CONF-831041--16

EVALUATION OF NEPA-BASED ENVIRONMENTAL COMMITMENTS AT FOUR GEOPRESSURED GEOTHERMAL DESIGN WELLS[1]

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To be published in the Geothermal Resources Council Transactions, Portland, Oregon
October 24-27, 1983

[1]Research sponsored by the Geothermal and Hydropower Technologies Division, U.S. Department of Energy, under contract W-7405-eng-26 with Union Carbide Corporation.

DISCLAIMER

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ABSTRACT

This study verifies the implementation and effectiveness of environmental mitigation and monitoring commitments made by the U.S. Department of Energy in National Environmental Policy Act documents [Environmental Assessments (EAs)] prepared for four geopressure design well projects, one in Texas and three in Louisiana. The evaluation was based on visits to the project sites conducted by Oak Ridge National Laboratory staff in August 1982 and April 1983, and on a review of monitoring and project activity reports provided by DOE subcontractors. Subcontractors responsible for drilling and testing activities at the well sites adequately implemented most of the mitigation measures described in each project's EA. Exceptions included the lack of impermeable liners for drilling mud pits at three sites and the lack of a ring levee at one site. Water quality, noise, and air monitoring were not performed as strictly as outlined in the EAs. A review of the data collected to date indicates that no significant environmental degradation has occurred. Additional or future monitoring needs, especially with regard to subsidence, microseismicity, and groundwater and soil sampling were recommended.

INTRODUCTION

In 1976, the U.S. Energy Research and Development Administration [ERDA; now the Department of Energy (DOE)], Division of Geothermal Energy, established a Geopressure Subprogram intended to encourage the development of a viable industry to exploit the geothermal geopressured resource along the Texas-Louisiana Gulf Coast. To stimulate industrial interest in development of the unproven geopressured resource, ERDA initiated exploration of the range of associated technical, economic, and institutional factors. ERDA's resource development support focused on exploration technology, resource assessment, and reservoir confirmation. Resource assessment has involved well production tests and the acquisition of specific geopressured reservoir information on a regional basis. Both these tasks have been accomplished, in part, by the drilling and testing of four geopressure design wells.

This report evaluates the environmental mitigation and monitoring commitments made by DOE with regard to specific activities of its geopressure design well program. The purpose of this study was to verify the implementation and effectiveness of measures outlined in environmental documents prepared for four geopressure design well projects pursuant to the National Environmental Policy Act (NEPA) of 1969. NEPA analyses are performed and published to satisfy legal requirements prior to the initiation of a proposed federal action. These analyses play a major role in the decision making that affects the future of many projects; however, more often than not, little or no follow-up analyses are carried out to assure decision makers that environmental protection requirements are actually implemented or that they are effective. Though NEPA requires follow-up for Environmental Impact Statements only, this study was performed to provide information regarding environmental assessments of the design well projects.

The study was conducted by Oak Ridge National Laboratory (ORNL) personnel, some of whom were involved in the preparation of the geopressure design well EA's. The projects evaluated included: Pleasant Bayou No. 1 in Brazoria County, Texas; Dow Parcperdue in Vermilion Parish, Louisiana; and Gladys McCall and Sweet Lake No. 1 well sites in Cameron Parish, Louisiana (see Fig. 1).

METHODOLOGY

To provide a basis for evaluation, the staff reviewed project site-specific EAs, Findings of No Significant Impact (FONSIs) or memos to file (if available and pertinent) and monitoring reports. The documents reviewed include:

- **Dow Parcperdue:** Draft Environmental Assessment, Dow Parcperdue Geopressure Project, Vermilion Parish, Louisiana, March 1980; memo to file dated May 9, 1980.
- **Gladys McCall:** Environmental Assessment, Geothermal Energy Geopressure Subprogram, DOE Gladys McCall Well Site, Cameron Parish, Louisiana, January 1981 (DOE/EA-0134); FONSI dated March 16, 1981.
- **Sweet Lake:** Environmental Assessment, Geothermal Energy Geopressure Subprogram, DOE Sweet Lake No. 1, Cameron Parish, Louisiana,

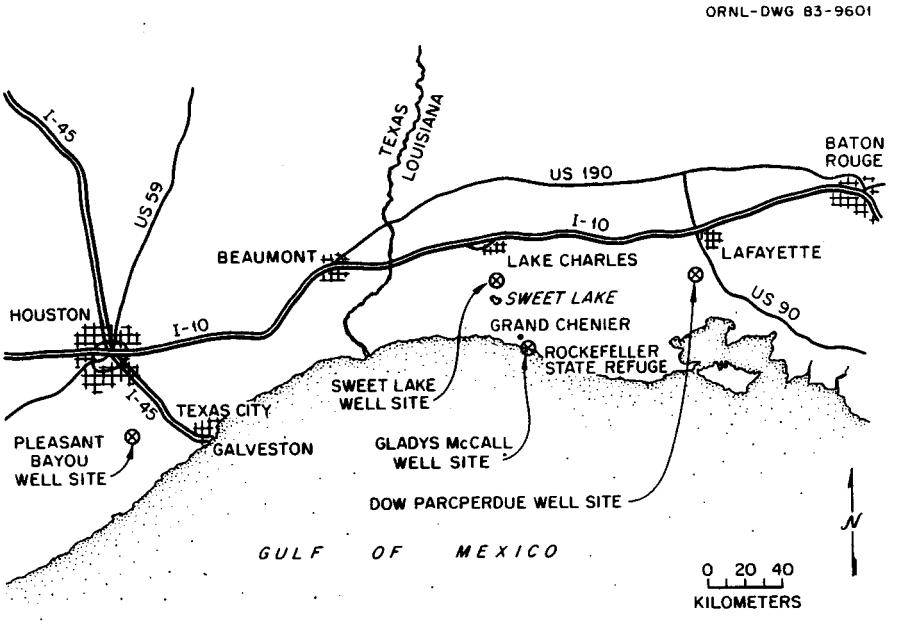

Fig. 1. Locations of the four geopressure design wells evaluated in this study.

February 1980 (DOE/EA-0065); FONSI dated March 11, 1980.

- **Pleasant Bayou:** Environmental Assessment, Geothermal Energy Geopressure Subprogram, GCO-DOE, Pleasant Bayou No. 1, Brazoria County, Texas, March 1978 (DOE/EA-0013); memos to file dated February 7, 1978; March 27, 1978; and January 15, 1979.

- **Monitoring Reports:** Louisiana--prepared by the Louisiana Geological Survey; Texas--prepared by the University of Texas, Bureau of Economic Geology.

A checklist was subsequently prepared identifying commitments made by DOE with regard to mitigation of potential environmental impacts, baseline and operational monitoring, and future decommissioning of each project. Each checklist included a general classification of the resource area affected, a reference to the document and page on which the commitment was made, a verbatim excerpt of each commitment, and an identification of the project phase in which the commitment was to be fulfilled.

Site visits were conducted on: August 10, 1982 and April 24, 1983, Dow Parcperdue; August 11, 1982, Sweet Lake; August 12, 1982 and April 25, 1983, Gladys McCall; and August 13, 1982, Pleasant Bayou.

The following evaluation of commitments presents a brief description of each geopressure project, highlights those areas in which divergence from a commitment was noted and indicates problems unique to specific sites.

EVALUATION OF COMMITMENTS

Dow Parcperdue

At Dow Parcperdue, a new well was drilled into the geopressured reservoir with the intent of producing from the reservoir until the resource was depleted. The project consisted of site preparation, drilling, flow testing, and site restoration. Site preparation began during late 1980-early 1981. The production well was completed in the summer of 1981 at a depth of about 4,069 m (13,350 ft), and preliminary flow testing began in October 1981. The injection well was drilled in early 1982 to a depth of about 1,524 m (5,000 ft) (C. K. Geoenergy, 1982). As of August 1982, the well produced about 1,590 m^3 (10,000 bbl) of brine per day, and about 4250 m^3 (150,000 ft^3) of gas per day. Increasing the brine production rate above this value produced severe sanding problems that restricted production to about half the design value. Because of these problems, DOE decided to decommission the Dow site in April 1983.

Verification of mitigation and monitoring commitments took place during site visits conducted in August 1982 and April 1983. The following concerns were noted:

- **Use of pit liners**--The drilling mud pit was approximately 61 x 102 m (200 x 335 ft) in size. The liner (8 mm black polyethylene) was torn for approximately 12 months, after which time it was repaired. During this period, toxic materials in the mud, if any, had a pathway by which to contaminate the soil and groundwater. An additional pit was constructed

at the well site as a temporary brine-holding pit [size approximately 31 by 61 m (100 x 200 ft)]. This was also lined, and during the August site visit, the liner appeared to be intact. However, during the completion of a build-up test on November 5, 1982, a drop in the level of brine in the brine pit was detected. Because no brine had been pumped, a leak was suspected. Inspection determined that brine had entered an adjacent drainage ditch. The brine pit was emptied by injection into the disposal well. Subsequent inspection of the liner identified two 33 m (110 ft) and two 20 m (65 ft) rips; the liner had apparently separated along field applied seams due to the upward pressure of gas bubbles (most likely methane from decomposition of organic matter). Louisiana State University began monitoring salinity and conductivity at several surface sites established because of the leak, and continued monitoring salinity-related parameters (i.e. chloride) at previously established surface and groundwater monitoring stations. Data collected on November 15, 1982 indicated that conductivity and salinity were above background levels. Levels of water quality parameters associated with salinity were observed to decrease with time; chloride concentration at the LeBlanc Ditch Station [approximately 5 km (3 mi) southwest of the well site] was about 273 ppm in November, and about 10.5 ppm in February (Trahan, 1983). When compared to mean concentrations of chloride in the geothermal brine (55,000 ppm; Keeley and Meriwether, 1983) contamination was relatively low. The environmental impacts of the torn liner appear to have been minimized by the quick action of the on-site crew in removing the water from the ditch and in flushing the ditch with fresh water. As part of the decommissioning of the Dow well, soil samples in the pit and around its north levee were analyzed by Southern Petroleum Laboratory in April 1983. Gulf Coast Agricultural Associates reviewed the soil analysis data and recommended that the entire north levee and no less than 0.3 m (1 foot) of soil on the bottom of the pit be removed for appropriate offsite disposal.

- **Hydrogen sulfide (H_2S) removal**--Because no measurable quantities of H_2S were found in the natural gas extracted from the well, H_2S removal equipment was not needed.

- **Fire extinguishers**--No fire extinguishers were located in the immediate vicinity of either the disposal well or the test well. The nearest extinguishers were in the trailers used as offices and a laboratory, located about 150 m (500 ft) from the wells.

- **Noise impacts**--Operational noise was minimal; the major noise source at the well was the diesel generator, which was intentionally located at least a mile from the nearest residence to minimize its impact.

- **Environmental monitoring**--The Environmental Monitoring Plan was followed except that air quality monitoring was performed for only a short time during well testing, and water quality monitoring was no longer conducted on at least a monthly basis.

  Due to funding cutbacks and the low potential for degradation, air quality monitoring at the Dow well was terminated on October 31, 1981. No significant air quality impacts were detected in the 1.25 years of monitoring conducted, which covered baseline (preconstruction) air quality, air quality during well drilling, and air quality during limited short-term flow testing (C. K. Geoenergy, 1981).

  The water quality monitoring program appeared capable of identifying significant changes in water quality resulting from well operations. The reporting of monitoring data could have been improved through discussion and interpretation by comparison with appropriate water quality criteria (e.g., Water Quality Criteria for Toxic Substances, 46 FR 79318-79) and by comparison with typical concentrations for the region.

  To detect subsidence, a first-order leveling survey was conducted at the site prior to well drilling. The survey was designed to permit comparisons of relative elevations before and after reservoir drawdown. Preliminary calculations indicate that subsidence from single wells would be minor and overshadowed by effects from oil production.

  Five borehole seismometers have been operated continuously around the site to determine the origin and magnitude of local microseismic events. Both for geopressure development and for regional concerns, microseismic monitoring should be continued for at least one year following production testing.

  The only ecological work at this site consisted of a review of existing literature to estimate baseline conditions. No monitoring was done and none was recommended, except in the case of a well blowout.

Sweet Lake

The Sweet Lake project was undertaken to drill and test a geopressure well on a 2-ha (5-acre) test site 23 km (14 mi) southwest of Lake Charles, Louisiana. Tests conducted to date include flow rates, fluid composition, temperature, gas content, geological characteristics, and the land subsidence potential. One geopressured zone at a depth of about 4,600 m (15,000 ft) has been tested for about six months. The well production (brine) averaged about 10,000 bbl/d, with about 0.54 to 0.62 m^3 (19 to 22 scf) of gas per barrel. In February 1982 a tubing leak was discovered in the production well; this and other

complications forced the operations to cease. The Sweet Lake well has been shut in, but may be reworked in 1983.

Verification of mitigation and monitoring commitments took place during a site visit conducted in August 1982. The following concerns were noted:

- **Water resources impacts**--All drilling muds at the Sweet Lake site were contained in tanks and hauled offsite by the drilling contractor (Berning, 1982a). Brine which could not be reinjected was stored in large blowdown tanks that were emptied by vacuum trucks and disposed of at approved sites. High-pressure pipes and valves were used on the casing below 610 m (2000 ft), in accordance with the Louisiana Department of Conservation Surface Casing Program (Berning, 1982a).

- **Environmental monitoring**--The air monitoring program conducted at the Sweet Lake well was adequate to address most air quality concerns associated with geopressure development. No adverse air quality impacts attributed to well drilling and operation were detected by monitoring. Data analysis should be conducted following decommissioning to address statistically significant changes in air quality during different phases of geopressure development.

  According to the Environmental Monitoring Plan, a baseline ambient noise survey was to have been conducted prior to site development; however, this was not done because of the project's low potential for long-term adverse noise impacts, based on noise studies conducted at Pleasant Bayou (Van Sickle, 1982).

  Sampling of surface water to date indicated seasonal variation in water quality and a gradient in concentrations between the fresh water near the site and the brackish water at the sampling stations closer to the Gulf of Mexico. Thus far, the data indicate no contamination from the geothermal well (Bebout et al., 1982). However, the maximum reported background concentrations of mercury observed in surface water are noteworthy because they exceed the EPA criterion for protection of aquatic life by over a hundredfold. These values are probably not atypical of estaurine waters which have high organic content and provide a biochemical environment amenable to the complexing of mercuric compounds.

  Subsidence and microseismic activity have been monitored at the Sweet Lake site, using methods similar to those described for the DOW site. The ecology of the Sweet Lake site and surroundings was characterized prior to drilling. No other ecological monitoring has been performed, nor was it recommended, except in the case of a well blowout.

Gladys McCall

The Gladys McCall project, located near Grand Chenier, Cameron Parish, Louisiana, initially used an abandoned well drilled for oil and gas exploration in 1970. After unsuccessful attempts to reenter the original well, a new well was drilled to approximately 5,185 m (17,000 ft), and an additional disposal-injection well was drilled. Site development began in early 1981; in the spring of 1982 the drilling was completed to the design depth. After 10 m (30 ft) of the production well tubing was perforated, pressure built on the casing from a tubing leak at 3,046 m (9,992 ft). The tubing was removed and bad joints were replaced in the fall of 1982. Flow testing is planned for 1983.

Verification of mitigation and monitoring commitments took place during site visits conducted in August 1982 and April 1983. The following concerns were noted:

- **Injection well**--The regulations followed for drilling and completion of the injection well were the state of Louisiana's rules for Underground Injection Control (UIC) rather than EPA rules. EPA's final regulations for the UIC program, issued in February 1982, will be followed during the flow testing and other future operations.

- **Onsite ponds and pits**--The practices currently in use depart slightly from the commitments stated in the EA. Prior to site preparation, the Gladys McCall site contained a pond filled with drilling mud from the well's original development. The contents of this pond were trucked offsite for disposal, and the ring levee was raised. The pond now contains spent mud from the drilling which deepened the well into the geopressured zone and from subsequent drilling of the present wells. Although this pond lacks an impervious liner, the muds which were used in well-drilling are reportedly nontoxic (Berning, 1982b) and will be removed when the well is completed or as part of site decommissioning. The pit used to collect spills from the drill site is also not lined with a synthetic liner. However, this pit is pumped soon after receiving any spilled materials (Berning, 1982b).

- **Storms**--At coastal sites such as this, the scheduling of project activities to avoid potential problems associated with major storms can conflict with project completion goals and funding constraints. During the August site visit, the construction rig for replacing the well casing was in place during the hurricane season. However, in the event of the threat of tropical storms, it is standard practice to remove any hazardous materials and portable equipment. If large drill rigs cannot be removed from the site, they are secured by lowering the derrick to a horizontal position (Berning, 1982b).

- **Environmental monitoring**--Although the EA stated that air quality would be monitored around the well site, none was performed (Van Sickle, 1982). This decision was based on the fact that air monitoring programs at the Dow and Sweet Lake sites detected few, if any, changes in air quality that could be attributed to well activity.

  Monitoring of surface water and groundwater quality was initiated in May and June 1981. As of August 1982, sampling was done on a monthly basis. Three surface-sampling stations and two wells for observation of groundwater were monitored within a 1 km radius of the site. Sampling to date has indicated seasonal variations and trends in water quality but no alteration of water quality that can be attributed to the test well (Bebout et al., 1982).

  Ecological parameters were used in a study of shoreline disappearance in the vicinity of the site before the commencement of testing. Beyond this and a baseline characterization of the site and surroundings, no ecological monitoring has been conducted, and no such monitoring is recommended. However, because of the ecological importance of the area and the proximity of the Rockefeller Wildlife Refuge, monitoring could become necessary if (1) results of water quality monitoring suggest that geopressure development could alter the local environment and damage marsh life, or (2) a blowout or other large spill should occur.

  Subsidence and microseismic activity have been monitored at and near the Gladys McCall site as for Dow and Sweet Lake; however, no firm conclusions have yet been drawn.

Pleasant Bayou

Tests conducted at the Pleasant Bayou geopressure well included flow rates, fluid composition, temperature, gas content, geologic characteristics, and the potential for subsidence due to subsequent fluid production (DOE, 1978). As a result of production problems with the first well at the site, a replacement well, Pleasant Bayou No. 2, was drilled on January 25, 1979 (DOE, 1979a) to 5,000 m (16,500 ft) (DOE, 1979b). Phase I production tests (short-term) were completed prior to June 1980 (C. K. Geoenergy, 1980). A series of problems with surface facilities and with the production tubing ensued; well No. 2 has been reworked to retrieve a portion of production lost downhole (C. K. Geoenergy, 1982; Blumhardt, 1982).

Verification of mitigation and monitoring commitments took place during a site visit conducted in August 1982. The following concerns were noted:

- **Site drainage**--The site is partly surrounded by the remnants of a former ring levee, and portions of the completed pad for well No. 2 drain offsite rather than into pits. As a result, some rainwater from the site drains offsite. Because of the cleanliness and otherwise effective construction of the site, such drainage does not constitute a problem. Erosion losses have been adequately mitigated because the pad is graveled and peripheral areas have been seeded. Similarly, the pad for well No. 1 has been leveled, access and work areas graveled, and the perimeter seeded.

- **Mud and reserve pits**--The mud and reserve pits are unlined and have not yet been filled, and hence no reinjection of liquid wastes has occurred. It was recommended that liquid wastes be reinjected or hauled to an approved disposal site and that solid residues be buried in the pits or hauled to an approved disposal site. The method chosen will depend on whether the pits remain in use as a part of further commercial development.

- **Flooding**--Although the possibility of flooding was not considered in the commitments, it was noted that the site is both within the 100-year floodplain and subject to flooding from a "standard project" hurricane. The area has been flooded ten times since 1939, including the flooding by Hurricane Carla in 1961 (DOE, 1978). It is possible that similar flooding in the future could result in damage to equipment and washing of stored liquid wastes to the surrounding areas. The need for completing a ring levee around the site was identified.

- **Environmental monitoring**--The air quality monitoring was adequate. Future data analysis should be done to characterize air quality during each phase of geopressure development at the site.

  The Bureau of Economic Geology, University of Texas, contracted Radian Corporation to conduct a baseline noise survey and to predict the impacts of geopressure development on background noise levels. The survey indicated that ambient day-night noise levels (L_{dn}) in the nearby Peterson's Landing area were between 40 and 50 dBA (Gustavson, 1979). To predict the noise impacts of geopressure development on the existing sound field, Radian measured sound levels from an operating drill rig of the same type that was planned for use at the Pleasant Bayou site. Next, mathematical techniques were used to simulate the attenuation of the drill rig noise with distance. The predicted sound levels from drilling operation were added to the baseline sound levels to produce a total sound level, which was then compared with criteria to determine if a significant impact would occur, whether mitigation measures would be needed, and how effective they would be in reducing the magnitude of the impact. The field survey conducted during drilling agreed with the modeling results by showing that noise from the drilling rig was masked by noise from the adjacent Monsanto plant and that implementation

of mitigation measures (i.e., proper rig orientation) achieved the desired result.

Monitoring of surface water and groundwater quality was initiated in March 1978; regular monthly sampling of both surface water and groundwater began in November 1978 at stations within a 1 km radius of the site. Sampling continued on a monthly basis until February 1982. Monitoring of shallow groundwater near the test well site indicated only minor influences from mixing with salt water. The sampling to date has indicated considerable variation in water quality but no alteration that can be attributed to the test well (Gustavson 1979 and 1982; Gustavson, Howard, and McGookey, 1980).

Baseline information on the ecology of the area was developed from field reconnaissance and existing literature; no further monitoring is needed except in the event of a blowout.

To detect subsidence, an initial leveling survey was conducted at the site and can be repeated following production testing (Boardman, 1980). Five microseismic stations were installed at Pleasant Bayou, permitting observation of fairly deep multiple microseismic events (Boardman, 1980). Microseismic monitoring should be continued at least until the completion of production testing.

ACKNOWLEDGEMENT

This paper is based on information contained in a report prepared by the Oak Ridge National Laboratory, Energy Division, Environmental Impact Section for the U.S. Department of Energy, Geothermal and Hydropower Technologies Division, Washington, D.C. Work was performed under Contract No. W-7405-eng-26, Union Carbide Corporation and the U.S. Department of Energy.

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