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The Class V Underground Injection Control Study

Volume 7

Sewage Treatment Effluent Wells

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SEWAGE TREATMENT EFFLUENT WELLS

The U.S. Environmental Protection Agency (USEPA) has conducted a study of Class V underground injection wells to develop background information the Agency can use to evaluate the risk that these wells may pose to underground sources of drinking water (USDWs) and to determine whether additional federal regulation is warranted. The final report for this study, which is called the Class V Underground Injection Control (UIC) Study, consists of 23 volumes and five supporting appendices. Volume 1 provides an overview of the study methods, the USEPA UIC program, and general findings. Volumes 2 through 23 present information summaries for each of the 22 categories of wells that were studied (Volume 21 covers two well categories). This volume, which is Volume 7, covers sewage treatment effluent disposal wells.

1. SUMMARY

Class V sewage treatment effluent wells are used in many places throughout the country for the shallow disposal of treated sanitary waste from publicly owned treatment works or treated effluent from a privately owned treatment facility that receives only sanitary waste. For the purpose of this study, injection wells that are used to dispose of industrial waste (not sanitary waste) from industrial wastewater treatment facilities (not publicly owned treatment works) are not sewage treatment effluent wells, but rather are industrial wells. In addition to being used for the purpose of wastewater disposal, sewage treatment effluent wells are commonly used where injection will aid in aquifer recharge or subsidence control, or to prevent salt water intrusion.

The effluent that is injected into sewage treatment effluent wells is generally subjected to secondary or tertiary treatment in a municipal wastewater treatment plant or a privately owned wastewater treatment plant. However, one facility identified in the study discharges effluent that is subject to only primary treatment to subsurface disposal units. Secondary treated effluent may contain fecal coliform and nitrates at concentrations above primary maximum contaminant level (MCLs), and either secondary or tertiary treated effluent also may exceed secondary MCLs for chloride, sulfates, or total dissolved solids (TDS). Available injectate quality data for sewage treatment effluent wells indicate that injectate samples have exceeded MCLs for fecal coliform, nitrates, TDS, and pesticides at at least one facility; however, many of these reported exceedances are represented by only one or two injectate samples, and data are not available to indicate whether these exceedances are one-time events or routine occurrences. Also, available information indicates that at least one facility is permitted to discharge injectate that exceeds the secondary MCL for chloride.

Approximately 42 percent of the documented sewage treatment effluent wells are located in Florida, and approximately 700 of these wells (35 percent of the total documented inventory) are located in the Florida Keys and inject into shallow (<50 feet) aquifers that are of extremely poor quality and that are not likely to be used as sources of drinking water. Approximately 26 percent of the total documented well inventory are located in California. Other sewage treatment wells in Florida, Arizona, and other states, are used to inject treated wastewater effluent for aquifer recharge, and may be

injecting into aquifers of drinking water quality. Nearly 19 percent of the documented wells are located in Hawaii. Hawaii UIC regulations do not allow operation of sewage treatment effluent wells within one quarter mile of a drinking water source, and it is anticipated that many of these wells inject into aquifers that are not of drinking water quality. No data were provided by survey respondents concerning the characteristics of injection zones for other states where sewage treatment effluent wells are currently operated.

Several studies and incidents have shown that sewage treatment effluent wells may have contributed to or caused ground water or surface water contamination. One study showed nitrate contamination of onsite ground water at a sewage treatment effluent site in New Hampshire where both primary treated effluent and septage were released into a leach field. Two sewage treatment effluent wells on the Island of Maui, Hawaii were thought to be causing surface water contamination through migration of nitrates in the injectate to surface water bodies. One of these wells has been shut down and the other is the subject of an ongoing enforcement action by USEPA. The U.S. Geological Survey is conducting a long-term study of the operation of sewage treatment effluent wells in the Florida Keys to assess whether migration of nitrates from injectate is contributing to surface water contamination.

Sewage treatment effluent wells are not vulnerable to spills or illicit discharges. The injectate is treated wastewater, and the wastewater treatment plants that generate the injectate are generally subject to effluent quality standards and monitoring, reporting, and record keeping requirements. Incidents where injectate failed to meet injectate quality standards would generally be detected, and corrective action would be taken by the wastewater treatment plant operator. Moreover, sewage treatment effluent injectate is piped to the well from the wastewater treatment plant, so contamination in route is unlikely, and the types and quantities of hazardous materials that would be present at a wastewater treatment plants is limited. Spills of hazardous materials (e.g., chlorine) into the wastewater treatment plant system are unlikely and would also generally be detected by the wastewater treatment plant effluent monitoring system.

According to the state and USEPA regional survey conducted for this study, there are 1,675 documented sewage treatment wells, and more than 1,739 wells are estimated to exist in the U.S. More than 95 percent of the documented wells are located in five states: Arizona (79); California (205); Florida (830); Hawaii (378); and Massachusetts (105). New York did not report any documented sewage treatment effluent wells in the state, but reported that there may be less than 50 undocumented wells.

Considering that sewage treatment effluent wells are associated with either publicly or privately owned wastewater treatment plants that are generally required to have operating permits, the inventory of sewage treatment effluent wells is considered to be relatively accurate compared with other injection well categories for which wells do not always receive permits. Nevertheless, there may be a somewhat larger or smaller number of sewage treatment effluent wells than these results suggest. For example, New Hampshire did not report any sewage treatment effluent wells in the state in its survey response; however, two facilities that inject treated effluent into subsurface disposal units, classified as injection wells for the purpose of this report, were identified through field visits. Conversely, Maine initially identified 168 sewage treatment effluent wells in its survey response; however, further investigation revealed that these facilities are discharging untreated wastewater effluent to subsurface disposal units and are therefore classified as large-capacity septic systems and not as sewage treatment effluent wells. Although no state UIC programs other than Maine and New Hampshire are known to have miscategorized sewage treatment effluent wells, if other states have done so, the reported inventory may either overestimate or underestimate the true number of sewage treatment effluent wells in the U.S.

States with the majority of sewage treatment effluent wells have developed and implemented regulatory programs to permit these wells. Specifically:

- In Florida, sewage treatment effluent wells are required to have individual permits and to meet MCLs.

- In Hawaii, regulations have established ground water protection zones where the construction of sewage treatment effluent wells is prohibited. Wells outside of these zones are required to obtain individual permits.

- Arizona requires sewage treatment effluent wells to obtain ground water protection permits, and requires well operators to demonstrate that MCLs will not be exceeded beyond the facility property boundary. Arizona also has published best management practices (BMPs) for the operation of wastewater treatment plants (and their associated sewage treatment effluent wells).

- California requires sewage treatment effluent wells to obtain individual permits.

- Massachusetts requires sewage treatment effluent wells to obtain ground water discharge permits.

The regulatory picture in several other states with few sewage treatment effluent wells in the current inventory is varied. States either permit sewage treatment effluent wells by rule (e.g., Texas, Idaho), require them to obtain ground water protection permits (e.g., New Hampshire), or require them to obtain individual permits (e.g., West Virginia). Some states (e.g., New Hampshire) establish ground water compliance zones (generally at the site boundary) while others (e.g., Idaho) require injectate to meet MCLs at the point of injection. In Wisconsin, the operator of a facility that discharges sewage treatment effluent into a subsurface soil absorption system that is constructed in the unsaturated zone above the water table is required to obtain a Wisconsin Pollutant Discharge Elimination permit. Direct discharge into a saturated formation is prohibited in Wisconsin.

These state regulatory programs are supplemented by regulatory standards and guidelines that apply to the operation of municipal wastewater treatment plants under the authority of the Clean Water Act and associated state regulations. BMPs for wastewater treatment plants have also been established by USEPA under the Clean Water Act. These BMPs are equally appropriate for treatment plants that discharge to surface water and those that discharge (inject) into ground water.

2. INTRODUCTION

The existing UIC Program regulations in 40 CFR 146.5 do not include a definition of sewage treatment effluent disposal wells. However, USEPA's *1987 Report to Congress (RTC) on Class V Injection Wells* defined such wells as those that are intended to "dispose of the effluent from wastewater treatment plants by injecting the wastewater into or above USDWs" (USEPA, 1987). According to the RTC, sewage treatment effluent wells are separate and distinct from aquifer recharge and salt water intrusion barrier wells, even though aquifer recharge wells and salt water intrusion barrier wells may inject treated wastewater effluent (USEPA, 1987). This study maintains this distinction, discussing sewage treatment effluent wells in Volume 7, salt water intrusion barrier wells in Volume 20, and aquifer recharge and aquifer storage and recovery wells in Volume 21. Wells that inject solely sewage treatment effluent are discussed in this volume, even if one of the purposes of the wells is to provide a salt water intrusion barrier, to recharge an aquifier, or for aquifer storage and recovery. Therefore, six aquifer storage and recovery well systems that are proposed to inject solely treated effluent are discussed in this volume, and are not discussed in Volume 21. On the other hand, wells that inject sewage treatment effluent mixed with other waters for these other purposes are discussed in either Volume 20 or 21.

The definition of "well" includes not only what is generally thought of as a well (i.e., a bored, drilled, or driven shaft) but also "improved sinkholes" and subsurface fluid distribution systems. Therefore, leach fields and sinkholes used for subsurface disposal of treated effluent are also within the scope of this study (after Deuerling, 1999). Further, both publicly owned treatment works (POTWs) and privately owned treatment facilities receiving solely sanitary waste are addressed in this volume.[1] Wells used to inject effluent from a privately owned treatment facility that receives industrial waste, however, qualify as industrial wells. In addition, wells that inject sewage treatment effluent beneath the lowermost formation containing a USDW qualify as Class I injection wells rather than Class V wells (this study examines only wells that release sewage treatment effluent into or above USDWs). Finally, large-capacity septic systems that dispose of sanitary waste from multiple dwellings business establishments are addressed separately in Volume 5, and dry wells used to dispose of raw (untreated) sanitary waste are classified as cesspools, which are being addressed in an initial UIC rulemaking on known high-risk Class V wells.

Since freshwater can be a costly and limited resource, more communities, especially those in arid regions of the U.S., are trying to derive some secondary benefits from treated wastewater effluent.

[1] Sanitary waste means liquid or solid waste originating solely from humans and human activities, such as wastes collected from toilets, showers, wash basins, sinks used for cleaning domestic areas, sinks used for food preparation, clothes washing operations, and sinks or washing machines when food and beverage serving dishes, glasses, and utensils are cleaned.

Most sewage treatment effluent wells are designed to also aid in aquifer recharge, subsidence control, or maintenance of a salt water intrusion barrier (Greeley and Hansen, 1991; Miller, 1991; Mills, 1991; O'Hare et. al, 1986; USEPA, 1987; Dellinger, 1997). The use of Class V injection wells that are designed exclusively for the purpose of sewage treatment effluent disposal appears to be limited.

3. PREVALENCE OF WELLS

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

As shown in this table, a total of 1,675 documented Class V sewage treatment effluent injection wells were reported in 15 of the UIC programs surveyed. In addition to these documented wells, USEPA Region 2 estimated less than 50 sewage treatment effluent wells in New York. Oregon UIC program estimated three sewage treatment effluent wells, and five UIC programs said that the true number of sewage treatment effluent wells in their states is unknown. The total estimated number of wells in the U.S. is greater than 1,739.

Because most Class V sewage treatment effluent wells programs require operating permits, this inventory information is considered relatively accurate when compared with the inventories for other types of Class V wells that are not regularly permitted (e.g., agricultural drainage wells). The true number, however, may be higher or lower than that shown in Table 1. For example, the total national inventory may be higher if some of the salt water intrusion barrier wells in New York, New Jersey, Florida, and Washington are in fact injecting only sewage treatment effluent (these wells are counted as salt water intrusion barrier wells in Volume 20 because the UIC programs did not indicate whether any of the wells are injecting treated effluent). Conversely, the total national inventory may be lower if some programs incorrectly counted large-capacity septic systems as sewage treatment effluent wells. While no states are known to have done so, for the final inventory shown in Table 1, the State of Maine originally classified 168 large capacity septic systems as sewage treatment effluent wells.

Similarly, competing factors may change the number of sewage treatment effluent wells in the future. In particular, the number of wells may decrease as more industrial facilities are able to discharge their sanitary wastes into municipal sewer systems. Conversely, the number of wells may increase as sewage treatment effluent is used more broadly for other purposes. The State of Washington has recently authorized the injection of tertiary treated effluent for aquifer storage and recovery (ASR) on a pilot basis. The Washington UIC program indicated that to

Table 1. Inventory of Sewage Treatment Effluent Wells in the U.S.

State	Documented Number of Wells	Estimated Total Number of Wells[a]	
		Number	Source of Estimate and Methodology
USEPA Region 1			
NH	29	unknown	Information collected by USEPA on two sewage treatment facilities during 1999 field visits to the New Hampshire Department of Environmental Services.
MA	105	105	Telephone conversation with Ms. Mary Beth Costello, Massachusetts Department of Environmental Protection, Bureau of Resource Protection (Costello, 1999).
ME	0	0	Mark Hyland of the Maine Department of Environmental Protection reported that the original estimate of 168 sewage treatment effluent wells reported in the Maine UIC program survey response were actually large-capacity septic systems; no sewage treatment effluent wells exist in Maine (Hyland, 1999).
USEPA Region 2			
NY	0	< 50[b]	Best professional judgement of USEPA Region 2.
PR	0	unknown	Territorial UIC program and USEPA Region 2 indicated in the survey that treatment effluent wells exist in Puerto Rico, but none are documented and no estimate is available.
USEPA Region 3			
WV	9	9	Permit program data.
USEPA Region 4			
FL	830[c]	830[c]	Permit program data and telephone conversation with Richard Deuerling with the Florida Department of Environmental Protection in Tallahassee, Florida (Deuerling, 1999).
KY	NR	unknown	State officials indicated that these wells do exist in Kentucky, but the Kentucky UIC program did not complete the survey, and no information is available concerning the number or location of such wells in the state (Goodman, 1999).
USEPA Region 5			
MI	0	11	USEPA Region 5 estimate.
OH	8	8	Data from Local Health Departments, UIC program inspections, and conversations with personnel from Ohio EPA District Offices, as reported in the survey response by Ohio EPA.
WI	3	3	Surveys conducted by Wisconsin Department of Natural Resources in 1989 and 1996.

Table 1. Inventory of Sewage Treatment Effluent Wells in the U.S.

State	Documented Number of Wells	Estimated Total Number of Wells[a]	
		Number	Source of Estimate and Methodology
Tribal Program	NR	NR	NA
USEPA Region 6			
TX	10	10	Telephone conversation with Steve Musick, Texas Natural Resource Conservation Commission, Ground Water Assessment Section, Water Quality Division (Musick, 1999).
USEPA Region 7			
NE	1	Unknown	Permit program data. The Nebraska UIC program reported that it does not have the resources available to prepare an estimate of the number of undocumented wells in the state.
USEPA Region 8			
WY	8	8	Permit program data.
USEPA Region 9			
AZ	79	79	Best professional judgement of the Arizona UIC program.
CA	205	unknown	Permit program data.
HI	378	378	Permit program data.
USEPA Region 10			
ID	8	8	Permit program data.
OR	2	>5[d]	Onsite and UIC staff estimates and UIC Database (updated 12/98) provided by Calvin Terada, of USEPA Region 10, per telephone conversation with Oregon UIC program personnel (Terada, 1999).
All USEPA Regions			
All States	1,675	> 1,739	The total estimated number counts the documented number when the estimated number is unknown or NR

NR Although USEPA regional, state and/or territorial officials reported the presence of the well type, the number of wells was not reported, or the response was not returned.

N/A Not Applicable.

a Unless otherwise noted, the best professional judgement for the estimated number of wells is that of the state or USEPA regional staff completing the survey response.

b Including less than 50 "estimated" sewage treatment wells but not including an "estimated" 200 salt water intrusion barrier wells for which the source of injectate could not be determined. These are counted as salt water intrusion barrier wells in Volume 20.

c In addition to the 824 documented sewage treatment effluent wells in Florida, there are six aquifer storage and recovery (ASR) facilities that are proposed to use reclaimed water (treated effluent) as injectate. These six wells are counted here as sewage treatment effluent wells because treated sewage, in the form of reclaimed water, is the only fluid injected below ground as part of the operation of these ASR wells.

d Including two documented and three estimated sewage treatment injection wells.

their knowledge there are no ASR wells injecting treated effluent, but expect that some such wells may become operational in the future. Florida has six ASR facilities that propose to use only reclaimed water (treated effluent) as injectate. These ASR systems are discussed in this volume and not in Volume 21.

Almost 97 percent of the documented sewage treatment effluent wells were reported in only five of the surveyed states: Arizona, California, Florida, Hawaii, and Massachusetts. Based on the estimate provided in the survey, New York may also have a relatively large number of sewage treatment effluent wells. A summary of the wells reported in these an other states is provided below.

Arizona

Arizona UIC program staff reported 79 sewage treatment effluent wells operating in the state, based on best professional judgement. The state program reported that some of these wells are believed to be receiving injectate from sources other than domestic wastewater treatment plant effluent; however, the number of wells receiving sewage treatment effluent mixed with other fluids were not provided in the survey response. Therefore, all 79 of the reported wells are included in the sewage treatment well inventory in Table 1. The Arizona Department of Environmental Quality (ADEQ) indicated that the majority of the wells are located in areas in the central and southeastern portions of the state that are not sparsely populated areas, and that the majority of the wells are located above state-designated aquifers (Day, 1999).

California

The Santa Ana Regional Water Quality Control Board (RWQCB) reported that there are 204 sewage treatment effluent wells operating in the region. The San Diego RWQCB reported that there is one operating sewage treatment effluent well in the San Diego region. The Santa Ana RWQCB also reported that there are an unknown number of privately-owned and undocumented leach fields (subsurface disposal units) that discharge treated effluent operating in the region. The other six RWQCBs in California did not complete survey responses for sewage treatment effluent wells.

The Chevron El Segundo Refinery has applied for a permit for ground water injection of recycled water to a liquid hydrocarbon recovery system at the refinery. Chevron had been injecting filtered ground water into the contaminated aquifer beneath the refinery as part of an aquifer remediation and aquifer recharge project. The RWQCB approved the redesignation of the aquifer, which would be required under California regulations for the injection of tertiary treated water into an aquifer. The West Basin Municipal Water District (WBMWD) which would supply the recycled water, indicated that approvals by the California Water Resources Control Board and the USEPA for this proposed project were anticipated in March 1999 (WBMWD, 1999).

Florida

Florida UIC program staff reported 824 documented sewage treatment effluent wells in in the state, based on permit program data, and reported no additional estimated wells that are not documented. The Florida UIC program also reported six proposed ASR wells that have applied for permits to inject only treated effluent; these are included in the inventory of sewage treatment effluent wells in Table 1. The permit status of these six ASR facilities, as of December 1998, is summarized in Table 2. More than 700 of the 830 sewage treatment effluent wells in Florida are located in the Florida Keys (Monroe County), mostly in areas where there are no USDWs.

Florida UIC program staff also reported that there are 34 ASR injection well facilities for which owners or operators have applied for construction or operating permits. Five of the 34 ASR facilities are conducting operational testing, and six have received state operating permits. Besides the six ASR facilities that are counted in the sewage treatment effluent well inventory because they are proposed to inject only sewage treatment effluent, the other ASR facilities in Florida are injecting (or will inject) a mixture of sewage treatment effluent and other fluids. These other facilities are discussed in Volume 21 on Aquifer Recharge and Aquifer Storage and Recovery Wells.

Hawaii

Hawaii UIC program staff reported 378 documented and no additional sewage treatment effluent injection wells operating in the state, based on permit records. All 378 injection wells receive effluent that is solely sanitary wastewater subject to secondary wastewater treatment. The Hawaii UIC program reported the locations of each sewage treatment effluent well operating in the state in the survey response.

Massachusetts

Massachusetts UIC program staff reported 105 documented sewage treatment effluent wells operating in the state, and did not report any additional estimated wells in the state that are not documented.

Michigan

Michigan UIC program staff did not provide an estimate of the number of sewage treatment effluent wells in its survey response. The injection well inventory provided by the state UIC program did not categorize Class V wells by well type. USEPA Region 5 staff, however, estimated that 11 sewage treatment effluent wells exist in Michigan based on a review of its injection well inventory.

Table 2. Aquifer Storage and Recovery Facilities Injecting Only Sewage Treatment Effluent in Florida

Facility Name	ASR Type*	Pre-Application	Construction Application Received	Construction Permit Issued	Well Constructed	Operational Testing	Operation Permit
Venice Gardens	RCW	X					
Englewood	RCW		X				
Hillsborough County NW	RCW				X		
New Smyrna Beach Expl.	RCW			X			
Manatee Southwest	RCW			X			
St. Petersburg SW	RCW		X				

***ASR Types:** RCW-Reclaimed water (i.e., sewage treatment effluent)

New Hampshire

New Hampshire UIC program staff did not report any sewage treatment effluent wells in its survey response. However, permit data collected during a USEPA field visit to the New Hampshire Department of Environmental Services indicate the existence of two domestic sewage treatment operations that discharge treated effluent into underground leach field systems. These facilities have been issued Discharge to Ground Water Permits by the State of New Hampshire Department of Environmental Services. One of these systems, operated by the Town of Ossipee, discharges both primary treated effluent and untreated septage[2] to ground water through 24 subsurface leach fields. The other system, located in the Town of Weare and operated by All Clear Services, discharges tertiary treated effluent from a Solar Aquatics System© (SAS) wastewater treatment system to a series of five subsurface discharge units. According to the Class V survey criteria, these subsurface discharge systems are classified as sewage treatment effluent injection wells. For the purposes of the inventory in Table 1, therefore, each individual subsurface discharge point is classified as an individual injection well.

New York

New York UIC program staff reported no documented sewage treatment effluent wells operating in the state, but USEPA Region 2 estimated that less than 50 sewage treatment effluent wells may exist in the state that are not documented. USEPA Region 2 did not provide any additional information concerning this estimate, which is based on their best professional judgement.

Oregon

Oregon UIC program staff reported two documented wells. It also estimated three additional sewage treatment effluent wells, but stated that this value represents an underestimate of the total number of such wells likely to exist in the state. The state believes that some facilities may be installing numerous smaller capacity injection wells to take advantage of exemptions from permit requirements for individual injection wells. These small capacity wells do not require permits and are, therefore, not in the state program inventory.

Texas

Texas UIC program staff reported that there is only one facility in the state that operates sewage treatment effluent wells, and that 10 such wells are operated at this location.

Wisconsin

Wisconsin UIC program staff reported three documented sewage treatment effluent wells. The Wisconsin Department of Natural Resources (WDNR) indicated that it expects that two of the three

[2] Septage is the sludge material pumped from sewage septic tanks when they are cleaned.

documented wells will be abandoned within five years because of the availability of sewer connections (WDNR, 1999).

Wyoming

Wyoming UIC program staff reported a total of eight documented wastewater effluent injection wells operated at two locations in the state. First, the Teton Village Water and Sewer District operates three wells that inject treated wastewater from the Teton Village Wastewater Treatment Plant (WDEQ, 1993). Second, the Aspen/Teton Pines Water and Sewer District operates five wells that inject treated municipal wastewater from the Aspen/Teton Pines Wastewater Treatment Plant.

4. SEWAGE TREATMENT EFFLUENT CHARACTERISTICS AND INJECTION PRACTICES

4.1 Injectate Characteristics

The types and concentrations of injectate constituents for sewage treatment effluent wells will vary depending on the type of treatment the wastewater undergoes in the sewage treatment plant prior to injection. The type of treatment, in turn, depends on the quality of the raw wastewater that enters the treatment plant and the intended method of disposal of the treated effluent. Domestic wastewater may undergo four levels of treatment as defined by Perry (1975):

- Preliminary treatment involves equalization, which avoids overloading the treatment system during peak flows; neutralization of the pH; oil and grease removal; metallic ion removal; and screening/grit removal.

- Primary treatment removes settleable solids through sediments. Advanced primary treatment may involve the addition of chemical compounds that aid in coagulation of solids, removal of phosphorous, and increased biological oxygen demand (BOD) removal.

- Secondary treatment, according to Rhyner (1995), is "biological removal of dissolved organic matter and inorganic matter." Inorganic compounds of environmental concern in domestic wastewater include phosphate and nitrogen compounds (in the form of ammonia, organic nitrogen, and nitrates), which can degrade the quality of receiving waters. These compounds can also be removed in the secondary treatment stage of an appropriately designed wastewater treatment system. Rhyner states that secondary treatment may reduce BOD by 90 percent, and can significantly reduce nitrogen and phosphorous. Activated sludge and trickling filter processes are the most frequently employed secondary treatment methods in the United States.

- Tertiary treatment is defined as "any process that follows secondary biological systems" (Perry, 1975). Tertiary treatment may be used in specific instances where phosphorous and nitrogen (in the form of ammonia, organic nitrogen, and nitrates) remain at unacceptable levels in an effluent stream (Perry, 1975), and may also involve the removal of "pathogenic microorganisms and viruses" (NC, 1996). Several state UIC programs reported that sewage treatment effluent well operators are employing tertiary treatment systems to meet injectate quality limitations. Such systems, which may include sand filtration, reverse osmosis, or microfiltration systems, are able to produce a high quality effluent that when injected, poses low risk of ground water contamination (NRC, 1996; Horan, 1990). However, the risk to sensitive populations and ecological receptors posed by the underground disposal of tertiary effluent continues to be the subject of ongoing research (Goldman, 1999).

Injectate quality data provided by state UIC programs and obtained through field visits indicate that sewage treatment effluent disposed by underground injection is generally subjected to secondary treatment at a minimum, and in many cases effluent is subjected to tertiary treatment. However, one subsurface disposal unit was identified in the study where injectate receives only primary treatment prior to injection.

Survey respondents provided injectate data for only a few of the sewage treatment effluent injection wells in their jurisdictions and some respondents did not provide any data for these wells. Additional injectate data for sewage treatment effluent wells were obtained from follow-up research and telephone contacts with permitting agencies. Altogether, the available injectate data for sewage treatment effluent wells represent only approximately 1 percent of the total inventory of more than 1,675 documented wells (six facilities located in three states and comprising 21 wells). These data are summarized in Sections 4.1.1 through 4.1.4.

4.1.1 Overview of Injectate Quality

The following examples of injectate quality for sewage treatment effluent wells were taken from the literature, from permit documentation provided by state regulatory agencies through the Class V injection well survey, and from permit data obtained through field visits and telephone contacts with state regulatory agencies. This information is organized by state in order to reflect the specific monitoring requirements and results in the different states. Because of differences in these requirements, the injectate quality data obtained from one UIC program may not be directly comparable to the data obtained from another program.

Arizona

ADEQ staff indicated that there is some variability in injectate quality for sewage treatment effluent wells, but that approximately 90 percent of these wells operating in Arizona meet drinking water MCLs at the point of injection. ADEQ staff also indicated that the wastewater treatment plants discharging to injection wells in Arizona use some type of tertiary treatment system in order to meet effluent (injectate) quality standards. Of the 79 sewage treatment effluent wells in Arizona, 41 were reported to have tertiary treatment including sand filtration, six were reported to have reverse osmosis systems, and 32 were reported to have microfiltration (Day, 1999).

California

Representatives of the San Diego and Santa Ana RWQCBs indicated in the survey responses that the 205 sewage treatment effluent wells operating in their regions (other than the salt water intrusion barrier wells) receive treated effluent that is subjected to secondary treatment. However, injectate data were not provided for these wells.

Florida

The Manatee County Public Works Department ASR system well injects exclusively reclaimed water (treated effluent) and are therefore classified as sewage treatment effluent wells. Table 3 summarizes the injectate data for these wells. Injectate monitoring data indicate that the effluent discharged to the Manatee County ASR system well meets primary and secondary drinking water standards for the constituents monitored.

Table 4 presents injectate data for secondary treated wastewater effluent injected into sewage treatment effluent wells in the Pinellas Peninsula in west-central Florida (Rosenshein and Hickey, 1997). In Monroe County (southwest Florida) the Monroe County Health Department (MCHD) monitors injectate quality for sewage treatment effluent wells operating in the county. Table 5 presents injectate data for aerobically treated residential wastewater effluent published by the MCHD (MCHD, 1997).

Hawaii

The City and County of Honolulu, Hawaii Department of Wastewater Management (HDWM) published data on injectate characteristics for wastewater treatment plants injecting treated effluent into Class V injection wells (HDWM, 1997). The HDWM operates three wastewater treatment plants (WWTP) on the island of Oahu, including the Kahuku WWTP, Paalaa Kai WWTP, and Waimanalo WWTP. Each facility injects secondary treated wastewater into systems of injection wells. Tables 6, 7, and 8 show the constituents found in wastewater injectate for the three injection well systems for years between 1993 and 1997. The injectate data for the Kahuku, Paalaa Kai, and Waimanalo WWTPs show that fecal coliform concentrations exceeded the primary MCL of 1/100 ml, and that concentrations of TDS exceeded the secondary MCL of 500 mg/l.

Massachusetts

Massachusetts UIC program staff provided injectate quality data for three wastewater treatment plants that inject treated effluent; these include a municipal wastewater treatment plant, a school complex, and a condominium complex. Monthly monitoring report summaries were provided by the Massachusetts Department of Environmental Protection (MDEP) for the Edgartown Wastewater Treatment Facility in Edgartown, The Easton School Complex in Easton, and the Fuller Pond Condominiums Trust in Middleton, Massachusetts. Injectate quality monitoring and monthly

Table 3. Injectate Data for the ASR System at Manatee County Public Works Department Water Treatment Plant, Manatee County, Florida

Parameter	Drinking Water Standard[a] (mg/l, unless otherwise indicated)	Health Advisory Level (mg/l, unless otherwise indicated)	Range of Concentrations (mg/l, unless otherwise indicated)
Total Trihalomethanes (TTHMs)	0.08 (P)	NA	0.012 - 0.015
Gross Alpha	15 pCi/l (F)	15 pCi/l (C)	1.0 - 1.5 pCi/l
Dissolved Oxygen	NA	NA	5.61 - 8.11
Total Iron	Secondary MCL: 0.3 (F)	NA	<0.02 - 0.03
Conductivity	NA	NA	250 - 360 uhmos
Total Dissolved Solids (TDS)	Secondary MCL: 500 (F)	NA	180 - 205
pH	Secondary MCL: 6.5 - 8.5	NA	7.1 - 8.0
Chloride	Secondary MCL: 250 (F)	NA	16.4 - 21
Sulfate	500 (P) Secondary MCL: 250 (F)	D	79 - 90
Total Alkalinity	NA	NA	12.2 - 21.8

Data Source: Manatee County Public Works Department, 1996

Regulatory Status: D - Draft; F - Final; P - Proposed

– means no discharge limit, MCL, or HAL specified
16. indicates primary MCL
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
NA means Not Applicable

Table 4. Constituents of Injected Wastewater Effluent, Pinellas Peninsula, Florida

Constituent	Concentration (mg/L)	MCL (mg/l)	HAL (mg/l)
Boron, dissolved	ND - 0.36	–	0.6 (NC)
Cadmium, dissolved	ND	0.005	0.005
Cadmium, total recoverable	ND	0.005	0.005
Copper, dissolved	ND	1 (S)	--
Copper, total recoverable	ND	1 (S)	--
Iron, dissolved	ND - 0.08	–	--
Iron, total recoverable	ND - 0.13	–	--
Lead, dissolved	ND	0.015	--
Lead, total recoverable	ND - 0.001	0.015	--
Zinc, dissolved	ND - 0.05	5 (S)	--
Mercury, total	ND - 0.0002	0.002	0.002
Silica	5 - 22	–	--
Total Nitrogen	12 - 25	–	--
Organic Nitrogen	1.6 - 11	–	--
Nitrite, as N	0 - 3.4	–	--
Ammonia, NH_4 as N	5 - 23	--	--
Nitrate, as N	0 - 3.2	10	--
Total Phosphorus, as P	2.5 - 9.3	--	--
Dissolved Solids	460 - 2,200	500.0 (S)	--
pH	6.4 - 8.6	6.5 - 8.5 (S)	--
Dissolved Oxygen	4 - 8.2	--	--
Chemical Oxygen Demand	59 - 120	--	--
Biochemical Oxygen Demand 5-day	2 - 49	--	--
Biochemical Oxygen Demand 20-day	19 - 150	--	--
Total Organic Carbon	7 - 28	–	--

Source: Rosenshein and Hickey, 1997.

–	means no discharge limit, MCL, or HAL specified
(S)	indicates secondary MCL (no notation means the value is a primary MCL)
(NC)	means the reported health advisory level is for non-cancer effects
ND	means Not Detected

Table 5. Constituents of Injected Aerobically Treated Effluent, Monroe County, Florida

Constituent	Concentration (mg/L)				
	1995	1996	1997	MCL (mg/l)	HAL (mg/l)
$CBOD_5$	ND - 30.6	ND - 72	ND - 150	–	--
TSS	ND - 276	ND - 820	ND - 131	–	--
Total Nitrogen	1.04 - 92.65	ND - 85.6	1.1 - 68	–	--
Total Phosphorus	ND - 13.4	ND - 72	ND - 0.42	–	--
pH	7.4 - 7.8	NR	NR	6.5 - 8.5 (S)	--
Chlorine	0 - 0.05	NR	NR	250 (S)	–

NR - Not Reported
ND - Not Detected

Source: MCHP, 1997.

Table 6. Constituents of Secondary Treated Wastewater Injectate, Kahuku WWTP Oahu, Hawaii 1993-1997

Constituents	Concentration Ranges mg/L (except as noted)						
	1993	1994	1995	1996	1997	MCL (mg/l)	HAL (mg/l)
BOD_5	98 - 99	NR	1 - 4	1 - 3	1 - 6	–	--
Suspended Solids	98 - 99	NR	1 - 2	1 - 4	1 - 2	–	--
Turbidity (NTU)	NR	NR	0.3 - 0.88	0.2 - 2.4	0.07 - 1.3	–	--
pH	6.61 - 7.32	6.59 - 7.27	6.77 - 7.11	6.58 - 6.82	6.59 - 7.06	6.5 - 8.5 (S)	--
Chloride	0.5 - 3.98	0.28 - 2.28	0.15 - 0.9	0.14 - 0.48	0.10 - 0.81	250.0 (S)	--
Total Kjedahl Nitrogen	NR	<0.05 - 6	0.3 - 1.6	0.1 - 0.8	0.3 - 0.5	10 (Hawaii state standard)	--
Ammonia as N	NR	<1.0 - 5.2	<0.1 - 0.46	0.1 - 0.3	0.1 - 0.2	–	--
Dissolved Oxygen	NR	NR	1.9 - 4.31	2.83 - 8.67	4.7 - 5.12	–	--
Fecal Coliform (CFU/100 ML)	NR	NR	1 - 58	1 - 4	2 - 7	1/100 ml	--
Nitrate + Nitrite	NR	0.8 - 1.56	2 - 15	13.5 - 27.5	26.0 - 27.2	--	–
Total Phosphorous	NR	2.24 - 3.1	1.94 - 3.91	2.56 - 2.82	2.87 - 3.1	–	--
Ortho-phosphorous	NR	NR	1.87 - 3.21	2.24 - 2.71	2.61 - 3.1	–	--
TDS	NR	NR	292 - 463	420 - 4,586	420 - 449	500.0	--
Surfactants	NR	NR	0.25 - 0.5	0.25 - 0.5	NR	0.5 (S)	–

Source: HDWM, 1997.

NR - Not Reported

Table 7. Constituents of Secondary Treated Wastewater Injectate, Paalaa Kai WWTP, Oahu Hawaii 1993-1997

Constituents	Concentrations mg/L (except as noted)						
	1993	1994	1995	1996	1997	MCL (mg/l)	HAL (mg/l)
BOD_5	98 - 100	99 - 100	2 - 6	3 - 7	3 - 6	–	--
Suspended Solids	97 - 100	99 - 100	1 - 6	2 - 6	1 - 4	–	--
Turbidity (NTU)	NR	NR	0.8 - 3.3	0.6 - 2.1	1.1 - 3.5	–	--
pH	6.53 - 7.2	6.5 - 7.39	6.82 - 7.3	6.87 - 7.4	6.84 - 7.28	6.5 - 8.5 (S)	--
Chloride	4.12 - 12.6	1.44 - 7.25	0.86 - 3.92	0.22 - 257	0.98 - 3.38	250.0 (S)	--
Total Kjedahl Nitrogen	NR	8.2	5.9 - 10.2	1.9 - 8.8	5.6 - 10.1	10 (Hawaii state standard)	--
Ammonia as N	NR	6.2	2.7 - 7.1	1 - 7.4	3.7 - 8.4	–	--
Dissolved Oxygen	NR	NR	3.45 - 5.63	4.05 - 8.02	2.34 - 3.99	–	--
Fecal Coliform (CFU/100 ML)	NR	NR	1 - 155.5	1 - 10	1 - 170	1/100 ml	--
Nitrate + Nitrite	NR	1.72	0.7 - 2.8	0.05 - 6.8	0.26 - 8.4	–	--
Total Phosphorous	NR	2.31	3.0 - 4.51	2.7 - 5.2	2.29 - 3.7	–	--
Ortho-phosphorous	NR	NR	2.09 - 4.51	2.7 - 4.76	2.06 - 3.7	–	--
TDS	NR	NR	430 - 532	425 - 460	397 - 456	500.0	--
Surfactants	NR	NR	0.25 - 0.5	0.25	NR	0.5 (S)	–

Source: HDWM, 1997.

NR- Not Reported

Table 8. Constituents of Secondary Treated Wastewater Injectate, Waimanalo WWTP Oahu, Hawaii 1993-1997

Constituents	Concentrations mg/L (except as noted)						
	1993	1994	1995	1996	1997	MCL (mg/l)	HAL (mg/l)
BOD_5	5 - 69	3 - 39	65 - 99	6 - 44	5 - 235	–	--
Suspended Solids	4 - 69	2 - 47	4 - 48	3 - 22	2 - 202	–	--
Turbidity (NTU)	NR	NR	1.8 - 27.5	1.8 - 9.5	1.5 - 11.3	–	--
pH	6.94 - 7.31	6.89 - 7.28	6.81 - 7.21	6.88 - 7.3	6.69 - 7.33	6.5 - 8.5 (S)	--
Chloride	0.23 - 1.55	0.16 - 1.67	0.15 - 2.48	0.08 - 2.97	0.52 - 2.05	250.0 (S)	--
Total Kjedahl Nitrogen	NR	2.3 - 10.6	1.8 - 11.1	6.3 - 17.1	5.3 - 13	10 (Hawaii state standard)	--
Ammonia as N	NR	1.9 - 9.0	0.1 - 8.2	4.7 - 12.6	2.9 - 9	–	--
Dissolved Oxygen	NR	NR	1.34 - 2.86	1.47 - 2.33	2.16 - 5	–	--
Fecal Coliform (CFU/100 ML)	NR	NR	58 - 14,300	170 - 48,000	36 - 25,002	1/100 ml	--
Nitrate + Nitrite	NR	0.2 - 7.4	0.3 - 0.17	0.06 - 2.6	0.3 - 4.2	–	--
Total Phosphorous	NR	1.8 - 2.56	1.64 - 2.23	1.58 - 2.7	1.3 - 3.42	–	--
Ortho-phosphorous	NR	0.64 - 12.0	1.8 - 1.92	1.5 - 2.6	1.0 - 2.72	–	--
TDS	NR	NR	232 - 359	256 - 491	305 - 337	500.0	--
Surfactants	NR	NR	0.25 - 0.5	0.25 - 1.0	NR	0.5 (S)	–

Source: HDWM, 1997.

NR - Not Reported.

reporting is required for these facilities as a condition of each facility's ground water permit. Ms. Marybeth Costello of MDEP's Bureau of Resource Protection indicated that although the reported parameters differ somewhat from one ground water permit to another, the requirements for the three facilities for which data were provided represent the "usual" requirements for discharge to ground water. Effluent (i.e., injectate) quality data and influent quality data (i.e., the wastewater treatment plant influent prior to treatment) are provided for the three facilities in Tables 9, 10, and 11 (Costello, 1999; MDEP 1999a; MDEP 1999b).

Nebraska

The single documented well in the state, operated by the Deuel County POTW, receives wastewater effluent that is subjected to secondary treatment prior to injection. The Nebraska UIC program did not provide any injectate data for this injection well.

New Hampshire

The New Hampshire program did not provide any injectate quality data for sewage treatment effluent wells operating in the state. However, information collected for two facilities that discharge effluent from domestic sewage treatment systems into leach fields or subsurface disposal systems indicates that one facility discharges teritary treated effluents and the other discharges primary treated effluents.

Texas

The ten injection wells operated by the El Paso Public Service Board (PSB) inject sewage treatment effluent that is treated to drinking water standards. Injectate data for the El Paso PSB injection well field are included in Table 12.

Wyoming

Table 13 summarizes injectate monitoring data provided by the Wyoming UIC program for the Teton Village Wastewater Treatment Plant injection wells. For parameters not specifically identified in the facility's permit, effluent concentrations must not exceed Class I ground water standards listed in Chapter VIII of the Wyoming Water Quality Rules and Regulations. Injectate monitoring data indicate that the effluent discharged to the Teton Village injection wells meets state UIC permit limits and meets primary and secondary drinking water standards. In fact, primary and secondary drinking water standard parameters, including chlorinated and nonchlorinated organic compounds, were not detectable in the effluent. Metals concentrations and total coliform data were not reported for the effluent. Concentrations of chloride, ammonia, nitrate, BOD, TDS, cyanide, and total phenols were below state permit limits and Class I ground water standards (WDEQ, 1994).

Table 14 summarizes injectate monitoring data provided by the Wyoming UIC program for the Aspen/Teton Pines Wastewater Treatment Plant. For parameters not specifically identified in the UIC

Table 9. Monthly Injectate Data Report Summary - Edgartown Wastewater Treatment Facility, Ground Water Pollution Control Permit UIC 24-1

January 1999 Report	Concentration (mg/l)		MCL (mg/l)	HAL (mg/l)
Parameter	Influent	Effluent		
Fecal Coliform	NR	1/100 ml	1/100 ml	--
Total Dissolved Solids	NR	299.75	500.0 (S)	--
Total Suspended Solids	117.75	2.15	--	--
Total Solids	402.0	337.0	--	--
5-Day Biological Oxygen Demand	192.26	3.37	--	--
Chlorides	NR	155.0	250.0 (S)	--
Ammonia (as N)	NR	0.10	--	--
Nitrates (as N)	NR	0.95	10.0	--
Total Nitrogen	24.5	1.89	--	--
Oil and Grease	11.0	4.9	--	--
Sodium	NR	116.4	--	--
Total Volatile Organic Compounds (VOC)	NR	NR	--	--
pH	6.38	6.88	6.5-8.5 (S)	--
Monitored Wastewater Influent Flow Rate 84,484 gallons per day.				

NR means not reported
– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected

Table 10. Monthly Injectate Data Report Summary - Fuller Pond Condominiums Trust, Ground Water Pollution Control Permit UIC 1-250

January 1999 Report	Concentration (mg/l)		MCL (mg/l)	HAL (mg/l)
Parameter	Influent	Effluent		
Fecal Coliform	NR	NR	1/100 ml	--
Total Dissolved Solids	NR	NR	500.0 (S)	--
Total Suspended Solids	166.0	18.7	--	--
Total Solids	496.0	440.0	--	--
5-Day Biological Oxygen Demand	264.0	14.1	--	--
Chlorides	NR	NR	250.0 (S)	--
Ammonia (as N)	6.48	0.56	--	--
Nitrates (as N)	NR	7.50	10.0	--
Total Nitrogen	NR	10.9	--	--
Oil and Grease	NR	<3.0	--	--
Sodium	NR	NR	--	--
Total Volatile Organic Compounds (VOC) (annual average - ppb)	NR	NR	--	--
MBAS (foaming agents) (quarterly test)	NR	NR	--	--
pH (maximum)	6.92	7.05	8.5 (S)	--
pH (minimum)	6.54	6.51	6.5 (S)	--
pH (sampled)	6.74	6.86	6.5-8.5 (S)	--
Average Wastewater Effluent Flow Rate 23,840 gallons per day.				

NR means not reported
– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk

Table 11. Monthly Injectate Data Report Summary - Easton Schools Complex Treatment Facility, Ground Water Pollution Control Permit UIC SE-0-615

February 1999 Report	Concentration (mg/l)		MCL (mg/l)	HAL (mg/l)
Parameter	Influent	Effluent		
Fecal Coliform	NR	16/100 ml	1/100 ml	--
Total Dissolved Solids	NR	NR	500.0 (S)	--
Total Suspended Solids	<10.0	<10.0	--	--
Total Solids	430.0	410.0	--	--
5-Day Biological Oxygen Demand	42.0	3.0	--	--
Chlorides	NR	NR	250.0 (S)	--
Ammonia (as N)	9.8	NR	--	--
Nitrates (as N)	NR	3.6	10.0	--
Total Nitrogen	NR	6.9	--	--
Oil and Grease	<5.0	<5.0	--	--
Sodium	NR	NR	--	--
Total Volatile Organic Compounds (VOC)	NR	NR	--	--
pH	7.17	7.34	6.5-8.5 (S)	--
Monitored Maximum Wastewater Influent Flow Rate 10,610 gallons per day.				

NR means not reported
– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk

Table 12. El Paso Water Utilities Public Service Board Permit Limits and Monitoring Requirements for Sewage Treatment Effluent Wells

Parameter	Monitoring Frequency	Monitoring Data 12/98	Monitoring Data 1/99	Discharge Limit (mg/l)	MCL (mg/l)	HAL (mg/l)
Chlorides	Twice Weekly	236.0	201.0	300.0	250.0 (S)	--
Sulfates	Twice Weekly	70.0	79.0	300.0	500.0	--
Nitrates (as N)	Every Eight Hours	7.01	5.03	10.0	10.0	--
Turbidity	Every Eight Hours	0.31 JTU	0.2 JTU	1.0 NTU	–	–
Arsenic	Every Two Weeks	0.002	0.002	0.05	0.05	0.002 (C)
Barium	Every Two Weeks	0.027	0.023	1.0	2.0	2.0 (NC)
Cadmium	Every Two Weeks	0.0005	0.0005	0.005	0.005	0.005 (NC)
Chromium (total)	Every Two Weeks	0.005	0.005	0.05	0. 1	0.1 (NC)
Copper	Every Two Weeks	0.0054	0.008	1.0	1.3	--
Iron	Every Two Weeks	0.02	0.03	0.3	0.3 (S)	--
Lead	Every Two Weeks	0.005	0.005	0.05	0.015	--
Manganese	Every Two Weeks	0.01	0.02	0.05	0.05 (S)	--
Mercury	Every Two Weeks	0.0005	0.0005	0.002	0.002	0.002 (NC)
Selenium	Every Two Weeks	0.01	0.01	0.01	0.05	--
Silver	Every Two Weeks	0.001	0.001	0.05	0.1 (S)	0.1 (NC)
Zinc	Every Two Weeks	0.01	0.5	5.0	--	2.0 (NC)
Total Dissolved Solids	Twice Weekly	722.0	650.0	1000.0	500.0 (S)	--
Endrin	Quarterly	0.001	NR	0.0002*	0.002	0.002 (NC)
Lindane	Quarterly	0.001	NR	0.0002*	0.0002	0.0002 (NC)
Methoxychlor	Quarterly	0.01	NR	0.04*	0.04	0.04 (NC)
Toxaphene	Quarterly	0.03	NR	0.005*	0.003	0.003 (C)
2, 4-D	Quarterly	0.00	NR	0.1*	0.07	0.07 (NC)
2, 4, 5-TP Silvex	Quarterly	0.0	NR	0.01*	0.05	0.05 (NC)

* Annual Average
– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
NR means Not Reported
ND means Not Detected

Table 13. Injectate Data from Wyoming UIC Program - Teton Village Water and Sewer District

WASTEWATER EFFLUENT (INJECTATE) MONITORING DATA - WYOMING UIC PROGRAM									
Monthly Average Data (mg/l)				UIC Permit Number 93-168				November 21, 1994 Monitoring Report	
Parameter	Effluent (Injectate) mg/l			Instantaneous UCL (Permit) Limit	4-Week Avg UCL Permit Limit	Annual Avg. Permit Limit	Class I Standard	MCL (mg/l)	HAL (mg/l)
	7/94	8/94	9/94						
Chloride	81.0	38.0	87.0	200.0	150.0	--	250.0	250.0 (S)	--
BOD (5-day)	3.99	4.3	0.45	15.0	10.0	--	--	--	--
Ammonia (N)	0.149	0.172	0.140	1.5	0.50	--	0.50	--	--
Nitrate (N)	2.17	2.60	1.63	15.0	10.0	--	10.0	10.0	--
TDS	160.0	200.0	310.0	600.0	--	450.0	1.0	500.0 (S)	--
Total Phenols	<0.01	<0.01	<0.01	0.050	--	0.10	0.001	--	4.0 (NC)
Total Cyanide	0.001	0.001	0.001	0.30	--	0.20	0.2	0.2	0.2 (NC)

Source: WDEQ, 1994

Table 13. Injectate Data from Wyoming UIC Program - Teton Village Water and Sewer District (continued)

WASTEWATER EFFLUENT (INJECTATE) MONITORING DATA - WYOMING UIC PROGRAM						
Annual Summary Data (mg/l)		**UIC Permit Number 93-168**			**November 21, 1994 Monitoring Report**	
Parameter	**Effluent (mg/l)**	**Instantaneous UCL (Permit) Limit**	**Annual Avg. (Permit) Limit**	**Class I Standard**	**MCL (mg/l)**	**HAL (mg/l)**
Benzene	ND	0.01	0.005	--	0.005	0.1 (C)
Carbon Tetrachloride	ND	0.01	0.005	--	0.005	0.03 (C)
1,2-Dichloroethane	ND	0.01	0.005	--	0.005	0.04 (C)
1,1-Dichloroethene	ND	0.014	0.007	--	0.007	0.007 (NC)
Trichloroethene	ND	0.01	0.005	--	0.005	0.3 (C)
1,1,1-Trichloroethane	ND	0.3	0.2	--	0.2	0.2 (NC)
Vinyl Chloride	ND	0.005	0.002	--	0.002	0.0015 (C)
o-Dichlorobenzene	ND	0.6	0.6	--	0.6	0.6 (NC)
(Cis) 1,2-Dichloroethene	ND	0.07	0.07	--	0.07	0.07 (NC)
(Trans) 1,2-Dichloroethene	ND	0.1	0.1	--	0.1	0.1 (NC)
p-Dichlorobenzene	ND	0.075	0.075	--	0.075	0.075 (NC)
1,2-Dichloropropane	ND	0.01	0.005	--	0.005	0.06 (C)
Ethylbenzene	ND	0.7	0.7	--	0.7	0.7 (NC)
Chlorobenzene	ND	0.1	0.1	--	--	--
Styrene	ND	0.1	0.1	--	0.1	0.1 (NC)
Tetrachloroethene	ND	0.01	0.005	--	0.005	0.07 (C)
Toluene	ND	1.0	1.0	--	1.0	1.0 (NC)

Table 13. Injectate Data from Wyoming UIC Program - Teton Village Water and Sewer District (continued)

WASTEWATER EFFLUENT (INJECTATE) MONITORING DATA - WYOMING UIC PROGRAM						
Annual Summary Data (mg/l)		**UIC Permit Number 93-168**			**November 21, 1994 Monitoring Report**	
Parameter	**Effluent (mg/l)**	**Instantaneous UCL (Permit) Limit**	**Annual Avg. (Permit) Limit**	**Class I Standard**	**MCL (mg/l)**	**HAL (mg/l)**
Total Xylenes	ND	10.0	10.0	--	10.0	10.0 (NC)
Total Trihalomethanes	ND	0.08	0.08	--	--	–

– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected

Source: WDEQ, 1994

Table 14. Injectate Data from Wyoming UIC Program - Aspen/Teton Pines Water and Sewer District

WASTEWATER EFFLUENT (INJECTATE) MONITORING DATA - WYOMING UIC PROGRAM										
1991 - 1996 Effluent Data (mg/l)							UIC Permit Number 89-391		Five Year Review of Operations 1996 Monitoring Report	
Parameter	Maximum Effluent (Injectate) Quality (mg/l)						Instantaneous UCL (Permit) Limit	Class I Standard	MCL (mg/l)	HAL (mg/l)
	1991	1992	1993	1994	1995	1996				
Chloride	117.7	75.6	99.3	65.0	81.7	66.8	250.0	250.0	250.0 (S)	--
BOD (5-day)	1.0	2.0	16.0	3.0	ND	ND	10.0	--	--	--
Ammonia (N)	ND	0.43	0.98	0.33	0.19	0.09	0.5	0.50	--	--
Nitrate (N)	4.20	4.95	3.16	4.48	3.29	2.99	10.0	10.0	10.0	--
TDS	407.0	343.0	334.0	327.0	324.0	324.0	500.0	1.0	500.0 (S)	--
Sulfates (SO_4)	27.0	42.0	22.0	25.0	22.0	19.0	250.0	--	500.0	--
Total Coliform	0.0	2.5	0.01	0.06	0.0	0.0	1/100 ml	--	1/100 ml	--
Total Cyanide	ND	ND	ND	ND	ND	ND	0.20	0.2	0.2	0.2 (NC)
Total Phenols	0.060	ND	ND	0.060	ND	ND	0.001	0.001	--	4.0 (NC)

– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected

Source: WDEQ, 1996

permit, effluent concentrations must not exceed state Class I ground water standards listed in Chapter VIII of the Wyoming Water Quality Rules and Regulations. Monitoring data indicate that the effluent discharged to the Aspens/Teton Pines injection wells meets state permit limits and Class I ground water standards. In particular, concentrations of total coliform, chloride, ammonia, nitrate, BOD, TDS, cyanide, and total phenols were below state permit limits and Class I ground water standards (WDEQ, 1996). Concentrations of other primary and secondary parameters, including chlorinated and non chlorinated organic compounds and metals, were not reported.

4.1.2 Inorganic Constituent Concentrations

Effluent from plants treating domestic wastewater can contain inorganic compounds such as nitrates, ammonia, phosphorous, chlorides, and sulfates. Other parameters of importance include total dissolved solids (TDS) and total suspended solids (TSS), and fecal coliform and other biological constituents.

Nitrates/Ammonia

As summarized below, almost all available injectate data for nitrates and ammonia indicate that total nitrate concentrations are less than 10 mg/l, the MCL for nitrate (as N), and ammonia concentrations are less than 30 mg/l, the draft health advisory level for ammonia. The only exception is one sample from the Fuller Pond Condominiums Trust Facility in Massachusetts, which had a total nitrogen result that is slightly above the MCL of 10 mg/l.

- Data for the Teton Village Wastewater Treatment Plant in Wyoming indicate total ammonia concentrations (as N) ranging from 0.140 to 0.172 mg/l and total nitrate concentrations (as N) ranging from 1.63 mg/l to 2.17 mg/l (three data points, maximum monthly value).

- Data for the Aspen/Teton Pines Wastewater Treatment Plant in Wyoming indicate total ammonia concentrations (as N) ranging from non detectable to 0.98 mg/l, and total nitrate concentrations (as N) ranging from 2.99 mg/l to 4.95 mg/l (five data points, maximum annual value).

- Data for the Edgartown Wastewater Treatment Facility in Massachusetts indicate a total ammonia concentration (as N) of 0.10 mg/l, a total nitrate concentration (as N) of 0.95 mg/l, and a total nitrogen concentration of 1.89 mg/l (single data point, maximum monthly value).

- Data for the Fuller Pond Condominiums Trust Facility in Massachusetts indicate a total ammonia concentrations (as N) of 0.56 mg/l, a total nitrate concentration (as N) of 7.50 mg/l, and a total nitrogen concentration of 10.9 mg/l (single data point, maximum monthly value).

- Data for the Easton Schools Complex Treatment Facility in Massachusetts indicate a total nitrate concentration (as N) of 3.6 mg/l and a total nitrogen concentration of 6.9 mg/l (single data point, maximum monthly value). Injectate ammonia concentrations were not reported for this facility.

- Data for the El Paso Utilities Public Service Board facility in Texas indicate total nitrate (as N) concentrations of 7.01 mg/l and 5.03 mg/l for consecutive monthly samples. Injectate concentrations for ammonia were not reported for this facility.

Sulfates

Available injectate data for sulfates indicate that total sulfate concentrations are less than 500 mg/l, the proposed primary MCL, and less than 250 mg/l, the secondary MCL. Specifically:

- Data for the Manatee County ASR Facility in Florida indicate total sulfate concentrations ranging from 79 mg/l to 90 mg/l.

- Data for the Aspen/Teton Pines Wastewater Treatment Plant in Wyoming indicate total sulfate concentrations ranging from 19 mg/l to 42 mg/l.

- Data for the El Paso Utilities Public Service Board facility in Texas indicate total sulfates concentrations of 70.0 mg/l and 79.0 mg/l for consecutive monthly samples.

Chloride

As listed below, available injectate data for chloride indicate that total chloride concentrations are less than 250 mg/l, the secondary MCL, with the exception of one reported value in Hawaii.

- Data for the Manatee County ASR Facility in Florida show total chloride concentrations ranging from 16.4 mg/l to 21 mg/l.

- Data for the three Oahu County WWTP facilities in Hawaii show total chloride concentrations ranging from 0.22 mg/l to 257 mg/l. The highest reported value for the Paalaa Kai WWTP exceeds the 250 mg/l secondary MCL for chlorides.

- Data for the Edgartown Wastewater Treatment Facility in Massachusetts show a chloride concentration of 155 mg/l.

- Data for the El Paso Utilities Public Service Board facility in Texas show chloride concentrations of 236 mg/l and 201 mg/l for consecutive monthly samples. While these values do not exceed the secondary MCL of 250 mg/l, the discharge permit limit for this facility for chlorides is 300 mg/l, which exceeds the secondary MCL.

- Data for the Teton Village Wastewater Treatment Plant in Wyoming show total chloride concentrations ranging from 38 mg/l to 87 mg/l.

- Data for the Aspen/Teton Pines Wastewater Treatment Plant in Wyoming show total chloride concentrations ranging from 65 mg/l to 118 mg/l.

Total Dissolved Solids

Available injectate data for TDS indicate that total TDS concentrations are less than 500 mg/l, the secondary MCL with the exception of the El Paso Public Service Facility and the Kahuku WWTP in Hawaii, where maximum TDS concentrations exceeded the secondary MCL. Specifically:

- Data for the Manatee County ASR Facility in Florida indicate TDS l concentrations ranging from 180 mg/l to 205 mg/l.

- Data for the three Oahu County WWTP facilities in Hawaii indicate TDS concentrations ranging from 232 mg/l to 4,586.0 mg/l. The highest reported value for the Kahuku WWTP exceeds the 500 mg/l secondary MCL for TDS.
- Data for the Edgartown Wastewater Treatment Facility in Massachusetts indicate a TDS concentration of 300 mg/l.

- Data for TDS were not reported for the Fuller Pond Condominiums Trust Facility in Massachusetts. Total solids concentration (including 18.7 mg/l total suspended solids, or TSS) was reported as 440 mg/l.

- Data for TDS were not reported the Easton Schools Complex Treatment Facility in Massachusetts. Total solids concentration (including < 10 mg/l TSS) was reported as 410 mg/l.

- Data for the El Paso Utilities Public Service Board facility in Texas indicate TDS concentrations of 722 mg/l and 650 mg/l for consecutive monthly samples. These values exceed the secondary MCL for TDS of 500 mg/l, but do not exceed the discharge permit limit for this facility of 1,000 mg/l TDS.

- Data for the Teton Village Wastewater Treatment Plant in Wyoming indicate TDS concentrations ranging from 160 mg/l to 310 mg/l.

- Data for the Aspen/Teton Pines Wastewater Treatment Plant in Wyoming indicate TDS concentrations ranging from 327 mg/l to 407 mg/l.

4.1.3 Biological Constituents

Effluent from wastewater treatment plants that treat sanitary wastes contain biological constituents, including viral and bacterial pathogens. In general, the indicator parameter used for monitoring pathogens in wastewater treatment plant effluent is total fecal coliform. According to the Arizona Department of Environmental Quality, Best Available Demonstrated Control Technology

(BADCT) Guidance Document for Domestic and Municipal Wastewater Treatment (ADEQ, 1998), the drinking water standard for total coliform, 1 CFU/100 ml, is set as an indicator below which pathogenic bacteria, viruses, and protozoa are assumed to be absent. Other parameters of importance to wastewater treatment plant effluent are 5-day biological oxygen demand (BOD).

Fecal Coliform

Available injectate data for sewage treatment effluent wells indicate that fecal coliform concentrations do not necessarily meet drinking water standards. The ADEQ defines BADCT for fecal coliform for direct discharge to ground water as the “the absence of these pathogens in the discharge” and Idaho UIC regulations prohibit the injection of effluent containing any detectible coliform.

Total coliform monitored between 1991 and 1996 for the Aspen/Teton Village Wastewater Treatment Plant effluent were generally non-detectable, with the exception of two reported samples of 2.5/100 ml and 1.9/100 ml, both values exceeding the drinking water standard for fecal coliform of 1/100 ml. Injectate data provided by the Massachusetts UIC program indicated fecal coliform concentrations of 1/100 ml and 16/100 ml for the Edgartown and Easton Schools Complex Wastewater Treatment Facilities. The fecal coliform concentration for the Easton Schools Complex exceeded the drinking water standard of 1/100 ml, however this value represents only a single data point.

Fecal coliform concentrations in injectate for the three WWTP facilities in Oahu County, Hawaii ranged from 1 - 48,000 CFU/100 ml. Fecal coliform concentrations in the injectate exceeded the primary MCL of 1/100 ml for fecal coliform at all three WWTP facilities in Hawaii in each year for which data were reported.

BOD

For the Aspen/Teton Pines Wastewater Treatment Plant, all injectate data reported in the 1991- 1996 five-year review of operations were below 10 mg/l 5-day BOD with the exception of one value of 16 mg/l. For the Teton Village Wastewater Treatment Plant in Wyoming, 5-day BOD was controlled to less than 5 mg/l, as compared to the permit discharge unit of 10 mg/l. Injectate data provided by the Massachusetts UIC program indicated 5-day BOD concentrations of 3.0 mg/l and 3.37 mg/l for the Edgartown and Easton Schools Complex Wastewater Treatment Facilities, and a 5-day BOD concentration of 14.1 mg/l for the Fuller Pond Condominiums Trust.

4.1.4 <u>Organic Constituents</u>

The injectate released in sewage treatment effluent wells should not be typically contaminated with non-chlorinated organic compounds, or chlorinated organic compounds, as demonstrated by the available sampling results summarized below. While significant concentrations of pesticides also would not be expected, available sampling data suggest that they may be present above levels of concern at some facilities.

Chlorinated and Non-chlorinated Organic Compounds

Available monitoring data indicate that injectate to sewage treatment effluent wells meets primary and secondary drinking water standards for chlorinated and non-chlorinated organic compounds. Trihalomethanes and other chlorinated organic compounds were not detected in effluent from the Teton Village Wastewater Treatment Plant. Injectate data for the Manatee County ASR Facility in Florida indicate that injectate concentrations of total trihalomethanes range from 0.012 mg/l to 0.015 mg/l. Injectate data provided by the Wyoming UIC program for Teton Village and Aspen/Teton Pines Wastewater Treatment Plants indicate that concentrations of non-chlorinated organic compounds were below method detection limits.

Pesticides

Concentrations of pesticides in the El Paso Public Service Board facility injectate exceeded (based on a single quarterly sample) MCLs and HALs for lindane and toxaphene. The data indicate a lindane concentration of 0.001 mg/l, which exceeds the primary MCL and HAL for lindane of 0.0002 mg/l, and a toxaphene concentration of 0.03 mg/l, which exceeds the primary MCL and HAL for toxaphene of 0.003 mg/l.

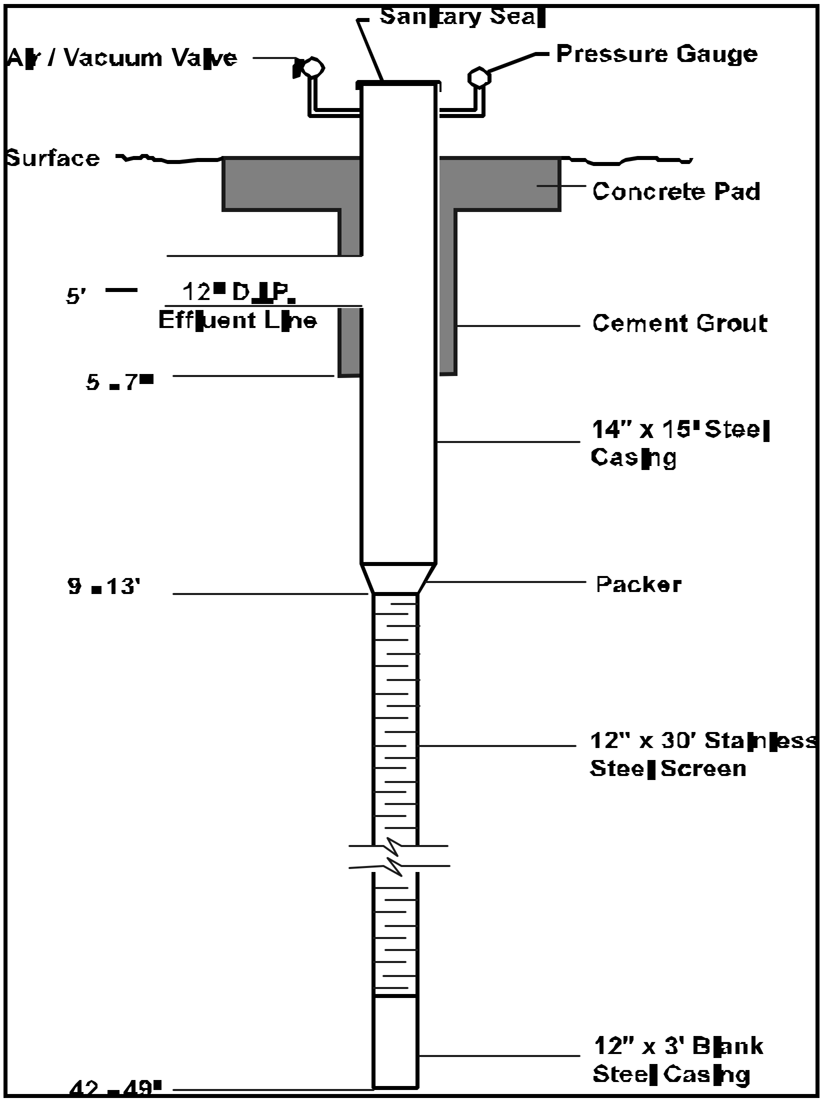
4.2 Well Characteristics

Most survey respondents did not provide data on well characteristics. However, information on a few operating sewage treatment effluent wells was obtained from literature sources and field visits. Figure 1 shows a schematic of a typical sewage treatment effluent injection well located in Florida. The characteristics of the well illustrated in Figure 1 are typical of sewage treatment effluent wells elsewhere; however, because the particular well is located in Florida where ground water tends to be shallow, the specific depths shown in the figure may not be appropriate for most sewage treatment effluent well sites across the United States.

Note also, as previously discussed in Section 2, that not all of the sewage treatment injection wells discussed in this volume are actually “wells” of the type depicted in Figure 1. Facilities that dispose of treated effluent through underground leach fields or other subsurface disposal units are also classified as sewage treatment effluent wells for the purpose of this report.

To help illustrate the characteristics of sewage treatment effluent wells, the following sections provide an overview of injection well siting, design, and construction criteria that are used in different state UIC programs. These characteristics are a function of the geology and hydrogeology of the area in which the well is constructed. As a result, the characteristics described below may be considered examples, but not necessarily representative of the total inventory of 1,675 documented sewage treatment effluent wells.

Figure 1. Typical Wastewater Effluent Injection Well



Source: USEPA, 1987

Florida

As mentioned in Section 3, more than 700 of the 830 sewage treatment effluent wells in Florida are located in the Florida Keys. These wells in the Florida Keys are typically installed in areas where the ground water is less than 50 feet in depth and contains more than 10,000 mg/l TDS, making it unsuitable for drinking water purposes. There are only two USDWs in the Florida Keys, on Key West and Big Pine Key, and the deepest ground water in these two USDWs is less than 50 feet deep. Drinking water is provided to the Florida Keys by aqueduct from mainland Florida.

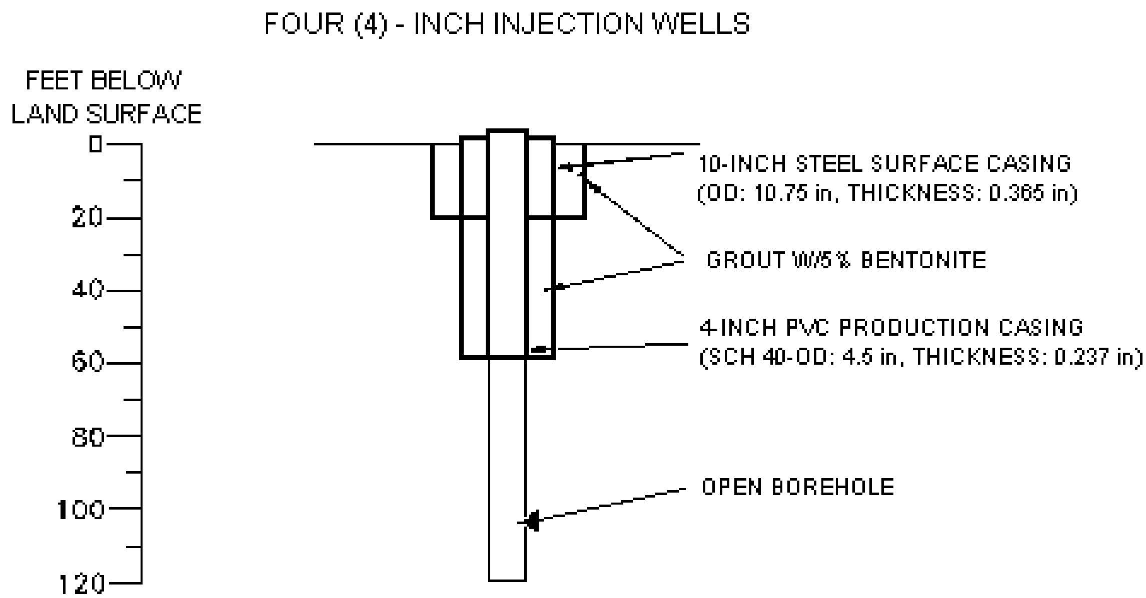
The Florida UIC program provided well siting and construction data for two proposed sewage treatment effluent well facilities and for one facility that is in operation. The existing facility and one of the two proposed facilities are publicly-owned aquifer recharge system wells, and the other facility is a privately-owned wastewater treatment plant. Well characteristics for these three facilities are described in this section.

Ocean Harbor Estates Wastewater Treatment Plant. Ocean Harbor Estates, located in Ocean Ridge, Florida, applied for permits to construct two Class V Injection Wells to dispose of treated effluent from a privately owned treatment facility serving 15 single family homes. Figure 2 is a diagram of the proposed injection well. The proposed well is 4 inches in diameter with a 10-inch steel surface casing. The 4-inch PVC casing depth is 60 feet and the open borehole extends to 120 feet deep (Murray Consultants, 1998). The applicant proposes to inject the effluent into salt water at a depth of 100 to 120 feet. According to the permit applicant, there is a confining unit above the injection zone and the injectate is not anticipated to affect any USDW.

According to the permit application information provided to the Florida UIC program, the wells in Ocean Harbor Estates will be constructed in accordance with SFWMD Chapter 40E-3, with the casing and cementing requirement of FAC Chapter 62-532. Geophysical logging data will be taken during construction of the injection well and the data will be used to identify the 10,000 mg/l (drinking water quality) TDS ground water interface, along with the depth, thickness, and physical characteristics of the confining zone. After construction is completed, but prior to well operation, the well casing will be pressurized with an inflatable packer placed to within 5 feet of the well casing. The well will be pressurized to 55 psi and held at that pressure for one hour, with a 5 percent (2.8) maximum pressure decline required to meet FDEP requirements for well construction. After the mechanical integrity test is completed, a 4-hour constant rate discharge test will be performed on each well. The discharge test will be conducted at a constant rate of 30 gpm.

After the pumping test is completed, an 8-hour pre-operational injection test will be performed using the discharge water obtained from the pumping test. Water levels will be measured hourly for 24 hours prior to the test, at set intervals during the test, and for two hours after the test is completed. Water will be pumped into the injection well at a rate of 15 gpm during the injection test. Background ground water quality data will be obtained from the injection well and from monitoring wells prior to injection of treated wastewater. Background ground water samples will be tested for primary and secondary drinking water standards and minimum criteria parameters.

**Figure 2. Typical Injection Well Construction Details,
Ocean Harbor Estates at Ocean Ridge**



Source: Murray Consultants, Inc., 1998.

Hillsborough County ASR Reclaim Project. The total depth of the Hillsborough County ASR Reclaim Project injection well is 400 feet, with casing diameters of 28 inches at 50 feet depth, 24 inches at 180 feet depth, and 16 inches at 200 feet deep. The pilot hole for the well is 425 feet deep. Three monitoring wells will be constructed with the injection well, one of which is to have a monitoring interval depth of 300 - 400 feet (in the Lower Suwannee formation). The two other wells will have a monitoring depth of approximately 150 feet (in the Tampa Member formation). The casing diameter for the monitoring wells is six inches (FDEP, 1998).

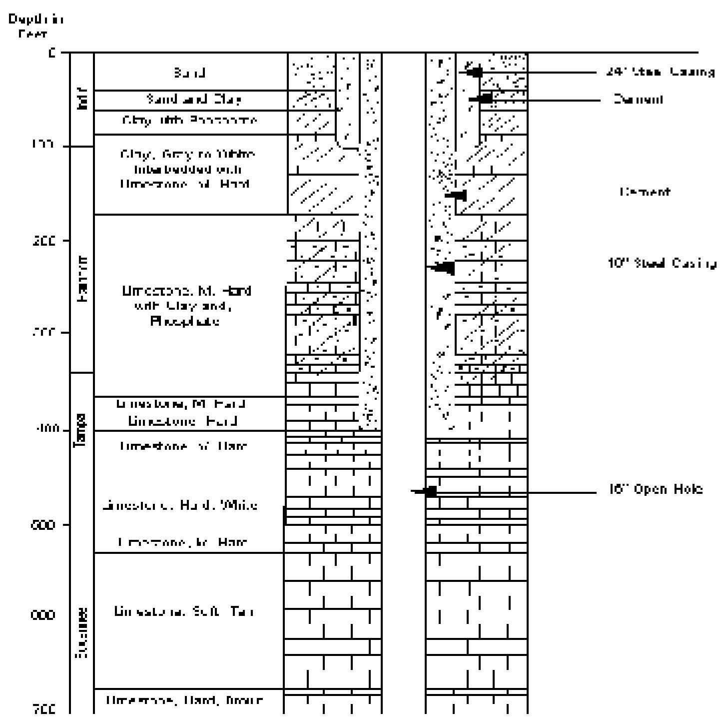
The well will be constructed under the supervision of a licensed Florida engineer, and daily progress reports will be submitted to the FDEP. As-built drawings of the injection well will be submitted to the FDEP after completion of construction. Data to be submitted to the FDEP prior to operational testing include lithologic/geophysical logs, injection zone background water quality, monitoring well background water quality, reclaimed water quality analysis, short term pump test data and evaluation, well completion specifications, and mill certificates for casings.

The operator will conduct operational testing of the injection well system to demonstrate that the well can assimilate the design daily flows before the FDEP will grant approval for operation. Monitoring equipment required for operational testing includes pressure gauges, flow meters, and recorders.

Manatee County Public Works Department Wastewater Treatment Plant -- Aquifer Storage and Recovery System. The Manatee County Public Works Department operates an ASR system consisting of two aquifer recharge and recovery wells. The well injects exclusively reclaimed water (treated effluent) into a limestone formation for storage and recovery (Pyne, 1995). Figures 3 and 4 illustrate the construction characteristics of the two wells and the characteristics of the formations in which the wells are constructed (Manatee County, no date). The two ASR system recharge wells each consist of a 24 inch inner diameter steel casing from ground level to a depth of 100 feet, a 16 inch inner diameter steel casing from ground level to a depth of 400 feet, and a 16 inch diameter open hole from 400 feet to 700 feet depth. Each 24 inch steel casing and 16 inch steel casing are grouted with cement. The Hawthorne formation, ranging in depth from 100 feet to 350 feet, is characterized by clay and medium hard limestone, and is a confining unit. At depths below 400 feet the Tampa formation is characterized by very hard limestone. At depths below 450 feet. the Suwannee formation ranges from hard white limestone, to soft tan limestone, to hard brown limestone at 700 feet. Below 700 feet, the Ocala limestone formation is a confining unit.

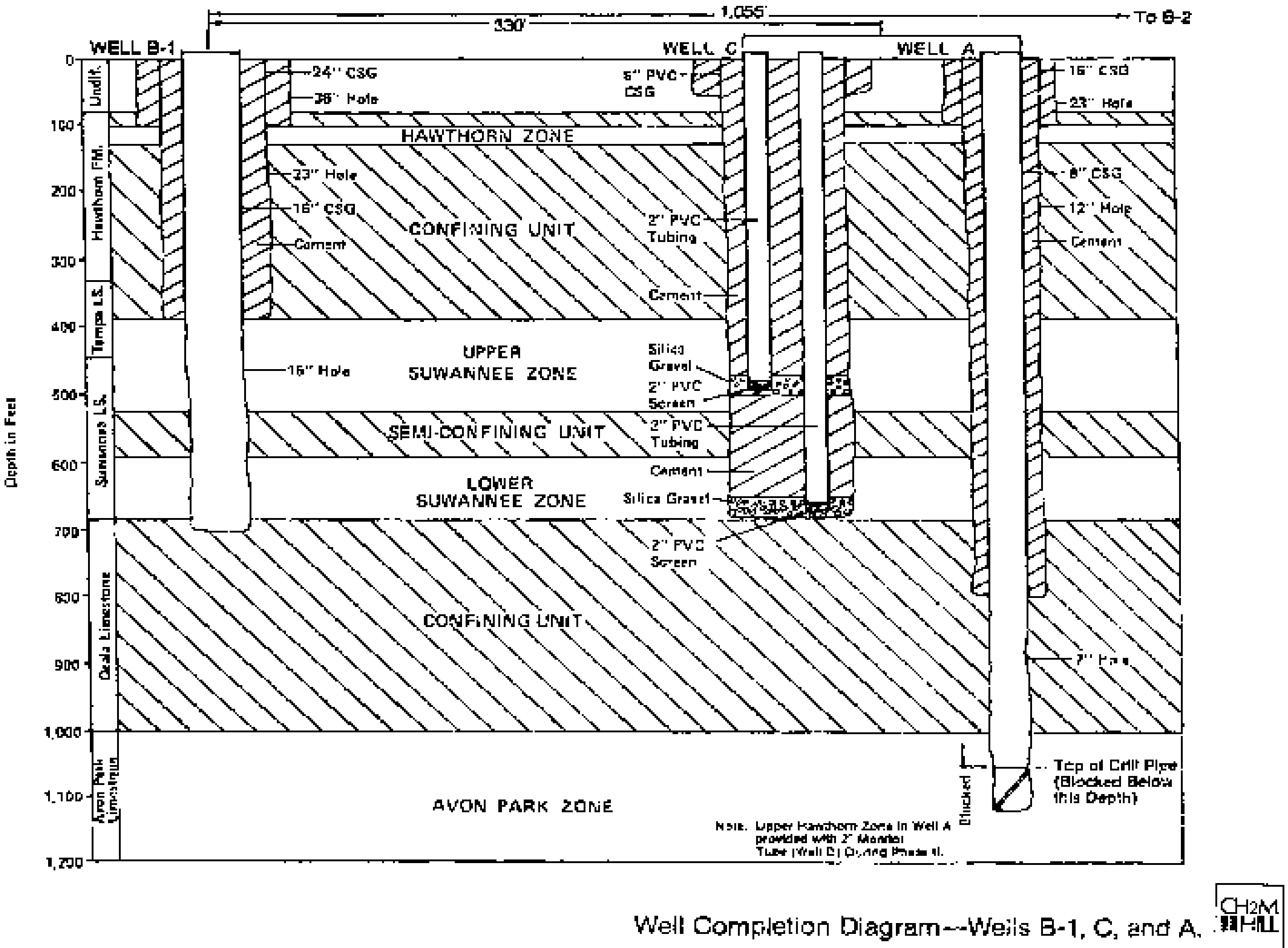
Pinellas Peninsular and Monroe County Aquifer Studies. The Pinellas Peninsula, an area in west-central Florida, contains numerous injection wells that introduce wastewater into saline limestone aquifers. Water stored in aquifers is used for various nonpotable uses, including recycling of wastewater effluent for sprinkler irrigation and aquifer storage for later nonpotable uses. Pinellas County plans call for a maximum storage capacity of 565 megaliters per day of treated effluent by 2002 (Rosenshein and Hickey, 1997). The Monroe County Health Department has estimated that there are currently 300 wastewater effluent injection wells that dispose of aerobically treated residential

Figure 3. Well Characteristics for Manatee County ASR System Recharge Well B-2



Well Completion Diagram — Well B-2. Manatee County Utilities Department

Figure 4. Well Characteristics for Manatee County ASR System Recharge Well B-1



wastewater, with an average daily injectate volume of 200 to 300 gallons per well. The MCHD considers the injectate volume range to be an estimate, since the population of the county varies seasonally. Injection generally occurs into limestone aquifer formations that are approximately 90 feet deep. The aquifer formation is characterized by saline ground water that is not suitable for drinking water purposes because of high dissolved solids content.

Hawaii

The Honolulu, Hawaii Department of Wastewater Management operates the Kahuku WWTP, Paalaa Kai WWTP, and Waimanalo WWTP in the island of Oahu. Each facility injects secondary treated wastewater to wells with depths ranging from 40 to 220 feet. Kahuku injects 0.4 million gallons per day (mgd) into six wells, Paalaa Kai injects 0.144 mgd into ten wells, and Waimanalo injects 0.7 mgd into seven wells.

New Hampshire

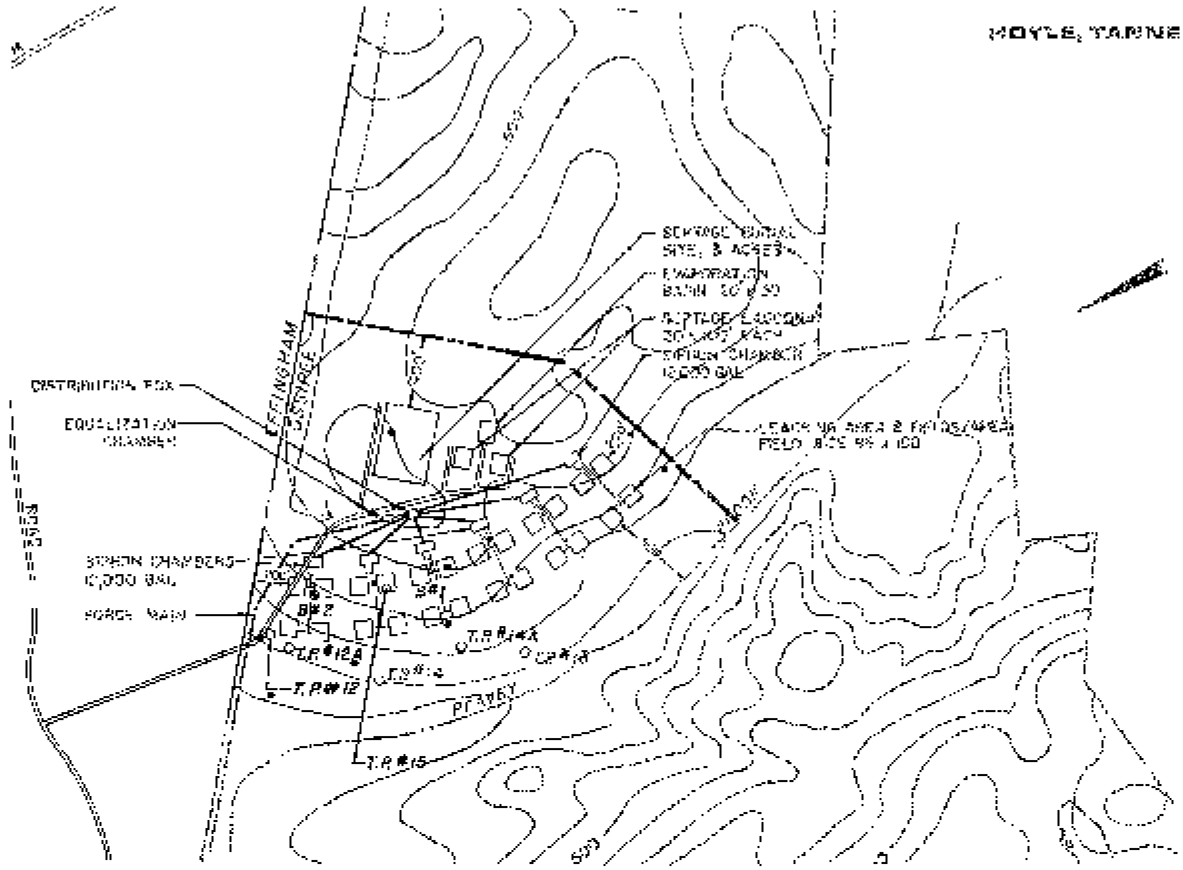
Well siting and construction data were collected for two facilities that discharge treated effluent from domestic sewage treatment systems to subsurface disposal units. These systems operate under State Discharge to Ground Water permits, and are classified as underground injection wells for the purposes of the survey.

Town of Ossipee Wastewater Treatment Facility Subsurface Treatment Facility. The Town of Ossipee Subsurface Treatment Facility was constructed in 1981, and consists of 24 leach fields that discharge primary treated wastewater effluent to ground water, and two septage lagoons that discharge untreated septage to ground water. The septage facility consists of two unlined septage lagoons, each 30' x 100' in area, one 20' x 30' evaporation basin, and a 3-acre septage burial site. The wastewater discharge facility consists of 12 leaching areas, each 96' x 100' in area, and each containing two leach fields. The 24 leach fields are supplied by six 12,000 gallon capacity siphon chambers. Primary treated effluent is suppled by a force main to an equalization chamber and distribution box, which supplies the siphon chambers and leach fields.

A plot plan of the Subsurface Disposal Facility is shown in Figure 5. Five ground water monitoring wells are situated around the Subsurface Treatment Facility, and there is also one surface water monitoring point located downstream of the facility on Peavey Brook upstream of the Plains Road Crossing. The closest leach fields are 500 feet from Peavey Brook and 200 feet from the facility boundary and the Ossipee Town Line. The 3 acre septage burial area is 400 feet from the closest facility boundary. The locations of the ground water monitoring wells are not clearly depicted in the facility plot plan, but the Discharge to Ground Water Permit for the facility indicates that all ground water monitoring wells are located within the Subsurface Treatment Facility Boundary (NHDES, 1997).

All Clear Services Solar Aquatics Wastewater Treatment System. The Solar Aquatics System© operated by All Clear Services is designed to treat domestic septage using a system of solar

Figure 5. Plot Plan For Town of Ossipee Subsurface Treatment Facility



Source: State of New Hampshire Department of Environmental Services, 1997.

tanks and a greenhouse. The characteristics of the SAS are described in the permit and permit application for the All Clear Services facility and in a literature article that describes a similar pilot-scale system located Harwich, Massachusetts (NHDES, 1996b; Teal and Peterson, 1993; EEA, 1999[3]). A plot plan of the All Clear Services SAS facility is shown in Figure 6.

Tertiary treated effluent is discharged to five subsurface disposal units. Each unit is 115 feet long, 5 feet in diameter, with 2.7 foot sidewalls, and filled with 1 ½ inch clean stone. The subsurface disposal units are buried under 12 inches to 18 inches of clean permeable backfill. The total effective area of the five subsurface disposal unit is 5,980 square feet. The subsurface disposal units are located on an approximately 111,000 square foot lot with an effective area of approximately 102,000 square feet (2.35 acres). The "effective area" does not include areas with greater than 35 percent slope or areas that are perennially wet. The subsurface disposal unit area is graded to shed storm water away from the subsurface disposal unit system. A typical cross section of a subsurface disposal unit system is shown in Figure 7 (Keyland, no date).

Texas

The ten injection wells operated by the El Paso Public Service Board (PSB) are positioned approximately three-quarters of a mile upgradient and one-quarter of a mile downgradient from the PSB's existing water system production wells. This position allows for a two-year retention time in the aquifer before the injected water is pumped into the El Paso water system by the PSB's production wells. The Hueco Bolson aquifer, which contains fresh water to a depth of 1,200 feet, provides more than 55% of El Paso's municipal water supply.

Figure 8 shows the schematic of a typical well design used for the injection wells located in El Paso. These wells have the following characteristics in common. First, each well has a gravel envelope, or pack, consisting of graded particles around the well screen. These particles are placed opposite to the production zones and are above the water table. This position prevents the pumping of particles during backwashing. The screen design for the wells are designed in such a way as to limit the discharge velocity of the effluent to 0.01 ft/s. This design was incorporated into the wells in order to limit (1) the occurrence of erosion within the aquifer's sand and clay layers; (2) the turbulence that could displace the gravel pack; and (3) the potential for well screen corrosion. Each well consists of a 3 ½-inch injection line that is used to recharge the reclaimed water. In addition, a 2-inch transducer pipe is used to measure the hydrostatic buildup in the well. Lastly, treated water from the Fred Hervey Water Reclamation Plant is pumped through a 30-inch pipe and then is distributed into each well through 8-inch diameter pipes.

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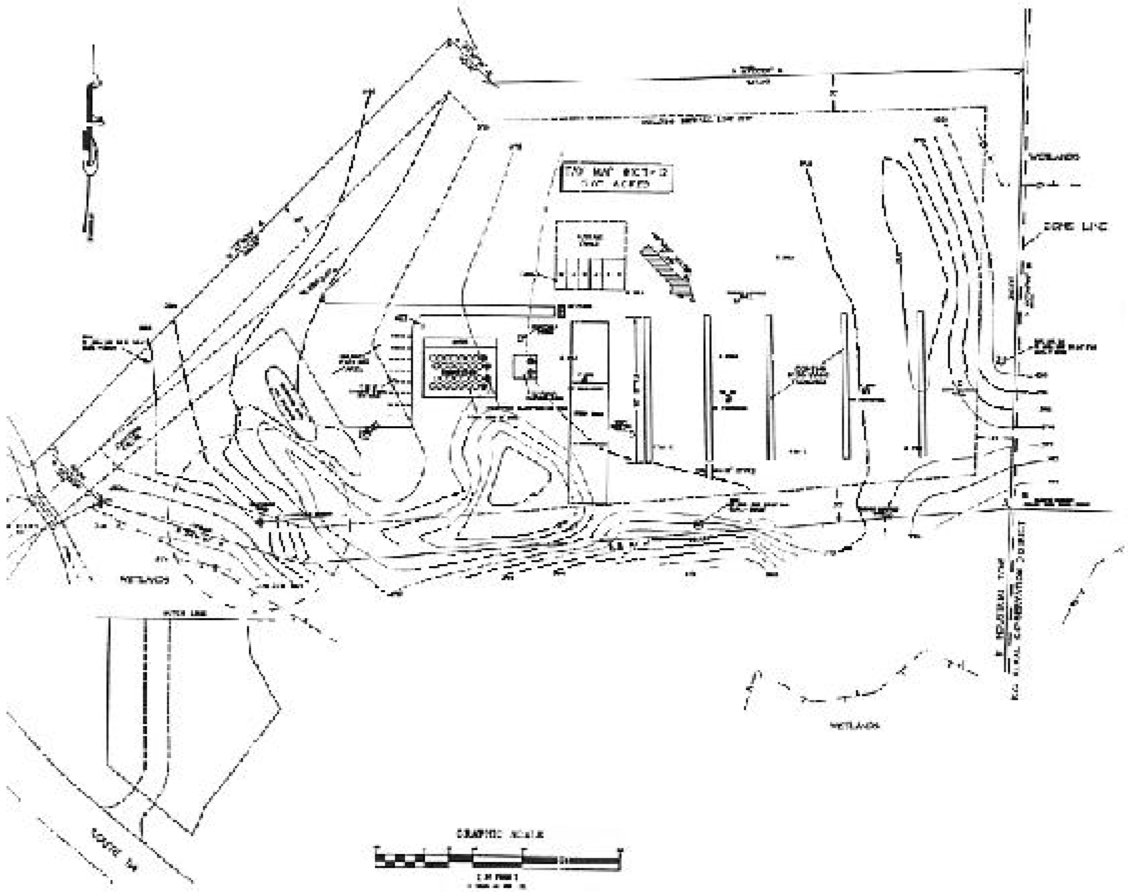
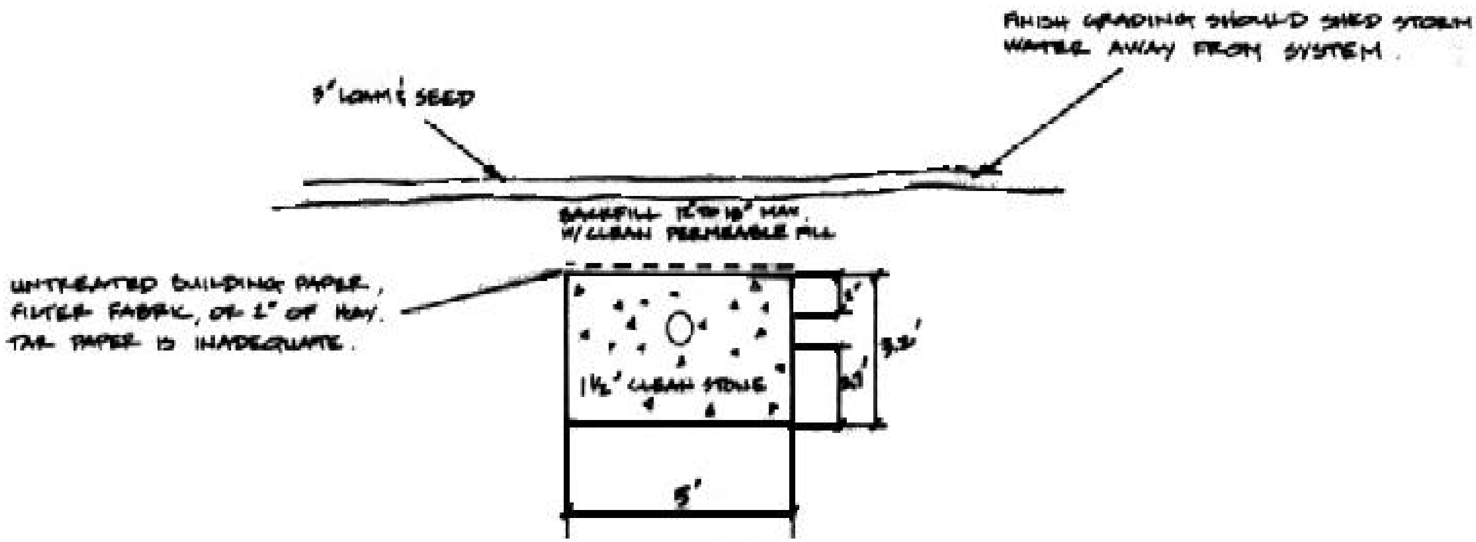
[3] Literature sources indicate that there are several Solar Aquatics System© facilities operating in Massachusetts that discharge to ground water, including a facility in Weston, Massachusetts (EEA, 1999). SAS facilities that would discharge to ground water have recently been proposed for Grand Traverse County, Michigan and San Juan Island, Washington (Grand Traverse County, 1999; San Juan County, 1999); however, state UIC programs did not provide injectate data or other permit data for these existing and proposed facilities.

Figure 6. Plot Plan For All Clear Services Solar Aquatic System Facility



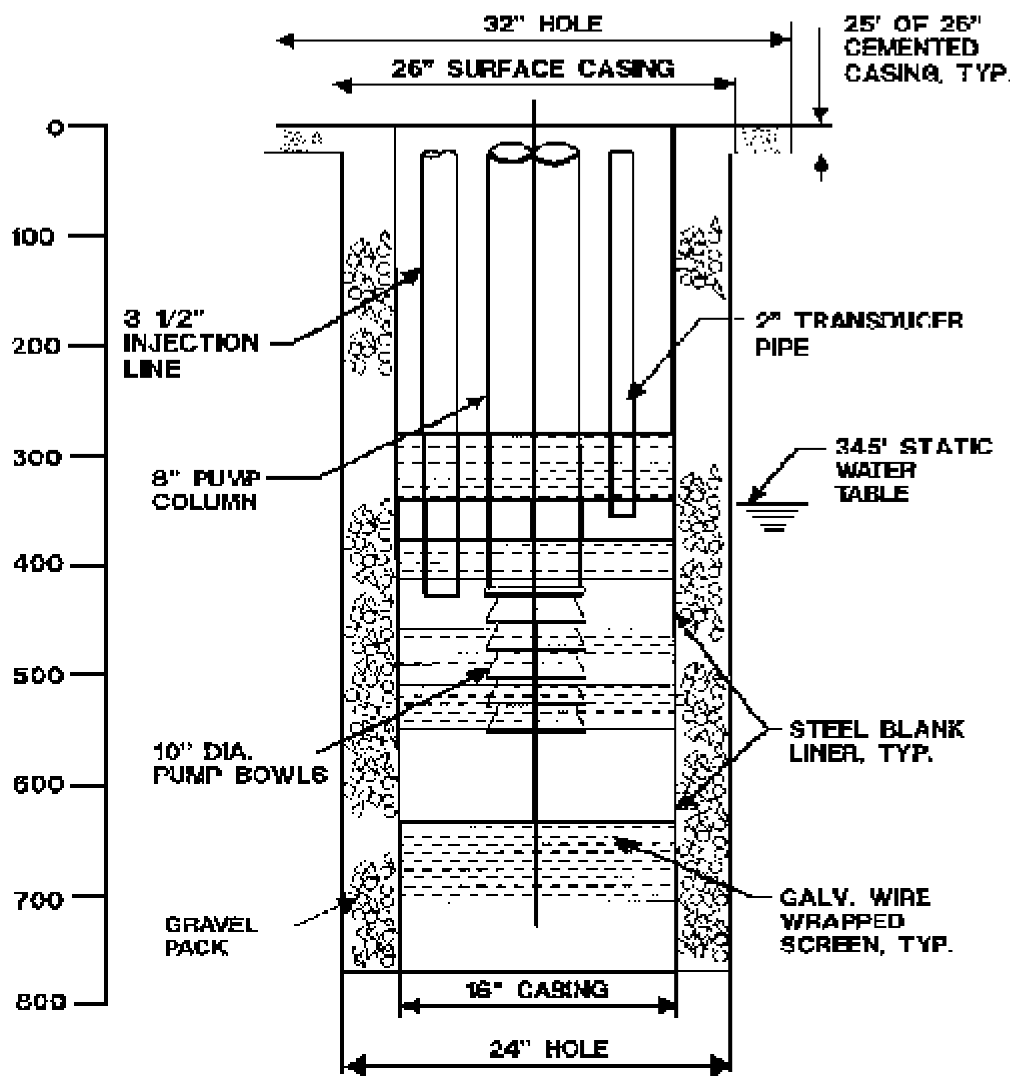
Source: State of New Hampshire Department of Environmental Services, 1996b.

Figure 7. Cross Section of Subsurface Disposal System, Solar Aquatic System Facility



Source: Keyland Enterprises, No Date.

Figure 8. Typical Recharge/Sewage Treatment Effluent Well Used For FHWRP/Hueco Bolson Recharge Project, El Paso, Texas



Wyoming

According to the UIC permit for the Aspen/Teton Pines Wastewater Treatment Plant Injection Wells, all injection wells will be constructed using 12-inch interior diameter 0.250-inch wall thickness pipe either driven or installed in a borehole and sealed at the surface with concrete grout. Injectate is delivered to the wells using a 10-inch diameter subsurface delivery line equipped with a subsurface control valve. The top of the well casing extends a minimum of 24 inches above grade and equipped with a locking cap, which must remain locked at all times except when measurements are being made.

4.3 Operational Practices

State Class V UIC permits for sewage treatment effluent wells generally include requirements for operational practices. Well operators are generally required to monitor injectate quality and operate a ground water monitoring system. Injectate quality permit limits and associated monitoring, reporting, and record keeping requirements have been set for sewage treatment effluent wells for chlorinated and non-chlorinated organic compounds, inorganic compounds and metals, and biological constituents. Examples of these operational practices in several states are described below.

California

Chevron El Segundo Refinery Aquifer Recharge and Remediation Project. The Chevron El Segundo Refinery has applied for a permit for the injection of recycled water to a liquid hydrocarbon recovery system. Until 1993, Chevron had been injecting filtered ground water into the contaminated aquifer beneath the refinery as part of an aquifer remediation and aquifer recharge project. This injection was conducted to establish hydraulic control of the ground water gradients and containment of floating liquid hydrocarbon (LHC) contamination, under a USEPA Permit Exemption to the "Toxicity Rule" which otherwise prohibits the injection of water failing hazardous waste criteria. The exemption expired in 1993, and since that time Chevron has been injecting potable water into the contaminated aquifer (WBMWD, 1999).

The California Department of Health Services determined that Chevron's proposal to inject and extract treated recycled water constitutes a ground water recharge project, and therefore, the tertiary treated water would be subject to more stringent reverse osmosis treatment requirements to protect potential Municipal Beneficial Uses (MUN) of drinking water supplies. The California Department of Health Services indicated that the ground water beneath the Chevron refinery is on the seaward side of the West Coast Basin Barrier Project. The aquifers west of the Barrier Project are intruded by seawater, and drinking water production wells are no longer operated west of the project.

The California Department of Health Services de-designated (to Non-MUN) a portion of the aquifer beneath and adjacent to the Chevron refinery after which time the aquifer could not be used as a drinking water supply. The RWQCB removed the MUN designation of the aquifer in the Basin Plan, amended the West Basin Municipal Water District's (WBMWD's) Water Recycling Permit, and issued injectate discharge permit requirements to Chevron. The WBMWD indicated that approvals by the

California Water Resources Control Board and the USEPA for this proposed project were anticipated in March 1999 (WBMWD, 1999; Reich, 1999).

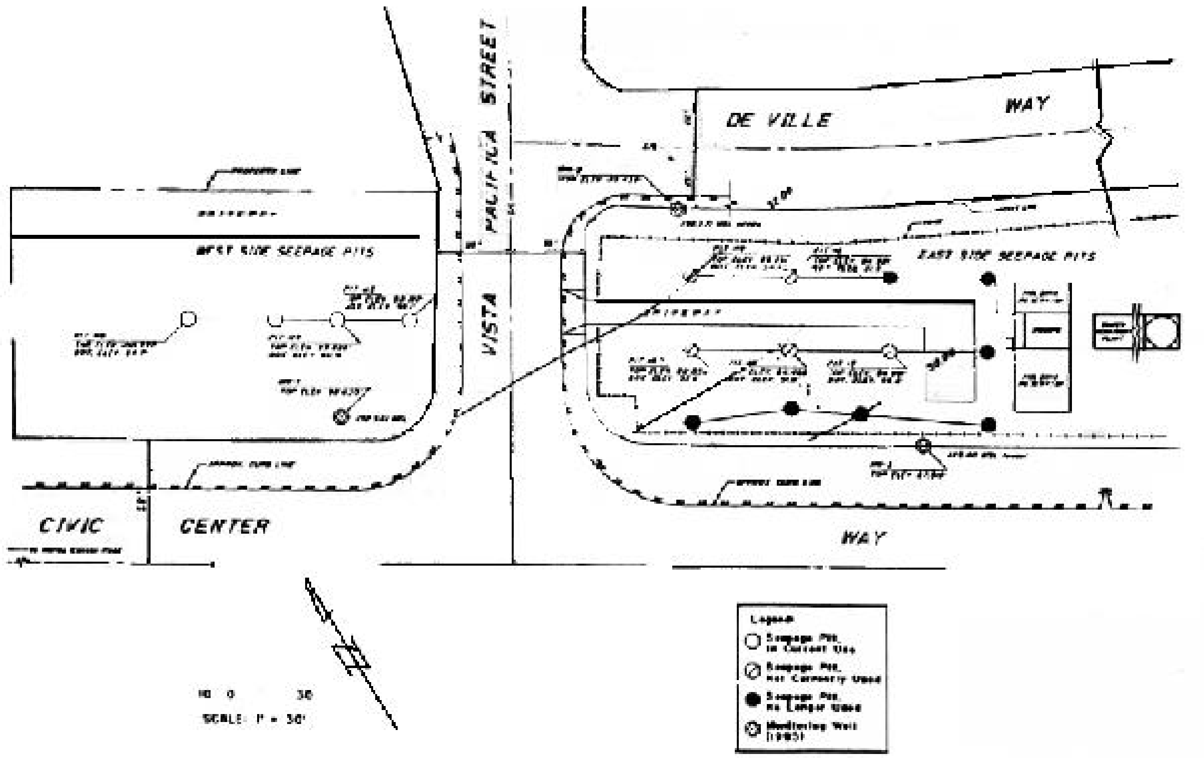
Malibu Water Pollution Control Plant. The Los Angeles County Department of Public Works owns and operates the Malibu Water Pollution Control Plant, which treats domestic wastewater from three condominium complexes in Malibu. Treated effluent from this facility is discharged to a series of seepage basins. The Los Angeles RWQCB has issued a tentative order requiring the Malibu Water Pollution Control Plant to be upgraded to achieve compliance with revised discharge limits by June 1, 2000, including limits for fecal coliform (LA RWQCB, 1998). The Malibu Water Pollution Control Plant is currently designed to provide secondary-treated effluent for the seepage pits. As of October 1998 the secondary treatment system had not been tested for effectiveness with respect to removal of BOD or suspended solids. The secondary treatment system consists of bar screening/communition, extended aeration, and secondary clarification, followed by dual media sand filtration.

The discharge to ground water area for the Malibu Water Pollution Control Plant consists of 16 seepage pits, 12 of which are located in an eastern disposal area and four of which are located in a western disposal area. The plant has a capacity of 37,500 gallons per day, and the average flow rate during 1997 was 28,348 gallons per day. The locations of the facility wastewater treatment plant, seepage pits, and ground water monitoring wells are shown in Figure 9.

According to the tentative order, the facility is currently subject to a permit that limits the total discharge from the facility to no more than 37,500 gallons per day and is required to maintain a minimum vertical distance between the bottom of the seepage basin and the top of the saturated ground water table of 5 feet. The facility has violated both of these permit limits in the past. According to the tentative order, no part of the treatment plant or seepage pit disposal system shall be closer than 150 feet to any water well, or closer than 100 feet to any watercourse. Under the tentative order, the facility will not be required to maintain a minimum distance between the saturated ground water table and the base of the seepage pits after the facility is upgraded to meet effluent limits for fecal coliform.

The RWQCB expressed concern that the local ground water could not continue to assimilate subsurface wastewater effluent discharges from the existing Malibu facility and from several new residential and commercial subsurface disposal facilities that have been proposed for the area. The current permit conditions for the facility, developed in 1987, do not contain requirements for the removal of nitrogen or other nutrient loads or pathogens from the effluent. The facility intends to upgrade the wastewater treatment plant to meet new discharge limits for fecal coliform contained in the tentative order. As of 1998, the Malibu Water Pollution Control Plant was not monitoring the effluent discharge to the seepage pits for pathogens. Under the conditions of the tentative order, the facility would upgrade the wastewater treatment train to add disinfection capability, as ground water beneath the plant may be in hydraulic connection with beaches down gradient of the facility. Under the tentative order, the County Department of

Figure 9. Plot Plan For Malibu Water Pollution Control Plant, Seepage Pits, And Ground Water Monitoring Wells



Source: County of Los Angeles Department of Public Works, No Date

Public Works would initiate a study of water quality impacts from discharges of wastewater effluent in the Malibu Valley area.

Revised effluent limitations for the Malibu Water Pollution Control Plant included in the tentative order are summarized in Table 15. According to the tentative order, waste discharged to the facility shall be limited to treated domestic wastewater. Wastewater effluent that does not meet the revised effluent limitations would be held in impervious containers prior to discharge at a permitted facility. The facility would also notify the RWQCB of any exceedance of influent or effluent permit limits under the tentative order. The facility would establish a baseline of nutrient levels in the effluent by monitoring effluent and ground water conditions, and would establish a ground water monitoring program to determine whether discharges have been or are impacting ground water quality. The facility indicated that although the current water quality objective for ground water beneath the plant is 2,000 mg/l TDS, ground water in wells upgradient of the facility show ambient TDS concentrations greater than 3,000 mg/l.

Florida

The Florida UIC program provided information for two proposed underground injection well systems that have received permits to construct but have not received permits to operate. These permits include proposed operating requirements for the injection wells. One facility is a privately owned domestic wastewater treatment plant, and the other is a POTW that is proposed to use treated municipal wastewater treatment plant effluent as injectate for an aquifer recharge system. The Florida UIC Program also provided permit data for an aquifer storage and retrieval well system operated by a municipal wastewater treatment plant.

Ocean Harbor Estates Wastewater Treatment Plant. As mentioned in Section 4.2, the permit applicant reports that there is a confining layer above the proposed injection zone. The applicant will construct one ground water monitoring well above the confining layer and one monitoring well below the confining layer to determine ground water quality prior to and during operation of the injection wells. The permit application indicates that the injectate will meet primary and secondary drinking water standards for all parameters with the possible exception of fecal coliform, nitrate, total nitrogen, ammonia, and BOD.

The proposed Ocean Harbor Estates Class V injection well project will serve 15 single family homes. Effluent will be treated by an extended aeration treatment process followed by TSS reduction and chlorination. The proposed injection rate for each well is 6 gpm at a pressure not greater than 10 psi. The plant design incorporates a flow meter and pressure gauge on each well and a pressure switch set to alarm whenever injection pressure exceeds the limit of 10 psi. The plant design also includes a pressure relief valve. Ground water quality testing will be performed monthly for each monitoring well for TDS, ammonia, total nitrogen, nitrate, chloride, fecal coliform, pH, temperature, and conductivity. The injectate will be monitored for total daily flow, daily average injection pressure, and primary and secondary drinking water parameters and minimum criteria parameters. The monitoring results will be submitted on an annual basis. A controlled quarterly test of well injectivity (rate/pressure) will be

Table 15. Revised Effluent (Injectate) Permit Limits for Malibu Water Pollution Control Plant

Parameter	Units	Monthly Average	Maximum	MCL (mg/l)	HAL (mg/l)
pH	pH	--	between 6.5 - 8.5 at all times	6.5 - 8.5 (S)	--
5-day BOD	mg/l	30	45	--	--
TSS	mg/l	30	45	--	--
Turbidity	NTU	10	15	--	--
Oil and Grease	mg/l	--	15	--	--
TDS	mg/l	--	2,000	500 (S)	--
Sulfate	mg/l	--	500	500 (S)	--
Chloride	mg/l	--	500	250 (S)	--
Boron	mg/l	--	2.0	--	--
Fecal Coliform	MPN/100 ml	--	200	1/100 ml	--
The wastewater effluent is required to be "oxidized, clarified, and filtered." Oxidized wastewater means wastewater in which the organic matter has been stabilized and is not putrescible, and which contains dissolved oxygen.					
The wastewater effluent is prohibited from containing any salts, heavy metals, or organic pollutants at levels that would impact ground water used for irrigation or ground water that is in hydraulic connection with surface waters designated for marine aquatic life.					

conducted in accordance with FAC 62-528.430(2)(c), including injection flow rate (MGD), injection pressure (psig) wellhead pressure with no flow (psig) and monitor zone water levels (feet) before, during, and after the injection test.

Hillsborough County ASR Project. The source water for this proposed ASR project is domestic wastewater treatment effluent from the Hillsborough County Northwest Water Reclamation Facility (WRF) (May, 1999). The Southwest District of the Florida UIC program has issued a permit to construct the WRF injection. A permit to operate has not been issued. The Florida UIC program requires that the wastewater effluent (injectate) from the WRF meet primary and secondary drinking water standards. The draft permit for the WRF states that any permit noncompliance constitutes a violation of the Safe Drinking Water Act.

The permit applicant is currently obtaining injectate characterization data to supplement their Florida UIC operating permit application. Staff of the Southwest District Florida UIC program indicated that wastewater effluent from the treatment plant currently does not meet drinking water standards for all parameters, and that the applicant is working to lower the effluent constituent concentrations to below primary drinking water standards in order to obtain the operating permit (Richtar, 1999). In the event the applicant is unable to meet primary drinking water standards for the effluent, the applicant could apply for a water quality criteria exemption from the Florida UIC program (Richtar, 1999).

The Hillsborough County ASR Project will perform monitoring of the reclaimed water every two months. Monitoring parameters include primary and secondary drinking water standards, the minimum criteria for sewage effluent, dissolved oxygen, and pathogens, including fecal coliform, cryptosporidium, and giardia lamblia (the operator is also required to submit background ground water quality data for these parameters prior to operation). The injection well operation will also be monitored for daily and monthly maximum, minimum, and average injection pressure, flow rate, and total reclaimed water volume recharged and recovered. Monitoring parameters for injectate and ground water included in the draft injection well facility permit are shown in Tables 16 and 17.

Manatee County Public Works Department Wastewater Treatment Plant -- Aquifer Storage and Recovery System. The Manatee County Public Works Department operates an ASR system consisting of two aquifer recharge and recovery wells. The wells inject exclusively reclaimed water (treated effluent) into a limestone formation for storage and recovery (Pyne, 1995). The maximum recharge volume for the ASR system is 316 million gallons (SWFWMD, no date). This volume was achieved on April 30, 1993. Stored water may be recovered during the wet season between June and September if the reservoir elevation is less than 30 feet above mean sea level (MSL). Water may be recovered during the dry season, October through May, if the reservoir elevation is below 36 feet MSL. Neither of these conditions were achieved between April 1993 and August 1996, and therefore no stored water was recovered from the ASR system during this period (MCPWD, 1996).

Table 16. Hillsborough County Water Dept. Reclaimed ASR Project Monitoring Parameters for Sewage Treatment Effluent Wells

Operational Testing Parameters	**Operational Testing Conditions**			
Minimum Criteria for Sewage Effluent Analysis	**Class V. Test Injection/Production Well Monitoring Process**	**Recording Frequency**	**Reclaimed Water Monitoring Parameters**	**Recording Frequency**
Toluene	Injection Pressure (psi)	Daily/Monthly	Nitrate (as N) (mg/l)	Weekly
1,2 Dichlorobenzene	Max., Min., and Avg. Injection Pressure	Daily/Monthly	Nitrite (as N) (mg/l)	Weekly
Chloroform	Flow Rate (gpm)	Daily/Monthly	Sodium (mg/l)	Weekly
1,2 Dichloroethylene	Max., Min., and Avg. Flow Rate	Daily/Monthly	Total Dissolved Solids (mg/l)	Weekly
Chloroethane	Total Volume: Recharged and Recovered (gal)	Daily/Monthly	Turbidity (NTU)	Weekly
Aldrin, Dieldrin	Gross Alpha (pCi/l)*	Monthly	Fecal Coliform (cts/100ml)	Weekly
Diethylphthalate	*Cryptosporidium** and *Giardia lamblia**	Monthly	Primary and Secondary DWS	Annually
Dimethylphthalate	Total and Fecal Coliform (cts/100ml)	Weekly	*Cryptosporidium*	Annually
Butylbenzylphthalate	Ammonia (as N) and Sulfate (mg/l)	Weekly	*Giardia lamblia*	Annually
Napthalene	Bicarbonate (HCO3) and Carbonate (CO3) (mg/l)	Weekly		
Anthracene	Calcium, Total Iron, Sodium, and Magnesium (mg/l)	Weekly		
Phenanthrene	Dissolved Oxygen and Total Dissolved Solids (mg/l)	Weekly		
Phenol	pH (std. units) and Temperature (Degrees Celsius)	Weekly		
2,4,6-Trichlorophenol	Specific Conductivity (umhos/cm)	Weekly		
2-Chlorophenol	Total Alkalinity and Total Kjeldahl Nitrogen (mg/l)	Weekly		
Ammonia (as N)	Turbidity (NTU)	Weekly		
Organic Nitrogen	Total Trihalomethanes (mg/l)*	Weekly		

Table 16. Hillsborough County Water Dept. Reclaimed ASR Project Monitoring Parameters for Sewage Treatment Effluent Wells

Operational Testing Parameters	**Operational Testing Conditions**			
Minimum Criteria for Sewage Effluent Analysis	**Class V. Test Injection/Production Well Monitoring Process**	**Recording Frequency**	**Reclaimed Water Monitoring Parameters**	**Recording Frequency**
Total Kjeldahl Nitrogen	Chloride	Weekly		
Nitrite (as N)				
Total Nitrogen				
Soluble Orthophosphate				
Total Phosphorus				
Antimony				
The sewage effluent analysis will also include dissolved oxygen, fecal coliform, *Cryptosporidium* and *Giardia lambia*				
An analysis of the reclaimed water will be performed prior to operational testing approval and every two months for a minimum of one year then annually thereafter.				
* Monthly production well monitoring will be conducted during cycle testing and for a minimum of one year, then monitoring will be conducted annually subject to the Department of Environmental Protection's written approval.				

Source: FDEP, 1998.

Table 17. Hillsborough County Water Dept. Reclaimed ASR Project Ground Water Monitoring Parameters

Ground Water Monitoring Well System Monitoring Parameters	Ground Water Monitoring Well Number and Reporting Frequency		
	SZMW-1	SMW-1	14-D
Maximum Water Level/Pressure*	Daily/Weekly	Daily/Weekly	Daily/Weekly
Minimum Water Level/Pressure*	Daily/Weekly	Daily/Weekly	Daily/Weekly
Average Water Level/Pressure*	Daily/Weekly	Daily/Weekly	Daily/Weekly
Gross Alpha (pCi/l)**	Monthly	none	none
Total Trihalomethanes (mg/l)**	Monthly	Monthly	none
*Cryptosporidium***	Monthly	Annually	none
*Giardia lamblia***	Monthly	Annually	none
Total Fecal Coliform (cts/100ml)	Weekly	Monthly	none
Ammonia (as N) (mg/l)	Weekly	Monthly	none
Bicarbonate (HCO3) (mg/l)	Weekly	Monthly	none
Carbonate (CO3) (mg/l)	Weekly	Monthly	none
Calcium, Chloride, Sodium (mg/l)	Weekly	Monthly	Monthly (Chloride Only)
Total Iron (mg/l)	Weekly	Monthly	none
Dissolved Oxygen (mg/l)	Weekly	none	none
Total Dissolved Solids (mg/l)	Weekly	Monthly	Monthly
Magnesium and Sulfate (mg/l)	Weekly	Monthly	Monthly (Sulfate Only)
Total Kjeldahl Nitrogen (mg/l)	Weekly	Monthly	Monthly
pH (std. units)	Weekly	Monthly	none
Specific Conductivity (umhos/cm)	Weekly	Monthly	none
Temperature (Degrees Celsius)	Weekly	Monthly	Monthly
Total Alkalinity (mg/l)	Weekly	Monthly	none
Turbidity (NTU)	Weekly	Monthly	none

*After completion of cycle testing, to be monitored continuously
**Monthly during cycle testing and for a minimum of one year, then annually thereafter with the FDEP's written approval. During all recharge, storage, and recovery cycles of the injection/production well, the permittee will submit a report entitled "Summary of the Monthly Monitoring Data" that includes the parameters and recording frequencies shown in this table.
Source: FDEP, 1998.

A 90 day test cycle was conducted between August 14, 1995 and November 1, 1995, and consisted of a recharge cycle, storage cycle, and recovery cycle. A total of 57.12 million gallons of water was stored for 30 days during this period. Recovery was conducted for 19 days, at which point 98 percent of the stored water had been recovered. The test cycle was designed by the FDEP to investigate water quality changes in the stored water. Samples of recharge water, stored water, and recovered water were collected from the recharge well and recovery wells (B-1 and B-2), and ground water samples were collected from four monitoring wells (A, C-1, C-2, and D). Test cycle monitoring parameters are summarized in Table 18.

Monitoring wells C-1 and C-2 are constructed above and below a semi-confining unit in the Suwannee Limestone formation. Well C-1 is constructed to a depth of 500 feet, above the semi-confining unit, and well C-2 is constructed to a depth of 700 feet, below the semi-confining unit. Monitoring well A is constructed to a depth of 1,050 feet, below the Ocala Limestone confining unit. Monitoring well D consists of a two-inch diameter monitoring tube installed into well A in the upper zone of the Hawthorne formation to a depth of 125 feet (Manatee County, no date). Water levels in each well were monitored weekly throughout the 90 day test cycle.

New Hampshire

The Town of Ossipee, New Hampshire, Wastewater Treatment Facility is permitted to discharge 375,000 gallons per day of septage and 115,000 gallons per day of primary treated domestic wastewater effluent to ground water through two unlined septage lagoons and 24 subsurface leach fields (NHDES, 1997). (The unlined lagoons are not considered to be injection wells and are not included in the inventory of wells in Table 1.) The discharge of primary treated wastewater effluent is subject to a Discharge to Ground Water permit, and the septage facility is subject to a permit from the NHDES Office of Waste Management (NHWSPCC, 1983a).

According to the Discharge to Ground Water Permit for the Subsurface Treatment Facility, the Town of Ossipee conducts quarterly monitoring of ground water and local surface water quality and submits quarterly and annual monitoring reports to the NHDES. However the permit only requires monitoring of the volume of septage and treated wastewater effluent discharged to the Subsurface Treatment Facility. Neither the current permit nor the previously issued permit for the Subsurface Treatment Facility requires direct monitoring of effluent (i.e., treated wastewater or septage) quality. Both the previously issued permit, dating from 1983 (NHWSPCC, 1983b), and the current permit requires the permit holder to allow access to the NHDES for the purposes of collecting effluent samples; however, no such data were reported.

The Discharge to Ground Water Permit for the Subsurface Treatment Facility establishes a Ground Water Discharge Zone (GDZ) that represents the “compliance zone” for the facility. The permit prohibits any violation of New Hampshire Ambient Groundwater Quality Standards (AGQS) at the boundary of the GDZ, or violation of any New Hampshire surface water quality standards at the boundary of the GDZ.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995

Well B-1 - Recharge Water Quality

Parameter	Well B-1	Well B-1	Well B-1	Well B-1	MCL (mg/l)	HAL (mg/l)
	8/16/95	8/23/95	8/30/95	9./6/95		
TTHMs (mg//l)	0.012	0.015	0.013	0.014	0.08 (P)	NA
gross alpha (pCi/ml)	1.5	1.0	1.3	1.2	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	5.51	8.11	5.83	6.4	NA	NA
Total Iron (mg/l)	<0.02	<0.02	0.03	0.03	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	360	250	300	300	NA	NA
TDS (mg/l)	205	200	180	194	Secondary MCL: 500 (F)	NA
pH (standard units)	7.1	8.0	7.4	7.5	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	17.1	16.4	17.1	21	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	90	82	79	81	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	15.1	20.3	21.8	12.2	NA	NA
All samples were collected during recharge of Well B-1						

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable

Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Well B-1 - Storage Water Quality

Parameter	Well B-1	Well B-1	Well B-1	Well B-1	MCL (mg/l)	HAL (mg/l)
	9/13/95	9/20/95	9/27/95	10/4/95		
TTHMs (mg//l)	0.080	0.077	0.081	0.075	0.08 (P)	NA
gross alpha (pCi/ml)	1.7	2.4	3.5	3.2	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	NR	6.5	6.7	7.7	NA	NA
Total Iron (mg/l)	0.07	0.09	0.08	0.03	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	370	340	390	390	NA	NA
TDS (mg/l)	233	258	271	263	Secondary MCL: 500 (F)	NA
pH (standard units)	7.8	7.8	7.1	8.0	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	26.6	25.9	23.9	25.6	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	85	93	95	95	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	32.7	44.9	52.5	54.8	NA	NA
All samples were collected from Well B-1 during the 30 day storage cycle period.						

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable
Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Well B-2 - Storage Water Quality

Parameter	Well B-2	Well B-2	Well B-2	Well B-2	MCL (mg/l)	HAL (mg/l)
	9/13/95	9/20/95	9/27/95	10/4/95		
TTHMs (mg//l)	0.074	0.052	0.058	0.029	0.08 (P)	NA
gross alpha (pCi/ml)	2.3	2.3	2.4	4.3	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	4.2	3.8	3.0	8.0	NA	NA
Total Iron (mg/l)	0.02	0.08	0.1	0.11	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	370	380	415	380	NA	NA
TDS (mg/l)	249	254	282	240	Secondary MCL: 500 (F)	NA
pH (standard units)	7.9	8.1	7.2	8.0	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	25	23.3	22.1	23.6	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	86	93	95	96	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	38.5	50.2	55.5	56.9	NA	NA
All samples were collected from Well B-2 during the 30 day storage cycle period.						

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable
Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Well B-1 - Recovery Water Quality

Parameter	Well B-1	Well B-1	Well B-1	Well B-1	MCL (mg/l)	HAL (mg/l)
	10/11/95	10/18/95	10/25/95	11/1/95		
TTHMs (mg//l)	0.075	0.022	0.012	NR	0.08 (P)	NA
gross alpha (pCi/ml)	3.2	4.8	4.1	NR	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	6.0	5.8	3.8	NR	NA	NA
Total Iron (mg/l)	0.05	0.03	0.04	NR	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	410	420	410	NR	NA	NA
TDS (mg/l)	260	285	290	NR	Secondary MCL: 500 (F)	NA
pH (standard units)	7.8	7.8	7.7	NR	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	25.4	21.4	20.7	NR	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	96	98	110	NR	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	57.9	69	80.3	NR	NA	NA

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable
Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Well B-2 - Recovery Water Quality

Parameter	Well B-2	Well B-2	Well B-2	Well B-2	MCL (mg/l)	HAL (mg/l)
	10/11/95	10/18/95	10/25/95	11/1/95		
TTHMs (mg//l)	0.029	0.004	0.001	ND	0.08 (P)	NA
gross alpha (pCi/ml)	4.3	4.8	4.2	5.4	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	6.0	3.4	1.6	3.5	NA	NA
Total Iron (mg/l)	0.11	0.03	0.09	0.11	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	410	440	510	450	NA	NA
TDS (mg/l)	253	264	328	345	Secondary MCL: 500 (F)	NA
pH (standard units)	7.4	7.8	7.8	7.8	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	23.1	19.3	19.3	19.4	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	97	108	120	123	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	60.7	81.8	100	106	NA	NA

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable
Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Monitoring Wells

Parameter	Well A	Well C-1	Well C-2	Well D	MCL (mg/l)	HAL (mg/l)
	9/11/95	9/11/95	9/11/95	9/11/95		
TTHMs (mg//l)	0.0005	0.0036	0.0005	0.0035	0.08 (P)	NA
gross alpha (pCi/ml)	4.4	8.3	0.6	15.6	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	0.56	0.89	0.65	5.65	NA	NA
Total Iron (mg/l)	1.58	0.042	0.02	3.7	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	80	1,573	568	642	NA	NA
TDS (mg/l)	320	419	308	333	Secondary MCL: 500 (F)	NA
pH (standard units)	6.7	7.1	6.7	7.2	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	14.5	15.4	20.1	11.5	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	129	156	22	<2	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	77	127	197	290	NA	NA
All samples were collected during recharge of Wells B-1 and B-2.						

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable

Source: Manatee County Public Works Department, 1996.

Table 18. Monitoring Data for 90 Day Test Cycle for Manatee County Public Works Department Aquifer Storage and Retrieval System - August 16 - November 1, 1995 (continued)

Monitoring Wells

Parameter	Well A	Well C-1	Well C-2	Well D	MCL (mg/l)	HAL (mg/l)
	11/1/95	11/1/95	11/1/95	11/1/95		
TTHMs (mg//l)	0.080	0.077	0.081	0.075	0.08 (P)	NA
gross alpha (pCi/ml)	1.7	2.4	3.5	3.2	15 pCi/l (F)	15 pCi/l (C)
Dissolved Oxygen (mg/l)	no sample	6.5	6.7	7.75	NA	NA
Total Iron (mg/l)	0.07	0.09	0.08	0.03	Secondary MCL: 0.3 (F)	NA
conductivity (uhmos/cm)	370	34073	390	390	NA	NA
TDS (mg/l)	233	258	271	263	Secondary MCL: 500 (F)	NA
pH (standard units)	7.8	7.8	7.1	8.0	Secondary MCL: 6.5 - 8.5	NA
Chloride (mg/l)	26.6	25.9	23.9	25.6	Secondary MCL: 250 (F)	NA
sulfate (mg/l)	85	93	95	95	500 (P) Secondary MCL: 250 (F)	D
alkalinity (mg/l)	32.7	44.9	52.5	54.8	NA	NA
All samples were collected during recovery from Well B-1.						

-- means no discharge limit, MCL, or HAL specified
P means proposed MCL
F means final MCL
D means draft HAL
NC means the reported health advisory level is for non-cancer effects
C means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable
Source: Manatee County Public Works Department, 1996.

The Subsurface Treatment Facility is permitted to discharge only domestic wastewater to the leach fields, and only domestic septage to the septage lagoons. Any grit, oil, sludge, or other wastes generated by the facility are required to be disposed of only in NHDES-approved facilities. The facility is required to submit to the NHDES as-built plans for any alternation, modification, repair, or other construction activities at the facility, and is required to notify the NHDES of any plans to alter or abandon the leach fields or septage lagoons. The facility conducts quarterly monitoring of ground water and local surface water quality, and reports results to the NHDES on a quarterly and annual basis. Monitoring parameters for the Subsurface Treatment Facility are summarized in Table 19. Historical monitoring data and current monitoring data for the Subsurface Treatment Facility ground water monitoring wells and surface water monitoring location are summarized in Table 20.

All Clear Services, located in the Town of Weare, New Hampshire, is permitted to discharge 5,000 gallons per day of tertiary treated wastewater to ground water via five subsurface leaching trenches, each with a discharge capacity of 1,000 gallons per day (NHDES, 1996b). The influent to the Solar Aquatics Treatment System is septage trucked from residential septic tank units. As described in Section 4.2, the Solar Aquatics System© (SAS), provides biological tertiary treatment of the influent using solar tanks and a greenhouse system. All Clear Services is required to monitor effluent (injectate) from the tertiary treatment system on a monthly basis for BOD, fecal coliform, pH, total nitrogen, total phosphorus, and nitrate, and on a semiannual basis for VOCs and metals. The effluent discharge is required to comply with New Hampshire AGQS. Influent quality data for the untreated septage and effluent data for the tertiary treated effluent were not provided with the permit data for the SAS facility.

The All Clear Services facility receives septage trucked from domestic septic tanks, generally ranging in size from 400 to 1,200 gallons capacity. The septage trucked from the septic tanks is first blended in the truck itself, as the trucks can collect septage from two or more septic tanks serviced on a single run. The septage is then mixed further at the All Clear Services facility in one of six storage tanks ranging in size from 6,000 to 10,000 gallons capacity. The septage is then transferred to a Receiving Tank through a Bar Screen/Degritter. In some cases, the septage may be transferred directly from trucks through the Bar Screen/Degritter to the Receiving Tank. Septage is pumped from the Receiving Tank to a Blending Tank, which is always operated at full capacity. After primary clarification, the septage enters the greenhouse portion of the treatment process. The greenhouse consists of 24 translucent solar tanks (four sets of six tanks connected in series) that are covered with floating or racked plants with roots extending into the septage, to allow biological activity and photosynthetic activity (EEA, 1995; EEA, 1999). Following the solar tanks are a secondary clarifer, sand filter, and two man-made wetland cells. A portion of the secondary sludge from the process is activated sludge recycled into the Blending Tank. Solids processing consists of 700 gallons per day (GPD) of sludge processed in an aerobic digester followed by composting in three man-made reed beds that are designed to be cleaned once every four years (NHDES, 1995).

The Discharge to Ground Water Permit for the Subsurface Treatment Facility does not establish a GDZ that represents a “compliance zone” for the facility. The permit prohibits any violation

Table 19. Ground Water and Surface Water Monitoring Parameters for Town of Ossipee Subsurface Treatment Facility

Monitoring Location	Sample Type	Sampling Frequency	Parameters
B-101	Ground Water	Quarterly	Nitrate
		Semi-Annually	Static Water Elevation, pH Chloride, Ammonia (N), E. Coli Nitrate, Nitrite, Total Nitrogen Specific Conductivity Total Phosphorus, Phosphate (P) COD, BOD(5), Temperature
		Annually	VOCs, (method 8260), SWDA Metals
B-104	Ground Water	Quarterly	None Required
		Semi-Annually	As for Ground Water Well B-101
		Annually	VOCs, (method 8260), SWDA Metals
B-105	Ground Water	Quarterly	None Required
		Semi-Annually	As for Ground Water Well B-101
		Annually	VOCs, (method 8260), SWDA Metals
B-108	Ground Water	Quarterly	Nitrate
		Semi-Annually	As for Ground Water Well B-101
		Annually	VOCs, (method 8260), SWDA Metals
B-109	Ground Water	Quarterly	Nitrate
		Semi-Annually	As for Ground Water Well B-101
		Annually	VOCs, (method 8260), SWDA Metals
S-1	Surface Water	Quarterly	Nitrate
		Semi-Annually	As for Ground Water Well B-101
		Annually	None Required

SWDA Metals include: Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, and Silver.
S-1 Monitoring Location is downstream of the site on Peavey Brook and upstream of Plains Road Crossing.

Source: NHDES, 1997.

Table 20. Monitoring Data Illustrating Exceedances of New Hampshire Ambient Ground Water Quality Standards for Town of Ossipee Subsurface Treatment Facility

Well Number	Nitrate Concentration (ppm)							Nitrate mg/l
	10/1989	2/1990	11/1990	3/1991	5/1994	9/1994	10/1995	2/1998
B-101	10	NR	17	14	NR	12	NR	18
B-105	NR	NR	NR	NR	10	NR	NR	NR
B-108	NR	NR	NR	NR	11	11	14	30
B-109	15.5	29	NR	NR	NR	NR	NR	12
Surface Water	NR	NR	NR	NR	NR	NR	NR	0.34

The Ground Water Discharge Zone (GDZ) for the Subsurface Disposal Facility extends to the facility property line.
NR means Not Reported

Source: Town of Ossipee, 1998a.
NHDES, 1998a.

Table 20. Monitoring Data Illustrating Exceedances of New Hampshire Ambient Ground Water Quality Standards for Town of Ossipee Subsurface Treatment Facility (continued)

Parameter	Well 101	Well 105	Well 109	Surface Water	MCL (mg/l)	HAL (mg/l)
	4/23/98	4/23/98	4/23/98	4/23/98		
pH (field)	6.4	NR	7.1	7.0	6.5 - 8.5 (S)	--
E. Coli (per ml)	<1/100ml	<1/100ml	<1/100ml	<1/100ml	1/100 ml	--
Nitrate (N, mg/l)	11	1.9	9.0	<0.20	10.0	--
Nitrite (N, mg/l)	<0.005	<0.005	<0.005	<0.005	1.0	--
Total Nitrogen (mg/l)	0.29	0.12	0.23	0.22	--	--
Phosphorus (P, mg/l)	0.03	0.02	0.05	0.05	--	--
Conductivity (umho/cm)	369	50	140	62	--	--
Ammonia (N, mg/l)	<0.1	<0.1	<0.1	<0.10	--	--
Chloride (mg/l)	58	NR	24	76	250 (S)	--
COD (mg/l)	10	NR	51	7.8	--	--
5 Day BOD (mg/l)	<6.0	<6.0	98	<6.0	--	--
Ortho-Phosphate (mg/l)	0.02	0.01	0.03	0.02	--	--
Depth to Water (feet)	21.24	NR	50.02	NA	NA	NA
Monitoring results for "drinking water" metals, including arsenic, antimony, beryllium, barium, cadmium, chromium, mercury, selenium, and thallium were reported to be below method detection limits for all ground water wells sampled on 5/29/98. Concentrations of nickel in ground water sampled ranged from <0.005 mg/l to 0.02 mg/l.						

-- means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable

Source: Town of Ossipee, 1998a.
NHDES, 1998a.

Table 20. Monitoring Data Illustrating Exceedances of New Hampshire Ambient Ground Water Quality Standards for Town of Ossipee Subsurface Treatment Facility (continued)

Parameter	Well 101	Well 104	Well 105	Well 108	Well 109	MCL (mg/l)	HAL (mg/l)
	7/29/93	7/29/93	7/23/93	7/23/93	7/29/93		
pH (field)	6.1	6.7	5.9	5.9	6.1	6.5 - 8.5 (S)	--
Fecal Coliform per 100ml	114	10	210	10	18	1/100 ml	--
Fecal Streptococci Bacteria per 100ml	0	0	0	0	0	--	--
Nitrate (N, mg/l)	10	0.10	3.1	82	63	10.0	--
Total Kjeldal Nitrogen (mg/l)	<0.10	<0.10	<0.10	<0.10	0.95	--	--
Phosphorus (P, mg/l)	0.51	0.72	0.13	0.11	1.1	--	--
Conductivity (umho/cm)	270	30	230	260	190	--	--
Ammonia (N, mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10	--	--
Chloride (mg/l)	42	<3.0	10	35	35	250 (S)	--
COD (mg/l)	25	46	31	51	44	--	--
Ortho-Phosphate (mg/l)	<0.04	0.08	<0.04	<0.04	<0.04	--	--
Depth to Water (ft)	22.68	18.27	32.40	41/85	51.62	NA	NA

-- means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable

Source: Town of Ossipee, 1998a.
NHDES, 1998a.

of New Hampshire AGQS or surface water quality standards with any discharges associated with the permit for the facility.

NHDES staff indicated that typical septic system discharge facilities are required to have a minimum “setback” distance from the property line such that a GDZ can be established for the attenuation of nitrates and other constituents in the discharge. The small size of the All Clear Services facility (2.55 acres) would ordinarily be too small for a conventional septic system discharge facility. However, because the discharge from the All Clear Services facility meets New Hampshire AGQS, the NHDES indicated that “conceptually there is no need for a nitrate setback if the discharge meets AGQS” (NHDES, 1995).

The All Clear Services SAS Facility is permitted to discharge only treated domestic wastewater to the subsurface disposal units. Any grit, oil, sludge, or other wastes generated by the facility will be disposed of only in NHDES-approved facilities. The facility will submit to the NHDES as-built plans for any alternation, modification, repair, or other construction activities at the facility, and will notify the NHDES of any plans to alter or abandon the treatment system. The NHDES specified both influent (septage) and effluent (injectate) quality limits for the SAS, and also established permit requirements for periodic monitoring of influent, effluent, and ground water quality (NHDES, 1995; NHDES, 1996). Ground water monitoring wells were situated two-thirds of the distance, as ground water flows, from the subsurface disposal units to the property line. Monitoring wells were established in each possible direction of ground water flow, as well as at one upgradient location (NHDES, 1995). For the All Clear Services SAS facility, one ground water monitoring well is situated on site in each of the four compass directions from the discharge point. Influent and effluent discharge quality limits for the SAS facility are summarized in Table 21 and ground water monitoring parameters are summarized in Table 22.

Texas

The El Paso Public Service Board and the Fred Hervey Water Reclamation Plant (FHWRP) operate ten underground injection wells for the disposal of treated wastewater effluent. The FHWRP uses primary, biological, physical-chemical treatment, and disinfection to treat the influent water to meet drinking water standards. The FHWRP treatment system consists of screens, degritters, a primary settling basin, a powder activated carbon process aeration basin, first stage clarifiers, second stage denitrification basins, a second stage clarifer, activated carbon regeneration, a lime coagulation unit, a recarbonation unit, sand filters, ozone disinfection, granular carbon filters, chlorination, and clear well storage.

Most of the operating requirements for the El Paso PSB UIC project relate to operation of the Water Reclamation Plant, rather than operation of the injection wells themselves. The Water Reclamation Plant is operated and maintained by a sewage plant operator who holds a valid certificate of competency. The facility is operated and maintained to achieve an optimum efficiency of treatment capability. This includes monitoring of effluent (i.e., injectate) flow and quality as well as appropriate grounds and building maintenance. In the event that flow measurements reach 75% of the permitted average flow for three consecutive months, the facility will initiate engineering and financial planning for expansion of the facility. If the flow measurements reach 90% of the permitted average flow for three consecutive months, the facility will obtain authorization from the Texas Water Commission to commence construction of the necessary additional treatment and/or collection facilities.

Table 21. Influent and Effluent Quality Limits for All Clear Services Solar Aquatics System Facility

Parameter	Influent (mg/l)	Effluent (mg/l)	MCL (mg/l)	HAL (mg/l)
Biological Oxygen Demand (BOD)	5000	30	250	—
Total Suspended Solids (TSS)	8000	30	—	—
Total Nitrogen (N)	400	10	—	—
Total Phosphorus (P)	50	10	—	—

Effluent (injectate) is required to meet New Hampshire AGQS.

Table 22. Ground Water, Effluent, and Influent Monitoring Parameters for All Clear Services Solar Aquatics System

Monitoring Location	Sampling Frequency	Parameters
Ground Water Monitoring Wells MW-1, MW-2, MW-3, MW-4	Prior to system startup and Semi-Annually	Static Water Elevation Fecal Coliform Nitrate, Nitrite, Total Nitrogen Specific Conductivity
	Prior to system startup	VOCs, (method 8260), SWDA Metals
Effluent	Monthly	BOD(5), pH, Volume Fecal Coliform Nitrate, Total Nitrogen Total Suspended Solids Total Phosphorus (P)
	Semi-Annually	VOCs, (method 8260), SWDA Metals
Influent	Monthly	BOD(5), pH, Volume Total Nitrogen Total Suspended Solids Total Phosphorus (P)

Monitoring well MW-1 is North, MW-2 is South, MW-3 is East, and MW-4 is West of the discharge location.

SWDA Metals includeArsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, and Silver

Wyoming

The Wyoming UIC program provided operating data for both sewage treatment effluent well installations operating in the state. These include the Teton Village Wastewater Treatment Plant and the Aspen/Teton Pines Wastewater Treatment Plant. The Wyoming UIC program provided copies of ground water pollution control permits and ground water monitoring data for these wells (WDEQ, 1989; WDEQ 1993). Each permit contains background ground water quality monitoring data, wastewater effluent (injectate) quality estimates and permit limits, and injectate monitoring requirements.

The Teton Village Permit allows the Water and Sewer District to operate only one of the three injection wells at any one time. The well used is varied each month. According to the Permit, the injection system is controlled such that standing water on the surface does not appear within a radius of 200 feet from the injection wells. Ground water monitoring wells are sampled each calendar quarter for the parameters listed in Table 23. The ground water monitoring wells are sampled for organic compounds annually for comparison with permit limits. For parameters not specifically identified in the permit, any violation of a Class I water quality concentration in Chapter VIII of the Wyoming Water Quality Rules and Regulations is also a violation of the UIC permit. Three hundred gallons of water are withdrawn from each monitoring well prior to sampling to ensure that a representative ground water sample is obtained. Ground water monitoring data for the Teton Village Wastewater Treatment Plant injection well system are included in Table 24.

The total injected volume for the five wells is limited to 500,000 gallons per day, and the operator monitors total injected volume to the wells and also the injection pressure if the injection pressure is greater than atmospheric pressure. The injection pressure is limited by the permit to no more than 17 pounds per square inch gauge (psig). The operator samples the effluent quality once per week for comparison to effluent quality permit criteria, and once per quarter for comparison to volatile and semi-volatile organic compounds. The operator controls the discharge volume and pressure of each well to prevent fracturing of confining strata.

The operator files a quarterly report of monitoring data for the injection wells to the WDEQ, including a summary of any permit exceedances or system upsets that occurred during the quarter. The operator will report any noncompliance that may endanger health or the environment within 24 hours.

The operator also will notify the WDEQ 180 days before abandoning an injection well. The well abandonment procedures in the permit the well casing to be filled with concrete up to a depth of 36 inches. The top 36 inches of the casing will be cut off and the land reclaimed. The permit prohibits the conversion of an injection well to any other purpose. Monitoring wells may be converted to other purposes with the approval of the WDEQ.

According to the Aspen/Teton Pines Permit, the injection system is controlled such that standing water on the surface does not appear within a radius of 200 feet from the injection wells. Wastewater treatment plant design estimates for effluent quality included with the permit

Table 23. Ground Water Monitoring Parameters - Teton Village Ground Water Pollution Control Permit UIC 93-168

Parameter	Permit Ground Water Quality Limit (mg/l)	Permit Effluent Discharge Limit mg/l			MCL (mg/l)	HAL (mg/l)
		Instantaneous Limit (UCL)	4 Week Rolling Avg.	Annual Average (UCL)		
Total Dissolved Solids	500.0	600.0	--	450.0	500.0 (S)	--
5-Day Biological Oxygen Demand	10.0	15.0	10.0	--	--	--
Chlorides	150.0	200.0	150.0	--	250.0 (S)	--
Ammonia (as N)	0.5	1.5	0.5	--	--	--
Nitrates (as N)	10.0	15.0	10.0	--	10.0	--
Cyanides (CN)	--	0.3	--	0.2	0.2	0.2 (NC)
Total Phenols	0.001	0.050	0.010	0.010	--	4.0 (NC)
Total Coliform	1/100 ml	2/100 ml	1/100 ml	--	1/100 ml	–

-- means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported

Table 24. Ground Water Data from Wyoming UIC Program - Teton Village Water and Sewer District

GROUND WATER MONITORING DATA FROM WYOMING UIC PROGRAM										
Teton Village Water and Sewer District							**Monitoring Data in units of mg/l**		**September 27, 1994 Monitoring Report**	
Teton Village, Wyoming							**UIC Permit Number 93-168**			
Ground Water Parameter	Ground Water Monitoring Well Concentration mg/l						4-Week Avg UCL (mg/l)	Class I Standard	MCL (mg/l)	Health Advisory Level (mg/l)
	OH-13	OH-15	OH-18	OH-19	OH-20	OH-24				
Chloride	55.0	2.0	29.0	4.0	4.0	1.0	150.0	250.0	250.0 (S)	--
BOD (5-day)	0.00	0.0	00.0	0.0	0.0	0.0	10.0	--	--	--
Ammonia (N)	<0.01	0.126	<0.01	<0.01	<0.01	<0.01	0.50	0.50	--	--
Nitrate (N)	1.11	<0.01	<0.01	<0.01	<0.01	<0.01	10.0	10.0	10.0	--
TDS	252.0	162.0	220.0	160.0	148.0	92.0	--	450.0	500.0 (S)	--
Total Phenols	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	0.001	--	4.0 (NC)
UCL = Upper Control Limit, not to be exceeded in any sample										

-- means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported

Source: WDEQ, 1994.

application are shown in Table 25 (WDEQ, 1989). Injection of any biological, hazardous or toxic, or potentially toxic substances in concentrations that exceed primary drinking water standards is a violation of the permit. The operator samples each monitoring well and any idle injection well each calendar quarter for the parameters listed in Table 26. The listed concentrations constitute a "point of compliance" monitoring system. Any violation of a water quality concentration in Chapter VIII of the Wyoming Water Quality Rules and Regulations is also a violation of the UIC permit. The operator withdraws 500 gallons of water from each monitoring well prior to sampling to ensure that a representative ground water sample is obtained.

The operator controls the discharge volume and pressure of each well to prevent fracturing of confining strata. The operator also samples the effluent quality once per week for comparison to effluent quality permit criteria, and once per quarter for analysis of volatile and semi-volatile organic compounds. The total injected volume for the five wells is limited to 400,000 gallons per day, and the operator monitors total injected volume to the wells and the injection pressure. The injection pressure is recorded in the form of static water level in each injection well and each monitoring well. The operator files a quarterly report of monitoring data for the injection wells to the WDEQ, including a summary of any permit exceedances or system upsets that occurred during the quarter. The operator will report any noncompliance that may endanger health or the environment within 24 hours.

Three ground water monitoring wells are spaced equally across the south side of the plant site, and one well is located in the northeast and northwest corners of the site. The monitoring wells are constructed such that the entire receiver open to the injection wells is penetrated by the monitoring wells. The facility operator submitted as-built plans for all wells constructed along with a plan map showing all wells and relative elevation. The operator also constructed a 400,000 gallon emergency overflow facility (equivalent to 24 hours of flow) as a condition of the permit.

The operator will notify the WDEQ 180 days before abandoning an injection well. The well abandonment procedures in the permit call for the well casing to be removed from the ground and the hole filled with bentonite slurry having a 10 minute gel strength of 20 pounds per 100 square feet and filtrate volume not to exceed 13.5 cc. The top 20 feet of the hole is to be filled with concrete having a 28-day compressive strength of 3000 psi. The permit prohibits the conversion of an injection well to any other purpose.

5. POTENTIAL AND DOCUMENTED DAMAGE TO USDWs

5.1 Injectate Constituent Properties

The primary constituent properties of concern when assessing the potential for Class V sewage treatment effluent wells to adversely affect USDWs are toxicity, persistence, and mobility. The toxicity of a constituent is the potential of that contaminant to cause adverse health effects if consumed by humans. Appendix D of the Class V Study provides information

Table 25. Design Estimate Wastewater Effluent Quality - Aspen/ Teton Pines Ground Water Pollution Control Permit UIC 89-381

PARAMETER	Permit Design Estimate (mg/l)	Instantaneous (UCL) Limit (mg/l)	MCL (mg/l)	HAL (mg/l)
Total Dissolved Solids	300.0	500.0	500.0 (S)	--
5-Day Biological Oxygen Demand	5.0	10.0	--	--
Total Suspended Solids	3.0	--	--	--
Sulfates (SO4)	50.0	250.0	500.0	--
Chlorides	55.0	250.0	250.0 (S)	--
Ammonia (as N)	0.5	0.5	--	--
Nitrates (as N)	5.0	10	10.0	--

– means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported

Table 26. Ground Water Monitoring "Point of Compliance" Limits - Aspen/Teton Pines Ground Water Pollution Control Permit UIC 89-381

Parameter	Permit Point of Compliance Limit (mg/l)	Instantaneous Discharge Limit (UCL) (mg/l)	MCL (mg/l)	HAL (mg/l)
Total Dissolved Solids	500.0	500.0	500.0 (S)	--
5-Day Biological Oxygen Demand	10.0	10.0	--	--
Total Suspended Solids	--	--	--	--
Sulfates (SO_4)	250.0	250.0	500.0	--
Chloride	250.0	250.0	250.0 (S)	--
Ammonia (as N)	0.5	0.5	--	--
Nitrates (as N)	10.0	10.0	10.0	--
Cyanides	0.2	0.2	0.2	0.2 (NC)
Total Phenols	0.001	0.001	--	4.0 (NC)
Static Water Level	No higher than 6 inches below ground surface	NA	NA	NA
Total Coliform	1/100 ml	1/100 ml	1/100 ml	–

-- means no discharge limit, MCL, or HAL specified
(S) indicates secondary MCL (no notation means the value is a primary MCL)
(NC) means the reported health advisory level is for non-cancer effects
(C) means the reported health advisory level is for a 10^{-4} cancer risk
ND means Not Detected
NR means Not Reported
NA means Not Applicable

on the health effects associated with contaminants found above drinking water MCLs or HALs in the injectate of sewage treatment effluent wells and other Class V wells. As discussed in Section 4.1, the contaminants that have been observed above drinking water MCLs or HALs in sewage treatment effluent wells injectate are fecal coliform, TDS, nitrates, and pesticides.

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

In addition to chemical factors affecting adsorption, physical factors such as ground water hydraulic gradient, hydraulic conductivity, porosity, and bulk density also affect mobility. The point of injection for sewage treatment effluent wells may be within a permeable, coarse-grained unit in some areas. Such conditions are likely to allow constituents of concern in sewage treatment effluent well injectate to be highly mobile. For example, one unique characteristic of Hawaii geology is lava tubes formed by volcanic activity. Florida hydrogeology is unique in that ground water is located close to the surface in many parts of the state, and in that the majority of the sewage treatment effluent wells operating in the state are located in the Florida Keys, a marine environment. In Arizona, sewage treatment effluent wells are generally located in the central and southeastern portions of the state above state designated aquifers.

Some of the "sewage treatment effluent wells" reported in the survey are not actually "wells" at all, but are leach fields that are classified by definition as "sewage treatment effluent wells." These systems are designed specifically to disperse injectate constituents into soils and ground water. In settings where the receiving formation contains substantial clay or silt content, and does not include solution cavities or fractures, the mobility of some sewage treatment effluent injectate constituents may be "retarded." This is especially true for many metals, which, depending on pH and other site-specific factors, can undergo fixation and adsorption processes that decrease mobility within the soil-ground water system.

Also, the siting and design of sewage treatment effluent wells in some states (e.g., Florida, Hawaii) may be based on a confining layer between the injection zone and an underlying USDW. However, geologic "confining units" may not be as effective in confining injectate as may be initially reported. A geologic confining unit may be shown to be effective in confining the injectate over the short term, but it may require 10 to 20 years of observation to observe leakage of the confining unit (Kwader, 1999).

Literature data for fecal bacteria and viruses report a wide range of migration potential, and it is therefore difficult to define the fate and transport characteristics of these biological constituents in ground water. Depending on soil characteristics, fecal bacteria and viruses that reach ground water tend to not be detectable after traveling a lateral distance of 100 meters from an injection well. Experiments by Robeck et al. (1962) concluded that natural filtration occurs as a result of ground water movement. Their experiments noted that the action of the soil, not bacterial die-off, was responsible for lowering bacteria counts in their experiments (Fetter and Holzmacher, 1974). If the injection environment features fractured or fissured rock formations, pathogens may travel further before biological soil action reduces their presence to negligible levels. Chlorinating biologically treated effluent negatively affects the natural removal of coliform in soil (Paling, 1987). Depending on the exact features of the receiving aquifer and effluent, treated effluent must spend a given period of time within the ground water aquifer (and must have traveled a distance away from the injection site) before the effects of the injectate on the ground water are no longer detectable. In the event that vadose zone attenuation calculations are used to support location-specific injectate standards, it may be necessary to conduct soil column studies or other analytical studies to provide data to support the attenuation calculations.

5.2 Observed Impacts

No environmental damage cases involving ground water contamination with fecal coliform from sewage treatment effluent injectate were reported in the survey responses. However, only a small amount of data for either injectate concentrations or ground water concentrations of bacteria and viruses are available. As noted in Section 4.1, wastewater treatment effluent used as injectate is generally treated to secondary standards, and in some cases is treated to tertiary standards. Bacteria and viruses are generally not completely eliminated from wastewater effluent subjected to secondary treatment.

One environmental damage case was identified for nitrate contamination of ground water resulting from operation of a sewage treatment effluent well (subsurface disposal unit). In this case, the injectate receives only primary treatment prior to injection, and the facility operator reported that based on monitoring data, ground water onsite was contaminated with nitrates at levels exceeding drinking water standards. The Hawaii UIC program reported two environmental damage cases involving release of nutrient laden injectate to surface water, and the State of Florida and the USGS are investigating the potential effects of operation of sewage treatment effluent wells in the Florida Keys on surface water quality. Available information on the environmental performance of sewage treatment effluent wells in different states is discussed below.

Arizona

The Arizona UIC program reported that the program is unaware of any contamination of USDWs resulting from operation of a sewage treatment effluent well in Arizona. Mr. Troy Day of the ADEQ indicated that there have been occasional short-term violations of sewage treatment effluent well injectate quality standards at the discharge (injection) point, but that to his knowledge, none has affected ground water quality at the ground water monitoring point (Day, 1999).

California

The California UIC program has not reported any incidents of USDW contamination from operation of sewage treatment effluent injection wells in California.

In addition, a multi-part epidemiological study done in the Los Angeles area tried to determine if there was any detrimental effect from consuming recovered secondary treated wastewater effluent that had been used for basin recharge beginning 30 years earlier. The study found no statistically significant detrimental effect from consumption of the recovered water (Sloss, 1992). A study similar to the Los Angeles basin recharge study was conducted in California and concluded that there were no negative short term effects from the consumption of treated wastewater in the study area (Nellor et. al., 1985). Lark, Chang, and others, however, found that a number of hepatitis outbreaks could be traced to contaminated ground water supplies resulting from wastewater effluent injection. Their studies indicated that virus contaminated water traveled several hundred feet through soil, and affected both deep and shallow drinking water wells. It was discovered that fissured or fractured substrata were likely responsible for the disease outbreaks (Fetter and Holzmacher, 1974).

Florida

The Florida UIC program did not report any incidents of USDW contamination from operation of any individual sewage treatment effluent injection well in Florida, including aquifer recharge and salt water intrusion barrier systems. However, most of the sewage treatment effluent wells reported to be operating in Florida are in the Florida Keys, a marine environment. Fresh water sewage treatment effluent is of lighter density than sea water and will tend to float on sea water and disperse laterally. Also, chlorine is toxic to lower forms of life, and this potential for ecological toxicity is not reflected in drinking water standards by which injectate quality is usually evaluated. The USGS and the State of Florida are conducting a study of the operation of sewage treatment effluent wells in the Florida Keys. The study methodology and results to date are summarized below, along with a separate study by the University of South Florida examining viral tracers in the Florida Keys.

USGS Study of Geology and Human Activity in the Florida Keys. The USGS is conducting research, supported by the Florida Department of Environmental Protection (FDEP) and the USEPA, to study the movement of injected water and its potential effects on surface water quality and coral reef ecosystems. This research is part of a broader study of geology and human activity in the Florida Keys being conducted by the USGS. The USGS reported that the local population, the USEPA, and the National Oceanic and Atmospheric Administration (NOAA) perceive that excessive algal growth, coral diseases, and marine grass and sponge mortality are caused by release of sewage treatment effluent nutrients migrating from ground water into surface water on both sides of the Florida Keys (USGS, 1993; USGS, 1998).

The USGS reported in 1998 that treated sewage effluent is injected into the limestone under the Florida Keys through onsite disposal systems, including approximately 25,000 septic tanks, 5,000 cesspools, and 1,000 Class V Injection wells (USGS, 1998). Note that the Florida UIC program reported that approximately 700 of the 830 sewage treatment injection wells reported to be operating in Florida are located in Monroe County. The USGS reported that the depth of sewage treatment effluent injection wells in the Florida Keys ranges from 10 to 30 meters. The USGS is conducting a series of tracer studies to determine the rate and direction of ground water flow and the contamination levels of saline ground water in the Florida Keys and Florida Bay.

In 1998, the USGS installed 78 submarine monitoring wells in the Florida Keys reef tract, Florida Bay, and Shark River Slough, and an additional 14 wells in Biscayne Bay. Six multi-depth monitoring wells were also installed on shore at the Florida Keys Marine Laboratory. Twenty of the 84 wells were installed in two 200 foot diameter circular clusters on opposite sides of Key Largo, each with an injection well at the center. Each of these wells is screened at 20 feet and at 45 feet depths. The tracer studies provided data to determine ground water flow direction and flow direction. Additional studies are planned to collect water from wells in Florida Bay for chemical analysis to determine whether contaminated waters are entering the bay from below.

The results to date of this ongoing study have shown that ground water flow direction is primarily perpendicular to the Florida Keys, toward the east and the reef tract, and the maximum flow rate toward the east is approximately 100 meters per month (1 kilometer per year). Tidal pumping and higher sea level in Florida Bay are the two main driving forces for ground water flow. According to the USGS, the tracer study has already led to modifications of Florida regulations concerning the installation of sewage disposal wells, and has led USEPA to determine that “the geology of the Florida Keys is not suitable for the use of waste disposal wells” (USGS, 1998). The study results reported by the USGS did not indicate to what extent the operation of septic tanks, cesspools, and sewage treatment effluent wells may be contributing to the perceived degradation of water quality in Florida Bay and the reef tract.

Florida Study of Viral Tracers in Florida Keys Sewage Treatment Effluent Wells. The University of South Florida (USF) conducted a series of tracer studies at a simulated injection well on Key Largo and at an existing permitted sewage treatment effluent well on Long Key. For both studies, the USF researchers developed a viral tracer composed of several types of viruses propagated on hosts and injected into the simulated well on Key Largo and the operating well on Long Key using tap water as a carrier. The site for the Key Largo study consisted of a series of man-made canals that are lined with residences that operate septic tanks and hotels that operate package wastewater treatment plants and sewage treatment effluent injection wells. A simulated injection well was constructed 20 meters from one canal. The injection well consisted of a 1 inch internal diameter PVC pipe in a well drilled to a depth of 12.2 meters with a screened interval of 10.7 - 12.2 meters. One ground water monitoring well was collocated with the injection well, at a depth of 3 meters. A third ground water monitoring well was located 50 meters off shore and drilled to a depth of 12.2 meters with a screened depth of 11 - 12.2 meters. Four surface water sampling sites were located in the man-made canals.

The site for the Long Key study consisted of an existing Class V sewage treatment effluent well with a 6 inch internal diameter drilled to a depth of 90 feet and cased to a depth of 60 feet. The Long Key injection well receives treated effluent from an activated sludge package treatment plant. The well has a maximum injectate flow rate of 1,500 gallons per day. Ground water monitoring wells were installed in pairs, one deep (13.7 meters) and shallow (4.6 meters) in the same hole, with the exception of the off shore monitoring well, which was installed 60 meters off shore (83 meters from the injection well) at a depth of 4.6 meters.

For the Key Largo study, the viral tracer was pumped into the well with 20 liters of tap water over a 4 hour period. For the Long Key study, viral tracer was divided into five equal aliquots and one aliquot was added to the injection well each hour for five hours while the well was receiving treated effluent from the package wastewater treatment plant. For the Key Largo study, ground water sampling commenced eight hours after the initiation of the tracer study for the on shore monitoring wells, and 20 hours after initiation of the tracer study for the off shore well. For the Long Key study, sampling commenced at all monitoring locations eight hours after the initiation of the tracer study.

For the Key Largo study, the viral tracer was detected in the off shore ground water monitoring well as early as 20 hours after commencement of the tracer test, which was the earliest time that the off shore well was sampled. The viral tracer was detected in the shallow ground water monitoring well collocated with the injection well and surface water 20 meters from the injection well 8 hours after the initiation of the tracer study, and was also detected in surface water samples taken “upstream” of the injection well, as well as in offshore surface water samples. Viral tracers were detected in off shore ground water as early as 20 hours after the initiation of the tracer test. Rates of tracer migration to surface water sample points ranged from 2.5 m/hr to 35.5 m/hr, with an average rate of 19.5 m/hr, and migration patterns showed evidence of tidal pumping and a combination of ground water and surface water flow. These migration rates are similar to rates reported in previous studies by Paul, et. al. (1995) in the same environment when tracing septic tank wastewater. Paul, et. al. notes that the simulated injection well used for the Key Largo study was more shallow and of smaller diameter (1 inch as opposed to 6 to 9 inches inner diameter) than Class V sewage treatment effluent wells permitted by current Florida regulations.

For the Long Key study, viral tracers were detected in on shore ground water monitoring wells as early as 8 hours after the initiation of the tracer study (the earliest time the monitoring wells were sampled). Migration of viral tracers was detected both in the direction of Florida Bay (north of the injection well site) and towards the Atlantic Ocean (south of the site), and average migration rates were on the order of 1 m/hr towards the Florida Bay ground water monitoring location and 2 m/hr towards the Atlantic Ocean surface water monitoring location. Viral tracers were detected in the off shore ground water monitoring well 76 hours after the initiation of the tracer test, and in surface water in the Atlantic Ocean 53 hours after the initiation of the test. Average migration rates for the Long Key study were much lower than for the Key Largo study, possibly indicating the effect of tidal pumping and surface water transport pathways for the Key Largo study and the absence of such pathways for the Long Key study. For the Long Key study, there was no evidence of tidal pumping, and the closest canal is 106 meters from the injection well. Movement of ground water from the Long Key site through porous limestone, rather than through surface water, could contribute to the longer travel times for the Long Key study.

Hawaii

The Hawaii UIC program did not report any incidents of USDW contamination resulting from operation of sewage treatment effluent wells in the state. The program, however, reported two incidents of surface water contamination related to operation of sewage treatment effluent wells.

Wailuku-Kahului Wastewater Reclamation Facility. Wailuku-Kahului Wastewater Reclamation Facility on Maui disposed of treated municipal wastewater through four injection wells within meters of the ocean. The reclamation facility is located adjacent to the Kahana Pond Wildlife Refuge. Inspections in 1992 by the Hawaii Department of Health identified daily spills of wastewater from the plant and a leaking injection well. The State of Hawaii and USEPA pursued enforcement action against the reclamation facility, which is ongoing. Individuals reported that one month after the injection well commenced operation, the water in the adjacent pond turned bright green, which could indicate an increase in nutrient availability. Ground water monitoring is being conducted through an USEPA grant to the Hawaii Department of Land and Natural Resources.

Lahaina Wastewater Reclamation Facility. In 1991, the Lahaina Wastewater Reclamation Facility in Maui was injecting treated municipal wastewater into four injection wells situated 600 meters from the ocean. At that time, the west coast of Maui was experiencing algae blooms. Although a tracer study did not indicate any large effluent plume from the Lahaina facility, and did not demonstrate the cause of the algae blooms, USEPA issued a permit to Maui County that promoted the County to reduce nitrogen levels in wastewater and to begin using the wastewater for irrigation rather than for injection.

New Hampshire

The New Hampshire UIC program did not report any incidents of USDW contamination from operation of sewage treatment effluent wells in the survey response. However, permit data for the Town of Ossipee subsurface treatment facility obtained through a field visit to the permitting agency indicated that elevated levels of nitrate in ground water were attributable to discharge of treated wastewater effluent to ground water.

The New Hampshire Department of Environmental Services (NHDES) reported that the Town of Ossipee Subsurface Treatment Facility was issued a five-year Discharge to Ground Water Permit in 1983, and that the facility operated with an expired permit between 1988 and 1994. The NHDES received an application for permit renewal from the Town of Ossipee in 1994 (NHDES, 1996a). The NHDES required that the Town of Ossipee address several issues prior to the renewal of the permit for the facility, including exceedances in nitrate levels in monitored ground water at several monitoring locations.

The NHDES reported that based on historical ground water sampling data, concentrations of nitrates exceeded New Hampshire AGQS in on site monitoring wells. The NHDES required the Town to submit a new ground water contour map to show the direction of ground water flow within 100 feet of the ground water discharge zone and a revised water quality monitoring program to monitor the trend of nitrate migration. The NHDES also indicated that a Response Plan under New Hampshire regulation ENV-WS 410.10(f) may be required if regulated contami-nants (i.e., nitrates) were found to have migrated significantly from the facility. The NHDES also required monitoring of ground water and surface water downgradient of the existing monitoring wells. Historical monitoring data and current monitoring data for the Subsurface Treatment Facility ground water monitoring wells are summarized in Table 22 in Section 4.3.

Note that, as discussed above, the Discharge to Ground Water Permit for the Subsurface Treatment Facility prohibits any violation of drinking water quality standards in the ground water <u>at the compliance boundary of the facility</u> (i.e., the ground water discharge zone extending to the facility property line) and the NHDES did not indicate in the correspondence provided whether any exceedances of ground water quality standards had occurred in offsite locations. Also, the Subsurface Treatment Facility discharges both primary treated wastewater effluent and untreated septage to the leach field. NHDES has not determined whether the septage discharge, primary treated effluent discharge, or combination thereof is primarily responsible for the exceedances of ground water quality standards for nitrates.

6. BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) associated with sewage treatment effluent injection wells relate to well design, construction, operation, maintenance, and rehabilitation, and to the design and operation of the wastewater treatment plant that generates the injectate (effluent) for the well. There are two general categories of BMPs, those that affect the potential for operation of the well to affect ground water (or surface water) quality, and those that affect the physical operating characteristics of the well itself.

With respect to protection of ground water or surface water quality, one of the most important BMPs simply involves the production of appropriate quality effluent at the source (i.e., the wastewater treatment plant). Injectate that meets primary drinking water standards at the point of injection has a lower potential to adversely affect ground water or surface water quality than injectate that does not meet primary drinking water standards. However, it is possible that even injectate that meets primary drinking water standards could have adverse effects on ground water or surface water quality, because of the presence of byproducts for which drinking water standards have not been developed, or because of the presence of nutrients and other biological constituents that can affect surface water ecosystems. Conversely, reclaimed water and untreated ground water that do not meet all drinking water standards have been successfully injected into ASR wells without rendering the withdrawn water inadequate for future beneficial use (Dernlan, 1999).

With respect to well operation, injection of primary drinking water quality effluent does not necessarily prevent operating and maintenance concerns for sewage treatment effluent injection wells. It is important to control other characteristics of the injectate, including air entrainment, dissolved solids content, pH, chlorides, and presence of bacteria, for which there may not be primary drinking water standards, to avoid operating and maintenance problems such as scaling, clogging and corrosion (Greeley and Hansen, 1991; Driscoll, 1986). Conversely, reclaimed water and untreated ground water that does not meet all drinking water standards has been injected into ASR wells without clogging (Dernlan, 1999). BMPs related to ground water and surface water quality protection and injection well operation and maintenance are discussed further in this section.

The USEPA published a draft guidance document for sewage treatment effluent wells, entitled Draft - Publicly Owned Treatment Works (POTW) Injection Well Systems Guidance (USEPA, no date). This document contains general guidance concerning design, operating, and maintaining POTW injection systems (now referred to as sewage treatment effluent wells). The ADEQ has published a draft guidance document entitled Draft Best Available Demonstrated Control Technology (BADCT) for Domestic and Municipal Wastewater Treatment that includes guidance on well siting, design, operation, maintenance, and aquifer protection (ADEQ, 1998). The ADEQ determines BADCT for municipal and domestic wastewater treatment and disposal facilities on a site specific basis and based on negotiation with the permit applicant. The guidance document states that BADCT does not mean simply reducing pollutants to drinking water standards, and states that discharge reduction to an aquifer that is achieved solely by means of site characteristics (e.g., attenuation of injectate constituents in the vadose zone) does not in itself constitute BADCT. The ADEQ is developing an Aquifer Protection Permit Guidance Document as a companion to the BADCT Guidance Document. Other state UIC programs, for example, the Idaho UIC program, have incorporated BMPs directly into their UIC program regulations. Most programs incorporate Best Available Technology or Best Management Practices into the operating permits for sewage treatment effluent injection wells as part of the Class V well permitting process.

The following discussion notes BMPs for sewage treatment effluent wells that are closely related to the protection of ground water quality. The discussion is neither exhaustive nor represents an USEPA preference for the stated BMPs. Each state, USEPA Region, and federal agency may require certain BMPs to be installed and maintained based on that organization’s priorities and site-specific considerations.

6.1 Injection Well Siting, Construction, and Design

6.1.1 Well Siting and Construction Criteria

Proper design and construction of wastewater effluent injection wells is important because “minor mistakes in design or construction can result in damage to the well and subsequent economic loss and potential degradation of the environment”(Warner, 1981). It is important to properly cement, case, and protect wells from corrosion (Warner, 1981). For example, one environmental damage case cited by the Hawaii UIC program involved a sewage treatment effluent injection well that experienced a cracked casing, allowing effluent to migrate to surface water.

According to the USEPA Draft Publicly Owned Treatment Works (POTW) Injection Well Systems Guidance, geologic and hydrologic information should be gathered to the greatest extent possible prior to construction in order to ensure proper performance of the injection wells (USEPA, no date). Such information may include data on hydraulic gradient, ground water flow direction, and ground water travel time to drinking water sources or environmental receptors. State UIC programs generally require that such information be collected prior to well construction as part of the Class V injection well construction and operating permit process. The engineer or geologist who designs and supervises installation of the injection well must demonstrate as part of the permit application process what will happen to the effluent once it is injected, and demonstrate that the well is going to be safe to operate at design conditions. Data on the local ground water composition and characteristics can also be used to determine whether or not injected sewage treatment effluent will affect ground water quality. The 1987 RTC indicated that background ground water quality tests and injection and pumping tests are generally performed for new injection wells (USEPA, 1987) and background data and operational testing are generally required by state UIC program regulations as a condition of the construction and operating permits for the injection wells.

6.1.2 Well Design Criteria

According to Driscoll (1986), injection wells are much more likely to fail than typical water wells, and the consequences of water chemistry, air entrainment, thermal interference, and presence of suspended solids are more important for injection wells than they are for water wells. However, with the exception of injectate entrance velocity and well screen length, general design standards for water wells are applicable to injection wells, particularly for ASR wells that are used both as injection and production wells. For injection wells, fine solids contained in the injectate will collect in the aquifer formation outside the well screen, and over time the formation may become clogged. Driscoll reported that operation of an aquifer recharge well with injectate containing as little as 1 mg/l of sand can clog the well within a short time, and pressure build up in recharge wells has been attributed to even lower injectate solids concentrations. Clogging of screens is a significant problem in injection well operations, and therefore screen length and open area should be optimized. Typically, the entrance velocity for an injection well should be 0.05 ft/sec; those of an injection well are typically designed with well screen lengths that are twice as long as for a water production well of equal capacity. If the well is used only for injection (i.e., for sewage treatment effluent disposal or aquifer recharge, but not as an ASR well) dry sand or gravel zones above the aquifer may also be screened to improve well performance (Driscoll, 1986).

6.1.3 Siting and Design for ASR Wells

Sewage treatment effluent wells used for aquifer recharge or ASR may have somewhat different design criteria than injection wells used only for the injection of treated effluent for disposal. Operation of an aquifer storage and recovery well will affect the water table elevation. The water table in the vicinity of the injection well would “mound” while effluent was being injected, mirroring the drawdown cone that would be observed while ground water was being recovered (Driscoll, 1986; Uhlman, 1999). The cone of depression of an ASR well can have a pronounced effect on the static level of an aquifer, particularly a confined aquifer, when ground water is being withdrawn. An ASR well operates in the same manner as a drinking water production well, however, the recharge rate of the well will generally not be equal to the production capacity of the well. Because of the potential effects on water table elevation, the location, spacing, and operation of an ASR well is important to other private and public utility ground water users in the vicinity (Dwarkanath, 1999).

6.2 Injection Well Operation and Maintenance

6.2.1 Operation and Maintenance

Injection well operators should have standard procedures for well operation and maintenance as a condition of operation. Maintenance requirements for sewage treatment effluent injection wells vary depending on the site and the injectate constituents. Proper well operation and maintenance will help ensure that the system functions properly for its design life and that the potential for ground water contamination is minimized.

Each injection well should be limited to operate at the flow rate and pressure for which it was designed (USEPA, 1987; Driscoll, 1986). This minimizes the risk of unforseen events, such as casing failure or seepage of injectate to the surface, that might occur if design limits are exceeded. Also, design flow rate, pressure, and other well parameters are specific to the characteristics of both the injectate and receiving formation. For weakly consolidated and stratified (e.g., coastal plain) sediments, injection pressure must be minimized to prevent fracturing of the formation. Pressures as low as 0.5 lb/ft can fracture sediment formations.

For sewage treatment effluent wells, where injectate may meet primary drinking water standards, operation and maintenance requirements may be less severe than for other categories of Class V injection wells, such as solution mining wells. However, injection of effluent that meets primary drinking water standards does not guarantee that operation and maintenance problems will be minimized (Dernlan, 1999; Driscoll, 1986). Close control of injectate solids content, chloride concentration, temperature, pH, and other water quality factors are important to maintain the long term operation of the injection well. Chloride concentrations in injectate of greater than 500 mg/l and TDS concentrations greater than 1,000 mg/l (i.e., twice the secondary MCLs for these constituents) can contribute to corrosion. High injectate pH (above 7.5) can contribute to well incrustation and iron precipitation can occur at iron concentrations as low as 0.25 mg/l (i.e., below the secondary MCL of 0.3 mg/l). Magnesium can precipitate at concentrations as low as 0.2 mg/l if the pH is high in the presence of dissolved oxygen. Dissolved oxygen concentrations greater than 2 mg/l indicate a corrosive environment (Driscoll, 1986). Regardless of injectate quality, the injection well facility should have regularly scheduled maintenance and well inspections that are conducted by the facility operator and are independent of any scheduled state UIC program inspections.

Two types of fouling have been reported in sewage treatment effluent wells operating in Florida (Kwader, 1999). Injectate containing a high concentration of dissolved oxygen can cause precipitation of calcium and magnesium from minerals from the injectate which can form scale that can plug screens and boreholes. Oxygen and elevated levels of reduced iron (iron sulfide) can promote growth of iron-reducing bacteria that can also cause plugging of injectate receiving zones.

6.2.2 Well Cleaning and Rehabilitation

Sewage treatment injection wells are subject to clogging and scaling, and therefore wells and ancillary equipment should be cleaned regularly. Regular cleaning will reduce the frequency of clogging and the subsequent possibility of well degradation or failure due to greatly reduced infiltrative capacity or increase in well pressure. In some cases, anti-scalants, chlorine, corrosion inhibitors, or bacteriostatic agents may be injected into wells (Rayburn, 1999; Driscoll, 1986). Mineral deposits from well incrustation (e.g., calcium carbonate) are typically removed by injecting a strong solution of hydrochloric, sulfamic, or hydroxyacetic acid into the well to dissolve deposits. Driscoll (1986) reported that for an 4 inch diameter well, approximately 1 gallon of 30 percent hydrochloric acid solution would be needed for every foot of well screen, and approximately 15 gallons per foot would be needed for a 16 inch diameter well. Chlorine, hypochlorite, chlorine dioxide, potassium permanganate, and other strong oxidizing agents are used for control of bacterial contamination in wells.

6.2.3 Emergency Response

The injection well facility should be prepared to address any evidence of well failure or ground water contamination. In some cases, emergency response provisions are incorporated into operating permits for injection wells. Although many sewage treatment effluent injection wells do not normally inject effluent that can contaminate ground water, systems should be prepared to respond to emergencies that may occur as a result of a breakdown in the treatment and injection processes. Indications of contamination may include "surface seeping of wastewater, monitoring well data showing that the wastewater plume has moved outside of its intended area, algae growth near coastal areas where a nexus between ground water and surface water exists, mechanical integrity failure, and an increase or decrease in annular pressure." (USEPA, no date). Environmental damage cases for the Hawaii UIC program involved surface seepage of injectate, resulting in contamination of surface water with injectate nutrients (i.e., nitrogen, phosphorous). If contamination is detected, the injection well should be removed from operation while the potential contamination and its source are investigated (USEPA, no date).

6.3 Injectate Treatment

6.3.1 Denitrification

Denitrification is a biological process for the conversion of ammonia or nitrates in wastewater effluent to elemental nitrogen gas. This process may be effective in limiting the potential for environmental damage. Denitrification technologies for Fixed Growth Reactors and Suspended Growth Reactors are identified as BADCT in the Draft ADEQ BADCT Guidance Document. Denitrification occurs through biological reaction of nitrified wastewater in an anoxic environment with bacteria and an additional source of carbon (e.g., methanol) which may be fed to the reactor along with the wastewater. Mixing in Suspended Growth Reactor vessels may be accomplished using equipment similar to standard flocculation equipment. The denitrified wastewater is then aerated for 5 to 10 minutes to strip out the nitrogen gas which would otherwise inhibit settling of the wastewater sludge. Settled sludge may either be returned to the denitrification system or disposed of. Denitrification may also be conducted in a fixed film reactor similar to a pressure filter or a gravity deep bed filter, using either coarse or fine media and either an upflow or downflow configuration. A supplemental source of carbon (e.g., methanol) is also required for Fixed Growth Reactor denitrification, however Fixed Growth Reactors require less contact for denitrification than do Suspended Growth Reactors, and can accept a higher hydraulic rate of application than Suspended Growth Reactors.

The ADEQ Draft Guidance Document indicates that these technologies are well developed at full scale, but that economic considerations are a factor in the level of denitrification that can be achieved. The Guidance Document notes that denitrification processes may readily achieve wastewater effluent concentration as low as 1 mg/l total nitrogen, but notes that the ability to achieve these treatment levels depends upon skilled operators and requires reliably controlled pH, temperature, and chemical feed rates. The Guidance Document notes that small package treatment plants can readily achieve wastewater effluent concentrations between 5 mg/l and 10 mg/l total nitrogen (ADEQ, 1998).

6.3.2 Microbial Removal

The Draft ADEQ Guidance Document notes that certain site characteristics may act to remove pathogens from wastewater prior to entry into ground water. However, the BADCT for direct discharge into ground water is defined as the absence of pathogens. Because filtration and sorption of pathogens are media-specific, and not well-quantified in the literature, the Draft Guidance Document requires that these properties be tested in situ or in laboratory columns before they can be applied to BADCT.

In general, removal of pathogens from sewage treatment effluent has been achieved through chlorination. The dosage of chlorine required to remove pathogens will depend upon the quality of the influent to the treatment system and the effectiveness of any prior treatment processes. However, heavy doses of chlorine to domestic wastewater can cause the formation of chlorinated organic compounds, including trihalomethanes (Kwader, 1999). For this reason, the ADEQ does not consider chlorination to be BADCT for new wastewater treatment systems.

6.4 Chlorine Use Reduction

According to the ADEQ BADCT Guidance Document, new wastewater effluent disinfectant technologies such as ozonation, ultraviolet exposure, and use of other chemicals are gaining acceptance as alternatives to wastewater chlorination because of concerns over byproducts formed during chlorination. (ADEQ, 1998). Chlorination of domestic and municipal wastewater effluent, which contains high concentrations of organic matter, will result in the formation of trihalomethanes, including bromoform, chloroform, chlorodibromomethane, and dichlorobromomethane, which are priority pollutants. ADEQ does not consider wastewater effluent chlorination or treatment with chlorine derivatives to be BADCT for new wastewater treatment facilities, based on the potential for formation of carcinogenic byproducts from chlorination, and because equivalent treatment technologies (e.g., ozonation, ultraviolet exposure) for pathogens are available and demonstrated.

Wastewater subjected to secondary treatment may not meet MCLs for biological constituents such as fecal coliform. Discharges of primary and secondary treated effluent have increased potential for impacts to ground water and surface water quality. Discharges of tertiary treated effluent have lower potential for impacts to ground water and surface water quality; however, treated wastewater may include chlorination byproducts and other products for which MCLs or injectate discharge standards have not been established, and the potential for effects from chlorination byproducts and other byproducts for which drinking water standards have not been developed has not been evaluated (Goldman, 1999; Wilson, 1999). For example, the MCLs for trihalomethanes and haloacetic acids, which are common byproducts of chlorine disinfection and which are not commonly found in ground water, are proposed to be lowered in the future. In-situ degradation of trihalomethanes and haloacetic acids has not been studied in detail, but studies of ground water attenuation capabilities for these and other compounds are being conducted in California and Colorado (Bloetscher, 1999). Depending upon the specific degradation characteristics of these compounds in ground water, current operation of sewage treatment effluent wells may result in elevated concentrations of these compounds in ground water that could potentially violate the USEPA "non-endangerment" provisions (see 40 CFR 144.12(a), discussed in Section 6.1) in the future (Wilson, 1999).[4]

7. CURRENT REGULATORY REQUIREMENTS

7.1 Federal Programs

Several federal, state, and local programs exist that either directly manage or regulate Class V sewage treatment effluent wells. On the federal level, management and regulation of these wells falls primarily under the UIC program authorized by the Safe Drinking Water Act (SDWA). Some states and localities have used these authorities, as well as their own authorities, to extend the controls in their areas to address concerns associated with sewage treatment effluent wells. In addition, USEPA and states have established regulatory standards, guidelines, and BMPs applicable to municipal wastewater treatment plants under the Clean Water Act (CWA).

7.1.1 SDWA

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

[4] The federal UIC program regulation in 40 CFR 144.12(a) does not generally allow injection of treated water that does not meet primary MCLs into an ASR well (Wilson, 1999).

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

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

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

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

State staff must conduct source water assessments which are comprised of three steps. First, state staff must delineate the boundaries of the assessment areas in the state from which one or more public drinking water systems receive supplies of drinking water. In delineating these areas, state staff must use "all reasonably available hydrogeologic information on the sources of the supply of drinking water in the state and the water flow, recharge, and discharge and any other reliable information as the state deems necessary to adequately determine such areas." Second, the state staff must identify contaminants of concern, and for those contaminants, they must inventory significant potential sources of contamination in delineated source water protection areas. Class V wells, including sewage treatment effluent wells, should be considered as part of this source inventory, if present in a given area. Third, the state staff must "determine the susceptibility of the public water systems in the delineated area to such contaminants." State staff should complete all of these steps by May 2003, according to the final guidance.[5]

7.1.2 CWA

The federal National Pollutant Discharge Elimination System (NPDES) program is predicated on discharges of effluent to “navigable” waters of the U.S., which are broadly defined (e.g., waters connected by a culvert to navigable waters are covered). For some states (e.g., Texas), court decisions have stated explicitly that navigable waters do not include ground water. In contrast, a number of states define “waters of the state” broadly to include ground water as well as surface water. Therefore, state Pollution Discharge Elimination System (PDES) Programs frequently are responsible for permitting injection wells. When that is the case for state PDES Programs, it is noted and described in Section 7.2.

The NPDES program and state PDES programs have established regulatory standards and guidelines that apply to the operation of municipal wastewater treatment plants under the authority of the CWA. BMPs have also been established by the USEPA and the states under the CWA and associated state laws. These BMPs and state guidelines are equally appropriate for treatment plants that discharge to surface water or ground water. Also, as outlined in more detail in Section 7.2, certain states explicitly classify ground water as “waters of the state” and regulate sewage treatment injection wells under the state PDES program.   In this case, provisions of the state PDES program apply to both the treatment facility and the sewage treatment effluent wells.

7.2 State and Local Programs

Fifteen states are known to contain sewage treatment effluent injection wells. Arizona, California, Florida, Hawaii, and Massachusetts each contain a significant number of documented wells. New York is estimated to have a significant number of wells.

The statutory and regulatory programs addressing sewage treatment effluent wells in the six states with the largest numbers of documented or estimated wells, as well as eight other states, vary widely. USEPA directly implements the UIC Class V program in Arizona, California, Hawaii, Michigan, and New York. In each of these states, there is additional state jurisdiction over sewage treatment effluent wells through state regional water quality boards in California, through the states’ PDES programs in New York and Michigan, through the aquifer protection permit program in Arizona, and through administration of the UIC program by the state Department of Health (in Hawaii). Florida, Idaho (for wells deeper than 18 ft.), Massachusetts, New Hampshire, Oregon, and Wyoming are all UIC Class V Primacy States that issue individual permits for sewage treatment effluent wells.   Idaho (shallow wells), Texas, and West Virginia, which are also Primacy States, issue either individual permits or authorize by rule. Attachment A of this volume describes how sewage treatment effluent wells are addreswed in each of these states. In brief:

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

- USEPA Region 9 directly implements the UIC Class V program in Arizona. In addition, Arizona issues Aquifer Protection Permits to operators of sewage treatment effluent wells, and requires well operators to meet Best Available Demonstrated Control Technology (BADCT). The Draft ADEQ BADCT Guidance Document defines the best treatment level or pollutant concentration which can be achieved by applying BADCT. BADCT guidelines are discussed in Attachment A of this volume. Arizona requires compliance with drinking water standards at a ground water point of compliance (i.e., ground water depth at site boundary) rather than at the point of injection, and allows consideration of attenuation characteristics of the formation. However, the ADEQ reported that in practice, permit applicants for sewage treatment effluent wells generally propose to meet state ground water quality standards at the point of discharge, because of the amount of data and associated calculations that applicants would be required to submit to demonstrate the attenuation of injectate constituents.

- USEPA Region 9 directly implements the UIC Class V program in California. In addition, Regional Water Quality Boards establish local requirements for underground injection well siting, construction, and operation. Injectate is generally required to meet primary drinking water standards. In one instance, however, a regional water quality board has permitted at least one facility to discharge secondary treated wastewater. Regional water quality boards also set setback requirements for sewage treatment effluent wells on a site-specific basis For example, the Los Angeles County facility would be required to be a minimum of 150 feet to any water well, or a minimum of 100 feet from any water course. Counties also may establish their own requirements. Orange County, for example, prohibits any drinking water well to be located within 2,000 feet from any sewage treatment effluent well, and has also established a groundwater protection limit for total nitrogen, rather than only for total nitrates (Olson, 1999).

- USEPA Region 9 has direct implementation authority in Hawaii, but the state Department of Health administers the UIC Class V program. Hawaii's regulations prohibit the siting of any new Class V sewage treatment effluent injection well above a USDW, regardless of the injectate quality, and the regulations require that wells be located a minimum of one quarter mile from any potable drinking water well. Special buffer zones are required if the well is located in a caprock formation that overlies a volcanic USDW under artesian pressure, and special standards apply if the well is constructed above a large void such as a lava tube. Injection wells in Hawaii may not be operated in a manner that allows movement of a fluid containing contaminants into a USDW.

- USEPA Region 5 directly implements the UIC Class V program in Michigan. In addition, the Michigan Natural Resources and Environmental Protection Act prohibits discharge of effluent into "waters of the state". The state defines "waters of the state" to include ground water, and the state may use this provision to require state permits for sewage treatment effluent wells.

- USEPA Region 3 directly implements the UIC Class V program in New York. In addition, New York regulations prohibit discharge of effluent into "waters of the state". The state defines "waters of the state" to include ground water, and the state may use this provision to require State Pollution Discharge Elimination System permits for sewage treatment effluent wells.

- In Florida, a Primacy State for the UIC Class V program, sewage treatment effluent wells must obtain individual permits. Class I injection well construction standards may be applied to any Class V well for which the injectate does not meet primary and secondary drinking water standards, and operation of an injection well may not violate water quality standards. A representative of the Florida UIC program indicated that sewage treatment effluent well injectate in Florida are required to meet primary drinking water standards, but not necessarily secondary drinking water standards (Wilson 1999). Sewage treatment effluent wells operating in Monroe County are required to provide reasonable assurance that the operation of these wells will not cause or contribute to violation of surface water quality standards.

- In Idaho, a Primacy State for the UIC Class V program, wells more than 18 feet deep are permitted individually permitted, while shallower wells are permitted by rule. Idaho regulations specify the minimum distance an injection well may be sited from any ground water source that may be harmed by bacterial contaminants, based on the flow rate of injectate to the well. Minimum distance criteria for injection wells with a design flow rate greater than 5 cubic feet per second are determined on a case-by-case basis. However, the location criteria regulations do not apply to injection wells that inject fluids that meet all state drinking water standards. Idaho regulations prohibit contamination of ground water at "any place of beneficial use" with coliform bacteria, and the regulations allow the Idaho UIC program to recommend BMPs to reduce coliform concentrations in injected fluids.

- In Massachusetts, a Primacy State, facilities discharging effluent to groundwater are required to obtain either a Major or Minor Ground Water Discharge Permit (GWDP) depending on the flow rate of injectate. A GWDP requires that no discharge may result in a violation of state ground water quality standards. Special operating conditions are established in the permit on a case by case basis.

- New Hampshire, a Primacy State, issues permits to discharge to groundwater for at least one facility for discharge of wastewater effluent that is only subjected to primary treatment and does not meet drinking water standards. New Hampshire establishes ground water discharge zones and minimum setback distances for sewage treatment effluent wells, including subsurface disposal units, on a site-specific basis, depending upon the quality of the injectate. The injectate is not required to meet primary or secondary drinking water standards at the point of injection, but ground water at the point of compliance (outside the ground water discharge zone) is required to meet ground water quality standards.

- Oregon, a Primacy State, has enacted regulations prohibiting operation of any well that would allow movement of fluids containing contaminants into USDWs or that would cause a significant degradation of public waters or a public health hazard. Injection wells in Oregon are subject to individual permits. Permit and public notice requirements are less stringent for injection wells with design flow rates less than 5,000 gpd. The Oregon UIC program indicated that facilities may be constructing systems of injection wells, each with a design flow rate less than 5,000 gpd, for this reason (Eckley, 1999)

- Wyoming's UIC Class V program regulates new domestic wastewater treatment plant disposal facilities that dispose of treated effluent after secondary treatment through individual permits. The two such systems under development in Wyoming will be required to obtain an individual permit. Each permit is required to include a "point of compliance" which may be either the injectate itself or at the location of a down gradient monitoring well. Class V injection wells may not be located within 500 feet of any active public water supply well, whether or not the injection well and the public water supply well are located in different aquifer formations.

- Texas is a UIC Class V Primacy State. The single sewage treatment effluent well facility in Texas received an individual permit to construct. The Texas Natural Resources Control Commission (TNRCC) has promulgated specific construction requirements for injection wells, including sewage treatment effluent wells, but no specific operating requirements, which may be established by permit on a case by case basis. A permit may not be issued to any facility that would allow movement of fluid containing contaminants into a USDW, and permits must include provisions as reasonably necessary to protect fresh water from pollution.

- West Virginia is a Primacy State for the Class V UIC program. Class V injection wells are authorized by rule unless the Division of Environmental Protection requires an individual permit (per state regulations). Sewage effluent injectate must receive at least secondary treatment prior to injection. Owners or operators of wells are required to meet various operating, monitoring, and reporting requirements, and may be required to take corrective action (e.g., closure) if the injection of fluids causes a violation of the primary drinking water rules.

ATTACHMENT A
STATE AND LOCAL PROGRAM DESCRIPTIONS

Fifteen states are known to contain sewage treatment effluent injection wells. Collectively, Arizona, California, Florida, Hawaii, and Massachusetts contain almost 97 percent of the documented wells. New York may also have a significant number of wells. The following sections summarize the programs used to control sewage treatment effluent wells in these and other states.

Arizona

USEPA Region 9 directly implements the UIC Class V program. In addition, under the Arizona Revised Statutes (Title 49, Chapter 2, Article 3 - Aquifer Protection Permits) any facility that "discharges" is required to obtain an Aquifer Protection Permit (APP) from the Arizona Department of Environmental Quality (ADEQ). An injection well is considered a discharging facility and is required to obtain an APP, unless ADEQ determines that it will be "designed, constructed, and operated so that there will be no migration of pollutants directly to the aquifer or to the vadose zone."

Permitting

The Arizona Aquifer Protection Permit Rules (Chapter 19, sub-chapter 9, October 1997) defines an injection well as "a well which receives a discharge through pressure injection or gravity flow." Any facility that discharges is required to obtain an individual APP from ADEQ, unless the facility is subject to a general permit. Permit applications must include specified information. This includes topographic maps, facility site plans and designs, characteristics of past as well as proposed discharge, and best available demonstrated control technology, processes, operating methods, or other alternatives to be employed in the facility. In order to obtain an individual permit, a hydrogeologic study must be performed. This study must include a description of the geology and hydrology of the area; documentation of existing quality of water in the aquifers underlying the site; any expected changes in the water quality and ground water as a result of the discharge; and the proposed location of each point of compliance.

Operators must demonstrate that the facility will be designed, constructed, and operated as to ensure greatest degree of discharge reduction and aquifer water quality will not be reduced or standards violated. By rule, presumptive best available demonstrated control technology, processes, operating methods or other alternatives, in order to achieve discharge reduction and water quality standards, are established by ADEQ.

An APP may require monitoring, record keeping and reporting, a contingency plan, discharge limitations, compliance schedule, and closure guidelines. The operator may need to furnish information, such as past performance, and technical and financial competence, relevant to its capability to comply with the permit terms and conditions. A facility must demonstrate financial assurance or competence before approval to operate is granted. Each owner of an injection well to whom an individual permit is issued must register the permit with ADEQ each year.

ADEQ designates a point or points of compliance for each facility receiving a permit. The statute defines the point of compliance as the point at which compliance with aquifer water quality standards shall be determined and is a vertical plane down gradient of the facility that extends through the uppermost aquifer underlying that facility. If an aquifer is not or reasonably will not foreseeably be a USDW, monitoring for compliance may be established in another aquifer. Monitoring and reporting requirements also may apply for a facility managing pollutants that are determined not to migrate.

Siting and Construction

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

Operating Requirements

All wells must be operated in such a manner that they do not violate any rules under Title 49 of the Arizona Revised Statutes, including Article 2, relating to water quality standards, and Article 3, relating to APPs. Water quality standards must be met in order to preserve and protect the quality of waters in all aquifers for all present and reasonably foreseeable future uses. The Arizona UIC program does not require sewage treatment well injectate to meet primary drinking water standards at the point of injection, but rather allows applicants for sewage treatment effluent well permits to consider ground water flow direction, travel time, and attenuation in siting sewage treatment effluent wells. Mr. Troy Day of the ADEQ indicated that because a large amount of data are required to conduct the required attenuation calculations, most sewage treatment effluent well operators in Arizona have accepted permit conditions requiring injectate to meet drinking water standards at the point of injection (Day, 1999).

Monitoring Requirements

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

The Draft ADEQ Best Available Demonstrated Control Technology (BADCT) Guidance Document defines the best treatment level or pollutant concentration which can be achieved by applying BADCT. These effluent concentration guidelines are shown in Table A-1. Site

Table A-1. Best Available Demonstrated Control Technology for Domestic and Municipal Wastewater Discharges - ADEQ Water Quality Division

PARAMETER	OPTIMUM REDUCTION	NOTES
Fecal Coliform	2.2 CFU/100 ml, Geometric Mean	BADCT for Fecal Coliform for other than direct discharge to ground water. Drinking water standard is 1.0 CFU/100 ml
Fecal Coliform	"absence of these pathogenic constituents in the discharge"	BADCT for Fecal Coliform for direct discharge to ground water
Turbidity	1.0 FTU	
Nitrogen	1.0 mg/l to 10.0 mg/l	Actual value will depend on process type and size of facility
Fluorides	Safe Drinking Water Act MCL	
Hazardous Substances with MCLs	Safe Drinking Water Act MCL	Except those hazardous substances noted below
Hazardous Substances without MCLs	Action level or concentration representing 1 E-06 cancer risk	Action level or concentration, whichever is lower
Hazardous Substances pursuant to ARS 49-243.D	None detectable, based on method detection limit	Category includes reasonably anticipated and known carcinogens and "acute hazardous wastes" per 40 CFR 261.33(e) [Discarded commercial chemical products]
Arsenic	0.05 mg/l	Primary MCL
Barium	1.0 mg/l	Primary MCL
Cadmium	0.010 mg/l	Primary MCL
Chromium	0.05 mg/l	Primary MCL
Lead	0.05 mg/l	Primary MCL
Mercury	0.002 mg/l	Primary MCL
Selenium	0.01 mg/l	Primary MCL
Silver	0.05 mg/l	Primary MCL
Methoxychlor	0.10 mg/l	Primary MCL
2, 4, D	0.10 mg/l	Primary MCL
2, 4, 5 TP Silvex	0.01 mg/l	Primary MCL
Trichloroethane	0.005 mg/l	Primary MCL
Carbon Tetrachloride	0.005 mg/l	Primary MCL

characteristics are part of BADCT only to the extent that they control the quality of the discharge before it reaches the ground water. Dilution of the discharge once pollutants have entered the ground water is not considered part of BADCT. The Draft Guidance Document describes the types of data permit applicants may submit to the ADEQ to take into account soil properties, vadose zone properties, and vadose zone thickness (depth to ground water) in determining BADCT. The ADEQ reported that in practice, permit applicants for sewage treatment effluent wells generally proposed to meet state ground water quality standards at the point of discharge, because the amount of data and associated calculations that applicants are required to submit to the ADEQ to demonstrate the attenuation of injectate constituents is extremely burdensome to the applicant. As part of the permit process, permit applicants are generally required to conduct laboratory scale soil column studies and associated field studies to demonstrate and characterize the attenuation process (Day, 1999).

Plugging and Abandonment

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

Financial Responsibility

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

California

USEPA Region 9 directly implements the UIC program in California. In addition, the California Water Quality Control Act (WQCA) establishes broad requirements for the coordination and control of water quality in the State, sets up a State Water Quality Control Board, and divides the State into nine regions, with a RWQCB that is delegated responsibilities and authorities to coordinate and advance water quality in each region (Chapter 4 Article 2 WQCA). A RWQCB can prescribe requirements for discharges (waste discharge requirements or WDRs) into the waters of the State (13263 WQCA). These WDRs can apply to injection wells (13263.5 and 13264(b)(3) WQCA).

Permitting

Although the RWQCB do not permit injection wells, the WQCA provides that any person operating, or proposing to operate, an injection well (as defined in §13051 WQCA) must file a report of the discharge, containing the information required by the Regional Board, with the appropriate Regional Board (13260(a)(3) WQCA). Furthermore, the Regional Board, after any necessary hearing, may prescribe requirements concerning the nature of any proposed discharge, existing discharge, or material change in an existing discharge to implement any relevant regional water quality control plans. The requirements also must take into account the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, and the factors that the WQCA requires the Regional Boards to take into account in developing water quality objectives, which are specified in §13241 of the WQCA ((13263(a) WQCA). However, a Regional Board may waive the requirements in 13260(a) and 13253(a) as to a specific discharge or a specific type of discharge where the waiver is not against the public interest (13269(a) WQCA).

The WQCA specifies that no provision of the Act or ruling of the State Board or a Regional Board is a limitation on the power of a city or county to adopt and enforce additional regulations imposing further conditions, restrictions, or limitations with respect to the disposal of waste or any other activity which might degrade the quality of the waters of the State (13002 WQCA).

Siting and Construction

Construction standards from Bulletin 74-90 of the Department of Water Resources generally apply. Orange County, California requires that well operators provide a 2,000 foot distance to the nearest potable water supply well for all injection wells that inject reclaimed water (treated wastewater effluent) (Hildebrand, 1999).

Operating Requirements

A RWQCB may, in establishing or reviewing any water quality control plan or waste discharge requirements, or in connection with any action relating to any plan or requirement, may investigate the quality of any waters of the state within its region (13267(A) WQCA). The state board may require any person, including a person subject to a waste discharge requirement, to furnish any information that may be reasonably required to determine whether the injection well could affect the quality of the waters of the state (13267(B) WQCA).

Florida

Florida has primacy for the Class V wells. Chapter 62-528 of the Florida Administrative Code (FAC), effective June 24, 1997, establishes the UIC program, and Part V (62-528.600 to 62-528.900) addresses criteria and standards for Class V wells.

Class V wells are grouped for purposes of permitting into eight categories. Group 3, Domestic Wastewater Wells, consists of wells used to discharge effluent or reclaimed water from domestic wastewater treatment facilities. The category does not include wells that receive only domestic wastewater but have the capacity to serve fewer than twenty persons per day, or wells that receive non domestic wastewater. This category therefore can be expected to include most sludge effluent treatment wells.

Permitting

Underground injection through a Class V well is prohibited except as authorized by permit. In addition to other requirements, in Monroe County (the Florida Keys) all Class V Group 3 wells designed to inject domestic wastewater are required to provide reasonable assurance that operation of the well will not cause or contribute to a violation of the surface water standards in Chapter 62-302 FAC. Owners and operators are required to obtain a Construction/Clearance Permit before receiving permission to construct. The applicant is required to submit detailed information, including well location and depth, description of the injection system and of the proposed injectate, and any proposed pretreatment. When site-specific conditions indicate a threat to a USDW, additional information must be submitted. Class V Group 3 wells are also required to obtain an operation permit, not to exceed 5 years. Finally, all Class V wells are required to obtain a plugging and abandonment permit.

Siting and Construction

Florida regulation 62-528.605, Well Construction Standards for Class V Wells, contains construction standards for Class V wells constructed in the state, including wastewater effluent injection wells that are not Class I wells. The Florida UIC program may apply design standards for Class I wells to any Class V well "if the Department determines that without the application of Class I permitting criteria, the Class V well may cause or allow fluids to migrate to an underground source of drinking water that may cause a violation of a primary or secondary drinking water standard . . . or may cause fluids of significantly differing water quality to migrate between underground sources of drinking water." Class I standards will not be required for Class V wells if the injectate meets primary and secondary drinking water standards. Drilled Class V wells are required to meet the casing and cementing requirements of Chapter 62-532 FAC, and wastewater effluent injection wells are required to be cased at least 60 feet depth with an open hole completion to 90 feet.

Class V wells are required to be constructed so that their intended use does not violate the water quality standards in Chapter 62-520 F.A.C. at the point of discharge, provided that the drinking water standards of 40 CFR Part 142 (1994) are met at the point of discharge.

Operating Requirements

All Class V wells are required to be used or operated in such a manner that they do not present a hazard to a USDW. Domestic wastewater effluent must meet criteria established in specified rules of the F.A.C.[6] Pretreatment of injectate must be performed, if necessary to ensure the fluid does not violate the applicable water quality standards in 62-520 F.A.C.

The Florida UIC program classifies aquifers either as USDWs or as “exempted aquifers” for the purposes of exemption from Class V injection siting requirements or discharge limitations, and uses a concentration threshold of 10,000 mg/l for classification of an “exempt aquifer.”

Sewage treatment effluent wells installed in Monroe County are required as part of the Class V operating permit application to provide reasonable assurance that operation of these wells will not cause or contribute to violation of surface water quality standards. According to a representative of the Florida Department of Natural Resources (FDNR), wastewater treatment effluent injected into wells located above USDWs in Florida is required to meet primary drinking water standards, however injectate does not necessarily meet secondary drinking water standards (Wilson, 1999).

Monitoring Requirements

Monitoring generally will be required for Group 3 wells, unless the wells inject fluids that meet the primary and secondary drinking water standards in 62-550 F.A.C. and the minimum criteria in Rule 62-520, and that have been processed through a permitted drinking water treatment facility. Therefore, sewage effluent treatment wells can be expected to be monitored, unless the state determines that there is a reasonable assurance that they will comply with the rule without monitoring. Monitoring frequency will be based on well location and the nature of the injectate and will be addressed in the permit. Group 3 wells will be required to submit periodic reports.

Plugging and Abandonment

The proposed plugging method will be approved as a condition of the permit.

Hawaii

USEPA has UIC direct implementation authority in Hawaii, but the state Department of Health administers the UIC Class V program. Chapter 23 of Title 11 of the Hawaii Administrative Rules (HAR), effective July 6, 1984, amended November 12, 1992, establishes the state UIC program.

Permitting

Class V wells are grouped for purposes of permitting into 6 subclasses. Both the Subclass A and Subclass AB well categories include sewage injection wells. Subclass A wells inject fluids into USDWs; Subclass AB inject only into exempted aquifers. Nonresidential waste disposal systems that receive solely sanitary wastes from buildings that generate less than one thousand GPD of wastewater, however, are excluded from coverage by the UIC rules.

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[6] Rules 62-600.420(1)(d)2, and 62-600.540(2) and (3) or 62-610.660 F.A.C., as appropriate.

No injection well may be constructed unless a permit application has been made and the construction has been approved. A permit for injection into USDW will be based on evaluation of the contamination potential of the local water quality by the injection fluids and the water development potential for public or private consumption. Permits are issued not to exceed five years. Permit applications must include specified information (11-23-12, 11-23-13, and 11-23-16 HAR). For injection wells sited "mauka" of the state-defined UIC line ("mauka" being defined as toward the Hawaii mountains or toward an encircled protected aquifer) the permit applicant is required to submit background water quality data, including concentration data for chlorides, TDS, and coliform, from several of the water supply wells nearest the proposed location of the injection well. Permit applicants are also required to submit a well log, including lithology of injection intervals(s) and confining formation(s) and physical and structural characteristics of the formations encountered, initial water level, and subsequent water levels, particularly for artesian conditions, and tidal fluctuations and efficiency. Permit application documents must be prepared by a licensed Hawaii engineer or geologist.

Siting and Construction

Wells are required to be sited beyond an area that extends at least one-quarter mile from any part of a drinking water source, including not only the surface expression of the water supply well, tunnel, or spring, but also all portions of the subsurface collection system (The UIC line). Special buffer zones are required if the well is located in a caprock formation that overlies volcanic USDW under artesian pressure (11-23-10 HAR).

State UIC program regulations have prohibited the siting of any new sewage treatment effluent well directly above a USDW since 1984. The Hawaii UIC program classifies aquifers either as USDWs or as "exempted aquifers" for the purposes of exemption from Class V injection siting requirements or discharge limitations, and uses a TDS concentration threshold of 5,000 mg/l for classification of an "exempt aquifer."

The state UIC program also has Class V injection well siting criteria requiring that any new well be sited a minimum of 0.25 miles from any drinking water source, and 0.5 miles from existing drinking water sources drawing from state-designated artesian aquifers. A buffer zone of at least 50 feet of confining materials (e.g., caprock) is required between the bottom of an injection well and the top of a volcanic aquifer, and injection pressure is required to remain below the pressure of the volcanic aquifer or below 2 psi, whichever is greater. The state regulations also require that in the event that an injection well is constructed in a large void, such as a lava tube, the permit applicant must demonstrate that the void does not slope inland, by constructing test borings, or is required to construct well such that the solid cased portion of the well passes entirely through the void.

Specific construction standards for each type of well are not specified, due to the variety of injection wells and their uses. If large voids such as lava tubes or solution cavities are encountered, special measures must be taken to prevent unacceptable migration of the injected fluids (11-23-09 HAR).

Operating Requirements

The rules pertaining to wastewater systems (Title 11 Chapter 62 HAR) specify wastewater effluent requirements applicable to treatment works (11-62-26 HAR) for BOD and suspended solids, adopt by reference USEPA regulations in 40 CFR 125 and 40 CFR 133, and specify a chlorine residual for treatment works using a subsurface disposal system other than soil absorption. They also specify peak flow and backup requirements for proposed subsurface disposal systems (11-62-25 HAR). Hawaii has established a "total nitrogen" limit of 10 mg/l, rather than a limit for nitrates alone. The basis for the "total nitrogen" limit is that ammonia can transform into nitrates in the environment. The "total nitrogen" limit is therefore considered to be more protective than a standard for nitrates alone (Olson, 1999).

A Class V well may not be operated in a manner that allows the movement of fluid containing a contaminant into a USDW, if the presence of that contaminant may cause a violation of any national or state primary drinking water rule or otherwise adversely affect the health of one or more persons. All wells must be operated in a manner that does not violate any rules under Title 11 HAR regulating water quality and pollution, including Chapter 11-20, relating to potable water systems, Chapter 11-62, relating to wastewater systems, and Chapter 11-55, relating to water pollution control. The state may also impose other limitations on quantity and quality of injectate as deemed appropriate. An operator may be ordered to take such actions as may be necessary to prevent a violation of primary drinking water standards, including cessation of operations (11-23-11 HAR). A Class V well may not be operated in a manner that allows the movement of fluid containing a contaminant into a USDW, if the presence of that contaminant may cause a violation of any national or state primary drinking water rule or otherwise adversely affect the human health.

Monitoring Requirements

Operating records generally will be required for sewage effluent treatment wells, including the type and quantity of injected fluids and the method and rate of injection (11-23-12 HAR).

Plugging and Abandonment

An operator wishing to abandon a well must submit an application. The well must be plugged in a manner that will not allow detrimental movement of fluids between formations (11-23-19 HAR).

Idaho

Idaho is a Primacy State for UIC Class V wells and has promulgated regulations for the underground injection control program in the Idaho Administrative Code (IDAPA), Title 3, Chapter 3. Deep injection wells are defined as more than 18 feet in vertical depth below the land surface (37.03.03.010.11 IDAPA). Wells are further classified, with Class V Subclass 5W12 defined as water treatment plant effluent wells (37.03.03.025.01.r IDAPA).

Permitting

Construction and use of shallow injection wells is authorized by rule, provided that inventory information is provided and use of the well does not result in an unreasonable contamination of a drinking water source or cause a violation of water quality standards that would affect a beneficial use (37.03.025.03.d. IDAPA). Construction and use of Class V deep injection wells may be authorized by permit (37.03.03.025.03.c IDAPA). The regulations outline detailed specifications for the information that must be supplied in a permit application (37.03.03.035 IDAPA).

Siting and Construction

Wells must be constructed by state-licensed well drillers if deeper than 18 feet, and must conform to the state Minimum Well Construction Standards. The plans for wells that are less than 18 feet deep are reviewed by the Idaho Department of Water Resources, and also may be reviewed by local authorities (37.03.03.045.04 IDAPA). The proposed location of the well must be described in the permit application, and if operation of the well could cause unreasonable contamination of a drinking water source or cause a violation of the water quality standards at a place of beneficial use, the well cannot be permitted at that site.

Operating Requirements

Standards for the quality of injected fluids and criteria for location and use are established for rule-authorized wells, as well as for wells requiring permits. The rules are based on the premise that if the injected fluids meet MCLs for drinking water for physical, chemical, and radiological contaminants at the wellhead, and if ground water produced from adjacent points of diversion for beneficial use meets the water quality standards found in Idaho's "Water Quality Standards and Wastewater Treatment Requirements," 16.01.02 IDAPA, administered by the Idaho Department of Health and Welfare, the aquifer will be protected from unreasonable contamination. The State may, when it is deemed necessary, require specific injection wells to be constructed and operated in compliance with additional requirement (37.03.03.050.01 IDAPA (Rule 50)). Rule-authorized wells "shall conform to the drinking water standards at the point of injection and not cause any water quality standards to be violated at the point of beneficial use" (37.03.03.050.04.d IDAPA).

Monitoring, record keeping, and reporting may be required if the State finds that the well may adversely affect a drinking water source or is injecting a contaminant that could have an unacceptable effect upon the quality of the ground waters of the State (37.03.03.055 IDAPA (Rule 55)).

Idaho UIC program regulations prohibit contamination of ground water at "any place of beneficial use" with coliform bacterial from operation of any injection well. Regulation IDAPA 37.03.03. Rule 50.02(b) allows the Idaho Department of Water Resources to recommend the use of BMPs to reduce the concentration of coliform bacteria in injected fluids. Injection of fluid "containing or suspected of containing" fecal contaminants of human origin into any Class V well is prohibited under IDAPA Rule 50.02(b)(vi). The Department may also require the use of well treatment technology, including ozonation and chlorination devices, sand filters, and settling pond specifications to reduce the concentration of coliform bacteria in injected fluids.

Plugging and Abandonment

The Idaho Department of Water Resources (IDWR) has prepared "General Guidelines for Abandonment of Injection Wells," which are not included in the regulatory requirements. IDWR expects to approve the final abandonment procedure for each well. The General Guidelines recommend the following:

C If possible, the casing should be pulled. If casing is not pulled, cut casing a minimum of two feet below land surface. The total depth of the well should be measured. If the casing is left in place, it should be perforated and neat cement with up to 5% bentonite can be pressure-grouted to fill the hole. As an alternative, when the casing is not pulled, you may use course bentonite chips or pellets. If the well extends into the aquifer, the chips or pellets must be run over a screen to prevent any dust from entering the hole. No dust is allowed to enter the bore hole because of the potential for bridging. Perforation of casing is not required under this alternative. If well extends into the aquifer, a clean pit-run gravel or road mix may be used to fill bore up to ten feet below top of saturated zone or ten feet below the bottom of casing, whichever is deeper, and cement grout or bentonite clay used to surface. The use of gravel may not be allowed if the lithology is undetermined or unsuitable. A cement cap should be placed at top of casing if not pulled, with a minimum of two feet of soil overlying filled hole/cap. Abandonment of well must be witnessed by IDWR representative.

Financial Responsibility

No financial responsibility requirement exists for rule-authorized wells. Permitted wells are required by the permit rule to demonstrate financial responsibility through a performance bond or other appropriate means to abandon the injection well according to the conditions of the permit (37.03.03.35.03.e IDAPA).

Massachusetts

Massachusetts is a UIC Primacy State for Class V wells. The definition of Class V wells states that Class V includes injection wells not included in Classes I through IV (310 CMR 27.03(5)). Injection of fluids through wells is prohibited except as authorized, and provided there is compliance with the Environmental Code and the Underground Water Source Protection Rules. The Division of Water Pollution Control (DWPC) administers the ground water discharge permit program under 314 CMR 5.00, and GWD permits are used to regulate discharge of liquid effluent (314 CMR 5.03(2)(d)). A permit is required for any facility that discharges a liquid effluent into a Class V injection well.

Permitting

Discharge of pollutants to the ground water is prohibited without a Ground Water Discharge Permit issued by the Massachusetts Department of Environmental Protection (DEP). Discharge of liquid effluent into a Class V injection well is specifically stated to require a Discharge Permit (314 CMR 5.03).

Systems required to obtain a Ground Water Discharge Permit (GWPD) will obtain a Minor GWDP if they discharge from 15,000 gpd to 150,000 gpd. Dischargers in excess of 150,000 gpd, or providing treatment of sewage more advanced than secondary treatment, which includes nitrification/denitrification and/or phosphorus removal will obtain a Major GWDP. Both must supply a complete engineering report, including hydrogeological data, from a Professional Engineer, final engineering drawings, a ground water monitoring well plan, and supporting information.

Operating Requirements

A Ground Water Discharge Permit requires that no discharge may result in a violation of the Massachusetts Ground Water Quality Standards, and other general conditions (314 CMR 5.19) as well as special conditions established on a case-by-case basis, and creating effluent limitations, monitoring, recordkeeping, reporting, compliance schedules, and other specific requirements (314 CMR 5.10). Discharges must meet water quality based effluent limits specified in 314 CMR 5.10(3)(a) through (c), which vary depending on the classification of the ground water affected by the discharge. In addition, for POTWs with design flows greater than 15,000 gpd, technology-based effluent limits are specified that also vary according to the classification of the ground water into which the discharge occurs. The state's three ground water classes and designated uses are established according to 314 CMR 6.00.

Plugging and Abandonment

The state's rules do not contain explicit requirements for plugging and abandonment. However, they provide that if there is any movement of injection or formation fluids into USDW, the DWPC may prescribe such additional requirements as may be necessary for corrective action, including closure through plugging and abandonment, to prevent such movement (310 CMR 27.10).

Michigan

USEPA Region 5 directly implements the UIC Class V program in Michigan. In addition, Michigan's Natural Resources and Environmental Protection Act (NREPA)(1994 P.A. 451, Part 31) prohibits discharge of any waste or waste effluent into the waters of the state without a permit (§ 324.3112). NREPA defines "waters of the State" to include ground waters (§3101) and provides that a person may not discharge directly or indirectly into the waters of the State a substance that is or may become injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other uses that are being made or may be made of such waters (§3109(1)(a) and (b)).

Permitting

The Michigan Department of Natural Resources, Water Resources Commission has promulgated rules under the authority of Part 31 NREPA for the protection of ground water quality that provide for the nondegradation of ground water quality in usable aquifers, define the requirements for hydrogeological study before permitting a discharge into ground waters, and establish ground water monitoring requirements for ground water discharges (Part 22 Rules 323.2201 - 323.2211). The Water Resources Commission also has promulgated requirements for wastewater discharge permits (Part 21 Rules 323.2101- 323.2192). According to these rules, a point source discharge includes a well from which wastewater is discharged CR 323.2104(vi)) Waste and wastewater are defined broadly under the rules to include wastewater and waste effluent resulting from industrial and commercial processes and municipal operations ((R 323.2104(q) and (r)).

Siting and Construction

There are no siting or construction requirements or operating requirements for wells injecting treated effluent from wastewater treatment plants treating only sanitary wastewater.

New Hampshire

New Hampshire is a Primacy State for Class V UIC wells. Part Env-Ws 410 of the New Hampshire Administrative Code (NHAC) establishes the State's ground water protection program, which includes underground injection registration. The State has established a policy that, unless due to a natural condition or specifically exempted, all ground waters of the State shall be suitable for use as drinking water without treatment, and that ground water shall not contain any regulated contaminant at a concentration greater than the ambient ground water standards in Env-.Ws 410.05 (Env-Ws 410.03 NHAC). However, the rules contain a specific exemption for a discharge within a ground water discharge zone permitted under a ground water management permit (Env-Ws 410.08 NHAC).

Permitting

A ground water discharge permit is required to be obtained by certain categories of discharges. These include discharge of nondomestic wastewater which contains a regulated contaminant and has received treatment by BAT before discharge (Env-Ws 410.08(a)(5) NHAC). Discharge of a nondomestic wastewater that contains regulated contaminants and does not receive treatment by BAT, and discharge of nondomestic wastewater that contains a regulated contaminant which exceeds the ambient groundwater quality standards are both prohibited (Env-Ws 410.07 NHAC). However, a ground water discharge of a nondomestic wastewater that does not contain a regulated contaminant, if the discharge is regulated in accordance with Env-Ws 410.32, is considered to have a permit by rule and to be exempt from the requirements of Env-Ws 410.08 (Env-Ws 410.08(c)(5) NHAC). Under

Env-Ws 410.32, owners of facilities that discharge nondomestic wastewater that does not contain a regulated contaminant must register the discharge with the state. The information that must be supplied at registration includes a description of the facility and the types of wastewater handled at the facility, the wastewater's chemical characteristics, a description of the disposal method, and the discharge rate, volume, and schedule. Sampling and analysis may be required. Nondomestic wastewater is not defined in Part 410 Env-Ws; domestic wastewater is defined as wastewater from human sanitary uses. Discharge of domestic wastewater from a subsurface disposal system with a design flow equal to or greater than 20,000 gallons per day also requires a permit.

Siting and Construction

The NHDES allows for consideration of site characteristics in applying state Ambient Ground Water Quality Standards for sewage treatment effluent wells. The New Hampshire Department of Environmental Services (NHDES) indicated that typical septic system discharge facilities (including facilities that discharge treated effluent to subsurface disposal units) are required to have a minimum "setback" distance from the property line such that a Ground Water Discharge Zone (GDZ) can be established for the attenuation of nitrates and other constituents in the discharge. The minimum required distance for "nitrate setbacks" for conventional septic system discharges and sewage treatment effluent wells (i.e., leach fields) located in New Hampshire is calculated based on the distance between the discharge point(s) and the facility property line. Permit applicants are prohibited from any violation of state ground water quality standards outside of the GDZ. Any monitored exceedances of state ground water quality standards within the GDZ require initiation of corrective action, but are not in and of itself a permit violation (NHDES, 1998).

The NHDES requires permit applicants to prepare a ground water contour map for the proposed site of a leach field for treated wastewater effluent. The ground water monitoring wells used to characterize the site geology and hydrology are required to be installed under the supervision of a qualified geologist, and the ground water contour map is also required to be prepared by a qualified geologist. The contour map is required to be based on a minimum of two rounds of ground water elevation measurements. The applicant is also required to submit a receptor map, based on an official tax map, showing the locations of all properties and water supply wells within l000 feet of the ground water discharge zone (GDZ) of the site (NHDES, 1995).

New York

USEPA Region 3 directly implements the UIC Class V program in New York. In addition, under the State's Environmental Conservation Law, the Department of Environmental Conservation, Division of Water Resources (DWR) has promulgated regulations in the State Code Rules and Regulations, Title 6, Chapter X, Parts 703, 750 -758. These regulations establish water quality standards and effluent limitations, create a state pollutant discharge elimination system requiring permits for discharges into the waters of the state, specify that such discharges must comply with the standards in Part 703, and provide for monitoring in Part 756. New York defines groundwater as part of the waters of the state.

Permitting

Applications for a State Pollution Discharge Elimination System (SPDES) permit must be submitted on a required form, describe the proposed discharge, supply such other information as the DWR requests, and are subject to public notice. SPDES permits must ensure compliance with effluent limitations and standards, and will include schedules of compliance, monitoring requirements, and records and reports of activities (Parts 751 - 756).

Operating Requirements

Effluent limits (Part 703) in the SPDES permit must be met. Only treated effluent may be discharged to ground water. Effluent limits for oil and grease are 15 mg/l, total nitrogen (as N) is 10 mg/l, TDS is 1,000 mg/l, and foaming agents is 1,000 µg/l. Monitoring and reporting requirements in the SPDES permit must be met.

Siting and Construction Requirements

New York law requires all well drillers on Long Island to be licensed (Chapter 338).

Oregon

Oregon is a Primacy State for UIC Class V wells. The UIC program is administered by the Department of Environmental Quality (DEQ). Under the State's Administrative Rules (OAR) pertaining to underground injection, a "waste disposal well" is defined as any bored, drilled, driven or dug hole, whose depth is greater than its largest surface dimension, which is used or is intended to be used for disposal of sewage, industrial, agricultural, or other wastes and includes drain holes, drywells, cesspools and seepage pits, along with other underground injection wells (340-044-0005(22) OAR). Construction and operation of a waste disposal well without a Water Pollution Control Facility (WPCF) permit is prohibited. Certain categories of wells are prohibited entirely, including wells used for underground injection activities that allow the movement of fluids into an USDW if such fluids may cause a violation of any primary drinking water regulation or otherwise create a public health hazard or have the potential to cause significant degradation of public waters. In addition, DEQ administers rules governing on-site sewage disposal systems (340-071-0100 to 0600 OAR). Oregon regulations prohibit the use of reclaimed water (treated effluent) for aquifer storage and recharge (Eckley, 1999).

Permitting

Subsurface disposal of sewage treatment effluent is addressed by DEQ under its rules for on-site sewage disposal. Although the DEQ is authorized to enter into agreements with local governments for those governments to become the DEQ's agent in permitting such systems, state staff review and approve permits for sewage effluent wells. Permits are issued as Water Pollution Control Facility (WPCF) permits pursuant to 340-071-0162 OAR (340-0710100 (157) OAR).

Permit applications under 340-071-0162 OAR must include, among other requirements, a land use compatibility statement from the local land use planning agency, a copy of a favorable site evaluation report, and other specified information. For systems with a design flow of 5,000 gpd or greater, special public notice requirements are imposed.

Construction and Operation

The rules pertaining to all underground injection activities provide that permits for use of waste disposal wells must include minimum conditions relating to their location, construction, or use and a time limit for authorized use of such wells (340-044-0035 OAR). In addition, any underground injection activity that may cause, or tend to cause, pollution of groundwater must be approved by DEQ, in addition to other permits or approvals required by other federal, state, or local agencies (340-044-0055 OAR).

Abandonment and Plugging

Upon discontinuance of use or abandonment a waste disposal well is required to be rendered completely inoperable by plugging and sealing the hole.

Texas

Texas is a Primacy State for UIC Class V wells. The Injection Well Act (Chapter 27 of the Texas Water Code) and Title 3 of the Natural Resources Code provide statutory authority for the underground injection control program. Regulations establishing the underground injection control program are found in Title 30, Chapter 331 of the Texas Administrative Code (TAC).

Permitting

Underground injection is prohibited, unless authorized by permit or rule (331.7 TAC). By rule, injection into a Class V well is authorized , although the Texas Natural Resources Control Commission (TNRCC) may require the owner or operator of a well authorized by rule to apply for and obtain an injection well permit (331.9 TAC). No permit or authorization by rule is allowed where an injection well causes or allows the movement of fluid that would result in the pollution of an USDW. A permit or authorization by rule must include terms and conditions reasonably necessary to protect fresh water from pollution (331.5 TAC). Sewage treatment effluent wells are not specifically identified in the rules as Class V wells, but the category is not limited to the well types specified in the rules (331.11 (a)(4) TAC).

Siting and Construction

All Class V wells are required to be completed in accordance with explicit specifications in the rules, unless otherwise authorized by the TNRCC. These specifications are:

- A form provided either by the Water Well Drillers Board or the TNRCC must be completed. The annular space between the borehole and the casing must be filled from ground level to a depth of not less than 10 feet below the land surface or well head with cement slurry. Special requirements are imposed in areas of shallow unconfined ground water aquifers and in areas of confined ground water aquifers with artesian head. In all wells where plastic casing is used, a concrete slab or sealing block must be placed above the cement slurry around the well at the ground surface; and the rules include additional specifications concerning the slab. In wells where steel casing is used, a slab or block will be required above the cement slurry, except when a pitless adaptor is used, and the rules contain additional requirements concerning the adaptor. All wells must be completed so that aquifers or zones containing waters that differ significantly in chemical quality are not allowed to commingle through the borehole-casing annulus or the gravel pack and cause degradation of any aquifer zone. The well casing must be capped or completed in a manner that will prevent pollutants from entering the well. When undesirable water is encountered in a Class V well, the undesirable water must be sealed off and confined to the zone(s) of origin. (331.132 TAC)

Operating Requirements

No operating requirements are specified. Chapter 331, Subpart H, " Standards for Class V Wells" addresses only construction and closure standards (331.131 to 331.133 TAC). The Commission retains the authority to abate and prevent pollution of fresh water resulting from any injection activity by requiring a permit, by instituting appropriate enforcement action, or by other appropriate action (331.3(c) TAC).

Mechanical Integrity Testing

Injection may be prohibited for Class V wells that lack mechanical integrity. The TNRCC may require a demonstration of mechanical integrity at any time if there is reason to believe mechanical integrity is lacking. The TNRCC may allow plugging of the well or require the permittee to perform additional construction, operation, monitoring, reporting, and corrective actions which are necessary to prevent the movement of fluid into or between USDW caused by the lack of mechanical integrity. Injection may resume on written notification from the TNRCC that mechanical integrity has been demonstrated (331.4 TAC).

Plugging and Abandonment

Plugging and abandonment of a well authorized by rule is required to be accomplished in accordance with §331.46 TAC (331.9 TAC). In addition, closure standards specific to Class V wells provide that closure is to be accomplished by removing all of the removable casing and filling the entire well with cement to land surface. Alternatively, if the use of the well to be permanently discontinued, and if the well does not contain undesirable water, the well may be filled with fine sand, clay, or heavy mud followed by a cement plug extending from the land surface to a depth of not less than 10 feet. If the use of a well that does contain undesirable water is to be permanently discontinued, either the zone(s) containing undesirable water or the fresh water zone(s) must be isolated with cement plugs and the remainder of the wellbore filled with sand, clay, or heavy mud to form a base for a cement plug extending from the land surface to a depth of not less than 10 feet (331.133 TAC).

Financial Responsibility

Chapter 27 of the Texas Water Code, "Injection Wells," enacts financial responsibility requirements for persons to whom an injection well permit is issued. A performance bond or other form of financial security may be required to ensure that an abandoned well is properly plugged (§ 27.073). Detailed financial responsibility requirements also are contained in Chapter 331, Subchapter I of the State's UIC regulations (331.141 to 331.144 TAC). A permittee is required to secure and maintain a performance bond or other equivalent form of financial assurance or guarantee to ensure the closing, plugging, abandonment, and post-closure care of the injection operation. However, the requirement, unless incorporated into a permit, applies specifically only to Class I and Class III wells (331.142 TAC).

West Virginia

West Virginia is a Primacy State for the Class V UIC program. Regulations establishing the UIC program are found in Title 47-13 West Virginia Code of State Regulations. In addition, the state Board of Health has enacted Sewage Treatment and Collection System Design Standards. Although the state does not define a category of Class V wells as sewage effluent disposal wells, its definitions specify that they are not exclusive, and that the Class V requirements can cover undefined categories of wells (47-13-3.4.5 WVAC). The Board of Health requirements for sewage treatment works include specifications for effluent lines to sewage stabilization ponds, anaerobic lagoons, and aerated lagoons, details on lagoon design, and sludge handling and disposal, requirements for sludge dewatering, sludge disposal methods, and requirements for land application of sewage effluent. The latter requirements state that land disposal of effluent that has received primary treatment only shall not be permitted (Part 111, Section 16.1). Finally, the state's Water Pollution Control Act (Title 22 Article 11 of the West Virginia Code) specifies that it is unlawful for any person, without a permit, to allow sewage, industrial wastes, or other wastes, or the effluent therefrom, produced by or emanating from any point source, to flow into the waters of the state (22-11-8 (b) WVC). Waters of the state are defined to include water on or beneath the surface (22-11-3 (23) WVC). Outlet is defined as the terminus of a sewer system or the point of emergence of any water-carried sewage, industrial wastes, or other wastes, or the effluent therefrom, into any waters of the state, and includes a point source (22-11-2(b)(14) WVC).

Permitting

Class V injection wells are authorized by rule unless the Office of Water Resources of the Division of Environmental Protection (DEP) requires an individual permit (47-13-12.4.a. and 47-13-13.2 WVAC). Injection is authorized initially for five years under the permit by rule provisions. However, under the authority of the Water Pollution Control Act, sewage effluent wells are permitted under the WPCA (22-11-8 and 9 WVC). Permits are based on an application form containing information required by the DEP and are issued for a period not to exceed five years (22-11-10 and 11 WVC).

Operating Requirements

Under the WPCA, sewage effluent injectate must receive at least secondary treatment prior to injection. Quarterly monitoring is required. Under the UIC requirements, owners or operators of Class V wells are required to submit inventory information describing the well, including its construction features, the nature and volume of injected fluids, alternative means of disposal, the environmental and economic consequences of well disposal and its alternatives, operation status, and location and ownership information (47-13-12.2 WVAC).

Rule-authorized wells must meet the requirements for monitoring and records (requiring retention of records pursuant to 47-13-13.6.b. WVAC concerning the nature and composition of injected fluids until 3 years after completion of plugging and abandonment); immediate reporting of information indicating that any contaminant may cause an endangerment to USDWs or any malfunction of the injection system that might cause fluid migration into or between USDWs; and prior notice of abandonment.

The rules enact a general prohibition against any underground injection activity that causes or allows the movement of fluid containing any contaminant into USDW, if the presence of that contaminant may cause a violation of any primary drinking water regulations under 40 CFR Part 142 or promulgated under the West Virginia Code or may adversely affect the health of persons. If at any time a Class V well may cause a violation of the primary drinking water rules the well may be required to obtain a permit or take such other action, including closure, that will prevent the violation (47-13-13.1 WVAC). Inventory requirements for Class V wells include information regarding pollutant loads and schedules for attaining compliance with water quality standards (47-13-13.2.d.1 WVAC).

If protection of a USDW is required, the injection operation may be required to satisfy requirements, such as for corrective action, monitoring, and reporting, or operation, that are not contained in the UIC rules (47-13-13.2.c.1.C. WVAC).

Mechanical Integrity

A Class V well required to obtain an individual permit will be required to demonstrate that the well has mechanical integrity.

Plugging and Abandonment

A Class V well required to obtain an individual permit will be subject to permit conditions pertaining to plugging and abandonment to ensure that the plugging and abandonment of the well will not allow the movement of fluids either into a USDW or from one USDW to another. A plan for plugging and abandonment will be required.

Financial Responsibility

A Class V well required to obtain an individual permit will be required to demonstrate financial responsibility for plugging and abandonment.

Wyoming

Wyoming is a Primacy State for UIC Class V wells. The Wyoming Department of Environmental Quality, Water Quality Division, oversees the Class V UIC Program. Wyoming Statute 35-11-301(a)(i) & (ii) provides that no person, except when authorized by a permit, may discharge any pollution or wastes into the waters of the state or alter the physical, chemical, radiological, biological, or bacteriological properties of any waters of the state. All groundwater within Wyoming, including water in the vadose zone, is considered water of the state.

Permitting

On April 14, 1998, the Water Quality Division promulgated Chapter 16, Wyoming Water Quality Rules and Regulations (WWQR&R) establishing the underground injection control program. Sewage treatment effluent wells are defined either as 5E4 wells (new domestic wastewater treatment plant disposal facilities that dispose of treated domestic waste after treatment to at least secondary treatment standards) or wells falling into the residual Class 5F2 of other facilities that inject fluids into or above an USDW that are not included in Classes I through IV. Wells in class 5E4 are required to obtain an individual permit. Wells in Class 5F2 also are required to obtain an individual permit (16 WWQR&R Appendix A).

Individual permit applications are required to include, among other information, a calculation to determine the maximum area affected by the injected waste and a detailed description of the area of review. Information must be provided about the substances proposed to be discharged, including type, source, and chemical, physical, and toxic characteristics, construction and engineering details; information about the receiver and any relevant confining zones; water quality information, including background water quality data that will facilitate the classification of the ground waters which may be affected by the proposed discharge, topographic maps showing the facility, bedrock and surficial geology, and other wells, springs, subsurface fluid distribution systems, and surface water systems (16 WWQR&R Section 6). A separate permit to construct is not required for Class V wells (16 WWQR&R Section 5(a)(v)).

Siting and Construction

The Class V UIC rules include construction requirements. All wells must meet the design standards in Chapter 11, WWQR&R, Parts B and G (which establish design and construction standards for municipal and domestic sewage systems, treatment works, and disposal systems and well construction standards). They must be constructed to allow the use of testing devices and to provide for metering of the injectate volume (16 WWQR&R Section 10). The requirements in 11 WWQR&R

Part G include requirements for well location, sealing the annular space, surface construction, casing, sealing strata, and plugging and abandonment. Class V facilities may not be located within 500 feet of any active public water supply well, regardless of whether the well is completed in the same aquifer. The minimum distance may be increased, or the well may be prohibited entirely, within a wellhead protection area, source water protection area, or water quality management plan area (16 WWQR&R Section 10(n)).

Operating Requirements

The extent and design of a monitoring program, including pre-discharge, operational, and post-discharge monitoring, sufficient to deal with the pollution potential of the proposed discharge may be required in the permit (WWQR&R Section 11(a)). All permits must include a point of compliance, which may be either the point of injection or at downgradient monitoring wells. The operator is also required to develop and implement a written waste analysis plan, which must be approved by DEQ (WWQR&R Section 11 (c) and (f)).

Plugging and Abandonment

Chapter 16 WWQR&R Section 12 establishes abandonment standards for all Class V wells. Section 12(a) through (c) provides that Class V facilities may be abandoned in place if the following conditions are met and if it can be demonstrated to the satisfaction of the administrator that no hazardous waste has ever been discharged through the facility; no radioactive waste has ever been discharged through the facility; all piping allowing for the discharge has either been removed or the ends of the piping have been plugged in such a way that the plug is permanent and will not allow for a discharge; and all accumulated sludges are removed from any septic tanks, holding tanks, lift stations, or other waste handling structures prior to abandonment. Facilities which cannot demonstrate compliance with these requirements may be abandoned in place if tests are run on sludges accumulated in the septic tanks, holding tanks, lift stations, or other waste handling structures which shows that none of these materials contain characteristic hazardous waste or radioactive waste; monitoring of the groundwater in the immediate area of the facility shows that there are no toxic materials (substances) present in the groundwater at levels higher than class of use standards, which are present as a result of the injection; or some other method acceptable to the administrator. Facilities which cannot make the demonstrations required under either approach must be excavated to the point where contamination is no longer visible in the soil. At that point, samples shall be taken of the soil for all hazardous constituents which may have been discharged through the system. Materials excavated shall be removed from the site for disposal under approval of the Solid and Hazardous Waste Management Division.

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