Please Pass the Salt: Using Oil Fields for the Disposal of Concentrate from Desalination Plants

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Abstract

Desalination is becoming a much more viable alternative for fresh-water supply. However, desalination plants need a place to put their concentrate. One promising possibility is injecting concentrate into oil and gas fields where formation pressures have been greatly lowered due to past oil production. To show that oil and gas fields can accept injected concentrate from desalination plants, we investigated the physical and chemical characteristics of six typical areas across Texas and identified possible permitting paths and permitting improvements for concentrate disposal. We found that it is technically feasible to inject concentrate into depleted oil and gas fields, although the concentrate may require pretreatment to prevent clogging of the formations. Concentrate can be injected into oil and gas fields, but only if certain conditions are met (such as more stringent well construction requirements and purpose of injected water). Permitting the injection of concentrate could be made easier through general permitting of a special non-hazardous Class I injection well. It may also be possible to create a special category of Class I or Class V injection well. There are also potential federal solutions, but changing rules at the federal level has been an onerous and thus far unsuccessful endeavor. In short, it is technically feasible to inject concentrate into oil and gas fields and there are several options for making the permitting of concentrate disposal wells easier and more affordable.

Introduction

Desalination of seawater or brackish groundwater is becoming a much more viable alternative for fresh-water supply in Texas and the rest of the United States. In arid parts of West Texas, desalination may be the only viable future water resource. Desalination technology has progressed considerably over the past ten years and become much more affordable, and desalination is certainly one of the only drought-proof water resources available. However, one important issue that remains for many communities is: Where do we put the concentrate resulting from desalination? This disposal issue is important because of environmental concerns and because of cost. Desalination concentrate is often detrimental to flora and fauna, and inland concentrate disposal can be 10 to 25 percent of the total cost of desalination projects amounting to over 100 million dollars on larger projects.

There are several alternatives for concentrate disposal from desalination activities. One promising possibility in Texas and elsewhere in the U.S. is deep-well injection in oil and gas fields where formation pressures have been greatly lowered due to past oil production. Oil and

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gas fields are promising in Texas because (1) they occur in many parts of the state, (2) oil-field operators already have considerable experience injecting oil field brine wastes in these fields, (3) the costs are lower, and (4) the impact to the environment is negligible to non-existent.

Oil and gas fields occur in many parts of Texas including all of the Gulf Coast and much of the interior of the state (Figure 1). These oil and gas fields are near likely sources of water for desalination: brackish groundwater (Figure 2) and saline water from the Gulf of Mexico. These fields are also near many small- to large-sized communities across Texas that may have future water needs.

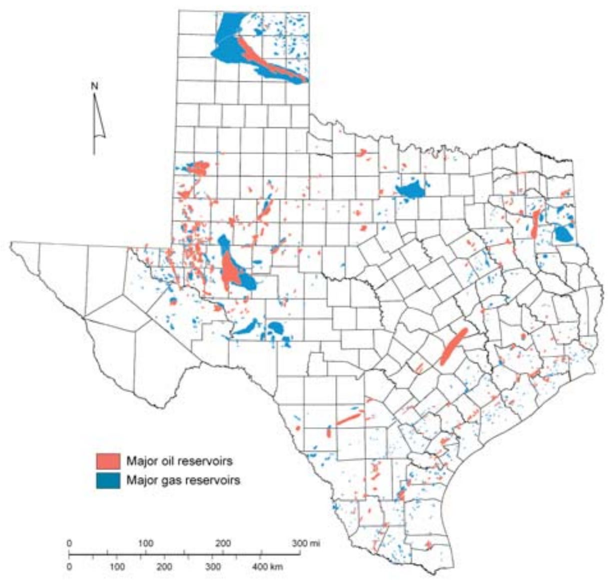

Figure 1-Location of major oil and gas reservoirs in Texas.

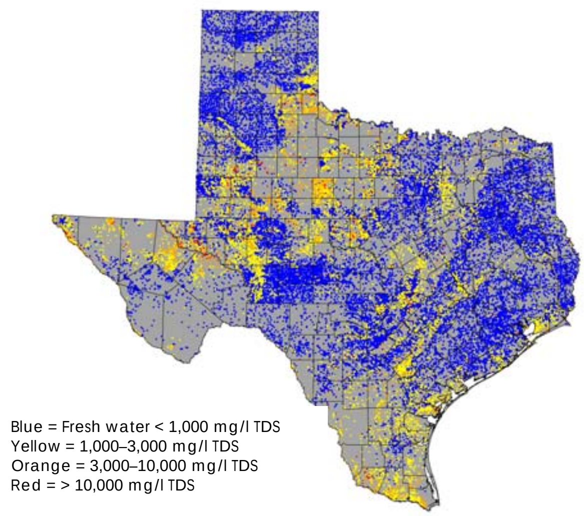

Figure 2-Location of brackish groundwater resources in Texas according to water-quality analyses in the Texas Water Development Board water well database

Texas has a growing interest in desalination as a source of potable water. The 2002 Texas State Water Plan (TWDB, 2002a) identifies several possible new plants across the state. Since publication of the 2002 Texas State Water Plan (TWDB, 2002a), additional communities have considered desalination more seriously due to decreasing costs, the success of the Tampa project, and an initiative by Texas Governor Rick Perry to develop a large-scale demonstration seawater desalination project (TWDB, 2002b).

The oil and gas industry in Texas has a great deal of experience in injecting fluids because a substantial amount of fluids are already being injected into oil and gas fields. When oil is produced from a field, brine is also brought to the surface. In mature producing fields, ten times more formation water may be produced than oil. Producers need to dispose of this brine and therefore inject it back into the field. In Texas, there are over 31,000 active permitted injection wells in oil and gas fields. More than 700,000 acre-feet of high-salinity brines per year are being injected through these wells. The costs of injecting concentrate into oil and gas fields will likely be lower than other disposal choices. Deep well injection is likely to be much more cost effective than open-ocean discharge.

Properly sited, installed, and operated injection wells in oil fields will not adversely affect the environment. In many cases, the injected concentrate will represent an improvement in water quality in the oil fields. Along the Gulf Coast, deep-well injection would prevent the need for disposal of concentrate into environmentally sensitive bays and estuaries and into the Gulf of Mexico. Inland injection would prevent the disposal of concentrate in streams, rivers, and local water-treatment plants. Many people believe that oil fields will readily accept the quality and volume of concentrates from desalination plants. In some cases, operators would welcome the concentrate as 'make-up' water to help produce additional oil (Please pass the salt!).

The cost of concentrate disposal could be reduced even more if communities could dispose of this waste down the same or similarly equipped wells that accept oil field brines. In many cases, the concentrate would be a better quality than the injected brine. However, current permitting in Texas essentially requires a Class I permit that requires considerably more expensive well construction and considerably more expensive and lengthy permitting periods. A hazardous waste disposal well requires millions of dollars and more than a year to obtain a permit. An oil field brine disposal well requires a couple months and a few thousand dollars.

The purpose of this study was two-fold: (1) to show that oil fields can accept injected concentrate from desalination plants and (2) to recommend changes to statute and rules that would allow the disposal of concentrate in oil fields, thereby saving operators considerable money and making water more affordable to communities across the state.

The purpose of this paper is to summarize the results of the study that the Texas Water Development Board and the Bureau of Economic Geology did with funding from the U.S. Bureau of Reclamation. Technical details of this study can be found in Mace and others (2004, in prep).

The current permitting process

The EPA divides injection wells into five classes: Class I through Class V (CFR 1989a, b). **Class I injection wells** are used to inject hazardous waste beneath the lowermost formation containing an underground source of drinking water. These wells also include industrial and municipal waste disposal wells and wells for disposing radioactive waste.

Class II injection wells are used to inject fluids brought to the surface in connection with oil and natural gas operations and the storage of hydrocarbons. The injected waste fluid (usually salt water) can be commingled with wastewater from gas plants unless those waters are classified as hazardous waste at the time of injection.

Class III injection wells are used to inject fluids related to the extraction of minerals exclusive of oil and natural gas. This includes the mining of sulfur by the Frasch process, the in-situ production of uranium or other metals, and solution mining of salts or potash.

Class IV injections wells are used for the disposal of hazardous or radioactive waste in shallow wells. These wells are prohibited unless the wells are used to inject contaminated ground water that has been treated and is being injected into the same formation from which it was drawn.

Class V injection wells are injection wells not included in Class I, II, III, or IV. This class includes a wide range of injection wells ranging from air conditioning return flow to wells used for controlling subsidence.

Of the five classes of injection wells, Class I wells are perhaps the most pertinent to the disposal of concentrate. To a lesser extent, Class V wells can also be used for concentrate disposal but are not as common. Class II injection wells have never been used for the disposal of concentrates from desalination operations and are authorized only for the disposal of fluids resulting from oil and gas operations. Some wells in Texas are dually permitted as Class I and Class II wells.

The typical amount of time required to process and obtain a Class I non-hazardous injection well permit from the TCEQ ranges from one to three years. Hazardous well permits take even longer. Legislation passed by the Texas Legislature in 2003 exempts applicants for a Class I injection well permit for the disposal of concentrates from desalination operations from the requirements of a contested case hearing (Chapter 27.021, Texas Water Code, relating to Permit for Disposal of Brine from Desalination Operations).

Chapter 331 of the Texas Administrative Code (relating to Underground Injection Control) which implements the provisions of the Injection Well Act (Texas Water Code, Chapter 27) provides details on construction (Chapter 331.62), operating (Chapter 3331.63), monitoring (Chapter 331.64), reporting (Chapter 331.65) and recordkeeping (Chapter 331.67) requirements for all injection wells (including Class I injection wells) under the jurisdiction of TCEQ.

The entire Class II-D permitting process can be completed within 30 to 45 days from the date of the Texas Railroad Commission (RRC) receiving an administratively complete application. The typical fee for a Class II permit ranges from approximately $250 to $400.

Well siting and design and the permitting process depend on the type of Class V injection well. EPA (1999) discusses the 26 different types of Class V injection wells.

Approach

To show that oil and gas fields can accept injected concentrate from desalination plants, we first identified depleted oil and gas fields in Texas and selected and characterized six areas for analysis. After we selected our analysis areas, we investigated formation pressures, modeled the interaction of concentrate and formation fluids, analyzed water sensitivity, and modeled injectivity. We also investigated possible permitting paths for the disposal of concentrate and for allowing the disposal of concentrate down Class II injection wells.

Identify depleted oil and gas fields

The purpose of this task was to create a map of depleted oil and gas fields in Texas to identify possible locations for injection of concentrate from desalination operations. To do this, we reviewed past studies (Galloway and others, 1983; Kosters and others, 1989) and current information (location of Class II injection wells) to map the distribution of depleted oil and gas fields around Texas and plotted the location of oil field injection and disposal wells.

Select and characterize analysis areas

We chose six analysis areas based on the location of mature oil and gas fields, oil and gas fields from various geological basins, the locations of shallow Class II injection wells, areas with demonstrated water needs (based on the State Water Plan), and availability of brackish groundwater. For each analysis area, we characterized the general geology, mineralogy, porosity, permeability, aquifers, brackish water sources, and additional parameters of interest such as average variation of temperature and pressure with depth and formation compressibility. We accomplished this with a number of published and purchased sources of data and a review of the literature for each analysis area.

Investigate formation pressures

We followed the methodology presented in Smyth and others (1998) in analyzing the separation between formation pressures and the base of usable quality water (defined as water with total dissolved solids less than 10,000 parts per million [ppm]). To do this, we queried H15 databases at the RRC. For a given field, we investigated the separation of the 95th percentile formation pressure and the 5th percentile base of usable quality water.

Model interaction of concentrate and formation fluids

The injection of concentrate into an oil and gas reservoir may cause some unwanted side effects such as formation damage. Formation damage occurs by a number of processes that include scale formation and migration of fines. This may lead to a reduction in reservoir production or injection rate of the concentrate. This reduction occurs by plugging of pores from scaling minerals, precipitates, or fines. We evaluated the brackish and formation water compositions (data from TWDB, U.S. Geological Survey, LBG-Guyton [2003], and IHS Energy) and used geochemical models (PHREEQC by Parkhurst and Appelo [2002] and SOLMINEQ by Kharaka and others [1988]) along with a Monte Carlo statistical approach to analyze the results of mixing formation waters and concentrates.

Analyze water sensitivity

Oil and gas fields, like most geologic formations, contain clays. When water of a different composition moves into a formation, the clays may expand or separate from each other (deflocculate) and become mobile in the water. Expanding and mobile clays can also plug the formation. Water sensitivity describes how clays respond to the water chemistry. To investigate water sensitivity in the analysis areas, we used total cation concentration to divalent cation concentration plots (Schuerman and Bergersen, 1990) to indicate which clays may deflocculate when concentrate is injected into an oil or gas formation. We also investigated cation stripping using mass action ratios. Cation stripping can also cause clays to deflocculate.

Evaluate historical water injection

We interviewed commercial disposal services and reviewed the RRC's H-1 forms to determine existing practices of water flood operations, sources and volumes of water used, and capacity of the oil and gas fields to accept concentrate volumes. We collected information on the type of injected fluid (for example, salt water, brackish water, fresh water, air, gas, CO_2, or polymer) and the purpose of the injection (disposal or secondary recovery). Secondary recovery is the process of injecting fluids into the reservoir to "flush out" more oil. The volume of water needed for secondary recovery is generally 150 to 170 percent of the targeted pore volume (Thomas and others, 1987, p. 44-41). Highest demand for external water occurs at the beginning of the water flood before breakthrough at the producing wells. Return water is progressively re-injected unless precluded by the treatment cost of the produced water. It is common in the industry to convert a production well into an injection well as the water flood front passes by. The external water source for enhanced recovery could be surface waters (rivers and lake), fresh-water aquifer, brackish-water aquifer, and produced water possibly from the same formation.

Model injectivity

Injectivity is the physical ability of the oil and gas fields to take water. We modeled injectivity for our six analysis areas by calculating the flow rate that would result from combining the formation physical characteristics (porosity, permeability, and compressibility) and pressure requirements (admissible surface pressure, well depth, and head loss).

Recommend possible permitting paths

The objective of this task was to identify currently available permitting paths and make recommendations for an easier and less expensive process for permitting injection of concentrate from desalination operations. To do this, we first reviewed federal and state regulations and discussed the permitting process with staff and officials from the U.S. Environmental Protection Agency (EPA), the Texas Commission on Environmental Quality (TCEQ), and the Railroad Commission. Once we evaluated the permitting process, we investigated the different ways we could change the process to allow for the disposal of concentrate into Class II disposal wells.

Results

Our results on identifying depleted oil and gas fields, selecting and characterizing analysis areas, investigating formation pressures, modeling interaction of concentrate and formation fluids, analyzing water sensitivity, evaluating historical water injection, modeling injectivity, and recommending possible permitting paths are presented below.

Depleted oil and gas fields

Based on atlases of major oil and gas fields in Texas by Galloway and others (1983) and Kosters and others (1989), we developed a detailed map of major oil and gas fields of Texas (Figure 1). With some overlap, the atlases describe a total of 450 and 868 oil and gas reservoirs, respectively. In addition, we linked complementary information (production, depth, net pay, and average permeability and porosity) already in digital form (Holtz and others, 1991; Garrett and others, 1991) to the maps for use in other parts of the study.

The cumulative production of these reservoirs is large enough to accept concentrate produced in the more than 20 years of a desalination plant's life. The State of Texas has produced about 60 billion barrels of oil since the end of the 19^{th} century. The production of four million gallons per day (MGD) of drinking-quality water results in about one MGD of concentrate. This volume of concentrate is a production of about 700 gallons per minute (gpm) or about 8.7 million barrels per year.

The oil and gas producing regions of the state are along the Gulf Coast, in north-east Texas, in the Permian Basin area of Texas near Midland-Odessa, in the Texas Panhandle, and in north-central Texas (Figure 1). The Class II injection wells for the injection and disposal of oil field brines are closely associated with these oil and gas fields (Figure 3).

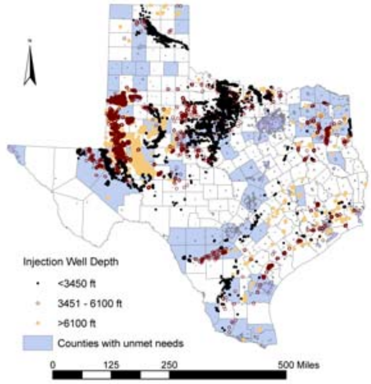

Figure 3-Locations of Class II injection wells with corresponding completion depths. Counties with water-supply needs are shown in blue.
Note: Class II injection wells split into 3 depth groups of equivalent size (~25,000 points with depth information out of ~30,000 active injection wells).

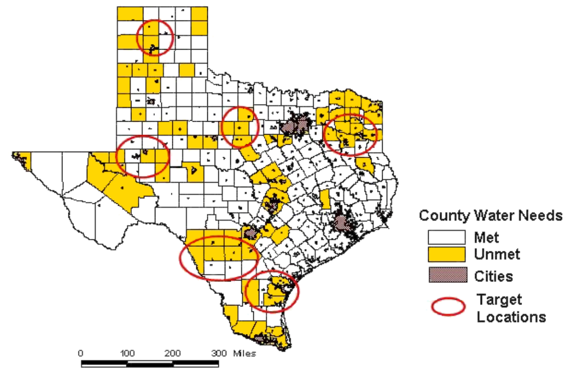

Figure 4-Texas counties with water-supply needs in 2050 (data from TWDB, 2002a).

Analysis areas

We based the selection of our six analysis areas on the location of (1) mature oil and gas fields (Figure 1), (2) oil and gas fields from various geological basins, (3) Class II injection wells (Figure 3), (4) areas with demonstrated water needs or an interest in desalination to meet future water needs (Figure 4), and (5) available brackish groundwater resources (Figure 2). Based on these maps, we selected the six analysis areas from different basins across the state (Figure 4). The basins include the Anadarko basin, the East Texas basin, the Permian basin, the Gulf Coast basin, the Fort Worth basin, and the Maverick basin. These analysis areas are representative of Texas basins, reservoirs, and brackish and formation waters (Table 2) and are representative of typical conditions in the rest of the state.

The reservoirs in these analysis areas are the most prolific in their respective areas and are thus the most likely to have the highest pressure depletion. Because these reservoirs have also been heavily produced, they are most likely to have a dense infrastructure able to carry fluids at the surface through pipes. The Granite Wash Formation is the most important oil producing unit of the Anadarko Basin and yielded significant amounts of gas. The San Andres-Grayburg formations of the Permian Basin are the shallowest major oil producing unit of the basin and still contain non-negligible amounts of gas. The Woodbine Formation in the East Texas Basin produced huge amounts of oil. The Fort Worth Basin in the analysis area produces relatively minor amounts of oil from the Bend Conglomerate and Atoka formations while the Maverick Basin yielded relatively large amounts of oil from the San Miguel and Olmos formations. The Frio Formation in the southern Gulf Coast Basin is also a prolific oil and gas producer.

The analysis areas have a range of brackish groundwater available for desalination (Table 1). Although the Anadarko, Fort Worth, and Maverick basin analysis areas have a low availability of brackish groundwater as defined by LBG-Guyton Associates (2003), a low availability may be sufficient for a relatively modest desalination facility with a feed water stream of five MGD. Productivity is a function of transmissivity and other aquifer parameters while production cost is mainly a function of depth to water. These parameters are variable across the six analysis areas as they are for the brackish aquifers of Texas. Mace and others (2004) and Nicot and Chowdhury (in review) discuss details concerning the general geology, petrography and mineralogy, porosity and permeability, formation waters, aquifers and brackish groundwater resources, and additional parameters for the six analysis areas.

Formation pressures

We found that many wells in depleted oil and gas fields had formation pressures much less than the lowest-most source of drinking water. This means that there is no hydraulic potential for fluids in the oil and gas formations to move into overlying aquifers. Many of the wells we investigated would qualify for an Area of Review variance – a variance that removes the requirement for a survey of unplugged wells that might allow injected fluids to migrate upward and endanger overlying aquifers. This variance is granted when there is little to no chance of upward migration.

Interaction of concentrate and formation fluids

We found that concentrate could be injected into most oil and gas fields without causing the precipitation of minerals. In some cases, the concentrate would need a pre-treatment with anti-scalants to prevent precipitation.

Table 1-Brackish water availability in the six analysis areas (LBG-Guyton Associates, 2003).

Water planning region	Aquifer	Availability	Productivity	Production cost
Anadarko Basin				
A – Panhandle	Ogallala	Low	High	Low to Moderate
	Dockum	Low	Low	Low
Permian Basin				
Region F	Ogallala	Moderate	High	Low to Moderate
	Dockum	High	Low to Moderate	High
	Rustler	Moderate	Low	High
East Texas Basin				
D - Northeast Texas	Carrizo-Wilcox	High	Moderate	Moderate to High
Fort Worth Basin				
G – Brazos	Trinity	Low	Low	Low
Maverick Basin				
L – South Central Texas	Carrizo-Wilcox	Low	Low	Moderate to High
Gulf Coast Basin				
N – Coastal Bend	Gulf Coast	Moderate	Moderate to High	Low

Water sensitivity

We found that clays would be a problem with raw concentrate in all of the basins. However, pre-treatment and operational solutions (such as adjusting the injection rate, progressive mixing with formation water, and injecting a buffer) can be used to solve clay issues.

Table 2-Feed water source, injection formation, counties, and major oil and gas fields for the analysis areas.

Basin	Brackish water source	Formation	Counties	Major fields
Anadarko	Ogallala and Dockum aquifers	Panhandle (granite wash /dolomite)	Carson Armstrong Moore Potter	Panhandle
Permian	Ogallala, Dockum, and Rustler aquifers	San Andres Fm (carbonates)	Ector Midland Andrews	Cowden North Cowden South Goldsmith Means McElroy
East Texas	Carrizo-Wilcox aquifer	Woodbine Fm (sandstone)	Van Zandt, Wood Smith Gregg Upshur	East Texas Van Hawkins New Diana
Fort Worth	Trinity aquifer	Bend Conglomerate (sandstone) and Glen Rose Fm (carbonates)	Shackelford Young Stephens Eastland	Boonsville Breckenridge Kildare Rodessa
Maverick	Carrizo-Wilcox aquifer	San Miguel and Olmos Deltaic Fms (sandstone)	Maverick Zavala Frio Dimmit Atascosa	Sacatosa Big Wells Chittim Big foot Catarina
Southern Gulf Coast	Gulf Coast aquifer	Frio Fm (Sandstone)	Nueces Jim Well Kleberg	TCB Seelington Borregos Stratton Brayton

Historical water injection

We found that less than half of the injected water was water produced from the oil and gas formations. The remainder was taken from nearby fresh, brackish, and slightly saline aquifers. Therefore, oil and gas fields in Texas have been injecting fresh and brackish water for decades with apparently no concern. Operators are injecting considerable amounts of water in the Permian Basin and none in the southern Gulf Coast Basin. Significantly, fresh water is often mixed with produced waters, presumably to limit formation damage. That same practice of blending water of different origins could also apply to concentrates. This historical perspective indicates that at least some reservoirs in all of the analysis areas can accept fresh and brackish water in large volumes.

Injectivity

We found that the median injection rate for a single well is about 10 gallons per minute (gpm) in the Anadarko, Permian, Fort Worth, and Maverick basins and about 280 and 470 gpm in the southern Gulf Coast and East Texas basins, respectively. These calculations are biased toward lower flow rates. Injection rates could be increased by screening more intervals and stimulating the wells. A lower injectivity would require a larger number of injection wells for the same volume of concentrate.

Possible permitting paths

The EPA did not specifically consider the injection of concentrate from desalination operations when they published their final technical regulations for the underground injection control program in 1980. This is because injection of concentrate was not an issue when they wrote the regulations. Many believe that concentrate disposal wells logically fall under Class I because Class I includes municipal waste in its definition. However, others believe that concentrate disposal wells could also be permitted under Class V.

The options discussed below source from discussions with permitting experts at the EPA, EPA Region 6, TCEQ, and the Railroad Commission. TWDB lawyers also reviewed federal and state statute and rules. The first four options can be achieved now with current EPA and TCEQ regulations, although in some cases the process could be made easier. The last three options would require memos of agreement, changes in regulations, and/or changes in statute.

<u>Non-Hazardous Class I</u>

In Texas, the requirements for a non-hazardous municipal Class I injection well are similar to the requirements for a hazardous Class I injection well. These requirements are more stringent than EPA regulations. Permitting concentrate injection wells could be made easier in Texas if the state adopted minimum EPA standards for permitting non-hazardous Class I injection wells. Recent state legislation (House Bill 2567 of the 78th Texas Legislature) eliminated the contested case hearings from Class I injection wells disposing concentrate from desalination operations. TCEQ could make permitting, construction, and operation easier and less expensive by adopting EPA minimum requirements for municipal non-hazardous Class I injection wells.

<u>Class II</u>

There is a way to inject concentrate in an existing Class II well without having to acquire a Class I permit: injecting the concentrate as ‘make-up’ water as part of enhanced recovery operations. Oil-field operators often flood their reservoirs with water to liberate additional oil. While water produced from the formation may be enough for these enhanced recovery operations, operators may need water in addition to that produced from the formation – what operators term ‘make-up’ water. If concentrate was the source of make-up water, there would be no need for any additional permitting – the Class II permit would be fine. However, a desalination plant would need assurances that an oil-field operator could consistently accept the volume of concentrate for a set period of time for this to be a realistic option.

<u>Class V</u>

Depending on the quality of the concentrate and formation water, it may be possible to permit a concentrate disposal well as a Class V injection well. El Paso Water Utilities (EPWU) is considering this option for the disposal of their concentrate (Bill Hutchison, EPWU, personal communication). In EPWU's case, the formation in question has a TDS less than 10,000 ppm, and their concentrate is expected to be of better quality than the formation water. Therefore, because they are disposing concentrate in an underground source of drinking water (USDW), something not considered in the other injection well classes, they may be eligible for a Class V permit. A Class V permit is desirable in this case because the permit can be granted by rule with a turnaround time of about 60 days. The EPA could consider creating a special sub-class of Class V injection wells for the disposal of concentrate. This option is currently being internally debated at EPA.

Dual-Permitted Wells

One way to dispose of concentrate in a Class II injection well is to also permit that injection well as Class I or perhaps also as a Class V injection well. However, for an injection well to hold a Class I-Class II dual permit, the well would have to meet TCEQ's construction requirements for a Class I well, follow the TCEQ Class I process in acquiring a permit, and follow TCEQ requirements for monitoring. A dual-permitted well would then be able to accept Class I and Class II fluids. Texas currently has some Class I-Class II permitted wells (Steve Seni, RRC, personal communication, 2004).

General Permit for Class I Concentrate Injection Wells

A general permit would greatly simplify and decrease the time to attain a non-hazardous Class I permit. A general permit would involve getting a permit for a general class of injection wells. In this case, the general class of wells would be concentrate injection wells. Approval of the general permit requires going through the full approval process of a Class I injection well. Once a general permit is attained, anyone can apply for a permit under the general permit. If those permits meet the requirements set forth in the general permit, then the permit is granted. The advantage of the general permit is that it reduces the permitting process to an administrative review. If the application meets the requirements set forth in the general permit, the permit is granted. Therefore, instead of taking one to three years to attain a Class I permit, it might take as little as 60 days for a complete application. Implementation of a general permit would require the cooperation of the TCEQ.

Special Class I for Concentrate Disposal in Class II

Because most of the underground injection control program is a legacy program, that is, under the control of the state, some believe that the state can create its own category under Class I for the disposal of concentrate in Class II wells. Under this scenario, TCEQ, in cooperation with the Railroad Commission, would create a special non-hazardous Class I category that would grant a Class I permit to a well for concentrate disposal if the well already has a Class II permit. This process would only require an administrative review – a review that could be completed within 60 days. However, this approach may require that candidate wells meet Class I construction requirements. This requirement may decrease the number of qualified Class II wells. As a result of this study, the TWDB, TCEQ, EPA, and Railroad Commission are considering this option.

Change the Federal Regulations

The federal regulations could be changed in a number of ways to assist in the disposal of concentrate. However, EPA seems to be reluctant to open up it rules to accommodate desalination operations. Regardless, changing EPA's rules is likely to be a long and onerous process. The desalination industry has attempted to induce wholesale changes to EPA's rules concerning concentrate disposal with little success. Nevertheless, changes in the EPA's rules could include a special category of Class V injection wells for desalination that considers the specifics of concentrate disposal. EPA could also change the definition of what is allowed to be injected into Class II wells to include desalination concentrates. Another option is to create a special category of Class I injection wells for concentrate disposal considering the special concerns of the disposal.

Conclusions

Desalination is becoming a much more viable alternative for fresh-water supply. However, desalination plants need a place to put their concentrate. One promising possibility is injecting concentrate into oil and gas fields where formation pressures have been greatly lowered due to past oil production. Oil and gas fields are promising in Texas because they occur in many parts of the state, oil- and gas-field operators have considerable experience injecting oil field brines into these fields in more than 30,000 wells, and the impact to the environment is negligible to non-existent. The cost of concentrate disposal could be reduced even more if communities could dispose of concentrate down the same or similarly equipped wells that accept oil field brines. Unfortunately, the current permitting environment does not allow this option. Instead, desalination plant operators would be expected to apply for a Class I permit (millions of dollars and years) instead of using a Class II permitted well (which only requires thousands of dollars and months for a permit). The purpose of this study was to show that oil fields could accept injected concentrate from desalination plants and to recommend changes to statute and rules that would allow the disposal of concentrate in oil fields.

To show that oil and gas fields could accept injected concentrate from desalination plants, we first identified depleted oil and gas fields in Texas and selected and characterized six areas for analysis. These analysis areas in the Anadarko, Permian, East Texas, Fort Worth, Maverick, and Southern Gulf Coast basins are in areas where there are oil and gas fields, there is source of brackish groundwater, and there is a need for additional fresh-water supplies. After we selected our analysis areas, we investigated formation pressures, modeled the interaction of concentrate and formation fluids, analyzed water sensitivity, and modeled injectivity (Table 3).

We found that many wells in depleted oil and gas fields had formation pressures much less than the lowest-most source of drinking water. This means that there is no hydraulic potential for fluids in these oil and gas wells to move into overlying aquifers. We found that concentrate could be injected into oil and gas fields without causing the precipitation of minerals. In some cases, the concentrate would need a pre-treatment with anti-scalants to prevent precipitation. We found that clays would be a problem with raw concentrate in all of the basins. However, pre-treatment and operational solutions (such as adjusting the injection rate, progressive mixing with formation water, and injecting a buffer) can be used to mitigate clay issues. We found that the median injection rate for a single well is about 10 gpm in the Anadarko, Permian, Fort Worth, and Maverick basins and about 280 and 470 gpm in the southern Gulf Coast and East Texas basins, respectively. These rates could be increased by screening more intervals and stimulating the wells. A lower injectivity would require a larger number of injection wells for the same amount of concentrate. This work suggests that injection of desalination concentrates in the formation water will likely not be a problem if the injection water and the formation are appropriately pretreated, as is done routinely by the oil industry in the injection of produced waters.

Table 3-Summary of conclusions.

Basin	Score relative to scaling	Score relative to water sensitivity	Score relative to injection rate	Score relative to pressure depletion
Anadarko				
	Medium	High	Low	Very High
Permian				
	Medium	High	Low	High
East Texas				
	Medium	Low	High	High
Fort Worth				
	Medium	Medium	Low	High
Maverick				
	Medium	Medium	Low	High
Southern Gulf Coast				
	Medium	Low-Medium	High	High

To recommend changes to statute and rules that would allow the disposal of concentrate in oil and gas fields, we reviewed current statute and rules and met with staff from the Texas Railroad Commission, the Texas Commission on Environmental Quality, and the U.S. Environmental Protection Agency (headquarters and Region 6).

Depending on the specifics of the case, a desalination plant can obtain a Class I or Class V permit for concentrate disposal. The permitting process under Class I could be made easier if Texas followed EPA's minimum requirements for a Class I municipal (non-hazardous) disposal well. Texas currently requires that non-hazardous Class I wells meet the same requirements as hazardous Class I wells. Recent legislation has eliminated the contested case hearings from Class I injection wells disposing of concentrate from desalination operations.

Disposal of concentrate in a Class II well would require a dual permit: Class I-Class II or Class II-Class V. However, to attain a dual permit, the well would have to meet Class I or Class V requirements. Concentrate could be injected directly into a Class II well with no additional permits if the concentrate was used in enhanced oil recovery. However, desalination plant operators would need assurances that oil field operators would take their volume of concentrate over the life of the plant.

The permitting process under Class I could be made easier by using a general permit. The general permit would experience all of the public hearings and scrutiny of the Class I process.

However, once the general permit was approved, permit applications that met the requirements of the general permit would only need an administrative review – a savings of years and perhaps millions of dollars. Because Texas has primacy of its underground injection control program, it may also be possible to create a special category of Class I permitting for the disposal of concentrate in Class II permitted wells.

Another option is to change the permitting process at the federal level. These changes could include creating a special category under Class V, creating a special category under Class V, or allowing Class II disposal wells to accept concentrate. However, attempts to change these rules at the federal level have been an onerous and thus far unsuccessful task.

In short, it is technically feasible to inject concentrate into oil and gas fields and there are several options for making the permitting of concentrate disposal wells easier and more affordable.

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