# GROUNDWATER RESEARCH SUBCOMMITTEE MEETING RECORD

**TIME AND DATE:**
9:00 AM, Wednesday, January 19, 2011

**LOCATION:**
Texas Commission on Environmental Quality Campus Building F, Room 2210, 12100 Park 35 Circle, Austin, TX 78753

**PURPOSE OF MEETING:**
Second quarter regular business meeting

**AGENCIES/ENTITIES REPRESENTED:**

Bureau of Economic Geology [BEG]
Texas AgriLife Research
Texas Commission on Environmental Quality [TCEQ]
Texas Department of Agriculture [TDA]
Texas Groundwater Protection Committee [TGPC]
Texas State Soil and Water Conservation Board [TSSWCB]
Texas Water Development board [TWDB]
United States Geological Survey [USGS]

**ATTENDEES:**

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| Bridget Scanlon | BEG, Co-chair of the GW Research Subcommittee of the TGPC |
| Kevin Wagner | Texas AgriLife Research |
| Allen Berthold | Texas AgriLife Research |
| Cary Betz | TCEQ, Chairman of TGPC |
| Lauren Bilbe | TCEQ |
| Radu Boghici | TWDB |
| Mike Chadwick | TCEQ |
| Alan Cherepon | TCEQ |
| Richard Eyster | TDA |
| Donna Long | TSSWCB |
| Robin Lynch | TCEQ |
| Marylynn Musgrove | USGS |
| Joseph L. Peters | TCEQ |
| Leslie Smith | TDA |
| L. Scott Underwood | TCEQ |
| Michael H. Young | BEG |

## MEETING SUMMARY:

## Call to Order and Introductions

Dr. Bridget Scanlon and Mr. Kevin Wagner called the meeting to order at about 9:02 AM. Dr. Bridget Scanlon, the Bureau of Economic Geology (BEG) is one of the Co-chairs. Mr. Kevin Wagner, with Texas Water Resources Institute (TWRI), Texas AgriLife Research, was acting as a Co-chair at this meeting, sitting in for Dr. B. L. Harris who could not be present. The first order of business was to have everyone introduce themselves.

## Discussion of Sources of Funding and Current Calls for Proposals

The discussion started with the consideration of a list of potential research topics from a document handed out by Mr. Wagner, entitled *Project Ideas for Future TCEQ Research*. The first item on the list was **Fate of land applied materials**. This is an issue discussed by the Subcommittee before. In the past a map was provided by TCEQ showing all the permitted land application sites. However, the Subcommittee has not yet followed-up with a proposal or white paper. Mr. Wagner interjected that our purpose with this discussion was to identify some of the top groundwater research priorities in the state -- not necessarily specific projects, but in general what type of research will be needed over the next five years. We have quite a large list of research needs to choose from, but we should select maybe the top five, so we can start developing some concepts and white papers and then pursue some funding to start meeting some of these research needs that we have in the state. Dr. Scanlon asked Ms. Musgrove what the USGS was doing under the topic of **Fate of land applied materials**. She responded that the USGS has a national program looking at contaminants in lake and reservoir sediments, including emerging contaminants but also, metals, organics, VOCs, PCBs, and pesticides. The program does include some studies within Texas. The question of emerging contaminants is important, because they are a potential future regulatory concern. Dr. Scanlon asked Mr. Betz whether anyone at TCEQ would be interested in the topic of **Fate of land applied materials**. Mr. Betz responded that he didn't know, but that Dr. Scanlon should contact Miss April Hoh in the Water Quality Division for an answer. Dr. Scanlon asked Dr. Michael Young, a new Associate Director at the BEG, about the work he was doing with emerging contaminants. Dr. Young responded that they were working on a project that dealt with the tertiary treatment of waste water and the fate of about twelve different pharmaceuticals and endocrine disrupting chemicals (EDCs) and how they are transformed or retarded within the soil/root interface. The project has been going on for about two years and is just about complete. Dr. Scanlon asked Ms. Musgrove what the USGS had done on the Edwards concerning emerging contaminants. She responded that there had been some minor work consisting mostly of some analyses of a few samples, and thus far the indication is that they are not being detected, probably because of dilution. Dr. Scanlon asked Mr. Wagner if there were any emerging contaminant studies at A&M. He responded that there was a little, but it was not a big area of study at this time, probably due to limited funding. There was some work in the Civil Engineering, Agricultural Engineering, and Soil and Crop Sciences Departments.

Dr. Young informed us that analyses for emerging contaminants cost about a $1,000 per sample, which means that considerable funding is required for a project. Dr. Scanlon asked if emerging contaminants was something that the American Water Works Association (AWWA) would be interested. Dr. Young responded that he thought that entities such as the AWWA, the Water Reuse Research Foundation, and the Water Environment Foundation (WEF) would certainly be interested. These organizations are to a large extent supported by water utilities. Dr. Scanlon and Mr. Betz agreed in expressing the idea that the TWDB, in their State Water Plan, was probably relying more and more on reuse in determining available water supplies. Dr. Scanlon concluded by saying she would follow-up with Ms. Hoh on the subject of land application. She then asked Mr. Betz if there was anyone at the TCEQ that was looking into emerging contaminants. Mr. Betz responded that the Water Supply Division of TCEQ was doing a pharmaceutical study that was mostly a compilation of data, but that he wasn't sure what the status of it was. However, the last he heard, the final report was in the review process. He said he would check to see if the report had been finalized.

Moving to the second item on the project ideas list, **Groundwater perchlorate contamination**, Dr. Scanlon asked Mr. Betz about the status of drafting the proposed perchlorate regulations at TCEQ. He responded that he hadn't heard anything for quite a while and that it was probably on the back burner for the time being. Dr. Scanlon concluded that we could probably drop consideration of this project idea for the time being.

Dr. Scanlon went on to **The link between agricultural management and ground-water nitrate**, the third item on the list. She went on to express her desire to get a copy of the National Institutes of Health (NIH) supported study at A&M on nitrates and neural tube defects. Mr. Wagner responded that he had no information on the study. Dr. Scanlon stated that nitrates are the most widespread contaminant and she asked Ms. Musgrove if it was much of an issue for the Edwards. Ms. Musgrove responded that the concentrations in the Edwards are well below regulatory levels, but there is some indication that they are increasing over time. After some further discussion Mr. Wagner suggested that we need to organize and digest all the studies done on nitrates thus far and determine if there are some knowledge holes that still need to be filled. Mr. Eyster informed the attendees, that even though there were some watersheds of concern, there currently were no TMDLs due to high nitrates.

Next there was some very limited discussion of **$CO_2$ storage,** the fourth item on the handout. Mr. Betz commented that this activity would be regulated by the Texas Railroad Commission. The TCEQ's involvement will be very limited.

The fifth item, **The characterization of groundwater surface water interactions in the state with respect to water quantity and quality**, was discussed next. Mr. Wagner had the opinion that this topic would be very important in certain parts of the state. However, it's not a subject of interest to the state as a whole. It's more of a watershed specific type of assessment, such as for the Nueces watershed which interacts with the Edwards Aquifer. Projects would have to identify specific watersheds where

there would be a need for these types of studies. Mr. Betz responded that the groundwater staff at TCEQ has some concerns that management of streams to achieve desired future conditions will be involving stream base flow. There has been an increase in the number of streams that no longer flow and of streams that were once gaining streams that are now loosing streams. This seems to be a phenomenon of increasing concern especially in the fifty year planning horizon. The groundwater and surface water planning does not mesh very well. Of course water quality comes into the picture as well. Mr. Betz went on to agree with Mr. Wagner that topic is not of concern statewide, but it would be especially important in the areas where streams cross aquifers, especially in the recharge zones. Those areas, where this is an issue, need to be identified. Dr. Scanlon asked Mr. Boghici if he had anything to add to the surface water/groundwater interactions discussion in reference to the TWDB. He responded that they had an ongoing project aimed at the characterization of groundwater, anthropogenic and natural influences being considered. But, there is nothing specific in the project having to do with surface water and groundwater interactions.

Dr. Scanlon also brought up the subject of endangered species. She asked Mr. Betz about the mussels that may be put on the endangered species list. Mr. Betz responded that there were seven to nine mussel species that have been proposed for listing. Seven will almost certainly be listed, but the problem is that the preliminary evidence indicates that it isn't chemical contamination or predation that is endangering these mussels, but rather things like flooding and other factors out of human control. But there are some other species, fish and bird species, that are more directly affected by base flow. An example would be the ongoing litigation over minimum stream base flows for the maintenance of the whopping crane population. Dr. Scanlon concluded that **The characterization of groundwater surface water interactions in the state with respect to water quantity and quality** would be a subject to which we should devote a white paper. Dr. Scanlon opined that the GAM models should probably be updated to take surface water and groundwater interactions more into account. Reductions in base flow are obviously affecting state groundwater and any science that can be developed would be helpful to the legislature and courts to make decisions.

Dr. Scanlon went on to item six on the list, **Desalination and specific aspects of desalination such as disposal of desalination concentrate**. Mr. Betz suggested that perhaps there has been enough study in this area for the time being. Rules have been put in place for desalination operations, and until there is somewhat of a track record for the operation of desalination plants, there is probably no immediate need for any more studies. Dr. Scanlon brought up the need for characterizing brackish water resources, but the TWDB is carrying out some of these studies, and Mr. Boghici mentioned that the TWDB is planning on doing some modeling of some of the brackish water aquifers that may be important for desalination, but this is still in the stage of preliminary planning.

Item number seven, **Develop a database on chemical characteristics of soil water to quantify reservoir of contaminants in the unsaturated zone derived from atmospheric and land surface processes**, was the next item of discussion. Mr. Betz suggested that perhaps this item should be combined with item number one, **Fate of land**

**applied materials**. There was a consensus on combining the two items and the discussion moved on to the next item.

The subject of item eight is **Aquifer Storage and Recovery (ASR) Programs in Texas**. Dr. Scanlon asked how much groundwater conservation districts were relying on ASR. Mr. Betz responded that there were only two true ASR projects in Texas. One is in San Antonio which is injecting Edwards Aquifer water into the Carrizo-Wilcox Aquifer and the other is the city of Kerrville using surface water to inject into the Trinity Aquifer for municipal use. ASR projects may be desirable in the Edwards; however, there is a legal problem with injecting water into the Edwards. It is against state law to inject any water other than Edwards water into the Edwards Aquifer. And even if Edwards water is used, it must be chemically or biologically unaltered, which means it can't be chlorinated and bacteria must not be introduced into it. Therefore, there are a number of technical issues that must be worked out before there is any major ASR in the Edwards. ASR would be useful in the Edwards as a means to maintain spring flows in times of drought. The Edwards Aquifer Recovery Implementation Program (EARIP) is relying heavily on the first phase of San Antonio's ASR project, and for the second phase they will be either enhancing the existing ASR project or developing a second ASR project. There have been a number of ASR project proposals across the state. The TCEQ permits any injection into an aquifer. ASR injection wells are permitted as a Class V. There is some discussion at EPA about creating another class of injection well specifically for aquifer recharge and ASR. It would probably be designated as a Class VII well since the Class VI designation has been assigned to CO2 wells. On a national level, the Ground Water Protection Council (GWPC) is working on exploring various options. For one, they are commissioning a study to establish the universe of ASR projects nationwide. Texas is working closely with GWPC on the study. ASR has been mentioned in the 50-year planning horizon. Any projects would need to be permitted by TCEQ and in each case it would need to be determined that an adequate study had been accomplished to comply with the laws of the state in protecting groundwater. Suitability of ASR projects is determined on a case by case basis rather than establishing a groundwater standard that would indicate which aquifers are suitable for ASR. It would be very difficult to carry out a single study that would identify every aquifer or portion of aquifer that would be suitable for ASR. Dr. Scanlon concluded that ASR is an important topic and would be worthwhile to pursue.

The discussion moved to item number nine, the **Quantification of the vulnerability of dynamic aquifer systems, such as karst and alluvial aquifers, to contamination, focusing particularly on pathogens**. Mr. Wagner asked Ms. Long and Ms. Bilbe what is being done with the Nonpoint Source Management Plan, because it had recently been a topic of discussion in reference to redoing or updating its section under vulnerability analysis. Ms. Long responded that it was beginning to be discussed by the Nonpoint Source Task Force, but the development of the topic was in its early stages. Ms. Bilbe added that there will not be time to update the upcoming version of the Nonpoint Source Management Plan concerning this topic, but that they are working on an update for a future Management Plan. Ms. Long also informed the Subcommittee that they have been discussing with EPA the possibility of changing the five-year cycle of the Nonpoint Source Management Plan to a two-year cycle that would correspond with the 303d list. At this point EPA is favorable to the change. Dr. Scanlon asked about when the next Requests for Grant Applications for nonpoint source projects would take place.

Ms. Long and Ms. Bilbe responded that it would be in the Summer. Dr. Scanlon asked Mr. Wagner to describe the work that they were doing on pathogens. He responded that they were working on the Colorado River just below Austin to look at surface water – groundwater interaction with respect to bacteria. This portion of the river is known to have been impaired by bacteria. There are concerns that septic systems and other sources of bacteria may be impairing the alluvia aquifer in this area and then in turn affecting the river. And, conversely, the bacteria in the river may be affecting the alluvial aquifer and thus the well users along this segment. Dr. Scanlon suggested that this topic is also very important and a topic for which we should develop a white paper. Mr. Wagner suggested that the first thing that should be looked at would be a state wide study to determine aquifer vulnerability, something that would be very useful for nonpoint source management. Then some specific areas could be targeted for study. Ms. Long responded that the Nonpoint Source Task Force was discussing this issue, whether DRASTIC should be updated or some other method should be pursued.

It was decided that the next topic, item ten, the **Quantification of impacts of irrigation on water quality and status of irrigation return flow**, should not be pursed for now. There has been a lot of recent work on this topic.

Item eleven on the hand out, the **Evaluation of groundwater treatment methodologies for effectiveness and economics in relationship to removal of contaminants**, was discussed next. Mr. Wagner reminded those present that this was the topic that Dr. Harris had recommended. It concerns point-of-use treatment of groundwater for groundwater users in small rural communities where it isn't feasible to have a public water treatment facility. Dr. Scanlon suggested that the topic be broadened to well users in general and also include education to alert well users of any contamination problems of which they may not be aware.

Dr. Scanlon asked Mr. Betz about fluoride contamination. Mr. Betz responded that TCEQ personnel are working with EPA on possibly developing a new set of standards. Fluoride has both primary and secondary MCL standards. The secondary standards are for esthetic issues, but both standards are being reevaluated. The issue is being pursued by Mr. Elston Johnson, the Section Manager of the Public Drinking water Section of TCEQ. Dr. Scanlon informed the meeting that fluoride is of concern even in the Edwards Aquifer. Ms. Musgrove responded that there was a lot of fluoride in the saline zone and some in the Trinity Aquifer, and that anywhere there is saline influence on the Edwards there is potential for a fluoride problem. Dr. Scanlon added that most of the High Plains of Texas would be exceeding the MCL if it was reduced to 2.0 mg/L. Mr. Betz volunteered to speak further with Mr. Johnson to get more information on fluoride.

Dr. Scanlon observed that the project ideas list did not mention fracking (hydraulic fracturing), which is a hot topic at this time. She suggested that we should write a white paper on the subject. Mr. Betz concurred.

Mr. Boghici brought up another issue that was not on the list. Some people at the University of Texas at Dallas have been studying the incidence of renal and pelvic cancer

in populations that use groundwater in areas of lignite deposits. Mr. Boghici informed us that he had brought forth this topic at the TWDB, as an internally requested research topic, but that it would probably not be funded there. The renal disease problem is well documented in the Balkans: in Romania, Serbia, and Bulgaria. People's kidneys shrivel up and leading to death. They have also found that in the areas of Texas and Louisiana where lignite is present, there is four times the incidence of the need for kidney dialysis. Dr. Scanlon agreed that this would be a good topic of study to pursue. She explained that this was why she was interested in the National Institutes of Health (NIH) study on the link between nitrates and neural tube defects. Perhaps NIH would fund a study on this issue.

Dr. Scanlon asked, of all the ideas covered by our discussions, which were the ones that we wanted to retain for the development of white papers. In summary, the subcommittee started with the list of eleven (See attached.) to which **Fracking** and **Health aspects of lignite deposits associated with groundwater** were added. Also, emerging contaminants was discussed with item one, **Fate of land applied materials**, and characterizing brackish water was brought up with item six on the list, **Desalination and specific aspects of desalination such as disposal of desalination concentrate**. Furthermore, it was decided that items number two, three and ten on the list would be dropped from consideration and that items one and seven would be combined. This gives nine items that the Subcommittee considered important and worthy of white papers. Mr. Wagner suggested that we should narrow the number down to the top five and then choose the top two priority items to give us a manageable list with which we can start drafting the white papers. It may be rather overwhelming to attempt white papers for the whole list all at once. Mr. Betz suggested that we put the writing of a white paper for **Fracking** aside for the time being since it's now under heavy scrutiny at the national level with EPA carrying out a study. We probably need to wait for any information that will come from these activities before we decide on a white paper for **Fracking**. Dr. Scanlon asked what five should be selected as priority. She suggested items five and eight from the list. Mr. Wagner went on to suggest items nine and eleven from the list, and **Health aspects of lignite deposits associated with groundwater** as the fifth item.

The final priority list of five research topics for which the Groundwater Research Subcommittee will pursue the drafting of white papers is as follows.

1. **The characterization of groundwater - surface water interactions in the state with respect to water quantity and quality**
2. **Aquifer Storage and Recovery (ASR) Programs in Texas**
3. **Quantification of the vulnerability of dynamic aquifer systems, such as karst and alluvial aquifers, to contamination focusing particularly on pathogens**
4. **Evaluation of groundwater treatment methodologies for effectiveness and economics in relationship to removal of contaminants**
5. **Health aspects of lignite deposits associated with groundwater**

**Adjournment**

The meeting adjourned at 10:03 AM.]

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Minutes prepared by Joseph L. Peters, February 18, 2011

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A document entitled *Project Ideas for Future TCEQ Research*, which contains a list of research needs topics, follows on the next page.

Project Ideas for Future TCEQ Research

Bridget Scanlon, Bill Harris, Kevin Wagner, and Steve Walden

Texas Bureau of Economic Geology and Texas Water Resources Institute

January 2010

1. **Fate of land applied materials: It is critical to assess the impacts of land applied materials, such as sewage sludges, biosolids, and manure related to sewage plants, CAFOs, and AFOs, on underlying aquifers**. Transport rates of nutrients, including nitrogen and phosphorus, trace elements, and possibly pathogens may vary depending on application rates, precipitation amount and timing, vegetation type, and soil type. Field studies should be conducted to quantify the penetration depth of different elements, such as nitrogen, phosphorus, trace metals, and pathogens. The relative importance of piston versus preferential flow should be evaluated to determine if contaminants are bypassing the unsaturated zone. Assessing potential linkages between land application processes and surface water and groundwater quality is critical for understanding the vulnerability of water resources to potential contamination from such sources. Best management practices to reduce impacts of land applications on the environment should include field investigations, modeling analyses, and risk assessment. The assimilative capacity of different aquifers can also be addressed in these studies. The results of such studies will provide valuable information for performance of these systems in different parts of the state over major and minor aquifers under different climate conditions, crops, and soil types.

2. **Groundwater perchlorate contamination: High levels of groundwater perchlorate have been found in the High Plains aquifer, with concentrations up to 200 ug/L.** Proposed concentrations for MCLs are 24.5 ug/L based on the most recent NRC report. While previous studies have characterized the regional distribution of perchlorate concentrations in groundwater and have conducted limited studies on unsaturated zone reservoirs of perchlorate, it is important to conduct more detailed studies that link land use, unsaturated zone reservoirs, and potential future groundwater levels. Additional drilling and sampling should be conducted to evaluate impacts of agricultural management on development and mobilization of perchlorate reservoirs and potential build up of perchlorate in crops that would provide another pathway for perchlorate to humans.

3. **This study will link agricultural management with groundwater nitrate contamination to reduce future contamination because nitrate is the most widely distributed contaminant in Texas aquifers**. Preliminary studies indicate that some of the nitrate in the unsaturated zone is natural in origin. These studies have linked land use with unsaturated zone reservoirs and potential future groundwater concentrations with mobilization of these reservoirs. We have conducted detailed studies in the southern High Plains, Seymour, and Gulf Coast aquifers. Examples of activities that could be conducted to reduce future groundwater nitrate contamination include timing of fertilizer application (fall

versus spring), growing winter cover crops to sequester nitrogen, and promoting denitrification.

4. **$CO_2$ storage: what could be the impact on the water quality of Texas aquifers if several large projects start injecting $CO_2$?** Brackish water pushed up-dip? Metal mobilization if leakage occurs?. This is an emerging topic of interest around the world in which BEG is a leader. This project will crystallize the underlying issues for Texas and apply BEG researcher's knowledge to assess potential impacts of $CO_2$ injection on fresh groundwater quality, including mobilization of trace metals and upward flow of brine mixing with fresh water. The Gulf Coast aquifer is targeted for injection because so much $CO_2$ in produced in the Gulf Coast. It will be very important to understand potential impacts of $CO_2$ on the quality of fresh water aquifers in the Gulf Coast.

5. **Characterize groundwater surface water interactions in the state with respect to water quantity and quality.** It is important to better understand how groundwater and surface water systems interact in the state to avoid double accounting of water with respect to assigning water rights and to assess impacts of groundwater discharge on surface water quality in different regions. Fundamental studies on stream hydrograph separation and evaluation of linkages between water quality in streams and adjacent aquifers are essential first steps in this process.

6. **While the Texas Water Development Board has several studies ongoing related to desalinization, it is important for TCEQ to work on specific aspects of these studies, such as disposal of desalination concentrate and drinking water treatment residuals.** Generation of brine from desalination of saline and brackish water to produce drinking water creates concentrated brine. Treatment of drinking water sources to meet the states drinking water standards also produces a residual that must be managed. Information on the chemical composition and concentration levels is an essential prerequisite to determining appropriate disposal strategies. This study should build on the original reconnaissance study of brackish and saline water conducted by LBG Guyton for the TWDB and characterize the chemistry of brackish and saline water. In addition, residuals from operating desalination plants can be sampled and analyzed to determine the distribution of chemical parameters and concentration levels.

7. **Develop a database on chemical characteristics of soil water to quantify reservoir of contaminants in the unsaturated zone derived from atmospheric and land surface processes**: Much of the contamination in aquifers is derived from atmospheric deposition, land surface processes (irrigation, fertilization) or geologic sources in the unsaturated zone (arsenic). Although the state has an active groundwater sampling program, our understanding of reservoirs of potential contaminants in the vadose zone and impacts on underlying aquifers is limited. This study would develop a database on chemical characteristics of soils from all the previous drilling and conduct additional drilling to assess whether aquifer contamination is derived from atmosphere or vadose zone processes. Understanding the reservoir of salts (chloride, sulfate, nitrate etc) in the unsaturated zone derived from natural and agricultural practices and transport rates can be used

to predict potential impacts on underlying aquifers. This study can also help distinguish whether solutes in the unsaturated zone are derived from natural or anthropogenic processes, which is important for remediation purposes.

8. **Set the standards for Texas for water/aquifer compatibility and emphasize the technical hurdles to establishing Aquifer Storage and Recovery Programs in Texas.** ASR systems are an efficient technique to span seasonal dry periods. However, very few ASR locations exist in Texas compared to other states such as Florida. The State through TWDB has shown interest in developing the technology. This project will address standards for Texas of water/aquifer compatibility and assess technical issues that need to be overcome to establish ASR projects in different aquifers.

9. **Quantify vulnerability of dynamic aquifer systems, such as karst and alluvial aquifers, to contamination, focusing particularly on pathogens**: Karst and alluvial aquifers are extremely vulnerable to contamination because recharge rates and water fluxes through these systems are extremely high. Contamination from microbes and viruses is of particular concern in these systems. The Edwards and Brazos River Alluvium aquifers could be used as case studies for this analysis. Age dating of water would provide valuable information on flux distribution in the system. Evaluating different processes for attenuating contaminants in these systems, i.e. dilution versus adsorption on clays, would be important for understanding the assimilative capacity of these aquifers. Fate and transport of emerging contaminants, such as caffeine etc should be characterized in these systems also.

10. **Quantify impacts of irrigation on water quality and status of irrigation return flow:** Recent studies in the High Plains have focused on reducing water applications in irrigated areas to conserve water resources. However, irrigation water from groundwater in the southern High Plains has high total dissolved solids and limited applications means that salts in the vadose zone are not being flushed through the system. Deficit irrigation is resulting in soil salinization. Potential impacts of mobilizing these salts into the underlying aquifer need to be addressed. In addition, decreasing aquifer thickness reduces the assimilative capacity of the aquifer and further increases salt and nutrient concentrations. Stratification of groundwater quality needs to be examined because declining groundwater levels may also be associated with increasing groundwater salinity.

11. **Evaluate Groundwater Treatment Methodologies for effectiveness and economics in relationship to removal of contaminants**. Many of our groundwaters in Texas currently being used for drinking water for rural private residences contain unacceptable and unhealthy levels of contaminants such as arsenic and nitrates. Studies are needed to determine most effective and economically viable systems for detecting and treating the water to safe levels.