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September 1987

Water

Executive Summary of the Report to Congress

"Class V Injection Wells

- Current Inventory
- Effects on Ground Water
- Technical Recommendations"

EPA 570/9-87-007

EXECUTIVE SUMMARY OF THE REPORT

CLASS V INJECTION WELLS

- CURRENT INVENTORY
- EFFECTS ON GROUND WATER
- TECHNICAL RECOMMENDATIONS

PREPARED FOR THE

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF WATER

OFFICE OF DRINKING WATER

STATE PROGRAMS DIVISION

CLASS V TASK FORCE

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INTRODUCTION

The 1986 Amendments to the Safe Drinking Water Act require the USEPA (United States Environmental Protection Agency) to prepare and submit to Congress a report on Class V injection wells no later than September 1987. The purpose of the report is to summarize State Class V inventory and assessment reports in order to present a national overview of Class V injection practices in the United States. In accordance with the Amendments, the report to Congress must address the current inventory of Class V injection practices, the potential of these practices to adversely affect ground water, and State recommendations for siting, operation, and management.

The information and data contained in this Executive Summary have been summarized from the final report entitled "Class V Injection Wells -- Current Inventory; Effects on Ground Water; and Technical Recommendations." This report was prepared for the USEPA, Office of Water, Office of Drinking Water, by Engineering Enterprises, Inc. The report may be obtained from the U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 (703-487-4650 or Toll Free 800-336-4700). Please indicate the following EPA Document Number 570/9-87-006.

BACKGROUND

On December 16, 1974, Congress enacted the Safe Drinking Water Act (PL 93-523) to protect the public health and welfare of persons and to protect existing and future underground sources of drinking water (USDW). In Part C of the Act, Congress directed the USEPA to develop regulations for the protection of underground source(s) of drinking water from contamination by the subsurface injection or emplacement of fluids. In 1980, USEPA promulgated these regulations under 40 CFR Parts 144 through 146 and Part 124. The regulations specify minimum standards and technical requirements for the proper siting, construction, operation, monitoring, and plugging and abandonment of injection wells. In addition, the regulations specify that all underground injection is unlawful and subject to penalties unless authorized by a permit or rule.

The Act also mandated the development of a Federally approved Underground Injection Control (UIC) program for each State, Possession, and Territory. Approval of a particular program is based on a finding that the program meets minimum standards and technical requirements of SDWA Section 1422 or Section 1425 and the applicable provisions set forth in 40 CFR Parts 124, 144 and 146. States whose programs were submitted

to and approved by USEPA are known as Primacy States. These States have primary enforcement responsibility for the regulation of injection wells in their States. In those instances where a State has opted not to submit a program for approval or where the submitted program does not meet the minimum standards and technical requirements, the program is promulgated and administered by USEPA. States with Federally administered programs are known as Direct Implementation (DI) States and are subject to the regulations set forth in 40 CFR Parts 124 and 144 through 146. Currently, there are 22 DI States, Possessions, and Territories.

The UIC regulations define and establish five classes or categories of injection wells. Class I wells inject hazardous and non-hazardous waste beneath the lowermost formation containing an USDW, within one-quarter mile of the well bore. Class II wells are used in conjunction with oil and gas production. Class III injection wells are used in conjunction with the solution mining of minerals. Class IV wells are used to inject hazardous or radioactive wastes into or above a formation which is within one-quarter mile of USDW. (Class IV wells are prohibited by 40 CFR 144.13.) Class V wells include any wells that do not fall under Classes I through IV. Typically, Class V wells are used to inject non-hazardous fluids into or above underground sources of drinking water.

In 1980, USEPA chose to defer establishing technical requirements for Class V wells. Instead, these wells are authorized by rule. That is, injection into Class V wells is authorized until further requirements under future regulations are promulgated by USEPA. However, Class V wells are prohibited from contaminating any USDW or adversely affecting public health. Therefore, wells which are found to be violating this prohibition are subject to enforcement or closure. Some Primacy States require injection well permits while others currently implement authorization by rule or law.

The Agency has not established specific requirements for Class V wells for several reasons. By definition, the category of Class V encompasses a variety of well types ranging in complexity from radioactive waste disposal wells to storm water drainage wells. At the time of the original promulgation, little was known about the operation of these wells. The Agency reasoned that due to the large number and types of Class V wells in existence, the variability of injection fluids and volumes, the lack of knowledge concerning the extent of environmental damage caused by these wells, and the lack of knowledge concerning the consequences of bringing them under regulation, technical requirements could not be established that effectively would assure that operations of all Class V wells would not endanger USDW. Therefore, the Agency concluded that

it was necessary to develop an assessment of Class V injection well activities prior to regulatory development.

Under 40 CFR 146.52(a), USEPA requires owners and operators of Class V injection wells to notify the Director of the State or the Direct Implementation UIC program of the existence of all Class V wells under their control and to submit pertinent inventory information (as required under 40 CFR 144.26(a)). The Directors then are required, under 40 CFR 146.52(b), to complete and submit to USEPA a report containing the following:

1. Information on the construction features of Class V wells and the nature and volume of injected fluids;

2. An assessment of the contamination potential of Class V wells using hydrogeological data available to the State;

3. An assessment of the available corrective alternatives where appropriate and their environmental and economic consequences; and

4. Recommendations both for the most appropriate regulatory approaches and for remedial actions where appropriate.

The reports are required to be submitted no later than three years after the effective date of the State's UIC program approval. Reports on the Class V programs in the DI states and recommendations were prepared under the direction of the "Director" of that State program, i.e., the USEPA Regional Administrator.

As noted in the Introduction Section of this Executive Summary, the 1986 Amendments to the Safe Drinking Water Act require USEPA to prepare and submit to Congress a report on Class V injection. The report is to summarize the results of the State reports and to note State recommendations for the design, siting, construction, operation, and monitoring of each Class V well type that has the potential to contaminate ground water. Specifically, Section 1426(b) of the Act states:

> The Administrator shall submit a report to Congress, no later than September 1987, summarizing the results of State surveys required by the Administrator under this section. The report shall include each of the following items of information:
>
> 1. The number of categories of Class V wells which discharge nonhazardous waste into or above an underground source of drinking water.

2. The primary contamination problems associated with different categories of these disposal wells.

3. Recommendations for minimum design, construction, installation, and siting requirements that should be applied to protect underground sources of drinking water from such contamination wherever necessary.

While the intent of Section 1426 is clear, it should be noted that the definition of Class V does not limit injection to only "into or above USDW" and does not limit Class V wells to only "disposal wells." Class V spent brine return flow wells, inventoried to date, and Class V radioactive waste disposal wells are examples of wells which inject below the lowermost USDW. Aquifer recharge wells and mineral and fossil fuel recovery wells are examples of wells which are not used for disposal purposes. A list of Class V injection practices recognized by USEPA for the purpose of this report is presented in Table 1.

Although included in Table 1 as Class V injection wells, air scrubber waste and water softener regeneration brine disposal wells (well codes 5X17 and 5X18) are not included in the inventory and assessment portion of the report. At the time the State Class V injection well reports were written, air scrubber waste and water softener regeneration brine disposal wells are categorized as Class V injection wells. However, USEPA later determined that these well types, in certain situations, may fall under the Class II category rather than Class V. This was determined to be the case with those 5X17 and 5X18 wells inventoried in the State reports.

As can be seen in Table I, the Class V injection well category is large and diverse. This is due to the broad definition of Class V wells. If a well does not fit into one of the first four classes and meets the definition of an injection well, it is considered a Class V well.

Class V injection wells can be divided into two general types of wells based on construction. "Low-tech" wells 1) have no casing designs or have simple casing designs and well head equipment and 2) inject into shallow formations by gravity flow or low volume pumps. In contrast, "high-tech" wells typically 1) have multiple casing strings; 2) have sophisticated well equipment to control and measure pressure and volume of injected fluid; and 3) inject high volumes into deep formations.

TABLE I

CLASS V INJECTION WELL TYPES

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
	DRAINAGE WELLS (a.k.a. DRY WELLS)
5F1	Agricultural Drainage Wells - receive irrigation tailwaters, other field drainage, animal yard, feedlot, or dairy runoff, etc.
5D2	Storm Water Drainage Wells - receive storm water runoff from paved areas, including parking lots, streets, residential subdivisions, building roofs, highways, etc.
5D3	Improved Sinkholes - receive storm water runoff from developments located in karst topographic areas.
5D4	Industrial Drainage Wells - include wells located in industrial areas which primarily receive storm water runoff but are susceptible to spills, leaks, or other chemical discharges.
5G30	Special Drainage Wells - are used for disposing water from sources other than direct precipitation. Examples of this well type include: landslide control drainage wells, potable water tank overflow drainage wells, swimming pool drainage wells, and lake level control drainage wells.
	GEOTHERMAL REINJECTION WELLS
5A5	Electric power Reinjection Wells - reinject geothermal fluids used to generate electric power - deep wells.
5A6	Direct heat Reinjection Wells - reinject geothermal fluids used to provide heat for large buildings or developments - deep wells.
5A7	Heat Pump/Air Conditioning Return Flow Wells - reinject groundwater used to heat or cool a building in a heat pump system - shallow wells.
5A8	Ground-water Aquaculture Return Flow Wells - reinject groundwater or geothermal fluids used to support aquaculture. Non-geothermal aquaculture disposal wells are also included in this category (e.g. Marine aquariums in Hawaii used relatively cool sea water).

TABLE I

CLASS V INJECTION WELL TYPES

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
	DOMESTIC WASTEWATER DISPOSAL WELLS
5W9	Untreated Sewage Waste Disposal Wells - receive raw sewage wastes from pumping trucks or other vehicles which collect such wastes from single or multiple sources. (No treatment)
5W10	Cesspools - include multiple dwelling, community, or regional cesspools, or other devices that receive wastes and which must have an open bottom and sometimes have perforated sides. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Settling of solids)
5W11	Septic Systems (Undifferentiated disposal method) - are used to inject the waste or effluent from a multiple dwelling, business establishment, community, or regional business establishment septic tank. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Primary Treatment)
5W31	Septic Systems (Well Disposal Method) - are used to inject the waste or effluent from a multiple dwelling, business establishment, community, or regional business establishment septic tank. Examples of wells include actual wells, seepage pits, cavitettes, etc. The largest surface dimension is less than or equal to the depth dimension. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Less treatment per square area than 5W32)
5W32	Septic Systems (Drainfield Disposal Method) - are used to inject the waste or effluent from a multiple dwelling, business establishment, community, or regional business establishment septic tank. Examples of drainfields include drain or tile lines, and trenches. Must serve more than 20 persons per day if receiving solely sanitary wastes. (More treatment per square area than 5W31)
5W12	Domestic Wastewater Treatment Plant Effluent Disposal Wells - dispose of treated sewage domestic effluent from facilities ranging from small package plants up to large municipal treatment plants. (Secondary or further treatment)

TABLE I

CLASS V INJECTION WELL TYPES

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
	MINERAL AND FOSSIL FUEL RECOVERY RELATED WELLS
5X13	Mining, Sand, or Other Backfill Wells - are used to inject a mixture of fluid and sand, mill tailings, and other solids into mined out portions of subsurface mines whether what is injected is a radioactive waste or not. Also includes special wells used to control mine fires and acid mine drainage wells.
5X14	Solution Mining Wells - are used for in-situ solution mining in conventional mines, such as stopes leaching.
5X15	In-situ Fossil Fuel Recovery Wells - are used for in-situ recovery of coal, lignite, oil shale, and tar sands.
5X16	Spent-Brine Return Flow Wells - are used to reinject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts.
	OIL FIELD PRODUCTION WASTE DISPOSAL WELLS
5X17	Air Scrubber Waste Disposal Wells - inject wastes from air scrubbers used to remove sulfur from crude oil which is burned in steam generation for thermal oil recovery projects. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)
5X18	Water Softener Regeneration Brine Disposal Wells - inject regeneration wastes from water softeners which are used to improve the quality of brines used for enhanced recovery. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)
	INDUSTRIAL/COMMERCIAL/UTILITY DISPOSAL WELLS
5A19	Cooling Water Return Flow Wells - are used to inject water which was used in a cooling process, both open and closed loop processes.

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TABLE I

CLASS V INJECTION WELL TYPES

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
5W20	Industrial Process Water and Waste Disposal Wells - are used to dispose of a wide variety of wastes and waste-waters from industrial, commercial, or utility processes. Industries include refineries, chemical plants, smelters, pharmaceutical plants, laundromats and dry cleaners, tanneries, laboratories, petroleum storage facilities, electric power generation plants, car washes, electroplating industries, etc.
5X28	Automobile Service Station Disposal Wells - inject wastes from repair bay drains at service stations, garages, car dealerships, etc.
	RECHARGE WELLS
5R21	Aquifer Recharge Wells - are used to recharge depleted aquifers and may inject fluids from a variety of sources such as lakes, streams, domestic wastewater treatment plants, other aquifers, etc.
5B22	Saline Water Intrusion Barrier Wells - are used to inject water into fresh water aquifers to prevent intrusion of salt water into fresh water aquifers.
5S23	Subsidence Control Wells - are used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with overdraft of fresh water and not used for the purpose of oil or natural gas production.
	MISCELLANEOUS WELLS
5N24	Radioactive Waste Disposal Wells - include all radioactive waste disposal wells other than Class IV wells.
5X25	Experimental Technology Wells - include wells used in experimental or unproven technologies such as pilot scale in-situ solution mining wells in previously unmined areas.
5X26	Aquifer Remediation Related Wells - include wells used to prevent, control, or remediate aquifer pollution, including but not limited to Superfund sites.

TABLE I

CLASS V INJECTION WELL TYPES

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
5X29	Abandoned Drinking Water Wells - include those abandoned water wells which are used for disposal of waste.
5X27	Other Wells - include any other unspecified Class V wells.

Low-tech well types include agricultural drainage wells (5F1), storm water and industrial drainage wells (5D2, 5D4), improved sinkholes (5D3), heat pump/air conditioning return flow wells (5A7), some aquaculture return flow wells (5A8), raw sewage disposal wells and cesspools (5W9, 5W10), septic systems (5W11, 5W31, 5W32), some mine backfill wells (5X13), some cooling water return flow wells (5A19), some industrial process water and waste disposal wells (5W20), automobile service station waste disposal wells (5X28) and abandoned water wells (5X29).

High-tech well types include geothermal wells used for electric power or for direct heat (5A5, 5A6), some aquaculture return flow wells (5A8), domestic wastewater treatment disposal wells (5W12), mining, sand or other backfill wells (5X13), solution mining wells (5X14), in-situ fossil fuel recovery wells (5X15), spent brine return flow wells (5A16), some cooling water return flow wells (5A19), some industrial process water and waste disposal wells (5W20), some aquifer recharge wells (5R21), salt water intrusion barrier wells (5B22), subsidence control wells (5S23), radioactive waste disposal wells (5N24), experimental technology wells (5X25), and aquifer remediation wells (5X26).

HYDROGEOLOGIC CONSIDERATIONS

Half of the population of the United States currently is served by ground water, and studies show that demand for this resource is increasing at a rate of 25 percent per decade. The use of ground water is increasing at a faster rate than is the use of surface water. The degree to which each State depends upon ground water varies from less than one percent of total water withdrawals (District of Columbia) to 85 percent (Kansas).

The largest single use for ground water is irrigation, and the major areas of usage are the southwestern, midwestern, and southern states. The second largest use for ground water in the United States is as a drinking water supply. Forty-eight percent of the population relies on ground water as a drinking water supply. Roughly two-thirds receive their drinking water through public supplies, and the remainder are supplied through domestic wells.

Ground water aquifers are of two primary types, unconfined and confined. Unconfined, or water table, aquifers are the most common. Under unconfined conditions, the water table is exposed to the atmosphere such that the upper surface of the saturated zone is free to rise and decline through openings in the soil matrix. Available data suggest that most Class V injection is into or above unconfined aquifers. Confined, or artesian, aquifers are isolated from the atmosphere at the point of discharge by impermeable strata. The confined aquifer is subject to higher hydraulic pressure than atmospheric pressure, and certain high-tech Class V wells inject into these aquifers.

Waste disposal or other fluid emplacement through injection wells are potential causes of contamination to USDW. The distribution of contaminants within an aquifer can occur as discrete bodies, or "slugs," resulting from low volume or short term incidents of waste disposal/fluid injection. Cumulative effects of numerous slugs, or continual disposal of highly concentrated waste/injection fluid, or large volumes of waste/injection fluid from a single facility can cause widespread contamination. The degree of contamination ranges from slight deterioration in natural quality to the presence of toxic levels of heavy metals, organic compounds, inorganic contaminants, and radioactive materials.

Generally, Class V injection is into or above USDW. An USDW is defined as an aquifer or its portion which supplies any public water system or contains a sufficient quantity of ground water to supply a public water system and currently supplies drinking water for human consumption and contains fewer than 10,000 mg/l total dissolved solids and is not an exempted aquifer. Certain special Class V facilities are known to inject fluids below USDW. Potential for contamination to USDW varies and is dependent upon where injection occurs relative to USDW, well construction, design, and operation, injectate quality, and injection volumes. Class V injection practices which discharge directly into USDW are potentially more harmful to USDW than Class V injection above or below USDW because some protection of USDW may be provided by injection above or below USDW.

CLASS V INJECTION WELL INVENTORY

As defined in the report, there are seven general categories of Class V injection wells containing a total of 30 well types. Based on State inventories, it is estimated that there are 173,159 Class V wells in the United States and its associated Territories and Possessions. About 94 percent of all Class V wells belong to four main categories: drainage wells (58%), sewage related wells (25%), geothermal wells (6%), and mineral and fossil fuel recovery related wells (5%).

The numbers of Class V wells broken down by USEPA Regions are as follows:

Region IX: (CA, NV, AZ, GU, HI)	=64,214	=37%
Region X: (WA, OR, ID, AK)	=29,826	=17%
Region IV: (KY, TN, NC, SC, GA, AL, MS, FL)	=27,911	=16%
Region V: (MN, WI, MI, OH, IN, IL)	=17,772	=10%
Region VIII: (MT, ND, SD, WY, UT, CO)	= 9,015	= 5%
Region II: (NY, NJ, PR, VI)	= 8,950	= 5%
Region VII: (NE, KS, IA, MO)	= 6,675	= 4%
Region III: (PA, MD, DE, WV, VA, DC)	= 4,589	= 3%
Region VI: (NM, TX, LA, AR, OK)	= 3,843	= 2%
Region I: (ME, VT, NH, MA, RI, CT)	= 364	=>1%.

It should be noted that these numbers can be misleading, however. Because inventories were not conducted with consistent levels of resources and guidance, there is a high probability that the distribution of wells and the resulting conclusions are not entirely accurate.

CONTAMINATION POTENTIAL ASSESSMENTS

Contamination potential has been assessed for each well type in the report, using all available data. Because inventory databases varied widely for different well types, a unified system was needed with which to assess each well type equivalently. The assessment incorporates the following parameters:

1. Identification and potential usability of USDW;

2. Typical construction, operation, and maintenance procedures;

3. Chemical and physical characterization of injection fluid; and

4. Typical injected volumes.

Based upon this rating scheme, well types have been assessed qualitatively for contamination potential as high, moderate, or low. Certain Class V well types exhibit such variation in design and injectate quality that a spectrum of ratings (e.g., moderate to low, high to moderate, high to low) resulted. A few well types have an unknown potential for contamination due to extremely limited inventory databases. Contamination potentials for Class V wells currently are assessed as follows:

High Contamination Potential

- Agricultural drainage wells, 5F1;
- Improved sinkholes, 5D3 (high to moderate);
- Raw sewage waste disposal wells, 5W9, and cesspools, 5W10;
- Septic systems, 5W11, 5W31, 5W32;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Industrial process water and waste disposal wells, 5W20;
- Automobile service station waste disposal wells, 5X28; and
- Aquifer recharge wells, 5R21 (high to low).

Moderate Contamination Potential

- Storm water drainage, 5D2, and industrial drainage wells, 5D4;
- Improved sinkholes, 5D3 (high to moderate);
- Special drainage wells, 5G30 (moderate to low);
- Electric power, 5A5, and direct heat reinjection wells, 5A6;
- Aquaculture return flow wells, 5A8;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);

- Mining, sand, or other backfill wells, 5X13;
- In-situ fossil fuel recovery wells, 5X15;
- Cooling water return flow wells, 5A19 (moderate to low);
- Aquifer recharge wells, 5R21 (high to low);
- Experimental technology wells, 5X25 (moderate to low); and
- Abandoned drinking water/waste disposal wells, 5X29.

Low Contamination Potential

- Special drainage wells, 5G30 (moderate to low);
- Heat pump/air conditioning return flow wells, 5A7;
- Domestic wastewater treatment plant disposal wells, 5W12 (high to low);
- Solution mining wells, 5X14;
- Spent brine return flow wells, 5X16;
- Cooling water return flow wells, 5A19 (moderate to low);
- Aquifer recharge wells, 5R21 (high to low);
- Saline water intrusion barrier wells, 5B22;
- Subsidence control welld, 5S23; and
- Experimental technology wells, 5X25 (moderate to low).

Unknown Contamination Potential

- Radioactive waste disposal wells, 5N24; and
- Aquifer remediation wells, 5X26 (including hydrocarbon recovery injection wells).

Additional study is necessary in a number of areas. A primary concern of many States is that the existing inventory database is incomplete. It is recommended by many States that efforts continue to locate univentoried Class V facilities and to upgrade the existing database of technical data for inventoried facilities. Also, hydrogeologic studies on both local and regional scales, may need to be conducted for areas containing sensitive aquifers in order to define the potential impact of the various types of Class V injection practices. Table 2 presents a summary of available inventory data, types of fluids injected, and State recommendations.

CONTENT OF THE REPORT TO CONGRESS

Section One of the report is an introduction and summary of the findings of the report.

Section Two of the report is an overview of the ground water resource and current and projected use of the resource. Several hydrogeologic considerations, important when examining injection well practices, are discussed to provide the reader

TABLE 2

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Drainage Wells					
Agricultural Drainage Wells (5F1)	Nationwide: 1,338 wells New York: 150 wells Puerto Rico: no numbers West Virginia: no numbers Florida: no numbers Georgia: 43 wells Kentucky: no numbers Illinois: 6 wells Indiana: 72 wells Michigan: 15 wells Minnesota: 54 wells Oklahoma: no numbers Texas: 108 wells Iowa: 230 wells Missouri: no numbers Nebraska: 5 wells Colorado: no numbers North Dakota: 1 well Idaho: 572 wells Oregon: 16 wells Washington: 66 wells Potentially many times this figure in areas typified by irrigation.	Varies due to differing farming practices and soil types; potential agricultural contaminants include sediment, nutrients, pesticides, organics, salts, metals, and pathogens in some cases.	High	New York - SPDES Permit Florida - Permit Georgia - Banned Illinois - Rule Oklahoma - Rule Iowa - Diversion Permit Missouri - None Nebraska - Rule Utah - Rule Arizona - Permit Idaho - Permit if deeper than 18 feet Washington - Undecided	- Improvement of inventory efforts is essential. (PR, GA, IN, MI, MN, CO, OR) - Locate and properly plug all abandoned wells near Agricultural Drainage Wells. (IA) - Close surface inlets to allow infiltration through soil. (MO) - Raise the inlets above maximum ponding levels. (IA) - Require that injection fluids meet all or some drinking water standards. (NE, OR) - Require irrigation tailwater recovery and pumpback. (OR) - Use only necessary amounts of irrigation water and applied chemicals. (CA) - Require frequent monitoring of drinking water wells in surrounding areas. - Require detailed map with all well locations. (NE) - Require diagram of injection well construction. (NE) - Require siting of wells at least 2,000 ft. away from any stock, municipal, or domestic well. (NE) - Discourage use and encourage elimination of agricultural drainage wells by developing alternate methods. (IA)

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TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Storm Water Drainage Wells (5D2)	Nationwide: 80,000-100,000 wells reported for 39 States	Herbicides, pesticides, fertilizers, deicing salts, asphaltic sediments, gasoline, grease oil, tar and residues from roofs and paving, rubber particulates, liquid wastes and industrial solvents, heavy metals and coliform bacteria.	Moderate	Information applies to both 5D2 and 5D4 unless otherwise specified. Connecticut-Permit (5D2) Massachusetts-Exempt (5D2) New Jersey-NJPDES Permit New York-Permit if injected volume exceeds 1,000 GPD Maryland-Permit (5D4) Alabama-Permit (5D2) Florida-Permit Georgia-Banned Kentucky-Local (5D2), Permit (5D4) South Carolina-Permit (5D2) Tennessee-Permit (5D2) Illinois-Rule Wisconsin-None (5D2) Rule (5D4) Louisiana-Class II Regulations (5D4), Registration of Class V wells not required New Mexico-Registration Oklahoma-Rule Nebraska-Rule Montana-Permit (5D2) Utah-Rule Wyoming-Permit (5D2) Arizona-Registration California-Rule Hawaii-Permit Guam-Permit (5D2) Alaska-Permit (5D2) Idaho-Permit if deeper than 18 feet (5D2) Washington-None	Apply to both storm water and industrial drainage wells: - New wells should be investigated and added to FURS. (KY, UT, WA) - Construction of new industrial drainage wells should be limited or discouraged; storm water sewers, detention ponds, or vegetative basins are preferred. (OR, IL, KY, TN, UT). - Sand and gravel filters should be added to wells. (KY, TN) - Stand pipes should be constructed at the openings of wells. (KY, TN) - Limit future construction to residential areas. (IL) - All spills should be diverted away from industrial drainage wells (OR, UT, WA) - New construction of wells in areas served by storm water sewers should be prohibited. (CA, AZ) - Drainage wells should not be constructed within 200 ft. of water supply wells which tap lower water-bearing aquifers. (CA) - Deep wells should be plugged or cemented to avoid mixing between aquifers. (KY, TN) - Depth to water data should be made available to well drillers. (AZ) - Additional studies including use of monitoring wells should be conducted to study possible pollution sources and prolonged effect of industrial drainage wells on ground water. (FL, WI, KS) - An assessment of the effects of storm drainage wells should be conducted prior to completing an inventory because the inventory would be time-consuming and costly. (MT, OR) - Sediments extracted from drainage wells, catch basins, or sediment traps should be disposed in an appropriate landfill. (AZ) - A public awareness program should be implemented. (AZ) - All drainage wells should be identified and plugged. (WV)
Industrial Drainage Wells (5D4)	Nationwide: 3,802 wells reported for 23 States.	Similar constituents to those found in Stormwater Drainage Wells, though generally present in higher concentrations. Heavy metals such as lead, iron, and manganese. Organic compounds.			

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Improved Sinkholes (5D3)	Nationwide: 479 wells New Hampshire: 3 wells Puerto Rico: 10 wells Kentucky: 76 wells Tennessee: 5 wells Indiana: 26 wells Michigan: 103 wells Minnesota: 6 wells Missouri: 250 wells Virginia, West Virginia, Florida, and Ohio: numbers not yet confirmed. Potentially in all areas with limestone and dolomite lithologies at relatively shallow depths.	Runoff, from paved areas, containing lead and petroleum products from automobiles, pesticides from horticulture and lawn care, nitrates from fertilizers, and fecal material from wild and domestic animals; normal fallout from air pollutants may also be present.	High to Moderate	Puerto Rico-Permit Florida-Permit Georgia-Banned Kentucky-Local Tennessee-Permit Indiana-None Michigan-None Minnesota-None Ohio-None Missouri-None	- Training should be required for engineers and drillers in the proper construction of wells with special emphasis on sanitary sealing and protection against corrosion. Training should be slanted toward construction in Karst or limestone formations. (PR) - Careful dye trace studies should be run on any existing or improved sinkhole drainage systems, and occasional monitoring of both entering and exiting fluids should be run after the system is in operation. (MO)
Special Drainage Wells (5G30)	Nationwide: 1,557 wells Florida: 1,385 wells Louisiana: 1 well Montana: 55 wells Hawaii: 1 well Idaho: 7 wells Washington: 108 wells. Potentially present in all Regions.	Highly variable, depending on system design; for landslide control, ground water is generally used; swimming pool drainage fluid may contain lithium hypochlorite, calcium hypochlorite, sodium bicarbonate, chlorine, bromine, iodine, cyanuric acid, aluminum sulfate, algaecides, fungicides, and muriatic acid.	Moderate to Low	Florida-Permit/Rule Louisiana-Class II Regulations, Registration of Class V wells not required Nebraska-Rule Montana-Permit Hawaii-Permit Idaho-Permit if deeper than 18 feet.	- Random sampling and analysis of swimming pool wastewater for possible contaminants should be required. (FL)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Geothermal Reinjection Wells					
Electric Power Reinjection Wells (5A5)	Nationwide: 89 wells Texas: numbers not confirmed California: 65 wells Nevada: 16 wells Idaho: 4 wells Alaska: 4 wells	Vapor-Dominated Resource heavy metals (arsenic, boron, selenium), sulfates, and dissolved solids. Hot Water-Dominated Resource heavy metals (arsenic, boron, selenium), chlorides, dissolved solids, and acidic pH.	Moderate	Texas-Permit Nebraska-Rule Utah-Permit California-Permit Nevada-Permit Idaho-Permit	Apply to both electric power and direct heat reinjection wells: - Detailed study on the types of MIT available for geothermal systems and the resolution of each method. (NV) - Initial analysis of injectate and injection zone water conducted prior to full-scale injection operations; parameters of concern are temperature, inorganic constituents of Primary and Secondary Drinking Water Regulations, alkalinity, hardness, silica, boron, and ammonia nitrogen. (CA, NV) - Injection into non-thermal reservoirs if the thermal injection fluids meet drinking water requirements or if the receiving fluids are of equal or lesser quality. (ID)
Direct Heat Reinjection Wells (5A6)	Nationwide: 21 wells New York: no numbers New Mexico: 2 wells Texas: 1 well Colorado: 2 wells California: 1 well Nevada: 6 wells Idaho: 2 wells Oregon: 6 wells Utah: 1 well	Arsenic, boron, fluoride, dissolved solids, sulfates, chloride.	Moderate	New Mexico-Permit Texas-Permit Nebraska-Rule/Permit Utah-Permit California-Permit Nevada-Permit Idaho-Permit Oregon-Permit if injected volume exceeds 5,000 GPD	

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Heat Pump/Air Conditioning Return Flow Wells (5A7) (5W11)	Nationwide: 10,028 wells. Potentially present in all regions; more expected in areas characterized by climatic extremes. Reported in all States except the following: Maine, Rhode Island, Vermont, Puerto Rico, Virgin Islands, West Virginia, Alabama, Arkansas, Hawaii, American Samoa, TTPI, Guam, CNMI.	Primarily thermally altered ground water; additives designed to inhibit scaling, corrosion and incrustation when water high in metals and salts, or demonstrating high or low pH, is used.	Low	Connecticut-Permit Massachusetts-Permit if injected volume is greater than 15,000 GPD New Jersey-Rule/Permit New York-Permit Delaware-Permit Maryland-Permit Florida-Permit Georgia-Banned North Carolina-Permit South Carolina-Rule Illinois-Rule Minnesota-Permit Wisconsin-Rule Louisiana-Permit New Mexico-Registration Oklahoma-Rule Texas-Rule Missouri-Registration Nebraska-Rule Montana-None North Dakota-Rule Utah-Permit Wyoming-Permit Arizona-None California-Permit Alaska-Permit Idaho-Permit Oregon-Permit if injected volume is greater than 5,000 GPD Washington-Permit	- More research is needed on the theoretical environmental effects of heat pumps. (MO, AZ, SC) - Authorization by rule is appropriate for properly spaced and operated systems. (SC) - New regulatory programs should be directed at large-scale systems rather than at systems for single-family dwellings. (LA, OK, TX) - Records should be maintained by counties and periodically up-loaded to State databases in order to monitor well densities. (WA) - The State permitting agency should set construction standards and ensure that wells are constructed and operated properly. (FL, KS, MO, NE, SC, WA) - Permits for commercial developments should include requirements for water quality characterizations of both source and receiving water. (WA) - Return wells should be cased through top of injection zone. (IA) - Annular space should be cemented or grouted. (IA, KS, NE, TN) - Adequate spacing between production wells should be practiced. (KS, NE, SC) - Discharge should be into or above the supply aquifer. (LA, IA, KS, SC) - Closed loop systems should be required. (UT, TN) - Discharge should be to the surface rather than to an injection well. (LA) - The waste product should contain no additives or only approved additives (LA, KS, NE) - Volumes and temperatures of injection fluids should be monitored. (NC) - Analyses of receiving fluids should be conducted periodically. (KS, WA) - A licensed water well driller should be employed to install, rework, and/or plug and seal the well. (LA, IL) - New well installation in known or suspected contaminated aquifers should be prohibited. (WA)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Ground-water Aquaculture Return Flow Wells (5A8)	Hawaii: 7 active wells 3 standby wells 15 proposed wells Potentially found wherever marine or fresh water organisms are cultured in large quantities.	Large volumes of wastewater composed of essentially salt water with added nutrients, bacteriological growth, perished animals, and animal detritus. Effluent typically contains nitrates, nitrites, ammonia, high BOD, and orthophosphate.	Moderate	Nebraska-Rule Utah-Permit Hawaii-Permit Oregon-Permit if injected volume exceeds 5,000 GPD	- Regular sampling and analysis of injection fluid and injection zone fluid should be required (semi-annually). (HI) - Water to be disposed should be filtered and appropriately treated prior to injection. (HI) - Return waters should be carefully monitored at a point before and after treatment to ensure the measures being employed are sufficient to allow the water to be injected. (HI)
Domestic Wastewater Disposal Wells					
Raw Sewage Disposal Wells (5W9)	Nationwide: 980 wells Puerto Rico: 5 wells Pennsylvania: no numbers Illinois: 916 wells Indiana: 22 wells Michigan: 11 wells Minnesota: 10 wells Texas: 10 wells Hawaii: 3 wells Alaska: 3 wells	Generally poor quality, including high fixed volatiles, BOD, COD, TOC, nitrogen (organic, and free ammonia), chloride, alkalinity and grease.	High	Illinois-Banned Nebraska-Rule Utah-Banned Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Oregon-Rule	No recommendations concerning raw sewage disposal wells and cesspools were provided in State reports. However, the use of such disposal methods has been banned in several States.
Cesspools (5W10)	Nationwide: 6,622 wells New Jersey: 1 well New York: no numbers Puerto Rico: 67 wells Indiana: 22 wells Michigan: 18 wells Minnesota: 25 wells New Mexico: 14 wells Texas: 16 wells Nebraska: no numbers Wyoming: 3 wells Arizona: 17 wells California: 46 wells Hawaii: 57 wells Alaska: > 79 wells Oregon: 6,257 wells	Same as for Raw Sewage Disposal Wells.	High	New Jersey-NJPDES Permit New York-Permit if injected volume exceeds 1,000 GPD New Mexico-Banned Texas-Rule Nebraska-Rule Utah-Banned Wyoming-Permit Arizona-Permit California-Banned Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Oregon-Rule	

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Septic Systems (5W11, 5W31, 5W32)	5W11: 26,769 inventoried wells in 31 States 5W31: 4,435 wells in 13 States 5W32: 3,783 wells in 8 States	Varies with type of system; fluids typically 99.9% water (by weight) and .03 suspended solids; major constituents include nitrates, chlorides, sulfates, sodium, calcium, and fecal coliform.	High	Connecticut-Permit if volume injected exceeds 5,000 GPD Massachusetts-Permit if volume injected exceeds 15,000 GPD New Jersey-NJPDES Permit New York-Permit if volume injected exceeds 1,000 GPD Maryland-Permit (5W31) Alabama-Permit Florida-Permit Kentucky-Rule (5W31) South Carolina-Permit (5W32) Minnesota-Rule Wisconsin-Rule (5W31) Louisiana-Rule New Mexico-Registration Oklahoma-Rule Texas-Local Missouri-Permit Nebraska-Rule Montana-Permit North Dakota-Rule Utah-Permit Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit (5W31) Nevada-Banned (5W31), Permit (5W32) CNMI-None Alaska-Permit or Rule Idaho-Permit if deeper than 18 feet Oregon-Permit if injected volume exceeds 5,000 GPD (5W32) Washington-Permit/Rule	- Further study is recommended. (FL, MT, OR) - Proper construction and installation guidelines should be developed. (MO) - Ongoing training programs for sanitarians is recommended; should include hydrogeology, ground-water flow, theory of septic system operation, and potential risks to human health. (PR, MD, MN) - Siting should be conducted so as not to endanger water wells. (KS, NE) - All systems should be sited and designed individually. (TX) - Local planning groups should be encouraged to establish septic tank density limits. (NE) - Sewage disposal wells for private facilities should be phased out and replaced by alternate methods of treatment and disposal. (TX) - Well constructions should be investigated. (KS) - Statewide monitoring systems should be established and should include inventory methodology and database updates. (WA)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Domestic Wastewate Treatment Plant Effluent Disposal Wells (5W12)	Potentially present in all Regions. 1,099 wells inventoried nationwide in 19 States.	Injected fluid, after secondary or tertiary waste treatment, believed to be generally compatible with receiving formation; may contain high nitrates and fecal coliform if improperly treated.	High to Low	Massachusetts-Permit if injected volume exceeds 15,000 GPD New York-Permit Puerto Rico-Permit Florida-Permit Kentucky-Eliminate Illinois-Rule Indiana-Permit Michigan-Permit Texas-Rule/Permit Nebraska-Rule Utah-Permit Arizona-Permit California-Permit Hawaii-Permit Nevada-Banned Alaska-Permit or Rule Idaho-Rule Washington-Rule	- Operation should ensure that injection is restricted to rates and pressures dictated by site-specific hydrogeologic conditions (should involve monitoring). (WY, AL, HI). - Alternative methods of disposal and feasibility of upgrading existing plants should be evaluated. (VA) - In some cases, wells should be plugged. (KY)
Mineral and Fossil Fuel Recovery Related Wells					
Mining, Sand or Other Backfill Wells (5X13)	Nationwide: 6,500 wells Maryland: 1 well Pennsylvania: 811 wells West Virginia: 258 wells Alabama: no numbers Kentucky: 61 wells Tennessee: no numbers Illinois: 5 wells New Mexico: 11 wells Texas: 65 wells Missouri: 4,326 wells Colorado: 2 wells Montana: 10 wells North Dakota: 300 wells Wyoming: 74 wells Nevada: 1 well Idaho: 575 wells	Hydraulic or pneumatic slurries - Solid portion of slurries may be sand, gravel, cement, mill tailings/refuse, or fly ash. - Slurry waters may be acid mine water or ore extraction process wastewater.	Moderate	Maryland-Permit Pennsylvania-Mine operation West Virginia-Mine operation Alabama-Permit Kentucky-Permit Illinois-Rule New Mexico-Unknown Texas-Rule Missouri-None Nebraska-Rule Colorado-Rule Montana-Permit North Dakota-Rule Utah-Rule Wyoming-Permit Idaho-Rule	- Siting, design, construction, and operation should be specified in permit requirements. (IL) - Slurry injection volumes should be monitored and compared to calculated mine volume to prevent catastrophic failure. (WV) - Ground-water monitoring in areas containing potable water. (MO) - Site-specific study is necessary to determine the nature and extent of degradation from mine backfill wells. (MT) - Authorization of mine backfill wells without permits should continue where tailings are injected into formations that are effectively isolated from USDW. (ID)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Solution Mining Wells (5X14)	Nationwide: 2,025 wells New York: 48 wells Michigan: 15 wells New Mexico: 1,07[illegible] wells Wyoming: 14 wells Arizona: 870 wells California: 5 wells Potentially in other mining districts.	Weak acid solutions (sulfuric and hydrochloric) Ammonium carbonate Sodium carbonate/bicarbonate Ferric cyanide	Low	New York-Permit New Mexico-Permit Nebraska-Permit Utah-Permit Wyoming-Permit Arizona-Permit California-Permit	- Network of injection wells should not extend beyond surface projection of ore body. (CA) - New types of mechanical integrity tests for implementation with this well type should be studied. (AZ) - Hydrologic monitoring should be conducted to determine a water budget. (AZ)
In Situ Fossil Fuel Recovery Wells (5X15)	Nationwide: 66 wells Colorado: 23 wells Indiana: 1 well Michigan: 1 well Wyoming: 41 wells Potentially in other areas with relatively shallow, organic rich sub strata.	Underground coal gasification: - air, oxygen, steam, water, igniting agents such as ammonium nitrate-fuel oil (ANFO) or propane. In situ oil shale retorting: - air, oxygen, steam, water, sand, explosives, igniting agents (generally propane) Purpose in both cases is to initiate and maintain combustion. Combustion products include polynuclear aromatics, cyanides, nitrites, phenols.	Moderate	Texas-Permit Nebraska-Rule Colorado-Rule Utah-Permit Wyoming-Permit	- Conduct complete geologic and hydrogeologic investigations prior to system implementation. (WY) - Remediate zone fluids to minimize future contamination. (WY)
Spent Brine Return Flow Wells (5X16)	Nationwide: 121 wells New York: no numbers West Virginia: 2 wells Indiana: 8 wells Michigan: 33 wells Arkansas: 70 wells Oklahoma: 7 wells North Dakota: 1 well Potentially in Regions having commercially recoverable halogen deposits.	Limited to brines from which halogens or salts have been extracted; Potential for addition of other undefined constituents into waste stream.	Low	New York-Permit Arkansas-Permit Oklahoma-Rule Nebraska-Rule Utah-Rule	- Technical requirements specified in permits should be similar to those for oilfield brine injection wells or solution mining wells. (WV, AR) - Construction requirements should be developed based upon well operating parameters. (AR) - Mechanical integrity tests should be required. (AR) - Semi-annual comprehensive sampling and analysis of fluid and comparison of produced vs. injected fluid should be required. (AR)

TABLE 2, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Industrial/Commercial Utility Disposal Wells (5A19)					
Cooling Water Return Flow Wells (5A19)	291 wells inventoried nationwide; potentially many times this number, and would be located in all Regions.	Dependent upon type of system, type of additives, and temperature of water; open pipe systems may expose ground water to accidental introduction of surface contaminants, industrial spills, or unauthorized disposal of wastes.	Moderate to Low	Massachusetts-Permit if injection volume exceeds 2,000 GPD New Jersey-NJPDES Permit Alabama-Permit Florida-Permit Georgia-Permit South Carolina-Rule Illinois-Rule Wisconsin-Rule Arkansas-None New Mexico-Registration Iowa-Permit Nebraska-Rule Utah-Permit California-Permit Hawaii-Permit Alaska-Permit Idaho-Permit Oregon-Permit if injected volumes exceed 5,000 GPD Washington-Permit	- Minimum locating requirements for the injection well relative to any nearby municipal supply wells should be established. (NE, SC) - Wells should be grouted from at least 20 feet below land surface to land surface or to the water table. (NE) - Wells should be cased from surface to the top of the uppermost supply and injection zone. (AR) - Cemented annulus from surface to supply/injection zone. (AR) - Require minimum of 2 wells: supply well and return well. (AR, SC) - Wells should be constructed such that spent fluids are injected into source aquifer. (AR) - Open loop return flow wells should be prohibited. (FL, AR, NE, UT) - Wells should be plugged with cement upon abandonment. (AR) - Permit specifications needed: Detailed map showing all area wells. Diagram of injection well design. Diagram of entire system. Type and volume of injectate. (AR, NE)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Industrial Process Water and Waste Disposal Wells (5W20)	1,989 inventoried wells in 33 States.	Potentially any fluid disposed by various industries; can have high dissolved solids, suspended solids, alkalinity, chloride, phosphate, sulfate, total volatiles.	High	Connecticut-Permit Massachusetts-Permit New Jersey-NJPDES Permit New York-Permit Maryland-Permit Pennsylvania-Permit Alabama-Permit Florida-Permit South Carolina-Permit Illinois-Rule Wisconsin-Permit Texas-Class I Regulations Nebraska-Rule Utah-Banned Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit Alaska-Permit Idaho-Permit if deeper than 18 feet Oregon-Permit	- Inventory efforts should continue with high priority on identifying industrial disposal facilities. (PR, IN, WI, AK, WY) - Assume all industrial waste disposal has a deleterious effect on USDW, warranting immediate action. (PA) - Extensive ground-water evaluation studies should be conducted to identify areas which would be vulnerable to contamination by industrial waste disposal. (PR, AL) - Drainage areas surrounding industrial facilities should be studied and all possible pollution sources noted. (KS) - Inspection of these facilities should be mandatory, and conducted by teams backed by chemical or industrial engineers. (PR) - Monitoring programs should be required and sampling specifications should be tightened. (PR, MD, FL, KS) - Ground-water monitoring should be conducted using a minimum of one upgradient and two downgradient wells. (AZ) - Practice of injecting industrial process water and waste should be discouraged, and wastes routed to on-site treatment facilities or municipal sanitary sewer systems. (FL) - Discharge of industrial process wastes to septic systems should be discouraged. (PR, NE) - These wells should be permitted only when injection is into ground water containing greater than ten-thousand mg/l TDS. (FL)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Automobile Service Station Waste Disposal Wells (5X28)	Nationwide: 99 wells Connecticut: 1 well Rhode Island: 3 wells Vermont: 10 wells New Jersey: 18 wells New York: 3 wells Virginia: 1 well Florida: no numbers Illinois: 5 wells Indiana: 2 wells Michigan: 27 wells New Mexico: no numbers Iowa: 1 well Missouri: 5 wells Utah: 2 wells Nevada: no numbers Idaho: 21 wells	Waste oil, antifreeze, floor washings (including detergents, organic, and inorganic sediment) and other petroleum products.	High	Connecticut-Permit New Jersey-NJPDES Permit New York-Permit Florida-Permit Illinois-Rule Nebraska-Rule Utah-Banned Idaho-Rule	- Inventory update is vital. Guidelines for construction, operation, and overall regulation of these wells need to be established. (NY, PR) - Permits should show construction features, a plan to utilize separators and holding tanks, and a plan to sample and analyze injected fluids. (IA) - Underground holding tanks should be required. (UT) - Local building code and sewer pretreatment inspection should identify areas where discharge to sewers is prohibited. (UT)
Recharge Wells					
Aquifer Recharge Wells (5R21)	Nationwide: 3,558 wells New Hampshire: 1 well New York: 3,000 wells Florida: 349 wells Illinois: 1 well Minnesota: 1 well New Mexico: 30 wells Texas: 44 wells Kansas: 4 wells Nebraska: 4 wells Wyoming: 32 wells Arizona: 51 wells California: 52 wells Idaho: 7 wells Washington: 7 wells Potentially found in areas characterized by large withdrawals for drinking water or irrigation far in excess of recharge.	Dependent upon source; water quality changes noted include adsorption, ion exchange, precipitation and dissolution, chemical oxidation, biological nitrification and denitrification, aerobic or anaerobic degradation, mechanical dispersion, and filtration.	High to Low	New Jersey-Rule/Permit Florida-Permit Illinois-Rule New Mexico-Registration Texas-Permit Nebraska-Rule Utah-Rule/Permit Wyoming-Permit Arizona-Permit California-Permit Idaho-Permit if deeper than 18 feet	- Injection fluid should be of generally equivalent or better quality than injection zone fluid. (NE) - Standards for injectate quality must be on a case by case basis. (AZ) - Regular injectate sampling should be conducted. (NE) - Use of proper design, construction and operation is essential. (FL, NE)

TABLE 2, continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Saline Water Intrusion Barrier Wells (5B22)	California: 155 wells Florida: 2 wells Potentially found in coastal areas typified by abundant fresh water withdrawals for irrigation and/or drinking water.	Varies with type of source; examples include advanced treated sewage, surface urban and agricultural runoff, and imported surface waters.	Low	New Jersey-Rule/Permit Florida-Permit Nebraska-Rule Utah-Rule/Permit California-Permit Washington-Permit	- Pilot studies to define lithologic and hydrogeologic parameters influencing salt water intrusion should be conducted on site-specific basis. (CA) - Characterization of interaction of injectate and formation fluids is necessary. (CA)
Subsidence Control Wells (5B23)	4 wells inventoried for Wisconsin from state reports; it is believed inventory is incomplete; potentially present in desert and coastal areas typified by large, long-term ground-water withdrawals; areas having carbonate aquifers are particularly susceptible to subsidence.	See 'Aquifer Recharge Wells'	Low	Wisconsin-Permit Nebraska-Rule Utah-Rule/Permit	- Injectate quality should be monitored. (CA) - Proper well design, operation, and construction practices should be implemented. (CA) - For additional recommendations, see 'Aquifer Recharge Wells'
Miscellaneous Wells					
Radioactive Waste Disposal wells (5N24)	Unknown number, but existence confirmed for Tennessee, New Mexico, Idaho, and Washington in State reports.	Variety of radioactive materials, including Beryllium 7, Tritium, Strontium 90, Cesium 137, Potassium 40, Cobalt 60, beta particles, Plutonium, Americium, Uranium, and radionuclides.	Unknown	Illinois-Rule New Mexico-Banned Oklahoma-Rule Nebraska-Rule Utah-Rule/Permit Idaho-Permit if deeper than 18 feet Washington-Permit	- Discharges should satisfy all known, available, reasonable treatment and control methods. (WA) - Discharge to cribs and french drains should be pretreated prior to disposal. (WA) - Permits, permit compliance, and enforcement actions should be negotiated annually with EPA through the State/EPA Agreement Program. (WA)
Experimental Technology Wells (5X25)	225 wells in State reports; Potentially located in every Region.	Wide variety of injected constituents: highly acidic or basic compounds for solution mining; domestic wastewater containing high total suspended solids, fecal coliform, ammonia, BOD, pH; air is used in certain water recovery projects.	Moderate to Low	Alabama-Permit Florida-Permit Mississippi-Rule North Carolina-Permit Illinois-Rule New Mexico-Permit Nebraska-Rule Utah-Rule/Permit Wyoming-Permit Arizona-Permit California-Permit Hawaii-Permit Nevada-Permit	- Wells should not be sited and operated so as to permit injection into Class IIB aquifers. (CA) - Detailed hydrogeological studies should be conducted prior to any proposed injection. (CA) - Chemical analysis of waste stream periodically. (CA) - Mechanical integrity tests should be developed and conducted regularly. (CA, AZ)

TABLE 2 , continued

SUMMARY OF CLASS V INJECTION WELL DATA AND RECOMMENDATIONS

TYPE OF INJECTION WELL	LOCATION & NUMBER OF WELLS OR POTENTIAL LOCATION	TYPES OF FLUIDS INJECTED	GROUND-WATER (USDW) CONTAMINATION POTENTIAL	STATE REGULATORY STRUCTURE	RECOMMENDATIONS
Aquifer Remediation Wells (Including Oil Recovery Injection Wells) (5X26)	Nationwide: 355 wells Rhode Island: 2 wells New Jersey: 9 wells Puerto Rico: 1 well Alabama: 1 well North Carolina: 12 wells Indiana: 4 wells Michigan: 59 wells Minnesota: 7 wells Wisconsin: 17 wells New Mexico: 50 wells Oklahoma: 60 wells Texas: 37 wells Kansas: 15 wells Missouri: no numbers Nebraska: no numbers Colorado: 81 wells	Dependent upon hydrogeologic regimen, parameters of the contamination plume, and design of the remediation program; for refinery projects, typical injectate constituents are oil/grease, phenols, toluene, benzene, lead, iron.	Unknown	New Jersey-NJPDES Permit Alabama-Permit North Carolina-Permit Wisconsin-Rule Oklahoma-Rule Nebraska-Permit Utah-Rule/Permit California-Permit	- Implementation of registering and monitoring programs. (KS) - Construction standards should be similar to those established for discharge wells. (OK) Cased from surface through the top of the injection zone. (OK) Screened intervals through sands and gravels. (OK) Annulus should be grouted. (OK) - Injected fluid quality should be better than that of the fluid in the contaminated aquifer but not necessarily of drinking water standards. (FL)
Abandoned Drinking Water/Waste Disposal Wells (5X29)	3,050 wells inventoried. Potentially present in all areas having shallow fresh water aquifers.	Potentially any kind of fluid, particularly brackish or saline water, hazardous chemicals and sewage; documentation of nitrate and coliform contamination documented in Nebraska (Exner and Spalding, 1985); Domestic sewage disposal via these wells documented for 75 homes in Minnesota; also documentation for disposal of pesticides within agricultural runoff (Jones, 1973; Exner and Spalding, 1985).	Moderate	Utah-Banned The following states have plugging and abandonment regulations for water wells: Rhode Island, New Jersey, Puerto Rico, Delaware, Maryland, Pennsylvania, Virginia, West Virginia, Alabama, Florida, Georgia, North Carolina, Tennessee, Illinois, Michigan, Minnesota, Ohio, Wisconsin, Arkansas, Louisiana, Oklahoma, Texas, Kansas, Missouri, Nebraska, Colorado, North Dakota, South Dakota, Wyoming, Arizona, California, Nevada, Alaska, Idaho, Oregon, and Washington	- Must establish a better inventory of wells. (PR, IN, MI, MN) - Wells should be properly plugged using cement. (MN)

with an appropriate background. A general understanding of our ground-water resource is essential, considering that over 95 percent of Class V injection wells discharge directly into, above, or between USDW.

The inventory information submitted by the State UIC programs is presented and summarized in Section Three of the report. Inventory numbers are given by well type and by USEPA Regions and States. The sources of the inventory data are primarily State reports; however, inventory information also was obtained from personal interviews, the FURS database (Federal UIC Reporting System), reports other than the State Class V reports, and published literature.

Section Four of the report is presented in two parts. The first part is a discussion of methods and criteria used to determine ground-water contamination potential important in assessing each individual well type. The second part of Section Four consists of the individual well type assessments for the Class V wells listed in Table 1. Each assessment addresses well purpose; inventory and location; construction, siting, and operation; nature of injected fluids and injection zone interactions; hydrogeology and water usage; contamination potential of well type; current regulatory approach; and State recommendations for siting, construction, operation, and corrective or remedial actions. As with the inventory information, most data used in the well type assessments came from State's Class V reports. Additional data were gathered from published literature, unpublished reports, inspection and investigation programs, and personal interviews.

The Summary and Conclusions Section, Section Five, provides an overview of the preceding sections on inventory and assessment and contains a summary table for quick reference. Section Six of the report presents recommendations both for the inventory database and for each Class V well type assessed in the report. The recommendations are a summary of those given by the State reports. The recommendations include consideration of the technical aspects of Class V injection, such as siting, construction and operation.

Appendix A consists of State Report Summaries for each of the State Class V reports received. Appendices B and C contain the glossary and list of acronyms and abbreviations used, respectively. Appendix D consists of a general bibliography and other well-type specific bibliographies. Appendix E is a listing of supporting data, mainly case studies, used (to augment State report data) in assessing well types.