground water contamination will result is dependent primarily on overall mining operations rather than the specific construction and operational practices of the injection wells. Specifically, the chance of migration of the solubilized metals from the injection zone depends on the effectiveness of measures like ground water pumping and monitoring that are used to ensure that the leaching solution is contained within the *in situ* leaching zone.

No information was collected that indicates these wells are vulnerable to receive spills or illicit discharges.

The state and USEPA Regional survey results indicate that there are 2,694 documented solution mining wells in the U.S. (no more were estimated, indicating that there is substantial confidence in this documented number). Eight of these wells are associated with a uranium mine in New Mexico; the remaining wells occur at two copper mines in Arizona. Wells at one solution mining operation in Potash, Utah that meet the federal Class V definition are not included in this report because they are regulated by the state as Class III wells. Another solution mining well in Colorado that was initially permitted as an experimental Class V well is considered a Class III well. The prevalence of Class V solution mining wells in the future depends on a wide range of factors such as commodity prices and the development of lower cost mining and beneficiation processes.

Both Arizona and New Mexico control solution mining through the use of individual permits, although in Arizona, where the UIC program is implemented by USEPA Region 9, the state uses an Aquifer Protection Permit rather than a UIC permit. Both states have operating and monitoring requirements. Arizona also places requirements on construction and maintenance practices, and financial assurance must be demonstrated.

2. INTRODUCTION

The existing UIC regulations in Title 40 of the Code of Federal Regulations (CFR) define Class V injection wells to include "wells used for solution mining of conventional mines such as stopes leaching" (40 CFR 146.5(e)(13)). Class III injection wells, which are defined by 40 CFR 146.5(c), include injection wells used in extraction of sulfur by the Frasch process and *in situ* production of metals and other materials from ore bodies that have not been conventionally mined. The scope of this document is limited to injection wells regulated as Class V wells, i.e., wells used for injection into previously mined ore bodies.

The distinction between Class III and Class V solution mining injection wells was established in revisions to the UIC Technical Criteria and Standards (40 CFR 146) published on August 27, 1981 (46 *FR* 43156). USEPA made this distinction because the designs of some injection wells used in solution mining of previously mined ore bodies prevent the wells from meeting requirements applicable to Class III injection wells. In particular, injection wells used in solution mining of previously mined ore bodies may function as "vertical sprinklers" by distributing injected fluid throughout their length (much of which may he horizontal or angled, rather than vertical).[1] In such an application, the wells by design are unable to comply with the mechanical integrity requirements applicable to Class III injection wells. A specific example of a solution mining technique that uses Class V injection wells is called stopes leaching, in which fluids are circulated through the stopes (mined areas) of a conventional mine to dissolve minerals for subsequent extraction and recovery. Copper and uranium are examples of metals that are mined using Class V solution mining wells, but not necessarily using the stopes leaching technique.

3. PREVALENCE OF WELLS

For this study, data on the number of Class V solution mining wells were collected through a survey of state and USEPA Regional UIC Programs. The survey methods are summarized in Section 4 of Volume 1 of the Class V Study. Table 1 lists the numbers of Class V solution mining wells in each state, as determined from this survey. The table includes the documented number and estimated number of wells in each state, along with the source and basis for any estimate, when noted by the survey respondents. If a state is not listed in Table 1, it means that the UIC Program responsible for that state indicated in its survey response that it did not have any Class V solution mining wells.

In early 1999, a total of 2,694 Class V solution mining wells were reported in the U. S., and these are located in two states, New Mexico and Arizona. As indicated in Table 1, all of these reported Class V solution mining wells are located at three facilities: two copper mines in Arizona (1882 wells and 804 wells) and one uranium mine in New Mexico (8 wells). The facility in New Mexico, which is located in the Amborosia Lake area approximately 15 miles north of Grants and operated by Quivira Mining Company, has a permit that would allow construction of up to 12 injection wells (Yuhas, 1999). In Arizona, the facility with 1882 active wells plans to construct 60 new wells in 1999 and the facility with 804 active wells plans to construct 171 additional wells in 1999 (BHP Copper, 1999a, 1999b). Some other states, such as Wyoming, choose to impose requirements more stringent than the federal requirements by regulating all solution mining wells as Class III wells. Only wells regulated primarily as Class V (rather than Class III) solution mining wells are included in this document.[2]

[1] The injected fluid, which dissolves the target metal from the surrounding ore body, is then collected and extracted through other wells or from underground mine workings in which the fluid collects.

[2] A solution mining well that was originally classified as an experimental well in USEPA Region 8 is being reclassified as a Class III solution mining well.

Table 1. Inventory of Class V Solution Mining Wells in the U. S.

State	Documented Number of Wells	Estimated Number of Wells	
		Number	Source of Estimate and Methodology
USEPA Region 1 -- None			
USEPA Region 2 -- None			
USEPA Region 3 -- None			
USEPA Region 4 -- None			
USEPA Region 5 -- None			
USEPA Region 6			
NM	8	8	N/A
USEPA Region 7 -- None			
USEPA Region 8 -- None			
USEPA Region 9			
AZ	2,686	2,686	N/A
USEPA Region 10 -- None			
All USEPA Regions			
All States	2,694	2,694	N/A

N/A Not available.

4. INJECTATE CHARACTERISTICS AND INJECTION PRACTICES

4.1 Injectate Characteristics

Using chemical solutions to dissolve and then extract subsurface metals is termed solution mining or *in situ* leaching. Solution mining is used to extract a wide range of minerals, but only uranium and copper mining activities currently use injection wells that are included in the Class V subcategory of solution mining wells, based on the inventory information presented in Section 3 above. The lixiviants (injected fluids) used in uranium solution mining operations include sodium bicarbonate and/or sulfuric acid solutions. For copper solution mining, sulfuric acid is the primary active ingredient in the lixiviant.

4.1.1 Uranium

The Quivira Mining Company uranium mine performs stopes leaching in previously mined areas to extract uranium from the Westwater Canyon sandstone formation. Lixiviant composed of ground water, sodium bicarbonate, and/or sulfuric acid,[3] and recirculated mine water is circulated (injected and extracted) through the workings of 8 underground uranium mines (New Mexico Environment Department, 1997). As shown in Table 2, analyses of stopes leaching fluid samples collected in 1998 indicate that chloride, sulfate, TDS, manganese, molybdenum, radium, selenium, and uranium are present at concentrations that exceed MCLs or HALs. Detection limits for available data for arsenic, beryllium, and cadmium were above the MCL or HAL for these constituents so it is unclear whether these constituents are present at concentrations above MCLs or HALs.

4.1.2 Copper

BHP Copper, Inc. owns and operates Class V solution mining wells at the company's Pinto Valley and San Manuel mining facilities. Data on the chemical characteristics of the fluids injected into these wells were not available for inclusion in this report. Data on the composition of ground water samples collected within the *in situ* area sub-basin, which are thought to be indicative of injectate characteristics, are shown in Table 3. As shown, concentrations of sulfate, TDS, aluminum, arsenic, iron, manganese, lead, and zinc are above applicable drinking water standards or health advisory levels (i.e., MCLs or HALs).

4.2 Well Characteristics

4.2.1 Uranium

At the Quivera Ambrosia Lake old stope mining area, lixiviant is injected into the *in situ* leaching zone through polyvinyl chloride (PVC) tubing. Bore holes are drilled from the ground surface into the mine workings, which are approximately 300 to 500 feet below the surface. Tubing is then run down the holes and lixiviant is injected by gravity through the tubing into the mine with the bottom of the tubing oriented such that the injectate is sprayed onto the walls of the mine workings (Yuhas, 1999).

4.2.2 Copper

Solution mining for copper extraction following underground mining activity is illustrated in the schematic provided in Figure 1. (The heap leaching operation shown in Figure 1 is an optional element that may not be part of all solution mining operations.)

[3] Subsurface conditions are such that sulfuric acid addition is not routinely required to maintain the desired pH.

Table 2. Uranium Stope Leaching Fluid Characteristics
(concentrations in mg/l except as noted)

Constituent	Drinking Water Standards		Health Advisory Level		Leaching Fluid
	mg/l	P/S*	mg/l	C/N*	
Total Ra-226	5 **	P	20 **	C	128.0 pCi/L
Total Ra-228	5 **	P	20 **	C	1.60 pCi/L
Potassium	--		--		24.1
Sodium	--		--		375
Calcium	--		--		382
Magnesium	--		--		107
Chloride	250	S	--		429
Sulfate	500	P	--		1,370
pH	6.5 - 8.5	S	--		8
TDS	500	S	--		3,010
Aluminum	0.05 - 0.2	S	--		<0.1
Arsenic	0.05	P	0.002	C	<0.025
Barium	2	P	2	N	<0.1
Beryllium	0.004	P	0.0008	C	<0.05
Boron	--		0.6	N	0.2
Cadmium	0.005	P	0.005	N	<0.1
Calcium	--		--		380
Chromium	0.1	P	0.1	N	<0.1
Cobalt	--		--		<0.05
Copper	1.3	P	--		<0.1
Iron	0.3	S	--		<0.1
Magnesium	--		--		120
Manganese	0.05	S	--		0.22
Molybdenum	--		0.04	N	0.2
Nickel	0.1	P	0.1	N	<0.1
Selenium	0.05	P	--		0.7
Silicon	--		--		5.8
Silver	0.1	S	0.1	N	<0.1
Strontium	--		17	N	9
Tin	--		--		<0.1
Uranium	0.02	P	--		26
Vanadium	--		--		<0.1
Zinc	5	S	2	N	<0.1

* P=primary; S=secondary; N=non-cancer; C=cancer

** Standard is for Radium 226 & 228 combined; units are pCi/L.

Source: New Mexico Environment Department, 1998

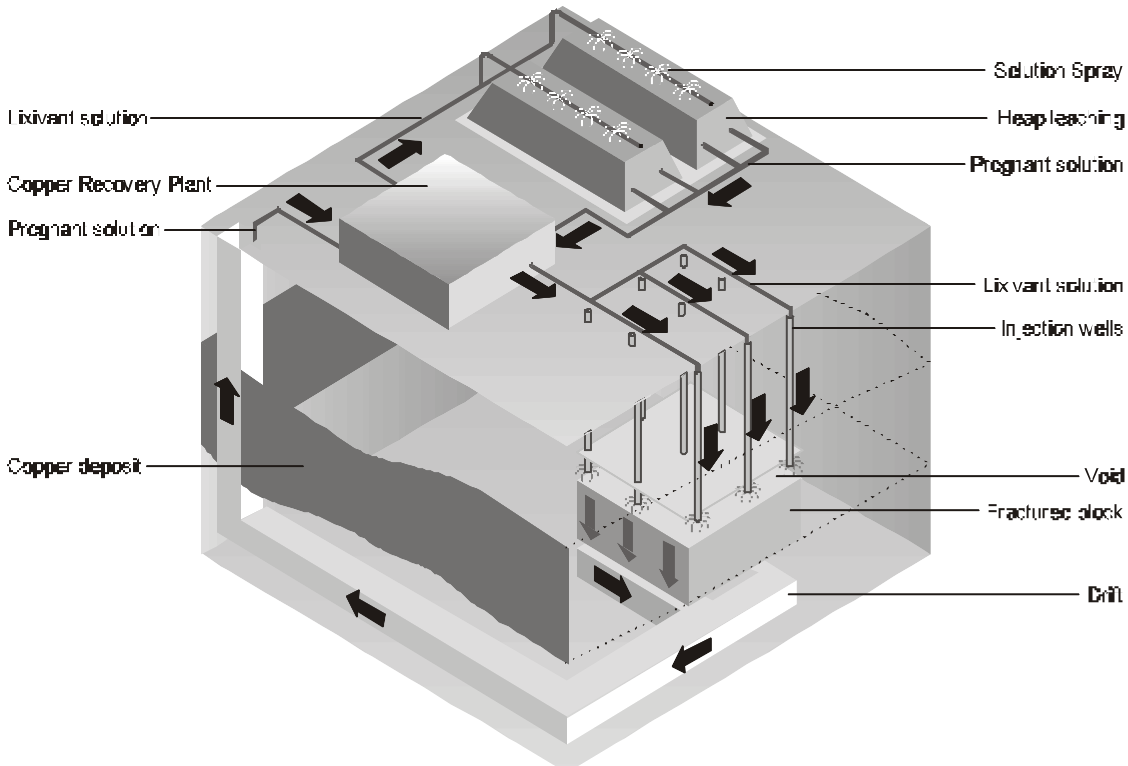
Table 3. Ground Water Quality Within the *In Situ* Area at Pinto Valley (Miami Unit)

(concentrations in mg/l)

	Drinking Water Standards		Health Advisory Levels		Well A*		Well B*	
Constituent	(mg/l)	P/S**	(mg/l)	N/C**	5/21/96	9/10/96	8/5/96	9/11/96
Calcium					354	251		510
Magnesium					32	27		290
Potassium					7	6		30
Sodium					25.1	25		50
Chloride	250	S			11	13		30
Sulfate	500	P			870	750	2740	4200
Fluoride	4	P			0.2	0.4	28	50
Nitrate	10	P			0.02	0.02	0.89	0.16
Nitrite	1	P			<0.01	<0.01	<0.01	<0.01
Silica					64	58		110
TDS	500	S			1360	1180		6090
pH (std. units)	6.5 - 8.5	S			6.6	6.7	4.3	4.1
Silver	0.1	S	0.1	N	0.007	<0.03		<0.3
Aluminum	0.05 - 0.2	S			1.84	2.9		112
Arsenic	0.05	P	0.002	C	0.106	0.062		0.035
Barium	2	P	2	N	0.03	0.11		0.2
Beryllium	0.004	P	0.0008	C	<0.002	<0.01		0.4
Bromide					<0.03	<0.03		<0.03
Cadmium	0.005	P	0.005	N	<0.003	<0.02	<0.02	<0.2
Cyanide	0.2	P	0.2	N	<0.01	<0.01		<0.01
Cobalt					<0.01	<0.05		1.3
Chromium	0.1	P	0.1	N	0.04	<0.05	<0.2	<0.5
Copper	1.3	P			0.42	0.28	99.3	210
Iron	0.3	S			2.77	27.9	240	479
Mercury	0.002	P	0.002	N	<0.0002	<0.0002		0.0007
Lithium					0.06	<0.1		<1
Manganese	0.05	S			0.487	0.76	48.5	68.7
Nickel	0.1	P	0.1	N	0.02	<0.1		1.6
Lead	0.015	P			0.04	0.1	0.1	<1
Phosphate					0.04	<0		0.21
Antimony	0.006	P	0.003	N	<0.002	0.002		0.01
Selenium	0.05	P			<0.001	<0.001		0.007
Thallium	0.002	P	0.0005	N	<0.002	<0.002		<0.002
Zinc	5	S	2	N	0.02	8.2	6.27	8.9

* Well A is MU-955; well B is MU-962
** P=primary; S=secondary; N=non-cancer; C=cancer
Source: WQARF, 1996.

Figure 1. Copper Solution Mining Facility



Source: Solution Mining Corporation, 1998.

At the Pinto Valley (Miami Unit) facility, Class V solution mining wells are located within a subsidence zone created by underground mining and portions of the injection well field are located in an area that has been mined by open pit methods. The 1882 active wells (as of 2/10/99) are typically constructed of 1-1/2 inch diameter polyvinyl chloride casing with 1/4 inch holes drilled approximately one per foot (BHP Copper, 1999a). The casing extends to depths ranging from approximately 20 to 891 feet below land surface. Injected solutions are recovered from a recovery well located in the injection well field and are pumped from levels within the underground mine (Turner, 1999a).

The San Manuel solution mining injection wells, like the wells at the Pinto Valley facility, are surrounded by a subsidence area created by underground mining. The wells are within a copper oxide open pit mine that directly overlies a sulfide underground mine where ore was extracted using block-caving methods. The ore body lies about 2,500 to 4,000 feet below the surface (BHP Copper, 1999b and 1999c), with an average rubblized (broken up) thickness of 1,625 feet (Schmidt, 1989). Injection wells at this facility are either associated with a well-to-well circuit, referred to as surface recovery, or a well-to-underground circuit, referred to as underground recovery. Typical surface recovery injection wells are constructed using 6 inch PVC casing and approximately 200 feet of well screen or slotted pipe to depths ranging from 300 to 800 feet below ground surface (bgs). Underground recovery injection well construction is similar, however the wells extend to 1,200 bgs or greater (Turner, 1999b).

Approximately 80 percent of the injected solution is recovered via production wells that are part of a well-to-well circuit. The balance of injected solution is recovered in the underground circuit through collection in containment structures at the 2675, 2375, and 1475 haulage levels[4] where it is pumped to the surface for processing (Turner, 1999b).

4.3 Operational Practices

The Ambrosia Lake uranium mine circulates (injects and extracts) up to 1,440,000 gallons per day of lixiviant composed of ground water, sodium bicarbonate, and/or sulfuric acid,[5] and recirculated mine water through the workings of 8 underground uranium mines using Class V wells with gravity flow (New Mexico Environment Department, 1997). Injectate is collected in the mine workings through gravity flow into drains, and pumped to a uranium mill for processing. The lixiviant used at this facility is recycled water from the mine, which is sufficiently acidic (without the addition of acid) to dissolve uranium from the sandstone. To maximize recovery of the lixiviant, ground water withdrawal is used to maintain ground water flow toward the mine (and leaching zone) (Yuhas, 1999).

At the copper production facilities that use Class V solution mining wells, the wells are operated manually under gravity flow conditions and no injection pressure is applied (BHP Copper, 1999a). The wells are designed to maximize contact of the leaching solution with the surrounding rock mass in the vadose zone, so mechanical integrity testing is not required (Turner, 1999a, 1999b).

The Pinto Valley Operation, Miami Unit, which is located in Gila County, began producing copper using *in situ* leaching of formerly block caved and conventionally mined copper oxide ore body in 1941.[6] Leach solution is pumped through high density polyethylene piping into the in-situ wellfield and injected into more than 30 miles of old underground workings and then is pumped to the surface for copper recovery (WQARF, 1996). Currently, the combined injection rate is approximately 3,300 gallons per minute for all active in-situ injection wells. The injection well field is located in an area that is a regional hydraulic sink. As a result, ground water flows are toward the underground workings, recovery well, and mine shaft, which make up the recovery system (Turner, 1999a).

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[4] The levels in the mine along or inside the ore body or closely parallel to it that are used to transport the mineral from stopes to the hoisting shaft.

[5] Subsurface conditions are such that sulfuric acid addition is not routinely required to maintain the desired pH.

[6] More than 500 million pounds of copper were produced using *in situ* leaching over the last 50 years (WQARF, 1996).

Use of Class V solution mining wells at the San Manuel copper production complex in Pinal County, Arizona is similar. Raffinate solution, a weak sulfuric acid from the solvent extraction plant, is injected and percolates through the oxide ore body. Currently, the combined injection rate is approximately 8,000 gallons per minutes (gpm) through approximately 800 injection wells. On-going development of the well field is anticipated to result in a peak injection rate of approximately 18,000 gpm (Turner, 1999b). The resulting copper bearing solution is collected in one of two ways: via recovery wells equipped with submersible pumps or in the old portion of the underground sulfide mine. In this old portion of the mine, panels have been dammed to create collection areas. The recovered solution has a high suspended solids content (about 600 mg/l), and is pumped to the surface and placed into sedimentation ponds, where the solution is clarified. Flocculants are added, the solution is then fed to the Plant Feed pond where it is combined with leach solution from the facilities heap leach, and sent to the solvent extraction plant (USEPA, No date). The injection well field is located within a cone-of depression created in the regional ground water system that is a result of mine dewatering necessary for on-going underground sulfide copper ore mining. As a result, ground water flows are radically inward toward the underground workings, recovery well, and underground recovery location (Turner, 1999a and 1999b).

Due to subsidence, plugging, and expansion of surface mining activities, well losses occur routinely and addition of new wells is an on-going activity. At the San Manuel facility, for example, the operational lifespan on a Class V solution mining injection well averages about 24 weeks (Schmidt, 1989).

At all three facilities, ground water is monitored, as part of overall mining facility operations, to provide for detection of unintended migration of injected fluids into surrounding formations.

5. POTENTIAL AND DOCUMENTED DAMAGE TO USDWs

5.1 Injectate Constituent Properties

The primary constituent properties of concern when assessing the potential for Class V solution mining wells to adversely affect USDWs are toxicity, persistence, and mobility. The toxicity of a constituent is the potential of that contaminant to cause adverse health effects if consumed by humans. Appendix D to the Class V Study provides information on the health effects associated with contaminants found above MCLs or HALs in the injectate of solution mining wells and other Class V wells.

Persistence is the ability of a chemical to remain unchanged in composition, chemical state, and physical state over time. Appendix E to the Class V Study presents published half-lives of common constituents in fluids released in solution mining wells and other Class V wells. All of the values reported in Appendix E are for ground water. Caution is advised in interpreting these values because ambient conditions have a significant impact on the persistence of both inorganic and organic compounds. Appendix E also provides a discussion of mobility of certain constituents found in the injectate of solution mining wells and other Class V wells.

Constituents in the injectate at concentrations above MCLs or HALs are generally present because they were solubilized during previous injection/recovery cycles and were not removed from solution during the recovery phase. They are both persistent and mobile to the extent that they are generally expected to remain in solution through subsequent injection/recovery cycles.

5.2 Observed Impacts

At all three sites reported to use Class V solution mining wells, injection is occurring into an ore body that is a water-bearing formation, or would be were it not for dewatering activities. The nature of the injectate and the objectives of the injection process are such that metals and other constituents are solubilized in the zone in which *in situ* leaching is conducted. At the copper facilities, mining, beneficiation, and processing operations have been conducted for decades and have included open pit and underground mining, heap leaching, acid production, and smelting and refining, in addition to *in situ* leaching. Hydrogeologic characteristics have been modified by the installation of miles of underground workings, the removal of millions of tons of ore, pumping to dewater the mine workings, and the accompanying subsidence. As a result, it is difficult to attribute the observed concentrations of metals above MCLs in the ground water to a specific activity conducted at the sites, including current *in situ* leaching activities.

The BHP Pinto Valley Miami Unit is within the boundaries of an area that was designated as the Pinal Creek site under the Arizona Water Quality Assurance Revolving Fund (WQARF) in 1989. The Pinal Creek site also includes the Van Dyke mine and the Cyprus Miami mine facilities. Investigation and remediation of ground water contamination at the site is in progress. At this time, it is not clear whether solution mining activities conducted at the Van Dyke mine during the 1970's and 1980's or at the BHP facility have contributed to the ground water contamination at the site (Pond, 1999; Kulon, 1998).

6. ALTERNATIVE AND BEST MANAGEMENT PRACTICES

Class V solution mining injection wells are used to solubilize metals from the host rock in and below the injection zone. As noted above, the principal means of providing protection of ground water resources during injection is to dewater the *in situ* leaching zone or ensure that ground water flows only toward, rather than away from, the leaching zone. Thus, monitoring and controlling injection and extraction rates are required to achieve the necessary balance. In addition, monitoring of the ground water in the vicinity of the *in situ* leaching area can aid in detecting outward migration should it occur. After injection activities are complete, flushing of the injection zone aids in removing residual injectate and returning the ore body to pre-leaching conditions (Charbeneau, 1984). Particularly in the case of uranium leaching operations, reducing agents are sometimes used to aid in reducing metal solubility in the leaching zone to pre-mining conditions.

Although not typically the case for solution mining wells in the current Class V inventory, in some situations there could be a USDW between the surface and the *in situ* leaching zone. In such situations, protection of the USDW from contamination is likely to require that solution mining injection wells be constructed and monitored with features similar to those of Class III wells.

7. CURRENT REGULATORY REQUIREMENTS

Several federal, state, and local programs either directly manage or regulate Class V solution mining wells. On the federal level, management and regulation of these wells fall primarily under the UIC program authorized by the Safe Drinking Water Act (SDWA). Some states and localities have used these authorities, as well as their own authorities, to extend the controls in their areas to address concerns associated with solution mining wells.

7.1 Federal Programs

Class V wells are regulated under the authority of Part C of SDWA. Congress enacted the SDWA to ensure protection of the quality of drinking water in the United States, and Part C specifically mandates the regulation of underground injection of fluids through wells. USEPA has promulgated a series of UIC regulations under this authority. USEPA directly implements these regulations for Class V wells in 19 states or territories (Alaska, American Samoa, Arizona, California, Colorado, Hawaii, Indiana, Iowa, Kentucky, Michigan, Minnesota, Montana, New York, Pennsylvania, South Dakota, Tennessee, Virginia, Virgin Islands, and Washington, DC). USEPA also directly implements all Class V UIC programs on Tribal lands. In all other states, which are called Primacy States, state agencies implement the Class V UIC program, with primary enforcement responsibility.

Solution mining wells currently are not subject to any specific regulations tailored just for them, but rather are subject to the UIC regulations that exist for all Class V wells. Under 40 CFR 144.12(a), owners or operators of all injection wells, including solution mining wells, are prohibited from engaging in any injection activity that allows the movement of fluids containing any contaminant into USDWs, "if the presence of that contaminant may cause a violation of any primary drinking water regulation . . . or may otherwise adversely affect the health of persons."

Owners or operators of Class V wells are required to submit basic inventory information under 40 CFR 144.26. When the owner or operator submits inventory information and is operating the well such that a USDW is not endangered, the operation of the Class V well is authorized by rule. Moreover, under section 144.27, USEPA may require owners or operators of any Class V well, in USEPA-administered programs, to submit additional information deemed necessary to protect USDWs. Owners or operators who fail to submit the information required under sections 144.26 and 144.27 are prohibited from using their wells.

Sections 144.12(c) and (d) prescribe mandatory and discretionary actions to be taken by the UIC Program Director if a Class V well is not in compliance with section 144.12(a). Specifically, the Director must choose between requiring the injector to apply for an individual permit, ordering such action as closure of the well to prevent endangerment, or taking an enforcement action. Because solution mining wells (like other kinds of Class V wells) are authorized by rule, they do not have to obtain a permit unless required to do so by the UIC Program Director under 40 CFR 144.25. Authorization by rule terminates upon the effective date of a permit issued or upon proper closure of the well.

Separate from the UIC program, the SDWA Amendments of 1996 establish a requirement for source water assessments. USEPA published guidance describing how the states should carry out a source water assessment program within the state's boundaries. The final guidance, entitled *Source Water Assessment and Programs Guidance* (USEPA 816-R-97-009), was released in August 1997.

State staff must conduct source water assessments that are comprised of three steps. First, state staff must delineate the boundaries of the assessment areas in the state from which one or more public drinking water systems receive supplies of drinking water. In delineating these areas, state staff must use "all reasonably available hydrogeologic information on the sources of the supply of drinking water in the state and the water flow, recharge, and discharge and any other reliable information as the state deems necessary to adequately determine such areas." Second, the state staff must identify contaminants of concern, and for those contaminants, they must inventory significant potential sources of contamination in delineated source water protection areas. Class V wells, including solution mining wells, should be considered as part of this source inventory, if present in a given area. Third, the state staff must "determine the susceptibility of the public water systems in the delineated area to such contaminants." State staff should complete all of these steps by May 2003 according to the final guidance.[7]

7.2 State and Local Programs

Two states, Arizona and New Mexico, have Class V solution mining injection wells that are covered in this document. Attachment A of this volume describes how each of these states currently addresses these wells. Both states issue individual permits, based on extensive permit application information.

- In Arizona, USEPA Region 9 directly implements the UIC program and does not issue individual permits to solution mining wells. Arizona, however, has a stringent permitting program under its Aquifer Protection Permit program. The state requires submission of detailed information on the design, operation, and other key features of proposed solution mining wells, which must demonstrate that well location, design, construction, or operation will not degrade aquifer water quality or violate MCLs. Ground water monitoring is required.

- New Mexico is a UIC Primacy State for Class V wells. However, the state regulates discharges from solution mining wells that may affect ground water under its Water Quality Act and Water Quality Control Commission regulations on permitting and ground water standards (Subpart III of Title 20, Chapter 6, Part 2) rather than its UIC regulations (Subpart V of Title

[7] May 2003 is the deadline including an 18-month extension.

20, Chapter 6, Part 2). Discharge plans must be submitted and approved by the state, based on information about the proposed discharge, location and quality of ground water most likely to be affected by the discharge, sampling and monitoring plans, and other information. The state issues an Aquifer Protection Permit rather than a UIC permit for Class V solution mining wells.

ATTACHMENT A
STATE AND LOCAL PROGRAM DESCRIPTIONS

This attachment describes the regulatory requirements in New Mexico and Arizona, the two states with Class V solution mining wells covered by this document.

Arizona

USEPA Region 9 directly implements the UIC program for Class V injection wells in Arizona. The region applies inventory requirements and uses permit by rule to ensure non-endangerment of USDWs. In addition, under the Arizona Revised Statutes (Title 49, Chapter 2, Article 3 - Aquifer Protection Permits) any facility that "discharges" is required to obtain an Aquifer Protection Permit (APP) from the Arizona Department of Environmental Quality (ADEQ) (§49-241.A). An injection well is considered a discharging facility and is required to obtain an APP, unless ADEQ determines that it will be "designed, constructed, and operated so that there will be no migration of pollutants directly to the aquifer or to the vadose zone" (§49-241.B).[8]

Permitting

The statute authorizes ADEQ to require an applicant for a permit to provide information on the design, operations, pollutant control measures, hydrogeological characterization, baseline data, pollutant characteristics, and closure strategy. Operators must demonstrate that the facility will be designed, constructed, and operated to ensure greatest degree of discharge reduction and to ensure that aquifer water quality will not be degraded or standards violated. ADEQ may establish best available demonstrated control technology, processes, operating methods or other alternatives, in order to achieve discharge reduction and water quality standards (§49-243).

The statute specifies that an APP requires monitoring, recordkeeping and reporting, a contingency plan, discharge limitations, a compliance schedule, and closure guidelines. The operator must furnish information, such as past performance, and technical and financial competence, relevant to its capability to comply with the permit terms and conditions. A facility must demonstrate financial assurance or competence before approval to operate is granted. Each owner of an injection well to whom an individual permit is issued must register the permit with ADEQ each year and pay an annual registration fee (§49-242).

ADEQ designates a point or points of compliance for each facility receiving a permit. The statute establishes "the point of compliance as the point at which compliance with aquifer water quality standards shall be determined" and as a vertical plane downgradient of the facility that extends through the uppermost aquifer underlying that facility. If an aquifer is not, or will not foreseeably be, a USDW, monitoring for compliance may be established in another aquifer (§49-244).

[8] The state, in its Aquifer Protection Permit Rules, defines "aquifer" as "an underground formation capable of yielding or transmitting usable quantities of water" (R 12-15-801.2).

ADEQ, in its Aquifer Protection Permit Rules (Chapter 19, sub-chapter 9, October 1997), defines an injection well as "a well which receives a discharge through pressure injection or gravity flow." Any facility that discharges is required to obtain an individual APP from ADEQ, although ADEQ is authorized to issue a single area-wide permit to facilities under common ownership located in a contiguous geographic area in lieu of an individual permit for each facility (§49.243P and R 18-9-122). ADEQ requires permit application to include detailed specified information as authorized by statute. This includes topographic maps, facility site plans and designs, characteristics of past as well as proposed discharge, and best available demonstrated control technology, processes, operating methods, or other alternatives to be employed in the facility. In order to obtain an individual permit, a hydrogeologic study must be performed. This study must include a description of the geology and hydrology of the area; documentation of existing quality of water in the aquifers underlying the site; any expected changes in the water quality and ground water as a result of the discharge; and the proposed location of each point of compliance (R18-9-108).

Well Construction Standards

No injection wells may be constructed unless an APP has been completed and approved. Wells are required to be constructed in such as manner as not to impair future or foreseeable use of aquifers. Specific construction standards are determined on a case-by-case basis.

Operating Requirements

All wells must be operated in such a manner that they do not violate any rules under Title 49 of the Arizona Revised Statutes, including Article 2, relating to water quality standards, and Article 3, relating to APPs. Water quality standards must be met at the point of compliance (§49.244) in order to preserve and protect the quality of waters in all aquifers for all present and reasonably foreseeable future uses.

Monitoring Requirements

Monitoring, both of the injectate and of the receiving formation, is required for solution mining wells to ensure compliance with APP conditions and ensure that aquifer water quality standards are met as outlined under 49-223 of the Arizona Revised Statutes. The permit establishes, on a case-by-case basis, alert levels, discharge limitations, monitoring, reporting, and contingency plan requirements. Alert level is defined as a numeric value, expressed either as a concentration of a pollutant or a physical or chemical property of a pollutant, which serves as an early warning indicating a potential violation of any permit condition. If an alert level or discharge limitation is exceeded, an individual permit requires the facility to notify ADEQ and implement the contingency plan (R18-9-110).

Financial Responsibility

An individual permit requires that an owner have and maintain the technical and financial capability necessary to fully carry out the terms and conditions of the permit. The owner must maintain a bond, insurance policy, or trust fund for the duration of the permit (R-18-9-117).

Plugging and Abandonment

Temporary cessation, closure, and post-closure requirements are specified on a case-by-case basis. The facilities are required to notify ADEQ before any cessation of operations occurs. A closure plan is required for facilities that cease activity without intending to resume. The plan describes the quantities and characteristics of the materials to be removed from the facility; the destination and placement of material to be removed; quantities and characteristics of the material to remain; the methods to treat and control the discharge of pollutants from the facility; and limitations on future water uses created as a result of operations or closure activities. A post-closure monitoring and maintenance plan is also required. This plan specifies duration, procedures, and inspections for post-closure monitoring (R-18-9-116).

New Mexico

New Mexico is a UIC Primacy State for Class V wells. Regulations promulgated by the New Mexico Water Quality Control Commission in Title 20, Chapter 6, Part 2 of the New Mexico Administrative Code (NMAC) establish requirements for ground and surface water protection. Subpart III of Title 20, Chapter 6, Part 2, which addresses permitting and ground water protection, applies to all discharges that may affect ground water,[9] including injection into Class V solution mining wells.[10]

Permitting

The purpose of Subpart III is to control discharges onto or below the surface to protect all ground water of the state that has an existing concentration of 10,000 mg/l or less TDS. Generally, if the existing concentration of any water contaminant in ground water is in conformance with standards specified in Section 3103 of Subpart III, degradation of the ground water up to the standard will be allowed. If the existing concentration of any contaminant exceeds the standard in Section 3103, that

[9] "Ground water" is defined as "interstitial water which occurs in saturated earth material and which is capable of entering a well in sufficient amounts to be utilized as a water supply" (20-6-2-I-1101.V NMAC).

[10] Subpart V of Title 20, Chapter 6, Part 2 establishes additional specific requirements "for effluent disposal wells and *in situ* extraction wells." An *in situ* extraction well definition specifically excludes wells that would be considered Class V injection wells (I-1101.Z NMAC), so compliance with the requirements in Subpart V is not required.

concentration will be the allowable limit if the discharge at that concentration will not result in concentrations at any point of withdrawal for current or foreseeable future use in excess of the Section 3101 standards (20-6-2-III-3103 NMAC) .

Before operations can begin, a discharge plan must be submitted and approved by the New Mexico Environment Department. This plan must specify the quantity, quality, and flow characteristics of the discharge; the location of the discharge and of any bodies of water, watercourses and ground water discharge sites within one mile of the outside perimeter of the discharge site, and existing or proposed wells to be used for monitoring; the depth to and TDS concentration of the ground water most likely to be affected by the discharge; flooding potential of the site; methods of sampling; depth to and lithological description of rock at base of alluvium below the discharge site, and any other information that may be necessary to demonstrate that discharge will not result in ground water contamination (20-6-2-III-3106.C NMAC). When a plan has been approved, discharges must be consistent with the terms and conditions of the plan, which functions as a permit, although the term is not used.

Operating Requirements

No operating requirements are specified.

Monitoring Requirements

The discharge plan will provide for the installation, use, and maintenance of effluent monitoring devices, monitoring devices for the ground water most likely to be affected by the discharge, monitoring in the vadose zone, continuation of monitoring after cessation of operations (the rule does not specify how long such monitoring must continue), periodic submission of monitoring results, and reporting of any other information that may be required (20-6-2-III-3107 NMAC). In practice, annual inspections include ground water sampling.

Financial Responsibility

No financial assurance requirements are specified.

Plugging and Abandonment

No plugging and abandonment requirements are specified.

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