EPA-570/9-79-014

ANALYSIS OF COSTS UNDERGROUND INJECTION CONTROL REGULATIONS

CLASS I AND CLASS III WELLS
CLASS IV AND CLASS V WELLS

SUBMITTED TO.

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF DRINKING WATER
WASHINGTON, D. C.

BY.

TEMPLE, BARKER & SLOANE, INC.
33 HAYDEN AVENUE
LEXINGTON, MASSACHUSETTS 02173

MAY 1979

NOTICE

This report replaces the following supporting documents referenced in the Federal Register Notice of 40 CFR Part 146, April 20, 1979, page 23752:

2. "Analysis of Costs Underground Injection Control Regulations, Class I and III."

3. "Methods and Costs for Inventory and Assessment of Injection Wells Covered Under Classes IV and V."

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PART ONE

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PREFACE

This report has been submitted to the United States Environmental Protection Agency in partial fulfillment of Contract Number 68-01-4778 by Temple, Barker & Sloane, Inc., 33 Hayden Avenue, Lexington, Massachusetts. This report supercedes the report "Analysis of Costs, Underground Injection Control Regulations, Subparts C and E," submitted May 3, 1978. This current version has been prepared in support of the reproposed UIC Regulations of April 20, 1979.

The contributions of state offices, trade associations and operating companies during the course of this study proved to be invaluable. Specifically, The American Mining Congress, The Salt Institute, and members of sulfur-producing, salt, and potash companies were particularly helpful. Geraghty & Miller, Inc., groundwater geologists and hydrologists, provided extensive information on costs of compliance and physical characteristics of the practices.

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I. INTRODUCTION AND CONCLUSIONS

INTRODUCTION

This report presents an analysis of the costs associated with implementing the requirements for Class I and Class III wells under the proposed Underground Injection Control (UIC) regulations. Class I wells include "industrial and municipal disposal wells and nuclear storage and disposal wells that inject below all underground sources of drinking water in the area." Class III wells consist of "all special process injection wells, for example, those involved in the solution mining of minerals, in situ gasification of oil shale, coal, etc., and the recovery of geothermal energy."[1]

Earlier versions of the presently proposed UIC regulations had classified these wells differently. For example, the 1976 UIC regulations grouped these wells under its Subpart C. Under the August 1977 draft UIC regulations, deep disposal and storage wells were covered under Subpart C, while mining, geothermal, and in situ gasification wells were to be regulated under Subpart E. As is clear from the definitions above, Subpart C wells are equivalent to Class I wells, and Subpart E wells are equivalent to Class III wells.

Though the well classification schemes have changed, the intent of the UIC regulations has remained the same. These regulations were developed by EPA in response to directives in the Safe Drinking Water Act (Public Law 93-523)--to establish minimum requirements for effective state programs to prevent underground injection practices which endanger underground sources of drinking water. Specifically, the states are required to (1) prohibit unauthorized underground injection, (2) require applicants for underground injection permits to prove that the injections will not endanger drinking water sources, and (3) adopt inspection, monitoring, recordkeeping and reporting requirements consistent with the intent of the Act.

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[1] Definitions for both Class I and III from Proposed Rules, Federal Register, Vol. 44, No. 78, April 20, 1979, pg. 23740.

SCOPE OF THE STUDY

Temple, Barker & Sloane, Inc. (TBS) conducted a study of the proposed UIC regulations to determine the costs of compliance for specific injection well practices, for certain industries, and for state agencies. The study determined the costs to operators associated with:

- Applying for a permit
  - --Submitting required information
  - --Performing a test of the mechanical integrity of a well
  - --Repairing a leaky well, if necessary
- Conducting periodic monitoring
- Reporting periodically to the state director.

These cost data were then combined with data on the number and probable compliance status of wells contained within each well class in order to estimate total costs for operators. Total costs were grouped into two categories: total one-time costs and annual recurring costs. Total one-time costs would be associated with the preparation of the permit application, including conducting a test of mechanical integrity of the well, and supplying ownership and location data, engineering data, maps and cross sections, and anticipated operating data. Annual recurring costs include costs to well operators for monitoring the wells which have been issued UIC permits, and for reporting data to state directors on a regular basis.

In addition, the study determined the costs to state agencies associated with:

- Developing a state regulatory program
- Reviewing permit applications and granting permits
- Reviewing data submitted periodically by well injectors
- Preparing and submitting reports periodically to the EPA administrator
- Enforcing the accepted state program.

These cost data were developed on a per state basis and combined to estimate total costs to all states. Again, total costs were divided into total one-time costs and annual recurring costs. Total one-time costs include costs associated with developing state programs, granting permits for existing sites, and holding public hearings when necessary. Annual recurring costs include costs associated with conducting quarterly reviews of data for known practices, preparing and submitting reports regularly to the EPA administrator, and enforcing the UIC regulations where practices are thought to be in non-compliance.

The economic analysis was primarily conducted for individual wells and sites. The results of the analysis were then projected to cover all known sites in the 57 states and territories. Only incremental costs were considered, that is, those costs directly attributable to federal UIC requirements and not required by any existing state programs.

SUMMARY CONCLUSIONS

The conclusions derived from this study are summarized below.[2] Each conclusion is discussed in more detail later in the report.

Class I Wells: Costs to Operators

- Total one-time costs to operators for all identified practices would range from $335,000 to $2.3 million as shown in Table I-1. The most significant costs would result from the requirements for mechanical integrity tests and repairs, if necessary, for municipal and industrial waste-disposal wells.

[2] The total costs in these tables have been rounded off to figures which reflect their general degree of precision.

Table I-1

CLASS I WELLS
SUMMARY OF ESTIMATED INCREMENTAL ONE-TIME COSTS[1]
TO OPERATORS

(thousands of 1977 dollars)

Practice	Incremental One-Time Costs
Waste-Disposal Wells	$335 to $2,300
Nuclear Storage and Disposal Wells	0
Total All Practices	$335 to $2,300

[1]One-time costs include permitting, mechanical integrity testing and repairing where testing shows well failure.

- Annual recurring costs to operators for all identified practices would range from $48,000 to $58,000, as shown in Table I-2. The most significant costs would result from the requirement for quarterly reporting to the Director.

Table I-2

CLASS I WELLS
SUMMARY OF ESTIMATED INCREMENTAL ANNUAL RECURRING COSTS
TO OPERATORS

(thousands of 1977 dollars)

Practice	Incremental Annual Recurring Costs
Waste-Disposal Wells	$40 to $50
Nuclear Storage and Disposal Wells	$8
Total All Practices	$48 to $58

Class III Wells: Costs to Operators

- Total one-time costs for operators for all identified practices would range from $1.7 million to $2.9 million, as shown in Table I-3. The most significant costs would result from the requirements for mechanical integrity tests and repairs, if necessary, for wells used for solution mining of salt.

Table I-3

CLASS III WELLS
SUMMARY OF ESTIMATED INCREMENTAL ONE-TIME COSTS[1]
TO OPERATORS

(thousands of 1977 dollars)

Practice	Incremental One-Time Costs
Geothermal Wells	$0
In-Situ Gasification	0
In-Situ Uranium Leaching	0
In-Situ Copper Leaching	$42
Frasch Sulfur Mining	$24
Solution Mining of Salt	$1,585 to $2,670
Solution Mining of Potash	$54 to $115
Total All Practices	$1,705 to $2,851

[1]One-time costs include permitting, mechanical integrity testing and repairing where testing shows well failure.

- Annual recurring costs to operators for all identified practices would range from $80,000 to $140,000, as shown in Table I-4.

Table I-4

CLASS III WELLS
SUMMARY OF ESTIMATED INCREMENTAL ANNUAL RECURRING COSTS TO OPERATORS

(thousands of 1977 dollars)

Practice	Incremental Annual Recurring Costs
Geothermal Wells	$0
In-Situ Gasification	0
In-Situ Uranium Leaching	0
In-Situ Copper Leaching	$37
Frasch Sulfur Mining	$7 to $67
Solution Mining of Salt	$16
Solution Mining of Potash	$20
Total All Practices	$80 to $140

Class I Wells: Costs to States

- Total estimated one-time costs to the 24 states with Class I well practices would range from $500,000 to $870,000, as shown in Table I-5.

Table I-5

CLASS I WELLS
SUMMARY OF ESTIMATED ONE-TIME COSTS TO ALL STATES

(thousands of 1977 dollars)

Task	Incremental One-Time Costs
Developing State Programs	$90 to $220
Program Hearings	$70
Permitting Existing Sites	$240 to $480
Permit Hearings	$100
Total One-Time Costs	$500 to $870

- Total estimated annual recurring costs to all states with Class I wells would range from $469,000 to $815,000, as shown in Table I-6.

Table I-6

CLASS I WELLS
SUMMARY OF ESTIMATED ANNUAL RECURRING COSTS TO ALL STATES
(thousands of 1977 dollars)

Task	Incremental Annual Recurring Costs
Quarterly Reviews	$125
Quarterly Compliance Reports	$21
Annual Reports	$23 to $94
Enforcement	$300 to $575
Total Annual Costs	$469 to $815

Class III Wells: Costs to States

- Total estimated one-time costs to all states with Class III wells would range from $264,000 to $509,000, as shown in Table I-7.

Table I-7

CLASS III WELLS
SUMMARY OF ESTIMATED ONE-TIME COSTS TO ALL STATES
(thousands of 1977 dollars)

Task	Incremental One-Time Costs
Developing State Programs	$28 to $73
Program Hearings	$22
Permitting Existing Sites	$160 to $360
Permit Hearings	$54
Total One-Time Costs	$264 to $509

- Total estimated annual recurring costs to all states with Class III wells would range from $131,000 to $230,000, as shown in Table I-8.

Table I-8

CLASS III WELLS
SUMMARY OF ESTIMATED ANNUAL RECURRING COSTS TO ALL STATES
(thousands of 1977 dollars)

Task	Incremental Annual Recurring Costs
Quarterly Reviews	$39
Annual Reports	$7 to $26
Enforcement	$85 to $165
Total Annual Costs	$131 to $230

Limits of the Analysis

A significant degree of uncertainty has been introduced into the analysis of costs for several reasons:

- The inventory of injection well practices is incomplete. In most cases, no formal national inventory has been compiled. In some cases, available records are out-of-date, and no projections for the near future have been accumulated. Moreover, the inventory of practices used in this report was compiled in late 1977 and was not updated with the completion of these reproposed UIC regulations.

- The area of review (or zone of endangering influence) is to be specified by each state director. That zone will determine the extent of information that must be supplied in the permit application and therefore the level of effort required by the operator to complete the application. Much of the cost to the operator of compiling permit application data has been included to allow for the need to assemble information relevant to the area of review. This is especially true for copper, Frasch sulfur, salt, and potash mining practices.

- The operator is responsible for reviewing all available well reports of producing and abandoned wells within the area of review, as well as for proposing appropriate corrective action for improperly completed and/or plugged wells penetrating the injection zone within the area of review. Though an attempt has been made to estimate the extent of efforts required to accomplish these tasks, little documented information exists regarding the number and location of these wells. It should not be unduly difficult for most injection well operators to locate wells near their facilities if well reports have been submitted to local or state agencies. If corrective action is required, plugging costs could range from $6,000 to $20,000 per well.

  State sources do not anticipate that operators would be required to cement or plug additional wells due specifically to the UIC regulations, as some form of corrective action is currently required in all states where these wells are considered to be a potential problem. In other states, regulators are unable to determine the potential problems associated with abandoned well requirements due to lack of data. Operators experiencing hardship because of these requirements may inform the state of their particular difficulties. These data will be considered by the states during the implementation of the UIC program. However, EPA believes that if the number of such wells is high, the costs will be high but the danger to underground sources of drinking water will be high as well. This study did not include any costs to the operator for completing and/or plugging producing and abandoned wells.

- There is a lack of experience at the state level in regulating underground injection practices in a single, consistent program. The overall estimate of manpower and cost requirements has been developed from a base of little actual experience and many assumptions have been made regarding staff organization, usefulness of existing information, and similarities with other regulatory programs. EPA's consolidated permit program is intended to assist states in carrying out several regulatory programs simultaneously with an efficient use of state resources. That approach may lessen start-up problems at the state level.

- The proposed UIC regulations require a demonstration of "fiscal responsibility of permittees." The permittee must assure adequate (financial) resources, "for example, in the form of a performance bond or a trust fund, to close, plug, and abandon the well as prescribed by the permitting authority." Costs to the operator for this requirement have not been included in this cost analysis for two reasons: (1) most states already require plugging bonds for new well permits and (2) for older wells or sites, the cost of a plugging bond would be about $100 over the five-year period covered in this analysis. This is estimated to provide up to $5,000 per well in plugging coverage if the operator defaults on his responsibilities. Current estimates of the cost to plug a well are within this range.

METHODOLOGY

A brief discussion of the methodology and key assumptions used in the analysis of the costs of compliance with the proposed UIC regulations is presented in the following paragraphs. An understanding of the analytic approach and assumptions will aid in evaluating the conclusions and their implications.

Categorization and Characterization of Injection Well Practices

Nine specific injection well practices are included in well classes I and III of the UIC regulations. For the purpose of this study, each unique practice was analyzed separately.

Using information available in previously completed EPA studies and the advice of state officials, hydrogeologic consultants, well drillers, trade associations and operators, the environments at the sites and the characteristics of existing wells were analyzed to develop an understanding of the status of current practices. An estimated inventory of existing and planned future sites in the 57 states and territories was accumulated.

Research was conducted to determine the type of potential contamination possible from each practice, and the history of reported cases of actual contamination. Discussions were held with hydrologists who had analyzed the problem for EPA in the past and with state officials who were responsible for responding to public complaints of contamination.

Comparison of Existing State Regulations and Proposed UIC Regulations

For each practice, and to the extent possible in each of the states in which the practices were found, existing state regulations and levels of enforcement were compared to requirements set forth in the federal UIC program. The intent was to identify those areas where incremental effort would be required as separate from those situations in which state officials said that they already enforce current programs at a level of effort consistent with federal UIC requirements.

Calculation of Costs of Compliance with Proposed UIC Regulations

The consultants compiled an inventory of the estimated number of wells and sites for each practice and assessed the likelihood that a percent of the wells in each practice would incur compliance costs. By multiplying unit costs and inventory count, and probability for incurring costs, total costs were calculated for all aspects of compliance.

The unit cost estimates for complying with federal UIC requirements were obtained from many sources including EPA publications and officials, state permit files, well drillers, company engineers and field supervisors. Due to the variation in estimates, all costs were developed as ranges. Only incremental costs were considered, that is, if operators currently were responsible for particular state compliance costs these were omitted from development of similar federal costs of compliance. All costs in this study, in the analysis of Class II well impacts, and in the Class IV and V study, were stated in 1977 dollars. Thus, total impacts can be examined on a consistent basis.

Determination of Significance of Costs of Compliance to Operators

Research was conducted to determine, for each injection well practice, the economic strength of its industry as a whole and the financial characteristics of the operating companies within the industry. An attempt was made to evaluate the relative impact of the calculated UIC compliance costs. In a few cases, general industry data were readily available, such as in the Bureau of Mines Mineral Yearbook. In most cases, data were scarce, sometimes due to the fact that individual companies protected operating performance information for competitive and anti-trust purposes, sometimes due to the fact that companies were vertically integrated and did not separate aspects of their operations when reporting financial performance.

Determination of State Program Manpower Time and Cost Requirements

Each aspect of state program manpower requirements and costs was identified and researched, including costs associated with program development, permitting, monitoring, reviewing, and reporting. Costs were separated into one-time costs and annual recurring costs.

Interviews were conducted with state officials to determine the current status of groundwater regulations within their states, the level of staffing and enforcement for control of existing injection well practices, and changes anticipated in response to federal UIC requirements. The NPDES permit program was also used as a guide in estimating staff time and related personnel cost because that program has provided EPA with a broad base of experience in industrial permitting.

A key assumption in developing state program cost estimates in this study was that the mix of personnel required to carry out the program would be available for all states simultaneously. During interviews with state officials, each said that personnel would be available. However, when examining the aggregate needs for all states and all groundwater protection programs expected to be enforced within the next several years, there was some question as to the simultaneous availability of manpower resources with appropriate background and experience.

II. COSTS TO OPERATORS

OVERVIEW

This chapter discusses costs to operators of injection well practices covered under Well Classes I and III of the proposed UIC regulations. Specifically, these practices include municipal and industrial waste-disposal wells injecting into saline aquifers, nuclear storage and waste-disposal wells, geothermal wells, in-situ gasification, in-situ uranium and copper leaching, Frasch sulfur processing, and solution mining of salt and potash.

The objective of this research and analysis has been to provide EPA with estimates of the impacts of proposed UIC regulations in terms of both required physical modifications to practices and costs associated with those modifications and with other requirements of the regulations. The analysis has included the following steps:

- Develop a technical understanding of operating techniques used in the practice
- Identify production, pilot, and proposed sites
- Review existing state regulations governing the practices
- Identify where potential modifications to current practices might be required by the UIC regulations and develop estimates of the cost of such changes
- Develop total incremental cost estimates for each practice
- Analyze the economic impact of these costs on affected companies and industries, where possible.

The results of these analyses are summarized in the following paragraphs. Succeeding sections of this chapter contain more detailed reviews of each of the practices with the costs of compliance highlighted.

Table II-1 presents an overview of the existence and location of injection well practices covered under proposed UIC regulations. Industrial and municipal waste-disposal wells are most broadly distributed across the states, and those sites are the most numerous. Usually, each disposal site has one well, though occasionally a few wells are located at a single site. Texas, Louisiana and Michigan account for two-thirds of all industrial and municipal waste-disposal wells. The mining practices generally have many wells per site; for example, there are about 50 Frasch wells at sites in Texas and Louisiana and about 10 salt wells per site in Michigan and Ohio. In all, this study estimates that approximately 309 existing Class I wells at 309 sites and 2,000 existing Class III wells at approximately 97 sites will be impacted by these regulations.

A review of existing state regulations governing injection-well practices and the protection of groundwater indicates that legal statutes differ widely among states. Though all states generally provide for the protection of groundwater and possess authority to initiate action against contaminators, most states do not have specific regulatory programs which control permitting, monitoring, and reporting requirements to the extent specified in the proposed federal UIC regulations. In addition, control of underground injection activities is usually divided among several state agencies which may function independently of each other.

Federal UIC regulations should not require well operators to modify current practices, but will require changes in preparation of permit data, compliance with mechanical integrity test requirements, and submission of monitoring and reporting information.

Permit data adequate for compliance with the proposed regulations could be obtained from state files for wells which are not new, but the data must be current, accurate and complete. There was general agreement among industry sources that additional time and effort would be needed to fulfill the provisions of the new permit applications. This is a result of requirements in the April UIC regulations for maps showing "the number, or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, mines (surface and subsurface), quarries, public water systems, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected." Detailed physical information is required for all wells within the area of review. The requirement for hydrogeologic maps and cross sections of the area affected by the proposed injection would also add incremental time to permit

TABLE II-1

ESTIMATED COUNT AND DISTRIBUTION OF PRACTICES

State	Industrial and Municipal Disposal Wells (injecting into saline aquifers)[1]	Nuclear Waste Disposal Sites[2]	Geothermal Sites[3]	In-Situ Gasification Sites[4]	Mining Sites[5]				
					Uranium Leaching	Copper Leaching	Frasch Sulfur Process	Solution Mining of Salt	Solution Mining of Potash
Alabama	5							1	
Arizona						4			
Arkansas	1								
California	4		2						
Colorado	1				1			1	
Florida	6								
Hawaii	3								
Illinois	5								
Indiana	12	1							
Iowa	1								
Kansas	28							5	
Kentucky	3	1							
Louisiana	65						4	13	
Michigan	30							8	
Mississippi	1								
Nevada	1								
New Mexico	1	2	1			1		4	
New York	4	1						5	
North Carolina	4								
North Dakota								1	
Ohio	10							3	
Oklahoma	14							2	
Tennessee	3								
Texas	85			1	10		6	8	
Utah									1
West Virginia	7							3	
Wyoming	1			2	10				
Total	304	5	3	3	21	5	10	54	1

Sources:

1. Dr. Donald Warner, Compilation of Industrial and Municipal Injection Wells in the United States, EPA-520/9-74-020, 1974.
2. Nuclear Regulatory Commission data.
3. Bureau of Mines and State sources in California and New Mexico.
4. Bureau of Mines and State sources in Texas and Wyoming.
5. Bureau of Mines data and Regional and State sources.

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application preparation. Operating data would be required to an extent not previously requested in permit applications and would therefore add to the requirements for data to be submitted to state agencies.

The mechanical integrity test, as specified in the UIC regulations, would be performed to demonstrate the absence of significant leaks through the tubing, packer, or casing, and the absence of fluid migration between the outer casing and the well bore. Several acceptable test methods are listed in the regulations, and the director, with the approval of the administrator, has the authority to accept additional methods for testing. Well drilling experts have assisted the consultants in an analysis of the most appropriate tests and their related costs to be used in each practice. Results of this study have led to the conclusion that the test requirements for mechanical integrity would impact most heavily on the practices of waste-disposal wells and solution mining of salt, and on Frasch sulfur practices if the test for mechanical integrity is required on these short-lived wells.

Incremental monitoring and reporting requirements would have minimal impact on the existing injection-well practices. The least significant impact would be no incremental time or a few days per year of staff support to conduct monitoring tests and record and report the results. The most significant impact would occur in Frasch sulfur mining where existing monitoring techniques might be inappropriate for new UIC requirements and a system of monitor wells might be required at each site.

LIMITS OF THE ANALYSIS

There are areas of uncertainty in the economic analysis which could affect the conclusions. Those which have been identified to date include: (1) the accuracy of current inventory information, (2) the zone of endangering influence, and (3) improperly completed and/or plugged wells. These areas are discussed below.

Accuracy of Current Inventory Information

The costs presented in this report are based on information obtained in a comprehensive well inventory compiled in late 1977. Since then, additional Class I and Class III wells have been constructed and begun operation. The cost impact of this recent growth is not expected to distort the major results of this analysis for two reasons: (1) for Class I, the five-year cost estimates presented in the analysis for the most costly practice, waste disposal wells injecting below all underground sources of drinking water, have incorporated a growth rate of 20 new wells per year; and (2) for Class III, recent information reveals an increase in the inventory count of 13 sites, with the greatest increase (10 additional sites) occurring for uranium leaching sites and geothermal sites. However, as is discussed in the sections on in-situ uranium leaching and geothermal practices, UIC requirements will result in modest incremental operating requirements.

The Zone of Endangering Influence

The area to be reviewed by the director in the issuance of a permit may be either the zone of endangering influence as based on a formula or a zone determined by a specific radius. The suggested formula considers such influences as hydraulic conductivity and thickness of the injection zone, time of injection and injection rate, specific gravity of formation fluid, original hydrostatic head of formation fluid, and the hydrostatic head of the underground source of drinking water. Alternative formulas of equal soundness may be used if based on the parameters listed above. The specific radius takes into consideration geology, hydrology, population, groundwater use, and historical and other factors relating to potential endangerment.

Once the director has determined the specific zone for each practice or area, it is the operator's responsibility to protect drinking water sources in that zone from contamination by his practice. The extent of the zone of endangerment determines the amount of information that must be supplied in the permit application, especially information pertinent to producing wells, injection wells and abandoned wells, dry holes, surface bodies of water, mines, quarries, and other pertinent features. A choice of zone size for an injection practice should therefore be evaluated on the bases of economic and administrative feasibility as well as on the basis of the degree of public health protection afforded. Large zone sizes would increase permit application costs for the well operators and raise permit review costs for the states.

The costs of permit application and review used in this study are estimates obtained from discussions with various well operators and state regulators. Developed on a state-by-state and practice-by-practice basis, the estimates are based on experience and judgment, particularly in regard to two major areas of uncertainty: (1) the expected difficulty involved with gathering the information required in the permit application, and (2) the expected size of the zone of endangering influence for states with these practices.

Improperly Completed and/or Plugged Wells

The purpose of the operator's review of completion and/or plugging reports of all producing and abandoned wells penetrating the injection zone is to determine if these wells would allow migration of contaminated fluids into drinking water aquifers through the unplugged shafts of improperly completed wells. It has been recognized that the potential for these wells to degrade groundwater quality is dependent on the well's original function, design and construction, the site geology, and the hydraulic characteristics of the emplaced fluids.[3]

There are two areas of uncertainty with this requirement that could significantly impact on costs associated with the UIC program. These are (1) the operator's extent of responsibility, and (2) the magnitude of the repair requirements for the operator. These are discussed in the following paragraphs.

The operator is responsible for reviewing all active and abandoned well reports and for proposing the type of remedial actions to be taken when necessary. In some injection areas, the number of abandoned wells is thought to be quite large and the public records are inadequate. The operators in these areas may find the task of locating and describing all abandoned wells within the prescribed area of review to be both time-consuming and costly. Operators have argued, also, that the requirement to plug and/or properly complete these wells could be very expensive. The magnitude of the expense is difficult to estimate for several reasons. The extent of the zone of endangering influence is uncertain, as the director must make that determination for each practice or area in each state. The number of improperly abandoned wells which endanger drinking water sources is unknown and could range from none to several at each site depending on the history of well drilling and completion in each area. Furthermore, of the wells located within the area of review, it is only those improperly completed or abandoned wells that actually penetrate the injection zone under consideration that will require corrective action.

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[3] Impact of Abandoned Wells on Ground Water, EPA-600/3-77-095, August 1977. Ecological Research Series, p. 1.

During discussions held with state-level water regulators, most said that their current approach to the control of endangerment from abandoned wells provided adequate protection regardless of the specific language in their regulations. A few others believed that there was room for improvement, especially in the extensiveness of geographic coverage, but that costs incurred would primarily be state enforcement costs. By far the largest number of states were characterized by (1) general plugging language, (2) poor historical data on abandoned wells, (3) enforcement in response to specific complaints of contamination and during initial permitting of the injection practice, and (4) confidence that a careful check in the area of review of existing wells would confirm that there are no contaminating abandoned and producing wells among those that exist.

No incremental costs to operators have been attributed to the UIC program for those practices in states where corrective action is already required. In other states, regulators lacked supporting data to say that any wells would require cementing or plugging, and, therefore, no costs could be attributed to the UIC regulations for those states.

CLASS I PRACTICES

The following discussions provide, for each practice and to the extent possible, a technical description of the practice, inventory and location of known sites, current state regulations for identified sites, and practical and cost impacts of UIC regulations for those sites and their operating companies.

Waste-Disposal Wells Injecting Below Underground Sources of Drinking Water

Waste-disposal wells covered under proposed UIC regulations have been separated into two groups: (1) wells injecting below all underground sources of drinking water in the area (defined as Class I wells) and (2) wells injecting into or above underground sources of drinking water (defined as Class IV and V wells, depending on the characteristics of the waste injected). This discussion centers on the former group; the latter group will be discussed in a subsequent report.

Waste-disposal wells are sometimes referred to as deep waste-disposal wells or industrial and municipal injection wells. A wide variety of wastewater is injected, including chemicals, pharmaceutical products, metal manufacturing wastes and municipal sewage. Deep disposal wells have been drilled to depths greater than 8,000 feet but are typically between 1,000 and 6,000 feet deep.

Several attempts have been made to compile an inventory of these wells, especially during the last ten years when there developed an increasing awareness of the limited capability of surface waters to receive effluents without violation of standards. In July 1975 a report was submitted to the EPA entitled Review and Assessment of Deep-Well Injection of Hazardous Waste by L. R. Reeder and others.[4] This report updated the 1974 compilation of industrial and municipal wells prepared principally by Dr. Donald Warner.[5] The consultants used the more recent, 1975, inventory to assess the impact of proposed UIC regulations on waste-disposal well practices. A total of 383 wells were reported to be permitted as of 1975. Of those wells, 209 were in operation, 38 were not operating but unplugged, and 57 were drilled but never used. The remaining 79 were never drilled, were plugged, or the status was unknown. More than one half of the operational facilities were located in Louisiana and Texas. Most sites of deep waste-disposal wells were the location of just one Class I well. However, there were a few sites, especially at large petrochemical companies, where two or three wells occupied a single site. The analysis which follows is based on 300 currently operating wells at approximately 300 sites to reflect that these numbers are, at best, an estimate of current practices. Where appropriate, costs are also calculated to reflect the 100 new waste-disposal wells expected to begin operation in the next five years.

All states with deep disposal wells have some type of underground disposal regulations; however, the strictness of existing regulations varies widely. In general, the proposed UIC regulations are consistent with regulations in those states with the most numerous deep disposal well practices. Texas, Louisiana and Michigan have recently adopted specific, stringent requirements for permitting, monitoring and reporting. Other states have detailed requirements for permitting new wells, and more general guidelines for ongoing operations. In the latter

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[4] L. R. Reeder and others, Review and Assessment of Deep-Well Injection of Hazardous Waste, Solid and Hazardous Waste Research Laboratory, National Environmental Research Center, Cincinnati, Ohio, 1975.

[5] EPA-520/9-74-020, Compilation of Industrial and Municipal Injection Wells in the United States.

group of states, the test of mechanical integrity and the frequency of reporting would impose incremental requirements on injection well operators, though no additional effort is anticipated in permitting existing or new wells.

Mechanical integrity testing would be required under the proposed regulations to verify that leaks do not exist in the long string casing, in the tubing, or in the packer; and that there is no fluid movement through vertical channels adjacent to the injection well bore. In order to develop costs of compliance associated with the mechanical integrity test requirements, it is necessary to know the construction characteristics of the deep waste-disposal wells. One state source indicated that, to his knowledge, all wells in that state have tubing and packer; yet when consultants reviewed the construction details in the permit data in the references cited earlier, they found that approximately half the permitted wells have tubing and packer and half do not. In addition, a packer may be pulled and not replaced, while a state source in Kansas reported that, when wells without tubing and packer are repaired, the state specifies at that time that tubing and packer must be installed. These variances lend some uncertainty to the analysis. It is assumed here that, as in the references cited, half the wells have tubing and packer and half do not.

Section 146.12c of CFR Part 146 states that "All Class I injection wells, except for those municipal wells injecting only non-corrosive wastes, shall inject fluids through tubing and packer set immediately above the injection zone." Moreover, the program director would have the discretion to permit the use of alternatives to tubing and packer in cases where they would provide adequate protection of underground sources of drinking water. This report reflects the assumption that the UIC regulations will not require that incremental action will be necessary regarding retrofitting existing Class I wells that do not have tubing and packer.

All wells are required to pass an approved test of mechanical integrity. For wells without tubing and packer, geophysical logging can be performed to test the integrity of the long string casing. A pressure test could also be performed: however, this test is more costly than logging. It would be possible, at the discretion of the director, for those wells with tubing and packer to submit annulus data to comply with the regulations, thus incurring no incremental expense. For wells with tubing and for wells with tubing and packer, a pressure test would be performed after the packer and/or tubing are removed. Absence of fluid migration through vertical channels between the casing and borehole could be demonstrated through well records showing the presence of adequate cement to prevent migration, or through the results of tests such as a cement bond log, sonic log, dual vention log or temperature log. These procedures are cited as examples to give a general impression of technical requirements of mechanical integrity testing.

Table II-2 illustrates the costs associated with testing waste-disposal wells for the presence of leaks and fluid migration. These cost estimates were derived from interviews with well drilling firms and well drilling service firms and represent the costs of testing typical wells. Because of the unique characteristics of each disposal well, a more extensive examination of costs would be necessary to better assess the economic impact. The cost of testing is estimated for 125 wells, as the remainder of the wells are located in Texas, Louisiana and Michigan--states which reported that the mechanical integrity test is already required. The cost is estimated to range from $5,000 for geophysical logging to $35,000 for downhole pressure testing. The total cost of testing is estimated to range from $300,000 to $2.10 million for the estimated 125 operating wells in states that do not currently require the mechanical integrity test.

Table II-2

COST OF TESTING MECHANICAL INTEGRITY OF WASTE-DISPOSAL WELLS
(thousands of 1977 dollars)

Well Construction	Estimated Number of Wells[1]	Testing Cost Per Well	Total Cost
With tubing and packer	65	0	0
With tubing and no packer or without tubing and packer	60	$5 to $35	$300 to $2,100
Total	125		$300 to $2,100

[1]The estimated number of wells for each well construction was derived from permit data in Compilation of Industrial and Municipal Injection Wells, 1974, prepared principally by Dr. Donald Warner.

Well drilling experts have estimated that approximately two percent of all existing disposal wells will fail the mechanical integrity test and require repair. There is even more variance in repair procedures than in mechanical integrity testing. Costs for repair, which will include costs of testing to determine the location of the leak, have been derived from interviews with well drilling firms and well drilling service firms and represent costs of repairing typical wells. The total cost range for the repair process is between approximately $35,000 and $200,000, as illustrated in Table II-3 and discussed in greater detail in the following paragraphs.

Table II-3

COST OF REPAIRING WASTE-DISPOSAL WELLS
(thousands of 1977 dollars)

Well Construction	Estimated Number of Wells That Will Leak[1]	Total Repair Cost Per Well	Total Cost
With tubing and packer	1	$17.5 to $100	$17.5 to $100
With tubing and no packer or without tubing and packer	1	$17.5 to $100	$17.5 to $100
Total	2		$35 to $200

[1]The estimated number of wells for each well construction was derived from permit data in Compilation of Industrial and Municipal Injection Wells, 1974, prepared principally by Dr. Donald Warner, and the estimate of well drilling experts that two percent of wells will leak.

For wells without tubing and packer with a leak in the long string casing, a pressure test and bridge-plug and packer interval pressure test can be performed to locate the leak. The pressure test cost will range between $25,000 and $35,000, and the bridge-plug and packer interval pressure test will cost an additional $12,500 or a total of approximately $50,000. The cost of repairing the long string casing can range between $5,000 and $50,000. The total cost of repairing wells without tubing and packer will range between $50,000 and $100,000, based on a cost of testing for leak location of $50,000 and a cost of leak repair of $5,000 to $50,000.

To locate a leak in the long string in wells with tubing and no packer and in wells with tubing and packer a bridge-plug and packer interval pressure test will be required at an incremental cost of approximately $12,500. If there is a leak in the tubing or packer, remedial action incorporating either repair or replacement of the tubing and packer would be necessary. The expense for this procedure would exceed $40,000, not including the cost of pulling the tubing and packer, which would be incorporated in the pressure testing expense. Therefore, the cost of the repair process would range from $17,500 for a bridge-plug and packer interval pressure test and minor repair of the long string casing to $100,000 for a bridge-plug and packer interval pressure test, extensive repair of the long string casing and replacement of the tubing and packer.

The increase in new wells has averaged 20 operating wells annually for the past several years. As this trend is expected to continue within the next five years approximately 100 new wells will become operational. Effective construction designs are already required for new disposal wells by state permitting agencies; consequently, no incremental expense for construction or reworking should be incurred. The test for mechanical integrity should be performed as part of a standard construction policy and would not result in additional costs.

Thus, the total one-time costs for both existing and new wells complying with the proposed regulations over the next five years are expected to be in the range of $335,000 to $2.3 million.

Recurring annual expenses would also be associated with deep disposal well operations. As present requirements concerning monitoring of operations closely parallel federal UIC regulation requirements, it has been assumed that no incremental monitoring would be required. It has been estimated, however, that additional reporting would be necessary for the wells located in states other than Texas, Louisiana and Michigan, and could be satisfied with one day per quarter per well for an annual cost of approximately $300 per well. Therefore, total annual recurring costs would approximate $40,000 for 125 wells and $50,000 for the 170 new and existing wells located in states other than Texas, Louisiana and Michigan.

Table II-4 presents estimated one-time as well as recurring costs resulting from the requirements of the proposed UIC regulations.

Table II-4

WASTE-DISPOSAL WELLS INJECTING INTO SALINE AQUIFERS

SUMMARY OF COSTS TO OPERATORS

(thousands of 1977 dollars)

Number of Existing Sites	300 (or less)
Number of Existing Wells	300
Additional Wells Next 5 Years	100
One-Time Costs	
Mechanical Integrity Test	\$300 to \$2,100
Well Repairs	\$35 to \$200
	\$335 to \$2,300
Annual Recurring Costs	
Reporting	\$40 to \$50

TBS

It should be recognized that the owners of the disposal wells are almost all relatively large firms and that the three companies with the largest number of deep disposal wells account for 25 percent of all operating wells. Few small firms operate their own deep disposal wells; consequently, the probability of significant economic dislocation due to the regulations is small.

Nuclear Storage and Waste-Disposal Wells

Nuclear storage and waste-disposal wells used for the injection of fluids would be covered by proposed UIC regulations. Five operating sites have been located at which fluid radioactive wastes are injected underground. New Mexico has two nuclear disposal sites. The Anaconda Company injects liquid uranium processing wastes into a deep injection well that is 1,800 feet deep with multiple casings and several monitoring wells. The Los Alamos Laboratory puts solid wastes into pits and also has several shafts that are lined with asphalt into which a radioactive cement slurry is disposed. Extensive dry-well monitoring is conducted at the New Mexico sites to insure that no radioactive migration occurs. In New York, Nuclear Fuels Service (NFS) has in the past used trenches, tanks, and hydrofracturing, but these practices have been discontinued. There are additional sites in Maxey Flats, Kentucky, and Michigan City, Indiana, where liquid wastes are disposed of below the ground.

Due to the characteristics of the disposed products, there is ongoing concern that radioactive wastes will migrate into and contaminate freshwater aquifers. In one documented case, the NFS site in West Valley, New York, was closed because some radioactive materials had seeped into a nearby stream. In Kentucky, state officials have been examining the need to close the Maxey Flats nuclear waste-disposal site after radioactivity was detected in water which had seeped into a newly-dug unused burial trench. At the present time, extensive state and federal regulations for permit and design requirements exist to insure safe disposal of nuclear wastes. These regulations typically are at least as strict as the requirements of the UIC regulations; consequently, it is unlikely that either operating changes or additional permitting would be required for either new or existing wells.

Due to the increased frequency in monitoring and reporting required by the UIC regulations, annual recurrent costs for nuclear waste disposal would include incremental monitoring costs of $5,000 for all five sites, based on two hours per week per site, and $3,000 for additional reporting costs for all five sites at a frequency of two days per quarter per site. Therefore, total annual recurring costs would be $8,000 for the five nuclear disposal sites.

Table II-5 highlights the incremental costs associated with the compliance of nuclear waste disposal wells with proposed UIC regulations.

Table II-5

NUCLEAR WASTE-DISPOSAL WELLS
SUMMARY OF COSTS TO OPERATORS
(thousands of 1977 dollars)

Number of Sites	5
Number of Wells	5
One-Time Costs	$ 0
Annual Recurring Costs	
Monitoring	$ 5
Reporting	3
Total Annual Recurring Costs	$ 8

CLASS III PRACTICES

The following discussions provide for each practice to the extent possible, a technical description of the practice, inventory and location of known sites, current state regulations for identified sites, and practical and cost impacts of UIC regulations for those sites and their operating companies.

Geothermal Wells

At the present time, there are three geothermal sites with a total of 13 disposal wells. In California, the Geysers field has eight injection wells that are currently operating. The East Mesa experimental field in California's Imperial Valley has two injection wells. In New Mexico, the Valles Caldera site has three injection wells.

migrate into drinking water sources, then the total estimate would be reduced proportionately, to less than one billion gallons per year. Other leakage rates would alter the total figure proportionately.

Data from Maryland, Florida, and Nassau County, New York, were used to develop a national profile of volumes injected by Class IV wells. As may be seen in Table II-2, 660 million to 1.7 billion gallons of hazardous wastes may be disposed of yearly by these wells into or above underground sources of drinking water. A "best" estimate of discharged volume would be approximately one billion gallons yearly.

Table II-2

CLASS IV WELLS - NATIONAL PROFILE

SIZE CATEGORIES	
I:	Wells injecting less than 100 gallons per day (gpd)
II:	Wells injecting between 100 and 1,000 gpd
III:	Wells injecting over 1,000 gpd
WELL POPULATION	
I:	4,000 to 8,000; best estimate - 6,000 wells
II:	500 to 1,000; best estimate - 750 wells
III:	500 to 1,000; best estimate - 750 wells
TOTAL:	5,000 to 10,000; best estimate - 7,500 wells
ANNUAL WELL INJECTION VOLUMES--MILLION GALLONS PER YEAR (MGY)	
I:	15 MGY to 50 MGY; best estimate - 30 MGY
II:	19 MGY to 62 MGY; best estimate - 38 MGY
III:	625 MGY to 1,625 MGY; best estimate - 938 MGY
TOTAL:	659 MGY to 1,737 MGY; best estimate - 1,006 MGY

It also appears that a few high volume facilities account for a disproportionate percentage of the hazardous waste volume discharged. High volume facilities, i.e., facilities injecting over 1,000 gallons per day (gpd), represent approximately 10 percent of the national Class IV well population. However, these facilities appear to discharge over 90 percent of the hazardous waste volume attributable to Class IV wells. Small volume facilities, representing 80 percent of all Class IV wells, appear to inject only 3 percent of Class IV well hazardous waste volume.

A national estimate of Class V injection volumes cannot be developed without data which is to be collected during the state

New geothermal wells are expected to become operational within the next several years; however, the exact number is uncertain. It is likely that additional wells would be located at existing sites; therefore, area permits would be applicable. Since effective construction designs are a current requirement of state and federal regulations, no incremental construction, testing, or reworking expenses would be incurred.

When discussing with state experts the requirements for proper plugging of abandoned wells, they have said that there is a possibility that some abandoned wells exist off the sites within the zone of endangerment, but the number would be difficult to judge. If remedial action were necessary, plugging costs could range from $6,000 to $20,000 per abandoned well.

In terms of annual recurring costs, incremental costs would not be incurred by operators of these wells as a result of the UIC requirements for weekly monitoring and quarterly reporting. Monitoring is currently performed on a regular, ongoing basis as a component of the control of these practices. Reporting frequency as dictated by DOE will be at least quarterly and probably monthly.

Table II-6 highlights the likely conclusions discussed above.

In-Situ Gasification

There are three basic in-situ gasification processes: recovery of oil shale, coal, and tar sand oil and gas. To recover oil shale, hydraulic or explosive fracturing or reverse combustion is introduced through injection wells in order to increase

Table II-6

GEOTHERMAL WELLS

SUMMARY OF COSTS TO OPERATORS

(thousands of 1977 dollars)

Number of Sites	3
Number of Wells	13
One-Time Costs	
Permitting	$ 0
Testing	$ 0
Total One-Time Costs	$ 0
Annual Recurring Costs	
Monitoring	$ 0
Reporting	$ 0
Total Annual Recurring Costs	$ 0

the size of a permeable drainage channel. Then the combustion zone is ignited, and oil and gas are produced. The spent fracturing gels and other solvents are typically disposed of through deep disposal wells. In-situ gasification of coal involves both an ignition well for introducing the fire and an injection well for providing an oxygen source for the fire. Gases are then given off by the air-injection induced fire. Tar sand oil and gas recovery has been attempted with pyrolysis through several production and injection wells.

In-situ production from oil shale has occurred from time to time, but no permanent commercial production field has been established. In-situ gasification of coal is still in its experimental stages. Pilot sites have been established at the Laramie-ERDA site at Hanna, Wyoming, and at the Lawrence Livermore Laboratory's Powder River Basin site near Gillette, Wyoming. In Texas, the Texas Utilities Generating Company has a site at Fairfield. Two other proposed sites have been located in West Virginia and Texas. The only known site for in-situ tar sand oil and gas recovery in the United States is located near Vernal, Utah. Experimental recovery was conducted there in 1975. In general, the practice of in-situ gasification has grown rapidly in Canada, and may follow the same trend in the United States as the Federal government encourages the development of alternate forms of energy.

A potential hazard of these processes is that the failure of the injection or production wells in these operations could cause the fracturing agents or the product itself to contaminate drinking water aquifers. To date, no incidences of contamination have been reported.

In-situ gasification operations are located in states with relatively stringent regulations covering the protection of groundwater. These states are sensitive to the value of groundwater supplies that have suitable quality for short-term and long-term domestic and commercial use. Therefore, the economic impact resulting from an existing site's complying with proposed UIC regulations is expected to be minimal. Current operations in Texas are required to have monitoring wells and an aquifer restoration program and to properly plug abandoned wells. Wyoming is in the process of requiring equally strict protection policies separate from the UIC program.

The site data presented above were taken from information available in late 1977 and were used in a cost analysis of the August 1977 draft UIC regulations. The same information has been used in the present analysis. One or more of these sites may have progressed to a production stage since the time of data collection; however, should these sites be converted to production use, it is possible that states would regulate them as oil and gas (energy-producing) practices rather than as mining or waste-disposal practices, but all would comply with federal permitting, monitoring and reporting requirements under the UIC regulations. No incremental costs can be associated with the UIC program at this time. This conclusion is shown in Table II-7.

Table II-7

IN-SITU GASIFICATION
SUMMARY OF COSTS TO OPERATORS
(thousands of 1977 dollars)

Number of Sites	3
One-Time Costs	
Permitting	$ 0
Total One-Time Costs	$ 0
Annual Recurring Costs	
Monitoring	$ 0
Reporting	$ 0
Total Annual Recurring Costs	$ 0

In-Situ Uranium Leaching

In-situ uranium leaching is used to reclaim low-grade deposits of uranium that cannot be recovered economically through alternative means. The process employs dilute sulfuric acid solutions (or alkaline solutions such as ammonium carbonate) that are introduced into an ore body to create a uranium solution. The solution is then typically pumped back through the production well to the surface.

Twenty-one currently active sites have been identified in three states. In Colorado, there is one pilot operation. Texas has six commercial operations and four pilot sites, and New Mexico has two operations in the permitting state, two that are presented inactive, and one whose application has been withdrawn. In addition, there are 14 sites in Wyoming, including three in the permit application stage, one that has discontinued operations, and ten pilot sites. Exploratory drilling is being conducted in South Dakota.[6]

The potential hazard of this recovery process is the possibility of contamination of potable aquifers by leachants used to recover uranium and by the uranium itself. No reported incidences of significant contamination have been attributed to this process. However, the process is relatively new, and major studies are still to be completed regarding monitoring and aquifer restoration programs.

The three states with existing uranium leaching operations have general requirements for monitoring wells, the proper plugging of abandoned wells, and an aquifer restoration program. Wyoming officials have been working closely with the Nuclear Regulatory Commission (NRC) staff and hydrology consultants to develop acceptable standards for systems of monitoring wells surrounding uranium mining fields. One current theory is that,

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[6]The Texas Department of Water Resources reported, in a phone conversation with TBS in May 1979, that the practice of in-situ uranium leaching is growing in that state due to economic incentives. There are seven active, commercial sites currently and at least as many planned for future development. These seven sites have over 4,000 injection wells and almost 2,000 recovery wells. The projected total for installed wells by May 1980 at these seven sites is about 6,700 injection wells and 4,600 recovery wells. In addition, new companies may establish sites in Texas in the near future.

The permit process now requires the accumulation of extensive data. Operators spend three to twelve months in data preparation and the state spends six to nine months reviewing the application.

Monitor wells are required on the perimeter of the site at 400-foot intervals, especially where aquifers are known to exist. Operators are required to monitor twice each month, primarily for conductivity, uranium and ammonia.

The Texas Department of Water Resources estimates that the UIC program will not establish requirements for the operators in addition to those already required by the state. However, state regulators will experience impacts as a result of performing administrative tasks associated with repermitting, reporting, and encouraging public participation.

at a minimum, 24 monitor wells would be required to adequately cover an ore body. Monitoring wells would be located in arrays above and below the body in the appropriate surrounding zones and would provide a water quality profile sufficient to meet state standards and would actually exceed UIC requirements. Texas and Colorado are also participating in studies to provide assurance that monitoring wells will detect leachate excursion before irreparable damage occurs to the aquifer.

The issue of aquifer restoration has been under study for the past several months with no conclusive results to date. Wyoming requires that aquifers must be "returned to baseline in geologic time" after termination of the mining activities. This has proved to be geochemically and physically impossible in pilot tests because ammonia is adsorbed and absorbed into the surrounding clay and permanently alters the baseline readings of the aquifer. A five-phase restoration process has been attempted with little success. Economics of the process have not been considered to date because the pilot projects primarily considered the environmental feasibility of the restoration program rather than the economic feasibility.

It is impossible to predict at this time what the economic impact will be to operators, or even if the operations will be allowed to continue as production sites in areas other than those where water quality is already poor. State sources have indicated that permitting, operating, and reporting standards will be established whether or not a UIC program exists. Therefore, no incremental costs have been attributed to the UIC regulations for in-situ uranium leaching. This conclusion is reflected in Table II-8.

Table II-8

IN-SITU URANIUM LEACHING
SUMMARY OF COSTS TO OPERATORS
(thousands of 1977 dollars)

Number of Sites	21
One-Time Costs	
Permitting	$ 0
Total One-Time Costs	$ 0
Annual Recurring Costs	
Monitoring	$ 0
Reporting	$ 0
Total Annual Recurring Costs	$ 0

In-Situ Copper Leaching

The process of in-situ copper leaching is used to recover low-grade ore deposits and involves injection into a well of a dilute sulfuric acid leachant or water and withdrawal of a copper sulfate solution. A block caving technique is also used in which a huge ore body has 1,000 holes (wells) drilled through it to increase percolation and a surface leachant is applied to dissolved copper deposits that are subsequently pumped back up to the surface.

At the present time, the consultants have identified two operating and two pilot sites in Arizona. One operation in New Mexico, owned by Occidental Minerals, is in the permitting stage. Formerly there were also copper leaching operations in Nevada, Montana, Utah, and Michigan.

There is concern that the use of injected copper leaching solutions could contaminate freshwater aquifers around production sites. There have, in fact, been incidences of groundwater contamination reported in the Miami, Arizona area.

New Mexico currently has groundwater regulations that require monitoring wells, the proper plugging of abandoned wells, and an aquifer restoration program. In addition, according to New Mexico state sources, special legislation concerning this type of recovery process is anticipated in the near future. Since New Mexico's current regulations are relatively stringent, no operating changes should be required as a result of complying with federal UIC regulations.

In contrast to New Mexico, Arizona has a fragmented system of regulating and has no specific regulations covering leaching wells beyond the development phase. When the UIC regulations are enforced, Arizona sites could incur significant impacts, especially in block caving operations, which use no casing and cementing program, and no monitoring wells and have no aquifer restoration program. The Arizona sites would have to be evaluated for their effect on underground sources of drinking water. However, it is possible that they are located in areas where aquifers would be designated as non-potable.

The economic impact resulting from complying with the proposed UIC regulations should be slight in New Mexico. Since monitoring wells, a restoration program, and the proper plugging of abandoned wells are currently required in that state, the only incremental one-time expense for the existing site should be one man-month of effort at $1,700 for completing the application requirements. In Arizona, a substantial effort of approximately six months per site would be required to apply for a permit. Much of this effort would involve the setting of standards for monitoring continuing operations. Based on $1,700 per month and four sites, the permitting cost would be $40,000.

The Arizona sites would incur an incremented expense for the installation of monitor wells to establish baseline aquifer conditions and to detect any leachant excursion due to the mining process. Well drilling experts have estimated that the average cost of installing a monitor well would be $20,000. Each well lasts approximately 25 years. The present UIC regulations require five monitoring wells at each site. Thus, the cost for installing these wells at each site is estimated to be $4,000 per site per year for each of the Arizona sites. Therefore, incremental annual recurring costs for the in-situ leaching sites would include $18,000 for daily monitoring costs based on one hour of monitoring time per site per day spread over five monitoring wells per site and $16,000 for monitor well installation costs for a total of $34,000 per year. Also, additional reporting costs of $3,000 based on one day per site and one day for all five monitoring wells per site per quarter would be required. The total recurring cost for the copper leaching sites would be $37,000.

According to data available in 1977, in-situ copper leaching is used only for low-grade recovery and represents less than one percent of the total $2.5 billion of domestic copper production. It is important to note that the process of in-situ copper leaching has been marginally economical in recent years due to low copper prices, slack demand, and price inelasticities of the product. Several plants have been closed and significant growth in this area is not expected in the foreseeable future.

Table II-9 presents one-time and annual recurring costs which would be absorbed by operators due to UIC regulations.

Table II-9

IN-SITU COPPER LEACHING
SUMMARY OF COSTS TO OPERATORS
(thousands of 1977 dollars)

Number of Sites	5
Number of Wells	-
One-Time Costs	
Permitting	$42
Total One-Time Costs	$42
Annual Recurring Costs	
Monitoring	$34
Reporting	$ 3
Total Annual Recurring Costs	$37

TBS

Frasch Sulfur Mining

Elemental sulfur, resident in the lower part of cap rock overlying salt domes or salt strata, is mined by the Frasch process. The process involves injecting super-heated water into a sulfur bearing formation, melting the sulfur, and raising the melted sulfur to the surface by injecting compressed air near the bottom of the well. Sulfur mined by the Frasch process is generally 99 percent pure.

Ten mine fields with approximately 500 wells in Texas and Louisiana account for all current Frasch mining. Wells are replaced on average within one year, though the life of a well ranges from a few months to 18 months. Approximately 35,000 wells have been drilled since the inception of this practice more than 80 years ago.

Due to the hydrogeologic environment along the Gulf Coast, fresh or brackish water used for injection contains less dissolved salts than the surrounding formation waters of the cap rock. According to state regulatory officials there has been no reported contamination of drinking water aquifers.

Texas and Louisiana regulate Frasch sulfur mining at the exploratory stage only. Engineering plans, drilling specifications, and abandonment procedures must be acceptable before the states approve an application. Though state rules are comprehensive enough to cover all stages of the practice, state officials responsible for enforcement of UIC regulations have stated that it may not be necessary to impose more stringent controls on Frasch processing where the practice takes place in an environment that precludes use of groundwater as a future drinking water resource. However, the regulators would encourage the enforcement of federal UIC standards in areas where groundwater reserves are of high quality.

The economic impact on Frasch sulfur operations resulting from complying with proposed UIC regulations could range broadly from a relatively modest level to an extensive level, depending on the discretionary judgment of the state director. Permit application information includes engineering data, maps and cross sections, and proposed operating data. It is likely that the director will determine that existing information is adequate. However, approximately one to two man-months of effort at $1,700 per month (salary plus fringe benefits) would be required to gather and submit the data for each mainland site. One sulfur mining company operating offshore fields has estimated that the cost of preparing permit applications would be as high as $4,000 per site. (Mining costs for offshore operators are two to five times higher than mainland costs.) Therefore, total one-time permitting expenses for 10 fields, assuming three are offshore, would be approximately $24,000.

No incremental costs would be incurred due to mechanical integrity test requirements. New Frasch wells currently must satisfy mechanical integrity requirements prior to injection. State officials in Texas and Louisiana conduct site visits during drilling and carefully review design and construction specifications. Existing Frasch wells have such a short life that mechanical integrity test data submitted during drilling would suffice for federal UIC requirements.

Incremental monitoring costs would range from no cost, assuming states continued current requirements, to potentially high costs, assuming a system of monitor wells was required at one or more sites. One producer estimates that five perimeter monitor wells, each replaced every five years because of subsidence, would be necessary for each site. According to this producer, costs per site on an annual basis would be $5,500 to drill and maintain five monitor wells and $3,000 to draw and analyze weekly samples. Therefore, total annual monitoring costs would range from no cost (no wells required) to $8,500 per site (five wells required). Total monitoring costs for 7 mainland sites would range from no cost to $60,000. It is likely that monitor wells would not be required for offshore practices; therefore, costs have not been included for those 3 sites.

Incremental annual reporting costs would be anticipated and would cost approximately $700 per site based on two man-days per quarter, or $7,000 for 10 sites. Combining monitoring and reporting costs, total recurring costs would range from $7,000 to $67,000 for 10 sites.

The costs discussed above are summarized in Table II-10.

Table II-10

FRASCH SULFUR MINING

SUMMARY OF COSTS TO OPERATORS

(thousands of 1977 dollars)

Number of Sites	10
Number of Wells	500 (approximately)
One-Time Costs	
Permit Applications	$24
Mechanical Integrity Test	0
Total One-Time Costs	$24
Annual Recurring Costs	
Monitoring	$0 to $60
Reporting	$7
Total Annual Recurring Costs	$7 to $67

TBS

A potentially large expense not included in the above analysis relates to improperly plugged abandoned wells. Extraction of sulfur by the Frasch process occurs in fields where oil, gas, and sulfur extraction have taken place over a number of years. Thousands of abandoned wells exist in these fields. If a state director determined that one of these wells was improperly plugged and endangered underground sources of drinking water, the Frasch producer would incur a cost ranging from $6,000 to $20,000 to properly plug the well. Since state officials have informed the consultants that no contamination has been reported to date, and therefore that the likelihood of the existence of improperly plugged abandoned wells is slight, the likelihood of encountering significant remedial costs appears to be low. However, the determination remains within the director's discretion.

The market value of Frasch production is $250 million per year (1977). Additional operating costs, especially for fuel, have been passed on to the consumer without adversely affecting demand. Prices have generally improved due to continuing strong demand for sulfur. Therefore, minimal economic impact may be expected to result from enforcement of the proposed UIC regulations.

Solution Mining of Salt

Solution mining of salt takes place in salt domes and salt beds. Domed salt is typically mined at a depth of 10,000 feet by injecting fresh or brackish water through a tubing in a cased and cemented well. Brine is withdrawn through the annulus. Bedded salt is typically mined at 2,500 feet using a similar practice or using a system of separate injection and production wells. Caverns created during solution mining are used for storage of natural gas or liquid petroleum products.

Salt is mined at about 50 sites in the United States, with principal production located in Texas and Louisiana (domed salt) and Michigan, New York, Ohio, and Kansas (bedded salt).[7] Approximately 500 wells are currently operating. Each well lasts an average of seven years, though the range is several months to about twenty years. Solution mining of salt has been practiced for more than 100 years.

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[7] Though the inventory shown in Table II-1 details 54 sites, not all sites are active at all times. For the purpose of this analysis 50 sites were assumed to be active during the first five years of the UIC program.

Though the mining sites are located near underground drinking water sources, the consultants have not been able to locate any reported contamination as a result of mining operations per se. Subsidence has been reported in Michigan due to compaction of strata after mining.

Existing regulations to control solution mining of salt vary among the producing states. Texas and Louisiana, accounting for 55 percent of salt production, regulate applications for exploratory drilling permits only. Rules and regulations to protect pollution to groundwater may be issued with the permit, but no monitoring requirements are imposed. New York, Kansas, and Ohio have broad regulatory power on a case-by-case basis, generally consistent with proposed UIC regulations with the exception that monitoring and reporting are not legally required. In Michigan, Mineral Well Act #325 is in complete compliance with proposed UIC regulations except for specific requirements relative to the frequency of monitoring and reporting.

Incremental one-time costs would be incurred for permitting and testing of existing wells. In all states except Michigan, more extensive research and paperwork would be required to prepare permit applications. It has been estimated that one to two man-months of effort at $1,700 per month (salary and fringe benefits) would be sufficient for each field. Submitting permits for 50 fields would cost a total of $85,000 to $170,000. According to technical experts, an appropriate test for mechanical integrity of existing wells would cost $3,000 to $5,000 per well. Such testing for 500 wells would total $1.5 million to $2.5 million.

Solution mining of salt requires monitoring on a regular, frequent basis to assure operators of the efficiency of their process. Therefore, it is likely that no additional steps would be necessary to comply with monitoring requirements of the UIC program. Due to the requirement for quarterly frequency of reporting, operators would experience some incremental recurring costs. These have been estimated to be $16,000 based on one day per quarter for each of the 50 existing sites.

Therefore, total incremental costs attributable to UIC regulations would range from $1.6 million to $2.7 million in one-time costs and $16,000 in annual costs. These are summarized in Table II-11.

In addition to the above estimates, a Michigan state official has reported that implementation of Michigan's strict regulations increased the cost of well design and drilling by

15 percent. That belief has been discussed among EPA staff; since no clear consensus has emerged, that impact on costs has not been included in the analysis.

Table II-11

SOLUTION MINING OF SALT

SUMMARY OF COSTS TO OPERATORS

(thousands of 1977 dollars)

Number of Sites	50 (approximately)
Number of Wells	500 (approximately)
One-Time Costs	
Permit Applications	$85 to $170
Mechanical Integrity Test	$1,500 to $2,500
Total One-Time Costs	$1,585 to $2,670
Annual Recurring Costs	
Monitoring	$0
Reporting	$16
Total Annual Recurring Costs	$16

Salt extracted by the practice of solution mining carries a market value of $120 million per year. During the last few years, substantial price increases have been passed on to the consumer to cover rising costs of fuel and other energy-related expenses. Concentration of producers is significant; 12 companies account for 88 percent of salt production. UIC compliance costs are not likely to cause significant hardship for these major producers.

Solution Mining of Potash

Solution mining of potash is accomplished at a depth of approximately 3,000 feet using either of two methods: (1) Water is injected into an existing mine cavity through injection wells which are cased and cemented to the surface. Potassium chloride and sodium chloride brine are extracted through a cased and cemented well; (2) Water is injected through the annulus of a well which is drilled, cased, and cemented to the surface. The saturated brine is extracted through the inside casing.

One operating field with 18 wells (17 injection and one extraction) exists in Moab, Utah, and is operated by Texasgulf, Inc. No contamination of underground drinking water sources has been reported in the vicinity of that field. That company also is exploring two pilot sites near the western Canadian border.

Utah's Water Pollution Control Act generally protects "beneficial uses of such waters, surface and underground"; however, a specific program would be required when Utah is included in the UIC regulatory program.

The economic impact resulting from Utah's inclusion in UIC enforcement should be modest. A Texasgulf, Inc. staff engineer estimates that permitting the Moab, Utah site would result in a one-time cost of $20,000 to $30,000 to cover consultants' fees for preparing a thorough study of engineering and hydrogeologic characteristics, maps and cross sections of all underground sources of drinking water, and anticipated operating data. Since Texasgulf does not have the available staff to complete permit applications, professional geologic consultants would be hired to develop the required data. Mechanical integrity (pressure) test of the injection wells would cost $2,000 to $5,000 per well, for a total cost of approximately $60,000. All known abandoned wells in the field are thought to be properly completed and plugged, as that is an operating requirement in extractive mining if future problems are to be avoided. Therefore, no cost would be incurred by the operator.

Recurring incremental costs would be encountered due to a change in monitoring and reporting requirements. Currently, materials balance is monitored monthly. The requirement for weekly monitoring and quarterly record-keeping would exceed available company manpower. Texasgulf estimates that one additional full-time employee would be needed in the field at a salary of $20,000 per year (including fringe benefits).

Total incremental costs for potash mining operations under the UIC regulations would be approximately $54,000 to $105,000 in one-time costs and $20,000 in annual costs. Table II-12 summarizes these costs.

Potash production in the United States was valued at approximately $160 million in 1974. Currently, solution mining at Texasgulf accounts for about 5 percent of total production, yielding a market value of $8.5 million. During the last few years, potash production costs have been severely affected by a general rise in price levels, particularly for fuel, power, and explosives. Though Texasgulf says that additional increases in costs could make the mining practice economically infeasible, to date price rises have been passed on to the consumer without noticeably affecting demand. However, solution mining of potash

Table II-12

SOLUTION MINING OF POTASH
SUMMARY OF COSTS TO OPERATORS
(thousands of 1977 dollars)

Number of Sites	1
Number of Wells	17
One-Time Costs	
Permit Applications	$20 to $30
Mechanical Integrity Test	$34 to $85
Total One-Time Costs	$54 to $115
Annual Recurring Costs	
Monitoring and Reporting	$20
Total Annual Recurring Costs	$20

is becoming more difficult due to the reduction in the amount of reserves and the greater drilling depth required to extract remaining supplies. The fixed cost component of total operating costs has been increasing at the same time that reserves have been decreasing. This could lead to further price pressures for the industry.

III. STATE PROGRAM COSTS

INTRODUCTION

The Safe Drinking Water Act of 1974 was passed by Congress with the intent that states exercise primary enforcement responsibility for proposed regulations. Consistent with that intent, proposed UIC regulations place responsibility at the state level for protection of existing and potential underground sources of drinking water from contamination caused by underground injection of fluids. Additionally, the regulations are intended to be administratively compatible with existing state programs while broadening and strengthening these programs.

The objective of the following analysis is to estimate the general level of incremental staff required to implement UIC programs at the state level and to determine for what regulatory functions the staff will be needed. The analysis is presented in terms of manpower, time, and dollar requirements.

The NPDES permit program has provided EPA with a broad base of experience in industrial permitting. Analyses have been conducted by EPA to determine the amount of staff time and related personnel cost associated with this program on a per permit basis. For a major NPDES permit, for example, ten man-days were required using a mix of personnel. These standards have been used by TBS in the estimates of UIC program staff requirements and costs.

Several functions specific to the UIC regulations are required to be performed at the state level. These include:

- Development of a state plan for regulation and enforcement of the UIC program, and submission of that plan to the state legislature and federal EPA administrator

- Submission of semi-annual reports to EPA administrator during development of the state plan and prior to receiving approval of the plan

- Review of permit applications, issuance of permits if approved, and possible public hearing with respect to UIC permit application

- Collection and periodic review of reporting data submitted by permittees
- Enforcement of the operator requirements of the UIC regulations, e.g., mechanical integrity testing, monitoring, corrective action where necessary, and record-keeping
- Submission of quarterly reports to EPA administrator on the compliance status of Class I wells within the state
- Submission of annual reports to EPA administrator summarizing regulatory action at the state level during preceding year.

STATE PROGRAM ELEMENTS

Each of these elements, along with its related manpower estimate, is discussed in greater detail below. After this discussion, the manpower estimates are compiled in tabular form and cost totals are developed.

Development of a State Plan

Most states already have underground injection control programs which are similar, at least in part, to the proposed federal UIC standards. For example, states with industrial or municipal disposal wells have programs regulating these wells, and states with Frasch sulfur practices have programs regulating these wells. However, control of underground injection activities is usually divided between two or more state agencies which may function independently of each other. Moreover, the extent of regulation of specific practices may vary from permit control only to extensive control over permitting, monitoring, and reporting requirements.

Although states have fully staffed agencies administering existing responsibilities, present estimates are that states will have to augment their staffs in order to plan and develop comprehensive UIC regulatory programs. Furthermore, to ensure adequate public participation in program formulation, these programs must pass through a period of public hearings and comment before they can be submitted to the EPA administrator for approval.

Incremental manpower requirements for program development are expected to range from 8 to 15 work-days of effort per state for states with no or very few Class I and Class III practices.[8] About 32 states and territories belong in this "minimal effort" category. The remaining 25 states may need 30 to 80 man-days each to develop suitable UIC programs. The lower end of this range applies to states with few injection practices or with existing UIC programs comparable to the federal UIC regulations; the upper end of the range applies to states with many injection well practices and/or without adequate existing programs.

Staff time needed for hearings on the state plan is expected to vary similarly. States with no or few practices have been estimated to require an average of five work-days per state for hearings. The more heavily impacted states are estimated to devote an average of 25 days per state for hearings.

Submission of Semi-annual Report to EPA

States are required to submit semi-annual reports to EPA during the time they are developing their state plans. These reports are designed to provide EPA with information on the states' progress in formulation of an approvable program for the regulation of well classes existing within the state. A typical state is expected to submit one semi-annual report to EPA during its 270-day period of program development. The effort is estimated to require approximately five man-days per state for states with Class I wells and three man-days per state for states with Class III wells. These estimates are included in the total staff needs described in Development of State Plan above.

Review of Permit Applications, Issuance Permits, and Public Hearings

States granted primacy are responsible for assuring the EPA administrator that all terms and conditions of an approved permitting program are carried out. The requirements at the state level are extensive. They include:

- Determination of the area of review, whether it is the zone of endangering influence or an area described by a specific radius

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[8] This estimate refers to the work-hours needed to develop a state program for both Class I and Class III wells.

- Review of permit applications, each application containing detailed maps, plans, test results, and operating data
- Provision for public hearings, where required, and preparation of a summary of the Director's response to any public comments which have been submitted.

As discussed above, states generally have agencies involved in the process of permitting new and existing practices. However, additional and more comprehensive requirements necessitate augmenting the current staffing levels. The estimate of incremental time required to review and process permits for individual operating sites ranges from 5 to 40 days each. These estimates apply to applications for both existing and new injection sites.

Since the level of complexity of each application relates to the type of practice being permitted, the estimates of time requirement vary by practice. The resulting range of 5 to 40 days per permit represents a low estimate of 5 days for an existing deep waste-disposal well likely to already have a permit file, and a high estimate of 40 days for certain Frasch sulfur fields.

With the permitting of many of these practices, public hearings will be required according to the provisions of the regulations. For some practices, hearings will very likely be needed, while for other less controversial practices they are less likely. For each hearing required, approximately 20 days of state staff time have been allocated in these estimates.

Time Requirement Assumptions

As discussed above, each state program function has been assigned an estimated time requirement range. In most cases, the range presented above has been developed on a per practice basis. Tables III-1 and III-2 present the ranges estimated for each practice; first, for processing permit applications, and, second, for the proportion of permits that would require a public hearing. The first column of each table also shows the number of sites in the 57 states and territories where these practices are known to be operating commercially or as pilot projects.

As the number of deep waste-disposal well practices is growing rapidly, an additional 100 wells are included in the count to reflect that expansion over the next five years. As in the previous analysis, these new wells are assumed to occupy individual sites. This growth will have an effect on the calculation of costs for different program elements. For one-time program functions such as permitting of sites, all 405 Class I sites are used in computation of total five-year cost for that task. This is because each of the 405 sites will be affected once and only once during the five-year period by this requirement. However, certain recurring program functions, such as quarterly reviews of operators' reports, will require additional state effort each year as the Class I well population increases from 304 sites in the first year of program operation to 400 sites in the fifth year. Rather than calculating different yearly costs for these program functions, this analysis has used an average five-year Class I well population of 357 wells in developing average annual costs for Class I recurring program functions.

Table III-1

CLASS I WELLS

STATE PROGRAM TIME REQUIREMENT ASSUMPTIONS

Practice	Total Number of Sites	Man-days/Site for Permitting	Proportion of Permits Requiring Hearings (percent)
Deep-Waste Disposal	400	5-10	10
Nuclear Storage and Waste Disposal	5	5-10	50

Table III-2

CLASS III WELLS

STATE PROGRAM TIME REQUIREMENT ASSUMPTIONS

Practice	Total Number of Sites[1]	Man-days/Site for Permitting	Proportion of Permits Requiring Hearings (percent)
Geothermal	3	5-10	0
In-Site Gasification	3	10-20	0
Uranium Leaching	21	20-40	50
Copper Leaching	5	20-40	50
Frasch Sulfur	10	30-40	25
Salt Solution Mining	50	10-30	15
Potash Solution Mining	1	10-30	0

[1]The number of sites includes production and pilot operations, and for solution mining practices, it includes permitted sites whether or not they are currently operating.

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Collection and Review of Reporting Data

The regulations require each permittee to submit monitoring data to the state regulatory body on a quarterly basis. For operators with more than one site under permit, the submission would be on a site-by-site basis.

The state program requirement is to receive, review, and file these data when they are submitted on a quarterly basis. Six man-hours per submission for a Class I site and seven man-hours per submission for a Class III site have been allocated to this task, though the time required would be less in many cases. In at least a few cases, however, state personnel would need to review data carefully and follow up with permittees to verify data items. Such reviews could take more than a single man-day, pulling the average review times up to the six and seven man-hour figures given above for Class I and Class III wells, respectively.

Enforcement

States are to have the responsibility of enforcing the requirements of the UIC regulations. The term "enforcement," in this report, refers to state efforts aimed at educating and working with well operators as well as efforts devoted to detecting infractions and to penalizing operators responsible for those infractions. The states are expected to offer educational assistance to well operators, conduct inspection and surveillance programs, and respond to reports of groundwater contamination. This study assumes that eight man-days of effort are required annually for a minimally impacted state, whereas 120 to 240 man-days of effort should be needed annually for moderately to maximally impacted states.

Submission of Quarterly Reports to EPA

Reports on the compliance status of all Class I wells within the state must be submitted by the state director to EPA each quarter. The information required by EPA in these reports will be an organized summary of the data received by the state each quarter from the Class I well operators and will require one man-hour of effort per site for each quarterly report submitted to EPA. These reports will provide the foundation for the annual report to EPA on the status of Class I wells.

Submission of Annual Reports to EPA

On an annual basis, each state must prepare and submit a report to EPA summarizing regulatory activities that have taken place in the state under the program. The report would contain information on applications for permits received, permits issued, quarterly reports received, and other regulatory action. States minimally impacted by the regulatory requirements for Class I and Class III wells are estimated to use three man-days of effort each in preparing these reports annually. States more heavily impacted could require from 5 to 35 man-days of effort per state for annual report preparation.

AGGREGATE STATE MANPOWER REQUIREMENTS

Methodology

The manpower estimates presented above must be combined with further information in order to project a total manpower requirement for each well class. As may be seen in Table III-3 on the next page, labor estimates for each program element presently belong to two major categories: site-based estimates and state-based estimates.

These two categories are used only as a convenient means of displaying the labor estimates obtained in the course of this study. They are not meant to imply that program elements shown with site-based manpower estimates are analogous to "variable" costs or that program elements shown with state-based manpower estimates are analogous to "fixed" costs.

"Site-based estimates" refer to labor requirements expressed as being proportional, albeit roughly, to the number or type (category of injection practice) of sites involved. Although well population is not the only factor determining the total labor requirements for these program elements, it is perhaps the primary factor.

Table III-3

SITE- AND STATE-BASED LABOR ESTIMATES

Program Element	Manpower Estimate
Site-Based	
Permitting	5-40 man-days/site, depending on practice
Permit hearings	20 man-days/hearing[1]
Quarterly review of monitoring data	6 man-hours/Class I site per quarter 7 man-hours/Class III site per quarter
Quarterly report to EPA	1 man-hour/Class I site per quarter
State-Based	
Program development	8-15 man-days/"minimal effort" state 30-80 man-days/"moderate to maximal effort" state
Program hearings	5 man-days/"minimally impacted" state 25 man-days/"moderate to maximally impacted" state
Enforcement	8 man-days/"minimally impacted" state per year 120-240 man-days/"moderately to maximally impacted" state per year
Annual reports	3 man-days/"minimally impacted" state per year 5-35 man-days/"moderately to maximally impacted" state per year

[1]Number of hearings required estimated from number of sites.

"State-based estimates" refer to labor requirements expressed as being proportional to the number or type (level of effort or level of impact expected) of states involved. Well population is implicitly taken into account, as is the adequacy of present state regulation of the well classes.

Information on these additional parameters had been supplied earlier, both in the text and tables of this report. This allows conversion of the labor requirements for important program elements into more manageable form, i.e., into labor estimates for each program element for each class of wells, or for each injection practice. The computational formulas and component variables may be seen in Table III-4.

Table III-4

COMPUTATIONAL FORMULAS AND VARIABLES USED IN
COMPUTING LABOR ESTIMATES FOR PROGRAM ELEMENTS

Program Element	Cost Calculated	Class I Wells	Class III Wells
Program Development	One-time	$k_1 (32 \cdot slp_1 + 25 \cdot slp_2)$	$k_2 (32 \cdot slp_1 + 25 \cdot slp_2)$
Program Hearings	One-time	$k_1 (32 \cdot slh_1 + 25 \cdot slh_2)$	$k_2 (32 \cdot slh_1 + 25 \cdot slh_2)$
Permitting	One-time	$\sum_{c=1}^{2} n_c \cdot pl_c$	$\sum_{c=3}^{9} n_c \cdot pl_c$
Permit Hearings	One-time	$\sum_{c=1}^{2} n_c \cdot Pc \cdot hl$	$\sum_{c=3}^{9} n_c \cdot Pc \cdot hl$
Quarterly Reviews	Annual	$\sum_{c=1}^{2} 4 \cdot n_c \cdot ml_1$	$\sum_{c=3}^{9} 4 \cdot n_c \cdot ml_2$
Enforcement	Annual	$k_1 (32 \cdot el_1 + 25 \cdot el_2)$	$k_2 (32 - el_1 + 25 \cdot el_2)$
Quarterly Reports	Annual	$\sum_{c=1}^{2} 4 \cdot n_c \cdot ql$	n/a
Annual Report	Annual	$k_1 (32 \cdot rl_1 + 25 \cdot rl_2)$	$k_2 (32 \cdot rl_1 + 25 \cdot rl_2)$

k_1, k_2 = relative level of effort required for Class I and Class III well populations, respectively

slp_1, slp_2 = state labor required to develop state program plan for minimal effort states and moderate-to-maximal effort states

slh_1, slh_2 = state labor required to conduct program hearing for minimally and moderately-to-maximally impacted states

c = category of injection practices (9 categories)

n_c = number of sites

pl_c = labor requirement to permit one site

Pc = probability that a public hearing will be required

hl = labor required to conduct a permit hearing

ml_1, ml_2 = monitoring labor required to review each quarterly submission from well operation for Class I and Class III sites

el_1, el_2 = labor requirement for enforcement for minimally and moderately-to-maximally impacted states

ql = report preparation labor required for each quarterly report to EPA

rl_1, rl_2 = report preparation labor required for annual reports to EPA for minimally and moderately-to-maximally impacted states

Estimates of Manpower Requirements-- Class I Wells

One-Time State Manpower Estimates

As may be seen in Table III-5, the largest time requirement, 9 to 19 man-years of effort, has been estimated to arise from issuing permits for existing UIC programs.[9] The second largest amount of effort would be the four to nine man-years used in developing state plans. Permit hearings require four man-years and program hearings three man-years. Total one-time state manpower requirements range from 19 to 34 man-years of effort.

Table III-5

CLASS I WELLS

ONE-TIME STATE MANPOWER ESTIMATES

Program Element	Manpower Required (Man-Years)
Program Development	3.5-8.5
Program Hearings	2.7
Permitting	9.2-18.5
Permit Hearings	3.8
	19.2-33.5

Recurring State Manpower Estimates

These recurring annual manpower requirements begin once a state completes its program development and initial permitting of existing sites. As these tasks will be completed over a period of five years, the number of sites to be reviewed each year will depend on the rate at which the state personnel permit new and existing sites. For the purposes of this discussion it is assumed that permits will be issued for all known sites.

Table III-6 shows these costs. Enforcement constitutes the largest component of the on-going effort with an estimated 12 to 22 man-years of effort expected in each calendar year. Although this level of effort would range widely among states,

[9]This report assumes 220 man-days per man-year.

the average state effort would be between one-quarter and one-half years. The tasks of reviewing quarterly reports from operators will require an additional five man-years, while submittal of quarterly and annual reports to EPA will take from one and a half to four man-years. Overall, on-going efforts will require from 18 to 31 man-years of effort or one quarter to one-half full-time person in an average state.

Table III-6

CLASS I WELLS

ANNUAL RECURRING MANPOWER ESTIMATES

Program Element	Manpower Required (Man-Years)
Quarterly Reviews	4.9
Enforcement	11.5-22.1
Quarterly Reports	0.8
Annual Report	0.7-3.4
	17.9-31.2

Estimates of Manpower Requirements--Class III Wells

One-Time State Manpower Estimates

Again, as may be seen in Table III-7, the largest one-time cost to the states is in permitting, requiring 6 to 14 man-years. Program development costs and permit hearings require one to three man-years and two man-years, respectively. Program hearings will take up to one man-year of effort. Total one-time manpower requirements for all states range from 10 to 20 man-years.

Table III-7

CLASS III WELLS
ONE-TIME STATE MANPOWER ESTIMATES

Program Element	Manpower Required (Man-Years)
Program Development	1.1-2.8
Program Hearings	0.9
Permitting	6.2-13.8
Permit Hearings	2.1
	10.2-19.6

Recurring State Manpower Estimates

Table III-8 presents the annually recurring costs to the states for regulation of Class III wells. The greatest annual cost is in enforcement, needing three to six man-years of effort. Quarterly reviews of well reports take up to two man-years, and submission of an annual report to EPA requires 0.3 to one man-year of effort for all states. In all, five to nine man-years of effort are required annually.

Table III-8

CLASS III WELLS
ANNUAL RECURRING MANPOWER ESTIMATES

Program Element	Manpower Required (Man-Years)
Quarterly Reviews	1.5
Enforcement	3.3-6.3
Annual Report	0.3-1.0
	5.1-8.8

STATE COSTS FOR MANPOWER REQUIREMENTS

The state requirements above have all been estimated in terms of time or manpower needed. To convert these to actual costs requires an estimate of the weighted average state staff wage and fringe benefit level. Experience with NPDES permitting has shown that the ratio of technical or supervisory personnel to clerical personnel has been about 70/30. Using this ratio along with recent wage and benefit rates,[10] an estimated cost per man-year of $22,500 has been used in the NPDES program.

Using this manpower wage estimate, and adding 15 percent to the base salary for direct expenses such as office supplies and travel, the one-time state costs for Class I wells would be in the range of $500,000 to $870,000 for the 57 states and territories. The one-time state costs for Class III wells range from $264,000 to $509,000. The annual recurring costs for Class I wells for 57 states and territories fall in the range of $469,000 to $815,000; the annual recurring costs for Class III wells range from $131,000 to $230,000. These costs are presented in Table III-9.

Table III-9

STATE PROGRAM
TOTAL COSTS
(57 states and territories)
(thousands of 1977 dollars)

Class I Wells	
One-Time Costs:	
Program Development	$ 90-220
Program Hearings	70
Permitting	240-480
Permit Hearings	100
	$500-$870
Annual Recurring Costs:	
Quarterly Reviews	$146
Enforcement	300-575
Quarterly Reports	5
Annual Reports	19-94
	$470-$820
Class III Wells	
One-Time Costs:	
Program Development	$ 28-73
Program Hearings	22
Permitting	160-360
Permit Hearings	54
	$264-$509
Annual Recurring Costs:	
Quarterly Review	$ 39
Enforcement	85-165
Annual Report	7-26
	$131-$230

[10] These estimates were provided to TBS in 1978 by the Office of Water Enforcement of the EPA.

PART TWO

ANALYSIS OF COSTS
UNDERGROUND INJECTION CONTROL REGULATIONS
CLASS IV AND CLASS V WELLS

PREPARED FOR:

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER SUPPLY

BY:

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MAY 1979

TBS

PREFACE

This report has been submitted to the United States Environmental Protection Agency in partial fulfillment of Contract Number 68-01-4778 by Temple, Barker & Sloane, Inc. (TBS), 33 Hayden Avenue, Lexington, Massachusetts. This is a revision of a report submitted May 2, 1978, titled Analysis of Costs, Underground Injection Control Regulations, Subpart F Injection Well Practices, prepared jointly by Geraghty & Miller, Inc. and TBS.

This current version incorporates revisions to the UIC regulations as they appear in the reproposed regulations of April 1979. The most significant change is the redistribution of Subpart F wells into two categories: Class IV and Class V wells. Class IV includes wells used by generators of hazardous wastes or hazardous waste management facilities to inject into or above underground sources of drinking water. Class V consists of wells that were not included in well Classes I through IV. This latter class includes, though is not limited to, wells injecting nonhazardous materials into or above underground sources of drinking water.

In addition to the classification changes, this report incorporates newly collected information gathered by TBS during state visits regarding Class IV wells, alternative disposal methods and costs, and the status of state regulatory programs.

TBS acknowledges the significant contribution to this study of Geraghty & Miller, Inc., groundwater hydrology consultants. The report issued jointly in 1978 would have been difficult to produce without their collaboration. In the process of revising that report to incorporate consideration for Class IV and Class V wells, Jim Geraghty provided valuable advice and served as a critical reviewer as data were accumulated.

TBS acknowledges the informed assistance of federal, state, and county regulators, especially in EPA's Office of Drinking Water, in Maryland, and in Nassau County, New York, respectively.

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I. INTRODUCTION

BACKGROUND

History

Section 1421 of the Safe Drinking Water Act (SDWA, PL 93-523) requires that a federal-state system of regulations be established to insure that actual and potential underground sources of drinking water are not endangered by the injection of contaminants.[1] As a result of the SDWA, regulations describing the State Underground Injection Control (UIC) program were proposed by the Environmental Protection Agency (EPA) to establish minimum requirements for effective state programs (40 CFR Part 146, August 31, 1976).

Initially, three categories of injection wells were included in these regulations (Subparts C, D, and E). Later drafts of the UIC regulations recognized four categories of injection wells (Subparts C, D, E, and F). These categories were based on two major considerations: (1) the depth of the injection well relative to nearby underground sources of drinking water, and (2) the principal function of the well, e.g., oil and gas production, waste disposal, or mining and energy production.

Currently Proposed UIC Regulations

The currently proposed UIC regulations have differentiated between injection well categories still further. The Preamble to the reproposed regulations (40 CFR Part 146, April 20, 1979) gives definitions for these new classes:

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[1]EPA's proposed definition (in 40 CFR Part 146, April 20, 1979) of "underground sources of drinking water" includes all aquifers, or their portions, which are presently providing drinking water and, "as a general rule, all aquifers or their portions with fewer than 10,000 ppm/TDS." States are allowed to exclude portions of aquifers which are not "in a real sense" potential drinking water sources. In this report, the term "freshwater aquifer" is used as a synonym for "underground sources of drinking water" as defined by the regulations.

- "Class I includes industrial and municipal disposal wells and nuclear storage and disposal wells that inject below all underground sources of drinking water.
- "Class II includes all injection wells associated with oil and gas storage and production.
- "Class III includes all special process injection wells, for example, those involved in the solution mining of minerals, in situ gasification of oil shale, coal, etc., and the recovery of geothermal energy.
- "Class IV includes wells used by generators of hazardous wastes or hazardous waste management facilities to inject into or above underground sources of drinking water.
- "Class V includes all other injection wells."[2]

The major change from earlier draft versions has been the decision to redistribute the well practices injecting into or above underground sources of drinking water among well Classes IV and V. These two classes pose different degrees of threat to human health and the environment and are, therefore, to be regulated separately. However, as both classes of wells are thought to be of serious concern, they have required additional attention and are the subject of this report.[3]

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[2] Subpart F of 40 CFR Part 146 describes Class V in more detail, stating that this class "includes but is not limited to the following types of injection wells: waste disposal wells, such as dry wells, non-residential septic system wells, and sand backfill wells; and recharge wells, such as drainage wells, cooling water return flow wells, air conditioning return flow wells, salt water barrier wells and subsidence control wells (not associated with oil and gas production)."

[3] In 1978, Temple, Barker & Sloane, Inc. (TBS) assisted EPA in the evaluation of several possible regulatory approaches for the wells covered by the then Subpart F. This earlier study has been updated and included as Appendix B in the present report for two purposes: (1) to provide historical perspective on the problem of regulating wells injecting into or above underground sources of drinking water, and (2) to explain the reasoning underlying the structure of the currently proposed UIC regulations.

The states are required to develop state programs to administer and enforce the minimum requirements and standards of the federal UIC regulations. In addition to developing procedures and plans for implementation of general UIC program requirements, the states must develop programs for each class of wells present in their state. States are also required to adopt rules to regulate well practices that do not presently exist in that state in order to guard against the possibility of unregulated future injection.

The minimum requirements for an acceptable state program regulating Class IV wells are as follows:

- Inventory of Class IV wells
- Formulation of an enforcement strategy that will result in the closure of Class IV wells within three years of the effective date of the UIC program
- Ban on new Class IV wells
- Review of quarterly reports submitted by Class IV well operators
- Submission of quarterly and annual reports to EPA
- Periodic inspection and surveillance procedures
- Adequate enforcement penalties.

For Class V wells, the states are given two years after the effective date of the UIC program in which to complete and submit to EPA:

- An assessment of the contamination potential of Class V wells
- An assessment of the regulatory alternatives for these wells
- Recommendations for federal regulatory action.

Furthermore, the states are required to take immediate action on Class V injection practices that pose a significant risk to human health. After receiving and evaluating reports from the states, EPA will promulgate further national requirements for the regulation of Class V wells.

Operators of Class IV wells are also subject to minimum UIC requirements as soon as a state program becomes effective. Specifically, operators must:

- Notify the program director of their existence and the endangerment potential of their operations
- Periodically monitor injection well parameters and groundwater quality
- Submit quarterly reports to the program director on the results of monitoring
- Close wells when scheduled to do so by the program director.

Generators no longer using Class IV wells as their means of disposal must, under the Resource Conservation and Recovery Act (RCRA), dispose of future hazardous wastes in an approved hazardous waste management facility and participate in the RCRA manifest tracking system if disposing of over 100 kilograms of hazardous waste off-site.

Soon after the effective date of a UIC program, operators of Class V wells must submit the following to the state program director:

- Notification of the existence of Class V wells
- Construction features of the well
- Nature and volume of injected fluids
- Alternative means of disposal available to the operator
- Environmental and economic consequences of well disposal and its alternatives.

EPA has also decided to consolidate the regulations for its major permit programs. These regulations are to be published in the near future as revisions to 40 CFR Parts 122, 123, and 124, which currently refer to the Clean Water Act's NPDES regulations. The major permit programs included in this undertaking are: the UIC program under the Safe Drinking Water Act (SDWA); the NPDES regulations of the Clean Water Act; and the hazardous waste management program under RCRA.

STATEMENT OF PROBLEM

Little information is readily available on the number of wells injecting into or above underground sources of drinking water. These well practices are generally associated with smaller industrial, commercial, and municipal facilities. Many of these practices are thought to be widespread, such as the injection of wastes into non-residential septic systems, multi-family septic systems, dry wells, and the injection of storm-water runoff into drainage and recharge wells. Others are used only in a few scattered locations, as in the case of injection wells installed to control land subsidence. All of these wells have a potential for contaminating underground sources of drinking water. This threat of contamination is real, and its consequences significant, because groundwater is used for drinking water by more than half the population of the United States.

SCOPE OF INVESTIGATION

The purpose of this investigation was threefold: (1) to describe selected Class IV and V injection well practices, to determine the number of these wells, and to estimate the volume of fluid injected by these wells into or above underground sources of drinking water; (2) to assist EPA in its determination of methods of regulating these practices; and (3) to estimate the costs of regulation to both industry and the states for these two well classes.

Most of this investigation was conducted in a five-month period during the fall and winter of 1977-1978. Information was obtained through a literature survey, telephone interviews with federal, state, and local officials and industry representatives, a mail survey, and visits to state and local offices. In all, 22 states were contacted and visits were made to 14 of these states.

A second investigation was carried out in the winter of 1979. Its purpose was to improve on the earlier estimates of Class IV well population and unit costs of disposal alternatives.

MAJOR FINDINGS

The major findings and conclusions of this investigation cover four areas: well population, well injection volume, industry costs, and state costs.

Well Population

- Class IV and V wells exist in large numbers. Eight states with the most complete data reported approximately 60,000 of these wells, and these states appear to be somewhat representative of the rest of the country.

- Based on the limited information available, a most likely national estimate for Class IV well population is 7,500 wells. The probable well population is estimated to range from 5,000 to 10,000 wells.

- A national estimate for Class V wells, projected on the basis of information available from eight states, is 250,000 wells.

Well Injection Volume

- These wells constitute a contamination threat to the nation's underground drinking water sources. For Class IV wells, the contamination threat resides in the nature rather than the volume of the fluids injected. For Class V wells, the contamination potential arises more from the volume of fluids injected, as the quality is generally considered to be nearly as good as the quality of the receiving aquifer. In only the eight states that provided the most complete data on wells injecting into or above underground sources of drinking water, and using conservatively low assumptions, these Class V wells are estimated to discharge nine billion gallons or more of fluid per year directly or indirectly into freshwater aquifers. The actual national volume is undoubtedly much higher. In contrast, all the wells belonging to Classes I, II, and III are estimated to leak an annual volume of about eight billion gallons of fluid, assuming a conservatively high leakage rate of one percent of all injected fluids. This leakage volume is based on an estimated annual injection volume of 850 billion gallons.

- On a nationwide basis, Class IV wells are estimated to inject over a billion gallons of hazardous fluids yearly. Expected injection volumes range from 660 million gallons to 1.7 billion gallons yearly.

- On a nationwide basis, Class V wells' injection volumes may exceed 30 billion gallons yearly.

Industry Costs

- Total five-year costs to industry resulting from the proposed Class IV well regulations are estimated to be $120 million (in 1977 dollars) for a Class IV well population of 7,500 wells.[4] Total costs could range from $80 million to $160 million, based on well population range estimates of 5,000 to 10,000 wells. Using a well population estimate of 7,500 wells, the five-year costs for each of the various program tasks are shown in Table I-1.

Table I-1

CLASS IV WELLS
TOTAL FIVE-YEAR COSTS TO INDUSTRY
(thousands of 1977 dollars)

Program Element		Total Five-Year Cost
One-Time		
Notification	$ 1,100	
Total Five-Year One-Time Costs		$ 1,100
Recurring		
Monitoring	$13,800	
Quarterly Reports	1,700	
Alternative Disposal	99,000	
Manifests	4,700	
Total Five-Year Recurring Costs		$119,200
Total Five-Year Cost to Industry		$120,300

- Costs to industry have not been developed for Class V wells because the proposed regulations currently require only an assessment, conducted by the state. Costs to individual operators

[4] Industry costs have been shown as five-year costs to illustrate the continuing effects of the UIC (and subsequently, RCRA) regulations on Class IV well operators and on hazardous waste generators using these wells.

are expected to be nominal, based on the use of simplified registration procedures. Estimates of costs to the operators will be developed when a national regulatory strategy for Class V wells has been proposed.

State Costs

- Total program costs to the 57 states and territories for the proposed Class IV well regulations are estimated to be $2.9 million, in 1977 dollars.[5] Total program costs could range from $2.2 million to $4.2 million, depending on well population. Assuming a well population of 7,500 wells, the total costs for each of the program elements are shown in Table I-2.

Table I-2

CLASS IV WELLS
TOTAL FIVE-YEAR COSTS TO STATES
(thousands of 1977 dollars)

Program Element		Total Cost
One-Time		
Program Development	$ 101	
Program Hearings	34	
Semi-annual Report	34	
Well Authorization	220	
Total Five-Year One-Time Cost		$ 389
Recurring		
Quarterly Reviews	$ 662	
Quarterly Reports	264	
Annual Report	264	
Enforcement Visits	1,322	
Total Five-Year Recurring Costs		$2,512
Total Five-Year Program Cost to States		$2,901

[5] For purposes of consistency throughout the report, total costs to industry and states are reported as five-year costs. Three years is the allowable lifetime for Class IV state regulatory programs, and costs for years four and five would be zero.

- Total assessment costs to the 57 states and territories for the proposed Class V regulations are estimated to range from \$5.2 million to \$7.2 million.[6] The range of one-time costs for each of the three program phases is shown in Table I-3.

Table I-3

CLASS V WELLS
TOTAL ASSESSMENT COSTS TO STATES
(thousands of 1977 dollars)

Program Element	Total Cost
Phase I: Data Collection and Review	\$1,600-\$2,220
Phase II: Field Verification	1,600- 2,220
Phase III: Evaluation and Recommendations	1,980- 2,730
Total Assessment Cost to States	\$5,180-\$7,170

[6] Two years is the specified lifetime for the Class V assessment process. Costs for state responsibilities beyond the second year have not been estimated, as the requirements have not yet been determined. For this analysis, costs for the three years following the assessment have been omitted, but there are expected to be additional regulatory costs to the states in the future.

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II. DESCRIPTION OF PRACTICES

EPA broadly defines well injection to mean the "subsurface emplacement of fluids through a bored, drilled, or driven well; or through a dug well where the depth is greater than the largest surface dimension and a principal function of the well is the subsurface emplacement of fluids."[7] Moreover, the regulations specify that Class IV includes "wells used by generators of hazardous wastes or hazardous waste management facilities to inject into or above underground sources of drinking water." Class V consists of all injection well practices not included in Classes I through IV.[8]

These general definitions denote the most important characteristics of the terms "well injection," "Class IV," and "Class V." More specifically, Class IV and V injection wells can be grouped into two broad categories, disposal wells and recharge wells, based on the principal purpose for which the wells are installed. Disposal wells are those wells that directly or indirectly inject wastes and include, but are not limited to, cesspools, conventional cased wells, dry wells, sand backfill wells, and septic system wells. Recharge wells are those wells that are used primarily for replenishing aquifers and include, but are not limited to, air conditioning return flow wells, conventional recharge wells, cooling water return flow wells, drainage wells, saltwater barrier wells, and subsidence control wells not associated with oil and gas extraction. Generally speaking, Class IV wells belong to the category of disposal wells, while Class V wells span both the disposal and recharge well categories.

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[7] State Underground Injection Control Program, Proposed Regulations, Federal Register, vol. 44, no. 78, April 20, 1979, p. 23738.

[8] To repeat, Class I includes "industrial and municipal disposal wells and nuclear storage and disposal wells that inject below all underground sources of drinking water in the area." Class II includes "all injection wells associated with oil and gas storage and production." Class III includes "all special process injection wells, for example, those involved in the solution mining of minerals, in situ gasification of oil shale, coal, etc., and the recovery of geothermal energy." Class IV includes wells "used by generators of hazardous wastes or hazardous waste management facilities to inject into or above underground sources of drinking water." Ibid., p. 23740.

Most of the injection wells discussed in this report are widely used throughout the nation and in practically every state. Commonly, as in the case of injection wells such as cesspools and septic system wells, the operators believe that these practices represent the best technological means of disposal of fluids. Furthermore, the operators are largely unaware that EPA is now looking upon these practices as threats to the potability of underground sources of drinking water. Also, in many instances, specifications and controls for these injection wells are prescribed in building codes or in the regulations of health departments because the wells are considered to be acceptable means of waste disposal.

Few of the types of injection wells covered by this report have ever been inventoried or assessed as to their contamination potential. Moreover, it is neither possible in the time presently available to determine actual counts of each category of injection well nor to determine actual volumes and toxicities of the fluids being emplaced through the wells. In this report, the quantitative estimates presented rely heavily on the information from the few states with significant well data.

TECHNICAL DESCRIPTION

There is a lack of common terminology to describe these wells. For example, a well that is accepting raw sewage might be described as a drainage well by its owner in Florida, whereas in other states it might be classified as a disposal well. Different geologic environments also may require different types of disposal wells. In the areas of lava terraces in the Columbia River Plateau area of Idaho and Oregon, for example, low permeability of the surficial geologic materials makes it necessary to employ an unusual combination of a septic tank and a shallow injection well for disposal of sanitary sewage. In Long Island, New York, the high permeability of the surficial soil deposits allows unlined sumps to be used to dispose of storm runoff; in other places, storm water might be injected through what is called a drainage well. The following sections give expanded definitions of the well practices discussed in this report.

Disposal Wells

These wells are used for the injection of wastes, and depending on the type of waste discharged into the well, each of the well practices described below may have facilities included in well Classes IV or V.

A cesspool typically consists of a concrete cylinder about five feet in diameter with perforated sides and an open bottom. It is buried at least several feet below ground surface. Waste water commonly is discharged directly to the cesspool, and there may be poor settling of solids before the effluent seeps into the surrounding soil. (Single-family domestic cesspools will not be regulated under these reproposed regulations.)

A conventional cased well is a vertical hole lined with a casing and designed for the sole purpose of injecting fluids. These wells are generally used for disposal of small volumes of wastes that cannot be disposed of to a municipal sanitary-sewage treatment system or where the only available treatment facility is too far from the site of waste generation. These wastes are injected under gravity flow or under pressure into a permeable zone.

A dry well is used for the injection of wastes into the unsaturated zone above an underground source of drinking water. These wells are designed to transmit untreated wastes into a permeable zone. In areas underlain by sand, dry wells are typically filled with gravel to control discharge and maintain the side walls.

A sand backfill well is used to inject a slurry, composed of a mixture of water and mine-refuse materials, to control land subsidence. The slurry can be injected under gravity or under pressure into numerous closely-spaced bore-holes or conventional cased wells.

A septic system well is used to inject the effluent from a septic tank that receives and treats sewage from a multi-family residence or from a commercial or industrial establishment, whether or not a conventional drainfield or cesspool is used. In addition to the biological process of anaerobic decomposition, physical settling of solids occurs in a septic tank. Effluent from the septic tank is discharged to a permeable zone through a leach field, trench bed, or shallow well. (Single-family septic system wells will not be regulated under these reproposed regulations.)

Recharge Wells

These wells are used for the injection of water to replenish an aquifer. It is expected that, except for a few special cases, all facilities belonging to this category will be included in Class V.

An air conditioning return flow well is used to inject water that is circulated through an air-conditioning system.

A conventional recharge well is used to inject water into an underground source of drinking water to augment natural infiltration or to increase the volume of water that is naturally in storage in an aquifer that is an underground source of drinking water.

A cooling water return flow well is used to inject water that has been used in an industrial or commercial cooling system.

A drainage well is used to inject urban, agricultural, or highway runoff, or excess ponded surface water.

A saltwater barrier well is used to inject water into an aquifer to prevent or retard intrusion of salty groundwater. A groundwater mound is established by the injection of freshwater through a series of wells located along the saltwater interface. The freshwater mound inhibits the lateral encroachment of salty groundwater.

A subsidence control well is used to inject water into an aquifer that is a non-oil and gas producing zone to reduce or eliminate land subsidence in an area of excessive pumping of groundwater. Compaction of the underground reservoir and subsidence of the land surface may result from the removal of groundwater. The reintroduction of water to fill voids and provide buoyancy to the aquifer materials can arrest subsidence and may even cause a surficial rebound of the land surface.

ESTIMATION OF THE NUMBER OF WELLS IN USE

As part of this investigation, estimates were made of the number of disposal wells and recharge wells in use and covered by well Classes IV and V. This effort represents perhaps the first attempt at making an estimate for more than a single state of the number of such wells that inject fluids into or above underground sources of drinking water. In most states, these wells have not been inventoried, and there is some uncertainty in regard to the identification and existence of these facilities, owing to the lack of common definition of the various injection well categories. Moreover, it is difficult to distinguish between some of the well practices solely on the basis of use and construction of the wells.

For convenience in estimating numbers, the injection wells were first grouped into the two broad categories, disposal wells and recharge wells, in order to separate wells receiving consistently poor quality water from those receiving water of a generally better quality. The wells were grouped, therefore, according to the purpose of the well and, to some extent, according to the expected quality of the injected fluid. This distinction is difficult to define sharply, however, because most of these wells are capable of accepting fluids of all qualities. For example, many of the recharge wells are drainage wells receiving urban or agricultural storm-water runoff. The fluids entering those wells are typically of very poor quality during the "first flush"[9] and then of relatively good quality. Also, some air conditioning return flow wells in Oregon typically transmit water of relatively good quality, but these wells may also receive some sanitary sewage intermittently. Further investigation was conducted to estimate total well populations for Classes IV and V. More recently, the study was extended to develop a better estimate of the number of wells in Class IV.

Due to a lack of data, the present analysis of injection wells only partly examines the issues related to the volumes injected by each of the various well categories. Several states have made preliminary estimates of the number of injection wells in some well categories. However, the studies by the states did not place much emphasis on the volume and toxicity of injected fluids. Preliminary estimates of volumes have been made during this study, but only to assess the general magnitude of the problem and to compare the contamination threat with that posed by injection wells covered under the other Classes of the UIC regulations.

Methodology

Information for the estimate of disposal wells and recharge wells was obtained primarily through: (1) a literature survey; (2) telephone interviews; (3) a mail survey; and (4) visits to state and county offices.

In performing the literature survey, the EPA library was used to obtain relevant publications, as were the consultants' libraries and technical files. Major sources are included in the bibliography at the end of this report.

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[9] The significance of "first flush" was decribed in Characterization and Treatment of Urban Land Runoff, Chapter VI, EPA-670/2-74-096, December, 1974.

Officials with various federal, state, and county agencies were contacted, including the U.S. Environmental Protection Agency, U.S. Geological Survey, U.S. Bureau of Census, state departments of environmental protection and of natural resources, state and county departments of health, and state oil and gas conservation boards. In all, 22 states were contacted--14 states through personal visits and the remaining 8 by telephone. Personal and telephone contacts were also made with trade and industrial associations that might be concerned with Class IV and V well practices. These included the Metal Finishers Foundation, the American Mining Congress, the American Water Works Association, the American Petroleum Institute, and the Manufacturing Chemists Association.

Most of the states that were contacted in the telephone interviews also received a mail survey and a copy of relevant Subparts of the September 23, 1977, draft of the proposed UIC regulations. The response to the mail survey was generally favorable.

Fourteen states (Arkansas, California, Colorado, Florida, Illinois, Indiana, Kansas, Maryland, Mississippi, New York, Ohio, Pennsylvania, Texas, and Washington) were visited by the consultants. These visits generally included personal interviews with state officials in several agencies as well as collection of relevant state regulations, case study materials, and available permit information.

Findings--Disposal and Recharge Wells

The states varied substantially in the amount of information which they possessed regarding the wells covered by Classes IV and V. A few had actually conducted inventories of wells in selected categories, such as air conditioning return flow wells, cesspools, or conventional cased disposal wells. Many state officials who lacked formal inventories did offer other estimates for selected well categories. Still other states either had no data or, in some cases, believed that none of these wells exists in their states. A detailed summary of the responses of each of the states is presented in Appendix A.

In three states reporting Class IV and Class V disposal wells and recharge wells, 10,000 or more wells per state were reported. These estimates, which were 13,000 for California, 12,000 for Pennsylvania, and 10,000 for Florida, represent the best professional judgment of state officials and the results of the literature and mail surveys. In several other states, estimates for wells were determined for only certain categories or certain parts of a state. These states and the respective estimated well numbers are: Maryland, 3,000; Idaho, 5,000; Oregon, 7,000; Ohio, 5,000; and Kansas, 5,000.

States that estimated they had only a few wells injecting into or above freshwater aquifers and that could not supply numbers included: Arkansas, Louisiana, Mississippi, and Oklahoma. In Arkansas and Mississippi, cesspools and septic tanks were cited by state officials as a cause of groundwater pollution. However, most cesspools in those states are generally used by private residences, and the UIC regulations do not include control of private residence septic systems and cesspools.

About 60,000 disposal wells and recharge wells were reported in the eight states that had the most complete data. About two-thirds of these wells are in the disposal well category, and about one-third are in the recharge well category (see Table II-1). Even these data are incomplete, as noted earlier, because most states did not have data on all types of Class IV and V wells, and, in some cases, the reported data do not represent all counties within the state.

Table II-1

REPORTED NUMBER OF CLASS IV AND CLASS V WELLS IN EIGHT STATES[1]

Type of Wells	Number of Wells[2]
Disposal Wells:	
• Non-Residential Cesspools, Dry Wells, and Septic-System Wells	25,000
• Conventional-Cased Wells	15,000
Recharge Wells:	
• Drainage Wells	15,000
• Other Recharge Wells	5,000
Total	60,000

[1]The states included are California, Florida, Idaho, Kansas, Maryland, Ohio, Oregon and Pennsylvania.

[2]The reported figures are incomplete counts of the wells in these states, but they do represent the information currently available to state officials. For most states, these figures represent three or fewer of the four categories listed. For some states, the estimate does not represent all counties.

Source: State and local officials. See Appendix A for details.

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The national implications are significant, even though the data are incomplete. First, even the 60,000 reported wells constitute a widespread practice and, as will be shown later, account for a significant volume of contamination entering the nation's underground drinking water sources.

Second, when these wells are studied more carefully, there will undoubtedly be many more than the 60,000 already identified. Even in the eight states, the total number should be higher because other categories will be identified, full geographic coverage will be attained, and the estimates presented above are only conservative minimum estimates provided by the states. It is likely that the final number in these states will exceed 60,000 by a wide margin.

Finally, the other 42 states and the federal territories which are covered by these regulations are also expected to identify significant numbers of Class IV and Class V wells. In this connection, it is believed that the eight states may be a fairly representative sample of the 50 states with respect to injection well practices endangering freshwater aquifers for the following reasons:

- These eight states account for a significant share of the population and business establishments in the country. Since the well practices studied here are considered to be related to both population and business activity, these states constitute a significant sample. In combination, they account for 28 percent of the country's population and 30 percent of the manufacturing and service establishments.

- These states contain an average, or slightly lower than average, percentage of population and business establishments which are <u>not</u> served by sewer systems. Since the use of wells injecting into or above underground sources of drinking water is thought to be most prominent in unsewered areas, these states should present a typical or even slightly low estimation of the national incidence of these wells. According to EPA statistics, 22 percent of the 1975 population of these eight states were not served by sewer systems, while the national figure was 27 percent for all 50 states. The range in these eight states was from a low of 10 percent in Ohio to a high of 46 percent in Idaho. The other 42 states account for just over three-quarters of the national population which was not served by sewers in 1975.

- In terms of hydrogeology, these states make up a sample of the major physical characteristics which determine the suitability of an area for such wells and the availability or lack of alternative means of disposal. These states represent all 10 of the groundwater regions in the United States, as described by H. E. Thomas.[10] As a group, these states are neither the most nor the least conducive areas for such wells and, except for approximately 10 mountain states which are geologically not favorable for such wells, constitute a fairly representative sample of the country.

Findings--Class IV Wells

There exist considerable variations among state inventories of Class IV wells. Generally, more extensive information is available in states that issue permits for the practice than in states where the practice is not allowed. The few states that do regulate Class IV well practices generally do so under the authority of environmental protection programs such as the NPDES program. Even states that issue permits for Class IV wells, however, do not consider their estimates highly reliable. Depending on local hydrogeologic conditions, the use of illegal wells can be extensive and difficult to detect. In addition, Class IV wells do not usually constitute a separate category in state inventories of disposal permits. Rather, these wells are incorporated with other forms of groundwater discharge such as leaching fields, and hazardous and nonhazardous wastes are not differentiated.

It is even more difficult to identify the extent of the practice in states that do not issue permits for Class IV wells. Such wells are usually identified only in response to specific complaints of groundwater contamination. Thus, it is difficult to project the number of Class IV wells on the basis of particular complaints.

[10] Thomas, H. E., The Conservation of Ground Water, McGraw-Hill Book Co., Inc., New York: 1951.

A preliminary total estimate of 5,000 to 10,000 Class IV wells, with a midpoint estimate of 7,500 wells, has been developed by projecting national estimates from more localized areas of the country that have relatively extensive information concerning the practice. These figures account for both estimates by officials in these areas of the number of existing Class IV wells which are not included in their inventories and for the results of extensive field work in Nassau County, New York. Until more extensive state survey data become available, however, more precise estimates cannot be developed. This midpoint figure, 7,500 wells, will be used in developing the total cost estimates for industry and state impacts.

Findings--Class V Wells

Class V wells far outnumber Class IV wells. An estimate can be developed based on data from the eight states cited earlier which provided the most detailed information on Class IV and V practices. These states are: California, Florida, Idaho, Kansas, Maryland, Ohio, Oregon, and Pennsylvania. The estimate must be based on three factors: (1) these eight states' share of the nation's population and business establishments (28 percent and 30 percent, respectively); (2) the relative degree of population without sewer service considered more likely to utilize these forms of disposal (22 percent for the eight states versus 27 percent nationally); and (3) the eight state estimate of the present number of Class IV and V wells (60,000). Combining these factors, and allowing for 5,000 to 10,000 Class IV wells nationally as estimated above, yields an estimate of over 250,000 Class V wells nationwide. This estimate will be refined after the assessment programs are conducted by the states.

POTENTIAL FOR GROUNDWATER POLLUTION

Determination of Pollution Potential

The quality of injected fluid can vary from poor quality wastewater injected by municipal, commercial, and industrial dischargers by means of disposal wells, to good quality water used in some recharge wells. The volume and toxicity of the injected fluid, along with the proximity to underground sources of drinking water, and the permeability of an aquifer, are among the principal factors that determine the groundwater pollution potential of the well practices. The limited capacity of the aquifer to attenuate the injected fluid by adsorption and dilution of the fluid by mixing are also important factors. Since the great majority of the injection wells in Classes IV and V inject into or above underground sources of drinking water, these two Classes pose a significant threat to groundwater quality.

Disposal wells generally inject waste fluids of a poorer quality than the fluid in the receiving aquifer. For example, these wells are used to inject raw, primary, and secondary sewage, industrial wastes, extremely acidic and alkaline wastes, floor washings, spent soaps, synthetic detergents, bleaches, and dirt and grease. The pollution potential is great because these wastes may contain large amounts of putrescible organic matter, nitrates, chlorides, pathogenic bacteria and viruses, and toxic heavy metals.

Drainage wells inject fluids of highly variable quality into underground sources of drinking water. For example, urban storm water varies in composition, and sometimes contains organic and toxic materials such as heavy metals. Agricultural runoff generally has a high content of organic chemicals resulting from the use of fertilizers. Air conditioning and cooling water return flow wells inject heated water that can raise the temperature of the ambient groundwater. Also, such water may contain rust inhibitors that can cause contamination of groundwater. Saltwater barrier wells and subsidence control wells inject fluids that may be of marginal or unusable quality. Fluids injected through recharge wells may contain suspended solids, organics, toxic metals, oil and grease, road de-icing salts, pathogenic bacteria and viruses, and fertilizers. Therefore, the groundwater pollution potential is high.

Class IV wells present the greatest pollution threat to underground sources of drinking water, on a per well basis. This fact is implicit in the definition of "hazardous waste" that is used to distinguish Class IV wells from Class V wells. This definition is given in Section 1004(5) of RCRA:[11]

"The term 'hazardous waste' means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may--

(1) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

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[11] P.L. 94-580, 42 USC 6903.

(2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

The range of materials covered by this definition includes the primary contaminants of the Safe Drinking Water Act, toxic heavy metals, pesticides, organic chemicals, bacterial and viral pathogens, and similar wastes.

Class V wells present an as-yet-undetermined degree of hazard to health and the environment. These wells account for the majority of wells listed as disposal wells, and for nearly all of the recharge wells. Wastewater quality can be extremely variable, both between wells and for the same well at different points in time. Therefore, some Class V wells may present a minimal threat to groundwater quality while others, after investigation, may be found to present a significant threat to groundwater quality. Further research is needed to develop an extended and intensive study of these wells' capacity for groundwater pollution.

Patterns of Contamination

Class IV and Class V injection wells are sources of contamination from which plumes of contaminated water extend downgradient for tens of feet to thousands of feet. Plumes of contaminated water emanating from seepage from dry wells or from wells that penetrate the upper part of the water table aquifer for a few feet generally lie at or just below the water table. In contrast, injection wells with long open sections that penetrate a large part of a shallow aquifer may result in the development of plumes that occupy almost the full thickness of the aquifer at and near the wells.

Plumes of wastes from injection wells can contaminate water-supply wells that are along the line of flow and downgradient from the injection well. In addition, small plumes from numerous individual injection wells can merge downgradient and create an areally extensive body of contaminated groundwater. Finally, contaminated water from shallow injection wells in recharge areas may move vertically downward into underlying artesian aquifers and, ultimately, cause contamination of deep public-supply wells.

Hydrogeologic Factors

Class IV and Class V injection wells are commonly used in hydrogeologic settings characterized by a shallow zone with good infiltration characteristics such as beds of permeable sand and gravel. Another favorable characteristic for these injection wells is a moderate depth to the water table (25 feet to 50 feet or more), which helps prevent a quick rise of the water table during injection and possible flooding at the land surface. Deposits of sand and gravel and cavernous rocks, such as limestone, or rocks, such as lava, with large bedding plane and other openings, are generally suitable for construction of shallow injection wells. In contrast, rocks of low permeability, such as granite, gneiss, and schist, and sediments, such as silt and clay, are generally of little or no use as sites for construction of shallow injection wells.

Relative Volumes of Contamination

Very little information on the volumes of liquids injected from Class IV and Class V disposal and recharge wells is available from the literature or from state officials contacted during this study. Volumes for individual cases can be identified, and judgmental estimates are sometimes offered by local and state officials, but almost no statistically supportable data exist.

Accordingly, conservative estimates were developed for the purpose of determining how significant a contamination threat is posed by the wells injecting into or above freshwater aquifers in comparison with the threat posed by the other practices covered by the UIC regulations.

The major conclusions arising from this investigation are as follows:

- The volume of fluids actually entering the nation's drinking water aquifers is greater for the wells included in Class V than it is for all the wells covered under Classes I, II, and III combined; however, the fluids injected by Class V wells are generally of a higher water quality than that injected by other well classes.

- Class IV wells are estimated to inject 660 million gallons to 1.7 billion gallons of hazardous wastes annually into or above strata containing underground aquifers

- An exact estimate for the volume injected through Class V wells cannot be made; however, the data from the eight states suggests that recharge volumes alone may exceed 30 billion gallons annually and that disposal into other Class V wells would increase that number.

These conclusions are discussed more fully below.

A minimum estimate of total annual volume discharged from or above freshwater aquifers was developed. In only the eight states that provided the best data on disposal and recharge wells and using a conservatively low assumption of 1,000 gallons per week for estimating average daily volumes discharged, these wells are estimated to discharge nine billion gallons or more per year directly or indirectly into underground sources of drinking water. The actual volume could be greater in these states if less conservative assumptions for average daily volumes are used, and several times higher if extrapolated for the whole country.

In contrast, the estimate for the total volume of fluid leakage and migration into underground sources of drinking water from deep waste-disposal wells (Class I), oil and gas injection wells (Class II), and mining and related wells (Class III) is lower. Information on annual total injection volumes for wells in Classes I, II, and III were obtained from recent EPA reports.[12] Together, the wells in these categories are estimated to inject approximately 850 billion gallons of fluids annually. If as much as one percent of the injection fluids migrate eventually into drinking water sources (which would be a high rate by industry standards), then the total volume of fluids actually entering underground sources of drinking water from these well practices would be eight billion gallons per year. If the leakage rate were lower and only one-tenth of one percent of the injection fluids in these wells

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[12] For Class I wells, the number of wells and daily injection volumes were taken from <u>Compilation of Industrial and Municipal Injection Wells in the United States, Volume 1</u>, U.S. Environmental Protection Agency, October 1974. For Class II wells, the number of wells and annual injection volumes were taken from the report on Class II wells, <u>Preliminary Analysis and Findings, Estimated Cost of Compliance</u>, Arthur D. Little, Inc., February 15, 1979. For Class III wells, the number of wells was taken from <u>Analysis of Costs: Underground Injection Control Regulations, Class I and III Wells</u>, Temple, Barker & Sloane, Inc., May 1979.

migrate into drinking water sources, then the total estimate would be reduced proportionately, to less than one billion gallons per year. Other leakage rates would alter the total figure proportionately.

Data from Maryland, Florida, and Nassau County, New York, were used to develop a national profile of volumes injected by Class IV wells. As may be seen in Table II-2, 660 million to 1.7 billion gallons of hazardous wastes may be disposed of yearly by these wells into or above underground sources of drinking water. A "best" estimate of discharged volume would be approximately one billion gallons yearly.

Table II-2

CLASS IV WELLS - NATIONAL PROFILE

SIZE CATEGORIES	
I:	Wells injecting less than 100 gallons per day (gpd)
II:	Wells injecting between 100 and 1,000 gpd
III:	Wells injecting over 1,000 gpd
WELL POPULATION	
I:	4,000 to 8,000; best estimate - 6,000 wells
II:	500 to 1,000; best estimate - 750 wells
III:	500 to 1,000; best estimate - 750 wells
TOTAL:	5,000 to 10,000; best estimate - 7,500 wells
ANNUAL WELL INJECTION VOLUMES--MILLION GALLONS PER YEAR (MGY)	
I:	15 MGY to 50 MGY; best estimate - 30 MGY
II:	19 MGY to 62 MGY; best estimate - 38 MGY
III:	625 MGY to 1,625 MGY; best estimate - 938 MGY
TOTAL:	659 MGY to 1,737 MGY; best estimate - 1,006 MGY

It also appears that a few high volume facilities account for a disproportionate percentage of the hazardous waste volume discharged. High volume facilities, i.e., facilities injecting over 1,000 gallons per day (gpd), represent approximately 10 percent of the national Class IV well population. However, these facilities appear to discharge over 90 percent of the hazardous waste volume attributable to Class IV wells. Small volume facilities, representing 80 percent of all Class IV wells, appear to inject only 3 percent of Class IV well hazardous waste volume.

A national estimate of Class V injection volumes cannot be developed without data which is to be collected during the state assessment activities. Specifically, the volumes of fluid injected in these wells is uncertain and expected to vary widely from one type of well and location to another. The greatest volumes in Class V are expected to derive from recharge wells, which often are drainage wells for the disposal of storm water. In the eight states described earlier, approximately one-third of the wells and perhaps as much as three-quarters of the injected volume was in this category. Some drainage wells are estimated to discharge 10,000 gallons per minute during periods of high precipitation. Taking into account the intermittent nature of rainfall and the variation in watershed areas served by individual wells, one might conservatively estimate a range of average daily volumes exceeding 1,000 gallons per well. If one-third of the nation's Class V wells are of this type, as they were in the eight states, then the annual injection volume from these wells nationally would be approximately 30 billion gallons or more. The volumes injected through other forms of Class V wells would increase that number by an undetermined amount. It is significant to note that the fluids injected underground from recharge wells are generally of a higher water quality than that injected from other underground injection wells.

EXAMPLES OF GROUNDWATER CONTAMINATION BY CLASS IV AND CLASS V WELLS

The following case histories are provided as examples of the types of groundwater pollution problems associated with Class IV and Class V wells.

Class IV Wells--Case Studies

In some states, many small industrial and commercial plants illegally use cesspools and dry wells for the disposal of waste fluids. Small cheese manufacturers are an example of an industry that uses this type of disposal process. The states are aware of this problem and would be interested in investigating this type of pollution if federal funding were available through the UIC program. At the present time, state resources are not adequate to enable regulators to implement a more comprehensive enforcement program.

On Long Island, New York, a cardboard box manufacturer was discharging process wastewater containing glue chemicals to a cesspool. Upon the suggestion of the Suffolk County Department of Environmental Control, the box manufacturer recycled his process wastewater, and is now using it in the manufacture of glue. This method of recovering process wastewater has diminished operating costs of the plant and has eliminated the wastewater discharge as a source of groundwater pollution.

Endangerment of a Protected Groundwater System

A West Coast firm specializing in the disposal of liquid wastes, such as acids and caustics, was discharging 15,000 gallons per day (gpd) into a well about 40 feet deep. From the well, the wastes percolated into the underlying strata. This firm was operating under a Class I industrial waste disposal permit issued by the City of Los Angeles in December 1963 and July 1965. On July 29, 1976, the firm was notified by the California Regional Water Quality Control Board (RWQCB) that the site no longer met the state requirements because the disposal site was in hydraulic continuity with underlying groundwater, which, in turn, was in hydraulic continuity with waters of the Pacific Ocean and the saltwater intrusion barrier system operated by the Los Angeles County Flood Control District. The groundwater underlying the disposal site was already subject to saltwater intrusion, indicating that the acid wastes of the firm could migrate and damage the operation of the saltwater intrusion barrier system and contaminate the protected groundwater system on the other side.

The firm proposed to treat the wastes at another of its facilities prior to their disposal at the original site. The Board countered this proposal with requirements that were much stricter than the standard Ocean Plan effluent limitations because the Flood Control District had notified the RWQCB that the sink seaward of the saltwater barrier was filling and that the firm's disposal wells may have an adverse effect on the barrier operation. The firm found it impossible to meet the requirements; therefore, it ceased disposal of the wastes and completed construction of a sewer connection to the Los Angeles community sewer system. The cost of compliance was not released for use in this study.

Disposal of Pesticide Waste Water in a Bore Hole

The owner of an aerial pesticide spraying and dusting service, located in a small town in Texas, applied to the Texas Water Quality Board (TWQB) in May 1974 for a permit to dispose of pesticide-contaminated waste water in a 40-foot bore hole.

The facility was located at the local airport about one mile north of town. A domestic water well was located about 200 feet from the disposal bore hole. Other water wells, used for irrigation and domestic purposes, were located in the surrounding area. The underlying material is composed of sand and clay to a depth of 300 to 430 feet, with a static water level of 165 to 190 feet from the surface.

The owner disposed of insecticides, herbicides, and fungicides, from the clean-up of aerial spray planes, into a bore hole. The bore hole was located under a 50 foot square concrete slab sloped to drain into the hole. Approximately 3,000 gallons of water were used each operating season from early spring until late fall.

The remaining chemicals in the tanks on the planes were dumped into the bore hole, and the systems were flushed with clean water to remove any residue.

The director of field operations for the Texas Water Quality Board examined the site and surrounding area and recommended that the permit be denied. In his opinion, the process led to disposal of a hazardous waste into an unlined bore hole, and, if the waste had not yet migrated into ground water, it probably would in the near future. The owner was told to plug the bore hole to prevent surface water from passing through the zone and possibly carrying the contaminants into ground water. The owner was told to develop a suitable method for the disposal of the hazardous waste and submit his plans to the TWQB.

One year later, the owner informed the TWQB that he had not been able to develop plans for a new disposal facility, but that he was no longer using the bore hole. Instead, he was allowing the washwater to run into an open pit lined with drillers' mud and protected with a lock and chain-link fence. He was informed by the TWQB that this method was not approved either.

During the summer of 1975, the TWQB pursued the problem by obtaining sediment and water samples in the area to be used as evidence in possible litigation against the aerial sprayer. A pamphlet entitled "Aerial Applicator Pesticide Waste Control," developed by TWQB in consultation with various aerial applicators and the Aerial Applicators' Association of Texas, was delivered to the aerial sprayer to provide guidance in selecting an approved method of solving his wastewater problem.

According to the owner of the spray service, he continued as of mid-1978, to use the open pit. No action had been taken by TWQB on this case or on similar cases within this industry.

Recently the board was reorganized, and all outstanding spray applicator cases were turned over to the Texas Department of Agriculture. State Department of Agriculture sources report that staff and budget limitations prohibit a more aggressive approach to discouraging potential contamination from disposal of spray applicator wastewater.

Contamination of Fresh Water Aquifer from Metallic Waste Stream

This case history involves a precision and specification electroplating job shop in Huntington Station (Long Island), New York. The firm employs 13 people and has a gross income of approximately $500,000 per year.

Several metals are used in the electroplating process including nickel, cadmium, copper, tin, zinc, silver and others. The process waste water is high in heavy metals.

During the first 80 years of business, wastes were channeled to leaching pools and allowed to percolate in the ground. In 1962 the company installed a chromate treatment facility to destroy cyanide in the waste stream. There was no capital cost, and the incremental operating cost was about $300 per month. This was less than 1 percent of total operating costs.

The early 1970s brought greater ecological awareness to the Long Island counties. More stringent guidelines were set for allowable discharge of heavy metals, and the Suffolk County Department of Environmental Control recommended that this firm upgrade its treatment facility. It was difficult to find a treatment process which could detoxify a heterogeneous waste stream. Reverse osmosis, precipitation, and evaporation were considered; however, these processes were not technically feasible. The company worked on the problem for a few years, together with members of the Metal Finishers Foundation and local electroplaters. The amount of time invested was considerable; yet these small operators could not afford to hire extra personnel to study the waste-disposal problem as this industry is characterized by low profit margins and intense competition.

Late in 1976 the company contracted for the services of a liquid hauler at a cost of 10 cents per gallon. Operating cost for use of the hauling service was $2,000 per month, or approximately 7 percent of total sales. As a result of this cost, the firm reduced its use of water from 13,000 gpd to 1,000 gpd. Four hundred gpd of non-contact cooling water were discharged through a leaching field and eventually recharged the underlying aquifer. The hauling cost had been passed on directly to customers with an explanation that it was due to pollution-control requirements. The customers were sympathetic, as they were experiencing the same environmental protection pressures. However, the president of the firm believed that additional costs would not be accepted readily and would impact on his ability to compete in the marketplace.

The president of the firm was contacted again in January 1979 to see whether his costs had risen recently. The services of the liquid hauler are now about 13.5 cents per gallon, and the firm has reduced its volume to 7,200 gallons every two weeks--720 gallons per day. The firm president said that he could not reduce his water use further and maintain the quality of his finish. It was not clear whether his recent reduction in volume resulted from a lower level of production or from further economies in water use. Future regulations may add administrative costs to cover manifest handling, labeling, incident reporting, and general administration. These additional costs have been estimated to bring total hauling costs up to slightly more than 20 cents per gallon.[13]

Class V Wells--Case Studies

Injection of rendering wastes associated with slaughterhouses in Illinois, Indiana, and Ohio has caused ground-water contamination. In eastern Ohio, a slaughterhouse injects rendering wastes into a dug well. This type of waste generally has a high concentration of biochemical oxygen demand (BOD). The Ohio Environmental Protection Agency is aware of this practice but allows it to continue because the wastes are being injected into an aquifer with low specific capacity of wells in the aquifer and because it is not considered an important source of groundwater that needs to be protected. When this type of disposal is investigated in areas underlain by valuable ground-water resources and in other states, it is generally banned. Under the currently proposed UIC regulations, this practice would be banned in all states.

In Pennsylvania, sewage is discharged to abandoned mines through wells. The water in the mines is believed to have

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[13] Draft Economic Impact Analysis: Subtitle C, Resource Conservation and Recovery Act of 1976. Arthur D. Little, Inc., January 1979.

less than 10,000 mg/l of total dissolved solids (TDS) concentration. In addition, fly ash slurry is injected into wells to control subsidence. The State Department of Environmental Resources indicates that it has not received complaints of groundwater pollution regarding this practice.

Groundwater contamination has occurred in Bellevue, Ohio, as a result of the use of sewage disposal wells. In the City of Bellevue, there are appoximately 1,400 residential and commercial disposal wells and 200 municipally operated sewage disposal wells. The area is underlain by a limestone aquifer that has a high transmissivity. This type of aquifer is characterized by a high rate of groundwater movement. Between 1953 and 1960, approximately 80 disposal wells were drilled. In the middle 1960s a sewage collection and treatment system was completed. This system greatly reduced the use of disposal wells; however, storm water runoff is still injected through drainage wells.

Injection of runoff into highway and street drainage wells in Streeter, Illinois, and Modesto, California, has caused groundwater contamination. Modesto has approximately 3,000 wells of this type. The city has requested funds from the state to study and design an alternative disposal system.

In Tallahassee, Florida, thermal pollution of groundwater has been reported as a result of injection of air-conditioning cooling water. The majority of large air-conditioning systems in this area use ground water for condenser cooling. Groundwater is heated in the cooling process and is returned to the aquifer that is being pumped. Generally, cooling water supply wells and disposal wells are completed in the same zone of the aquifer. Due to the high temperature of injected water, groundwater temperature in the area has increased by 2°C to 3°C (5°F to 6°F). Three supply wells completed in the same zone as the disposal wells recorded temperatures as high as 32.2°C (90°F). The disposal wells were redesigned to inject into a deeper zone which is isolated from the shallower zone by thick beds of dolomite.

III. COSTS TO INDUSTRY
CLASS IV WELLS

INTRODUCTION

The continued operation of Class IV wells poses a serious threat to the quality of the nation's freshwater aquifers. Each year these wells discharge an estimated one billion gallons of hazardous wastes into or above underground sources of drinking water. The materials injected possess toxic, reactive, corrosive, and similarly harmful properties. Moreover, these substances may persist in the groundwater for years after injection.

However, regulation by permit does not appear to be a viable protective approach. The very nature of Class IV wells, i.e., injection of hazardous wastes into or above underground drinking water sources, frustrates any attempt to control their pollution potential through the use of rigorous construction and operating standards. Therefore, the reproposed federal UIC regulations have called for closure of all Class IV wells within three years of the effective date of the applicable state UIC program.

Upon closure of a well, the hazardous wastes formerly discharged therein must be disposed of elsewhere. If the waste generator cannot recycle these materials, then the hazardous wastes must be stored, treated, or disposed of at a RCRA-approved on-site or off-site hazardous waste management facility. If more than 100 kilograms of hazardous waste are to be transported off-site, then the generator is to participate in the RCRA manifest tracking system.

In any event, the UIC regulations for Class IV wells will lead to the following incremental activities for the well operator:

- Notification
- Monitoring of well injection and nearby well-water quality
- Submittal of quarterly reports to the program director
- Use of alternative disposal methods
- Participation in the RCRA manifest tracking system.

Each of these activities will be explained and discussed more fully in the next section.

OPERATOR REQUIREMENTS

The federal UIC regulations explicitly require the operator of a Class IV well to participate in the first three major activities mentioned above: apply for temporary authorization to operate an injection well, monitor injection well parameters and nearby well-water quality, and report quarterly to the program director. Furthermore, the operator must close his well when ordered to do so by the state UIC program director.

However, the UIC regulations do not require the hazardous waste generator to dispose of the displaced wastes in an approved hazardous waste management facility--this is entirely a RCRA requirement. Instead, the UIC regulations require that a Class IV well user turn to alternative disposal means. RCRA then stipulates that the disposal alternative must be at a RCRA-permitted hazardous waste management facility. Furthermore, if more than 100 kilograms of hazardous wastes are to be transported off-site, then the generating facility must participate in the RCRA manifest tracking system.

Costs for disposal of the displaced hazardous wastes at an approved facility and the cost of participating in the manifest tracking system have been included in this analysis because the UIC Class IV program is the direct cause of these activities. But it should be kept in mind that RCRA regulations play a large part in the costs shown here for these post-closure tasks.

Notification

All Class IV well operators must formally notify the program director of the existence of their practice. The notification information must include the name, location, and principal activity of the place of operation as well as a description of the types of hazardous wastes handled. Moreover, the well operator must submit information similar to that required on Part A of the RCRA permit application for hazardous waste management facilities: for example, a description of the types and amounts of hazardous wastes handled and a description of the manner in which the hazardous wastes are treated, stored, or disposed of at the facility.

Since the task requires only a few hours' work, it is estimated that formal notification will cost approximately $30 to $35 per well. Submission of further information on the contamination potential of the facility is estimated to cost $120 per well, on the average. Class IV wells appear to be, on the whole, small operations, and it is unlikely that completion of this latter task will take up more than a day and a half of the operator's time. The complete notification process has been assigned an average cost of $150 per well.

Monitoring

One of the conditions of temporary authorization is a requirement for periodic monitoring of injection well parameters and nearby well-water quality. The federal UIC regulations require, at a minimum, the following monitoring activities:

- Daily monitoring of variable injection flows for volume and hazardous characteristics
- Weekly monitoring of constant injection flows for volume and hazardous characteristics
- Weekly monitoring of existing water supply wells within the vicinity of the operation for parameters determined by the injection.

This study assumes that well operators will try to equalize injection flows or reduce disposal frequency in order to minimize monitoring costs. Furthermore, it has been assumed that facilities practicing variable injection would tend to dispose of their hazardous wastes on a periodic basis, following implementation of a state UIC program. This analysis assumes that facilities practicing variable injection would, on the average, dispose of their wastes on a weekly basis. Yearly costs of monitoring injection flows would then be similar for comparable facilities practicing either constant or variable injection.

The incremental cost of monitoring injection volume and its hazardous characteristics would depend also on factors other than the frequency of monitoring, i.e., the operator's present level of monitoring, the relative homogeneity of the injected hazardous waste stream, and the level of reporting detail required by the program director in identifying the hazardous characteristics of the waste stream. At present, this information is unavailable. The analysis must proceed instead from reasonable assumptions about the typical hazardous waste generator and expected UIC monitoring requirements.

Most, if not all, persons using or operating Class IV wells as disposal means will have a fair degree of knowledge on the chemistry and hazardous characteristics of the waste streams injected--if only because such information was required in the RCRA permit application. It is also likely that Class IV wells will have flowmeters or volumetric meters as part of their existing equipment in order to ensure injection flow rates maintained within the limits of well capacity.

The incremental cost of monitoring injection flows would arise, then, from the task of reading the meter weekly and logging the value read. There could be an incremental cost associated with the logging of the hazardous characteristics of the waste stream, but for small operations it is likely that only one waste stream is injected, while for larger operations handling several waste streams it is likely that a record of the substances injected is already being kept. In either case, the incremental cost of logging the waste streams' hazardous characteristics would be negligible or nonexistent.

An average weekly monitoring cost of $3.50 per well has been used in this study. This estimate is, of course, subject to the limitations of the assumptions made in the preceding paragraphs.

Class IV injection wells located near existing water supply wells are required to monitor the water quality on a weekly basis. However, little usable data exist on this subject, largely because few data exist on Class IV well practices in general, but partially because there is no objective definition of what constitutes a critical proximity between Class IV injection wells and nearby existing water supply wells. To be conservative, this analysis assumes that, on the average, one existing water supply well is located near each Class IV well.

The federal UIC regulations state that monitoring of water quality shall be for "parameters determined by the injection." The present analysis assumes that the monitoring test shall be for only one hazardous waste contaminant, e.g., the contaminant produced in greatest quantity or the most toxic contaminant produced. The costs of laboratory analysis would make a more comprehensive requirement prohibitively expensive for small operators. Furthermore, unless the hazardous substances discharged in the well have different diffusion properties, test results for one substance may indicate the relative concentrations of other substances injected in the same waste stream. Using the above stated assumption, weekly monitoring costs for water quality are estimated to average $20 per water supply well.

Quarterly Reporting

The results from both types of monitoring are to be submitted by the well operator to the program director each quarter. The present analysis assumes that the typical well operator will require a half-day of effort to compile, prepare, and submit this report, at a cost of $37.50 per report.

GENERATOR REQUIREMENTS

Alternative Disposal Methods

It is expected that the majority of Class IV well operators will respond to the proposed regulations by transporting their wastes to an approved hazardous waste disposal site. Firms injecting less than 1,000 gallons per day will probably find it economical to reduce waste streams through adjustments in their production process and to dispose of their entire remaining waste streams at an off-site facility.[14] Larger plants, with daily wastewater flows of over 1,000 gallons, will generally apply treatment to separate out the hazardous components of their waste streams and remove treatment sludges to off-site facilities. For these firms, treatment would reduce the volume of wastes requiring disposal to approximately 2 percent of the original waste stream.

Local conditions will strongly influence the costs of treatment and disposal. For purposes of arriving at a national cost estimate, however, this study has used typical standard costs for all plants within a given category. The cost of hauling/disposal has been estimated to be $.22 per gallon based

[14] Experience with NPDES permits has demonstrated a move toward volume reduction prior to hauling wastes to deep disposal wells.

on figures developed for EPA's Office of Solid Waste.[15] The costs of treatment will vary by industry. Because many of the affected plants will be electroplating operations, the costs for an electroplating plant generating 11,000 gallons per day of waste and requiring both clarification and cyanide removal were assumed to be typical. Based on data from EPA's Office of Water Planning and Standards, the annual capital and operating and maintenance costs for such a plant would be in the range of 0.9 to 1.5 cents per gallon. TBS has used the upper end of this range to obtain a conservative estimate of the total national cost.[16]

Table III-1 summarizes the annual costs of compliance with UIC regulations for Class IV wells based on the estimates of the number of wells and the volumes of flow developed earlier

Table III-1

CLASS IV WELLS

ANNUAL COSTS OF TREATMENT AND DISPOSAL

Volume Injected	Number of Wells	Total Annual Volume (million gallons per year)	Cost of Treatment/ Disposal (millions of 1977 dollars)	
More than 1000 gallons per day	750	938	Treatment: Disposal:	$14[a] 4[b]
Less than 1000 gallons per day	6,750	68	Disposal:	15[c]
Total	7,500	1,006 MGY		$33

[a]Assumes pretreatment cost of $.015 per gallon applied to total flow.

[b]Assumes hauling/disposal cost of $.22 per gallon applied to treatment sludges which are estimated to be 2 percent of the total wastewater volume.

[c]Assumes hauling/disposal cost of $.22 per gallon applied to entire wastewater stream.

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[15] Draft Economic Impact Analysis of Subtitle C, Resource Conservation and Recovery Act of 1976, Arthur D. Little, Inc., January 1979.

[16] It should be noted that this cost is also conservative in that it is based on a plant requiring cyanide removal, which is required only in certain electroplating processes.

in this report. Although small and medium-sized firms will tend to reduce the volume of their waste streams, no estimate can yet be made of the level of reduction that can be expected. Therefore, the cost analysis has taken a conservative approach and has assumed no reduction in waste stream volume for firms injecting less than 1,000 gallons per day. The total annual national treatment and disposal cost would be $33 million. Over one-half of this cost ($18 million) would be borne by the largest plants, which represent 10 percent of the total number of plants, at an average cost of $24,000 per plant. Plants injecting less than 1,000 gallons per day would incur an average cost of $2,200.

Manifests

One of the major components of the RCRA program for regulation of hazardous wastes is the manifest tracking system. Off-site shipments (greater than 100 kilograms per month) are required to be accompanied by a manifest describing the wastes. As the wastes are transported to their ultimate disposal site, all persons to whom responsibility is successively allocated are required to sign the manifest, retaining copies for their files. Moreover, these copies are to be stored for three years.

This report assigns an average cost of $2.67 to the generator's task of completing the manifest. Additionally, a cost of $68 per facility has been used as the annual cost of storage and filing for these manifests.[17]

METHODOLOGY

Total costs to industry were developed by identifying incremental activities necessitated by the Class IV regulations and estimating unit costs for the implementation of these activities. In this, the industry cost analysis for Class IV wells is consistent with earlier TBS cost analyses for Class I and Class III wells.

However, there are two major differences between the present analysis and the earlier analyses. These differences arise from the uncertainty of the Class IV well population

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[17] Manifest costs are from Draft Economic Impact Analysis of Subtitle C, Resource Conservation and Recovery Act of 1976, Arthur D. Little, Inc., January 1979.

estimate and from the unique regulatory approach to be used for Class IV wells. First, total manpower and cost estimates will be developed for well populations of 7,500 wells, 5,000 wells, and 10,000 wells. These represent the midpoint estimate and the lower and upper bounds, respectively, on the range of well population. Second, since all Class IV wells will be closed within three years of the effective date of the applicable state program, the relative mix of active program elements will change throughout the lifetime of the program. For example, the number of well operators engaged in monitoring and reporting activities declines while the number of waste generators using alternative disposal means increases as the program progresses. An economic analysis of this program must postulate a reasonable time pattern of well closure before costs can be computed.

This analysis assumes that all Class IV wells will be identified in the first six months and assessed in the second six months of program operation. Fifty percent of these wells are assumed to be closed in the second year and the remaining 50 percent are assumed to be closed in the third year. In other words, if 7,500 Class IV wells are identified in the first year of program operation, this analysis assumes that 3,750 of these wells will be closed by the end of the second year and that the remaining 3,750 active well operations will be closed by the end of the third year of program operation. The average active well population in the second year of program operation would be 5,625 wells, while in the third year, the average active well population would be reduced to 1,875 wells. Furthermore, it was assumed that all wells identified in the first six months of program operation would begin monitoring their operations and nearby supply wells soon after authorization and that each well operator would submit two quarterly reports to the program director during the latter half of the first year. These assumptions result in the task chronology and average well populations shown in Table III-2.

Operator program tasks and their estimated average costs are summarized in Table III-3. The information contained in Tables III-2 and III-3 has been used to compute expected industry expenditures for the three years of program operation and two years thereafter.

RESULTS

Total five-year costs to industry resulting from implementation of the Class IV regulatory program may be seen in Table III-4.

Table III-2

CLASS IV WELLS

CHRONOLOGY OF INDUSTRY TASKS AND WELL POPULATION

Year	Average Class IV Well Population[1]	One-Time Task	Recurring Tasks			
		Notification	Monitoring	Quarterly Reports	Alternative Disposal	Manifests
1[a]	7,500 (0)	1/well	1/wk/well for 26 weeks	2/well	n/a	n/a
2[b]	5,625 (1,875)	n/a	1/wk/well for 52 weeks	4/well	As necessary for each closed well	1/wk/ closed well
3[c]	1,875 (5,625)	n/a	1/wk/well for 52 weeks	4/well	As necessary for each closed well	1/wk/ closed well
4	0 (7,500)	n/a	n/a	n/a	As necessary for each closed well	1/wk/ closed well
5	0 (7,500)	n/a	n/a	n/a	As necessary for each closed well	1/wk/ closed well

[a]Class IV well operators conduct monitoring and reporting activities only during the last half of the year, since the first half of the year is devoted to the one-time task of notification.

[b]3,750 wells closed during this year.

[c]3,750 wells closed during this year.

[1]For each year, the first number shows the total population of active wells remaining at the midpoint of that year. The second number, in parentheses, shows the number of wells already closed by the program at the midpoint of that year.

n/a = not applicable.

Table III-3

CLASS IV WELLS

UNIT COSTS FOR INDUSTRY EXPENDITURES

Program Element	Unit Cost
One-Time	
Notification	$150/well
Recurring	
Monitoring	
• Injection parameters	$3.50/monitoring incident[1,2]
• Water quality	$20/monitoring incident[3]
Quarterly Reports	$37.50/report/quarter
Alternative disposal[4]	
• Large-volume generators	$24,000/well/year
• Medium- and small-volume generators	$2,200/well/year
Manifests	
• Filling out forms	$2.67/manifest
• Storage and filing	$68/facility/year

[1]A "monitoring incident" refers to a single occasion in which readings are taken or analytic tests are performed for one well in order to satisfy the monitoring requirements of the UIC regulations.

[2]Monitoring injection flow for volume and hazardous characteristics.

[3]Analytic test for one contaminant.

[4]See Table III-1.

Table III-4

CLASS IV WELLS

CHRONOLOGY OF INDUSTRY EXPENDITURES
(millions of 1977 dollars)

Year	One-Time Task: Notification	Recurring Tasks: Monitoring	Recurring Tasks: Quarterly Reports	Recurring Tasks: Alternative Disposal	Recurring Tasks: Manifests	Total Yearly Costs
1	1.1	4.6	0.6	-	-	6.3
2	-	6.9	0.8	8.2	0.4	16.3
3	-	2.3	0.3	24.8	1.2	28.6
4	-	-	-	33.0	1.55	34.55
5	-	-	-	33.0	1.55	34.55
Total	1.1	13.8	1.7	99.0	4.7	120.3

Total five-year costs to industry are estimated to be $120 million. The average yearly cost to industry is $24 million, and the average yearly cost per well is $3,200. Range estimates for these costs can be obtained by using population estimates of 5,000 and 10,000 wells. Total five-year costs may range from $80 million to $160 million. The average yearly cost to industry ranges from $16 million to $32 million, and the average yearly cost per well remains the same, $3,200.

Total yearly costs to industry increase quickly from $6.3 million in the first year of program operation to $35 million in the fourth year. Average industry expenditures in the first year are $840 per well, but in the fourth year average industry expenditures are $2,200 to $24,000 per well, or the cost of alternative disposal methods.

Recurring program tasks account for 99 percent of total program costs. The task generating the greatest cost impacts is alternative disposal. Alternative disposal costs, together with manifest costs, account for over 86 percent of the total five-year cost to industry. These are costs borne by the generators. If these costs had not been included in the analysis, total costs to industry would be $16.6 million, or an average yearly cost to well operators of $740 per well in the first three years of program operation.

IV. INCREMENTAL MANPOWER REQUIREMENTS AND COSTS TO THE STATES--CLASS IV WELLS

INTRODUCTION

The currently proposed UIC regulations call for all states and territories to develop Class IV well programs meeting minimum federal requirements. The primary requirement is formulation of an enforcement strategy that will close all Class IV wells within three years of program operation. Supplementary to this are requirements concerning program structure, criteria and administration.

The purpose of this analysis is to estimate the incremental manpower requirements and program costs to the states arising from regulation of Class IV wells. The labor and cost figures presented here are the best estimates available to date, though several simplifying but well-considered assumptions have been made in the estimation of labor and cost requirements for particular program elements.

PROGRAM ELEMENTS

The requirements for the states in the UIC program may be viewed as a series of related tasks. This study has grouped these tasks to form the following major program elements:

- Program development
- Program hearings
- Semi-annual report to EPA
- Closure notification
- Quarterly review of operator reports
- Quarterly reports to EPA
- Annual reports to EPA
- Enforcement

The components of and estimated manpower needs for each program element are discussed briefly below.

Program Development

States designated by EPA as those states for which an underground injection control program "may be necessary" must develop a UIC program and submit it to EPA within 270 days. EPA may extend this deadline for any state by an additional 270 days. Eventually, 57 states and territories will be listed.

Section 1421 of the Safe Drinking Water Act determined the minimum requirements for a state program to be as follows:

- Prohibition of any underground injection not authorized by permit (under certain circumstances a state may be allowed to regulate by rule)
- Protection of underground sources of drinking water
- Satisfaction of inspection, monitoring, recordkeeping, and reporting requirements
- Coverage of underground injections by federal agencies and by any person on property leased or owned by the United States.

The consolidated regulations describe the elements of an approvable state program in greater detail (40 CFR Part 123). In 40 CFR Part 146, minimum criteria and standards are set out for the state underground injection control programs which are to regulate injection wells. Subpart E of Part 146 describes specific responsibilities of the state and of the well operators regarding Class IV wells.

An initial survey of state underground injection control legislation and hazardous waste legislation has indicated wide variation among the states in their degree of control over Class IV well practices. The manpower estimate for program development used in this analysis, 15 man-days per state, is an estimate of the incremental manpower needs of a "typical" state, i.e., a state already possessing a limited degree of regulatory authority over Class IV well practices.

Program Hearings

The federal UIC regulations stipulate that a state UIC program can only be adopted following "reasonable notice and public hearings." Public participation requirements are explained in 40 CFR Part 124 of the consolidated regulations. An estimate of five man-days per state has been allocated to the task of holding public hearings and responding to public comments on Class IV wells.

Semi-annual Report to EPA

States are to submit semi-annual reports to EPA during the time they are developing their application for primacy. These reports will provide EPA with information on the states' progress in formulation of an approvable program for those well classes currently operating within each state. It is estimated that a typical state would submit one semi-annual report, utilizing five man-days of effort, to EPA during its 270-day program development period.

Closure Notification

Well operators must supply formal notification of their existence as well as provide information on the types and quantities of hazardous wastes handled. The program director will review these documents and notify the operator of the time by which closure must be accomplished and, if appropriate, of a compliance schedule leading to closure.

The director is to consider a number of criteria in reviewing these documents, including: the population affected or potentially affected by the injection, local geology and hydrology, toxicity and volume of the injected fluid, and injection well density. Review of the information contained in these documents is estimated to require two man-hours per application. Small operations would submit documents requiring less time to review, but large operations would undoubtedly supply documents requiring several days' review. These different review times are averaged in the present estimate.

Quarterly Review of Operator Reports

Each quarter, Class IV well operators will submit reports to the program director on the results of periodic monitoring required by the UIC regulations. Most reports should be relatively short, containing 26 weekly items: 13 records of the volume and hazardous characteristics of the injection stream and 13 records of nearby well-water quality.[18]

An average review time of two man-hours per report has been used in this study, and is intended to include time spent in following up on reports with incomplete or confusing data. It does not include time spent on site visits to wells with reports indicating contamination of groundwater. Such visits are to be included instead in the manpower requirements for enforcement.

Quarterly Reports to EPA

The state program director is to submit quarterly reports to EPA on the compliance status of Class IV wells within the state. It is expected that these reports will take the form of organized summaries of data obtained from quarterly operator reports and from enforcement visits. Less than one-half man-hour per well has been estimated as the quarterly manpower requirement for this task.

Annual Report to EPA

The annual report sent by the state program director to EPA will summarize the regulatory activities undertaken during the year and is expected to include an assessment of the status and progress of the Class IV well program. The information contained in the quarterly reports to EPA will probably form the database from which an intensive self-evaluation would proceed. Also, it is expected that during this time of evaluation, considerable effort will be devoted to the review and possible reformulation of a closure strategy for the upcoming year and that these plans will be included in the annual report to EPA. A labor estimate of 1.2 man-hours per existing Class IV well has been allotted to this effort.

Enforcement

Each state program must demonstrate adequate enforcement capabilities prior to approval by EPA. A plan of regular surveillance and inspection of operating facilities is required,

[18] As was explained in the previous chapter, this analysis assumes that nearly all well operators will be monitoring injection well parameters and nearby well-water quality on a weekly basis.

in addition to a range of enforcement tools such as civil penalties, criminal penalties, and injunctive relief.

One man-day per operating site has been chosen as the level of annual enforcement effort. This represents two half-day site visits to each operating facility every year. Time constraints and the inherent uncertainty of the subject matter precluded investigation into an estimate of manpower needs for correction of extended cases of noncompliance. These circumstances have therefore not been included in the present analysis.

METHODOLOGY

The unit manpower requirements given for each program element discussed above will be used to generate an estimate of total incremental manpower needs for the 57 states and territories. Table IV-1 below is a summary of those unit estimates.

Table IV-1

CLASS IV WELLS

ESTIMATED STATE MANPOWER REQUIREMENTS

Program Element	Manpower Estimate
One-Time:	
Program development	15.0 man-days/state
Program hearings	5.0 man-days/state
Semi-annual report	5.0 man-days/state
Closure notification	2.0 man-hours/well
Recurring:	
Quarterly review	1.0 man-hours/well/quarter
Quarterly report	0.3 man-hours/well/quarter
Annual report	1.2 man-hours/well/year
Enforcement	1.0 man-days/well/year

The program timing assumptions employed in the Class IV industry cost analysis will also be employed in this analysis. Table IV-2 shows the effects of these timing assumptions on the chronology of state program tasks and on the size of the Class IV well population. Approximately one year will be required to develop a state program. After the program is approved, all Class IV wells are to be closed within three years of the effective date of the program. In all, there will be four years of regulatory costs to the states. Tables IV-1 and IV-2 display the information used to develop estimates of total manpower needs for four years for the states.

Total state costs were computed by using an estimate of the weighted average state staff wage and fringe benefit level to convert total manpower needs into total budgetary needs. The manpower wage estimate is in 1977 dollars, and the value used, $22,500, is the same estimate used in the analysis of state costs done by TBS for well Classes I and III. A 15 percent overhead charge has been added to the $22,500 manpower wage estimate to cover direct expenses such as office supplies and travel.

Table IV-2

CLASS IV WELLS

CHRONOLOGY OF STATE TASKS AND WELL POPULATION

Year	Average Class IV Well Population	One-Time Tasks: Program Development	One-Time Tasks: Program Hearings	One-Time Tasks: Semi-annual Report	One-Time Tasks: Closure Notification	Recurring Tasks: Quarterly Reviews	Recurring Tasks: Quarterly Reports	Recurring Tasks: Annual Reports	Recurring Tasks: Enforcement Visits[e]
*[a]	7,500 (5,000 - 10,000)	1/state	1/state	1/state	n/a	n/a	n/a	n/a	n/a
1[b]	7,500 (5,000 - 10,000)	n/a	n/a	n/a	1/well	2/well	4/state	1/state	1/well
2[c]	5,625 (3,750 - 7,500)	n/a	n/a	n/a	n/a	4/well	4/state	1/state	2/well
3[d]	1,875 (1,250 - 2,500)	n/a	n/a	n/a	n/a	4/well	4/state	1/state	2/well
4	0 (0)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5	0 (0)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] "*" refers to the 270-day period during which the state programs are to be developed and program hearings held This period may be extended an additional 270 days with the approval of EPA.

[b] Quarterly reviews and enforcement visits are assumed to be conducted during the last half of the first year, and during the full year for the second and third years.

[c] 3,750 wells closed during this year.

[d] 3,750 wells closed during this year.

[e] The frequency of enforcement actions is not specified in the UIC regulations but was estimated by TBS based on discussions with state sources.

RESULTS

The discussion of total manpower requirements and costs will concentrate on results based on a starting Class IV well population of 7,500 wells, with limited reference to total resource needs expected for Class IV well populations of 5,000 and 10,000.

Total Manpower Requirements

A total of 112 man-years of effort, shown in Table IV-3, is estimated to be used by the states in carrying out the federal UIC regulations for Class IV wells. Each state will expend an average of 2.0 man-years of effort in developing and fully implementing program requirements.

For a Class IV well population of 5,000 wells, total manpower requirements are estimated to be 84 man-years of effort, or an average of 1.5 man-years per state. A Class IV well population of 10,000 would lead to total state manpower requirements of 161 man-years, or 2.8 man-years per state.

Table IV-3

CLASS IV WELLS

CHRONOLOGY OF STATE MANPOWER REQUIREMENTS

(man-years of effort)

(57 states and territories)

Year	One-Time Tasks				Recurring Tasks				Total Yearly Manpower Requirements
	Program Development	Program Hearings	Semi-annual Report	Closure Notification	Quarterly Reviews	Quarterly Reports	Annual Reports	Enforcement Visits	
*	3.9	1.3	1.3	-	-	-	-	-	6.5
1	-	-	-	8.5	8.5	5.1	5.1	17.0	44.2
2	-	-	-	-	12.8	3.8	3.8	25.6	46.0
3	-	-	-	-	4.3	1.3	1.3	8.5	15.4
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
	3.9	1.3	1.3	8.5	25.6	10.2	10.2	51.1	112.1

Recurring program tasks will take up the most time. Total recurring labor needs amount to 97 man-years, or 87 percent of total manpower needs. Total one-time labor needs for the states are estimated to be 15 man-years. For the three years of program operation, each state will employ, on the average, less than one full-time person to carry out program tasks.

Enforcement visits and quarterly reviews of operator reports will be the program elements employing the most manpower. Together, these two program elements account for over 68 percent of total state manpower needs for the Class IV well regulatory program.

The first and second years of program operation will be the most costly program years for the states in terms of man-years expended. The first year will require over 39 percent of the total state manpower budget for the program; the second year will require 41 percent of the total state manpower budget.

The first year of program operation may also be the most difficult year to administer. Five different program tasks will be carried out at this time: closure notification, quarterly reviews, quarterly reports, an annual report, and enforcement. Furthermore, all of these tasks will be performed for the first time in this year.

Total State Costs

As shown in Table IV-4, total state costs will be $2.9 million for all 57 states and territories. Each state will expend, on the average, approximately $51,000 in this effort to close down all Class IV wells.

For a Class IV well population of 5,000 wells, total state costs are estimated to be $2.2 million, or an average cost of $39,000 per state. A 10,000 Class IV well population is estimated to lead to total state costs of $4.2 million, or an average cost of $73,700 per state.

Table IV-4

CLASS IV WELLS

CHRONOLOGY OF STATE EXPENDITURES

(thousands of 1977 dollars)

(57 states and territories)

	One-Time Tasks				Recurring Tasks				
Year	Program Development	Program Hearings	Semi-annual Report	Closure Notification	Quarterly Reviews	Quarterly Reports	Annual Reports	Enforcement Visits	Total Yearly Costs
*	101	34	34						169
1				220	220	132	132	440	1,144
2					331	98	98	662	1,189
3					111	34	34	220	399
4									
5									
	101	34	34	220	662	264	264	1,322	2,901

V. GUIDELINES FOR AN ASSESSMENT CLASS V WELLS

INTRODUCTION

The assessment of Class V well practices is designed to aid state officials in determining the statewide impact of these well practices and to indicate regions within the states that may require special attention. The data and interpretations generated by the assessment will be used as the basis for an advisory report and, therefore, should be detailed enough for use in making general and specific regulatory decisions.

The major objectives of the assessment in a state are: (1) to identify the scope of injection well practices; (2) to develop a detailed description of the hydrogeologic environment; and (3) to identify the magnitude of potential contamination threats. It is expected that the assessment process will differ from state to state, depending upon the level of present state action and the availability of information in this area. In most states the process is expected to be an iterative one in which the early stages are focused on conducting a preliminary analysis of the problem and in which the later stages are devoted to improving the accuracy and depth of the assessment.

The following discussion presents the structure, content, and schedule of a hypothetical state assessment effort. These guidelines are meant to serve as a basis for cost estimation and should not be viewed as being prescriptive. The sections below describe the process generally and then in more detail for each phase. It is envisioned that there will be three major phases in the assessment process: (1) Phase I, program planning, data assembly, and preliminary review of operator-submitted and existing data; (2) Phase II, collection of field data; and (3) Phase III, analysis and interpretation of data, documentation of the findings of the state assessment, and formulation of a set of recommendations to EPA. These recommendations will form the basis for a national regulatory strategy for Class V well practices.

Phase I is estimated to take six months. During this time, operators of Class V wells are to submit information on their operations and on alternative disposal means open to them. The state will use these data and existing well and industry data to identify geographical areas where Class V injection wells are most likely to be numerous. Toward the end of the six months the results of both data-gathering efforts will be compared to determine the expected need for state action in locating non-reporting facilities.

Phase II is also expected to take six months. Its objectives are to confirm the existence of Class V injection wells indicated by the results of Phase I, including locating non-reporting individual Class V wells to the extent feasible, and to continue work begun in Phase I identifying the scope of practices and evaluating the hydrogeologic environment.

Phase III will last about 12 months. During this phase, the results of Phases I and II will be interpreted to determine actual and potential threats to underground sources of drinking water. The feasibility of technological alternatives will be studied, and priorities for regulatory action will be developed. Lastly, a formal set of recommendations, or advisory report, will be submitted to EPA at the conclusion of the assessment. The components of each phase are briefly described in Figure V-1.

Figure V-1

GENERAL STRUCTURE OF THE STATE ASSESSMENT PROCESS

Phase I

Scope of Practices

- Review operator-submitted data and existing data in state and local files
- Map significant characteristics (e.g., unsewered areas, population, and business establishments)
- Determination of areas for further investigation

Hydrogeology

- Map aquifer characteristics (location, yield, quality, and movement)
- Map groundwater use

Phase II

Scope of Practices

- Field work to confirm existence of wells and to identify alternatives

Hydrogeology

- Limited water quality sampling

Phase III

Combined Analysis

- Data analysis and interpretation
- Establishment of priorities
- Evaluation of technological alternatives
- Documentation of results for use in advisory report
- Submission of advisory report

PHASE I: DATA COLLECTION AND REVIEW

Scope of Injection Well Practices

The key factors in assessing the scope of Class V injection well practices are: (1) the number of disposal and recharge wells; (2) the location and depth of wells; (3) the use of wells; and (4) the volume and toxicity of injected fluids. Owing to the lack of readily available information from existing sources, both direct and indirect methods will be used to determine the scope of the practices. The information from indirect methods will be useful in determining the inferred regional concentration of facilities, whereas the information from direct methods will be particularly useful in determining the specific numbers of wells. In Phases I and II, the hydrogeologic environment investigation will be carried out simultaneously with the scope of the practices investigation, and these investigations will be mutually dependent.

At the conclusion of Phase I, it is envisioned that these methods of investigation will provide information that can be shown on transparent maps. A preliminary indication of the likely areas of Class V well concentrations can be obtained by overlaying maps from the effort to identify the scope of well practices and by overlaying maps from the effort to describe the hydrogeologic environment.

Many injection well practices covered under the term "disposal wells" in Class V violate existing state water-pollution control rules and regulations, especially those containing non-degradation clauses. Nevertheless, public information on the location and use of such facilities is generally not readily available because most of these practices have never been specifically investigated. The wells involved in these practices generally discharge fluids that have a poorer quality than that of the water in the receiving aquifers. Under certain locations and conditions, however, these practices are considered to be the best and most economical methods of disposal of wastes and may be under some type of regulation by state and local agencies. Similarly, some of the well practices covered under the term "recharge wells" in Class V are regulated to some extent by state and local agencies. Most wells in this category discharge fluid of relatively good quality; drainage wells, however, discharge relatively large volumes of water whose quality ranges from poor to good, depending on local conditions.

Direct Methods

Although the UIC program will require operators of Class V wells to identify themselves to the program director, not all operators will comply. The state will then have to use other direct methods to compile data on Class V wells, i.e., through the use of databases that have been developed for different government programs and purposes. There are numerous ways to compile such data; this section suggests some of the more obvious methods of securing the information.

One direct method of defining the scope of the Class V practices is through a review of federal, state, and local agency files. Various federal programs, for example, have peripherally involved the study of and the need for regulating some of the Class V practices. Federal agencies that have made studies involving some aspects of the use of Class V wells include: the EPA, the Department of Interior, the Department of Housing and Urban Development, the Department of Health, Education, and Welfare, and the Department of Transportation.

The EPA National Pollutant Discharge Elimination System (NPDES) might be a source of information. This program has extensive permit files that primarily describe specific industry methods of surface-water discharge and require annual inspection of individual industrial sites. It might be possible, through contact with regional EPA field inspection personnel and by examination of permit files, to ascertain the use of Class V wells in certain industry categories.

Several of the states that have assumed primacy for the NPDES program also have compiled more detailed information than that required by EPA. Some of these states have already made preliminary counts of the number of disposal and recharge wells. In New York and California, for example, a number of well practices, such as those covered under recharge wells, are already regulated through state programs. In addition, the California State Water Resources Control Board has made a preliminary count of the number of wells injecting into or above underground sources of drinking water in the state. Also, in California, numerous studies, funded by the federal and state governments, have focused on areas where these well practices have caused or could cause groundwater problems.

Some state and local departments of health already regulate some types of disposal wells such as cesspools, sumps, and septic system wells. Consequently, much information is available for these well practices, but an extensive file search would be required to compile the data.

Many of the Class V wells are constructed by well-drilling firms and designed by consulting engineering firms. Presumably, records of such injection facilities might be available in the files of such companies; however, this information may not be readily available for inspection.

Various published reports of federal and state agencies on general hydrogeologic studies, river basin studies, and Section 208 water-quality management studies also commonly contain well data and descriptions of discharge facilities that may include Class V wells.

Indirect Methods

The purpose of the indirect approach is to identify, within a particular state, geographic areas and industrial and commercial establishments that would be likely to have Class V wells. This information will be used later in Phase II to focus on areas and establishments to be investigated by field visits.

There are numerous indirect methods of determining the scope of injection well practices through examination and interpretation of information not specifically developed for this purpose. For example, some states require the use of a manifest system for industrial facilities that haul solid and liquid wastes. This system requires detailed record keeping of solid and liquid wastes from a production site, through hauling, to a disposal site. Knowledge of recorded quantities of wastes at a site could be helpful in determining potential volumes of waste generation in different industries.

Another indirect method of determining the number of wells in Class V is to map various physical and economic development features believed to be associated with the use of Class V wells. Examples of these features are: (1) unsewered areas within states; (2) population and concentration of industrial establishments; and (3) hydrogeologic characteristics which are conducive to the existence of Class V wells.

Hydrogeologic Environment

Evaluation of the hydrogeologic environment will be based on collecting existing data from various governmental and other sources. The key factors that are relevant to the UIC program are: (1) location of aquifers that are potential underground sources of drinking water; (2) quality of groundwater; (3) location of mineral, oil, or geothermal energy-producing zones;

(4) economic and technological limitations which may make recovery of groundwater impractical; and (5) areas where groundwater is so contaminated that it would be impractical to render the water fit for human consumption. Very general information about these subjects is available either in raw form, such as well logs and laboratory analyses, or in compiled form, such as published reports. Raw data are available from such agencies as the U.S. Soil Conservation Service, U.S. Geological Survey, state geological surveys, and state departments of health, water resources, natural resources, and environmental protection. Published reports are available from federal agencies, such as the EPA, the Army Corps of Engineers, and the U.S. Geological Survey, and from various state agencies. Technical journals of professional associations are also important sources of pertinent hydrogeologic data.

It is suggested that information concerning the key factors be represented in the form of hydrogeologic maps. Maps of this type may be used to summarize the broad lithologic and hydrogeologic characteristics of the sites. It is assumed that the general direction of groundwater flow can be deduced from these maps or other sources. The first level of effort of development of these maps will be a small scale compilation, covering an entire state. Larger scale maps can be developed in Phase II to provide more detailed information concerning local groundwater conditions.

Location and Yield of Aquifers

The usability of an aquifer as a continuing source of drinking water is dependent on its geologic structure and hydrologic characteristics, the amount of water in storage, and rate of recharge. The amount of water in storage can be determined from the dimensions of the aquifer and the porosity of the aquifer materials.

The rate of recharge is dependent on the annual average precipitation over an area, minus water losses due to evapotranspiration and runoff. In humid regions of the United States, groundwater recharge rates vary from several inches to over 20 inches per year. In arid regions of the United States, however, where evapotranspiration losses are equal to or exceed precipitation, little or no recharge occurs.

Groundwater Quality

Natural groundwater quality can range from poor to excellent, both areally and with depth. Generally, under natural conditions, the shallowest aquifers contain good water in almost all parts of the country. In places, however, the natural quality has been degraded by man's activities. There are numerous methods for describing groundwater quality which generally involve the determination of the distribution and concentration of selected chemical and biological constituents and physical characteristics. A convenient measure of the potability of groundwater is concentration of the total dissolved solids expressed in milligrams per liter. Water with a TDS content of up to 10,000 mg/l is considered to have a potential to be a usable source of drinking water. Water quality conditions by areas and aquifers can be illustrated on maps and sections. The basic data consist of chemical analyses of water samples from either published reports or agency files.

Groundwater Movement

Most groundwater is in continuous movement in aquifers. The rate and direction of movement are dependent on the permeability and thickness of the aquifer materials, the relative heads, and the hydraulic gradients. The relation of these factors is expressed in Darcy's law.

In a groundwater system, there are regions where percolating water from precipitation or from surface-water bodies moves downward to recharge the aquifer, and in other parts, water discharges upward or laterally to surface streams, to oceans, or to other aquifers. In still other places, water is lost from the shallow parts of the system by evapotranspiration.

Groundwater Use

The dependence of a population on groundwater for public water supply is reflected in the ratio of groundwater use to total public water supply use in an area. Present as well as future groundwater use is important in assessing the vulnerability of the hydrogeologic environment to contamination. Major public water supply wells should be located on a map, noting quantity of pumpage and location and depth of the supply aquifer.

Determination of Areas for Further Investigation

A comparison of the results of the several data-gathering efforts should be done prior to entry into Phase II. The objective will be to identify geographical areas hypothesized to contain high concentrations of non-reporting Class V well operations. This early analysis will serve as the basis for much of the fieldwork agenda planned for Phase II.

PHASE II: FIELD VERIFICATION

The objective of this phase of the assessment is twofold: to locate non-reporting Class V operations and to improve the quality of data on the scope of practices and the hydrogeologic environment obtained in Phase I. It will require extensive field work, not only to locate non-reporters, but to verify and support the analysis and interpretation behind the state advisory report.

Location of Non-Reporting Class V Well Operations

Not all Class V well operators will have identified themselves by the conclusion of Phase I, either through ignorance or misinterpretation of the UIC requirements. The state will have to devote time and effort to the problem of locating these facilities using means such as direct mailings, telephone calls, and site visits.

Some states may choose to levy fines or take court action against Class V facilities that did not identify themselves during Phase I. These punitive actions would serve to decrease or increase the costs of locating the non-reporting Class V operations during the assessment period. Although penalties are allowed, this study has not included estimates for them in the manpower and cost analysis. Instead, only estimates for the general assessment effort shall be included.

Scope of Injection-Well Practices

Significant progress in identifying the scope of Class V well practices in a state could be made by switching from indirect methods of identification to direct methods in Phase II. Instead of attempting to infer the likely existence of wells based upon levels of business activity and other characteristics, direct contacts will be made with county and local officials, industry associations, and business leaders. On a limited basis, selected site visits will also be conducted.

The site visits will be focused on high priority areas. They will be directed toward identifying three types of information regarding Class V wells: (1) the scope of the practices (i.e., the number of wells, their uses, and relative volumes of wastes); (2) the significance of the wells to the user (i.e., whether they are used to dispose of primary process wastes or merely to clean wastes, spills, or other types of fluid); and (3) the feasibility and costs of environmentally superior alternatives to well disposal.

These topics cannot be addressed with statistical significance--the numbers and uncertainty in each category and the constraints of budgets and time preclude a rigorous statistical approach. Therefore, this effort will be directed toward nonstatistical validation and refinement of the Phase I estimate of the scope of the problem. The field work should also identify some relevant case studies. Finally, it will improve the understanding on the part of the state project staff of the issues surrounding the feasibility, costs, and environmental effects of alternative methods of disposal at some sites.

Hydrogeologic Environment

One important thrust in Phase II will be to attempt to substantiate that some contamination occurs from these wells by performing limited water-quality sampling. Sampling could be performed on water from existing water supply wells and, even then, only on a limited basis due to the cost and time required for thorough analyses of water samples.

Chemical analyses for many constituents, including trace metals and organics, will have to be performed because the state staff will be investigating problems about which little may be known. On the other hand, samples taken near specific industrial sites may be analyzed only for those constituents thought to originate from the industrial source.

While this sampling effort may have limited significance due to the small sample size, it is likely to enhance the understanding of the problem and, through documentation of some case histories, to lend credence to the state assessment.

Other efforts in the hydrogeologic area are mainly extensions of the Phase I effort. One such task will be to introduce quantitative projections of future groundwater use. That evaluation should be developed on the basis of state population projections, and the water resource plans and the results should be plotted on a series of maps.

Two issues which must be studied but not necessarily illustrated on maps or overlays are the hydrogeologic factors of aquifer depth and groundwater movement. Both should be examined, particularly in areas with a high degree of groundwater vulnerability, in order to interpret and use the other information in any final state advisory report.

PHASE III: EVALUATION AND RECOMMENDATIONS

Phase III is the final phase of the state assessment and will involve analysis and interpretation of data collected in Phases I and II and the documentation of the findings and recommendations from the state assessment.

The quantitative data from Phase II will be at least partially in the form of improved Phase I overlay maps. Minor improvements in hydrogeological data should be incorporated. The biggest change, though, should be in the quality of the data on business concentrations and the expected numbers and types of Class V injection wells.

The results from Phases I and II should provide Phase III with: (1) an improved quantitative estimate of the scope of Class V wells and their coincidence with significant hydrogeological conditions; (2) better qualitative understanding of the problem posed by Class V wells; and (3) some limited understanding of feasible solutions for Class V problems.

The state must then establish some priorities based on a ranking of the problems by geographic locations, type of industry, type of well, volume and toxicity of substances being injected, and other factors where needed.

Finally, the state must organize and document all of the information and analyses which it collected during the assessment. This must be compiled in such a way that it can form the basis for the development of a formal set of recommendations to be submitted to EPA. The results of the assessment and the recommendations will be used to help formulate a national regulatory plan of action.

At the conclusion of the assessment effort, the state director must submit the following to EPA[19]:

- "An assessment of the contamination potential of the Class IV wells using information supplied by the operator and hydrogeologic data available to the State";

- "An assessment of the available corrective alternatives where appropriate and their environmental and economic consequences"; and

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

The recommendations could suggest a combination of regulatory forms such as a permit program for a small number of very serious practices; a set of rules for the construction and use of many wells which could constitute a ban on some forms; and no action at all on certain wells. The form of the national regulatory program will depend upon the sum of the 57 states' and territories' assessment of the scope of the practices, the magnitude of the potential contamination threat, and the feasibility of technical alternatives to the Class V wells. It is that eventual use to which the entire assessment process will be directed.

[19] "State Underground Injection Control Regulations," Federal Register, Vol. 44, No. 78, April 20, 1979, p. 23766.

VI. STATE PROGRAM MANPOWER AND COSTS—CLASS V WELLS

INTRODUCTION

An important element in developing the UIC program is estimation of the level of staffing and funding required by state agencies to carry out the assessment and use its results to form a set of recommendations for future regulatory action. The previous section described the steps of the assessment process. This section presents personnel and cost estimates for the entire Class V assessment program and is based on discussions held in 1978 with state officials in 22 states.

All these states have regulatory requirements to protect underground sources of drinking water, but the regulations in these states range from broad, general statements to specific requirements. Likewise, there is wide variation from state to state regarding the number of existing practices, the amount of available data describing those practices, and the level of detail of hydrogeologic data.

STAFFING

In the previous chapter, three phases were described in the guidelines to conducting an assessment. Phase I is characterized by program planning and assembling and reviewing existing data; Phase II by developing new sources of data to supplement and validate existing information; and Phase III by analyzing these data, determining technological alternatives to existing practices, setting priorities for a regulatory approach, and preparing an advisory report containing a set of recommendations for the most appropriate regulatory approach and for remedial actions where needed.

The number of persons required for an assessment and preparation of an advisory report is dependent on the scope of the well practices, the status of information, and the extent of regulations that currently exist in each state. Three general levels of effort have been identified during discussions with state officials. These are shown in Table VI-1 and are labeled minimal, moderate, and extensive. Each level of effort would enable the states included within the category to fulfill the UIC requirements for states in evaluating Class V wells.

Table VI-1
STAFFING REQUIREMENTS FOR
ASSESSMENT AND ADVISORY REPORT

	Phase I Time: 6 months	Phase II Time: 6 months	Phase III Time: 12 montns
Minimal Effort			
Supervisor	.1	.1	.2
Professional Staff	.3	.3	.3
Support Staff	.6	.6	.6
Total	1.0	1.0	1.1
Moderate Effort			
Supervisor	.2	.2	.3
Professional Staff	.5	.5	.5
Support Staff	1.0	1.0	1.2
Total	1.7	1.7	2.0
Extensive Effort			
Supervisor	.5	.5	1.0
Professional Staff	1.5	1.5	1.5
Support Staff	1.0	1.0	1.5
Total	3.0	3.0	4.0

The level of effort required during the first six months of the assessment process would range from one full-time person in each of the states requiring minimal effort, to 1.7 full-time persons in those states needing moderate effort, to three full-time persons where extensive effort would be required. In each of these cases, a supervisor would be needed to coordinate the effort. He would be assisted by other professional and support staff.

The supervisor would be a senior staff person who would be responsible for both the assessment and advisory report. He would provide continuity and leadership for the program and would coordinate the activities of the professional and support staff, other contributing agencies, and state legislative resources. An academic background consisting of an advanced degree in groundwater hydrology, geology, environmental or water-resources engineering, or a similar field of study, or the equivalent, would be a prerequisite, along with at least five years of experience in related fields. This position requires a wide range of administrative ability coupled with practical and theoretical experience. State officials indicated that such a supervisor could be drawn from existing state personnel, and may have other UIC program responsibilities simultaneously.

The prerequisites for the professional staff positions would be a B.S. degree in the areas of groundwater hydrology, geology, or perhaps environmental or water-resources engineering, and two or more years of field experience, preferably within the same state. Some state officials believe that professional staff would be readily available. In other states, there was some doubt about the ability to successfully fill these positions.

The required level of effort for the states and territories was based on the following criteria: 1) industrial concentration; 2) population concentration; 3) hydrogeologic conditions; 4) extent of regulation; and 5) physical size of state. It was determined that, of the 22 states contacted during this study, approximately 8 would require a minimal level of effort, 7 would require a moderate level of effort and 7 would require an extensive level of effort. Of the remaining 35 states and territories, approximately 23 are expected to require a minimal level of effort, 11 are expected to require a moderate level of effort, and 1 is expected to require an extensive level of effort. Table VI-2 shows the aggregate staffing needs for all Class V requirements.

Table VI-2

AGGREGATE STAFFING REQUIREMENTS
FOR TWO YEARS OF PROGRAM ASSESSMENT

Level of Effort	Man-Years Per State	Estimated Number of States	Total Man-Years*
Minimal	3.1	31	96.1
Moderate	5.4	18	97.2
Extensive	10.0	8	80.0
Total		57	273.3

Note: Total is for the two years of assessment and for all 57 states and territories. It is based on a mix of supervisor, professional staff, and support staff.

STATE COSTS

The levels of effort discussed above form the basis for an estimate of costs for each state. During interviews with state officials in 1978, prevailing salary ranges for state employees were identified. These wages were for 1977 and are expressed in terms of 1977 dollars. Their salaries included fringe benefits and other direct overhead items which were estimated to range from 35 to 100 percent of base salary. Supervisory salaries and overhead expenses ranged from $28,000 to $38,000 per year. The salary and overhead for professional staff ranged from $20,000 to $28,000 per year. Supporting staff salary and overhead costs ranged from $14,000 to $20,000 per year. Direct expenses for travel, per diem, supplies, and other items were estimated at $1,000 per man-year. This $1,000 figure is an average of field staff, who would spend more than this amount, and office staff and the supervisor, who would spend less.

The analysis of state program costs for Class V injection wells differs from the analysis of costs for Class I, II, and IV. In the latter analyses, an average annual salary of $22,500 was used to evaluate the costs to states. The $22,500 amount represented the NPDES staffing experience of a mix of supervisory, technical and clerical personnel required to carry out that program. In addition to the $22,500, direct expenses of $3,500 per man-year were budgeted to cover office supplies and travel. The salary ranges for Class V staffing are equivalent to the NPDES program but the mix of personnel differs. In NPDES, experience has shown the mix to be approximately 70/30 supervisory and technical to clerical; in Class V administration it is anticipated to be approximately 40/60 for a minimal effort and 2/1 for a maximum effort. These are shown in greater detail in Table VI-1.

Another determinant of costs discussed during the interviews with state officials was the method that would be used to acquire personnel to carry out these tasks. The alternatives discussed were: 1) hiring individuals on a contractual basis; and 2) hiring permanent staff under civil service or other state government personnel systems. The general preference was for contractual hirees to fill professional and support staff positions, because the state personnel systems were considered to be rigid and frequently constrained by personnel ceilings, and because employees would have to be hired for the long term. Contractual hirees, however, might be more expensive and less likely to be accepted by existing state staff and, perhaps, by plant personnel in the industries visited. The final decision apparently would be determined to a large extent by the prevailing state legislative climate towards hiring.

Table VI-3 shows the estimated cost requirements for a single state based on minimal, moderate, and extensive levels of effort during the assessment and state plan phases. These costs reflect the range of salary levels supplied by state officials and the mix of personnel shown in Table VI-1, and cover eighteen months of assessment work and six months of advisory report development. Individual state costs for the first six months range from $18,000 to $84,000. Costs for the program range from $57,000 to $282,000 per state, depending upon the level of effort required in the state.

Table VI-3

COSTS OF ASSESSMENT AND ADVISORY REPORT
(per state*)
(thousands of 1977 dollars)

Level of Effort	Phase I	Phase II	Phase III	Two-Year Total
Minimal	$18-$25	$18-$25	$21-$29	$57-$79
Moderate	$31-$43	$31-$43	$37-$51	$99-$137
Extensive	$61-$84	$61-$84	$83-$114	$205-$282

*Based on a mix of supervisor, professional staff, and support staff, as shown on Table VI-2.

Table VI-4 shows the estimated cost requirements for the 22 designated UIC states for the first year of the program. These costs are developed for three estimated levels of effort based on the status of existing inventories, regulatory approach, and level of industrial concentration. Total costs for two years range from $2.7 million to $3.7 million.

Table VI-5 shows the average total costs for assessment and state plan for 57 states and territories. On a national basis, the total program cost range is $5.2 million to $7.2 million for the two years.

Table VI-4

ASSESSMENT AND ADVISORY REPORT COSTS
FOR 22 DESIGNATED UIC STATES
(thousands of 1977 dollars)

Level of Effort	Number of States	Total Cost for Two Years
Minimal	8	\$ 456-\$ 632
Moderate	6	\$ 594-\$ 822
Extensive	8	\$1,640-\$2,256
Total	22	\$2,690-\$3,710

Table VI-5

ASSESSMENT AND ADVISORY REPORT COSTS
FOR 57 STATES AND TERRITORIES
(thousands of 1977 dollars)

Level of Effort	Average Cost Per State	Number of States	Total Cost for Two Years
Minimal	\$ 57-\$ 79	31	\$1,767-\$2,449
Moderate	\$ 99-\$137	18	\$1,782-\$2,466
Extensive	\$205-\$282	8	\$1,640-\$2,256
Total		57	\$5,189-\$7,171

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Appendix A

SUMMARY OF CONTACTS WITH STATE OFFICIALS

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Appendix A

SUMMARY OF CONTACTS WITH STATE OFFICIALS

Information for this appendix was obtained by Geraghty & Miller, Inc. and Temple, Barker & Sloane, Inc. during the period July 1977 - March 1978.

Source:	Comments:
ARKANSAS Mr. Bill Wright Geologist (interview) Oil and Gas Commission El Dorado, Arkansas November 3, 1977	The Oil and Gas Commission regulates injection wells and only permits injection into a zone in which TDS concentration is greater than 20,000 mg/l. It was estimated that excluding oil and gas related injection wells, there are: one sulfuric acid injection well and two cooling water blowdown injection wells.
ARKANSAS Mr. Hugh Hanna, Chief Mr. Chuck Crawson, Geologist (interview) Department of Pollution Control and Ecology Little Rock, Arkansas November 3, 1977	Class V wells are not considered a major threat to groundwater; however, leaky septic tanks have caused groundwater contamination in several cities. There are a few industrial septic tanks, but a dense concentration of household and municipal septic tanks have caused groundwater contamination. In addition, some older brine injection wells are completed in sources of groundwater.
CALIFORNIA Mr. Thomas E. Bailey, Assistant Chief (written response) Division of Planning and Research State Water Resources Control Board Sacramento, California July 27, 1977	Estimates were obtained from knowledgeable officials in State Regional Water Quality Control Boards. These officials gave gross estimates of the number of shallow disposal and recharge wells of each type. It was indicated that development of detailed information would require many man-years, and in the case of drainage wells, the information is physically impossible to obtain. The responses he submitted from his inquiry are summarized in Table A-1.

CALIFORNIA Mr. Alvin Franks, Supervising Engineering Geologist (interview) Division of Planning and Research State Water Resources Control Board Sacramento, California November 28, 1977	The city of Modesto is about 75 percent sewered. In non-sewered areas there are numerous wells injecting into or above freshwater aquifers. The Modesto Health Department tried to document the number of septic tanks being used in the city, but was not successful.
COLORADO Mr. Frank J. Rozich, Director Water Quality Control Board Mr. George A. Prine, Chief General Services Section Colorado Department of Health Denver, Colorado Mr. Carrol G. McDowell, Petroleum Engineer Oil and Gas Conservation Board Mr. John Romero, Chief (interview) Water Resources Engineer Division of Water Resources Department of Natural Resources Denver, Colorado July 28, 1977	There are probably some Class IV and V wells, but the state has adopted rules to control subsurface disposal and feels that the issue is being properly addressed. There may be perhaps 25 illegal industrial discharges to Class IV and V wells by small industries.
CONNECTICUT Mr. Bob Moore (telephone interview) Division of Water Compliance and Hazardous Substances Department of Environmental Protection Hartford, Connecticut December 15, 1977	There are no known nor allowed wells injecting into or above freshwater aquifers in the state. Most industries discharge their waste to municipal sewage systems.

FLORIDA Mr. Ralph H. Baker, Jr., Chief Bureau of Drinking Water and Special Programs Mr. Nick Mastro, Assistant Enforcement Administrator (interview) Division of Environmental Permitting Department of Environmetnal Regulation Tallahassee, Florida July 12, 1977	It was indicated that wells injecting into or above freshwater aquifers are numerous and that partial inventory of these wells has documented 6,080 such wells. (See interview with Mr. Husain below.)
FLORIDA Mr. Frederick Meyer (telephone interview) U.S. Geological Survey Miami, Florida July 22, 1977	There may be about 8,500 drainage wells in Dade County. In Orange County, a study by the U.S. Geological Survey indicated that a total of 419 such wells are in operation. In addition, it was indicated that there could be as many as 10,000 drainage wells in the state.
FLORIDA Mr. Mohammad Husain (telephone interview) Department of Environmental Regulation Tallahassee, Florida March 1, 1978	Information in a report entitled <u>Inventory of Drainage Wells</u>, July 21, 1977, was verified (see Table A-2). All wells recorded in this report are under permit.
IDAHO Jack Sceva, Geologist (interview) U.S. EPA-Region X Seattle, Washington September 8, 1977	In Idaho, there are several hundred drainage wells. In addition, there are approximately 5,000 Class IV and V wells in industrial, agricultural, and municipal categories.

ILLINOIS Mr. Rauf Piskin Environmental Geologist Division of Land and Noise Pollution Control Mr. Thomas E. McSwiggin Manager, Field Operations (interview) Division of Water Pollution Control Illinois Environmental Protection Agency Springfield, Illinois July 27, 1977	There are at least several hundred shallow industrial disposal wells. Some estimates run as high as several thousand wells injecting into or above freshwater aquifers.
INDIANA Mr. Joe Stallsmith, Chief (written response) Enforcement Branch Division of Water Pollution Control Indiana State Board of Health Indianapolis, Indiana August 17, 1977	There is no accurate count available of the number of wells injecting into or above freshwater aquifers. When these practices are identified during routine field investigations, steps are are taken to eliminate them.
KANSAS Mr. Bruce Latta, Chief Oil Field and Environmental Geology Section Mr. Marvin W. Glotzbach Geologist (interview) Bureau of Water Quality Division of Environment Department of Health and Environment Topeka, Kansas Mr. Alan McFarlan EPA--Region VII UIC Coordinator Kansas City, Missouri November 28, 1977	Industrial and municipal waste water is not being discharged through shallow wells to underground sources of drinking water. In 1973, the state started permitting air-conditioner and cooling-water return-flow wells.
KANSAS Mr. Herman Jansen (interview) Department of Health and Environment Topeka, Kansas November 28, 1977	The number of septic systems in the state is estimated to range from 50,000 to 100,000; 95% are believed to be residential systems. Therefore there could be 5,000 Class V wells.

KENTUCKY Mr. Michael McCann, Geologist (written response) Division of Water Quality Department of Natural Resources and Environmental Protection Frankfort, Kentucky January 24, 1978	No data have been compiled for information concerning wells injecting into or above underground sources of drinking water.
LOUISIANA Mr. Charles E. Bishop, Assistant Director (written response) Bureau of Environmental Sciences Office of Health Services and Environmental Quality Department of Health and Human Resources New Orleans, Louisiana December 15, 1977	No known wells injecting into or above freshwater aquifers in state.
MARYLAND Mr. Arnold Schiffman, Chief (written response) Permits Division Water Resources Administration Department of Natural Resources Annapolis, Maryland December 15, 1977	There are between 2,500 and 3,500 non-domestic septic system wells in the state.
MISSISSIPPI Mr. John Harper, Chief Law Enforcement Mr. Charles Branch Industrial Waste-Water Section (interview) Air and Water Pollution Control Commission Jackson, Mississippi November 4, 1977	There are some brine injection wells discharging into underground sources of drinking. It was indicated that there are a few wells injecting into or above freshwater aquifers in the state and are not a cause of groundwater contamination.

NEW MEXICO
Ms. Maxine Goad, Program Manager (written response)
Water Quality Division
Permits and Regulation Section
Environmental Improvement Agency
Department of Health and Social Services
Santa Fe, New Mexico
January 24, 1978

It was indicated that the practice of waste disposal through wells exists in several well categories defined in this report, but little information is available. In addition, if the definition of drainage well is interpreted broadly the count could represent a very large number.

NEW YORK
Mr. Robert O'Reilly
Principal Engineering Technician (interview)
Department of Environmental Conservation
Stony Brook, New York
November 9, 1977

It was estimated that there are approximately 1,000 air-conditioning return-flow wells, based on the number of state permits. No information is available for other wells injecting into or above underground sources of drinking water.

NEW YORK
Mr. James Pim, Chief (interview)
Water Pollution Control Section
Suffolk County Department of Environmental Control
Hauppauge, New York
November 9, 1977

In Suffolk County, most industries inject wastewater through leaching beds. The major industries in this county that discharge to groundwater are metal finishing, pharmaceutical, and food processing. No estimate of the number of wells injecting into or above freshwater aquifers.

NEW YORK
Mr. Francis Pader, Assistant Deputy Commissioner (interview)
Nassau County Department of Health
Mineola, New York
November 10, 1977

In Nassau County there are approximately 3,000 industrial firms discharging organic chemicals. A large percentage of these firms discharge to groundwater through cesspools.

OHIO
Mr. Russell B. Stein
Geologist
Public Water Supply Department
Mr. John Noyes, Geologist (interview)

Probably 200 air-conditioning return-flow wells are concentrated in the cities of Dayton, Columbus, and Cincinnati. In addition, in the City of Zanesville conventional cased wells are used to dispose of waste fluids into mines. Based on

OHIO (continued)
Ohio Environmental Protection Agency
Columbus, Ohio
July 14, 1977

the population of Zanesville, there may be at least 5,000 conventional cased wells. A report to the Ohio Water Commission indicated there may be 1,600 conventional cased wells in the city of Bellevue. This practice has diminished since the installation of a sewer system in the city. It was reported that the State Board of Health believes there may be as many as 200 floor drain dry wells being used for industrial waste disposal.

OREGON
Jack Sceva, Geologist
(interview)
U.S. EPA-Region X
Seattle, Washington
September 8, 1977

In Oregon there are approximately 3,000 wells injecting into or above underground sources of drinking water, including street drainage wells.

OREGON
Mr. R. Nichols
Mr. W. W. Bartholomew
(written response)
Water Resources Division
Department of Environmental Quality
Portland, Oregon
January 10, 1978

There are at least 5,000 non-domestic septic system wells and at least 2,000 drainage wells that are limited to Central Oregon. In addition, it is estimated that there are at least 20 air-conditioning and cooling return-flow wells. No estimate is available for the number of sumps, cesspools and dry wells, located primarily in Multnomah County.

PENNSYLVANIA
Mr. Carlyle Westlund, Chief
Division of Water Quality
Mr. John Osgood, Chief
(interview)
Ground-Water Quality Management Unit
Ground Water Section
Bureau of Water Quality Management
Department of Environmental Resources
Harrisburg, Pennsylvania
September 23, 1977

There are an estimated 10,000 conventional cased wells injecting sewage into deep mines, 2,000 abandoned water wells receiving wastes, and at least 500 highway drainage wells. An estimated 55,000 sand-backfill wells have been drilled to inject fly ash slurry; however, there is no estimate of the present number in operation. Therefore, the number of these wells and their volume of injected fluid are not included in the inventory.

TEXAS Mr. Bob Kent, Geologist (interview) Department of Water Resources Austin, Texas November 21, 1977	There are approximately 300 conventional recharge wells in the High Plains area of the state.
TEXAS Mr. W. Fred Rogers, Director (interview) Environmental Health Services Austin-Travis County Health Department Austin, Texas November 21, 1977	Non-domestic septic systems are generally used by restaurants, with approximately 2,000 of these systems in Austin and a total of 2,500 in Travis County. Dallas, Fort Worth, Houston, and San Antonio have extensive sewer systems.
VIRGINIA Mr. E. W. Ramsey, Geologist (written response) State Water Control Board Richmond, Virginia January 18, 1978	There are approximately 120 drainage wells in the state.
WASHINGTON Mr. Michael Palko Division Supervisor (interview) Office of Field Operations Department of Ecology Olympia, Washington September 9, 1977	Only a few wells injecting into or above freshwater aquifers are known to exist. Due to the large number of streams and rivers, much of the waste that might otherwise be injected is discharged to surface water under NPDES permit.

Table A-1

ESTIMATED NUMBER OF WELLS INJECTING INTO OR ABOVE FRESHWATER AQUIFERS IN THE STATE OF CALIFORNIA[1]

Category	Count	
Disposal		
Conventional Cased Wells	500	
Cesspools, Sumps, and Drywells	2,120	(± 20%)
Total	2,620	
Recharge		
Conventional Recharge Wells	170	(± 5%)
Drainage Wells	8,850	(± 10%)
Air-Conditioning and Cooling-water Return-Flow Wells	1,300	(± 40%)
Salt-Water Intrusion Wells[2]	300	
Subsidence Control Wells[2]	300	
Total	10,920	
Grand Total	13,540	

[1]Based on estimated count from Regional Water Quality Control Boards, Thomas E. Bailey, Assistant Chief, Division of Planning and Research, State Water Resources Control Board, Sacramento, California, September 2, 1977.

[2]Based on count in EPA-Preliminary Evaluation of Well-Injection Practices, Geraghty & Miller, Inc., April 1977.

Table A-2

INVENTORY OF DRAINAGE WELLS IN THE STATE OF FLORIDA BY COUNTY [1, 3]

County	Storm Water Runoff Wells	Surface Water and Lake Level Control Wells	Laundry Waste Wells	Air-Cond. Return-Flow Wells	Effluent Sewage Wells	Industrial Waste Wells	Other Wells[2]	Total
Alachua	2	2	-	5	-	-	-	9
Bradford	-	1	-	-	-	-	1	2
Brevard			1	7				8
Broward	31			7	1		4	43
Citrus	1							2
Clay	1						1	2
Collier				4				5
Columbia			1	1				1
Dade	145	259	54	2,637	6	146	1,955	5,205
Duval	1			2				3
Escombia				3				3
Hamilton	4			1				5
Hardee	5	1						6
Hernando						2		2
Hillsborough	3			100		1	4	108
Jackson	2							2
Jefferson	1	1		1				3
Lake	1	4		3			1	9
Leon	5	5		37				47
Levy	5							5
Madison	6	1					2	9
Manatee				10				10
Marion	12	13		15	1		5	46
Nassau			1		2			3
Orange	19	154	2	21	4	1	8	209
Palm Beach	11			10			58	79
Pasco				9			1	10
Pinellas				68			2	70
Polk		1		7	1	6	25	40
Putnam	1	4		1			1	7
Sarasota	1		1	14			5	21
Seminole	1	3					1	5
Sumter				1				1
Suwanee	55	1					1	57
Taylor				1				1
Volusia				44				44
Washington	1							1
Total	314	451	60	3,009	15	156	2,075	6,080

[1] No wells counted in 28 counties.

[2] Includes wells used for disposal of swimming pool water, wastes from water softener equipment, and other wastes.

[3] Source: Mohammad Husain, Florida Department of Environmental Regulation, 1977.

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Appendix B

REGULATORY HISTORY--
WELL CLASSES IV AND V

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Appendix B

REGULATORY HISTORY--
WELL CLASSES IV AND V

As part of this investigation, federal and state laws and regulations were reviewed to: (1) provide background information on regulatory authority and (2) determine the extent of present state programs. Based on this information, four alternative methods of regulation were formulated. The alternatives are compared briefly in this study. One regulatory approach stands out as superior and serves as the basis for the cost estimates presented in the body of this report.

FEDERAL PROGRAMS

Safe Drinking Water Act

The purpose of the Safe Drinking Water Act of 1974 (PL 93-523, referred to as "the Act") is to protect water quality of public water-supply systems, which are defined in Part B of the Act as systems having at least 15 service connections or regularly serving at least 25 individuals. The Act prescribes two methods of meeting this goal: (1) establishment of drinking-water standards, and (2) establishment of a system of assuring compliance with these standards and protecting underground sources of drinking water.

Part C (Sec. 1421-1424) of the Act calls for a method of protecting underground sources of drinking water by means of a state system of regulation. Under the requirements of the Act, state regulatory programs must provide at least the following items: (1) prohibition of unauthorized underground injection effective within three years after enactment of the Act; (2) requirement of applicant to bear the responsibility of assuring protection of underground sources of drinking water; (3) assurance that no regulation would allow endangerment of underground drinking water sources; (4) inspection, monitoring, recordkeeping, and reporting; (5) control over injection by federal agencies, whether or not the injection occurs on property owned or leased by the federal government; and (6) non-interference with oil and gas production, unless such requirements are essential to assure protection of underground sources of drinking water.[1]

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[1]Part C, Section 1421, PL 93-523, 93rd Congress, S. 433, December 16, 1974.

Committee Report

The House of Representatives Committee Report (Report No. 93-1185) that accompanied the Act broadly defines "underground injection" to include the underground emplacement of any contaminant, but not be limited to injection of wastes or injection for disposal. Single-family septic tanks and other residential waste-disposal systems are, however, specifically excluded from the regulatory program.

The Committee Report also broadly defines "underground injection which endangers drinking water sources" to cover any contaminant which may be put below ground level and which flows or moves, whether the contaminant is in semi-solid, liquid, sludge, or any other form or state that would prevent a public-supply system from complying with any primary water standard, or otherwise pose a threat to public health. The Committee Report indicates that all subsurface water with less than 10,000 mg/l of total dissolved solids should be designated as an underground source of drinking water, regardless of whether or not it is presently being used as such.

Previously Proposed UIC Regulations

On August 31, 1976, proposed regulations for the State Underground Injection Control Program (40 CFR Part 146) were published in the Federal Register by EPA. In the proposed regulations, Subpart C covered industrial and municipal waste-disposal wells, subsidence control wells, barrier wells, recharge wells, mining wells, storage wells, and geothermal wells; Subpart D covered oil and gas related wells; and Subpart E covered drainage wells.

Wells that were listed in Subpart C are used to inject fluids that range in water quality from relatively clean water (recharge wells) to industrial wastewater (disposal wells). In addition, these wells range in depth from a few feet to several thousand feet. Under Subpart C of the August 31, 1976, proposed regulations, these wells would have been regulated by permit.

That set of the proposed regulations separated wells into categories based on their function and design rather than on their depth and the quality of water in the zone of injection. Classification based on function, however, produced major difficulties. For example, wells to be permitted in Subpart C were required to have a casing cemented from the injection zone to the land surface to protect water containing 3,000 mg/1 or less of total dissolved solids. This requirement would have prohibited the use of most subsidence control wells and saltwater intrusion wells because these wells are usually designed to inject into water of this quality. Due to the permitting requirement, wells covered in Subpart C that inject into underground sources of drinking water would have been subject to stricter control than wells covered in Subpart E, which also may inject into underground sources of drinking water.

In 1977, EPA drafted another set of UIC regulations for internal review. These regulations separated injection wells into four categories that were described under Subparts C, D, E, and F. Subpart C covered wells used for disposal of municipal or industrial wastes into saline aquifers. Subpart D regulated wells used for oil and gas production. Subpart E covered wells used for mining, geothermal wells, and in situ gasificaton wells. Subpart F was involved with all wells injecting into or above freshwater aquifers.

CURRENT STATE REGULATORY PROGRAMS

All states have regulatory requirements to protect underground sources of drinking water. The coverage in each state ranges from broad, general statements to very specific instructions for banning, permitting, monitoring, and reporting requirements.

According to state officials who were contacted in the 22 states surveyed during this study, several states currently ban all practices which inject into or above freshwater sources. These states include Arkansas, Connecticut, Illinois, Kentucky, Louisiana, and Mississippi. The remaining states allow certain practices by rule or permit.

Control of these practices is typically the responsibility of more than one agency in each state. For example, in California, multi-unit septic systems serving greater than five units and saltwater barrier injection wells are the responsibility of the Regional Water Quality Control Boards, while other practices are regulated by the Division of Oil and Gas and Department of Health. In Texas, practices are regulated by the Texas Department of Water Resources, county health departments, city health departments, and the Department of Agriculture. No state currently has centralized responsibility for all practices that would be covered by an Underground Injection Control program.

The following table (Table B-1) summarizes current regulatory programs for states where information was available. The description of state programs in the table gives the appearance of more comprehensive protection from the effects of these types of wells than actually exists in most states. The major reason for this variance is the lack of a comprehensive state-level approach to regulation of these wells. Also, most state programs are limited to responding to individual complaints on a case-by-case basis.

Table B-1

EXISTING STATE PROGRAMS FOR WELLS WHICH INJECT INTO OR ABOVE DRINKING WATER SOURCES FOR 17 STATES REPORTING INFORMATION

State	Regulatory Program
Arkansas	No new wells allowed. Existing wells closely regulated by Oil and Gas Commission and Department of Pollution Control and Ecology.
California	State Water Resources Control Board, Department of Health, and Division of Oil and Gas have extensive permit, monitor, and report requirements.
Colorado	Regulation by rule and permit by Department of Health, Water Quality Control Commission, and Oil and Gas Conservation Board.
Connecticut	No wells allowed.
Florida	Most wells under permit and controlled by the Department of Environmental Regulation.
Illinois	Most practices banned by state laws. Illinois EPA has authority.
Indiana	All practices banned by the State Board of Health, Division of Water Pollution Control.

(continued)

Table B-1 (continued)

State	Regulatory Program
Kansas	No practices allowed.
Kentucky	No practices allowed.
Louisiana	No practices allowed.
Maryland	Extensive regulations under authority of Department of Natural Resources.
Mississippi	Most practices not allowed, regulated by Air and Water Pollution Control Commission.
New Mexico	New injection practices after June 1977 are required to have an "approved discharge plan." For practices in use before June 1977, a discharge plan may be required by the director[2] of the agency on a case-by-case basis.
New York	Regulation by rule and permit by Department of Environmental Conservation and Department of Health. Some practices banned, especially industrial wastewater disposal.
Ohio	Municipal waste disposal permitted by Department of Health. Industrial disposal banned. Permits required for cooling water and air conditioning return flow wells by the Ohio EPA.
Pennsylvania	The Department of Environmental Resources issues permits for the injection of secondary treated effluent through disposal wells until an alternative method of disposal is completed.
Texas	Regulations are extensive and enforced by several agencies including city and county health departments, Texas Department of Water Resources, and Department of Agriculture.

[2] In this report, director refers to the state official who is responsible for regulation of wells injecting into or above underground sources of drinking water.

SELECTION OF REGULATORY ALTERNATIVES FOR WELLS INJECTING INTO OR ABOVE FRESHWATER AQUIFERS

In determining a method of regulating these wells, the following factors were considered:

- Degree of drinking water protection
- Federal and state regulatory concerns
  - --consistency with intent of the Safe Drinking Water Act
  - --internal consistency with UIC program
  - --consistency with other current EPA programs
  - --consistency with states' current levels of technical data and support
  - --likelihood of acceptance of primacy by states
  - --ease of administration
  - --level of federal, state, and industry costs
  - --technical feasibility of alternatives
- Industry concerns
  - --technical feasibility of alternatives
  - --costs to industry

The most important consideration and the purpose of the entire UIC program is the protection of underground sources of drinking water. However, all factors must be addressed when comparing regulatory alternatives and in choosing the best option that can be reasonably implemented.

Alternative Regulatory Approaches

Four alternative approaches were formulated for regulation of wells which inject directly into or above underground sources of drinking water:

1. Within the UIC regulations, require a permit program for at least some of these practices
2. Within the UIC regulations, require the states to assess the threat of contamination from these wells and submit a detailed state plan to the administrator[3]

[3] In this report, administrator refers to the federal EPA official who is responsible for administration of the UIC program.

3. Withdraw consideration of these wells from the UIC regulations and study them in a separate national assessment

4. Within the UIC regulations, require state assessment of these wells coupled with regulatory control over the most potentially harmful practices.

The following is a discussion of each alternative and a presentation of recommendations for the most appropriate regulatory approach.

Alternative 1: Permit Program for at Least Some Practices

Disposal wells and recharge wells are numerous and would be difficult to permit on an individual or group basis, which a permit-program approach would require. Many disposal wells are illegal, hidden from view, and impossible to detect except by a detailed field inspection. For example, a small commercial laboratory may dispose of chemical waste fluids through a well in the basement of the building. Even where such polluters are aware of the illegality of their practice, they may prefer to remain anonymous as alternative waste-disposal methods would be costly or infeasible due to physical and geological conditions. In extreme cases, marginal industrial operations could be forced out of business should expensive waste treatment facilities be mandated by the state agency.

A permit program is a compromise between a ban and study approach because a total, immediate ban of shallow waste-disposal wells would be economically disruptive, administratively difficult, and practically impossible.

The following are the suggested major components of a permit program:

- The director would have the discretion to ban immediately those categories of practices which present an unreasonable risk to health, and to ban, after an appropriate period of time, all categories of practices for which economically feasible alternatives exist

- The state director would determine, for those practices not banned, which practices in his state should be regulated by permit rather than by rule

- For those practices to be regulated by permit the state director would determine when and where to allow exemptions based on criteria such as low toxicity and/or low volume, hydrogeologic characteristics, and population in the area relying on the affected underground sources of drinking water
- Some means would be allowed by which the director could group wells for area permits, thereby reducing the administrative burden
- Permits would be issued for practices over a period of a few years with priorities established for issuing permits for wells requiring greatest control first
- The director would impose monitoring, record-keeping, and reporting requirements for each permit as would be necessary to protect public health. In addition, the director would require public notification for each permit before its issuance and require that the injector periodically show that his well continues to be the best environmental means of disposing of the waste.

Pros and Cons of a Permit Program

A permit program would provide maximum protection of underground drinking water sources within the shortest time frame. It would be consistent with other Subparts of the UIC regulations.

An effective permit program would be costly, however, as substantial effort would be required to locate individual wells that are typically hidden from view. Operators probably would not come forward voluntarily unless they were convinced that they would be caught, and that they would receive an exemption anyway. State officials have expressed a lack of support for a permit program due to a belief that a response to complaints of contamination is more effective and a belief that their administrative burden would be excessive. In fact, some states would probably reject primacy if many of the wells injecting into or above potable aquifers were required to be regulated by permit.

Additionally, it is impossible to argue with certainty that technological alternatives to current practices are economically feasible for all shallow disposal and recharge well practices. Case histories indicate that several years' time and the cooperation of several groups, including state agencies, universities, trade groups, and operators, may be required to solve one industry's problem. Alternatives to some practices that occur in vast numbers would be prohibitively expensive. Given the current, incomplete characterization of wells, it is likely that some permit requirements may be inappropriate in that they may be established without a thorough understanding of all elements of operations, such as volumes, toxicity, alternatives, costs, and available resources.

Alternative 2: Within the UIC Regulations, an Assessment and Submission of State Plan

The previous chapters of this report described the types of wells that inject into or above underground sources of drinking water and discussed the problems of developing an exact inventory of these practices. A related problem, expressed by state officials during visits to 13 states and during telephone conversations and mail surveys with 9 other states, is the perception of the extent of the threat of contamination from these wells. Seven states, California, Florida, Kansas, Maryland, New York, Pennsylvania, and Texas, say they are actively regulating problem areas and industries on a selected basis, but they may be interested in additional federal support. Six states, Illinois, Indiana, Kentucky, New Mexico, Ohio, and Oregon, say there is a problem but only in selected industries and/or localities, and they would like to have federal support to study these wells, but they are not yet ready to formulate or enforce a permit program. Nine states, Arkansas, Colorado, Connecticut, Kentucky, Louisiana, Mississippi, Oklahoma, Washington, and West Virginia, say these wells either don't exist or create no problem, and therefore no regulatory program is necessary.

At this time, and for several reasons, it is impossible to demonstrate that the states are not in control of these injection practices. Reported cases of contamination are few and relatively isolated. Where cases have come to the attention of state regulators, careful study and constructive action have followed to discourage any further contamination. Characterization of well types and industries is still not detailed enough to provide convincing evidence of the potential for contamination to the states. This evidence would require state-specific facts about industries, hydrogeology, and case histories. This task is far beyond the scope of studies undertaken to date.

With the realization that data are sparse, the following have been suggested as major components of an assessment and state plan approach:

- The state director would compile an inventory, including number, location, and use of these well practices, and determine the toxicity and volume of the injected fluids

- The director would develop and compile hydrogeologic data, including information about geology and location of the aquifers, aquifer yield, groundwater quality, groundwater movement and groundwater use

- The director would develop data on present and future population and industrialization within the state, emphasizing the study of dependence on groundwater resources and the protection of the quality of public health

- The director would consider the technological alternatives available to existing practices, including injection into a deeper well, discharge into surface water (subject to Section 402 of the FWPCA), disposal in a sanitary landfill under RCRA, disposal into a municipal treatment facility, or injection after additional treatment

- The director would assess the risk to underground sources of drinking water based on the above data and would submit a state plan to cover new and existing injection wells. The plan would address the issues of regulatory priorities (i.e., substances, geographic areas, types of wells), time frame for implementation, rule vs. permit programs, and prohibitions.

Pros and Cons of an Assessment and State Plan

An assessment approach would allow time to study the least understood and most numerous practices of the UIC program. It would lead to an increased awareness at state, local, and industry levels of the risk of those practices while avoiding the costs and problems of a mandatory permit requirement. This approach would lead to a state plan that is consistent with the intent of the Safe Drinking Water Act and consistent with the approach toward the formulation of other pollution-control programs within EPA. The assessment approach would make acceptance of primacy by the states more likely than a permit program would, thereby decreasing the federal administrative burden.

On the negative side, the time lag between acceptance of primacy and submission of a state plan would delay ultimate action and therefore allow the threat of pollution to go unchecked for a time. Relative to the strict framework within which other practices are to be regulated in the UIC program, an assessment approach places the least immediate emphasis on the most serious contamination problems.

Alternative 3: Withdraw These Practices from UIC Program and Study in Separate National Assessment

As discussed in the previous paragraphs, little specific information is available about the practices which inject into or above underground sources of drinking water. A national assessment could be conducted outside the UIC regulations to obtain the following information:

- Scope of practices including number, location, toxicity, and volume of waste materials
- Documented cases of contamination
- Evaluation of potential for groundwater contamination
- Existing state programs
- Level of resources expended and required
- Needed additional regulations at the state level
- Recommended role of the federal government.

The UIC regulations could then be amended to incorporate conclusions reached as a result of conducting a national assessment, or a separate regulatory package could be formulated, as is intended for surface impoundments.

Pros and Cons of a National Assessment Outside the UIC Program

The other well categories of the UIC regulations cover practices for which a great deal of information is known, including specific location, count, and construction of those wells. Removal of wells that inject into or above underground sources of drinking water from the regulations would leave the package internally consistent. States would evaluate their willingness to accept primacy based on known practices and administrative requirements rather than unknown practices and hypothetical administrative burdens.

A separate national study would be consistent with the approach taken to the nationwide study of surface impoundments. The results of both these studies could lead to a coordinated regulatory approach.

A study approach would appear to be the least aggressive attack on the problem because groundwater experts have argued that these wells are a greater threat to water quality than any of the practices covered. A wait-and-see attitude may not be consistent with the intent of the Safe Drinking Water Act.

As part of the Act, grants will be made available to the states accepting UIC primacy to aid them in carrying out administrative responsibilities. There is no certainty that money would be available for an assessment of wells outside the UIC program.

Alternative 4: Within the UIC Regulations, Assessment with Regulatory Control Over the Most Potentially Harmful Practices

To repeat major points stated earlier, it appears that there exist substantial numbers of wells throughout the country that discharge fluids of variable quality into or above freshwater aquifers. Furthermore, there seems to be a general scarcity of data concerning the exact number, locations, and injection fluids of these wells. It is clearly not economic to attempt to permit all these wells, but it is just as clearly unsafe to take no action against these practices until an assessment has been completed.

Under these circumstances, it is worthwhile to separate the set of wells injecting into or above underground sources of drinking water into two subsets: (1) wells posing a serious threat to human health and the environment and (2) wells posing an as-yet-undetermined threat to human health and the environment. Wells of the former group may be regulated immediately by permit, by rule, or through bans, while wells of the second group may undergo assessment prior to formulation of a regulatory strategy.

The following are the suggested major components of a state regulatory program for wells injecting hazardous wastes into or above underground sources of drinking water:

- The director would determine the identifying characteristics of harmful materials and/or list such substances. Alternatively, a national list of hazardous substances, such as RCRA's, could be used for nationwide consistency

- Operators of facilities injecting hazardous substances into or above freshwater aquifers would identify themselves and describe their operations to the state director

- These wells would be granted temporary authorization to operate by the program director, with the understanding that they would be closed as soon as possible in order to protect public health and the environment

- New wells injecting harmful materials into potable groundwater sources could be banned

- Monitoring, record-keeping and reporting requirements for the operator would be a necessary condition of the temporary authorization granted by the state director

- Disposal of harmful materials formerly injected into wells would be coordinated with the requirements of other programs dealing with hazardous substances.

The suggested regulatory approach for wells injecting materials of indeterminant hazard into or above freshwater aquifers would be similar to the approach suggested in Alternative 2, assessment and submission of a state plan. In condensed form, the major components of this approach would be as follows:

- Compilation of well inventory
- Compilation of hydrogeologic database
- Assessment of state groundwater dependency, present and future
- Evaluation of acceptable disposal alternatives
- Analysis of accumulated data and formulation of state plan.

Before embarking on this program, EPA and the states should make sure the program's requirements will mesh with those of other programs dealing with waste disposal, i.e., RCRA and the NPDES permitting program of FWPCA. A consolidated permitting system would avoid duplication of effort for both the operators and program directors.

Pros and Cons of Assessment with Regulatory Control Over the Most Potentially Harmful Practices

This approach addresses both the need for immediate action in the instances where public health is endangered and the need for additional information prior to comprehensive regulation. In protecting the health of the public, the states will impose the greatest restraints primarily on the well operators doing the greatest harm. Furthermore, the task of regulating only the potentially dangerous well practices at first will be far less of an administrative burden than requiring all wells to be permitted.

As the states conduct assessments, there will arise two benefits: (1) better databases on the pollution potential of wells injecting into or above freshwater aquifers, and (2) an increased likelihood that states will accept primacy for a future regulatory program due to their heightened awareness of these wells' contamination potential. Moreover, the federal government will benefit by delegating the task of gathering data to the states, whose files will be better starting points for such an investigation.

The problems with this approach center on two points: identification of hazardous wastes and identification of wells injecting hazardous wastes. RCRA defines identifying characteristics of hazardous substances in addition to supplying a list of hazardous wastes. However, this information has to be circulated to all well operators in order to be useful.

Second, even if the information were to be widely circulated, there is little incentive for well operators injecting hazardous waste to come forward and identify themselves. A penalty for noncompliance would probably need to be imposed to encourage operators to report their activities.

Findings

The last of these regulatory approaches stands out as superior to the other three. It is aggressive in protecting the welfare of persons near wells demonstrating the greatest pollution potential while also being realistic about the lack of data regarding these wells in general.