DOE's Oil & Gas Environmental Research Program

January 1999, Vol. 4, No. 1

EYE on Environment

U. S. Department of Energy • National Petroleum Technology Office • P.O. Box 3628 • Tulsa, OK • 74101-3628

Use of Inactive Production Wells to Obtain a Variance to Area of Review Requirements for Injection Well Permitting in Texas

by Rebecca C. Smyth and Alan R. Dutton, The University of Texas at Austin, Bureau of Economic Geology

Permitting of Class II injection wells in Texas requires oilfield operators to perform an Area of Review (AOR) study to identify unplugged wells that could allow injected fluids to migrate upward under pressure from the production zone and endanger underground sources of drinking water. If an operator or group of operators in a field can document sufficient separation between the pressure head on a production zone and the base of useable quality water (BUQW) (**Figure 1**), the Railroad Commission of Texas (RRC) may issue a field-wide variance to the AOR requirement.

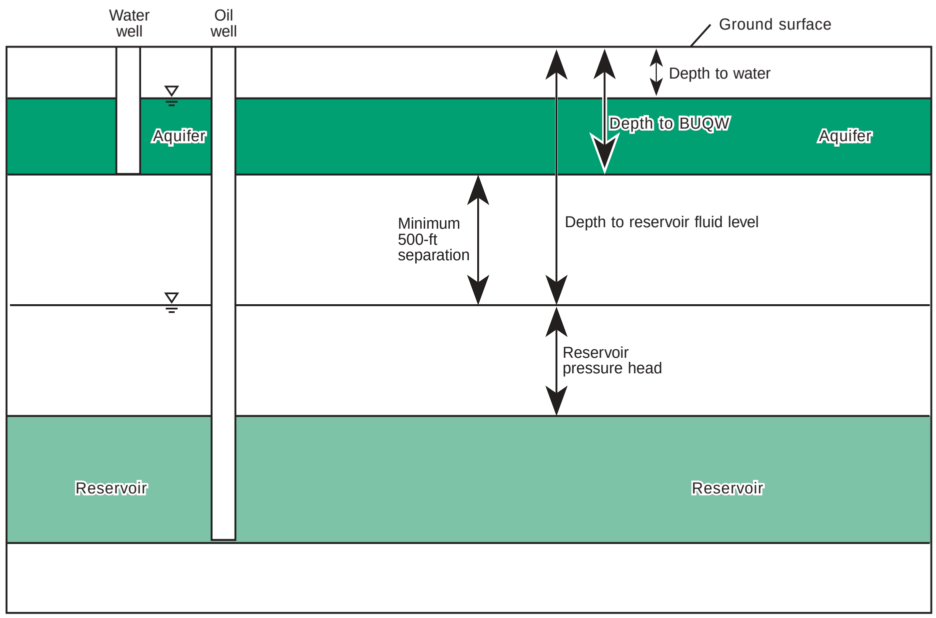

Figure 1 Comparison of depth to fluid level in reservoir to BUQW depth.

Environmental Considerations

Fluid levels in the production zone rise in response to increased pressures from injection. The area around an injection well where fluid levels increase and the amount of increase can be estimated by a pressure-front calculation. Oil fields that have inadequate separation between production-zone fluid levels and the BUQW elevation are more likely to create environmental impacts to ground and surface water by upward migration of salt water. On the other hand, if there is little chance that injection in a field will pose a threat to ground water, it should not be necessary for operators to expend time and resources to complete an AOR survey.

Use of Inactive Wells

Once oil wells are no longer economically producing at current market rates they are commonly shut in or temporarily abandoned. These wells are idle until oil prices

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increase or until they can be used to enhance oil recovery. In Texas, operators of wells that have been shut in and are at least 25 years old are required to submit Form H15 to the RRC to prove the wells are not leaking. This is accomplished through either a mechanical integrity test every five years or measurement of fluid levels annually. An inactive production well can serve as a monitoring well for measuring ambient reservoir pressures.

Case Studies in Texas

The University of Texas at Austin, Bureau of Economic Geology (BEG), working in conjunction with the RRC, conducted a survey of 113 oil fields within 36 counties in Texas (**Figure 2**) to evaluate the need for AOR studies in each field. We used an RRC database of H15 fluid-level measurements and BUQW's as defined by the Texas Natural Resource Conservation Commission (TNRCC) to determine separation between production-zone fluid levels and BUQW.

Out of more than 8,000 fields in the H15 database, 113 fields have sufficient fluid-level data and ongoing injection operations. The limiting factors in our analysis are number of available H15 fluid-level measurements necessary to confidently bound ambient field pressure and location of the wells. It is best to have a good distribution of H15 measurements across a field, including some near injection wells. H15 measurements from near an injection well can be used as a gauge of "worst-case" conditions of pressure buildup.

By graphically plotting H15 fluid levels and BUQW on histograms and looking at relative well locations, we screened fields that might readily qualify for an AOR variance. For example, Vealmoor field in Howard County, Texas (**Figure 3a**), qualifies for AOR variance because it has (**1**) a statistically significant number of H15 fluid-level measurements, given the spread of data (1,844 ft), (**2**) separation of 710 ft between the shallowest production zone fluid-level and BUQW, and (**3**) seven H15 wells located within 0.25 mi of injection wells.

Reinecke field in Borden County, Texas, needs additional data and further evaluation before it can qualify for AOR variance (**Figure 3b**). Two of the reservoir fluid-level (H15) measurements are less than 500 ft below the BUQW. These measurements may be unrepresentative of pressure head in the production zone. For example, some operators chose to ensure that casings of idle wells are not leaking by installing cast-iron bridge plugs (CIBP) and loading the casing with fluid; any changes in fluid level will indicate that the casing is leaking. The H15 form turned into the RRC will not note the presence of a CIBP. Also, according to our statistical analysis there are not enough H15 fluid-level measurements for Reinecke field to confidently state adequate separation exists given the large spread in data

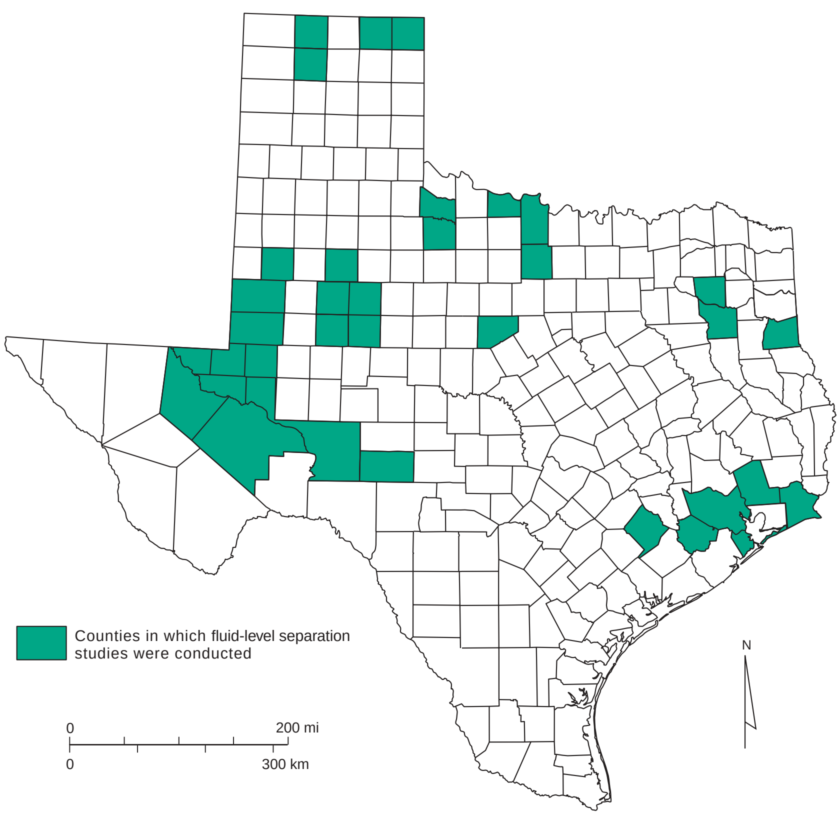

Figure 2 Texas counties in which oil fields were evaluated for AOR variance.

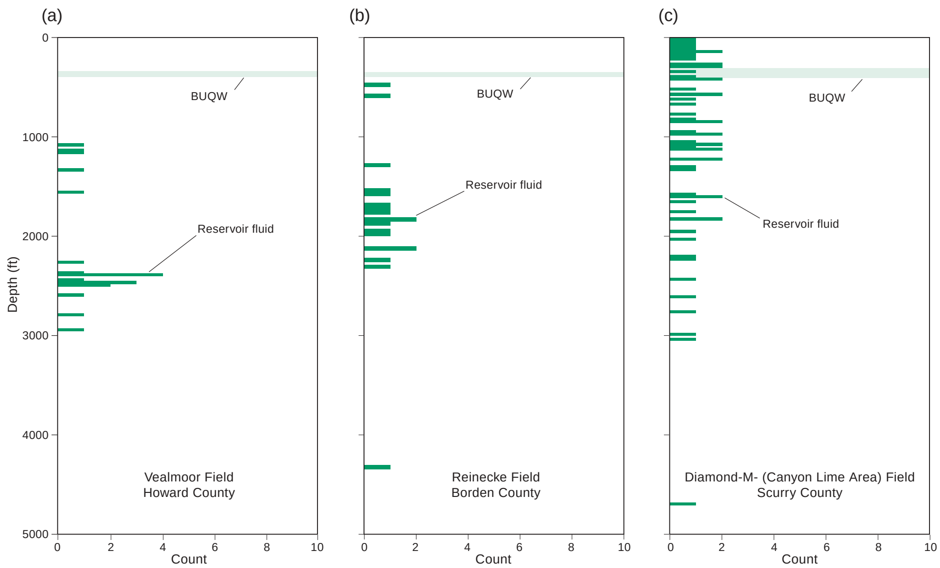

Figure 3 Example histograms showing BUQW and reservoir fluid levels for (a) Vealmoor, (b) Reinecke, and (c) Diamond -M- (Canyon Lime Area) fields.

(range of 3,829 ft).

Diamond -M- (Canyon Lime Area) field in Scurry County, Texas (**Figure 3c**), does not qualify for AOR variance on the basis of fluid-level separation. Many of the fluid levels in the reservoir are within 500 ft of or shallower than the BUQW. If there are open holes or casings adjacent to injection wells in this field, the potential exists for impacts to ground water.

Summary

Our results show that of the 113 fields studied (**1**) 24 fields can be recommended for AOR variance if more production-zone fluid-level data are submitted to RRC or if H15 well locations are approved by RRC, (**2**) 16 fields can be recommended for AOR variance if a single outlier value is resolved and if additional production-zone fluid-level data are submitted to the RRC, and (**3**) 2 fields can be recommended for AOR variance as they now stand. The two fields that qualify for AOR variance without additional data are Panhandle (Red Cave) in Moore County, Texas, and Vealmoor in Howard County, Texas.

We used the H15 database to work out a methodology that operators can follow to see if their fields can qualify for AOR variance but want to emphasize that the H15 data were not originally intended to be used in this way. Many more fields in Texas may qualify for AOR variance if additional representative fluid-level data from production zones are provided. Operators might work together to produce maps of fluid levels in production and injection wells for specific fields and facilitate the AOR variance process.

Reference

Smyth, R. C., Nava, R., Sullivan, E. J., and Mace, R., 1998, Methodology for determination of Texas oil fields eligible for variance from area of review requirements in underground injection control regulations for Class II injection wells: The University of Texas at Austin, Bureau of Economic Geology, prepared for Railroad Commission of Texas, variously paginated. Revised Final Technical Report available from Railroad Commission of Texas, Environmental Services, Underground Injection Control, P.O. Box 12967, Austin, Texas 78711-2967.

EYE *On Environment* features oil- and gas-related projects implemented through DOE's oil and gas environmental research program.

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Acknowledgments

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AREA OF REVIEW VARIANCE WORKSHOP

by Jerry R. Simmons, The Aspen Group (formerly with BDM Petroleum Technologies) and Kim S. Monti, The Aspen Group

The Area of Review (AOR) Variance Workshop was held in conjunction with the Ground Water Protection Council (GWPC) Annual Meeting in Sacramento, California (September 1998). The U.S. DOE, National Petroleum Technology Office (NPTO), conducted the daylong workshop summarizing DOE, industry and state efforts on AOR Variance projects. David Alleman, NPTO, Environmental Technologies Program Manager, summarized the efforts of DOE sponsored pilot studies in several states. The goals of the workshop were to give an overview of the programs in each state, noting similarities and differences, identifying lessons learned, and recognition of key areas of concern, which would have application or impact on other similar efforts in the future.

ORGANIZATION OF THE WORKSHOP

The workshop was attended by federal, state, industry, and contractors. Formal presentations on AOR variance activities were made by: M.G. Mefferd, **Conservation Committee of California Oil and Gas Producers**; Al Robb, **American Petroleum Institute**; Don Warner, **University of Missouri-Rolla**; Fernando De Leon, **Railroad Commission of Texas**; Michael Schmidt, **Oklahoma Corporation Commission**; Mike Stettner, **California Oil and Gas Division**; Bruce Langhus, **CH2M Hill**; and Jerry Simmons, **BDM-Petroleum Technologies**. An open panel discussion to note the differences and similarities of the efforts and identify key areas of concern followed the presentations. Panel participants were: David Alleman, **DOE**, **NPTO**; Ken Henderson, **California Oil and Gas Division**; Mike Schmidt, **Oklahoma Corporation Commission**; David Schieck, **Railroad Commission of Texas**; Lori Wrotenbury, **New Mexico Oil Conservation Division**; Alan Snider, **Kansas Corporation Commission**; Stan Belieu, **Nebraska Oil and Gas Division**; Steve Platt, **U.S. EPA Region 3**; Jerry Mullican, **Texas Bureau of Economic Geology**; and Jerry Simmons, **The Aspen Group**.

ECONOMIC IMPACT ON INDUSTRY

The AOR variance program was a direct result of Environmental Protection Agency (EPA) proposed rule changes to the Underground Injection Control (UIC) program. Under this ruling previously grandfathered injection wells would require an AOR to be performed. The Federal Advisory Committee has determined several categories of variance to the proposed rule, which will be allowed. The driving factor for variance is the economic impact on industry of regulatory programs, and the desire not to put in place federal regulations that potentially include requirements that are not necessary from a scientific/engineering perspective.

PANEL DISCUSSION

An invited panel facilitated by Don Frazier discussed the commonality of the implementation of AOR variance projects. The main lesson learned from these projects was that these efforts are data and labor intensive and without careful, and at times innovative planning, costs can be greater than anticipated. The key concern, based on the magnitude of the data required to conduct AOR variance investigations, was the need for large-scale electronic data management systems. API studies of individual state projects indicate that statewide or broad area AOR variance investigations can not be readily performed without electronic data management systems. Future efforts would benefit from the continued establishment of accurate, remotely accessible and user-friendly data systems. Creation of electronic data management systems has been a goal of DOE sponsored state projects.

HOW AOR VARIANCE PROJECTS ARE WORKING

BDM-PT was tasked by DOE to work with certain states on broad area AOR variance plans. Projects were initiated with Texas, Oklahoma and California to create statewide variance assistance plans. AOR Variance Committees were established in each state with members from three large and three small oil and gas companies, chaired by an official from the state regulatory agency. In each state, the Committee developed an AOR Variance assistance plan, which was submitted to DOE for approval.

Texas

The Texas plan included three specific tasks to assist with AOR variance: (**1**) The Texas Railroad Commission (TRRC) would need to change state UIC rules to allow for AOR variances in Texas. (**2**) Because several different AOR variance efforts have been completed or are underway in Texas (API and DOE sponsored), a need existed to summarize that work. (**3**) Using existing databases at TRRC and Bureau of Economic Geology (BEG) was recommended to identify fields with negative flow potential for possible AOR variance.

Summary of Texas effort

TRRC completed the UIC Rule change, allowing oil and gas operators to apply for a field or broad area AOR variance. Through TRRC, BEG conducted a study and summarized all AOR variance activities in the state. Using TRRC and BEG databases, BEG examined roughly 100 oil and gas fields for negative flow potential between the producing formation and underground source of drinking water (USDW). The results of that study demonstrated that five fields have the desired technical criteria for an operator to seek application for AOR variance; four more fields are possible candidates if appropriate technical information is gathered.

Oklahoma

Oklahoma's assistance plan consisted of three tasks: (**1**) Oklahoma Corporation Commission (OCC), Oil and Gas Division required assistance in well construction database input. (**2**) Hydrogeologic maps needed to be transferred from hard copy to electronic format. (**3**) Provide University of Missouri Rolla (UMR) with Petroleum Information (PI) electronic well data.

Summary of Oklahoma Effort

BDM-PT assisted the University of Oklahoma, GEO Information Systems, with data entry of well plugging reports, digital land grids and Natural Resources Information System (NRIS) mapping application software. Approximately 17,000 well plugging reports were entered into the system that ties to the land grid and mapping software. The state requires operators to include depth to ground water on drilling permit applications. In the second task, BDM-PT developed a methodology to convert the hard copy state maps to electronic format. Data from five counties was converted to this electronic format and delivered to the state data system. Early in the project, UMR conducted a statewide evaluation of AOR variance possibilities. To facilitate this study, BDM-PT provided UMR with the PI electronic database for the entire state of Oklahoma.

California

The California assistance focused on one main aspect, but this included an evaluation of the state computer system. The goal was to provide data input to the California well construction database. BDM-PT assisted in overall system design and architecture to create a fully integrated and interactive computer system.

Summary of California Effort

After installation and customizing the Risk Based Data Management System (RBDMS), BDM-PT worked with the Ventura District Office to develop a method for well construction data entry into the system. After testing and quality assurance procedures were implemented, data entry personnel were provided for all California Oil and Gas Division district offices. California also consulted with BDM Information Technology professionals on the design and architecture of a statewide fully integrated and interactive computer system.

Conclusions

In each state, Steering Committees recognized the need to have current, modern, electronic information available in order to perform large area AOR variances. Due to the volume of data required to perform field or broad area AOR variance investigations, the statewide AOR variance plans were updated to include computer systems that contained the necessary well construction, hydrologic, cultural, and historic information.

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CO_2 Recovery from Flue Gas for use in EOR

by Viola Rawn-Schatzinger, RMC, Inc.

Clear Air and Cheap CO_2

Air quality and the effort to minimize global warming were the catalyst for Mitsubishi Heavy Industries of Japan to develop a technology for recovery of CO_2 from flue gas. This article is based on a presentation made by Mitsubishi representatives to DOE and DOE sponsored project personnel in August 1998*. CO_2 recovery plants in Japan developed in partnership with Mitsubishi and Kansai Electric Power Co. have been so successful, that Mitsubishi is now seeking a dual market for cleaner air and CO_2 for use in Enhanced Oil Recovery projects (Iijima, 1998). CO_2 floods in U.S. oil fields are limited by economic considerations of either a nearby source of CO_2 or a nearby pipeline for CO_2. The recovery of CO_2 from flue gas offers an alternative to construction of pipelines, because it can be generated from power plants located close to or as part of many oil field operations.

New Energy-efficient Solvents — Reduce Costs and Improve Purity

CO_2 recovery from boiler flue gas has been used in the carbonated beverage industry for years, but the CO_2 production was not economic for large-scale use, and did not meet the needs for nationwide cleaner air. Mitsubishi started development of an improved CO_2 recovery system in 1990, and a pilot plant was built in 1991 in Japan by Kansai Electric. The new technology is based on two new energy-efficient solvents, KS-1 and KS-2.

The first stage in CO_2 recovery is a chemical absorption method to reduce the regeneration energy. The new solvents (amines) can reduce regeneration energy by about 20% compared to conventional methods. The second stage was the development of new absorber packing (KP-1) to reduce the pressure loss in the flue-gas blower, causing a significant saving in blower power. The new packing allows the gas to flow between mesh plates, which allow a higher area of contact, which in turn reduces pressure loss to the system. The process based on natural gas generation uses much cleaner amines than traditional coal gas generation source and is non-corrosive. **Figure 4** is a diagram illustrating the process.

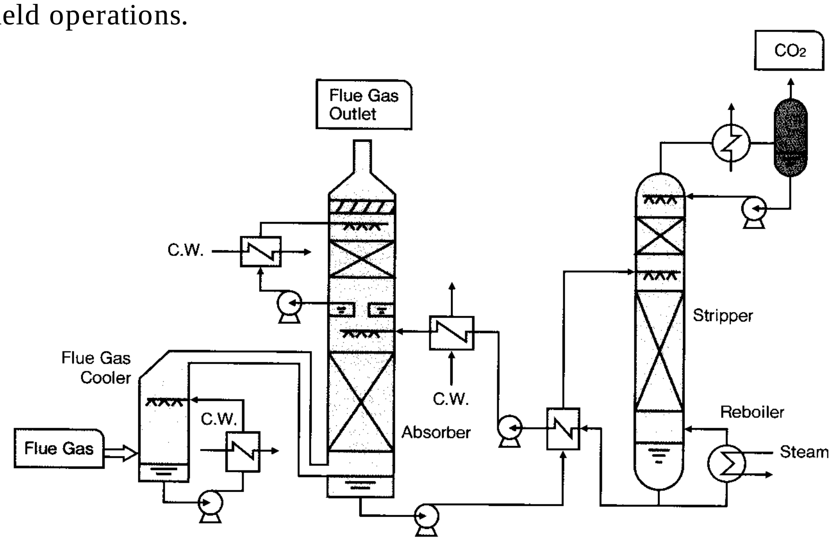

Figure 4 Design of the flow process in the recovery of CO_2 from flue gas (from Mitsubishi Heavy Industries, Ltd.)

Advantages of the System for Improved Air Quality

- Over 90% recovery of CO_2
- Energy-efficient, 25% cost reduction in energy production
- Reduce operating pressure by 1/7
- No corrosion to pipes
- Amines are recyclable

The CO_2 generated by the flue gas recovery method has potential in the United States for use in Enhanced Oil Recovery projects using CO_2. Costs for CO_2 could be significantly reduced by generating the CO_2 at power plants close to the CO_2 flood projects. Not only is the CO_2 generation less expensive, but the cost of transportation is dramatically reduced, particularly in places where no existing pipeline networks have been established. The numerous steam co-generation plants operating in oil fields in the San Joaquin Valley, California were cited as excellent potential flue gas recovery plants. These plants are located close to other oil fields where the use of CO_2 floods is being investigated. **Figure 5** shows a diagram of potential relationships. Mitsubishi personnel cited statistics based on 1997-98 production costs.

Advantages of the CO_2 Produced for EOR Projects

- Cost of CO_2 from gas turbine generation is $1.20 per MSCF
- Cost for CO_2 from flue gas boiler recovery is $.76 per MSCF
- CO_2 can be generated close to cite of CO_2 flooding operations
- CO_2 production can be tailored to small (50 megawatt) local generation plants
- 50 megawatt cogeneration plants for power and steam are standard in California where potential CO_2 floods are being investigated
- CO_2 produced is 99.9% pure
- Reduced corrosion saves money on maintaince of facilities

Conclusions

Mitsubishi Heavy Industries has developed a CO_2 recovery system that meets the needs for cleaner air, and economical supplies of CO_2 for Enhanced Oil Recovery projects. Tighter air quality control laws in Japan were the impetus for Mitsubishi to investigate the recovery of CO_2 from flue gas power generation plants. The United States has not mandated the same stringent air quality standards at this time, but future requirements may change towards lower allowable CO_2 emissions. The beneficial sideline of the research has been the discovery that inexpensive CO_2 can be generated at power plants anywhere in the world. This could allow the production of CO_2 close to where EOR projects are located; thus eliminating the costs of building and maintaining long distance pipelines form CO_2 sources.

References

Iijima, Masaki, 1998. "*A Feasible New Flue Gas CO_2 Recovery Technology for Enhanced Oil Recovery*": SPE 39686, 1998 SPE/DOE Improved Oil Recovery Symposium, Tulsa, Oklahoma, April 19-22, 1998. 11 pp.

* Presentation made by Masaki Iijima, Yusuke Yoshida, **Mitsubishi Heavy Industries, LTD** and Akiyoshi Mizoguchi, and Hiro Kakihara , **Mitsubishi Corporation** and J. A. Pachioli, **Mitsubishi International Corparation**: August 18, 1998, Bakersfield, California.

Area of Review

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With these systems in place, the states and industry will be able to investigate large areas of a state for potential variance in a fraction of the time it would take to perform this task by examination of hard copy records.

At the Project Close Out Workshop, representatives from industry, states and DOE/API contractors presented results of the efforts on AOR variance. Given the absence of an EPA rule change that requires AORs to be performed on all historic injection wells, the states and industry continue to reap the economic benefit of field or broad area AOR variance. The AOR variance project clearly demonstrates the additional benefit of up-to-date, modern, electronic data management systems, where specific oil and gas well information can be accessed by state agencies and industry to perform technical permit requirements in a cost-effective and timely manner.

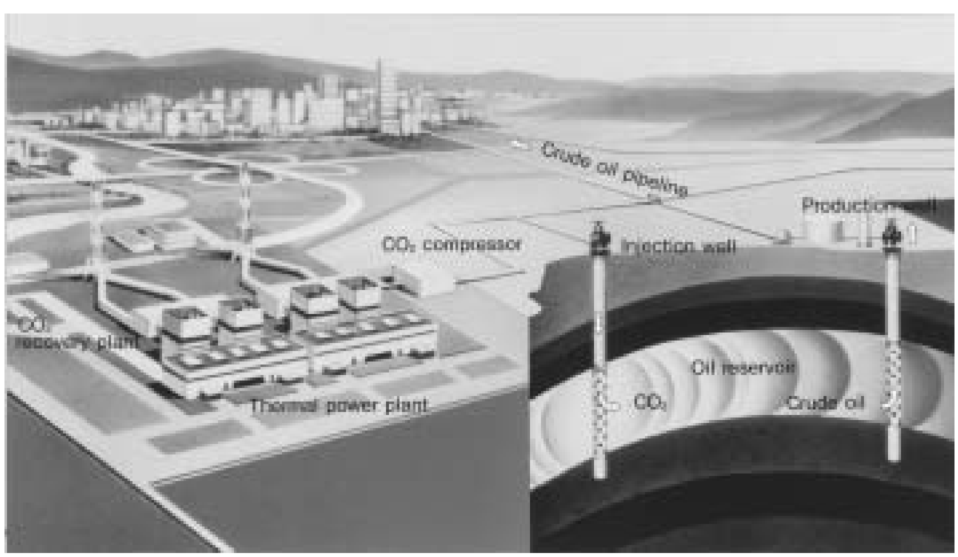

Figure 5 Plan for the location of CO_2 recovery from power plants adjacent to oilfields using CO_2 for EOR (from Mitsubishi Heavy Industries, Ltd.)

Calendar

January 12-13 1999

Ground Water Protection Council Annual Injection Meeting, New Orleans, Louisiana.

April 13, 1999

AAPG Division of Environmental Geoscience Annual Luncheon and Meeting, San Antonio, Texas. Speaker Dr. S. Fred Singer. **"Hot Talk, Cold Science; Global Warming's Unfinished Debate"**.

September 19-23, 1999

Ground Water Production Council Annual Meeting, Newport, Rhode Island.

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