

INJECTION WELLS

*An Introduction to Their Use,
Operation, and Regulation*

A publication of the

Ground Water
GWPC
Protection Council

~Dedicated to protecting the nation's ground water~

INTRODUCTION

What is a way to safely dispose of millions of gallons of liquid waste per year from many manufacturing sites? In what way can millions of gallons of municipal sewage-derived liquid waste be disposed of without impacts to lakes, rivers or oceans? How can we dispose of, or even better, use billions of gallons of fluids from oil and natural gas production to help produce more oil? How can valuable minerals be mined without constructing large, deep mines? What method can coastal communities use to slow down salt water migration into fresh drinking water?

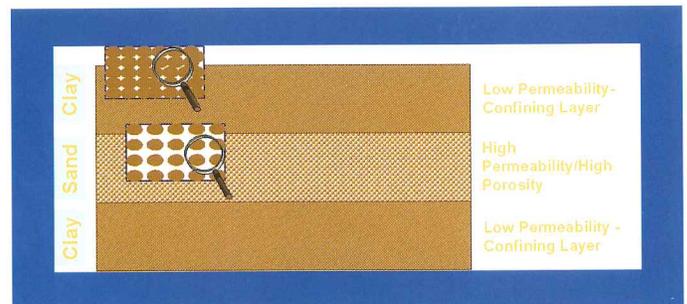
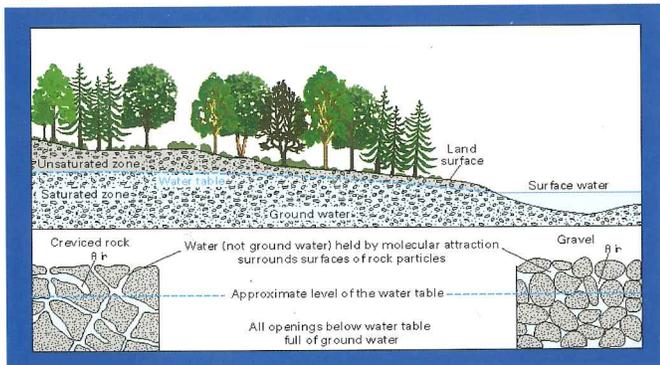
The answer to all of these questions can be summed up in two words: *underground injection*.

Ground Water

Water that is located in the subsurface is called ground water. To understand underground injection, a brief discussion of ground water and some geologic terms is essential, so let's begin.

Water is essential to life. Whether your drinking water comes from a public water supply or a private well or spring, your very existence depends upon having safe water. The average American household uses approximately 146,000 gallons of fresh water annually. Americans drink 1 billion glasses of tap water per day. Many homes and businesses use ground water. This water is located in small spaces in sand or rock, called pores, that are interconnected. The interconnected pores allow the water to move and be pumped out, or the water may flow out naturally, such as from an artesian well. The amount of water that infiltrates the subsurface varies widely, depending on land use, the type of soil present, and the amount of precipitation that falls.

Ground water is stored beneath the land surface of our local communities in formations of saturated rock, sand, gravel, and soil. Unlike surface water, ground water does not flow in a series of lakes and rivers. Instead, the precipitation that seeps into our soil continues its downward journey and eventually fills the pores of these subsurface formations. Ground water can also be replaced



or recharged when rock formations come into contact with surface water bodies such as lakes and rivers.

Formations that contain large enough amounts of water to feed springs or wells are called aquifers. Two factors determine the amount of water that aquifers can provide: porosity and permeability. Porosity is a measure of the amount of pore space, or holes, present in a rock. The more pores present, the greater the rock's ability to hold water. A rock with many pores has high porosity. Permeability refers to the degree to which the pores in the rock are connected, providing the ground water in the pores and cracks a way to move in the formation.

Ground water is found in rock, sand, gravel, and soil at a wide variety of depths. Ground water is essential to our public water supply systems, economic growth, national agricultural production, and the overall quality of life that we all share whether or not we are personally dependent on it for drinking water.

Estimates place the volume of nationally-usable ground water at 100 quadrillion gallons. However, a problem exists: the potential for ground water contamination. Once a ground water resource has been contaminated, cleaning it up to make it usable again can be extremely difficult, costly, and is sometimes not feasible at all.

Ground water can be extremely susceptible to contamination from a variety of common sources, including septic tanks, feed lots, fertilizer, highway de-icing salt, industrial processes, landfills, and underground storage tanks. It is important that these and other potential sources of contamination be

MOST AMERICANS ARE SURPRISED TO LEARN:

- 77 billion gallons of ground water are used in America each day, compared to 34 billion in 1950.
- 40% of the nation's drinking water and 92% of our total fresh water supply comes from ground water.
- 75% of our cities derive all or part of their water from underground sources.
- 99% of the rural population supply their own water from their own wells, using ground water.

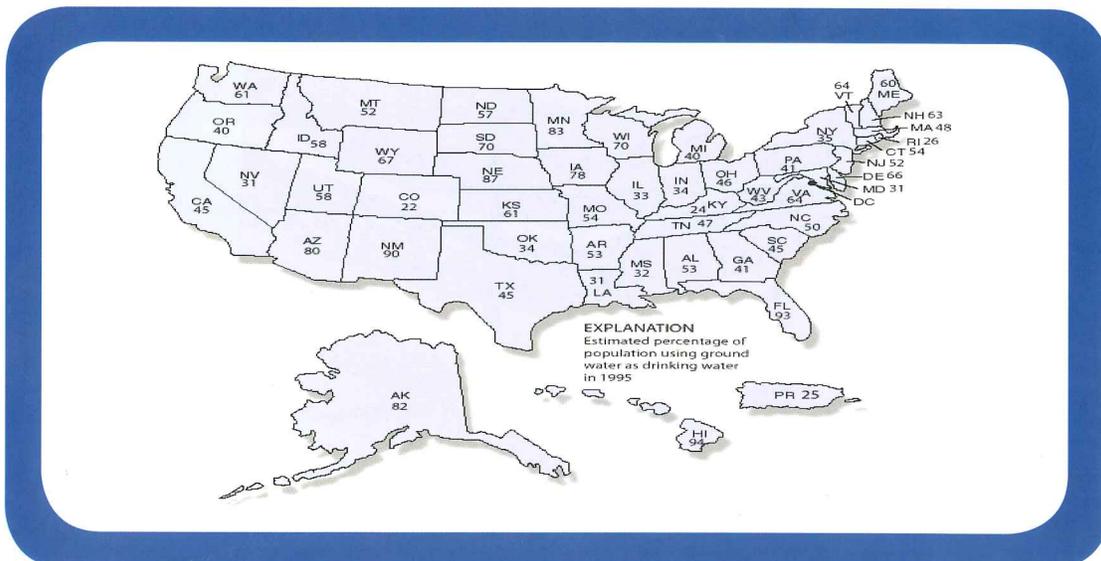
handled in ways that protect ground water. Some wastes are generated by industrial processes that are difficult or impossible to treat to levels that are safe for discharge at the surface. These materials may contaminate ground water resources if not kept away from them. Some of these wastes, in liquid form, can be pumped into formations deep below the earth's surface and permanently isolated from usable water resources.

Sandstone, a highly porous rock, generally allows water to move through its pores easily. Some rock formations, including many shales and clays, have very low vertical permeability and act as confining layers to fluid movement. Think of a sponge in between two thick layers of childrens clay. This is a simple version of how rock units in the subsurface can exist – a water filled formation with tight confining layers above and below that keep the fluid within the water-bearing layer. If liquid wastes are pumped into the sandy layer, represented by the sponge, the shale layers, represented by the clay, will keep the wastes trapped in the sandy layer and isolated from drinking water sources. There are approximately 190,000 wells in the United States that store or dispose of fluids in underground rock formations

trapped by shale layers, keeping the fluids away from underground sources of drinking water.

Ground water quality generally deteriorates with increased depth. Fresh water—that is, water with lower salinities and mineral content—is usually located nearer the earth's surface. Deeper rock formations contain water of limited quality or use, with high dissolved mineral content. Water with high salinity is not considered a potential source of drinking water. This is why these deep formations are used for disposal or injection of liquids.

Since the passage of several legislative acts in the 1970's that regulate waste disposal into water, air, and landfills, underground injection has grown in importance. In the petroleum industry alone, over two billion gallons of salt water are brought to the surface along with about two hundred million gallons of oil. The water is then separated, and re-injected deep underground each day. When disposed of at the surface, many of these fluids pose a risk of contaminating surface waters or ground water.



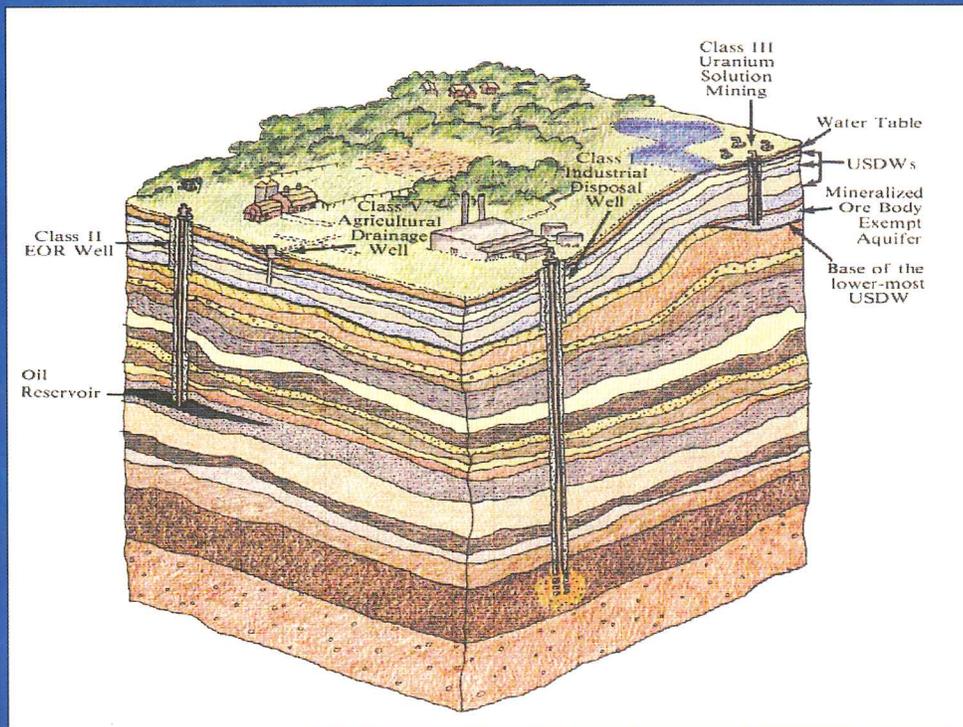
Underground Injection Wells

Underground injection is the placement of fluids into the subsurface through a well bore. Many of the wells used for injection are "high tech" in their construction, as discussed in this brochure. However, some are very simple, including dug wells, certain septic systems, and other shallow, simply constructed, subsurface fluid distribution systems. The practice of underground injection has become essential to many of today's industries, including the petroleum industry, chemical industry, food and product manufacturing companies, geothermal energy development, and many local small specialty plants and retail establishments. To dispose of fluids safely, the wells need to be in the right kind of geologic setting, properly constructed, operated, maintained, and checked through different kinds of monitoring.

In the late 1960's, the realization that subsurface injection could contaminate ground water if wells were not properly located and operated prompted many states to develop programs and methods to protect underground sources of usable water. Additionally, to increase ground water protection, a federal **Underground Injection Control (UIC)**

Program was established under the authority and standards of the federal Safe Drinking Water Act (SDWA) of 1974. This federal program establishes minimum requirements for effective state UIC Programs. Since ground water is a major source of drinking water in the United States, the UIC Program requirements were designed to prevent contamination of **Underground Sources of Drinking Water (USDW)** resulting from the operation of injection wells. A 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 either currently supplies a public water system, or contains less than 10,000 milligrams per liter of total dissolved solids and is not an exempted aquifer." Most ground water used as drinking water today contains less than 3,000 milligrams per liter of total dissolved solids (tds). However, the UIC Program protects waters with much higher mineral concentrations to ensure that all water with the potential to be treated and used as drinking water in the future is protected now. Since the passage of the Safe Drinking Water Act, state and federal regulatory agencies have modified existing programs or developed new strategies to protect ground water by establishing even more effective regulations to control the permitting, construction, operation, maintenance, monitoring, and closure of injection wells.

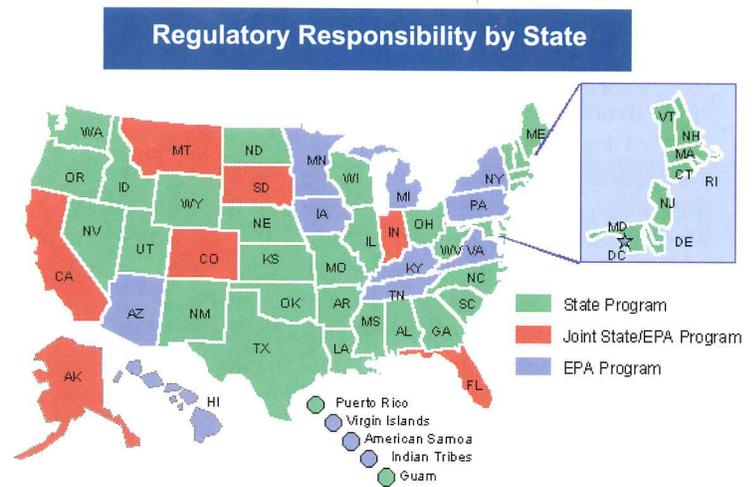
Injection Well Relationship to USDWs (Underground Sources of Drinking Water)



Injection wells are divided into five different classes. The classes are generally based on the kind of fluid injected and the depth of the fluid injection compared with the depth of the lowermost USDW. Class I wells are used to inject industrial or municipal waste to a depth beneath the lowermost USDW. Class II wells are used to dispose of fluids associated with the production of oil and natural gas. Class III wells are used to inject fluids to aid in the extraction of minerals. Class IV wells were used to dispose of hazardous or radioactive wastes into or above a USDW, but have been banned in all 50 states, unless they are part of a contaminated site cleanup. Though Class IV hazardous and radioactive waste disposal wells have been banned for many years, some are still periodically discovered and must be cleaned up and closed. Class V wells are all wells not included in Classes I-IV that are used to inject or dispose of non-hazardous waste into or above a USDW.

for one or more classes of injection wells. For instance, one agency may have authority over Class II wells, and another agency have authority over Class I and Class V wells. In states that have not received primary responsibility for the UIC Program, USEPA remains the responsible regulatory agency. These states are referred to as **Direct Implementation (or DI) States**, because USEPA directly implements the federal UIC regulations in these states. Some states share responsibility with the USEPA, with authority over some well classes residing at the state level, and other well classes being regulated by USEPA. For instance, in the map below, the State of Montana has primacy for Class II wells, while USEPA regulates other well classes.

The United States Environmental Protection Agency (USEPA) has given primary enforcement authority, called **Primacy**, over underground injection wells to those state agencies that have shown they are able to implement a UIC Program that meets USEPA's legal requirements. These requirements are in Sections 1422 and 1425 of the SDWA, and the Federal Register (40 Code of Federal Regulations Sections 144 through 147), the publication that includes all of the federal regulations. The states that USEPA has determined have regulations, laws, and resources in place that meet the federal requirements and are authorized to run the UIC Program are referred to as **Primacy States**. In many states, more than one state agency has Primacy



Injection Well Classification Chart

EPA CLASSIFICATION	INJECTION WELL DESCRIPTION	ACTIVE INVENTORY
CLASS I	Wells used to inject waste beneath the lowermost USDW	484 ¹
CLASS II	Wells used to dispose of fluids associated with the production of oil and natural gas	170,000 ²
CLASS III	Wells used to inject fluids for the extraction of minerals	19,925 ³
CLASS IV	Wells used to dispose of hazardous or radioactive wastes into or above a USDW	540
CLASS V	Wells not included in the other classes generally used to inject nonhazardous waste	1,500,000 ⁴

¹Source: GWPC Class I Inventory of the United States prepared by Texas World Operations, Inc., June 2005. Disposing of 9 billion gallons of waste per year

²Disposing of about 730 billion gallons of brine per year (Based on an average water vs oil production ratio of 10:1)

³Source: GWPC Class III Well Inventory prepared by Subsurface Technology, Inc., January 2004

⁴This number is based on a state by state estimate of Class V wells and is expected to increase when an inventory is conducted.

Class I Injection Wells: Injection Wells Used for Disposal of Hazardous, Industrial Non-Hazardous, and Municipal Wastewater Below USDWs

Some waste is an unavoidable byproduct of a myriad of manufacturing processes that create thousands of the products we use in the course of everyday living. Products such as steel, plastics, pharmaceuticals, and many others cannot be made without generating certain fluid wastes. While industry continues to research and implement ways to reduce waste by recycling and improving manufacturing processes, wastes are still generated that require disposal. There are many acceptable ways to do this job, including incineration, biological or chemical treatment, and landfills in properly located and constructed sites. Additionally, many millions of gallons of liquid wastes are generated in large municipalities from treated sewage. While some areas have rivers or other water bodies at the surface that can receive this treated water stream, others have very sensitive waters that make disposal of this wastewater unsafe and/or impractical. An environmentally acceptable way to deal with all of these wastes in many parts of the United States is disposal through injection wells. Injection wells penetrate thousands of feet below the earth's surface into rock formations where the waste is isolated from underground sources of drinking water. Class I wells typically inject anywhere from 1,700 to over 10,000 feet beneath the earth's surface. Most geologic formations containing potential drinking water sources are much shallower, within a few hundred feet of the ground surface.

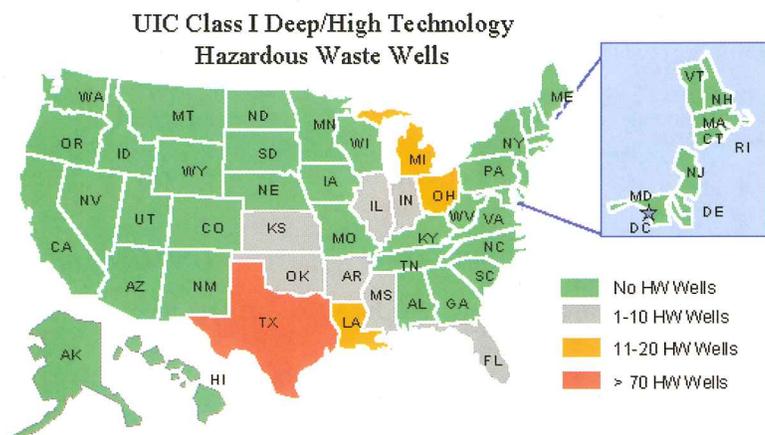
The suitability of this disposal method depends on the availability of appropriate underground rock formation combinations that have the natural ability to accept, yet confine, the wastes. It is this long term confinement that makes deep well disposal an environmentally sound waste disposal method. The ability of some rock formations to accept but confine liquids injected into them is the same characteristic that has held naturally occurring oil and gas

deposits for millions of years without allowing them to escape.

Because these wells inject waste below the deepest possible USDW, there is little chance of any negative effects on potentially usable ground water. In fact, in its March 2001 Study of Class I wells, the USEPA said that "the probability of loss of waste confinement due to Class I injection has been demonstrated to be low" and "existing Class I regulatory controls are strong, adequately protective, and provide an extremely low-risk option in managing the wastewaters of concern." In other words, the deep geologic formations that receive the waste (called the *injection zone*), the related confining layers above the injection zone, and the many layers of protection required in the construction, operating, and monitoring of wells, provide many safeguards against upward fluid movement, effectively protecting USDWs.

Class I wells can be subdivided by the types of waste injected: *hazardous, non-hazardous, and municipal waste water*. There are 291 active Class I injection facilities in 19 states; which have a total of 484 wells. Of these, 122 wells are listed as hazardous, 251 are non-hazardous and 111 are municipal waste. (*Class I Inventory of the United States*, June 2005, Texas World Operations, Inc. for GWPC) The greatest concentrations of Class I wells are located in the Gulf Coast, Great Lakes, and the Florida peninsular regions. A facility owner is required to apply for and receive a permit from the state or USEPA before constructing or operating any type of Class I well.

Hazardous Class I Injection Wells



Hazardous wastes are those industrial wastes that are specifically defined as hazardous in federal law and rules (40 CFR Part 261.3 under Section 3001, of Subtitle C of the Solid Waste Disposal Act, as amended by the 1976 Resource Conservation and Recovery Act, or RCRA). As seen in the figure to the left, very few states have Hazardous Class I injection wells. Many of these wells are located along the Texas-Louisiana Gulf Coast. This area has a large number of waste generators such as refineries and chemical plants as well as deep geologic formations that are ideal for the injection of wastes.

Non-Hazardous Industrial Class I Injection Wells

Non-hazardous wastes are any other industrial wastes that do not meet the legal definition of hazardous wastes and can include a wide variety of fluids, such as those from food processing. Texas and Kansas have the greatest number of wells in this category because these states have specific industries that generate large quantities of non-hazardous, liquid wastes. Non-hazardous industrial Class I wells are located in 19 states.

Municipal Class I Injection Wells

Municipal wastes, which are not specifically defined in federal regulations, are wastes associated with sewage effluent that has received treatment. Disposal of municipal waste through injection wells is currently practiced only in Florida. In Florida, this waste disposal practice is often chosen due to a shortage of available land, strict surface water discharge limitations, extremely permeable injection zones, and cost effectiveness.

Site Selection and Distribution

Site selection for a Class I disposal well is dependent upon geologic and hydrogeologic conditions, and only certain areas are suitable. Most of the favorable locations are generally in the mid-continent, Gulf Coast, and Great Lakes regions of the country, though some other areas are also safe for Class I well sites.

The process of selecting a site for a Class I disposal well involves evaluating many factors. Paramount in the consideration is the determination that the underground formations possess the natural ability to contain and isolate the injected waste. One important part of this determination is the evaluation of the history of earthquake activity. If a location shows this type of instability in the subsurface, it may mean that fluids will not stay contained in the injection zone, indicating the well should not be located in that particular location. A second important factor is determining if any improperly abandoned wells, mineral resources that provide economic reserves, or underground sources of drinking water are identified in the area. These resources are evaluated to ensure that the injection well will not cause negative impacts. Abandoned wells of any type—oil, gas, water, or injection that penetrate the proposed injection zone are investigated within a specified radius of the injection well to ensure that they were properly plugged. If they were not, they must be properly plugged to prevent them from becoming a means for the fluids injected into the Class I well

to escape upward, potentially contaminating ground water.

A detailed study is conducted to determine the suitability of the underground formations for disposal and confinement. The receiving formation must be far below any usable ground water and be separated from them by confining layers of rock, which prevent fluid migration upward. The injection zone in the receiving formation must be of sufficient size (both over a large area and thickness) and have sufficient porosity and permeability to accept and contain the injected wastes. The region around the well should be geologically stable, and the injection zone should not contain recoverable mineral resources such as ores, oil, coal, or gas.

Construction Requirements

The primary concern in the construction of a Class I injection well is the protection of ground water by assuring containment of the injected wastes through a **multilayer protection system**. A Class I injection well is constructed in stages, the first stage being the drilling of a hole to a depth below the lowermost USDW. A steel casing or surface pipe (usually between 6.5 and 15 inches outside diameter) is installed the full length of the bore hole and cement is placed outside of the casing from the bottom to the top of the hole. This provides a barrier of steel and cement that protects the ground water.

The second phase is to continue drilling below the surface casing down through the intended injection zone. After drilling is complete, a second, smaller, (generally between 4.5 and 10 inches outside diameter) protective pipe called injection casing is installed from the surface down to the injection zone and is cemented in place from bottom to top. An injection packer, which is like a drain plug with a hole in the middle, is located inside the long string casing above the injection zone by placing it on an even smaller protective pipe (about 2.5 to 7 inches in diameter), known as injection tubing, which is placed inside the long string. The space between the long string



and the injection tubing, called the annulus, is filled with a corrosion inhibiting fluid. When the seal on the outside of the injection packer is inflated tightly against the sides of the injection casing it forms a seal which keeps the annulus fluid in and the injection fluid out of the space above the packer. The pressure in this annular space is constantly monitored so that any change, indicating a failure of safety systems, would cause the well to be shut down for repairs before possible contamination of a USDW. The diagram below illustrates the basic components of a Class I well in a cutaway view.

Operating Requirements

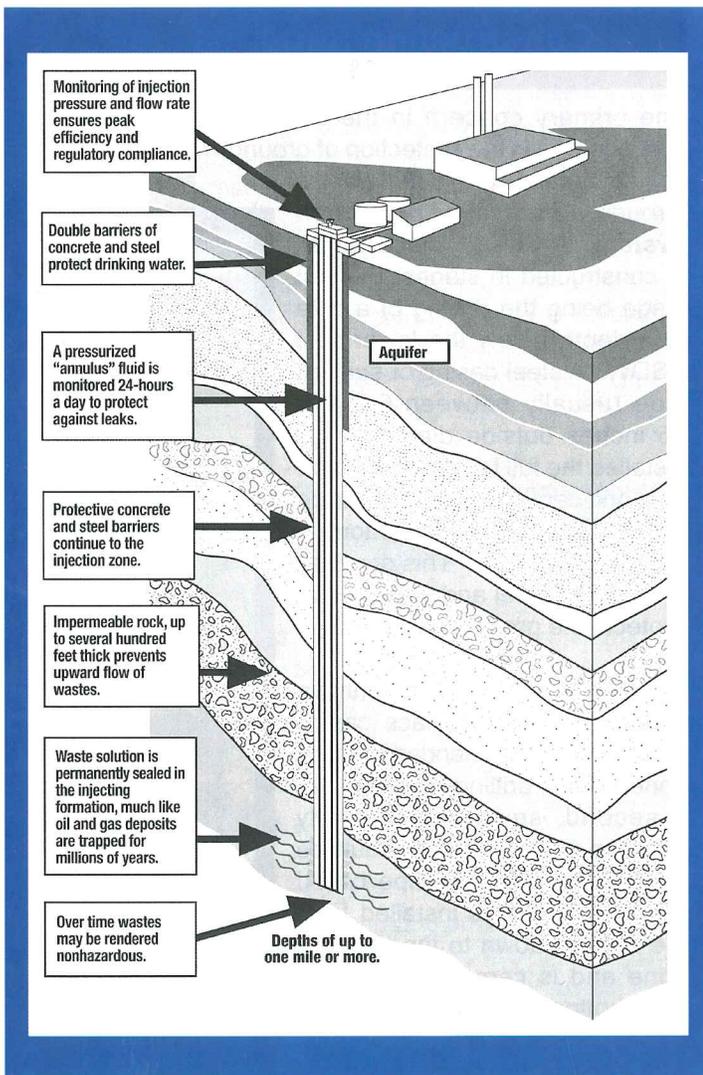
The operating conditions for the well are closely studied and are limited in the permit to make sure that the pressure at which the fluids will be pumped into the subsurface is safe, that the rock units can safely receive the volume of fluids to be disposed of, and that the waste stream is compatible with all the well construction components and the natural characteristics of the rocks into which the fluids will be injected.

Monitoring Requirements

Class I injection wells are continuously monitored and controlled, usually with sophisticated computers and digital equipment. Thousands of data points about the pumping pressure for fluid disposal, the pressure in the annulus between the injection tubing and the well casing (that shows there are no leaks in the well), and data on the fluid being disposed of, such as its temperature and flow rate, are monitored and recorded each day. Alarms are connected to sound if anything out of the ordinary happens, and if unusual pressures are sensed by the monitoring equipment, the well automatically shuts off. Disposal in the well does not resume until the cause of the unusual event is investigated, and the people responsible for operating the well and the regulatory agencies both are sure that no environmental harm has been or will be done by well operations. The wells are also tested regularly, using special tools that are inserted into the well to record data about the well and surrounding rock formations. These test results tell a geologist or engineer a great deal about conditions down in the well where we cannot otherwise see.

Regulators review all the data about the well operations, monitoring and testing frequently, and inspecting the well site to make sure everything is operating according to the requirements put in place to protect drinking water sources.

When a Class I well is taken out of service, the injection tubing is taken out and the well is plugged to prevent any waste movement. Often, a combination of mechanical plugs and cement are used to seal the wells, which are considered to be permanently secured—not abandoned. The large column of cement in the well ensures that nothing can move up or down in the well, protecting the ground water resources that could otherwise be affected. Properly located, designed, constructed, operated, and monitored Class I wells have proven through years of use and many studies to be an environmentally and technically-sound method of permanent liquid waste disposal.



NOT TO SCALE

Class II Injection Wells: Injection Wells Related to Oil and Gas Activity

Class II injection wells have been used in oil field related activities since the 1930's. Today there are approximately 170,000 Class II injection wells located in 31 states. All Class II injection wells are regulated by either a state agency which has been granted regulatory authority over the program, or by USEPA. Class II wells are subject to a regulatory process which requires a technical review to assure adequate protection of drinking water and an administrative review defining operational guidelines. The evaluation of the site suitability for a Class II injection well is very similar to that for a Class I nonhazardous waste injection well. The site's subsurface conditions are evaluated to make sure the formations will keep the fluids out of drinking water sources. The wells must be constructed to protect USDWs, and wells are tested and monitored periodically to ensure no drinking water is being negatively impacted by the operations.

Class II wells are categorized into three subclasses: **salt water disposal wells, enhanced oil recovery (EOR) wells, and hydrocarbon storage wells.**

Salt Water Disposal Wells

As oil and natural gas are brought to the surface, they generally are mixed with salt water. On a national average, approximately 10 barrels of salt water are produced with every barrel of crude oil. Geologic formations are selected to receive the produced waters, which are reinjected through disposal wells and enhanced recovery wells. These wells have been used as a standard practice in the oil and gas industry for many decades and are subject to authorization by regulatory agencies.

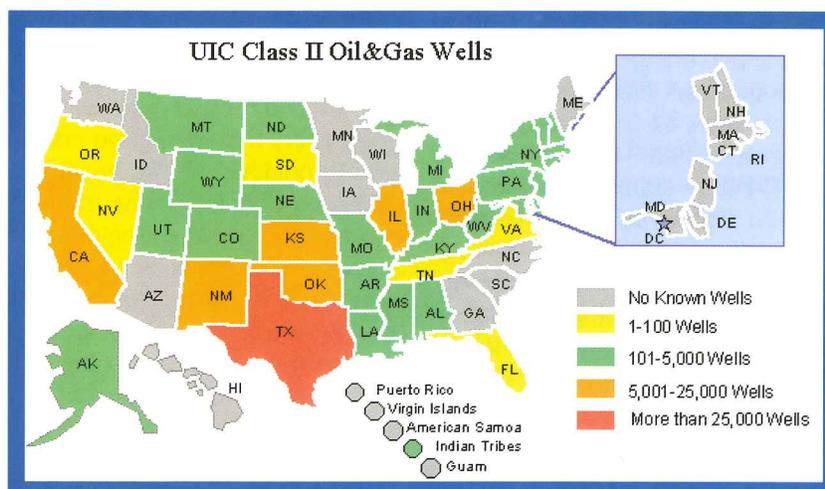
Enhanced Oil Recovery Wells

Enhanced Oil Recovery (EOR) injection wells are used to increase production and prolong the life of oil-producing fields. **Secondary recovery** is an EOR process commonly referred to as water-flooding. In this process, salt water that was co-produced with oil and gas is reinjected into the oil-producing formation to drive oil into pumping wells, resulting in the recovery of additional oil. **Tertiary recovery** is an EOR process that is used after secondary recovery methods become inefficient or uneconomical. Tertiary recovery methods include the injection of gas, water with special additives, and steam to maintain and extend oil production. These methods allow the maximum amount of the oil to be retrieved out of the subsurface. Approximately 60% of the salt water produced with oil and gas onshore in the United States is injected into EOR wells.

Hydrocarbon Storage Wells

Hydrocarbon storage wells are generally used for the underground storage of crude oil and liquid hydrocarbons* in naturally occurring salt or rock formations. The wells are designed for both injection and removal of the stored hydrocarbons. The hydrocarbons are injected into the formation for storage and later pumped back out for processing and use.

* Hydrocarbons fit this classification if they are liquid at standard temperature and pressure (75 degrees Fahrenheit at 14.7 pounds per square inch).



Construction Requirements

Construction of Class II injection wells must adequately confine injected fluids to the authorized injection zone to prevent the migration of fluids into USDWs. Through the permitting process, site specific requirements are imposed to address any unusual circumstances.

These injection wells are drilled and constructed using the same techniques as those for Class I wells, with steel pipe (called casing) cemented in place to prevent the migration of fluids into USDWs. Surface casing in conventionally constructed wells is cemented from below the lowermost USDW up to the surface to prevent fluid movement. Cement is also placed behind the injection casing at critical sections to confine injected fluids to the authorized zone of injection. A typical salt water injection well also has the injection tubing that was described earlier, through which the fluids are pumped from the surface down into the receiving geologic formations. As described in the section on Class I wells, a packer is commonly used to isolate the injection zone from the space between the tubing and injection casing above the packer, called the annulus. In some cases, multiple wells will be constructed under one permit, to manage the fluids in an entire oil or natural gas production field. The overall well system for injection is then evaluated by regulators to make sure all the components are properly constructed.

Operations

Typically, oil, gas, and salt water are separated at the oil and gas production facilities. The salt water is then either piped or trucked to the injection site for disposal or EOR operations. There, the salt water is transferred to holding tanks and pumped down the injection well. For EOR, the salt water may be treated or augmented with other fluids prior to injection. In some EOR cases, fresh water, or fresh water converted to steam, is injected to maximize oil recovery.

Injection well operations are regulated in ways to prevent the contamination of USDWs and to ensure fluid placement and confinement within the authorized injection zone. This includes limitations on factors such as the pressure that can be used to pump the water or steam into the well, or the volume of the injectate. Primacy states have adopted regulations which have been approved by USEPA as protective of USDWs for Class II injection well operations. These regulations address injection pressures, well testing, pressure monitoring, and reporting. Direct implementation states must meet operational guidelines developed directly by USEPA.

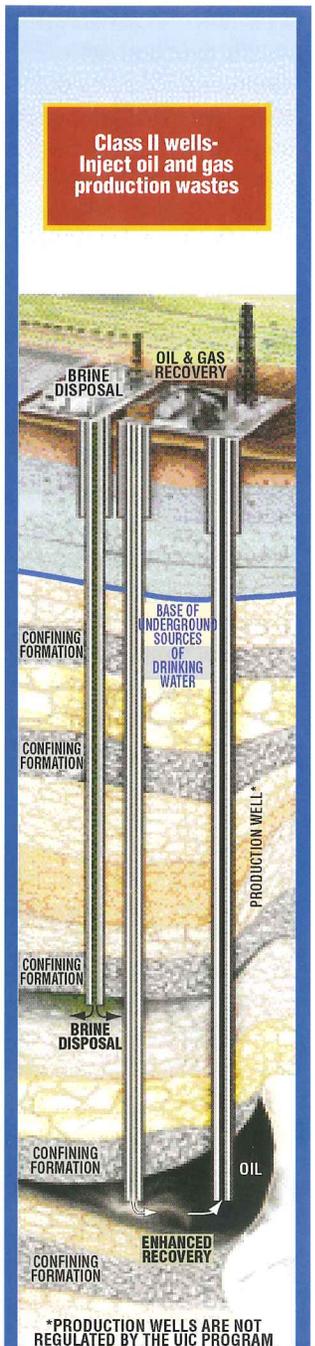
Testing and Monitoring

After placing Class II injection wells in service, ground water protection is assured by testing and monitoring the wells. Injection pressures and volumes are monitored as a valuable indicator of well performance. Effective monitoring is important since it can identify problems below ground in the well so that corrective action can be taken quickly to prevent endangerment of USDWs.

Tests that evaluate the conditions of the various well components and the formations in the subsurface are required prior to initial injection and no less than once every five years afterward. However, in some cases, more frequent testing may be required by regulatory authorities, if needed. All tests and test methods are rigorously reviewed by the State and/or USEPA. Test data, as well as data on the volume and characteristics of the fluids injected into the well, are regularly evaluated by regulatory agencies to make sure USDWs are protected by the operation and maintenance of the wells.

Closure

Closure of Class II wells must be conducted in a manner protective of USDWs. Although regulations vary slightly from state to state, a cement plug is commonly required to be placed in the well across the base of the lowermost USDW and near the surface.



Class III Injection Wells: Injection Wells Related to Mineral Extraction

Class III injection wells are found in 18 states. Every Class III injection well, whether located in a Primacy or Direct Implementation state, must be permitted through the authorized regulatory agency. The operating permit requires that a well meet any regulations the state has adopted to ensure the protection of USDWs. The permits may include specific requirements for well construction, monitoring, mechanical integrity testing, maximum allowable injection pressure, and reporting. Proper closure or plugging of all Class III injection wells must be conducted in a manner to protect USDWs from potential contamination.

The techniques these wells use for mineral extraction may be divided into two basic categories: **solution mining** of salts and sulfur, and **in situ leaching** (in place leaching) for various minerals such as copper, gold, or uranium.

Solution Mining

Solution mining techniques are used primarily for the extraction of salts and sulfur. For common salt, the solution mining process involves injection of relatively fresh water, which then dissolves the underground salt formation. The resulting brine solution is pumped to the surface, either through the space between the tubing and the casing in the injection well, or through separate production wells.

The technique for solution mining of sulfur is known as the Frasch process. This process consists of injecting superheated water down the space between the tubing and the casings of the injection well and into the sulfur-bearing formations to melt the sulfur. The molten sulfur is extracted from the subsurface through the tubing in the injection well, with the aid of compressed air, which mixes with the liquid sulfur and airlifts it to the surface.

In Situ Leaching

In situ leaching is commonly used to extract copper, gold, and uranium. Uranium is the predominant mineral mined by this technique. The uranium *in situ* leaching process involves injection of a neutral water solution containing nontoxic chemicals (e.g., oxygen and carbon dioxide) down the well. This fortified water is circulated through an underground ore body or mineral zone to dissolve the uranium particles that coat the sand grains of the ore body. The resulting uranium-rich solution is then pumped to the surface, where the uranium is extracted from the solution and the leaching solution is recycled back into the ore body through the injection well. This same general technology is employed for *in situ* leaching of other minerals, the only

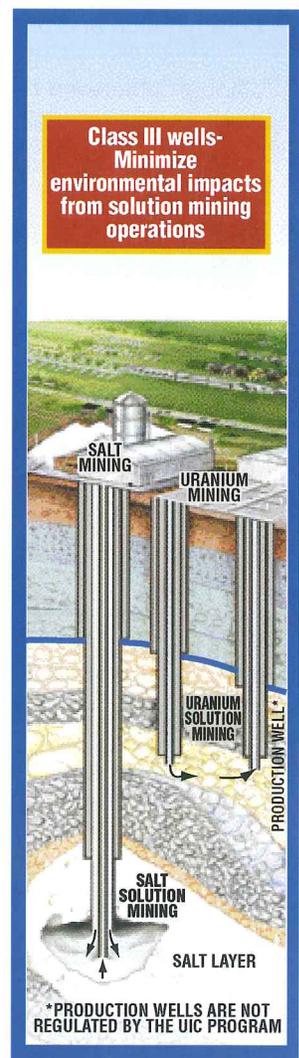
difference being the type of fluid used in the process.

The typical life of an *in situ* leaching well is less than five years. At the end of the *in situ* leaching operations, UIC regulations require restoration of the mined zone to its original quality. Given the purpose of Class III wells and their life span, Class III UIC projects often include many wells that are authorized through one permit, called an area permit. The standards in the permit apply to all of the wells in the project area.

Construction and Testing

Construction standards for Class III injection wells are designed to confine injected fluids to the authorized injection zone to prevent migration of these fluids into USDWs. Class III injection wells are drilled into mineralized rock formations and are cased with pipe which is cemented in place to prevent fluid migration into USDWs. Construction materials and techniques vary and depend upon the mineral extracted and the nature of the injected fluids.

Tests are required before initial operation of Class III injection wells to evaluate conditions of the well construction materials and the rock formations. Several different tests have been approved for this purpose. The tests are required to determine that there are no leaks in the tubing, casing, or packer and there is no fluid movement into a USDW. *In situ* leaching wells also require that the ore body be surrounded by monitoring wells to detect horizontal migration of the mining solutions. Additionally, overlying and underlying aquifers must be monitored to detect any vertical migration of these same fluids. This entire network closely monitors the mining activity performed through Class III wells to protect USDWs.



Class IV Injection Wells: Injection Wells Used for Hazardous and Radioactive Wastewater Disposal Into or Above USDWs

Class IV wells have been identified by USEPA as a significant threat to human health and the environment since these wells introduce very dangerous wastes into or above a potential drinking water source. USEPA has banned the use of these wells for many years. However, due to both accidents and illegal intentional acts, Class IV wells are still periodically found at various locations. As these wells are identified by state and federal UIC regulatory agencies, their closure is a high priority for the UIC Program. Regulators evaluate site conditions, determine what actions need to be taken to clean up the well and surrounding area, and permanently close the well so additional hazardous wastes cannot enter the subsurface through the well. This well class may include storm drains where spills of hazardous wastes enter the ground or septic systems where hazardous waste streams are combined with sanitary waste. When these wells are found, the UIC Program staff usually coordinates with the state or USEPA hazardous waste program staff to oversee actions required at the site to remove the contamination and protect USDWs.

Although otherwise banned, there is one instance where Class IV wells are allowed. In these cases the wells are used to help *clean up* existing contamination. Sites exist across the United States where hazardous wastes have

entered aquifers due to spills, leaks or similar releases into the subsurface. Under two separate federal laws, the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), regulators require and oversee the clean up of these contaminated sites. Some remediation technologies require the contaminated ground water to be pumped out of the subsurface, treated at the surface to remove certain contaminants, then pumped back into the contaminated formation. The process essentially creates a big treatment loop for the ground water. However, the water can still have contaminants at levels that meet the definition of hazardous waste when it is injected back into the subsurface, until the treatment process has time to remove more contaminants. Thus, these wells that are treating and cleaning up ground water technically are still Class IV wells. USEPA recognized that these site clean ups need to occur, and that the ban of Class IV wells was hindering the process. Since these wells are helping the environment, the agency changed the regulations to allow these wells to be used, as long as they are part of an approved regulatory clean up of the site. This is the only exemption to the ban on Class IV wells.

The ban on Class IV wells prevents ground water contamination by prohibiting the shallow injection of hazardous waste except as part of authorized cleanup activities.



Class V Wells: Injection Wells Not Included in the Other Classes

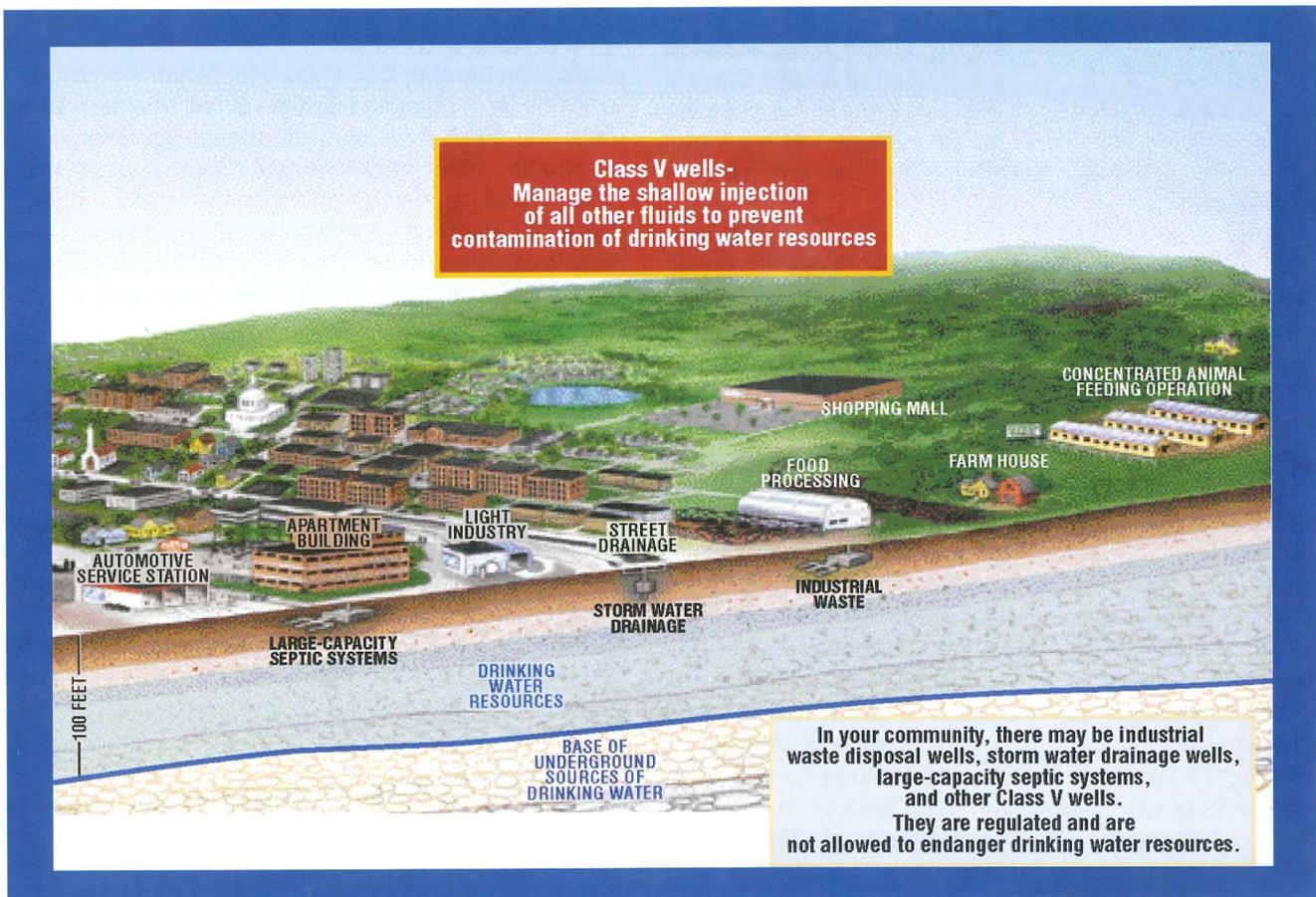
If a well does not fit into one of the first four classes of injection wells, but still meets the definition of an injection well, it is considered a Class V well. Class V injection practices recognized by USEPA include several individual types of wells, which range in complexity from simple cesspools that are barely deeper than they are wide, to sophisticated geothermal reinjection wells that may be thousands of feet deep. However, the number of shallow, relatively simple Class V wells is large, and the sophisticated, deep Class V wells are quite rare in comparison. Remember that injection wells are classified based on the type of waste disposed of and the depth of the disposal zone compared with the deepest USDW. In some parts of the country, USDWs can exist at great depths. Because injection above the USDW does not meet the definition of a Class I well, such wells are classified as Class V wells. Also, if the fluids injected are **NOT**:

1. Class I: Hazardous waste and non hazardous industrial or municipal waste injected below the lowermost USDW; or
2. Class II: From oil and natural gas activities; or
3. Class III: Related to mineral production; or
4. Class IV: Hazardous or radioactive wastes injected into or

above a USDW, the well defaults to the Class V category.

Class V injection wells can be located anywhere, but they are especially likely to exist in areas that do not have sewers. These unsewered areas are often the same areas where people are most likely to depend on ground water for their drinking water source, typically from private wells that do not undergo treatment at a public water supply system. The variety of Class V wells includes but is not limited to agricultural drainage wells, storm water drainage wells, large capacity septic systems, mine backfill wells, aquifer remediation wells, heat pump/air conditioning return flow wells, aquifer recharge wells, aquifer storage and recovery, saltwater intrusion barrier wells, subsidence control wells, and industrial disposal wells.

Not all Class V wells are used for disposal. Examples of Class V practices which are not disposal related include: aquifer recharge, aquifer storage and recovery, and saltwater intrusion control.



Class V Disposal Wells and Your Drinking Water

Class V wells injecting below the lowermost USDW have the least potential for contaminating ground water. Class V injection directly into USDWs has a greater potential to cause harm to water quality than discharges above the water table. Discharges above the water table may allow some contaminants to be removed from the waste through absorption by soils, and by degrading or otherwise changing as they move through shallow soils and some rock formations. However, some rock formations and soil types, such as sand, can allow fluids injected above USDWs to move very quickly without very much change. In these cases, the effect can be similar to injecting directly into the USDW.

Based on numbers obtained through a survey of the states, it is estimated that there are at least 1,500,000 Class V injection wells in the United States and its territories. The survey also suggests that about 83 percent of all Class V wells belong to two categories: drainage wells (approx. 57 percent) and sewage-related wells (approx. 26 percent).

USEPA has developed rules and a strategy for regulating Class V injection wells. Involvement by state and local government and the public in implementing the strategy is essential to its success. Many states have adopted regulations and ordinances for oversight of certain Class V wells. USEPA targeted those Class V wells which pose the greatest environmental risks as candidates for regulatory development, education and outreach, and enforcement when necessary.

Two groups of particular concern are **large capacity cesspools** and **automotive waste disposal wells**. Large capacity cesspools are any residential cesspools used by multiple dwellings, businesses, or other facilities that are not individual homes (such as schools and churches). The specific definition of a large capacity cesspool can vary slightly from state to state, and environmental regulators can help a facility determine if their cesspool is "large capacity." Large capacity cesspools dispose of untreated sewage into or above a drinking water source, creating significant risk for bacteria and viruses being introduced into drinking water. Automotive waste disposal wells are those used by motor vehicle repair or maintenance shops, car dealers, or any operation that disposes of fluids from vehicles (including trucks, boats, trains, planes, tractors, snowmobiles, and similar types of vehicles). Motor vehicle waste disposal wells have a high potential to receive drops and spills of vehicle fluids, such as oil, transmission fluid, antifreeze, solvents and degreasers, and other toxic materials. As these fluids

enter ground water, they can create a serious health risk if consumed in drinking water.

These two types of Class V wells were the subject of additional rulemaking due to the high risk they pose to USDWs. In 1999, USEPA finalized the *Underground Injection Control Regulations for Class V Injection Wells, Revisions*, known as the **Class V Rule, Phase I**, which establishes minimum federal standards for these two kinds of Class V wells. Some of the protective requirements of the Class V Rule, Phase I include a ban on new large capacity cesspools and the closure of all existing large capacity cesspools by 2005. New motor vehicle waste disposal wells are also banned, while existing wells in ground water protection areas and other designated sensitive ground water areas must either be permanently closed or permitted by the primacy state or USEPA to continue operating under the ban. Some UIC primacy states have made the requirements for existing motor vehicle waste disposal wells apply in the entire state, rather than limiting them to specific sensitive ground water areas. The owner or operator of a large capacity cesspool or motor vehicle waste disposal well is required to send a notice to the state or USEPA at least 30 days before beginning to close one of these wells. USEPA developed a special guide for owners and operators of motor vehicle waste disposal wells, to provide additional information about how the rule affects them. The document, entitled *Small Entity Compliance Guide: How the New Motor Vehicle Waste Disposal Well Rule Affects Your Business*, is USEPA publication number 816-R-00-018, November 2000, and is available by contacting USEPA's Small Business Division at (800) 368-5888. Additional information about large capacity cesspools, motor vehicle waste disposal wells, and other Class V wells is also available on the Internet at www.epa.gov/safewater/uic/. A video describing the regulation and closure of motor vehicle waste disposal wells is available in the UIC section of the GWPC website at www.gwpc.org.

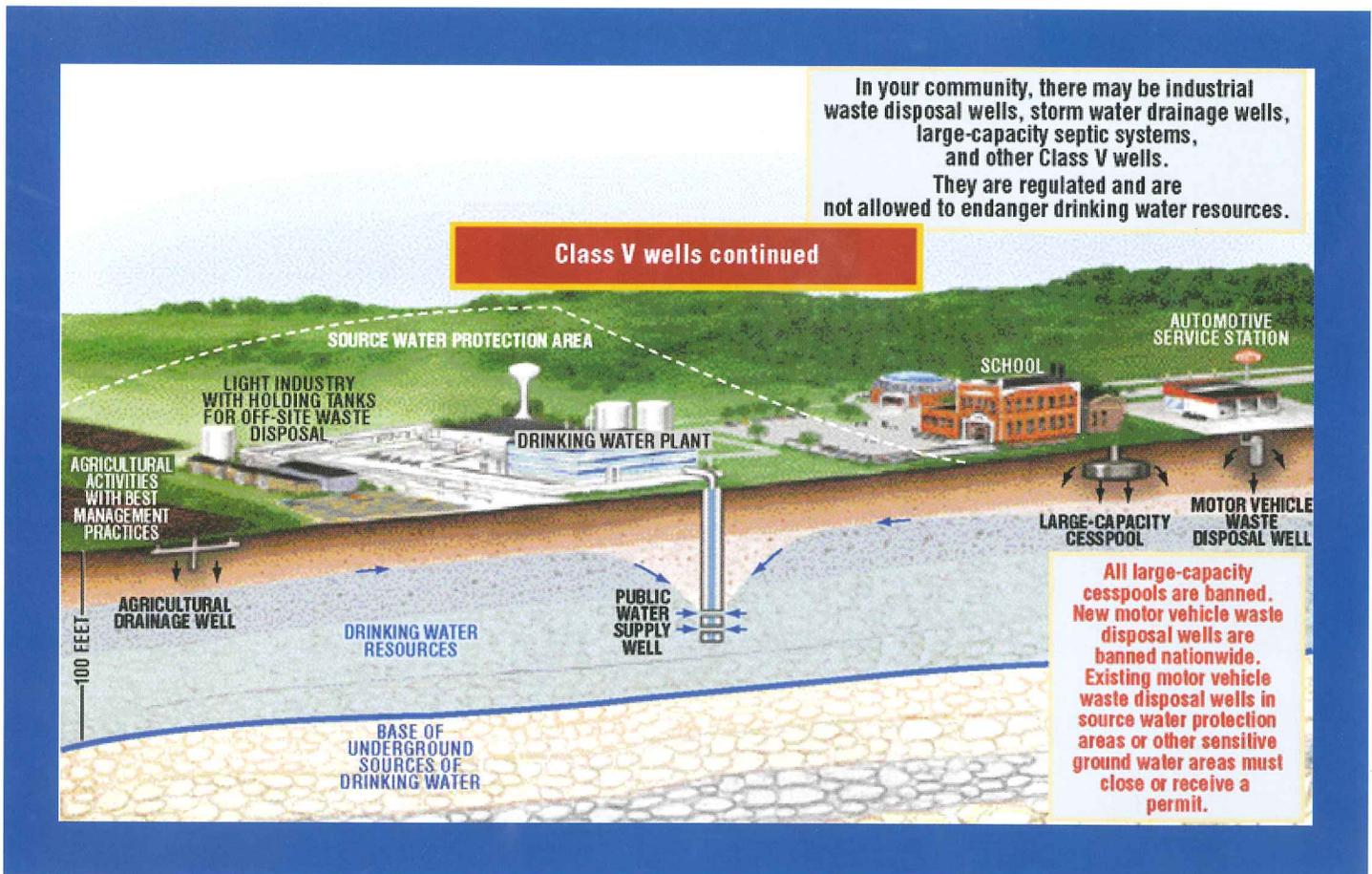
In June 2002, USEPA announced its final determination that, at that time, additional federal requirements were not needed for the remaining types of Class V wells (other than the motor vehicle waste disposal wells and large capacity cesspools). The determination also noted that the use and enforcement of existing federal UIC regulations are adequate to prevent Class V wells from endangering USDWs. This determination was made after completion of a national Class V study, a proposed determination, receipt of public comments and additional information received in response to the proposed determination, and a final assessment of all the data and information provided by the public and by various state UIC programs.

This determination certainly does not mean that Class V wells are not regulated. In fact, the only Class V wells

that are operating legally are those whose owners have submitted inventory information to the State or USEPA as required by regulation and are operating their wells in a way that does not endanger USDWs. The required inventory information is simple to prepare and submit, and each Regional USEPA office or primacy state has a form that an owner or operator of a Class V well should complete. If the state or USEPA office decides that additional information is necessary to ensure USDWs are not threatened by the operation of a well, the owner or operator will be asked for that information. There are cases in which a well that is not a large capacity cesspool or motor vehicle disposal well will be required to be subject to a permit or required to be permanently closed. This could occur with virtually any type of Class V well, due to local or state regulations that include additional requirements beyond the federal standards, or based on data that indicate the well poses a risk of contamination to nearby underground drinking water sources.

discussion of how the agency will continue to prioritize Class V program actions to ensure that these wells are constructed, operated, and maintained to protect USDWs. These actions include continuing to implement the long standing UIC regulations as well as the 1999 Class V, Phase I Rule, educating and assisting Class V well operators on best management practices and compliance tools, exploring non-regulatory approaches for voluntary Class V well standards and practices, and coordinating with other USEPA programs to educate and inform the maximum possible number of UIC well facilities. USEPA also will evaluate new information as it becomes available, and if new information illustrates additional needs in the Class V UIC Program, the agency will still be able to take additional steps, including developing additional federal regulations.

The June 2002 determination by USEPA included a



Public Awareness: The Key to Protecting Drinking Water

As you can tell from all the information in this brochure, protecting drinking water is a responsibility that everyone needs to take seriously. Being aware of your drinking water source is the first step. You then can actively participate in protecting it. This could include working with your local community in developing or helping implement an existing program to protect drinking water sources, known as *Source Water Protection*. While Class I, II, and III wells are heavily regulated, your community may have unidentified Class IV or Class V injection wells. Even though there are federal, state, or local regulations affecting a wide variety of potential ground water contaminant sources, each of us should learn how our community might be affected by any of them and, if we are, what we can do about it. Perhaps you will be the key to unlocking the information necessary to help your community identify these potential contaminant sources and protect your drinking water!

If you would like any additional information about a specific class of injection well, or the UIC Program in general, you may contact the Ground Water Protection Council at www.gwpc.org or at (405)516-4972. You can find more federal UIC information at www.epa.gov/safewater, or by contacting USEPA's Drinking Water Hotline at 1-800-426-4791 or by email at hotline-sdwa@epa.gov.

Ground Water GWPC Protection Council

OUR MISSION:

The Ground Water Protection Council is a national association of state ground water and underground injection control agencies whose mission is to promote the protection and conservation of ground water resources for all beneficial uses, recognizing ground water as a critical component of the ecosystem.

The Ground Water Protection Council provides a forum for stakeholder communication and research in order to improve governments' role in the protection and conservation of ground water.