

March 19, 1970

L. Squires, Chairman
Midland Plant Subcommittee

MIDLAND PLANT, DRL MEETING ON THE SUBSIDENCE QUESTION

On March 12, 1970 Dr. James T. Wilson and I attended a meeting held by DRL with Consumers Power Company to discuss the potential problem of subsidence at the Midland Plant site. I have asked Dr. Wilson to provide us with a letter report of his opinion as to whether this is a real or paper problem. The meeting resulted in DRL asking for more information and the applicant agreeing to provide part of the information desired. DRL asked for some micro seismic measurements and the applicant objected to obtaining them since he could not see how they would be useful. It appeared that a general subsidence could occur but not an abrupt offset. Bechtel thought the plant could tolerate a tilt of 2 or more inches in 500 feet and general or regional subsidence would not be a problem. An abrupt offset or scarping could not be tolerated.

A copy of my notes is attached for your information. Copies are being provided to the other ACRS members for their information.

J. C. McKinley
Staff Assistant

Attachment:

Minutes of DRL Meeting on
Midland Plant, Bethesda,
Md., March 12, 1970

cc: ACRS Members w/attachment
ACRS Staff w/attachment
James T. Wilson W/attachment

DRL MEETING ON MIDLAND PLANT
HELD BETHESDA, MARYLAND
MARCH 12, 1970

Highlights

DRL (A. T. Cardone) is concerned that there may be a subsidence problem under the Midland Plant site. To help allay this concern DRL held this meeting to request additional information from the applicant, including:

1. Does the applicant have basic survey data to show that no subsidence has occurred to date and from which future subsidence may be measured? If so, the applicant should provide the survey data.
2. The applicant should make a literature search for subsidence history over mining operations of comparable depth. A bibliography of case histories should be compiled.
3. The applicant should provide structural property data for the various strata overlying the salt beds, including information on bedding, joining and fracturing.
4. The applicant should provide information regarding the amount of material removed from each cavity, the cavity size and configuration. There should be a statement regarding the interconnection or lack thereof of the various cavities and the basis for these conclusions.
5. The applicant should analyze potential subsidence based on a family of cavity configurations and on the interaction of adjacent cavities.
6. The applicant should consider the effects of seismic events on the cavities and the consequences at the ground surface.
7. The applicant should state the tolerable limits of subsidence, tilt and offset for this reactor plant design.
8. The applicant should state his intent regarding measures that could be taken to stabilize the salt formation in the vicinity of the cavities.
9. The applicant should consider the installation of instruments to detect movement in the rock strata (micro-seismic instruments and slope indicators).
10. The applicant should analyze the effect of draw down in the brine wells on the support of the overlying beds.
11. The applicant should obtain a statement of Dow's intent regarding future mining operations including possible mining of the potassium chloride beds that lie about 8,000 feet below the surface. The statement should include the location and extent of future mining operations.

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Dr. J. T. Wilson suggested that the applicant provide the equations and calculations used by Woodward-Clyde Associates in preparing their report on subsidence that was submitted as part of Amendment No. 7 to the PSAR.

The representative from Dow thought the detailed boring logs from one well would be representative of all of the wells since the site is located over a very uniform and flat geologic formation. He stated that Dow had set up a survey grid to measure any subsidence but had not observed any over the 11 years that they have been mining. The wells used for mining are cemented and cased to a depth of 3950 feet and have never required maintenance for anything other than corrosion. No casings in the entire region have failed due to rock movement above the salt beds. In response to a question of possible plastic flow of the salt beds, the Dow representative stated that a well had been drilled but not put into production for some time. After 120-130 days the bore was gauged and no change in diameter in the salt beds was observed; thus Dow does not believe that plastic flow of the beds will be observed. Plastic flow is expected to become appreciable below about 7500 feet.

Mr. Allen of Consumers Power suggested that the experts determine the size cavity the overlying rock can safely span and see if any of the mined cavities approach that size. If they don't then there is no problem and if they do then the effect of cavity collapse will have to be evaluated further.

The applicant believes that regional subsidence is not a problem because they do not believe it will occur and if it does occur it will cause no distress in the nuclear plant. Tilting of at least 2 inches in 500 feet can be tolerated. The applicant believes that the only situation that could raise a safety question would be the possibility of an offset (scarping) occurring under the plant. They believe the overlying geologic formations preclude such scarping.

The nearest salt well is No. 10 which is now sealed and capped, the next nearest is No. 17 which is in standby status and not being mined. The Dow representative said that No. 17 could possibly be abandoned. The cavity under No. 17 is believed to be about 600 feet in diameter while the one under No. 10 is believed to be considerably smaller.

Mr. Allen said that he expects strong intervention on the Midland Plant application and he hoped the AEC would not raise theoretical issues that would feed the intervenors without having any real significance to the protection of the health and safety of the public.

Mr. Allen and his consultants could not see any use for micro-seismic data or a statement that they did not intend to stabilize the cavities. Mr. Allen does not intend to reply to inquires in these areas.

DRL and the applicant agreed to meet again to discuss progress on this issue on March 25, 1970.

OFFICE ▶	Dr. Wilson obtained a copy of "Investigation of the Influence of Certain Variables on the Subsidence Above Mined Areas" prepared by Woodward-Clyde & Associates for the Solution Mining Research Institute. Copies of this report		
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have been sent to members of the Midland Subcommittee.

Attendees

ACRS
J. T. Wilson, Consultant
J. C. McKinley, Staff

DRL
F. Schroeder
D. Muller
P. Howe
J. Murphy
D. Nunn
A. T. Cardone
H. Waldron, Consultant (USGS)

Consumers Power Company
R. D. Allen
W. E. Kessler

Bechtel Corporation
P. A. Martinez
R. Gray, Consultant
E. Collesa

Dow Chemical
F. J. Maddox
R. Bolton

Meeting of AEC Personnel and Consultants

Mr. Muller described the purpose of the meeting as an attempt to define the status and scope of the problem of subsidence at the Midland site.

Dr. Wilson thought the primary problem was the applicant did not know the configuration of the solution cavities produced by the salt mining operations. He noted that there is very little published information on subsidence. He wanted some more information from the applicant regarding when mining started, spacing of the wells, if hydrofracturing was performed, the amount of salt recovery, and if channeling was thought to have occurred.

Mr. Waldron (USGS) felt that the more data available the better. He felt the applicant should assume a single large cavity rather than multiple small cavities. He was not so concerned with a gradual subsidence as with a sudden offset displacement. He also suggested the possibility of plastic flow of the salt beds at this depth (4300 feet). A tendency for plastic flow would reduce the possibility for offset type of subsidence. He knew of only one case of offset subsidence and that was at Windsor, Canada across the river from Detroit over some rather shallow solution mining cavities. Mr. Waldron suggested that Dow be required to cease and desist mining in the vicinity of the site. He could not at this time spell out what he would consider suitably conservative assumption.

Mr. Howe thought that the AEC should give the applicant some guidance in this area.

Dr. Wilson needed to know some of the basic assumptions such as; cavity shape, horizontal span, height, amount of material removed to date and future production plans. He pointed out that changing the cavity shape affects the type of subsidence seen on the surface (this also depends on the properties of the overlying strata). He suggested a series of calculations for various shaped cavities.

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Dr. Wilson considered the Woodward-Clyde & Associates report (submitted with Amendment No. 7) to be fairly credible but he wanted to see the calculations and equations used. He thought the assumption of a cylindrical cavity was conservative from a scarping effect but not adequate for other effects. He was not alarmed at the subsidence potential because of the depth of the cavities (over 4,000 feet down). He thought the survey data would be very important in identifying and measuring any subsidence that had or might occur.

Mr. Cardone listed the additional information he thought the applicant should provide. He agreed to obtain copies of a U. S. Bureau of Mines report "Methods and Equipment for Measuring Subsidence" by Louis A. Panek. His list of additional information included:

1. Subsidence survey data
2. Literature search for case histories
3. Structural properties of the overlying strata
4. Cavity shape and size
5. Additional instrumentation to detect movement in the rock (micro-seismic devices and slope indicators)
6. Radioactive tracer injected into one cavity and monitored in another
7. Dow's intent regarding potassium chloride beds 8,000 feet below the surface
8. Tolerable strain limits of the nuclear plant
9. Actions planned to stabilize the area
10. Seismic considerations

Meeting with Consumers' Power Company and Consultants

Mr. Waldron explained that he had started to write his report to DRL saying subsidence was not a problem but then realized that he could not defend that position for the lifetime of the plant. He felt that he needed more information to provide assurance of a safe design. He admonished the applicant to make the worst assumptions possible in performing the analysis.

Mr. Kessler asked if DRL had any evidence of a problem in areas with similar geologic formations? He asked if there was any data available and what approach would show their assumptions valid?

Mr. Allen pointed out that his organization was attempting to come to grips with this 11th hour problem. He wondered if it was a matter of the applicant substantiating his conclusions or if DRL had some evidence of a problem?

Mr. Muller assured him that DRL did not have any calculations that show subsidence will be a problem.

Mr. Waldron pointed out that Woodward-Clyde & Associates had assumed a cavity shape. He wanted the shape varied to see the effects, if any, on the ground surface and to determine which is the worst case. He asked the applicant to examine the production from each well and to predict the size and shape of the cavity.

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Mr. Holton (Dow) said that information had been provided to Woodward-Clyde as well as bore logs and data from one well to a depth of 4300 feet. He did not have as extensive data from other wells but did have good lithological logs and production data. He felt the detailed data from the one well was representative of the others because of the very uniform geological structure. He knew of no fractures or faults in the area. He pointed out that there are actually seven levels of salt interlayered with dolomite. Because of this he thought the cavities would be more nearly cylindrical than "morning glory" shaped. (The "morning glory" shape results from insolubles coating the salt surface and inhibiting dissolution).

Mr. Waldron noted that the Woodward-Clyde report ignored potential time effects (plastic flow) on the cavities. He felt that this should be considered since the plant has a potential life of around 50 years.

Mr. Holton said that plastic flow becomes appreciable at depths below about 7500 feet. Dow had drilled a well into this salt bed (4300 feet) and had not put it into production right away. About 120 days later they gauged the hole and found no reduction in diameter so they conclude there is no plastic flow.

Mr. Cardone suggested the cavities might have fingers extending in different directions and that flow might be significant in that case.

Mr. Holton thought fingering would improve cavity stability. He noted that he had assumed a 50 feet thick salt layer, 50% dissolution leaving a cavity 25 to 30 feet high. He also pointed out that Dow removes only about 10% of the salt from a given field and that 90% is left in place.

Mr. Cardone questioned interaction of adjacent cavities on the potential for subsidence.

Mr. Holton stated that Dow knew which cavities were interconnected and which were not. The two nearest the site were not. He based this statement on the ability to pressurize either cavity to 1000 psi and not detect any flow into any other cavity.

Dr. Wilson pointed out the concern for scarping or an abrupt offset of the ground surface. He noted that a thin cavity was less likely to cause a scarp than a thick cavity.

Mr. Holton replied that they had calculated the cavity would have a diameter of about 636 feet. For analysis purposes they then doubled the diameter. He noted that in theory if one removed one cubic yard of material from any depth you would eventually see some effect at the ground surface but in practice it was often difficult or impossible to see.

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 Dr. Wilson thought the worst cavity shape would be a long tapered span with a
 subhigh vertical wall at one end. He felt that this configuration had the highest
 potential for producing a scarp. He asked if Dow had tried hydrofracturing to
 improve production.

but had

Mr. Holton said they had been unsuccessful in obtaining interconnections. He said that he had some additional background information on the Dow wells that had not been included in the Woodward-Clyde report. He challenged the theory that cavity collapse would be seen on the surface and pointed out the bulking effect of fragmenting rock. This bulking would soon fill the cavity.

Dr. Wilson expressed his desire to see the Woodward-Clyde calculations and assumptions.

Mr. Cardone noted that Woodward-Clyde had made a finite plastic analysis without considering bedding or joining effects of the overlying strata.

Mr. Holton said that the rock properties had been obtained from one set of cores and sonic logging of several bore holes.

Dr. Wilson thought that agreement could be reached on the properties of the overlying rock formations.

Mr. Allen thought that an analysis should be made to see how large a cavity the rock would span and compare this with the conservatively estimated cavity sizes.

Mr. Maddox noted that surface subsidence has never been noted where solution mining has been conducted at depths greater than 2500 feet. He pointed out that Dow has 11 years of experience at this site and has not observed any subsidence even at the top of the well casings. ~~There is no evidence of subsidence.~~

Mr. Cardone thought that there may be a hydraulic connection between the salt beds and an underlying brine strata 5000-5300 feet below the ground surface. The brine occurs in a sandstone formation. The current static pressure in this layer causes the brine to rise to within 1000 feet of the surface in the brine wells. Mr. Cardone wanted to know the effects of pumping this brine and reducing the static pressure supporting the overlying formations.

The applicant stated that he did not believe regional subsidence would pose a safety question. The problems arise if offset occurs. The worst offset described in the Woodward-Clyde report amounts to about 0.06 inch, even ten times that amount would not cause distress in the nuclear plant. The interaction and inter-connection of cavities might result in subsidence of about 0.15 inch over a mile area.

Mr. Allen did not want to expand on the Woodward-Clyde report since it was prepared for Dow and not the applicant. He wanted Bechtel to do an independent analysis and to arrive at an independent conclusion. He does not believe that regional subsidence is the issue. The applicant will submit information on the plant's ability to withstand tilt; it cannot withstand a sharp offset which he does not believe will occur.

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Midland Meeting

Mr. Cardone reviewed his list of additional pieces of information that DEL would like to have submitted.

The applicant could see no use for the data obtained from the micro-seismic instruments. Mr. Allen said that the applicant does not intend to take any measures to stabilize the salt formations. There are many things the applicant does not intend to do and he could see no value in listing them. Mr. Allen stated his intent to show that the plant is adequately safe and that he will submit additional supporting information but will not conduct the micro-seismic studies or state what he will not do.

Dr. Wilson was interested in the well casing maintenance history as an indication of rock movement.

Mr. Holton said that the wells were cased and cemented to a depth of 3950 feet and that there were no cases of casing failures in the entire region.

Mr. Allen said that the applicant expects strong opposition to the Midland Plant and asked the AEC not to raise paper issues that feed an intervenor but to be sure the issues raised are truly relevant to the health and safety of the public.

The applicant and DRL agreed to have another meeting on March 25, 1970. (This meeting was subsequently postponed to an unspecified date).

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Project: Midland Plant

Status: Construction Permit - first of two scheduled ACRS meetings, no letter at this meeting

Background: November 7, 1968, Volumes I & II of PSAR received
 January 10, 1969, Preliminary DRL report received
 January 13, 1969, Application formally filed
 January 22, 1969, Site visit and Subcommittee meeting
 January 23, 1969, DRL site report received
 February 4, 1969, Subcommittee meeting
 February 6-8, 1969, ACRS meeting on site related issues
 March 6, 1970, DRL report received
 March 24, 1970, Subcommittee meeting

The Midland Plant Units 1 and 2 are two loop (4 pumps) Babcock and Wilcox PWRs with design power levels of 2432 MWt. The plant is owned and will be operated by Consumers Power Company with the Bechtel Corporation as the A-E. The reactors are similar to the units provided for the Rancho Seco, Arkansas Nuclear One, and Three Mile Island plants.

A unique feature of the Midland Plant is the intent to supply approximately 4,050,000 lb/hr of process steam to the adjacent Dow Chemical Company plant.

The Committee made a preliminary site review in February 1969 and concluded at that:

"The Committee considers the site proposed to be unacceptable for use with reactor plants designed and analyzed as presently described in the PSAR. However, it believes that the site may be acceptable for use with reactor plants of the proposed power rating if: (1) The facility is equipped with adequate engineered safety features and protective systems; (2) the facility is analyzed sufficiently conservatively - particularly in respect to: determination of exclusion area and low population zone; assurance of low potential doses at short distances from the reactor in the unlikely event of a serious accident; evaluation of the number and location of people who could be safely and quickly evacuated in such an event; and, use of assumptions, for example those related to meteorology, in dose calculations; (3) the facility is designed, constructed, and utilized sufficiently conservatively; and (4) the facility is provided with thoroughly structured, effective emergency plans, including evacuation plans."

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DRL Review

DRL has concluded that the plant can be built without undue risk to the health and safety of the public if the following issues can be satisfactorily resolved.

- 1) potential for surface subsidence
- 2) stability of plant fill slopes
- 3) flood protection
- 4) meteorological monitoring program
- 5) control room protection against exterior hazards
- 6) vibration testing
- 7) cooling pond dike design
- 8) diversity in ECCS initiation signals
- 9) pressurizer high level alarm design
- 10) control room shielding
- 11) monitoring of process steam
- 12) coping with hydrogen

Subcommittee Review

At the March 24, 1970 Subcommittee meeting and in subsequent discussions the following topics were identified for discussion at the April ACRS meeting.

- 1) Radioactivity in the process steam exported to Dow.
- 2) The differences in the Midland Plant and the Indian Point/Zion plants including:
 - a. distance vs dose calculations
 - b. pressure vessel cavity design basis
 - c. post loss of cooling accident protection (FLOCAP)
- 3) Instrumentation and control systems and components.
- 4) Protection of the control room from the release of external toxic materials (chlorine from Dow).
- 5) Coping with hydrogen following a DBA.

The following topics were identified for discussion at the May ACRS meeting.

- 1) Failure to scram following anticipated transients
- 2) Seismic design
- 3) Subsidence
- 4) Emergency plans
- 5) Flood level

Another Subcommittee meeting is planned in April, prior to the May ACRS meeting.

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Excerpt fm 120th ACRS Meeting

Meeting with Director of Regulation (re MIDLAND)

3. 10 CFR Part 20 and Part 50 (Control of radwaste effluents to levels "as low as practicable"). - Mr. Price stated that the latest draft revision of Parts 20 and 50 (draft dated March 3, 1970) has been published for comment. This proposed revision requires that radwaste effluents from licensed facilities be held to values as "low-as-practicable." Applications for water reactors would have to describe the facilities, procedures, etc., to be provided to accomplish this. The basic limits of 10 CFR Part 20 remain unchanged. A press conference was held, and the subject was covered by the press in a "mixed" fashion.

A discussion was held of the implementation of "low-as-practicable" for Midland and for new applications for construction.

Mr. Price stated that, in the case of the Midland plant, Dow would have to obtain a materials license if the radioactivity in the steam was not below the "exempt" limit. Since the steam being exported to Dow is not actually being released to the environment, it is not clear that Part 20 limits or levels "as low-as-practicable" are applicable.

Mr. Price noted that the proposed revision of Part 20 is being used by the Staff for interim guidance in the spirit of the Commission's statement to minimize releases from water reactors. For example, the Tech. Specs. for the Monticello plant require plant operation to hold releases "as low-as-practicable".

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