DAVID VOORHIS
& ASSOCIATES
Data Research Regulatory & Petroleum Engineering
Consulting for the Oil & Gas Industry
281-A Mooring Circle
Austin, Texas 78734-4152
(512) 261 - 3476

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Mr. Larry D. Wright, P.E. (6WQ/S)
Branch Chief
Water Quality Protection Division - Source Water Protection
Environmental Protection Agency - Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Re: Response to your letter of April 14, 2000
Endangerment of Texas Ground water by the EPA Class II Injection Program

Dear Mr. Wright:

Thank you for your response to my February 8, 2000 letter. In general, your letter tells me that applicable Federal law (regulations) has your hands tied because a satisfactory level of compliance exists in the EPA Class II Injection Program at the Texas Railroad Commission (TRRC).

I'm dismayed that your department and EPA attorneys do not see the level of danger that exists with the current EPA Class II injection program. I also find it hard to believe, that as a licensed professional engineer in Texas, you have not spoken up and notified appropriate authorities within the EPA of the problems with the current program. As you probably know, it is one of your responsibilities as a licensed professional engineer in Texas, to notify appropriate authorities of the engineering science related problems such as those that exist in the EPA Class II Injection Program in Texas. In other words, if existing regulations do not protect public health, safety, welfare and property, it is your responsibility as a licensed professional engineer to make an effort to correct the problems in the regulations. Can different interpretation/enforcement of existing laws correct the endangerment problems that exist in the current EPA Class II Injection Program, without passing new laws?

Why do you not see the level of danger that exists with the current EPA Class II injection program in place at the Texas Railroad Commission? Maybe you are not aware of the facts concerning all of the documents and reports I have given authorities in the state of Texas? Maybe you are not aware of the facts concerning underground reservoirs and the physical characteristics of bentonite clays inside a borehole? Or, maybe you are trying to cover up for past incompetence (not necessarily yours) in the legislation, implementation and enforcement of the EPA Class II injection program? For these reasons, I will provide more information of why Texas ground water is endangered by the current EPA Class II injection program.

The remainder of this letter will discuss the following topics.

1) Disagreements with Specific Statements in your April 14, 2000 letter
2) Field Rules, Reservoir Size and Illegal Pressure Front Calculations
3) Physical Behavior of Clays in a Borehole
4) My information source(s) for the East Texas brine outbreak problems
5) Conclusion/Opinion concerning the ••••••••••• Well No. 6 injection well

I. **<u>Disagreements with Specific Statements in your April 14, 2000 letter</u>:**

I am concerned about the apparent, industry-wide incompetence concerning the petroleum engineering science related to underground injection and what appears to be your (EPA's) criteria for determining whether or not a well is improperly plugged.

I disagree with your tolerance for the current level of science that is being used in the EPA Class II injection program. Your statement on page 1, that "the required level of science applied to the permitting process could be improved," is an understatement. It is my opinion, and the opinion of many of my petroleum engineering colleagues, that the current level of science used in the program is incorrect and that the authors of these regulations were incompetent in matters of reservoir engineering and underground injection. In other words, the current level of science used in the program is incompetent and is counter to the requirement of correct and competent engineering outlined by the Texas Engineering Practice Act. As you know, the Texas Engineering Practice Act requires that practicing engineers in Texas protect the public health, safety, welfare and property.

I disagree with your criteria for determining whether or not a well is properly plugged for injection purposes. The statement on page 2 of your letter, "...proof is evident when broaches occur at the surface or fresh water wells are contaminated and the contamination can be traced back to injection activities." Your statement does not apply in determining whether or not a well is properly plugged in Texas. As a licensed and practicing engineer in Texas, you should be aware of the Texas law that describes how to determine the proper plugging of a well. The *Texas Natural Resources Code*, Title 3, Subchapter C, Section 89.041, specifies how the TRRC is to determine whether or not a well has been properly plugged. The section, with changes made effective August 29, 1983, is presented below in its entirety.

§ 89.041. Determining Proper Plugging

> If it comes to the attention of the commission that a well has been abandoned or is not being operated is causing or is likely to cause pollution of fresh water above or below the ground or if gas or oil is escaping from the well, the commission may determine at a hearing, after due notice, whether or not the well was properly plugged as provided in Section 89.011 or Section 89.012.

According to attorneys that have reviewed this law, a well is improperly plugged if it has only the **possibility** that it "...is likely to cause pollution of fresh water above or below the ground..." If you are making decisions regarding whether or not a well is properly plugged in Texas, this is the law that applies. If you don't follow Texas law when making engineering decisions in Texas, such as this criteria for determining proper plugging, you are in violation of the Texas Engineering Practice Act.

Texas law **does not require direct proof that pollution has occurred** to determine whether or not a specific well is improperly plugged. This law is written to identify improperly and properly plugged wells **BEFORE** pollution occurs. Your criteria identifies improperly plugged wells **AFTER** pollution occurs and it is counter to existing Texas law.

If you are going to practice engineering or make engineering decisions in Texas, Texas law applies. The information you give me indicates Texas Law is more stringent than Federal Law when identifying improperly plugged wells. And as a practicing engineer in Texas, the Texas law applies when Federal law is not as strict as the Texas law. Improperly plugged wells are to be identified **BEFORE** pollution occurs and **NOT AFTER** pollution occurs.

II. Field Rules, Reservoir Size and Illegal Pressure Front Calculations:

The Texas Railroad Commission has field rules which govern the development of oil and gas reservoirs in Texas. The purpose of the field rules is to "prevent waste and protect the correlative rights of owners of interests in the field." [1] Two of the many characteristics established through field rule hearings are the well spacing and well density requirements for the effective and efficient drainage of the reservoir(s). "The spacing and density provisions in the field rules are intended to establish regular development in a field and to avoid clustering of wells to the detriment of the reservoir." [2] Well density rules tend to reflect what an average well is expected to drain (drainage area) during its productive life. Some typical well density, well spacing and diagonal requirements (for the drilling unit) in effect in Texas are listed in the following table.

Well Density	Well Spacing (feet)	Diagonal Limit (feet)
640 acres	1867 - 3735	8500
320 acres	1320 - 2640	6500
160 acres	933 - 1867	4500
80 acres	660 - 1320	3250
40 acres	467 - 933	2100
20 acres	330 - 660	1500
10 acres	233 - 467	1100
5 acres	165 - 330	1000
2 acres	150 - 300	500

When there is not enough reservoir data to establish specific field rules, development drilling proceeds under Statewide Rules (SWR) 37 and 38. Under SWR 37 and 38, a minimum of 40 acres are assigned to each standard drilling unit. Wells drilled to depths less than 5,000 feet in Railroad Commission Districts 7B and 9, and McCullough are governed by County Regular rules. County Regular rules were established because the reservoirs in the area tend to be small in acreage, exist in multiple horizons and are highly lenticular. Wells developed under County Regular rules tend to have well densities (well drainage areas) that range from 2 to 15 acres, depending on the depth of the well. The exact well density and depth for a particular county can be determined by reviewing the specific County Regular rules for that specific county (Districts 7B and 9, and McCullough).

There is **no oil or gas field** in the state of Texas where the oil and gas reservoir has been identified as being infinite in size. All oil and gas reservoirs in Texas are of finite size. Reservoirs in the County Regular field rules areas tend to have the smallest reservoir sizes relative to other oil and gas field areas in Texas.

Reservoirs that are finite in size experience increases in pressure as fluid is injected and decreases in pressure as fluid is withdrawn. Reservoirs that are infinite in size experience no change in average reservoir pressure due to injection or withdrawal because the reservoir size is infinite. It is possible to have finite volume reservoirs that exhibit the pressure behavior of an infinite acting reservoir, where there is no change in the average reservoir pressure. Finite volume reservoirs that behave in this manner are in a steady state condition where reservoir injection volumes equal reservoir withdrawal volumes.

The reason for presenting this information is to show you that no infinite volume, oil and gas reservoirs exist in Texas. The current EPA Class II injection program in the state of Texas allows for the universal application of the infinite acting, pressure transient equation for pressure front calculations in Texas oil and gas reservoirs. Here, the term “universal application” means the equation is applied to all types of reservoirs and at all times of injection. As you know from my previous correspondence (March 2, 1998 letter/report), the **universal application is scientifically incorrect** and an incompetent engineering practice. The infinite acting pressure transient equation is applicable to reservoirs that are infinite in size or, where the pressure transient resulting from the injection operation is in the infinite acting time period (a very short period). The universal use of this equation, in instances other than the applicable situations described, is an incompetent practice of engineering. The Texas Engineering Practice Act makes the incompetent practice of engineering illegal. The typical infinite acting pressure front calculation approved at the Texas Railroad Commission is in a finite volume reservoir and at a time period beyond the infinite acting period. Hence, Texas injection projects approved or justified using the infinite acting pressure front calculations tend to be **illegal**.

Another reason pressure front calculations at the Texas Railroad Commission tend to be illegal is that they are **not** performed and sealed by licensed, competent engineers. The example calculation of my March 2, 1998 letter/report (sent to your office) for the •••••••••••Well No. 6 is illegal in that it did not contain the seal of a licensed engineer. Another area where it is illegal is the fact that the infinite acting pressure transient equation was used to justify an injection well in a finite volume reservoir, and it was used in a time period that was well beyond the infinite acting time period. This pressure front calculation is the incompetent practice of engineering and it too is illegal. If the engineering calculations were performed by someone other than a licensed, competent engineer, which appears to have been the case, the practice of engineering occurred without a license. The practice of engineering without a license is illegal. In this one example of pressure front calculations for the •••••••••••Well No. 6, there are probably THREE (maybe four) instances where the Texas Engineering Practice Act was violated. The three possible violations are: not sealing the engineering calculations with an engineering seal, the incompetent practice of engineering and the practice of engineering without a license. A fourth and likely violation is the aiding and abetting in the non-licensed practice of engineering.

If you are regulating or overseeing the type of pressure front calculations used in Texas you must be a licensed, competent engineer in Texas and you must follow Texas law. If this criteria is not met, you don't practice engineering or make engineering decisions in this state. It is possible that what appears to be your endorsement, acceptance or inaction concerning the universal use of the infinite acting pressure transient equation, in Texas, can be considered aiding and abetting in the illegal practice of engineering in the state of Texas. It is also possible that what appears to be your acceptance of the universal use of the infinite acting pressure transient equation for pressure front calculations, may bring into question your engineering competency in regards to these matters.

III. Physical Behavior of Clays in a Borehole:

A review of Texas well plugging regulations indicates that wells plugged prior to 1967 tended to be plugged predominately with mud laden fluid (if any) and a cement cap at the surface. Well plugged closer to the 1967-1969 period tended to be plugged predominately with mud laden fluid, include a short cement plug at the base of the fresh water sands and a cement cap at the surface. The most common clay type used in the mud laden fluid is believed to have been bentonite clay.

API funded studies performed by Warner etal [3] revealed some general characteristics about bentonite clay muds held within closed containers. It is believed the closed container were used to create idealized borehole volumes plugged with mud laden fluid. Bentonite clay muds of 9 to 9.5 pounds per gallon (ppg) were found to segregate into two stabilized sections over time. The top section contained water from the original mud laden fluid while the bottom section contained settled clay particles. Muds within the 9 to 9.5 ppg concentration tended to have a settled clay particle heights that ranged from 50 to 65 percent of the original fresh mud height. Conversely, the expelled water height above the settled clay particles tended to range from 50 to 35 percent of the original mud height. Laboratory measurement of the porosity within the settled clay particle section revealed water filled porosities as high as 84 percent. More specific information concerning porosities, permeabilities, settled mud height and mud weights within improperly plugged boreholes can be found in the Warner etal [3] report.

An explanation of why mud filled boreholes can become conduits for fluid migration involves a discussion of the physics inside a mud filled borehole. As mentioned above, boreholes plugged with mud laden fluid tend to segregate into a section of settled mud at the bottom of the hole and water from the settled mud on top. The settled mud has plastic characteristics because it has not had the time and overburden to fully undergo rock lithification processes. Because of its plastic characteristics, the horizontal stress exerted by the borehole materials is equal to the overburden stress of all the materials inside the borehole. When injection zone pressure is greater than the overburden stress of the materials inside the borehole, the borehole material is squeezed, elongated and compressed. Micro annulus and channel flow paths develop in the vacated space created by the compression and/or elongation of the borehole material. Micro annulus and channel flow paths tend to be highly permeable. This type of phenomenon is dependent on the configuration and characteristics of the borehole material. Sloughing beds and the bridging of beds may exist. Bridging beds may form efficient barriers to vertical flow; however, the reduced overburden stress under a bridging bed may increase the possibility of interaquifer flow below the bridging bed and cause problems elsewhere. Some wells plugged with mud may have bridging beds while others may not. It is the author's opinion that there is no way to be certain about the configuration of borehole materials inside a well plugged with mud without re-entering the well. In order to have greater certainty about the material inside an improperly plugged borehole, the borehole would need to be re-entered with a drill bit and a mud log of the material circulated to surface versus depth would need to be created and evaluated.

There seems to be some consensus that any fluid that migrates up an improperly plugged borehole will not pose a danger to fresh water sands due to the charging of zones below the fresh water sands. A better answer is that the fluid will flow into the path of least resistance. There are four dominate characteristics that affect leak off from the borehole into the permeable zones that lie between the authorized injection zone and the fresh water sands. These four characteristics are as follows:

1) **pressure within the zone and pressure in the borehole -** In order for fluid to flow into this zone, the pressure in the zone must be less than the pressure in the borehole.

2) **zone must be porous and permeable -** If there is no porosity and permeability there will be no flow. In

order to flow into the zone there must be interconnected pore spaces and it must be permeable. For this characteristic, fractures are considered to be a type of porosity and permeability.

3) **mud filter cake along the borehole wall -** Mud filter cake forms a restrictive permeability barrier for flow into porous and permeable zones. Even when mud filter cake has fallen off the borehole wall, clay particles can exist within the porous and permeable zone that were deposited when the filter cake formed on the borehole wall. These clay particles, within the pore throats, form permeability restrictions.

4) **vertical permeability with borehole material is several magnitudes higher than the permeability of the horizontal leak off zones -** Vertical permeability develops in boreholes plugged with mud through micro annulus and channel flow paths. These flow paths are created when injection fluid compresses and/or elongates the borehole material (settled clay and sloughed formation material). The vertical permeability that develops tends to be several magnitudes higher than the permeability within the porous and permeable zones that are exposed to the borehole. For this reason, most of the flow is believed occur in the higher permeability channel flow paths rather than the porous and permeable zones. The degree to which leak off will occur into the zone will depend on the zone height, zone porosity and permeability, borehole mud filter cake and zone pressure relative to the channel flow path area, permeability and pressure.

I have enclosed with this letter/report some of my engineering evaluations of how improperly plugged boreholes become conduits for oil field brine migration to fresh water zones. The injection into the ••••••• •••• Well No. 6 (of previous correspondence) was numerically simulated to see how fluid migration might occur under three possible drainage areas. Simulations were performed using a 2-D simulator that treated the improperly plugged wells as fully implicit sinks. These sinks were coupled to the Antlers fresh water zone through analytic equations describing vertical flow up the boreholes to the Antlers and the infinite acting pressure transient equation for the Antlers formation pressure. The vertical permeability within these improperly plugged boreholes increased as a function of pressure when injection zone pressure exceeded the overburden stress of the borehole material. Leak off from the boreholes to zones located between the Strawn injection zone and the Antlers fresh water zone was accounted for through the use of borehole efficiency factors. Treatment of the improperly plugged borehole link to the Antlers formation in this manner allowed for pseudo, 3-D numerical reservoir simulation of the oilfield brine migration. This approach was taken because of the area's **<u>limited/scarce</u>** reservoir data and because there is no sense in driving a tack with a sledge hammer when a regular (16 oz.) hammer will do the job (2-D versus 3-D numerical simulator argument). More details concerning the fluid migration simulations can be seen in the enclosed sections of my engineering report.

IV. <u>My information source(s) for the East Texas Problems:</u>

The information I have concerning the East Texas oil field brine outbreak problems came from conversations with four people. Two are employed with the Texas Railroad Commission's Environmental Services department, which is responsible for the EPA Class II injection program. The two remaining people are private sector attorneys in Austin. The Railroad Commission people I had conversations with are: Fernando DeLeon , P.E. (Engineering Supervisor) and Richard F. Ginn (Deputy Assistant Director - at the time). Some of the details of my conversations with DeLeon and Ginn are described in my Engineering Complaint (Engineering Board File H-17077) against the Texas Railroad Commission. The private sector attorneys are: Rick Lowerre and Michelle McFadden. Rich Lowerre has seen and has a copy of much of my work related to these issues. Most of my knowledge concerning the East Texas brine outbreak problems is from Rick Lowerre. He suggested I contact Michelle McFadden for more information. I was told she had a supporting role in the East Texas land owner lawsuit against the Texas Railroad Commission. My conversations with McFadden indicted she has been working with Region 6 EPA attorneys concerning the EPA Class II injection problems, and a law firm in Corpus Christi, Texas.

I have limited my exposure to Austin attorneys on these issues because they seem to be more interested in protecting the legal profession in regards to these matters (i.e., law entities that illegally perform petroleum engineering and make incorrect scientific decisions), than pursuing justice in my case. I also believe they have been a source of "ex parte" evidence against me, which has biased Austin attorneys from helping in my lawsuit. As mentioned in my previous letter, some Austin law firms are believed to be guilty of practicing petroleum engineering without a license. Assisting me in this case might be considered an attack on their legal peers.

V. <u>Conclusion/Opinion concerning the ••••••••••• Well No. 6 injection well</u>

Numerical reservoir simulation studies on the ••••••• •••• Well No. 6 injection operations indicate there is a danger of oilfield brine migration from the approved injection zone to the fresh water sands (Antlers formation). This danger is believed to be highly probable because the input data used in the reservoir simulations is believed to be a fair and likely representation of the study area's reservoir characteristic and injection operations. Also, I could find no evidence (in public records) that bridging beds and other no-flow barriers to fluid migration exist in the improperly plugged wells of the study area. Because of this brine migration danger and other reasons listed in this letter, the approval and operation of the ••••••• •••• Well No. 6 as an injection well (in its current form) should be considered an illegal project. This injection well and the manner in which it was approved, are illegal on many different points of the Texas Engineering Practice Act and the *Texas Natural Resources Code*.

The oilfield brine migration potential, that exists in the ••••••• •••• Well No. 6 injection operations, also exists in most of the state of Texas where injection operations are surrounded by wells plugged with mud-laden fluid. These problems are more prominent in older areas where there is low acreage well density (2 to 15 acres allocated per well) like the County Regular Field Rule areas of Texas.

Having attorneys respond to engineering matters, such as whether or not an injection operation poses a danger to fresh water sands, and without the opinion of a competent, licensed engineer, is **<u>illegal</u>** and isn't worth a hill of beans. The Texas Engineering Practice Act requires such statements, opinions and conclusions to be from competent, licensed engineers. There are valid scientific reasons to correct the endangerment problems that exist with the current EPA Class II injection program. These scientific reasons have already been documented in my Engineering Complaint against the Texas Railroad Commission (Engineering Board File H-17077) and in my other correspondence to government authorities concerning these issues.

If you or the EPA need further information, my services are available on a consulting fee basis.

Please call me at (512) 261 - 3476, or write to me at the address in my letterhead in you have any questions.

Yours truly,

ORIGINAL SIGNED by David Voorhis

David B. Voorhis, Ph.D., P.E.
Owner

<u>Enclosure</u>: Sections from an engineering report concerning oilfield brine fluid migration due to ••••••• •••• Well No. 6 injection operations.

<u>References:</u>

1) Lena Guerrero, James E. Nugent and Bob Krueger, *Discussion of Law, Practice and Procedure* , (Oil and Gas Division of the Railroad Commission of Texas, 1992), page 1.
2) Lena Guerrero, James E. Nugent and Bob Krueger, *Discussion of Law, Practice and Procedure* , (Oil and Gas Division of the Railroad Commission of Texas, 1992), page 4.
3) Warner, D. L. and McConnell, C. L.: "Abandoned Oil and Gas Industry Wells -- A Quantitative Assessment of their Environmental Implications," API Publication 4507 (1990).