BW - 6

SUBSIDENCE MONITORING REPORTS

DATE: 2008 - Present

Chavez, Carl J, EMNRD

From: Lisa Rice [lisa@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:15 AM
To: Chavez, Carl J, EMNRD
Subject: FW: kevin
Attachments: p3.tif; p1.tif; p2.tif; kevin.doc

From: Shallon Finkbone [mailto:shallon@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:02 AM
To: lisa@iandwinc.com
Subject: kevin

MR. Chavez: Here is some information on the subsidence monitoring on the Eugenie #1 for I & W, Inc. If you have any questions please contact me at lisa@iandwinc.com

Thank you for your time
Lisa Rice and Kevin Wilson

SURVEY
FIELD EQUIPMENT USED

One GPS unit was employed in the establishment of the state plane coordinates and geodetic coordinates of benchmarks and injection wells requested to be located.

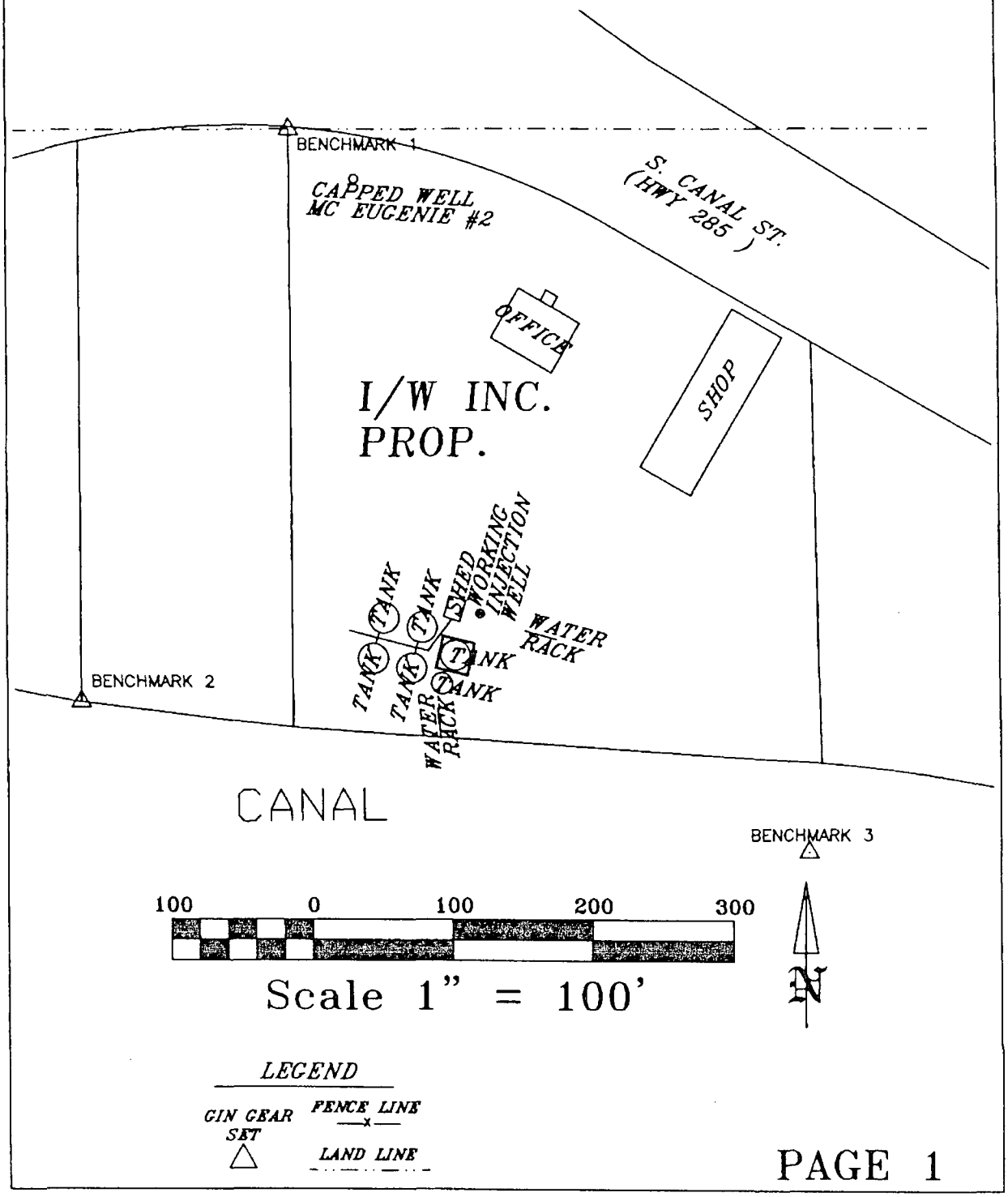
Unit 2 was a Topcon GPS HIPER+.

Receiver type: GGD GPS/GLONASS L1/L2.
Tracked signals: L1/L2, AND C/A, and P code and carrier, waas/egnds.
Survey mode: RTK.
Accuracy: H: 10mm + 1.0ppm x base line length.
V: 15mm + 1.0ppm x base line length.

Known government benchmarks in the near area to the project site were used to find the elevations of the wells and benchmarks requested.

EXHIBIT A

WELL AND BENCHMARK LOCATION FOR I/W INC. FOR PURPOSES OF MONITORING GROUND SUBSIDENCE



GEODETIC, NEW MEXICO EAST, AND ELEVATIONAL COORDINATES OF 3 BENCHMARKS AND 2 WELLS LOCATED ON THE I/W INC. PROPERTY.

BENCHMARK 1
LAT:32° 23' 20.6723"N
LONG:104° 13' 06.8066"W
ELEV: 3129.47'
N: 505293.551
E: 576763.208
DESCRIPTION: HWY R.O.W. R.R. IRON AT NORTHWEST CORNER OF PROPERTY

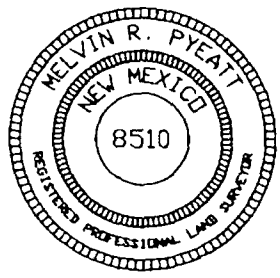
BENCHMARK 2
LAT: 32° 23' 16.6302"N
LONG: 104° 13' 08.5407"W
ELEV: 3130.49'
N: 504884.949
E: 576614.957
DESCRIPTION: R.R. IRON AT THE SOUTHWEST CORNER OF WEST ADJOINING PROPERTY

BENCHMARK 3
LAT: 32° 23' 15.5749"N
LONG: 104° 13' 02.5117"W
ELEV: 3131.73'
N: 504778.860
E: 577131.990
DESCRIPTION: PK NAIL SET IN A CONCRETE SLAB IN THE NORTH DRIVING LANE ON THE C.I.D. CANAL

CAPPED INJECTION WELL
LAT: 32° 23' 20.3236"N
LONG: 104° 13' 06.2666"W
ELEV: 3128.89'
N: 505258.357
E: 576809.542
DESCRIPTION: LOCATION WAS TAKEN ON THE SOUTHEASTERLY SIDE, ON THE GROUND, OF THE STAND PIPE

WORKING INJECTION WELL
LAT: 32° 23' 17.2503"N
LONG: 104° 13' 05.2321"W
ELEV: 3131.13'
N: 504947.906
E: 576898.570
DESCRIPTION: LOCATION IS ON THE EASTERLY FLANGE ON THE OUTSIDE CASING OF WELL

THE GEODECTIC COORDINATES LISTED HERE ARE WGS 1984, THE ELEVATIONS LISTED ARE NAVD 1988, THE STATE PLANE COORDINATES LISTED ARE NEW MEXICO EAST COORDINATES. THE GEODECTIC COORDINATES WERE OBTAINED ON MAY 9, 2008.



5/14/2008

May 27, 2008

Dear Mr. Chavez,

Sorry for the delay in the startup on the I&W Eugenie #1(BW-006) subsidence monitoring project. The original surveyor, Mr. Dan R. Reddy, Consultant and Engineering Company, had numerous delays that were health related. Mr. Reddy finally informed us that they were considering retirement. At that point I&W contacted Mr. Melvin R. Pyeatt's Surveying Firm and started our project again. Enclosed you will find I&W's initial startup for the subsidence monitoring project on the Eugenie #1 (BW-006).

Sincerely,

Kevin Wilson
Operations Manager

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Friday, February 29, 2008 2:49 PM
To: 'Lisa Rice'; 'iwcarlsbad@plateautel.net'
Cc: Price, Wayne, EMNRD; Jones, William V., EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: BW-6 Subsidence Monitor Eugenie #1 & 2 I & W, Inc.
Attachments: KS Subsid Monitor Case.tif; Monument Construction Examples 2-29-08.tif

Dear Ms. Rice, Mr. Wilson, et. al:

Good afternoon. The New Mexico Oil Conservation Division (OCD) has reviewed I & W's "Subsidence Monitor Eugenie #1 I&W Inc. proposal or report (report). The OCD is in the process of finalizing the discharge permit renewal for BW-6, which includes Items pertaining to subsidence monitoring listed below.

20 B. Subsidence Monitoring System: I&W, Inc. shall submit for long-term subsidence, a report displaying all subsidence monitoring stations and monitoring completed to date to address the requirements of the prior discharge plan by June 30, 2008. The report shall summarize and include subsidence tables and graphs to 0.01 ft. A map shall depict the facility and monitoring points to scale with verification of certified surveyor geodetic datums or elevations are properly recorded. The report shall propose a schedule for long-term surveying to ensure public safety subsidence/collapse issues are addressed due to the shallow nature of the brine cavity. The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public.

21. F. Capacity/ Cavity Configuration and Subsidence Survey: The operator shall provide information on the size and extent of the solution cavern and geologic/engineering data demonstrating that continued brine extraction will not cause surface subsidence, collapse or damage to property, or become a threat to public health and the environment. This information shall be supplied in each annual report. OCD may require the operator to perform additional well surveys, test, and install subsidence monitoring in order to demonstrate the integrity of the system. If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery.***

The OCD may approve the report with the following major conditions:

1) A map to scale is required with the survey monument points and nearest geodetic survey point depicted.

2) A USGS or DOT Geodetic Survey Elevation Point closest to the facility must be surveyed in with the rest of the approved monument points to establish an accurate survey for the facility subsidence monitoring program.

3) The number of markers or monuments in the report is not sufficient to address subsidence monitoring concerns at the facility. The OCD has attached a "Monument Construction Examples 2-29-08" file to illustrate acceptable monument construction options for the facility subsidence monitoring program. The OCD requires elevation monitoring at 1 nearby USGS or USDOT geodetic elevation monitoring datum; 4 monument datum locations; 2 top-of-casings (Eugenie #1 & 2) and associated ground elevations for public safety. The locations are as follows: 4 monuments or markers positioned at the four corners of the property (please refer to your map provided to the OCD); the nearby geodetic survey datum mentioned in Item # 2 above and the top-of-casings and associated ground elevations at the Eugenie Wells #1 & 2.

4) Survey monuments or markers are to be surveyed to the nearest 0.01 foot consistent with standard piezometer or monitor well top-of-casing and ground elevation surveying. The surveying shall be conducted biannually in July and January of each year for at least 2 years with an opportunity for more frequent or less frequent monitoring justified or based on the facility subsidence monitoring program data results and annual report.

5) An annual report illustrating the facility map to scale with monument or marker locations and subsidence tables and graphs with elevation data to the nearest 0.01 foot. The OCD has attached a US DOI report entitled, "Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS" (1986). A simple table and graph depicting each monument location elevation over time will satisfy this provision.

6) The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public.

7) In accordance with the discharge permit, "If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery.***"

8) The OCD is very concerned about the shallow depth of BW-6 (~ 600 ft. below ground surface) brine production and adjacent and nearby surface infrastructures (i.e., roadways, businesses, traffic, etc.) and population near to BW-6. Consequently, the OCD recommends that I & W increase the depth of its operations in the salt to facilitate a more structurally sound brine production operation and to minimize subsidence in the area.

Please contact me within 14 days of receipt of this provisional approval to discuss I & W's intent to meet the monument or marker install requirements with map to scale by June 30, 2008. The first survey should begin in July of 2008 as stated above. Thank you.

Please be advised that NMOCD provisional approval of this report does not relieve I & W Inc.of responsibility should their operations fail to adequately investigate and remediate contamination that pose a threat to ground water, surface water, human health or the environment. In addition, NMOCD approval does not relieve I & W of responsibility for compliance with any other federal, state, or local laws and/or regulations.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Lisa Rice [mailto:lisa@iandwinc.com]
Sent: Monday, February 11, 2008 11:53 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitor Eugenie #1 I & W, Inc.

Mr. Chavez:

In regards to the subsidence monitoring at I & W' S Eugenie #1 (BW 006) facility. The resurfacing work at our yard & brine station should be completed this week (2/15/08). I have included a site map for your review. The cavern is less than 80 feet in any direction from the well head. The three marked points are the proposed monitors that are in line of sight & the greatest distance from the well on I & W' s property.

The three markers will be constructed out of 3" pipe. The top of the pipe will be capped and a designated point will be marked for consistent monitoring. The pipe will be placed in a 12" hole approximately 4 feet deep with cement up to ground level. Approximately 1 foot will be above ground for our surveyor to use as a monitoring point.

If this sounds okay to you, we will go ahead and set the three monitors & let the cement be setting up. The surveyor / engineer will be ready to establish initial readings as soon as we contact him. Please let me know if this will be acceptable and we will get started.

Sincerely,
Kevin Wilson
Operations Manager

IC 9083

Bureau of Mines Information Circular/1986

Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS

By Robert C. Dyni

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 9083

Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS

By Robert C. Dyni

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald Paul Hodel, Secretary

BUREAU OF MINES
Robert C. Horton, Director

This report is based upon work done under an agreement between the Solution Mining

SUBSIDENCE INVESTIGATIONS OVER SALT-SOLUTION MINES, HUTCHINSON, KS

By Robert C. Dynl[1]

ABSTRACT

The Bureau of Mines in cooperation with the Solution Mining Research Institute conducted surface and subsurface investigations over five solution-mined salt cavities in the Hutchinson, KS, area. The purpose of these investigations was to determine the mechanisms that lead to the formation of sinkholes above collapsed solution cavities. Of the five salt-solution cavities investigated, four had collapsed and produced sinkholes prior to the time of the investigations; the fifth cavity was considered stable. Exploratory drilling and coring operations were conducted at all five sites; surface stability monitoring was conducted at three of them. The results of these studies indicate that excessive dissolution at the salt-shale contact of each collapsed cavity produced large, unsupported roof spans that ultimately exceeded the structural integrity of the overburden. The stable cavity was not exposed to excessive dissolution at the salt-shale contact; this limited the roof span and ensured a stable cavity. The data also show that surface settlement in the vicinity of the two surface-monitored sinkholes continued for approximately 7 years after the sinkholes formed, indicating that the rubble piles of the collapsed cavities were undergoing gradual consolidation.

[1]Physicist, Denver Research Center, Bureau of Mines, Denver, CO.

upper shale surface, then the roof will start receiving support by the rubble and the bulking process will be stopped (fig. 2*A*). A shallow sinkhole may develop as a result of the downward deflection of the shale roof and the consolidation of the rubble pile even though the bulking process has been halted (fig. 2*B*). If, however, the distance between the top of the cavity and the top of the rubble pile does not become zero before the roof reaches the upper shale layers, then a chimney forms and propagates through the upper shale layers to the unconsolidated soils near the surface. This material then flows down into the remaining void and can create a deep sinkhole (fig. 2*C*).

A trigger mechanism that reduces critical support from a marginally stable roof can consist of a reduction of brine pressure inside the cavity, a reduction of the buoyancy effect on shale fragments suspended from the roof of the cavity, or the removal of critical roof support by continuing salt dissolution. Hendron (4) indicates that these conditions most likely are interrelated and act simultaneously to initiate the failure of a cavity roof.

If all four conditions for rapid sinkhole development are met, a deep sinkhole as shown in figure 2*C* will most likely be the result. If, however, only a large unsupported roof span at the salt-shale contact and triggering mechanisms are present, shallow sinkholes as shown in figure 2*B* can possibly form. Shallow sinkholes do not develop as rapidly as deep sinkholes, and their dimensions may increase with time. As mentioned earlier, the bulking process in shallow sinkholes does not progress up to the ground surface, and no chimney is formed in the shale layers. If only the first condition is met, the unsupported shale layers above the cavity will tend to deflect down into the opening, producing subsidence on the ground surface. This subsidence develops gradually over a long period and affects a large surface area over the cavity (4, pp. 3-4). Further analysis on sinkhole failure mechanisms is provided by Hendron (4).

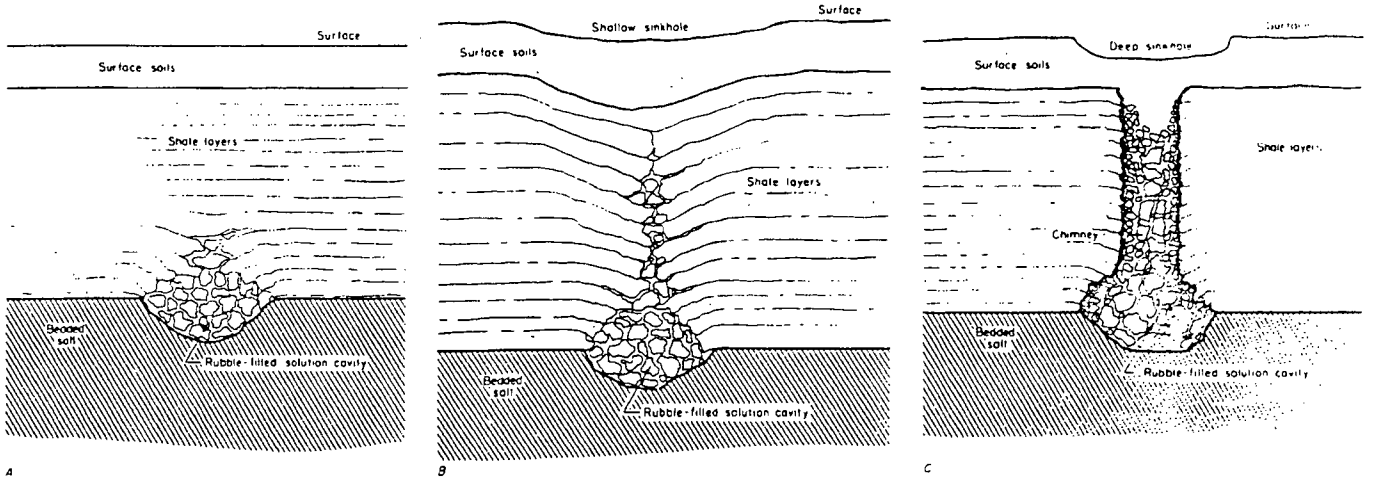


FIGURE 2.—Cavity collapse with surface deformations.

boring V-3. The inclined boreholes I-1 and I-2 were each about 260 ft in depth. Complete details on the drilling and coring procedures are given by Hendron (1, pp. 1-2).

Borings V-3 and V-4 each encountered the top of the salt deposit at a depth of approximately 420 ft. These borings found no evidence of any surface sands from the sinkhole, or any voids or disturbances in the strata overlying the salt. Borings V-1 and V-2, however, both found evidence of voids and disturbances in the shale at depths of approximately 240 to 245 ft, and boring V-1 also found a large void and surface sands from the sinkhole at a depth of about 388 ft. These findings indicate that an elongated cavity had developed in the northeast-southwest direction under the sinkhole, caused by the solution activity of the neighboring brine wells. The evidence also suggests that the roof shale over the salt had caved upward about 30 ft at the location of boring V-1, and that some large block movements of the shale had extended as much as 180 ft into the shale above the elongated cavity (1, pp. 7-8). Walters (6, p. 45) suggests that the configuration of the elongated cavity exceeded the span capabilities of the overlying rock layers. This allowed the failure of these layers to breach the uppermost shale layer and permit approximately 90,000 yd^3 of sand and gravel to move down into the opening (2, p. 2). The sand that was encountered in the inclined borings I-1 and I-2 indicates that an approximately 100-ft-diam chimney of sand was located below the center of the sinkhole. The sinkhole and the chimney both were elongated in the northeast-southwest direction, indicating that the influence of the underlying cavity elongated along the line of brine wells in the area (1, p. 8). Figure 5 shows

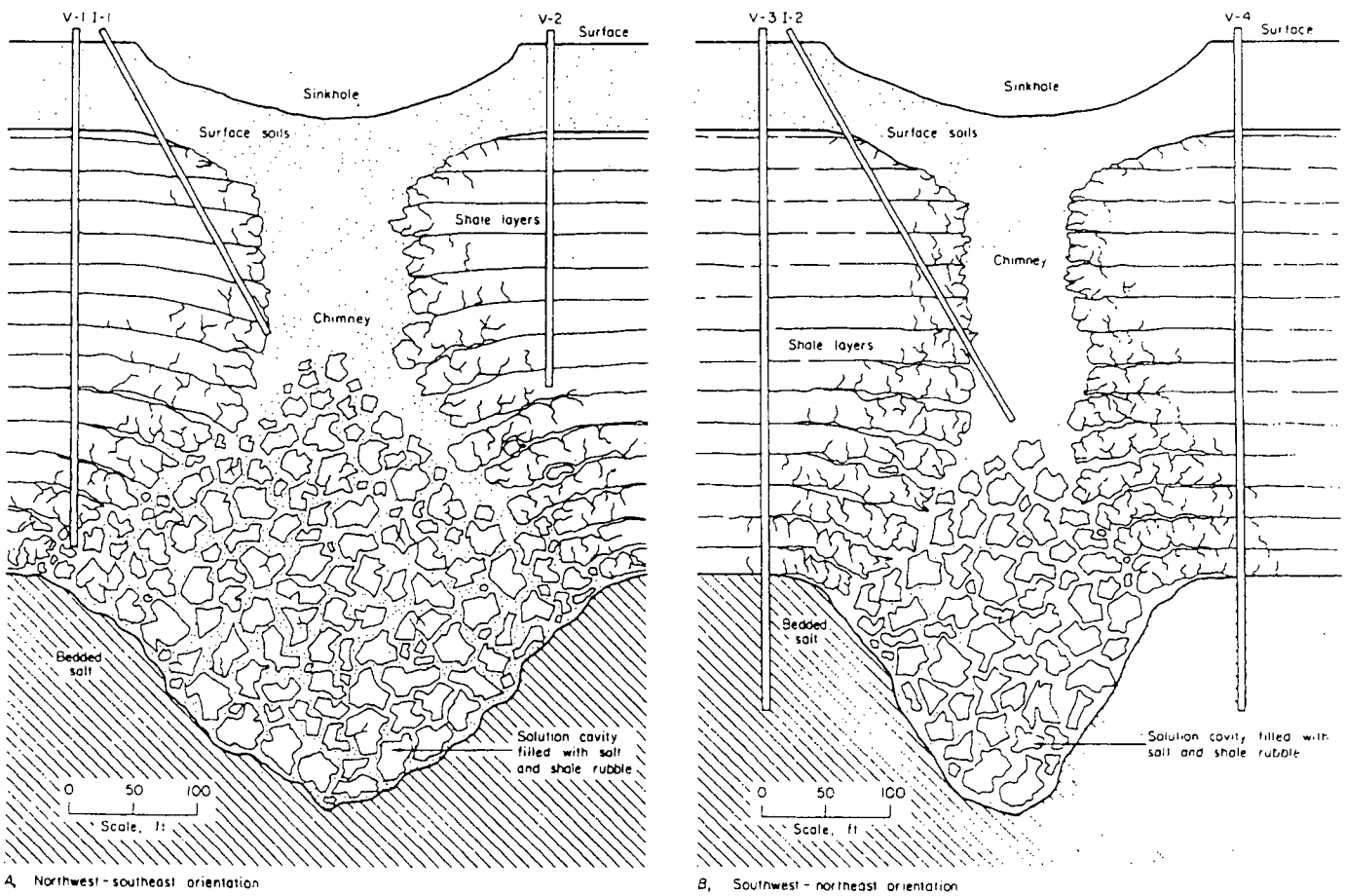


FIGURE 5.—Cross sections of Cargill sinkhole.

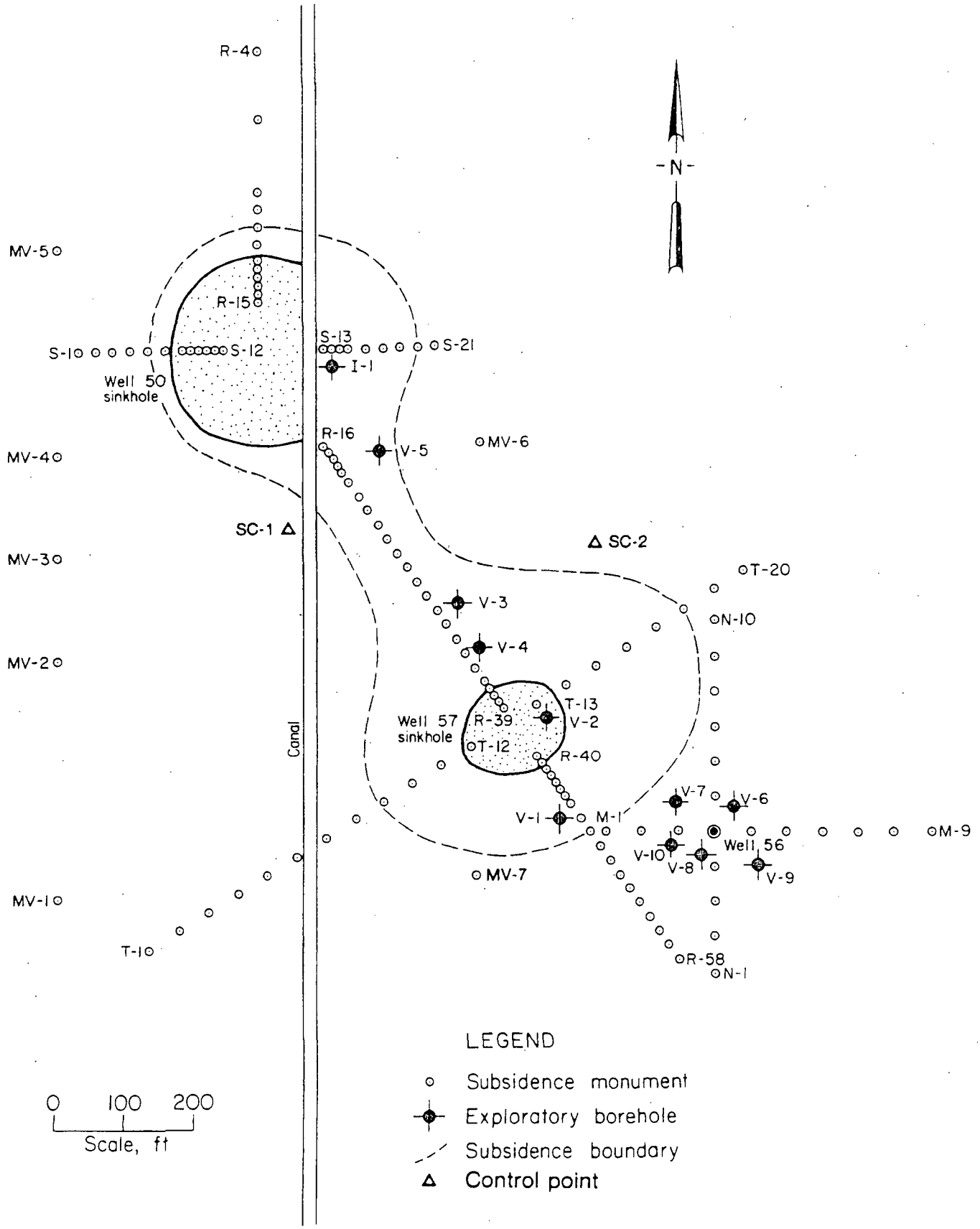


FIGURE 9.—Location of boreholes and subsidence monuments at Carey brinefield.

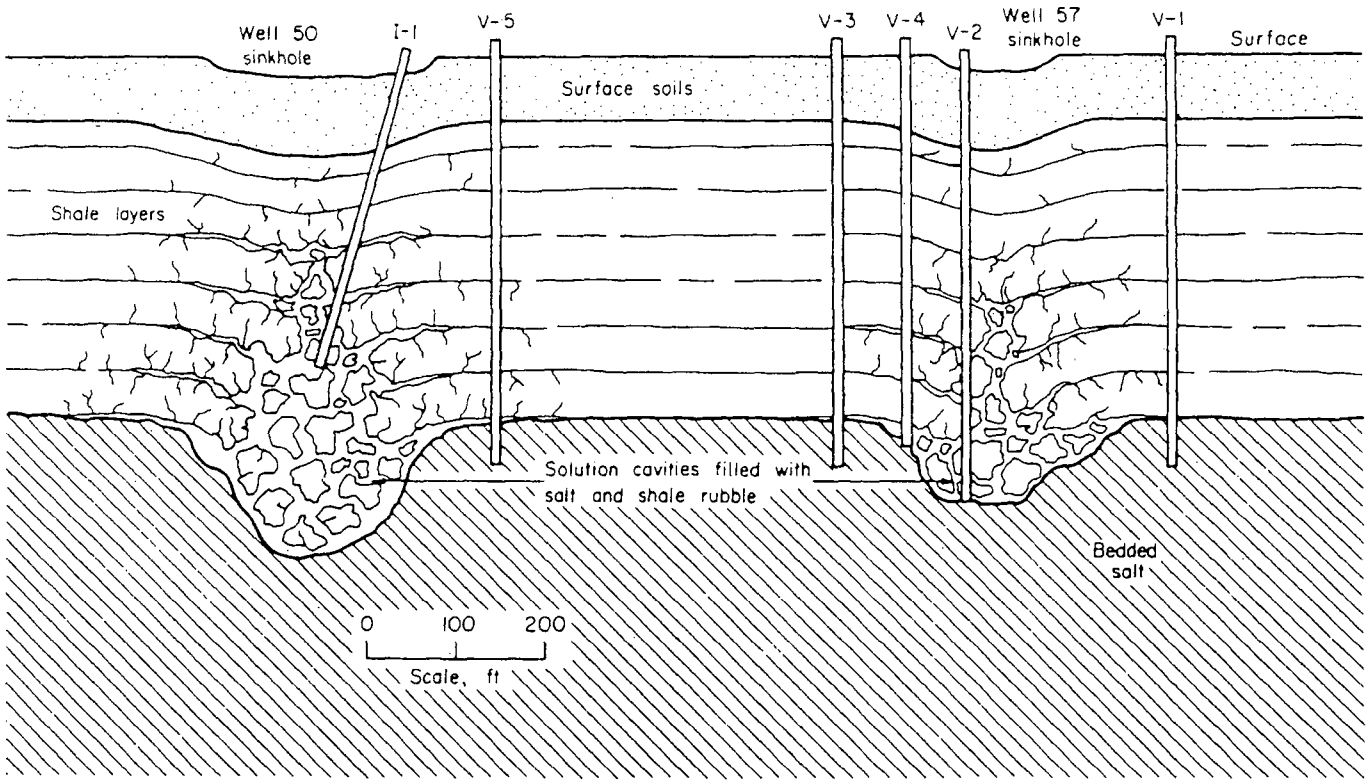
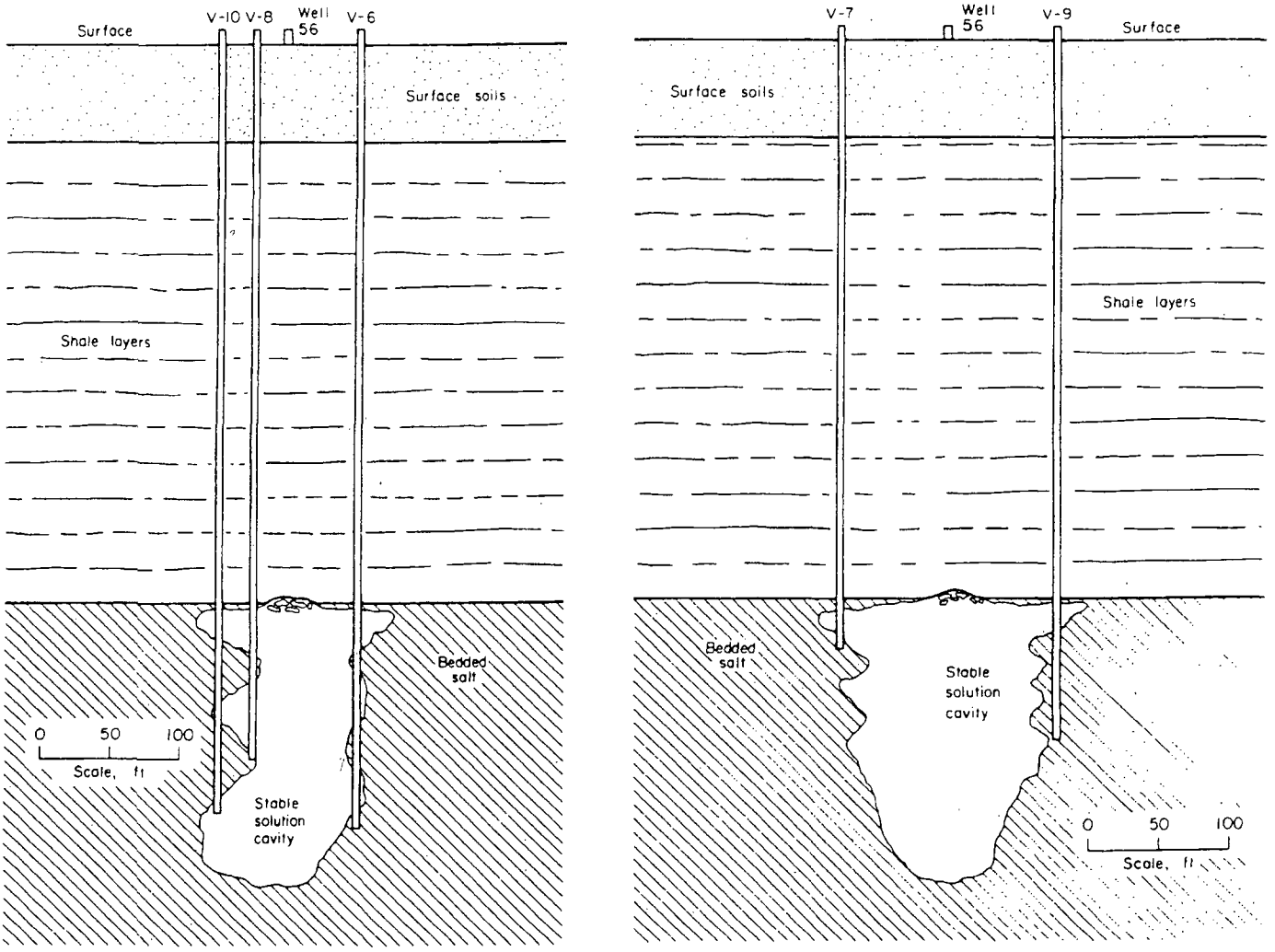


FIGURE 10.—Cross section of Carey sinkholes.

the cavity was in some stage of progressive failure, or if the cavity was presently stable but likely to fail in the future.

The investigation consisted of drilling and coring five (V-6 to V-10) exploratory borings and extending the subsidence-monitoring network to the area around well 56 (fig. 9). The Bureau was responsible for extending and monitoring the network, and SMRI was responsible for supervising the drilling and coring operations funded by the Bureau. Boring V-6 was advanced to a depth of 565 ft, boring V-7 to 436.5 ft, boring V-8 to 515 ft, boring V-9 to 502.5 ft, and boring V-10 to 552.5 ft (2, pp. 8-9). Details on the drilling and coring procedures are given by Hendron (2, pp. 8-9).

The drilling and coring results indicated the shale overlying the solution cavity was intact and undisturbed to within several feet of the salt-shale contact (fig. 11). Near the roof, the shale had softened and undergone bed separations. The cavity appeared to be elongated in the southeast-northwest direction with a roof span of about 150 ft. In the southwest-northeast direction, the roof span was estimated to be approximately 50 ft. The restricted roof span dimensions near the shale were most likely due to the fact that well 56 had been operated by pumping fresh water down the tubing that extended close to the bottom of the salt deposit. This resulted in most of the solutioning occurring deep in the salt and away from the overlying shale. The borings also indicated that there was only a limited amount of shale exposed in the roof of the cavity that was subjected to deterioration by fresh water (2, pp. 37-39). Hendron (2, p. 39) suggests that the limited exposure of the shale to the deteriorating action of fresh water beneath the well in combination with the limited roof spans over the cavity led to a stronger roof support and a stable cavity.



A, Northwest - southeast orientation

B, Southwest - northeast orientation

FIGURE 11.—Cross section of Carey well 56.

BUREAU OF MINES SURFACE SUBSIDENCE INVESTIGATIONS

FIRST AND SECOND INVESTIGATIONS

The investigations carried out at the Barton and Cargill sinkholes did not include surface monitoring programs.

CAREY 1978 SINKHOLES (THIRD INVESTIGATION)

Background

In 1979 the Bureau installed a subsidence-monitoring network around wells 50 and 57 in the Carey brinefield. A total of 154 survey points were used to monitor the horizontal and vertical ground surface movements in the vicinity of the two sinkholes. The network consisted of 1 existing control point, 4 Bureau-installed control points, 103 Bureau-installed subsidence monuments, 10 Carey-installed subsidence monuments, and survey marks set on the 6 exploratory borings and on 30 brine wells.

Subsidence-Monitoring Network Design and Construction

The network (fig. 9) was designed to monitor any positional changes of the ground surface associated with the two sinkholes around wells 50 and 57, as well as in other areas of the brinefield. The S-line (S-1 to S-21) and a portion of the

R-line (R-4 to R-15) subsidence monuments were positioned in the area around the well 50 sinkhole. These two monument lines intersected at right angles near the center of the well 50 sinkhole. The T-line (T-1 to T-20) and the remainder of the R-line (R-16 to R-58) monuments were positioned in the area around the well 57 sinkhole. These two monument lines intersected at right angles near the center of the well 57 sinkhole. The monuments R-16 to R-58 were also designed to monitor the area between the two sinkholes and were therefore oriented along the axis between the two sinkhole centers. The MV-line monuments were distributed throughout the area around the sinkholes to monitor any ground surface movements due to neighboring wells. The remainder of the survey points, including the wells, boreholes, and previously installed survey movements, were used to monitor movements of the ground surface over a large area around the two sinkholes. Control points P-1, P-2, and P-3 were placed in areas that were considered to be stable and not affected by solution mining activities; these control points were located in areas outside the area shown in figure 9. Control points SC-1 and SC-2 were located in the brinefield for the trilateration surveys and were checked for stability prior to each survey.

The 4 control points and the 103 monuments installed by the Bureau at the Carey brinefield were all of the same design and construction (fig. 12). The monument consists of a small inner pipe fitted with a pointed anchor on the bottom and a reference-marked cap on the top, and a large outer pipe which is used to drive the anchor below frost depth. The inner pipe extends through a cap on top of the outer pipe. The outer pipe is free to undergo movements due to frost heave or swelling and shrinking soils without affecting the inner pipe on which measurements are made. The monuments proved to be very stable and effectively guarded against soil distances throughout the entire time of the investigation.

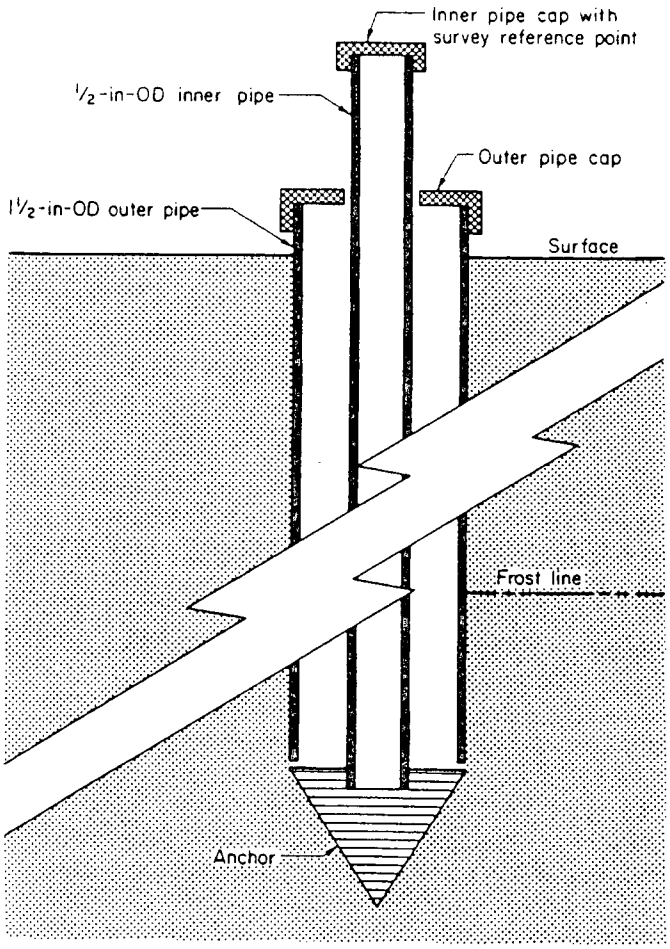


FIGURE 12.—Detail of Bureau-designed subsidence monument.

The wells, boreholes, and structures that were used as subsidence monuments all had survey marks that provided consistent reference points.

Monitoring Procedures

The procedures used to monitor positional changes in the network involved various survey techniques. Trialteration and traverse surveying procedures were used for horizontal control, and trigonometric and differential leveling procedures for vertical control. The horizontal control surveys, as well as the trigonometric level surveys, established initial and subsequent coordinates and elevations by measuring angles and distances from control points SC-1 and SC-2

to the monuments in the network. Although SC-1 and SC-2 were located within the brinefield boundaries, their stability was verified before each survey by using trilateration and differential leveling procedures from control points P-1, P-2, and P-3, which were located on stable ground away from the brinefield. The Bureau began surveying the network in June 1979 and continued through February 1983. A total of 17 vertical and 12 horizontal control surveys were performed.

Results--Vertical Movement

The results from the vertical control surveys indicated that both sinkholes experienced vertical settlements between June 1979 and February 1983. Appendix A contains data from the final vertical control survey of the Carey brinefield; these data were used to calculate the maximum vertical displacements of the subsidence monuments.

Data from the R-line indicated that vertical settlements occurred between monuments R-7 and R-50. From R-4 to R-15 (fig. 13) the settlements increased linearly, starting at monument R-8 and continuing toward the well 50 sinkhole. The maximum vertical settlement measured was 1.58±0.04 ft at R-15. From R-16 to R-39 (fig. 14) the subsidence was concentrated in the vicinity of the two sinkholes, with less movement at the midpoint between sinkholes. Vertical settlement in the area around R-16 was 0.18±0.04 ft; settlement in the area around the midpoint between sinkholes (R-26) was 0.09±0.04 ft; and settlement in the area around R-39 was 0.24±0.04 ft. Data from R-40 to R-58 (fig. 15) showed that the

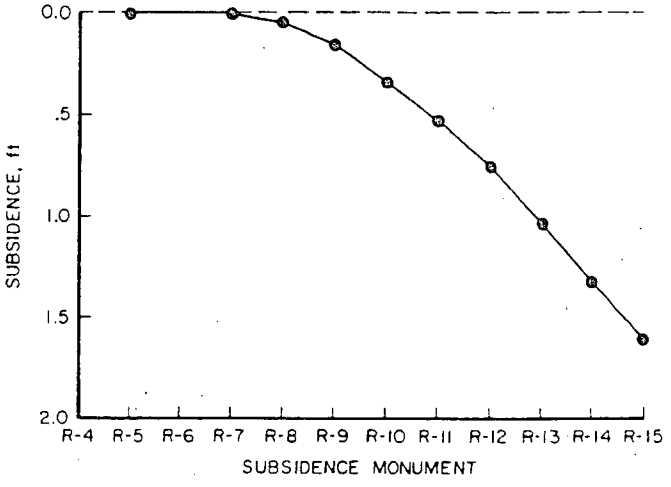


FIGURE 13.—Subsidence from R-4 to R-15.

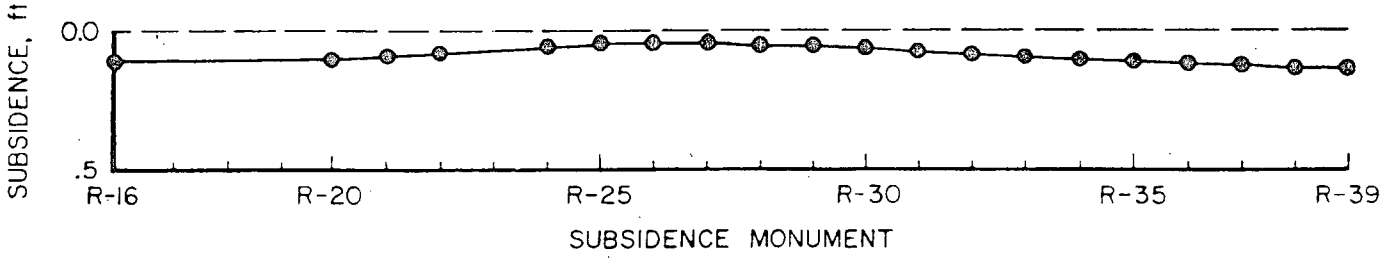


FIGURE 14.—Subsidence from R-16 to R-39.

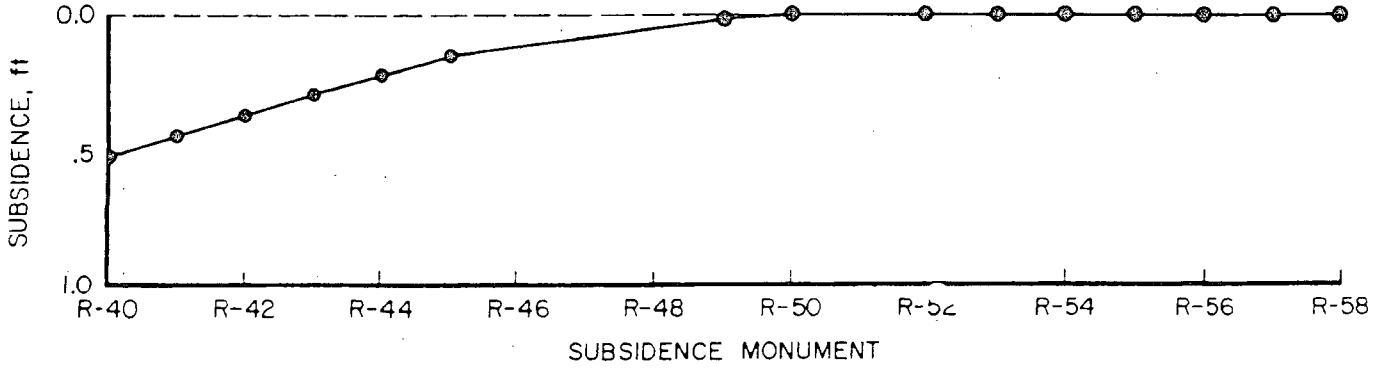


FIGURE 15.—Subsidence from R-40 to R-58.

settlement around the well 57 sinkhole began at R-49 and linearly increased toward the center of the sinkhole. The maximum settlement measured was 0.49±0.04 ft at R-40.

The S-line showed vertical settlement between S-5 and S-20. The line from S-1 to S-12 began movement at S-6 and continued to minearly increase to S-12 (fig. 16). Maximum subsidence of 1.81±0.04 ft was measured at monument S-12. Data from S-13 to S-21 (fig. 17) showed that movement began at S-20 and continued to linearly increase to S-13. The maximum subsidence at S-13 was 0.20±0.04 ft.

Data from the T-line indicated that vertical settlements occurred between T-8 and T-19. The line T-1 to T-12 (fig. 18) experienced movements that started at approximately T-9 and linearly increased to T-12; the maximum subsidence at T-12 was 0.23±0.04 ft. The line from T-13 to T-19 (fig. 19) showed movement that began at approximately T-18 and continued to linearly increase to T-13, where a movement of 0.34±0.04 ft was measured.

Results--Horizontal Movement

The results from the horizontal surveys indicated that minor horizontal movements occurred in the vicinity of the well 50 sinkhole. However, the data from the surveys were inconclusive as to whether any movement had occurred around the well 57 sinkhole. Any possible movements along the R-line from R-16 to R-58, from S-13 to S-21, and the entire T-line were of a magnitude less than could be detected by the surveys; the minimum observable movement was calculated to be ±0.35 ft. Appendix B contains data from the final horizontal control survey of the Carey brinefield; these data were used to calculate the maximum horizontal displacements of the subsidence monuments.

The R-line monuments underwent horizontal displacements oriented along the line from approximately R-10 to R-14 (fig. 20). The movement increased linearly in the direction toward the well 50 sinkhole. The movement at R-14 was approximately 1.0±0.35 ft.

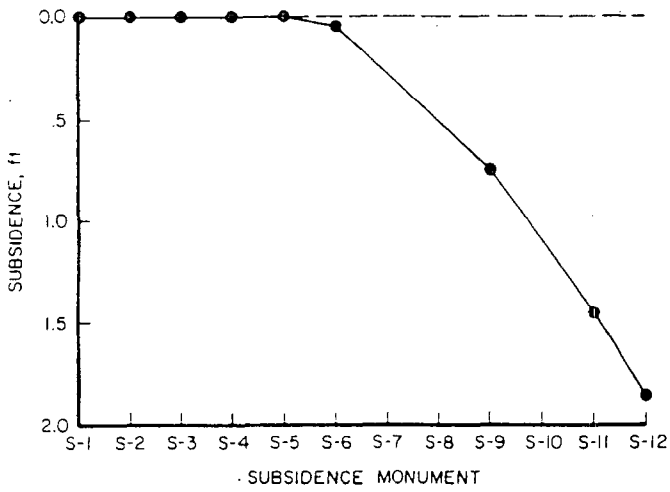


FIGURE 16.—Subsidence from S-1 to S-12.

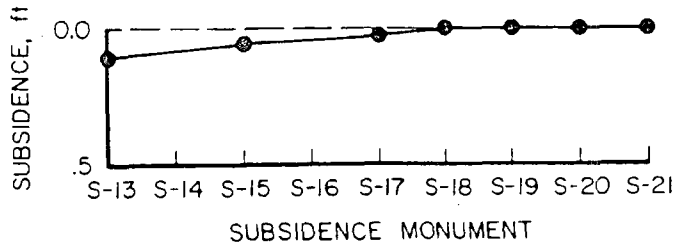


FIGURE 17.—Subsidence from S-13 to S-21.

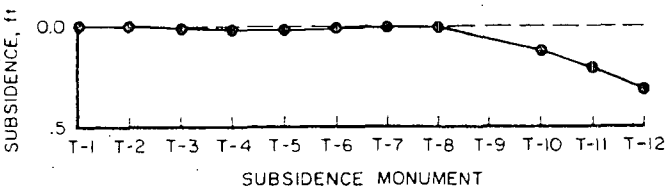


FIGURE 18.—Subsidence from T-1 to T-12.

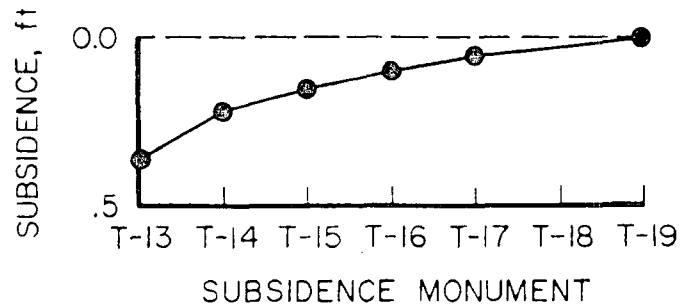


FIGURE 19.—Subsidence from T-13 to T-20.

The S-line monuments underwent horizontal movements that started at approximately S-5 and continued through S-12 (fig. 21). The movement was oriented along the line and increased linearly toward the well 50 sinkhole.

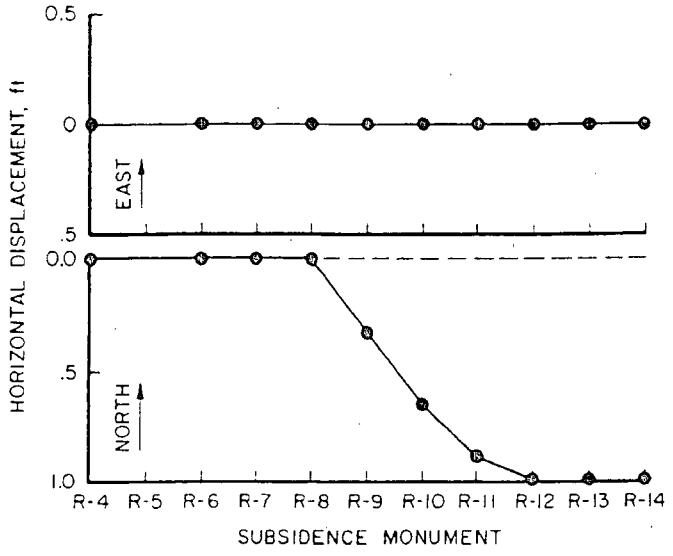


FIGURE 20.—Horizontal movement of R-4 to R-15.

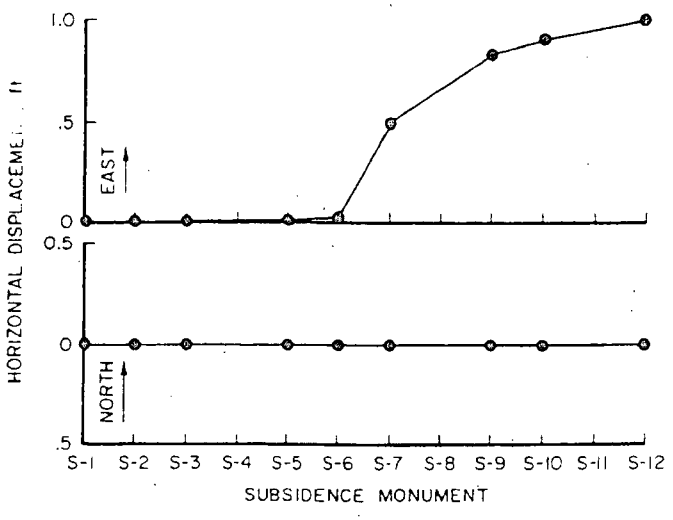


FIGURE 21.—Horizontal movement of S-1 to S-12.

The maximum horizontal movement at S-12 was measured to be approximately 1.0±0.35 ft in the direction toward the sinkhole.

The results of the surveys taken on the T-line and the R-line from R-16 to R-58 were inconclusive as to whether any horizontal movement had taken place. If any movement did occur, it was of a magnitude less than could be ascertained by the results of the horizontal surveys.

CAREY WELL 56 (FOURTH INVESTIGATION)

Background

As part of the fourth investigation, the Bureau monitored a subsidence network in the vicinity of well 56 located at the Carey brinefield. This network was designed to detect any positional changes of the ground surface due to cavity failure around well 56. The network consisted of 19 Bureau-installed subsidence monuments.

Subsidence-Monitoring Network Design and Construction

The area around well 56 was monitored by two perpendicular lines of subsidence monuments (fig. 9). The M-line (M-1 to M-9) was oriented in the east-west direction, and the N-line (N-1 to N-10) was oriented in the north-south direction. The intersection of these two lines occurred at well 56.

The design of the subsidence monuments used in the M-line and N-line was identical to that used for the monuments in the previous investigation (fig. 12). These monuments were installed by Carey personnel using the same techniques as were used by the Bureau in the third investigation.

Monitoring Procedures

As in the third investigation, the Bureau used trilateration and traverse surveying procedures for horizontal control of the subsidence-monitoring network, and trigonometric and differential surveying procedures for vertical control. The monitoring program began in May 1981 and continued through February 1983. Seven vertical and five horizontal surveys were performed.

Results

The data obtained from both the vertical and horizontal surveys indicated that

no apparent movement had occurred in the area around well 56 during the time of the fourth investigation. If any movement did occur, it was of a magnitude less than could be detected by the surveys.

INTERPRETATION OF RESULTS

FIRST AND SECOND INVESTIGATIONS

The analyses of results for the first and second investigations were not performed by the Bureau and are therefore omitted from this report. The analyses can be found in publications by Hendron (1, 3-4) and Walters (6).

THIRD INVESTIGATION

The survey data indicate that the subsidence in the vicinity of the two sinkholes continued throughout the period of the investigation. The results from the exploratory drilling program indicate that sagging shale beds were resting on the roof-fall rubble pile in the well 57 solution cavity; owing to the similarity and proximity of the two wells it was inferred that the well 50 cavity roof was resting on the roof-fall rubble pile in the well 50 cavity. The behavior of the subsidence around the two sinkholes was therefore most likely a result of the gradual settling of the sagging shale beds that was caused by the continued consolidation of the rubble piles on which the shale beds rested. As the rubble piles gradually compacted, the overlying strata responded with a gradual downward deflection into the rubble-filled cavities. If the consolidation processes ceased, the subsidence would also gradually cease; however, the subsidence was not halted, implying that consolidation was still occurring in the two collapsed cavities at the end of the investigation. It is logical to assume that the consolidation processes occurring in the rubble piles will, at some point in time, be completed, and subsidence still occurring after the completion of the investigation will eventually decrease and stop.

The characteristics of the subsidence occurring over the two failed cavities indicate that gradual yet significant settlement of the ground surface can be expected after the initial collapse of a solution cavity and the formation of a sinkhole. This conclusion is further supported by the continued settling of other major sinkholes in the region; the area around the 1952 Barton sinkhole, for example, is still experiencing some minor deformations (6). It is also logical to assume that a larger volume cavity with accompanying sinkhole will experience surface deformations of greater magnitude than a smaller volume cavity; a larger volume cavity will contain a larger rubble pile, and thus experience more initial collapse and eventual consolidation. This is evidenced by comparing the deformations occurring above the well 50 cavity and the smaller well 57 cavity.

The symmetry of the ground surface deformations around the two sinkholes was due to the geometries of the underlying cavities, since the subsidence areas were similar in plan to the probable cavity geometries. The subsidence around well 50 was found to extend approximately 190 ft on the north and west sides of the sinkhole. The area east of the sinkhole was affected by a drainage canal that runs north-south in the vicinity of well 50 (fig. 9); the canal and its effects on the subsidence around the well 50 sinkhole are explained later in this section. The well 57 sinkhole, however, did not have a similar ground surface deformation pattern. The subsidence around the well 57 sinkhole was elongated in the northeast-southwest direction and had a total span of approximately 570 ft. The span of subsidence in the southeast direction was about the same as the dimensions for the well 50 sinkhole subsidence pattern. This could have been the result of a cavity extending in the northeast-southwest direction, elongated by hydraulic connections to other brine

well 56 cavity to have a smaller roof span than the well 50 or well 57 cavities, it is apparent that smaller horizontal cavity dimensions were responsible for creating stable cavity conditions for well 56.

CONCLUSIONS

The four investigations performed by the Bureau in cooperation with the SMRI were designed to determine the characteristics and parameters of sinkhole formation over solution-mined salt cavities. The results from the exploratory drilling and coring investigations indicated that the Cargill sinkhole, the Barton sinkhole, and the two Carey sinkholes all were the result of solution-cavity roof failures caused by large, unsupported roof spans and deteriorating shale roof rock. In the case of the Cargill sinkhole, the cavity roof rock was completely breached, forming a chimney that piped approximately 90,000 yd^3 of surface soil into its interior. The overlying shales of the Barton and the two Carey solution cavities did not completely fail, resulting in these beds sagging and resting on the rubble piles in the solution cavities. The solution cavity of well 56 in the Carey brinefield appeared to be stable in that no sagging or major deterioration of the overlying shales had occurred.

The results of the surveying programs that monitored the ground surface around wells 50, 57, and 56 in the Carey brinefield indicated a relationship between cavity size and subsidence geometry. It was inferred from the drilling and coring program that the postfailure subsidence was due to the consolidation of the rubble piles on which the sagging shale beds rested.

It is evident after evaluating the surface monitoring and the drilling and coring data that the large, unsupported roof spans that ultimately failed were the result of the well completion and mining operation procedures used for each collapsed solution cavity. These methods allowed salt dissolution near the roofs of the cavities, creating the large, unsupported spans that eventually failed. The methods used for salt dissolution in the area have now been changed to prevent salt dissolution near the top of solution cavities so as to limit the dimensions of the cavity roofs. The resulting cavity configurations should be more stable.

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APPENDIX A.--FINAL VERTICAL CONTROL SURVEY OF CAREY BRINEFIELD

(Positive values correspond to downward movement)

Subsidence monument	Movement, ft[1]	Subsidence monument	Movement, ft[1]	Subsidence monument	Movement, ft[1]
M-1	0.02	R-19	NA	S-2	0.02
M-2	.00	R-20	0.22	S-3	.03
M-3	-.01	R-21	.13	S-4	.03
M-4	-.04	R-22	.11	S-5	.04
M-5	-.03	R-23	NA	S-6	.07
M-6	-.01	R-24	.11	S-7	NA
M-7	-.01	R-25	.09	S-8	NA
M-8	.00	R-26	.09	S-9	.75
M-9	.01	R-27	.16	S-10	NA
MV-1	.04	R-28	.10	S-11	1.44
MV-2	.01	R-29	.12	S-12	1.81
MV-3	-.01	R-30	.15	S-13	.20
MV-4	.02	R-31	.12	S-14	NA
MV-5	-.01	R-32	.14	S-15	.15
MV-6	NA	R-33	.16	S-16	NA
MV-7	.04	R-34	.18	S-17	.09
N-1	-.01	R-35	.29	S-18	.08
N-2	-.02	R-36	.23	S-19	.04
N-3	-.02	R-37	.23	S-20	.04
N-4	-.04	R-38	.26	S-21	.03
N-5	-.02	R-39	.24	T-1	.04
N-6	-.04	R-40	.49	T-2	.04
N-7	-.01	R-41	.42	T-3	.05
N-8	-.01	R-42	.32	T-4	.05
N-9	-.02	R-43	.30	T-5	.04
N-10	-.02	R-44	.30	T-6	.05
R-4	NA	R-45	.27	T-7	.01
R-5	.03	R-46	NA	T-8	.02
R-6	NA	R-47	NA	T-9	NA
R-7	.03	R-48	NA	T-10	.08
R-8	.05	R-49	.07	T-11	.14
R-9	.13	R-50	.04	T-12	.23
R-10	.37	R-51	NA	T-13	.34
R-11	.52	R-52	.02	T-14	.21
R-12	.74	R-53	.03	T-15	.15
R-13	1.03	R-54	.03	T-16	.10
R-14	1.31	R-55	.02	T-17	.05
R-15	1.58	R-56	.01	T-18	NA
R-16	.18	R-57	.01	T-19	.02
R-17	NA	R-58	.01	T-20	NA
R-18	NA	S-1	-.02		

NA Not available.

[1]Movement is elevation change between initial and final surveys.

NOTE.--Survey accuracy is ±0.04 ft. The error limits were determined by statistically averaging the standard deviations of stable subsidence monuments for all surveys.

APPENDIX B.--FINAL HORIZONTAL CONTROL SURVEY OF CAREY BRINEFIELD

(Positive values correspond to increasing easting or northing)

Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft	Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft
M-1	-0.17	0.04	R-19	NA	NA
M-2	-.19	.02	R-20	0.22	-0.20
M-3	-.06	.05	R-21	.11	-.09
M-4	-.14	.04	R-22	.23	1.61
M-5	-.20	.01	R-23	NA	NA
M-6	-.16	.02	R-24	.20	.17
M-7	-.06	.10	R-25	.14	.18
M-8	-.06	.11	R-26	.19	.03
M-9	-.04	.14	R-27	-.11	.49
MV-1	.09	.03	R-28	.17	-.02
MV-2	.07	.03	R-29	NA	NA
MV-3	.06	.03	R-30	.31	.09
MV-4	.11	.23	R-31	.13	-.03
MV-5	NA	NA	R-32	.20	-.08
MV-6	NA	NA	R-33	NA	NA
MV-7	.01	.04	R-34	.27	-.08
N-1	-.07	.05	R-35	-.02	.87
N-2	-.29	.00	R-36	.25	-.05
N-3	-.16	.03	R-37	.22	-.08
N-4	-.18	.02	R-38	.29	-.13
N-5	.01	.08	R-39	.05	-.04
N-6	-.22	-.01	R-40	-.22	.09
N-7	-.11	.05	R-41	.06	.07
N-8	-.16	.02	R-42	.04	.14
N-9	-.03	.12	R-43	.08	.13
N-10	-.12	.05	R-44	.14	.16
R-4	.26	.02	R-45	NA	NA
R-5	NA	NA	R-46	.15	.11
R-6	.26	.01	R-47	NA	NA
R-7	.22	-.04	R-48	NA	NA
R-8	.17	-.18	R-49	.26	.05
R-9	.22	-.40	R-50	.28	.01
R-10	.13	-.57	R-51	NA	NA
R-11	.17	-.62	R-52	.28	.06
R-12	.26	-.82	R-53	.28	.04
R-13	.01	-1.00	R-54	.61	.26
R-14	.13	-.97	R-55	.33	.08
R-15	NA	NA	R-56	.31	-.02
R-16	NA	NA	R-57	.20	.00
R-17	NA	NA	R-58	.25	.00
R-18	NA	NA	S-1	.26	.04

See footnotes at end of appendix.

(Positive values correspond to increasing easting or northing)

Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft	Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft
S-2.....	0.31	0.13	T-1.....	0.34	-0.15
S-3.....	.26	.09	T-2.....	.34	-.15
S-4.....	NA	NA	T-3.....	.33	-.15
S-5.....	.27	-.02	T-4.....	.21	-.27
S-6.....	.36	.08	T-5.....	.28	-.09
S-7.....	.45	.06	T-6.....	.30	-.12
S-8.....	NA	NA	T-7.....	.23	-.05
S-9.....	.85	.09	T-8.....	.26	-.07
S-10.....	.97	.30	T-9.....	NA	NA
S-11.....	NA	NA	T-10.....	.31	.04
S-12.....	1.12	-.09	T-11.....	.32	.00
S-13.....	-.04	-.11	T-12.....	.30	.02
S-14.....	-.06	-.46	T-13.....	.04	-.19
S-15.....	.01	-.17	T-14.....	.08	-.06
S-16.....	NA	NA	T-15.....	.06	.04
S-17.....	.14	-.15	T-16.....	.04	.06
S-18.....	.17	-.13	T-17.....	-.70	-.14
S-19.....	.17	-.07	T-18.....	NA	NA
S-20.....	.13	-.14	T-19.....	.05	.04
S-21.....	.13	-.12	T-20.....	NA	NA

NA Not available.

[1]Movement is change in horizontal coordinates between initial and final surveys.

NOTE.--Survey accuracy is ±0.35 ft. The error limits were determined by statistically averaging the standard deviations of stable subsidence monuments for all surveys.

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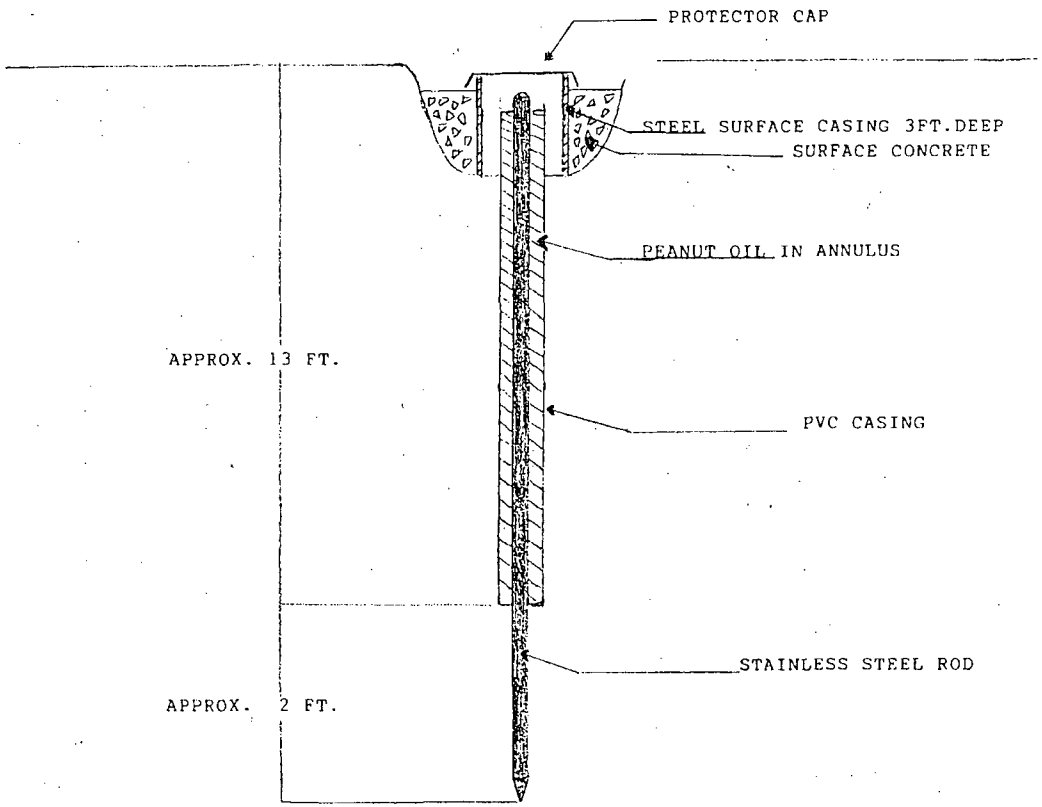


I & W, INC.
CARLSBAD, NM.
EUGENIE BRINE STATION

2.26.02

R-line (R-4 to R-15) subsidence monuments were positioned in the area around the well 50 sinkhole. These two monument lines intersected at right angles near the center of the well 50 sinkhole. The T-line (T-1 to T-20) and the remainder of the R-line (R-16 to R-58) monuments were positioned in the area around the well 57 sinkhole. These two monument lines intersected at right angles near the center of the well 57 sinkhole. The monuments R-16 to R-58 were also designed to monitor the area between the two sinkholes and were therefore oriented along the axis between the two sinkhole centers. The MV-line monuments were distributed throughout the area around the sinkholes to monitor any ground surface movements due to neighboring wells. The remainder of the survey points, including the wells, boreholes, and previously installed survey movements, were used to monitor movements of the ground surface over a large area around the two sinkholes. Control points P-1, P-2, and P-3 were placed in areas that were considered to be stable and not affected by solution mining activities; these control points were located in areas outside the area shown in figure 9. Control points SC-1 and SC-2 were located in the brinefield for the trilateration surveys and were checked for stability prior to each survey.

The 4 control points and the 103 monuments installed by the Bureau at the Carey brinefield were all of the same design and construction (fig. 12). The monument consists of a small inner pipe fitted with a pointed anchor on the bottom and a reference-marked cap on the top, and a large outer pipe which is used to drive the anchor below frost depth. The inner pipe extends through a cap on top of the outer pipe. The outer pipe is free to undergo movements due to frost heave or swelling and shrinking soils without affecting the inner pipe on which measurements are made. The monuments proved to be very stable and effectively guarded against soil distances throughout the entire time of the investigation.

Monitoring Procedures

The procedures used to monitor positional changes in the network involved various survey techniques. Trialteration and traverse surveying procedures were used for horizontal control, and trigonometric and differential leveling procedures for vertical control. The horizontal control surveys, as well as the trigonometric level surveys, established initial and subsequent coordinates and elevations by measuring angles and distances from control points SC-1 and SC-2

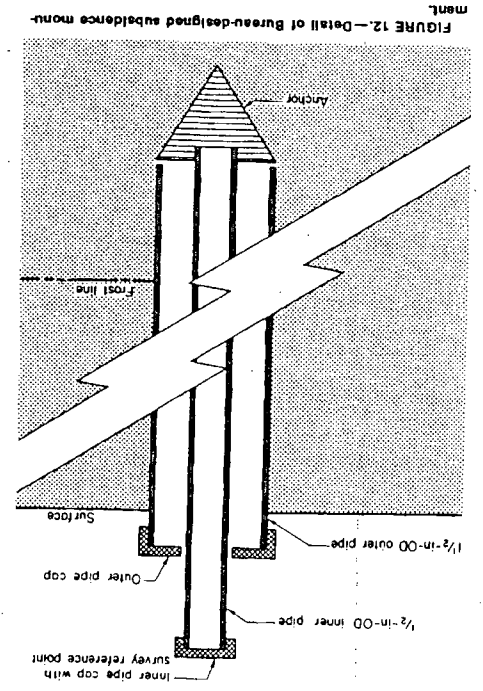


FIGURE 12.—Detail of Bureau-designed subsidence monument.

The wells, boreholes, and structure that were used as subsidence monuments all had survey marks that provided consistent reference points.

Monitoring Procedures

The procedures used to monitor positional changes in the network involved various survey techniques. Trialteration and traverse surveying procedures were used for horizontal control, and trigonometric and differential leveling procedures for vertical control. The horizontal control surveys, as well as the trigonometric level surveys, established initial and subsequent coordinates and elevations by measuring angles and distances from control points SC-1 and SC-2

Chavez, Carl J, EMNRD

From: Price, Wayne, EMNRD
Sent: Tuesday, February 19, 2008 3:08 PM
To: Chavez, Carl J, EMNRD
Subject: RE: I&W BW-6 Subsidence Monitoring Work Plan

I will handle!

From: Chavez, Carl J, EMNRD
Sent: Tuesday, February 19, 2008 3:07 PM
To: Price, Wayne, EMNRD
Subject: I&W BW-6 Subsidence Monitoring Work Plan

Wayne:

I am supposed to provide a response to their subsidence monitoring work plan. Do you want to do this or do you want me to respond? Thanks.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Monday, February 11, 2008 4:06 PM
To: 'Lisa Rice'
Cc: Price, Wayne, EMNRD
Subject: RE: Subsidence Monitor Eugenie #1 I & W, Inc.

Ms. Rice:

I am in receipt of your submittal and will respond soon. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Lisa Rice [mailto:lisa@iandwinc.com]
Sent: Monday, February 11, 2008 11:53 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitor Eugenie #1 I & W, Inc.

Mr. Chavez:

In regards to the subsidence monitoring at I & W' S Eugenie #1 (BW 006) facility. The resurfacing work at our yard & brine station should be completed this week (2/15/08). I have included a site map for your review. The cavern is less than 80 feet in any direction from the well head. The three marked points are the proposed monitors that are in line of sight & the greatest distance from the well on I & W' s property.

The three markers will be constructed out of 3" pipe. The top of the pipe will be capped and a designated point will be marked for consistent monitoring. The pipe will be placed in a 12" hole approximately 4 feet deep with cement up to ground level. Approximately 1 foot will be above ground for our surveyor to use as a monitoring point.

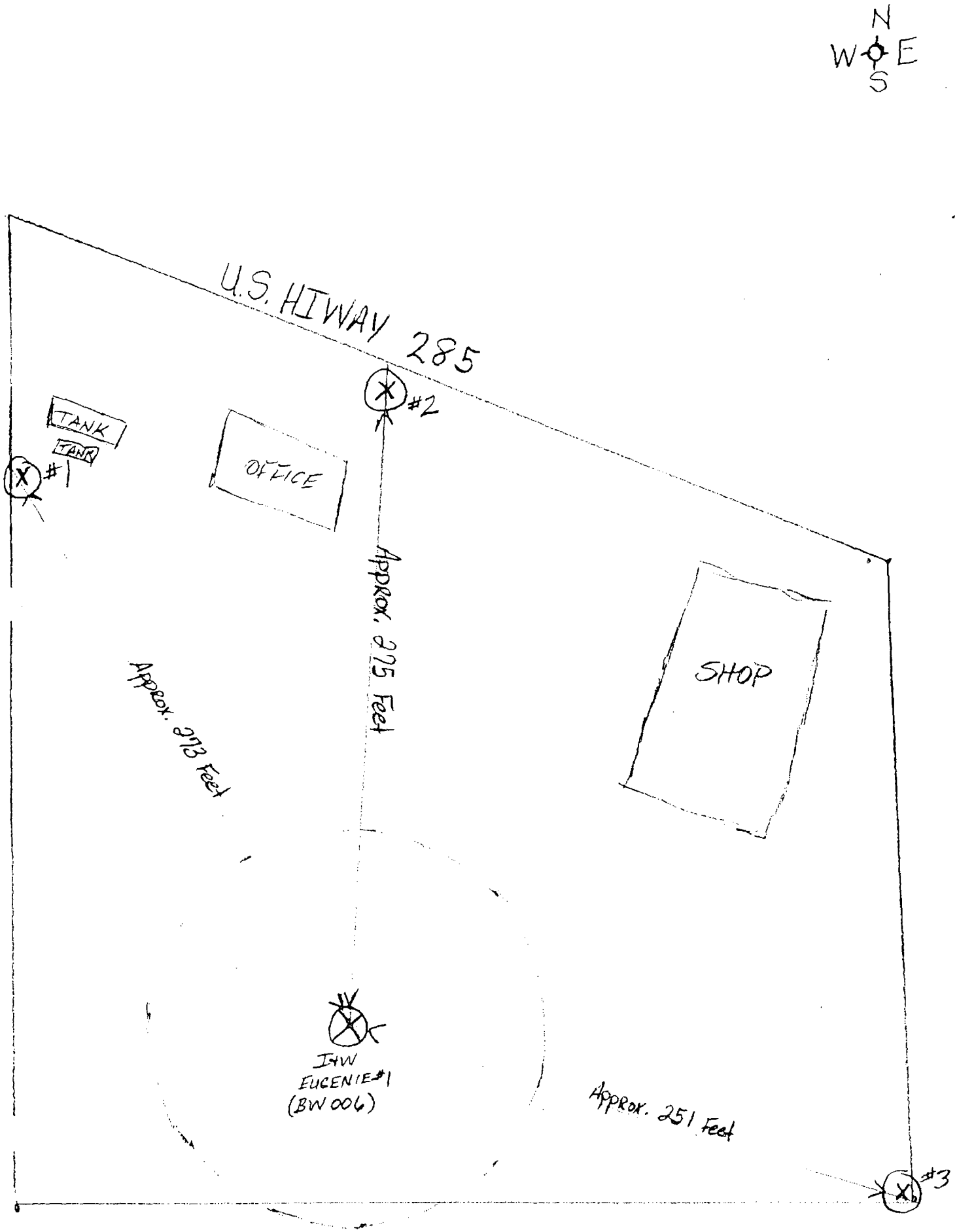
If this sounds okay to you, we will go ahead and set the three monitors & let the cement be setting up. The surveyor / engineer will be ready to establish initial readings as soon as we contact him. Please let me know if this will be acceptable and we will get started.

Sincerely,
Kevin Wilson
Operations Manager

Chavez, Carl J, EMNRD

From: Shallon Finkbone [shallon@iandwinc.com]
Sent: Monday, February 11, 2008 11:20 AM
To: lisa@iandwinc.com
Subject: map
Attachments: map.tif

Here you go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TANK
#1
OFFICE
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SHOP
Approx. 273 Feet
IHW
EUGENIE #1
(BW 006)
Approx. 251 Feet
#3

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, January 16, 2008 10:55 AM
To: 'iwcarlsbad@plateautel.net'
Cc: Price, Wayne, EMNRD
Subject: I&W BW-6

Kevin:

Hi. I have not received the subsidence survey proposal or report for I&W's Carlsbad Facility. Did you mail it to me? Thanks.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 11, 2007 10:01 AM
To: 'Lisa Rice'
Cc: Price, Wayne, EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: BW-6 Subsidence Monument Monitoring Program Information for Brine Cavern
Attachments: KS Subsid Monitor Case.tif

Mr. Wilson:

Re: I & W Inc. Eugenie #1: API# 30-015-22574 & Eugenie #2: API# 30-015-23031

Good morning. As a follow up to the recent OCD letter and telephone conversation this morning. Please find attached a subsidence monitoring report that may assist you in understanding the scope of the issues and concerns associated with shallow brine caverns. The report contains subsidence monument monitoring information that may assist you with the subsidence monitoring at your facility.

Please review the monitoring information (i.e., Fig. 9, 12, etc.). My Supervisor, Mr. Wayne Price seems to recall that there was a monitor well that was being surveyed to address this provision of the permit. Based on the attached report, I recommend at least five monitoring points at ~ 200 ft. spacing, including ground and top of casing elevations at both of the Eugenie BWs, and a subsidence monument at mid-point (if possible) between the brine wells. The other subsidence monuments should be selected based on best professional judgment of a certified surveyor. A monitor well drilling company may offer advice and the means for physically installing subsidence monuments. It would seem that swale areas away from the brine well network may be appropriate locations for the other monitor points. The survey elevations should be monitored on a semi-annual basis for the first couple of years (and as needed) and then annual monitoring (and as needed) may be appropriate thereafter. You will need to setup a format for your monitoring information to be made available at the request of the OCD and/or when subsidence monitoring warrants notification to the OCD.

Please provide the OCD with an update on your progress on or before May 4, 2007 and as events transpire thereafter. The shallow nature of the brine cavern is the reason why the OCD is concerned about subsidence in the vicinity of your facility and of course public health and safety in the area.

Please contact me if you have questions. Thank you.

From: Lisa Rice [mailto:iwcarlsbad@plateautel.net]
Sent: Wednesday, April 11, 2007 8:27 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitoring Program information

Dear Mr. Chavez

This is Kevin Wilson Operation Manager for I & W, Inc. We are in need of any information you may have to assist us in setting up the Subsidence monitoring Program on our Eugenie Brine station. I will be contacting survey companies for further information & we will keep you updated as to our progress. However any information or help you may have in assisting us in this matter would be greatly appreciated.

Sincerely,
Kevin Wilson
Operation Manager

Chavez, Carl J, EMNRD

From: Price, Wayne, EMNRD
Sent: Wednesday, April 11, 2007 8:20 AM
To: Chavez, Carl J, EMNRD
Subject: RE: BW-6 I & W Carlsbad & Letter Requesting Subsidence Monitoring

Carl, I think Kevin is probably misinformed, because I sure that they had installed a monitoring device, I could be wrong. However, yes go ahead and start the process.

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 11, 2007 8:08 AM
To: Price, Wayne, EMNRD
Subject: BW-6 I & W Carlsbad & Letter Requesting Subsidence Monitoring

Wayne:

Re:

I & W EUGENIE #1 BRINE -CARLSBAD
BW-6
Eugenie #1: 30-015-22574; Eugenie #2: 30-015-23031

Kevin called to inform me that he has looked for their subsidence monitoring information and they apparently did and have not addressed the issue. He has requested any info. we may have and I recommended that he contact a survey company to get started with a monitoring plan. I think we have an article on the subject that I can share with him. I told him that I would speak with you based on our letter (see attachment) to determine how we should proceed. What do you think? Thanks.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/
(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 11, 2007 8:08 AM
To: Price, Wayne, EMNRD
Subject: BW-6 I & W Carlsbad & Letter Requesting Subsidence Monitoring
Attachments: BW-6 IandW 3-13-07.doc

Wayne:

Re:

I & W EUGENIE #1 BRINE -CARLSBAD
BW-6
Eugenie #1: 30-015-22574; Eugenie #2: 30-015-23031

Kevin called to inform me that he has looked for their subsidence monitoring information and they apparently did and have not addressed the issue. He has requested any info. we may have and I recommended that he contact a survey company to get started with a monitoring plan. I think we have an article on the subject that I can share with him. I told him that I would speak with you based on our letter (see attachment) to determine how we should proceed. What do you think? Thanks.

Carl J. Chavez, CHMM
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E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/
(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, December 11, 2008 11:42 AM
To: 'iwcarlsbad@plateautel.net'
Cc: 'Shallon Finkbone'; Price, Wayne, EMNRD; Guye, Gerry, EMNRD; Sanchez, Daniel J., EMNRD
Subject: I & W Eugenie Brine Well C-103 Plug and Abandonment Status (BW-6) Carlsbad

Kevin:

Good morning. Can you please update the OCD on the status of plugging and abandonment of the brine well (API# 30-015-22574) at the I & W Facility? According to OCD records, we received a C-103 dated 7/24/2008 with PA description and indication that the C-103 was verbally approved by Wayne Price OCD District IV.

General OCD conditions for closure of the facility is to implement a subsidence monitoring program and install a seismograph at the facility with monitoring for 30 years with additional financial assurance to ensure that monitoring is maintained.

My Supervisor, Mr. Wayne Price will be in the office next week. Please contact me to discuss any questions that you may have. Also, the OCD is awaiting the final signed C-103 indicating that the well has been properly plugged and abandoned. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD

Sent: Friday, November 14, 2008 4:38 PM

To: 'ziatransports@gmail.com'; 'jrmillett@gmail.com'; 'rharrisnm@aim.com'; 'gandy2@leaco.net'; 'seay04@leaco.net'; 'iwcarlsbad@plateautel.net'; 'Patterson, Bob'; 'Dimas Herrera'; 'gil@mull.us'; 'David Pyeatt'; 'Wayne E Roberts'; Dennis L Shearer; 'garymschubert@aol.com'; 'dgibson@keyenergy.com'; 'Clay Wilson'; 'Prather, Steve'; Ronnie D Devore

Cc: Hill, Larry, EMNRD; Gum, Tim, EMNRD; Price, Wayne, EMNRD

Subject: Brine Well Moratorium Press Release Today

Attachments: PR-OCD Brine Well Moratorium.pdf

FYI, please see the attached NM OCD Press Release issued today. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

New Mexico Energy, Minerals and Natural Resources Department

November 14, 2008

NEWS RELEASE

Contact: Jodi McGinnis Porter,
Public Information Officer 505.476.3226

Energy, Minerals and Natural Resources Cabinet Secretary Prukop Orders a Six Month Moratorium on New Brine Wells

Oil Conservation Division to Investigate Brine Well Collapses and Provide Recommendations

SANTA FE, NM – Secretary Joanna Prukop today ordered the Oil Conservation Division to place a six month moratorium on any new brine well applications located in geologically sensitive areas. Secretary Prukop's action comes following the second brine well collapse in less than four months in southeastern New Mexico. The Secretary has also directed the Oil Conservation Division to work with the Environmental Protection Agency, other states, technical experts and oil and gas industry representatives to examine the causes of recent collapses, and provide a report with recommendations to the Oil Conservation Commission for a safe path forward. The report should be completed by May 1, 2009.

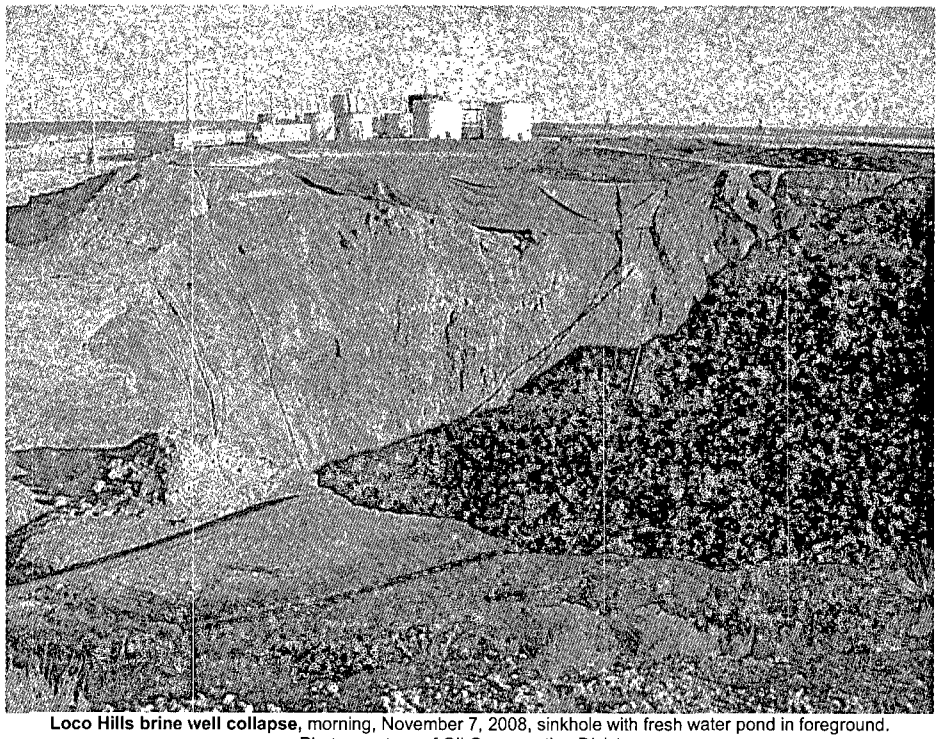
"I am deeply concerned by these two serious incidents and we are taking action to ensure the safety of our citizens and to protect the environment," stated Secretary Prukop.

Brine wells are an essential part of the oil and gas drilling industry, particularly in the southeastern part of the state. Oil and gas operators use brine water in the drilling process. Brine is saturated salt water which can be more salty than sea water. Brine is created by injecting fresh water into salt formations, allowing the water to absorb the salt and then pumping it out of the well. This method creates an underground cavity.

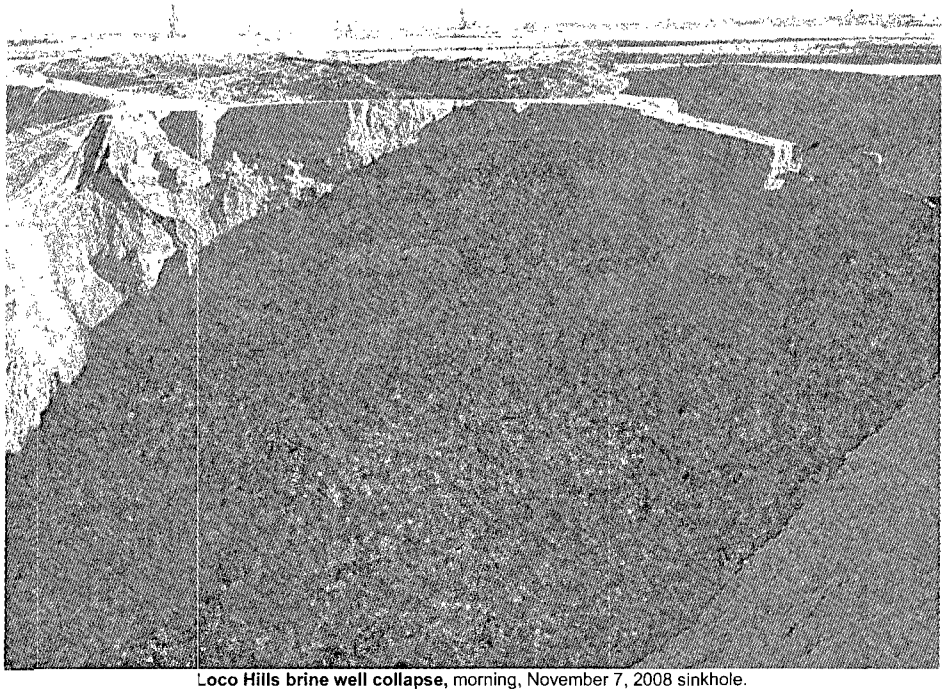
"The moratorium will provide time to properly evaluate the causes of the recent collapses and to discuss the development of new rules or guidelines to ensure the safety and stability of brine well systems," added Secretary Prukop.

The moratorium will only affect new wells and will not impact existing wells and facilities.

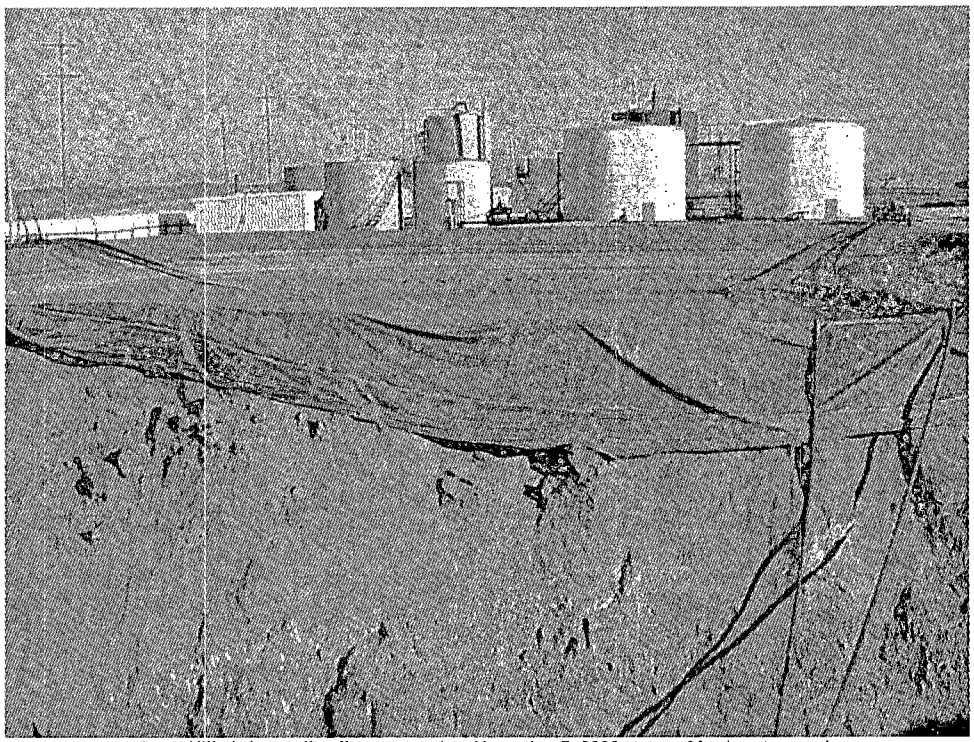
Below are photographs of the two recent collapses:



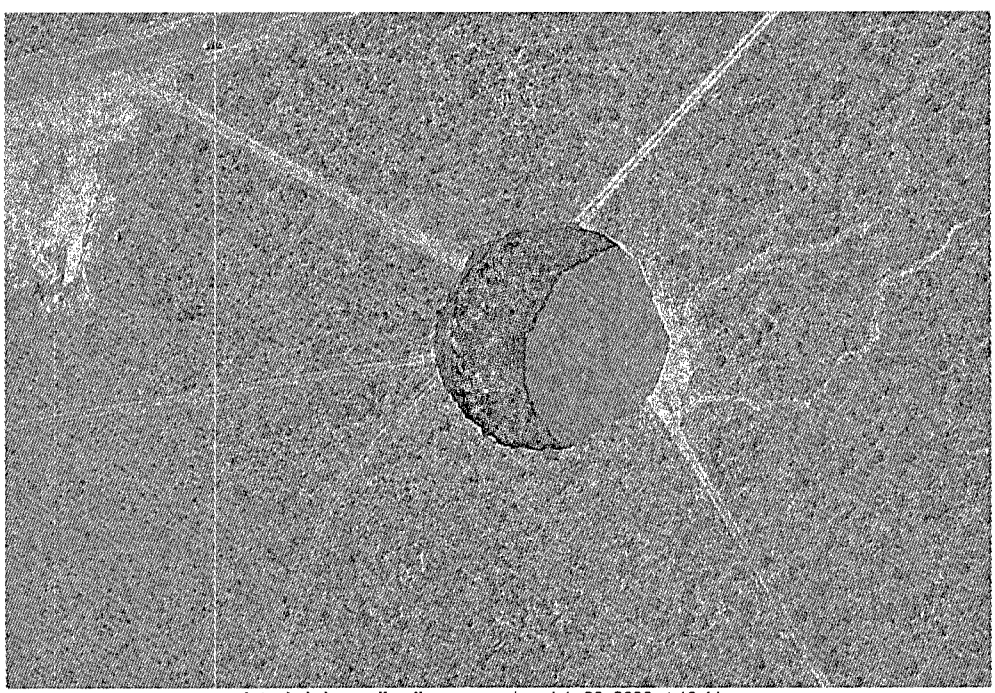
Loco Hills brine well collapse, morning, November 7, 2008, sinkhole with fresh water pond in foreground.
Photo courtesy of Oil Conservation Division



Loco Hills brine well collapse, morning, November 7, 2008 sinkhole.
Photo courtesy of Oil Conservation Division



Loco Hills brine well collapse, morning, November 7, 2008 status of fresh water pond.
Photo courtesy of Oil Conservation Division



Artesia brine well collapse, morning, July 20, 2008 at 10:44 am.
Photo courtesy of National Cave and Karst Research Institute

Artesia brine well collapse morning, July 22, 2008
Photo courtesy of National Cave and Karst Research Institute

#30#

The Energy, Minerals and Natural Resources Department provides resource protection and renewable energy resource development services to the public and other state agencies.

Oil Conservation Division
1220 South St. Francis Drive ▪ Santa Fe, New Mexico 87505
Phone (505) 476-3440 ▪ Fax (505) 476-3462 ▪ www.emnrd.state.nm.us/OCD

Chavez, Carl J, EMNRD

From: VonGonten, Glenn, EMNRD
Sent: Tuesday, November 04, 2008 1:20 PM
To: iwcarlsbad@plateautel.net
Cc: Price, Wayne, EMNRD; Chavez, Carl J, EMNRD; Sanchez, Daniel J., EMNRD
Subject: Contingency Plan for BW006

Lisa Rice, Kevin Wilson:

As we discussed, OCD is requiring I & W to submit a contingency plan for its brine well in Carlsbad by close of business on Friday, November 7, 2008 to both the Eddy County Emergency Management Service and to OCD. The contingency plan should include the following:

1) Contact list with phone numbers and email addresses for all organizations that I & W would need to contact if it were to detect subsidence or collapse at its brine well, including the Eddy County EMS, State Police, Carlsbad Police and Fire Departments, OCD District II office in Artesia and OCD Santa Fe office, etc.

2) Daily surveillance plan, including a log, that records I & W's daily inspections of the brine well and vicinity.

3) Weekly monitoring plan, including a log, that records I & W's weekly survey of its survey points.

4) Action plan for decommission the brine well by disconnecting all power, plumbing, and supply and production pipelines, etc. so that if a collapse occurs, the damage to surrounding infrastructure is minimized.

The intent of these additional requirements is so that if a collapse occurs, I & W will already have gone the process of preparing lists for contacting the appropriate organizations and plans for monitoring the brine well.

If you have any questions, please contact me - Wayne Price and Carl Chavez will be out of the office for several days.

Glenn von Gonten
Senior Hydrologist
Environmental Bureau
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505
505-476-3488
fax -476-3462
glenn.vongonten@state.nm.us

New Mexico Energy, Minerals and Natural Resources Department

Bill Richardson
Governor

Joanna Prukop
Cabinet Secretary
Reese Fullerton
Deputy Cabinet Secretary

Mark Fesmire
Division Director
Oil Conservation Division

Certified Receipt/Return Requested:

August 01, 2008

Attention Brine Well Operator(s):

One of the permitted brine wells has experienced a total collapse and created an enormous sinkhole. The well was located approximately 17 miles SE of Artesia, NM. on State Trust Land. The operator was Jim's Water Service and the brine well permit is BW-005. OCD has enclosed a press release with photos of the event.

The magnitude of this event warrants an immediate investigation of all brine wells in the state. Therefore, please find enclosed a "BRINE WELL INFORMATION REQUEST" form to be filled out and returned to this office no later than September 05, 2008. Failure to properly fill out and return the form in a timely manner may result in OCD requesting you shut down your operations until further notice. If you have any questions please do not hesitate to call me at 505-476-3490 or E-mail wayne.price@state.nm.us.

Sincerely,

Wayne Price
Environmental Bureau Chief
Oil Conservation Division

Attachments: (2)

Cc: EMNRD Cabinet Secretary-Joanna Prukop
OCD Director-Mark Fesmire
NMSLO- Brian Henington SF, Jim Carr-Carlsbad
BLM-Carlsbad Office- Dave Herrell
Eddy Co. Emergency Management-Joel Arnwine
NM State Police –Roswell Sgt. Les Clements
National Cave and Karst Research Institute- Dr. George Veni
NMOSE-John Stewart
Solution Mining Research Institute-John Voigt

Price, Wayne, EMNRD

From: Porter, Jodi, EMNRD
Sent: Wednesday, July 23, 2008 5:00 PM
Subject: PR-Secretary Prukop Proposes Stricter Conditions on Brine Wells State-wide
Attachments: PR-OCD.Brine.Wells07.23.08.pdf

New Mexico Energy, Minerals and Natural Resources Department

Bill Richardson
Governor

Joanna Prukop
Cabinet Secretary
Reese Fullerton
Deputy Cabinet Secretary

Mark Fesmire
Division Director
Oil Conservation Division

July 23, 2008

NEWS RELEASE

Contact: Jodi McGinnis Porter,
Public Information Officer 505.476.3226

Energy, Minerals and Natural Resources Cabinet Secretary Joanna Prukop Proposes Stricter Conditions on Brine Wells State-wide

Artesia brine well collapse prompts statewide review

SANTA FE, NM – Secretary Joanna Prukop has directed the Oil Conservation Division (OCD) to conduct a complete evaluation of the rules and regulations concerning brine wells, a method of creating saturated salt water used in oil and gas production. The OCD evaluation will include an internal audit and inspection of all existing brine wells in New Mexico. Secretary Prukop is considering strengthening oversight of brine wells to protect against well failures such as the recent collapse in Artesia that created a huge sinkhole and forced the closure of an Eddy County road.

"There are several brine wells in New Mexico and we must ensure that they are all properly monitored to ensure safety and stability," stated Cabinet Secretary Joanna Prukop. "We have now seen that these wells can collapse and the extensive damage such a collapse can generate."

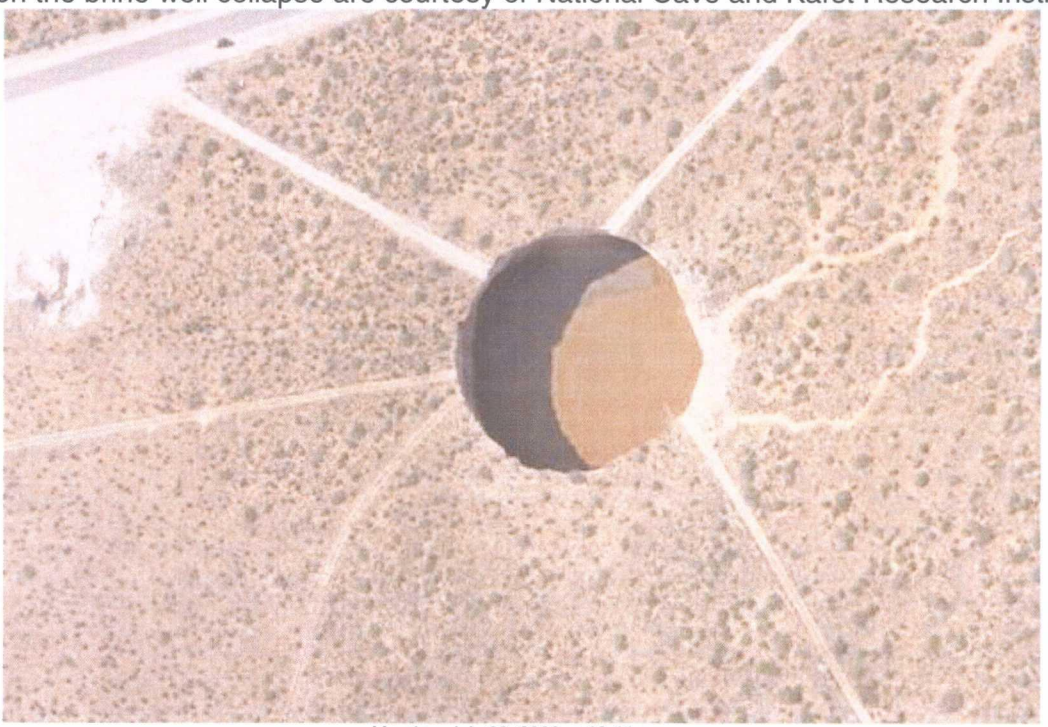
The Oil Conservation Division is continuing to monitor and investigate the collapse of the brine well, located on state trust land 17.3 miles southeast of Artesia, which is still active. The well is owned by Jim's Water Service. County Road 217 remains closed as a safety precaution, and a command center is on site. Division engineers estimate that the well is approximately 300 to 400 feet in diameter, 70 feet to the water level, and the actual depth to the bottom is unknown.

Scientists from the Oil Conservation Division, the Bureau of Land Management, State Land Office, the New Mexico

Bureau of Geology and Mineral Resources, and the National Cave & Karst Research Institute are all working together to assess horizontal and vertical movements to project any future subsidence. Work on a protective fence and keep-out signage began yesterday with completion expected on Friday.

In a related issue, the Oil Conservation Division has also been closely monitoring a brine well operated by I & W, Inc located in Carlsbad, NM. Yesterday, following ongoing inquiries from OCD the operator decided voluntarily to stop operation of the well The division will work with I & W, Inc. to ensure that the well is properly plugged, permanently abandoned, and monitored for the long term.

Images provided on the brine well collapse are courtesy of National Cave and Karst Research Institute:



Morning, July 20, 2008 at 10:44 am.
courtesy of National Cave and Karst Research Institute

New Mexico Energy, Minerals and Natural Resources Department

Bill Richardson
Governor

Joanna Prukop
Cabinet Secretary
Reese Fullerton
Deputy Cabinet Secretary

Mark Fesmire
Division Director
Oil Conservation Division

OIL CONSERVATION DIVISION
BRINE WELL INFORMATION REQUEST

GENERAL INFORMATION:
Operator Name_____ Well Name(s)_____ API Number _____ Brine Well Permit # _____ Date Permit Expires? _____ Location: Section _____Ts _____ Rg _____ FNL_____FSL_____FEL_____FWL_____ GPS of well(s): Lat: Long:
Have you reviewed and understand all of your permit conditions? Yes ☐ No☐ Are you presently deficient of any condition in your permit? Yes ☐ No☐ Don't know☐ Do you operate below grade tanks or pits at the site? Yes☐ No☐ Do all tanks, including fresh water tanks, have secondary containment? Yes☐ No☐ Do you think you have the expertise, knowledge and general understanding of what causes a brine well to collapse? Yes☐ No☐ Do you think OCD should provide guidelines on subsidence and collapse issues? Yes☐ No☐
SITING INFORMATION: ***Please provide the following information and depict on 7.5 minute (1": 2000') USGS Quad Map. Limit search to one mile radius.***
Is the brine well located within a municipality or city limits? Yes☐ No☐
Distance and direction to nearest permanent structure, house, school, *etc. if less than one mile:*
Distance and direction to nearest water well *if less than one mile:*
Distance to nearest watercourse(s), floodplain, playa lake(s), or man-made canal(s) or pond(s) *if less than one mile:*
Distance and direction to nearest known karst features or mines *if less than one mile:*

Distance and direction to nearest producing oil or gas well(s) *if less than one mile:* Provide API Number:
Distance and direction to nearest tank battery(ies) *if less than one mile:*
Distance and direction to nearest pipeline(s), including fresh water pipelines *if less than one mile:*
Distance and direction to nearest paved or maintained road or railroad *if less than one mile:*
Depth to ground water found above the Salado (salt section), regardless of yield:
Name of aquifer(s):
WELL CONSTRUCTION: ***Please provide the following information and attach a diagram depicting the brine well. Check box if attached:*** *Copy of a current well diagram:* *Attached* ☐ *Copy of formation record with tops:* *Attached* ☐ *Copy of geophysical well logs if available:* *Attached* ☐ *If not, well logs within one mile* ☐
Depth of the top of the salt below ground surface (feet):
Depth to the bottom of the salt below ground surface (feet):
Depth(s) to and thickness(es) of any anhydrite section(s) (located above the salt):
Depth of casing(s) shoe below ground surface (feet):_____ Is the casing shoe set in the anhydrite or other layer above the salt? Yes ☐ No ☐ Is the casing shoe set into the salt? Yes☐ No☐ If yes, how far into the salt?_____
Depth of tubing(s):
Do you suspect that your cavern has partially caved in? Yes☐ No☐ Don't know☐
OPERATIONS: *Please provide the following information.*
Start date of brine well operation:
Total volume of fresh water injected into the brine well to date (bbls) and how determined:

Total volume of brine water produced (bbls) to date and how determined:
Have you ever lost casing or tubing? If yes, please provide details. Document attached ☐
Do you maintain a surface pressure on your well during idle times? Yes☐ No☐
Have you noticed large amounts of air built up during cavity pressurization? Yes☐ No☐
Have you ever noticed fluids or air/gas bubbling up around the casing during testing or normal operations? Yes☐ No☐
MONITORING: ***Please provide the following information.***
Are you currently monitoring ground water contamination from your brine well or system? Yes ☐ No☐
Have you ever run a sonar log? Yes☐ No☐ *If yes,* please provide last date:_____
Provide cavern configuration (dimensions and volume) and method(s) used to estimate: If sonar report please attach ☐ *If other, please specify and provide a sketch of cavern:* ☐
Do you have a subsidence monitoring program in place? Yes ☐ No☐
Do you have any geophysical monitoring devices, such as a seismic device positioned near your brine well? Yes ☐ No☐
Have you submitted all of your monthly, quarterly, or annual reports to the OCD? Yes ☐ No☐
Have you failed a brine well mechanical integrity test (MIT)? If yes, please attach details and results. Attached ☐
Have you ever had a casing leak? Yes ☐ No☐ Have you ever had a cavern leak? Yes ☐ No☐ Don't know ☐ Have you ever exceeded the cavern fracture pressure? Yes ☐ No☐ Don't know ☐ Do you know how to calculate your maximum pressure? Yes ☐ No☐ Don't know ☐
Have you routinely looked for cracks or fissures in the ground surface around your brine well? Yes ☐ No☐
Do you have any minor or major cracks, fissures, tank settlement, line breakage from settlement or any minor subsidence. Yes ☐ No☐
During operations have you experienced any ground vibration, ground movement, or well movement after opening or shunting valves, pump start-up, shut-down, etc.? Yes☐ No☐

Have you ever experienced unexpected pressure gain or loss in the cavern? Yes☐ No☐ If Yes, was there a difference in your normal flow rate? Yes☐ No☐
Anytime during the past 5 years, have you experienced a noticeable difference between fresh water volume pumped into the well verses brine water produced? Yes ☐ No☐
Are you concerned about pulling the tubing due to the fact it may be difficult to re-enter the hole? Yes☐ No☐
Are you concerned about running a sonar tool in fear of losing tool because of debris in hole? Yes☐ No☐
Have you ever conducted a fly over of your well site? No☐ *Yes☐ if yes, please provide photo.* ☐ *Photo(s) attached*
Calculation: Please divide your estimated total volume of produced brine by 180,000 and multiply by 50. ***Example:*** If you have produced a total of 18,000,000 bbls of brine in the life time of the well then your calculation would be 18,000,000/180,000 = 100 x 50 = 5000. 1. Provide the calculated number above here:_____. 2. Now provide the depth (ft) from the surface to your casing shoe:_____ . Is the calculated number found in #1 above greater than #2? Yes☐ No☐
Comments or recommendations for OCD:

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment."

_____
Company Name-print name above

_____
Company Representative- print name

_____
Company Representative- Signature

Title_____

Date:_____

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, July 02, 2008 8:48 AM
To: 'Lisa Rice'
Cc: 'iwcarlsbad@plateautel.net'; Price, Wayne, EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: kevin & BW-6 Subsidence Monitoring Program

Ms. Rice:

Good morning. I met with Mr. Kevin Wilson (I & W) on December 12, 2007 at the facility to discuss the Subsidence Monitoring Program for the above subject facility in Carlsbad, New Mexico. On February 29, 2008, the OCD followed up with I & W via e-mail while working on the discharge permit renewal (BW-6) and provided some diagrams for acceptable monuments related to the subsidence monitoring sections of the permit. The OCD provided permit language with line items conditions that would help I & W fulfill its Subsidence Monitoring System requirements under the permit (see e-mail message w/ pertinent information from Feb. 29, 2008 e-mail below). I & W appears to have addressed Discharge Permit Item # 21F below. However, Permit Item # 20B "health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public" has not been adequately addressed by your May 27, 2008 submittal.

On May 27, 2008, I & W responded via an e-mail from you with information from Mr. Wilson on the facility Subsidence Monitoring Program. It appears that the original surveyor has been replaced by Mr. Melvin R. Pyeatt's Surveying Firm. Please refer to OCD comments in yellow highlight below that require your immediate attention.

20 B. Subsidence Monitoring System: I&W, Inc. shall submit for long-term subsidence, a report displaying all subsidence monitoring stations and monitoring completed to date to address the requirements of the prior discharge plan by June 30, 2008. The report shall summarize and include subsidence tables and graphs to 0.01 ft. A map shall depict the facility and monitoring points to scale with verification of certified surveyor geodetic datums or elevations are properly recorded. The report shall propose a schedule for long-term surveying to ensure public safety subsidence/collapse issues are addressed due to the shallow nature of the brine cavity. The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public.

21. F. Capacity/ Cavity Configuration and Subsidence Survey: The operator shall provide information on the size and extent of the solution cavern and geologic/engineering data demonstrating that continued brine extraction will not cause surface subsidence, collapse or damage to property, or become a threat to public health and the environment. This information shall be supplied in each annual report. OCD may require the operator to perform additional well surveys, test, and install subsidence monitoring in order to demonstrate the integrity of the system. If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery.***

The OCD may approve a Subsidence Monitoring Report with the following major conditions:

1) A map to scale is required with the survey monument points and nearest geodetic survey point depicted. (The nearest geodetic survey point (i.e., Govt. DOT marker, USGS Marker, etc.) is not depicted on the map. Please submit a new map.)

2) A USGS or DOT Geodetic Survey Elevation Point closest to the facility must be surveyed in with the rest of the approved monument points to establish an accurate survey for the facility subsidence monitoring program. (See Item #1 above to address this issue.)

3) The number of markers or monuments in the report is not sufficient to address subsidence monitoring concerns at the facility. The OCD has attached a "Monument Construction Examples 2-29-08" file to illustrate

acceptable monument construction options for the facility subsidence monitoring program. The OCD requires elevation monitoring at 1 nearby USGS or USDOT geodetic elevation monitoring datum; 4 monument datum locations; 2 top-of-casings (Eugenie #1 & 2) and associated ground elevations for public safety. The locations are as follows: 4 monuments or markers positioned at the four corners of the property (please refer to your map provided to the OCD); the nearby geodetic survey datum mentioned in Item # 2 above and the top-of-casings and associated ground elevations at the Eugenie Wells #1 & 2. I & W does not appear to have properly constructed monuments at all corners of the property. An official govt. geodetic elevation survey point is not depicted. Ground elevations at Eugenie Wells # 1 & 2 must also be surveyed to comply with Discharge Permit Item 20B.

4) Survey monuments or markers are to be surveyed to the nearest 0.01 foot consistent with standard piezometer or monitor well top-of-casing and ground elevation surveying. The surveying shall be conducted biannually in July and January of each year for at least 2 years with an opportunity for more frequent or less frequent monitoring justified or based on the facility subsidence monitoring program data results and annual report.

5) An annual report illustrating the facility map to scale with monument or marker locations and subsidence tables and graphs with elevation data to the nearest 0.01 foot. The OCD has attached a US DOI report entitled, "Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS" (1986). A simple table and graph depicting each monument location elevation over time will satisfy this provision. Submit a sample table showing the information that I & W will be collecting is requested.

6) The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public. Please submit a health and safety plan to satisfy this requirement of Discharge Permit Item 20B.

7) In accordance with the discharge permit, "If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery.***"

8) The OCD is very concerned about the shallow depth of BW-6 (~ 600 ft. below ground surface) brine production and adjacent and nearby surface infrastructures (i.e., roadways, businesses, traffic, etc.) and population near to BW-6. Consequently, the OCD recommends that I & W increase the depth of its operations in the salt to facilitate a more structurally sound brine production operation and to minimize subsidence in the area.

Please contact me upon receipt of this provisional approval to discuss I & W's intent to meet the monument or marker install requirements with map to scale by July 16, 2008. The first survey should begin in July of 2008 to be on schedule.

Please address the above highlighted items in the next 14 days. Please contact me if you have questions. Thank you for your cooperation in this serious matter.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Lisa Rice [mailto:lisa@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:15 AM
To: Chavez, Carl J, EMNRD
Subject: FW: kevin

From: Shallon Finkbone [mailto:shallon@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:02 AM
To: lisa@iandwinc.com
Subject: kevin

MR. Chavez: Here is some information on the subsidence monitoring on the Eugenie #1 for I & W, Inc. If you have any questions please contact me at lisa@iandwinc.com

Thank you for your time
Lisa Rice and Kevin Wilson

Chavez, Carl J, EMNRD

From: Lisa Rice [lisa@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:15 AM
To: Chavez, Carl J, EMNRD
Subject: FW: kevin
Attachments: p3.tif; p1.tif; p2.tif; kevin.doc

From: Shallon Finkbone [mailto:shallon@iandwinc.com]
Sent: Tuesday, May 27, 2008 10:02 AM
To: lisa@iandwinc.com
Subject: kevin

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Thank you for your time
Lisa Rice and Kevin Wilson

May 27, 2008

Dear Mr. Chavez,

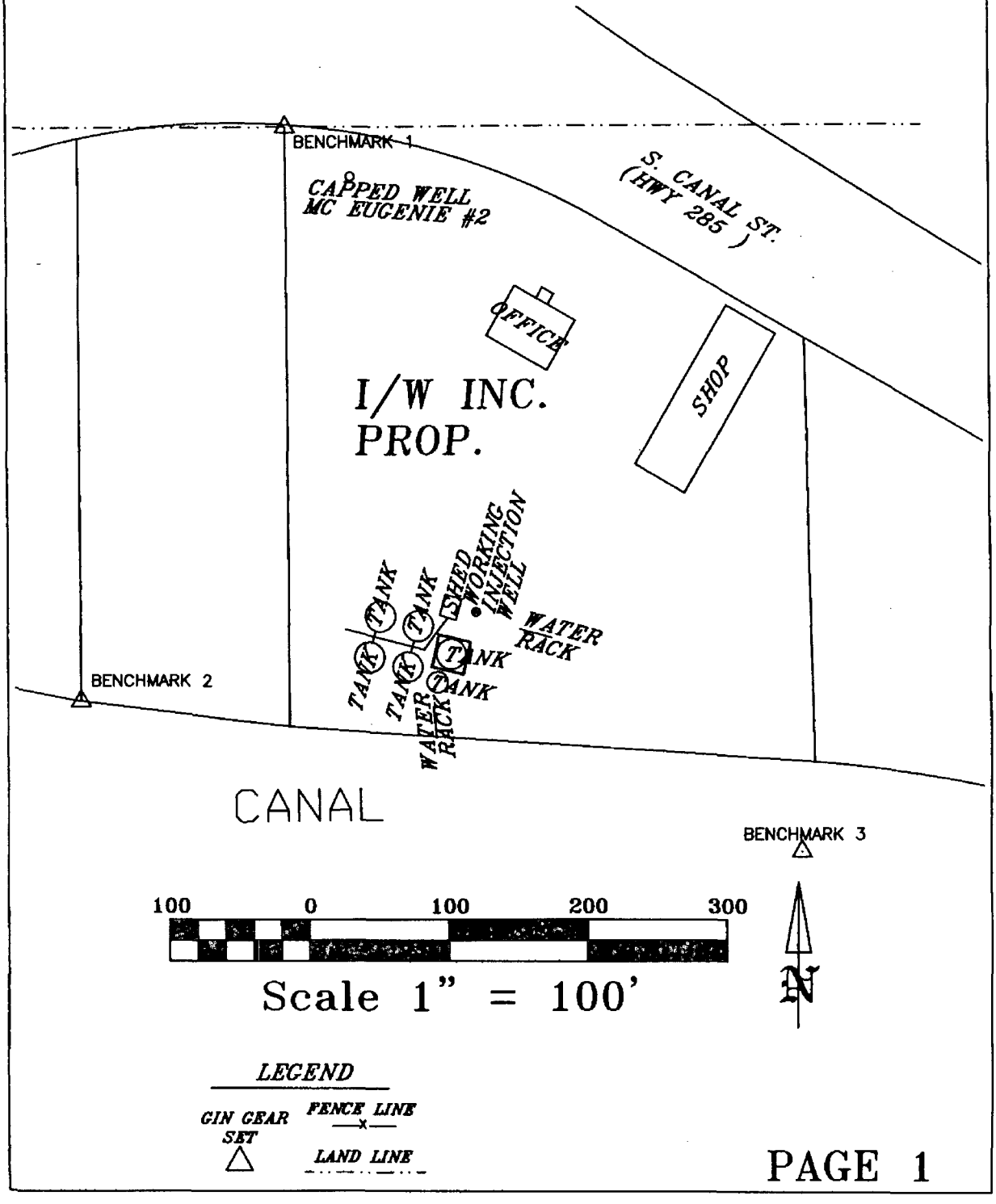
Sorry for the delay in the startup on the I&W Eugenie #1(BW-006) subsidence monitoring project. The original surveyor, Mr. Dan R. Reddy, Consultant and Engineering Company, had numerous delays that were health related. Mr. Reddy finally informed us that they were considering retirement. At that point I&W contacted Mr. Melvin R. Pyeatt's Surveying Firm and started our project again. Enclosed you will find I&W's initial startup for the subsidence monitoring project on the Eugenie #1 (BW-006).

Sincerely,

Kevin Wilson
Operations Manager

EXHIBIT A

WELL AND BENCHMARK LOCATION FOR I/W INC. FOR PURPOSES OF MONITORING GROUND SUBSIDENCE



SURVEY
FIELD EQUIPMENT USED

One GPS unit was employed in the establishment of the state plane coordinates and geodetic coordinates of benchmarks and injection wells requested to be located.

Unit 2 was a Topcon GPS HIPER+.
Receiver type: GGD GPS/GLONASS L1/L2.
Tracked signals: L1/L2, AND C/A, and P code and carrier, waas/egnds.
Survey mode: RTK.
Accuracy: H: 10mm + 1.0ppm x base line length.
V: 15mm + 1.0ppm x base line length.

Known government benchmarks in the near area to the project site were used to find the elevations of the wells and benchmarks requested.

GEODETIC, NEW MEXICO EAST, AND ELEVATIONAL COORDINATES OF 3 BENCHMARKS AND 2 WELLS LOCATED ON THE I/W INC. PROPERTY.

BENCHMARK 1
LAT:32° 23' 20.6723"N
LONG:104° 13' 06.8066"W
ELEV: 3129.47'
N: 505293.551
E: 576763.208
DESCRIPTION: HWY R.O.W. R.R. IRON AT NORTHWEST CORNER OF PROPERTY

BENCHMARK 2
LAT: 32° 23' 16.6302"N
LONG: 104° 13' 08.5407"W
ELEV: 3130.49'
N: 504884.949
E: 576614.957
DESCRIPTION: R.R. IRON AT THE SOUTHWEST CORNER OF WEST ADJOINING PROPERTY

BENCHMARK 3
LAT: 32° 23' 15.5749"N
LONG: 104° 13' 02.5117"W
ELEV: 3131.73'
N: 504778.860
E: 577131.990
DESCRIPTION: PK NAIL SET IN A CONCRETE SLAB IN THE NORTH DRIVING LANE ON THE C.I.D. CANAL

CAPPED INJECTION WELL
LAT: 32° 23' 20.3236"N
LONG: 104° 13' 06.2666"W
ELEV: 3128.89'
N: 505258.357
E: 576809.542
DESCRIPTION: LOCATION WAS TAKEN ON THE SOUTHEASTERLY SIDE, ON THE GROUND, OF THE STAND PIPE

WORKING INJECTION WELL
LAT: 32° 23' 17.2503"N
LONG: 104° 13' 05.2321"W
ELEV: 3131.13'
N: 504947.906
E: 576898.570
DESCRIPTION: LOCATION IS ON THE EASTERLY FLANGE ON THE OUTSIDE CASING OF WELL

THE GEODECTIC COORDINATES LISTED HERE ARE WGS 1984, THE ELEVATIONS LISTED ARE NAVD 1988, THE STATE PLANE COORDINATES LISTED ARE NEW MEXICO EAST COORDINATES. THE GEODECTIC COORDINATES WERE OBTAINED ON MAY 9, 2008.

5/14/2008

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Friday, February 29, 2008 2:49 PM
To: 'Lisa Rice'; 'iwcarlsbad@plateautel.net'
Cc: Price, Wayne, EMNRD; Jones, William V., EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: BW-6 Subsidence Monitor Eugenie #1 & 2 I & W, Inc.
Attachments: KS Subsid Monitor Case.tif; Monument Construction Examples 2-29-08.tif

Dear Ms. Rice, Mr. Wilson, et. al:

Good afternoon. The New Mexico Oil Conservation Division (OCD) has reviewed I & W's "Subsidence Monitor Eugenie #1 I&W Inc. proposal or report (report). The OCD is in the process of finalizing the discharge permit renewal for BW-6, which includes Items pertaining to subsidence monitoring listed below.

20 B. Subsidence Monitoring System: I&W, Inc. shall submit for long-term subsidence, a report displaying all subsidence monitoring stations and monitoring completed to date to address the requirements of the prior discharge plan by June 30, 2008. The report shall summarize and include subsidence tables and graphs to 0.01 ft. A map shall depict the facility and monitoring points to scale with verification of certified surveyor geodetic datums or elevations are properly recorded. The report shall propose a schedule for long-term surveying to ensure public safety subsidence/collapse issues are addressed due to the shallow nature of the brine cavity. The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public.

21. F. Capacity/ Cavity Configuration and Subsidence Survey: The operator shall provide information on the size and extent of the solution cavern and geologic/engineering data demonstrating that continued brine extraction will not cause surface subsidence, collapse or damage to property, or become a threat to public health and the environment. This information shall be supplied in each annual report. OCD may require the operator to perform additional well surveys, test, and install subsidence monitoring in order to demonstrate the integrity of the system. If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery.***

The OCD may approve the report with the following major conditions:

1) A map to scale is required with the survey monument points and nearest geodetic survey point depicted.

2) A USGS or DOT Geodetic Survey Elevation Point closest to the facility must be surveyed in with the rest of the approved monument points to establish an accurate survey for the facility subsidence monitoring program.

3) The number of markers or monuments in the report is not sufficient to address subsidence monitoring concerns at the facility. The OCD has attached a "Monument Construction Examples 2-29-08" file to illustrate acceptable monument construction options for the facility subsidence monitoring program. The OCD requires elevation monitoring at 1 nearby USGS or USDOT geodetic elevation monitoring datum; 4 monument datum locations; 2 top-of-casings (Eugenie #1 & 2) and associated ground elevations for public safety. The locations are as follows: 4 monuments or markers positioned at the four corners of the property (please refer to your map provided to the OCD); the nearby geodetic survey datum mentioned in Item # 2 above and the top-of-casings and associated ground elevations at the Eugenie Wells #1 & 2.

4) Survey monuments or markers are to be surveyed to the nearest 0.01 foot consistent with standard piezometer or monitor well top-of-casing and ground elevation surveying. The surveying shall be conducted biannually in July and January of each year for at least 2 years with an opportunity for more frequent or less frequent monitoring justified or based on the facility subsidence monitoring program data results and annual

report.

5) An annual report illustrating the facility map to scale with monument or marker locations and subsidence tables and graphs with elevation data to the nearest 0.01 foot. The OCD has attached a US DOI report entitled, "Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS" (1986). A simple table and graph depicting each monument location elevation over time will satisfy this provision.

6) The report shall also include: a health and safety plan for alerting the proper authorities, ensuring prompt evacuation of the community, and protection health and safety of the general public.

7) In accordance with the discharge permit, "If the operator cannot demonstrate the integrity of the system to the satisfaction of the Division then the operator may be required to shut-down, close the site and properly plug and abandoned the well. ***Any subsidence must be reported within 24 hours of discovery."***

8) The OCD is very concerned about the shallow depth of BW-6 (~ 600 ft. below ground surface) brine production and adjacent and nearby surface infrastructures (i.e., roadways, businesses, traffic, etc.) and population near to BW-6. Consequently, the OCD recommends that I & W increase the depth of its operations in the salt to facilitate a more structurally sound brine production operation and to minimize subsidence in the area.

Please contact me within 14 days of receipt of this provisional approval to discuss I & W's intent to meet the monument or marker install requirements with map to scale by June 30, 2008. The first survey should begin in July of 2008 as stated above. Thank you.

Please be advised that NMOCD provisional approval of this report does not relieve I & W Inc.of responsibility should their operations fail to adequately investigate and remediate contamination that pose a threat to ground water, surface water, human health or the environment. In addition, NMOCD approval does not relieve I & W of responsibility for compliance with any other federal, state, or local laws and/or regulations.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3491
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Lisa Rice [mailto:lisa@iandwinc.com]
Sent: Monday, February 11, 2008 11:53 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitor Eugenie #1 I & W, Inc.

Mr. Chavez:

In regards to the subsidence monitoring at I & W' S Eugenie #1 (BW 006) facility. The resurfacing work at our yard & brine station should be completed this week (2/15/08). I have included a site map for your review. The cavern is less than 80 feet in any direction from the well head. The three marked points are the proposed monitors that are in line of sight & the greatest distance from the well on I & W' s property.

The three markers will be constructed out of 3" pipe. The top of the pipe will be capped and a designated point will be marked for consistent monitoring. The pipe will be placed in a 12" hole approximately 4 feet deep with cement up to ground level. Approximately 1 foot will be above ground for our surveyor to use as a monitoring point.

If this sounds okay to you, we will go ahead and set the three monitors & let the cement be setting up.

The surveyor / engineer will be ready to establish initial readings as soon as we contact him. Please let me know if this will be acceptable and we will get started.

Sincerely,
Kevin Wilson
Operations Manager

Chavez, Carl J, EMNRD

From: Lisa Rice [lisa@iandwinc.com]
Sent: Monday, February 11, 2008 11:53 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitor Eugenie #1 I & W, Inc.
Attachments: map

Mr. Chavez:

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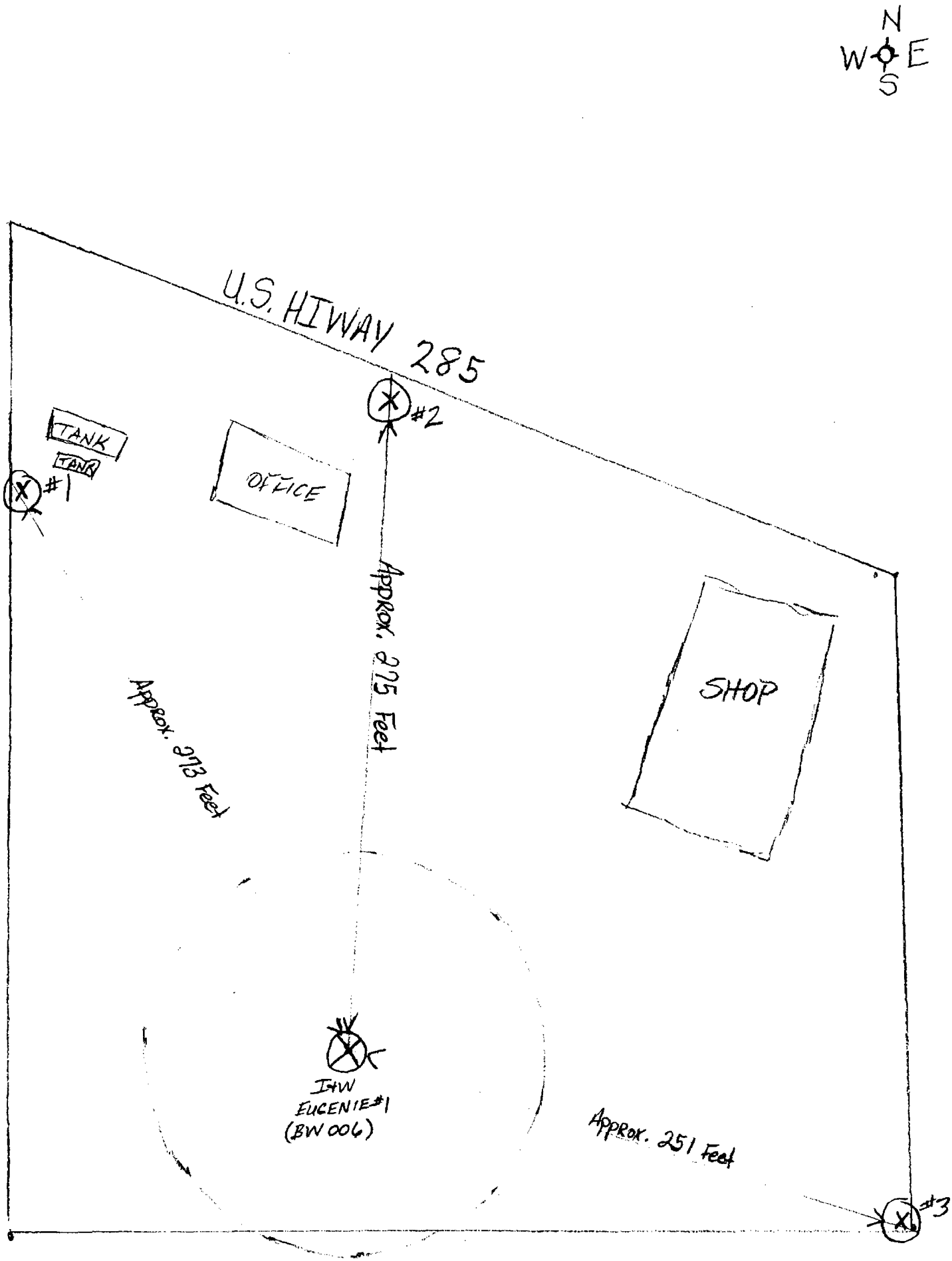
N
W
E
S
U.S. HIWAY 285
#2
TANK
TANK
#1
OFFICE
Approx. 275 Feet
SHOP
Approx. 273 Feet
I+W
EUCENIE#1
(BW006)
Approx. 251 Feet
#3

IC 9083

Bureau of Mines Information Circular/1986

Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS

By Robert C. Dyni

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 9083

Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS

By Robert C. Dyni

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald Paul Hodel, Secretary

BUREAU OF MINES
Robert C. Horton, Director

This report is based upon work done under an agreement between the Solution Mining

SUBSIDENCE INVESTIGATIONS OVER SALT-SOLUTION MINES, HUTCHINSON, KS

By Robert C. Dynl[1]

ABSTRACT

The Bureau of Mines in cooperation with the Solution Mining Research Institute conducted surface and subsurface investigations over five solution-mined salt cavities in the Hutchinson, KS, area. The purpose of these investigations was to determine the mechanisms that lead to the formation of sinkholes above collapsed solution cavities. Of the five salt-solution cavities investigated, four had collapsed and produced sinkholes prior to the time of the investigations; the fifth cavity was considered stable. Exploratory drilling and coring operations were conducted at all five sites; surface stability monitoring was conducted at three of them. The results of these studies indicate that excessive dissolution at the salt-shale contact of each collapsed cavity produced large, unsupported roof spans that ultimately exceeded the structural integrity of the overburden. The stable cavity was not exposed to excessive dissolution at the salt-shale contact; this limited the roof span and ensured a stable cavity. The data also show that surface settlement in the vicinity of the two surface-monitored sinkholes continued for approximately 7 years after the sinkholes formed, indicating that the rubble piles of the collapsed cavities were undergoing gradual consolidation.

[1]Physicist, Denver Research Center, Bureau of Mines, Denver, CO.

upper shale surface, then the roof will start receiving support by the rubble and the bulking process will be stopped (fig. 2*A*). A shallow sinkhole may develop as a result of the downward deflection of the shale roof and the consolidation of the rubble pile even though the bulking process has been halted (fig. 2*B*). If, however, the distance between the top of the cavity and the top of the rubble pile does not become zero before the roof reaches the upper shale layers, then a chimney forms and propagates through the upper shale layers to the unconsolidated soils near the surface. This material then flows down into the remaining void and can create a deep sinkhole (fig. 2*C*).

A trigger mechanism that reduces critical support from a marginally stable roof can consist of a reduction of brine pressure inside the cavity, a reduction of the buoyancy effect on shale fragments suspended from the roof of the cavity, or the removal of critical roof support by continuing salt dissolution. Hendron (4) indicates that these conditions most likely are interrelated and act simultaneously to initiate the failure of a cavity roof.

If all four conditions for rapid sinkhole development are met, a deep sinkhole as shown in figure 2*C* will most likely be the result. If, however, only a large unsupported roof span at the salt-shale contact and triggering mechanisms are present, shallow sinkholes as shown in figure 2*B* can possibly form. Shallow sinkholes do not develop as rapidly as deep sinkholes, and their dimensions may increase with time. As mentioned earlier, the bulking process in shallow sinkholes does not progress up to the ground surface, and no chimney is formed in the shale layers. If only the first condition is met, the unsupported shale layers above the cavity will tend to deflect down into the opening, producing subsidence on the ground surface. This subsidence develops gradually over a long period and affects a large surface area over the cavity (4, pp. 3-4). Further analysis on sinkhole failure mechanisms is provided by Hendron (4).

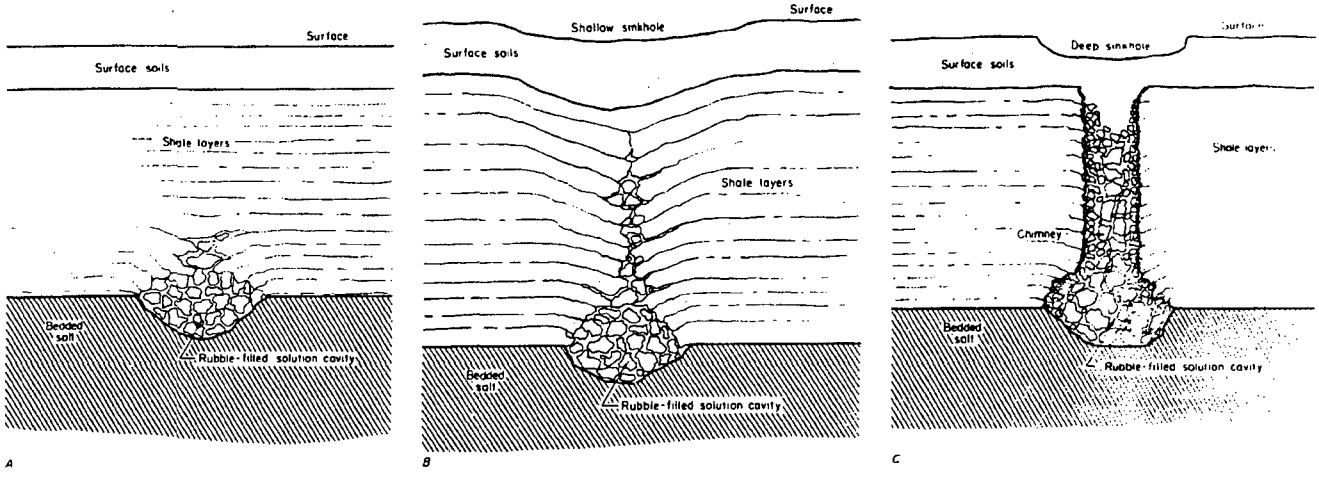

FIGURE 2.—Cavity collapse with surface deformations.

boring V-3. The inclined boreholes I-1 and I-2 were each about 260 ft in depth. Complete details on the drilling and coring procedures are given by Hendron (1, pp. 1-2).

Borings V-3 and V-4 each encountered the top of the salt deposit at a depth of approximately 420 ft. These borings found no evidence of any surface sands from the sinkhole, or any voids or disturbances in the strata overlying the salt. Borings V-1 and V-2, however, both found evidence of voids and disturbances in the shale at depths of approximately 240 to 245 ft, and boring V-1 also found a large void and surface sands from the sinkhole at a depth of about 388 ft. These findings indicate that an elongated cavity had developed in the northeast-southwest direction under the sinkhole, caused by the solution activity of the neighboring brine wells. The evidence also suggests that the roof shale over the salt had caved upward about 30 ft at the location of boring V-1, and that some large block movements of the shale had extended as much as 180 ft into the shale above the elongated cavity (1, pp. 7-8). Walters (6, p. 45) suggests that the configuration of the elongated cavity exceeded the span capabilities of the overlying rock layers. This allowed the failure of these layers to breach the uppermost shale layer and permit approximately 90,000 yd^3 of sand and gravel to move down into the opening (2, p. 2). The sand that was encountered in the inclined borings I-1 and I-2 indicates that an approximately 100-ft-diam chimney of sand was located below the center of the sinkhole. The sinkhole and the chimney both were elongated in the northeast-southwest direction, indicating that the influence of the underlying cavity elongated along the line of brine wells in the area (1, p. 8). Figure 5 shows

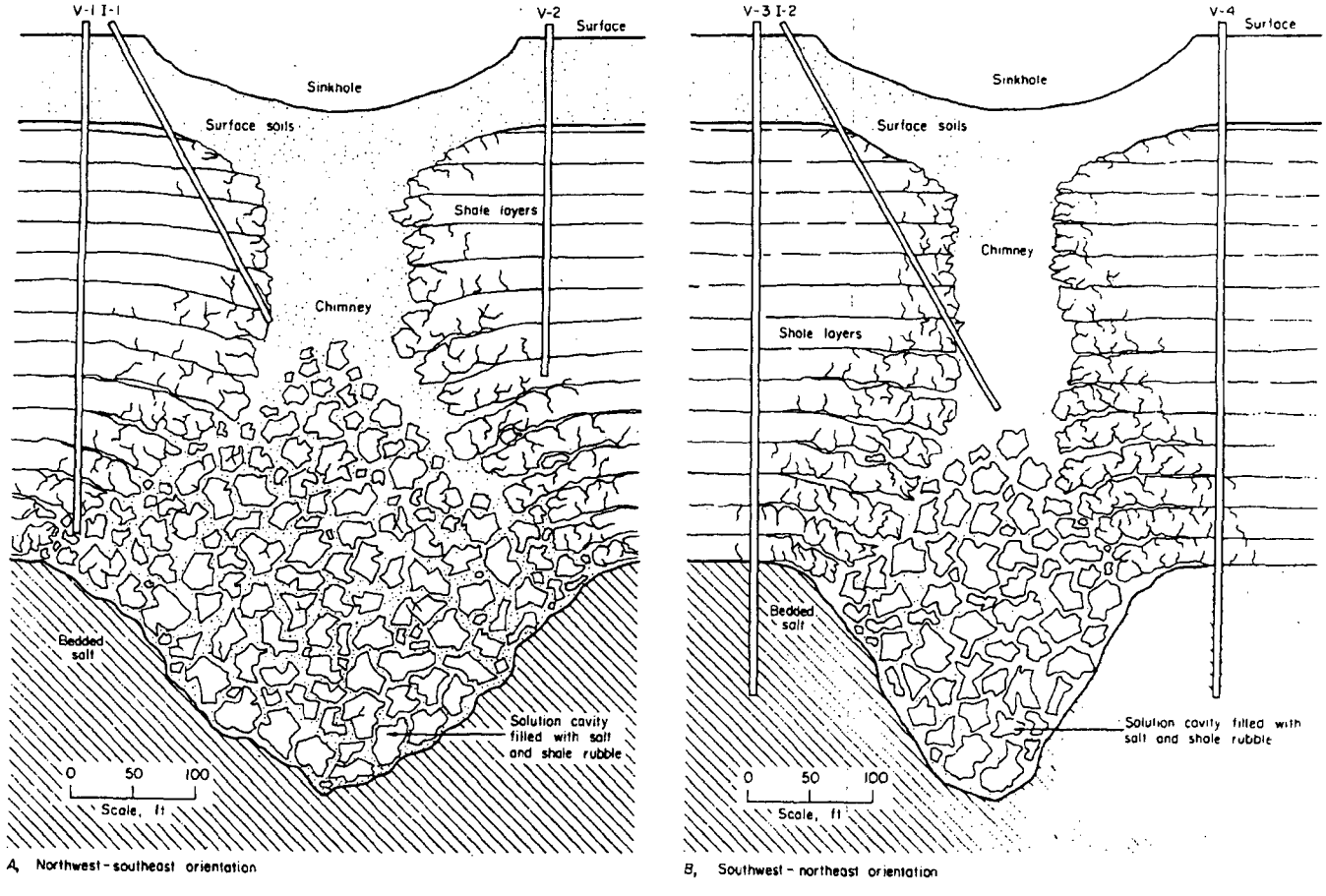

FIGURE 5.—Cross sections of Cargill sinkhole.

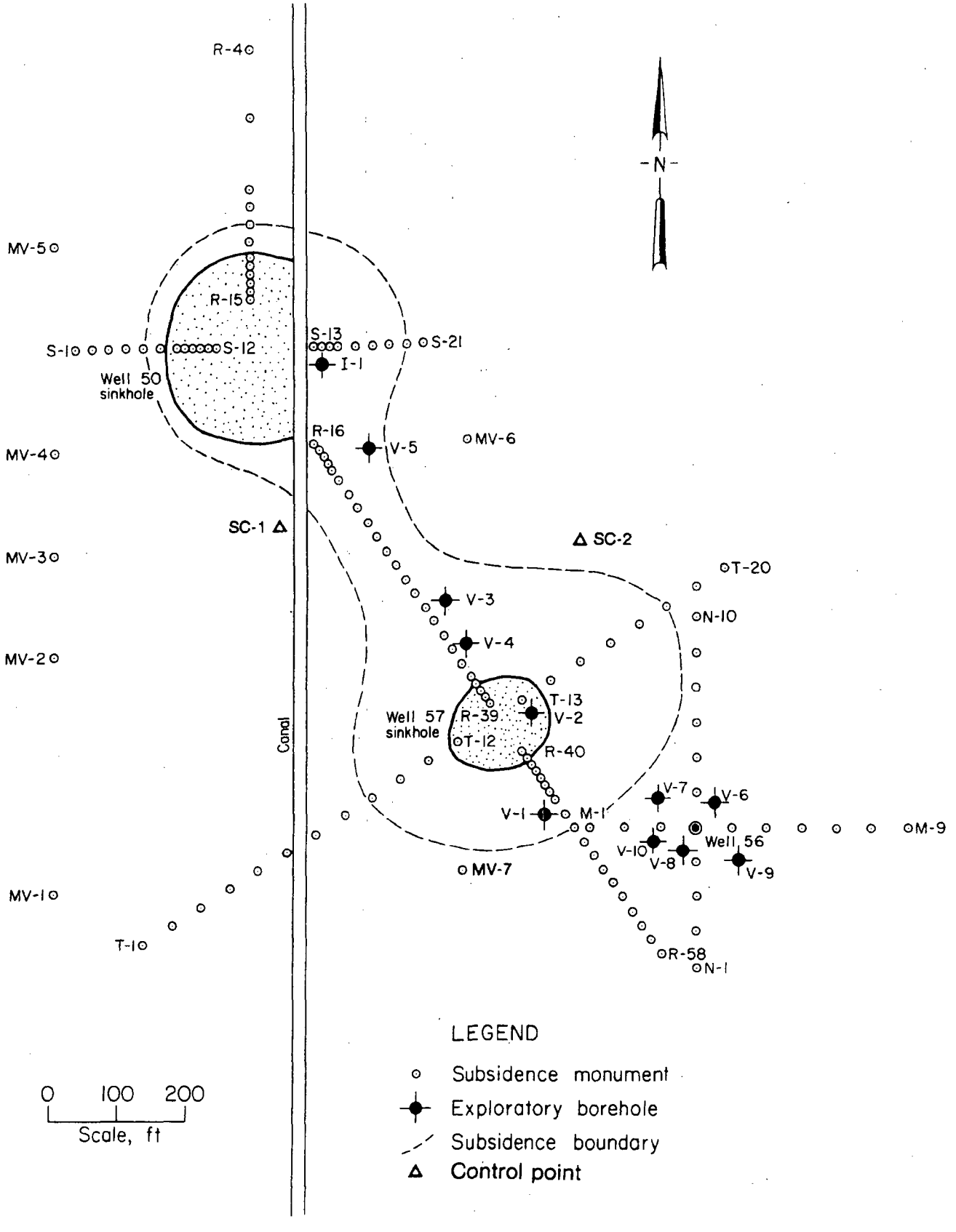

FIGURE 9.—Location of boreholes and subsidence monuments at Carey brinefield.

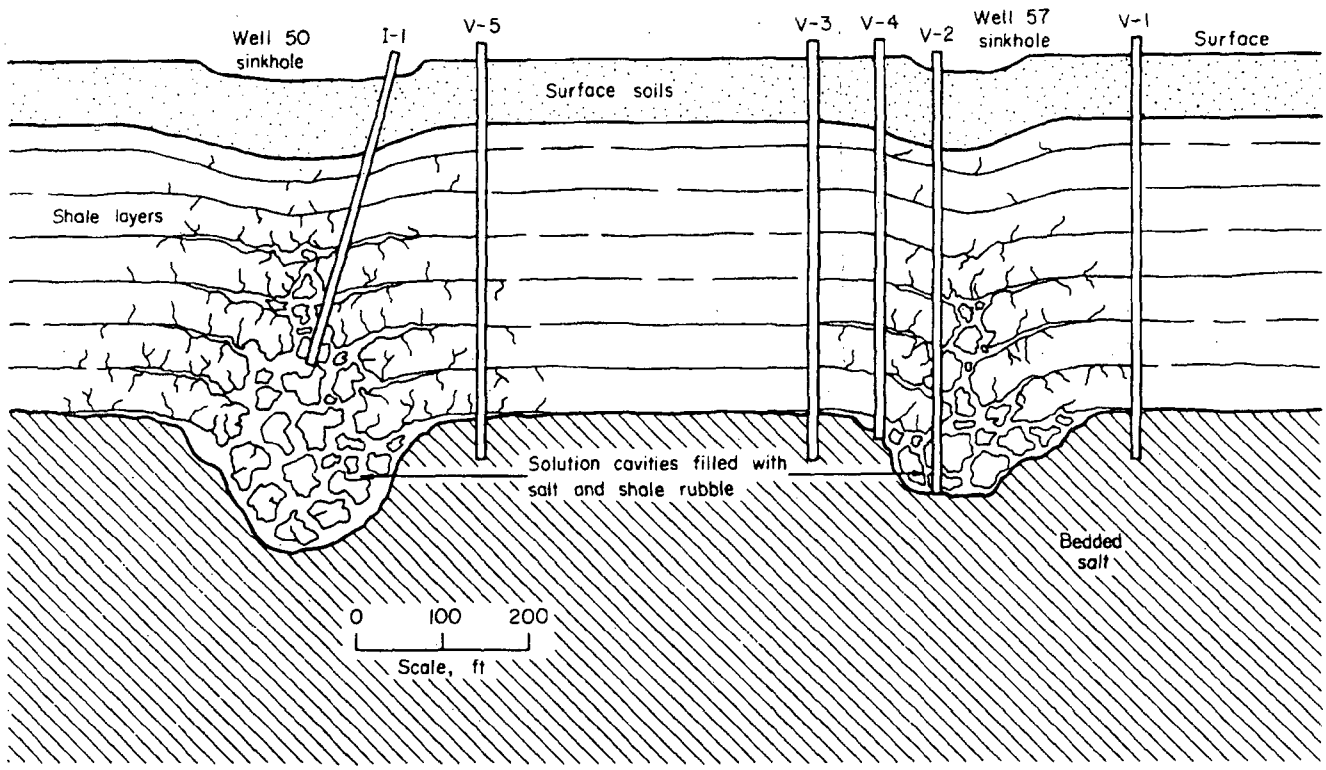

FIGURE 10.—Cross section of Carey sinkholes.

the cavity was in some stage of progressive failure, or if the cavity was presently stable but likely to fail in the future.

The investigation consisted of drilling and coring five (V-6 to V-10) exploratory borings and extending the subsidence-monitoring network to the area around well 56 (fig. 9). The Bureau was responsible for extending and monitoring the network, and SMRI was responsible for supervising the drilling and coring operations funded by the Bureau. Boring V-6 was advanced to a depth of 565 ft, boring V-7 to 436.5 ft, boring V-8 to 515 ft, boring V-9 to 502.5 ft, and boring V-10 to 552.5 ft (2, pp. 8-9). Details on the drilling and coring procedures are given by Hendron (2, pp. 8-9).

The drilling and coring results indicated the shale overlying the solution cavity was intact and undisturbed to within several feet of the salt-shale contact (fig. 11). Near the roof, the shale had softened and undergone bed separations. The cavity appeared to be elongated in the southeast-northwest direction with a roof span of about 150 ft. In the southwest-northeast direction, the roof span was estimated to be approximately 50 ft. The restricted roof span dimensions near the shale were most likely due to the fact that well 56 had been operated by pumping fresh water down the tubing that extended close to the bottom of the salt deposit. This resulted in most of the solutioning occurring deep in the salt and away from the overlying shale. The borings also indicated that there was only a limited amount of shale exposed in the roof of the cavity that was subjected to deterioration by fresh water (2, pp. 37-39). Hendron (2, p. 39) suggests that the limited exposure of the shale to the deteriorating action of fresh water beneath the well in combination with the limited roof spans over the cavity led to a stronger roof support and a stable cavity.

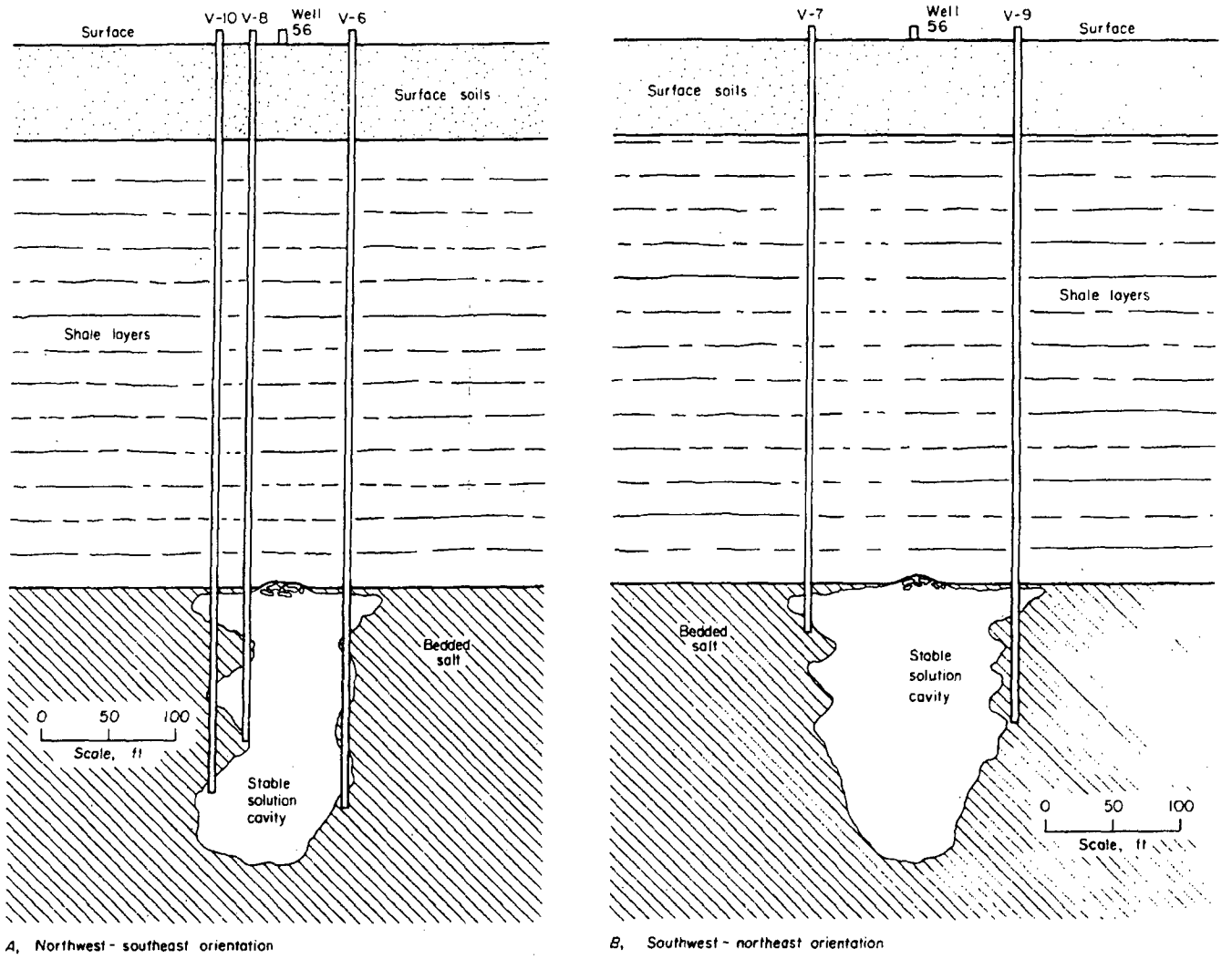

FIGURE 11.—Cross section of Carey well 56.

BUREAU OF MINES SURFACE SUBSIDENCE INVESTIGATIONS

FIRST AND SECOND INVESTIGATIONS

The investigations carried out at the Barton and Cargill sinkholes did not include surface monitoring programs.

CAREY 1978 SINKHOLES (THIRD INVESTIGATION)

Background

In 1979 the Bureau installed a subsidence-monitoring network around wells 50 and 57 in the Carey brinefield. A total of 154 survey points were used to monitor the horizontal and vertical ground surface movements in the vicinity of the two sinkholes. The network consisted of 1 existing control point, 4 Bureau-installed control points, 103 Bureau-installed subsidence monuments, 10 Carey-installed subsidence monuments, and survey marks set on the 6 exploratory borings and on 30 brine wells.

Subsidence-Monitoring Network Design and Construction

The network (fig. 9) was designed to monitor any positional changes of the ground surface associated with the two sinkholes around wells 50 and 57, as well as in other areas of the brinefield. The S-line (S-1 to S-21) and a portion of the

R-line (R-4 to R-15) subsidence monuments were positioned in the area around the well 50 sinkhole. These two monument lines intersected at right angles near the center of the well 50 sinkhole. The T-line (T-1 to T-20) and the remainder of the R-line (R-16 to R-58) monuments were positioned in the area around the well 57 sinkhole. These two monument lines intersected at right angles near the center of the well 57 sinkhole. The monuments R-16 to R-58 were also designed to monitor the area between the two sinkholes and were therefore oriented along the axis between the two sinkhole centers. The MV-line monuments were distributed throughout the area around the sinkholes to monitor any ground surface movements due to neighboring wells. The remainder of the survey points, including the wells, boreholes, and previously installed survey movements, were used to monitor movements of the ground surface over a large area around the two sinkholes. Control points P-1, P-2, and P-3 were placed in areas that were considered to be stable and not affected by solution mining activities; these control points were located in areas outside the area shown in figure 9. Control points SC-1 and SC-2 were located in the brinefield for the trilateration surveys and were checked for stability prior to each survey.

The 4 control points and the 103 monuments installed by the Bureau at the Carey brinefield were all of the same design and construction (fig. 12). The monument consists of a small inner pipe fitted with a pointed anchor on the bottom and a reference-marked cap on the top, and a large outer pipe which is used to drive the anchor below frost depth. The inner pipe extends through a cap on top of the outer pipe. The outer pipe is free to undergo movements due to frost heave or swelling and shrinking soils without affecting the inner pipe on which measurements are made. The monuments proved to be very stable and effectively guarded against soil distances throughout the entire time of the investigation.

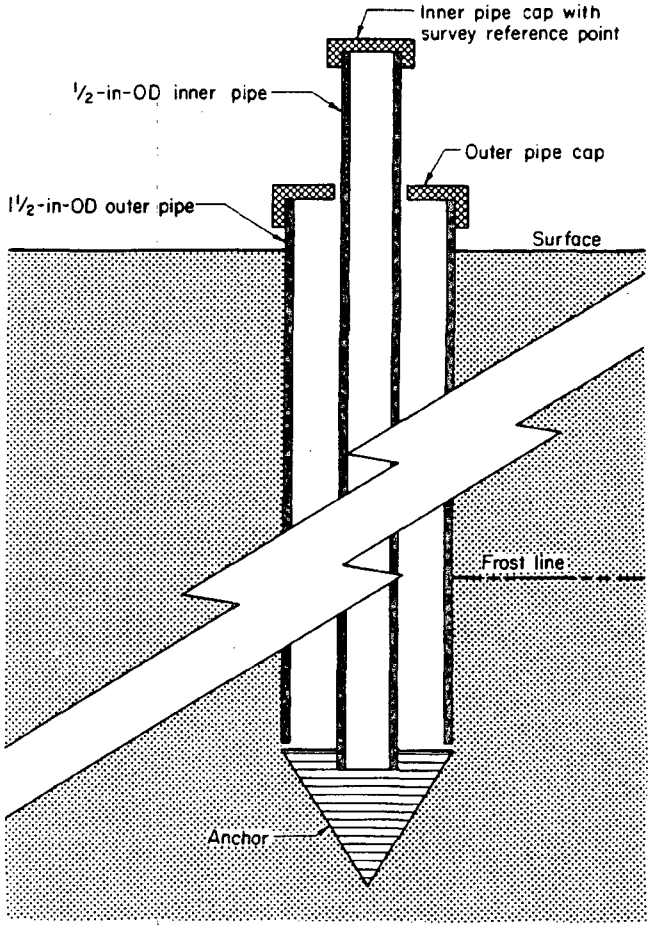

FIGURE 12.—Detail of Bureau-designed subsidence monument.

The wells, boreholes, and structures that were used as subsidence monuments all had survey marks that provided consistent reference points.

Monitoring Procedures

The procedures used to monitor positional changes in the network involved various survey techniques. Trialteration and traverse surveying procedures were used for horizontal control, and trigonometric and differential leveling procedures for vertical control. The horizontal control surveys, as well as the trigonometric level surveys, established initial and subsequent coordinates and elevations by measuring angles and distances from control points SC-1 and SC-2

to the monuments in the network. Although SC-1 and SC-2 were located within the brinefield boundaries, their stability was verified before each survey by using trilateration and differential leveling procedures from control points P-1, P-2, and P-3, which were located on stable ground away from the brinefield. The Bureau began surveying the network in June 1979 and continued through February 1983. A total of 17 vertical and 12 horizontal control surveys were performed.

Results--Vertical Movement

The results from the vertical control surveys indicated that both sinkholes experienced vertical settlements between June 1979 and February 1983. Appendix A contains data from the final vertical control survey of the Carey brinefield; these data were used to calculate the maximum vertical displacements of the subsidence monuments.

Data from the R-line indicated that vertical settlements occurred between monuments R-7 and R-50. From R-4 to R-15 (fig. 13) the settlements increased linearly, starting at monument R-8 and continuing toward the well 50 sinkhole. The maximum vertical settlement measured was 1.58±0.04 ft at R-15. From R-16 to R-39 (fig. 14) the subsidence was concentrated in the vicinity of the two sinkholes, with less movement at the midpoint between sinkholes. Vertical settlement in the area around R-16 was 0.18±0.04 ft; settlement in the area around the midpoint between sinkholes (R-26) was 0.09±0.04 ft; and settlement in the area around R-39 was 0.24±0.04 ft. Data from R-40 to R-58 (fig. 15) showed that the

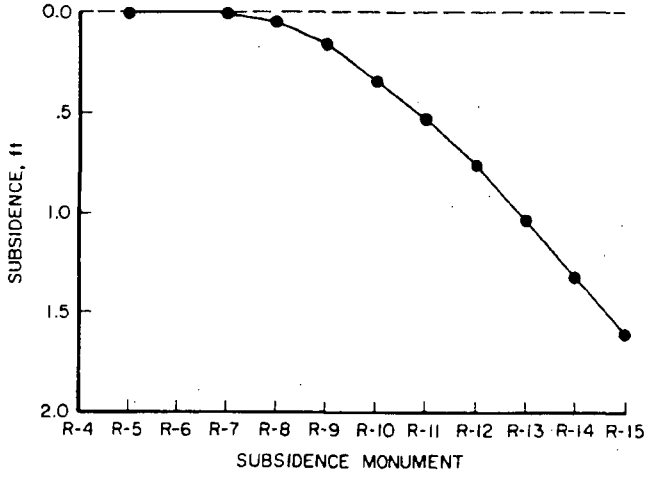

FIGURE 13.—Subsidence from R-4 to R-15.

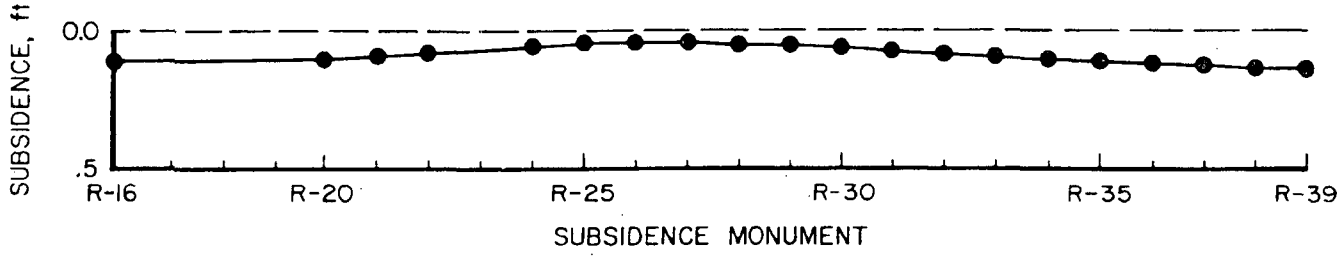

FIGURE 14.—Subsidence from R-16 to R-39.

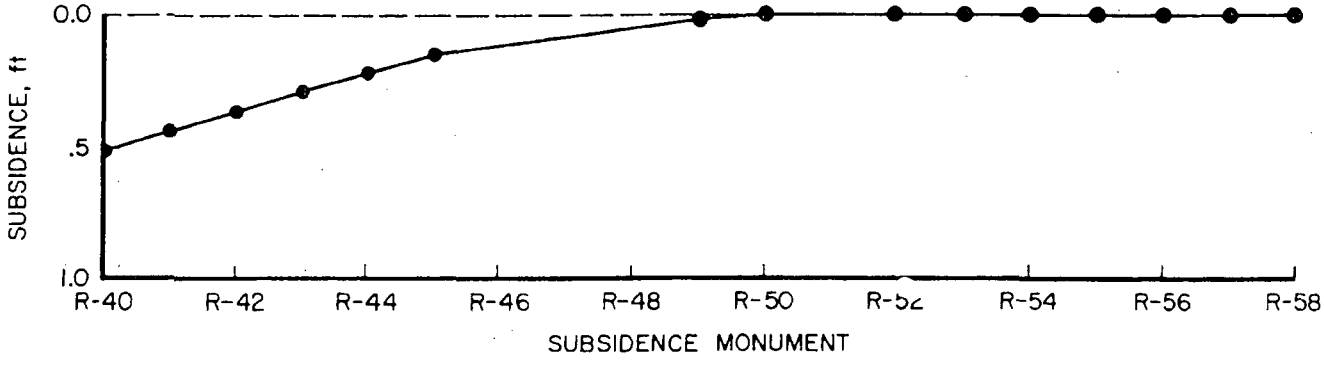

FIGURE 15.—Subsidence from R-40 to R-58.

settlement around the well 57 sinkhole began at R-49 and linearly increased toward the center of the sinkhole. The maximum settlement measured was 0.49±0.04 ft at R-40.

The S-line showed vertical settlement between S-5 and S-20. The line from S-1 to S-12 began movement at S-6 and continued to minearly increase to S-12 (fig. 16). Maximum subsidence of 1.81±0.04 ft was measured at monument S-12. Data from S-13 to S-21 (fig. 17) showed that movement began at S-20 and continued to linearly increase to S-13. The maximum subsidence at S-13 was 0.20±0.04 ft.

Data from the T-line indicated that vertical settlements occurred between T-8 and T-19. The line T-1 to T-12 (fig. 18) experienced movements that started at approximately T-9 and linearly increased to T-12; the maximum subsidence at T-12 was 0.23±0.04 ft. The line from T-13 to T-19 (fig. 19) showed movement that began at approximately T-18 and continued to linearly increase to T-13, where a movement of 0.34±0.04 ft was measured.

Results--Horizontal Movement

The results from the horizontal surveys indicated that minor horizontal movements occurred in the vicinity of the well 50 sinkhole. However, the data from the surveys were inconclusive as to whether any movement had occurred around the well 57 sinkhole. Any possible movements along the R-line from R-16 to R-58, from S-13 to S-21, and the entire T-line were of a magnitude less than could be detected by the surveys; the minimum observable movement was calculated to be ±0.35 ft. Appendix B contains data from the final horizontal control survey of the Carey brinefield; these data were used to calculate the maximum horizontal displacements of the subsidence monuments.

The R-line monuments underwent horizontal displacements oriented along the line from approximately R-10 to R-14 (fig. 20). The movement increased linearly in the direction toward the well 50 sinkhole. The movement at R-14 was approximately 1.0±0.35 ft.

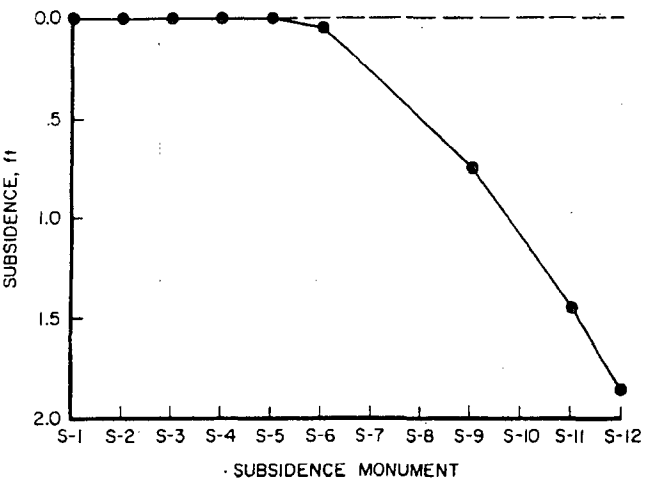

FIGURE 16.—Subsidence from S-1 to S-12.

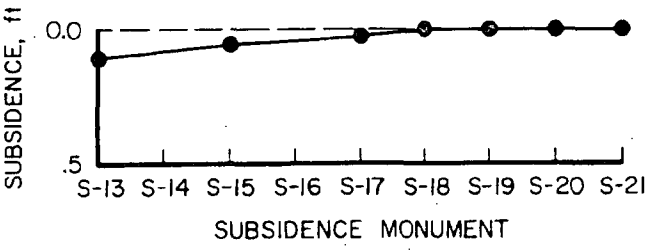

FIGURE 17.—Subsidence from S-13 to S-21.

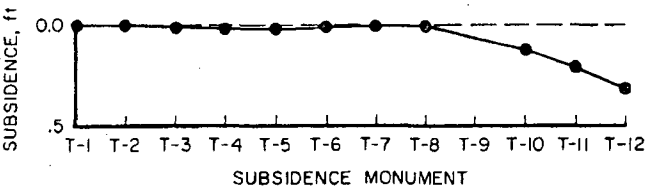

FIGURE 18.—Subsidence from T-1 to T-12.

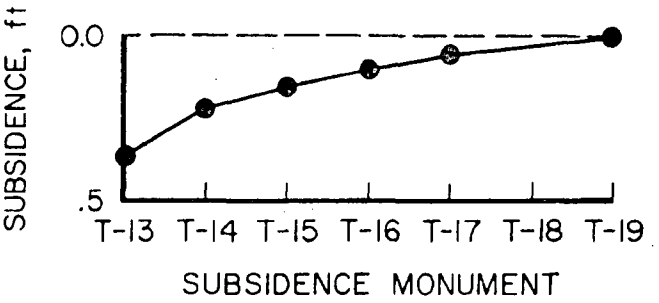

FIGURE 19.—Subsidence from T-13 to T-20.

The S-line monuments underwent horizontal movements that started at approximately S-5 and continued through S-12 (fig. 21). The movement was oriented along the line and increased linearly toward the well 50 sinkhole.

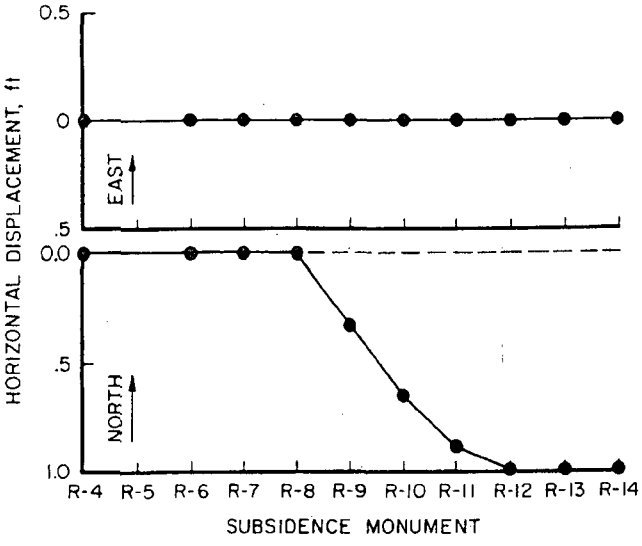

FIGURE 20.—Horizontal movement of R-4 to R-15.

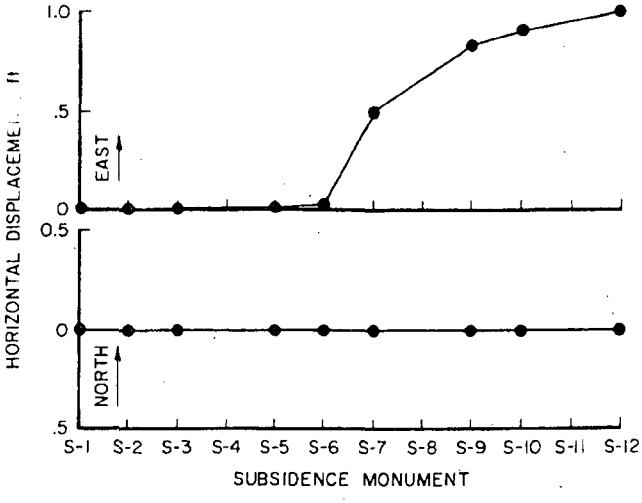

FIGURE 21.—Horizontal movement of S-1 to S-12.

The maximum horizontal movement at S-12 was measured to be approximately 1.0±0.35 ft in the direction toward the sinkhole.

The results of the surveys taken on the T-line and the R-line from R-16 to R-58 were inconclusive as to whether any horizontal movement had taken place. If any movement did occur, it was of a magnitude less than could be ascertained by the results of the horizontal surveys.

CAREY WELL 56 (FOURTH INVESTIGATION)

Background

As part of the fourth investigation, the Bureau monitored a subsidence network in the vicinity of well 56 located at the Carey brinefield. This network was designed to detect any positional changes of the ground surface due to cavity failure around well 56. The network consisted of 19 Bureau-installed subsidence monuments.

Subsidence-Monitoring Network Design and Construction

The area around well 56 was monitored by two perpendicular lines of subsidence monuments (fig. 9). The M-line (M-1 to M-9) was oriented in the east-west direction, and the N-line (N-1 to N-10) was oriented in the north-south direction. The intersection of these two lines occurred at well 56.

The design of the subsidence monuments used in the M-line and N-line was identical to that used for the monuments in the previous investigation (fig. 12). These monuments were installed by Carey personnel using the same techniques as were used by the Bureau in the third investigation.

Monitoring Procedures

As in the third investigation, the Bureau used trilateration and traverse surveying procedures for horizontal control of the subsidence-monitoring network, and trigonometric and differential surveying procedures for vertical control. The monitoring program began in May 1981 and continued through February 1983. Seven vertical and five horizontal surveys were performed.

Results

The data obtained from both the vertical and horizontal surveys indicated that

no apparent movement had occurred in the area around well 56 during the time of the fourth investigation. If any movement did occur, it was of a magnitude less than could be detected by the surveys.

INTERPRETATION OF RESULTS

FIRST AND SECOND INVESTIGATIONS

The analyses of results for the first and second investigations were not performed by the Bureau and are therefore omitted from this report. The analyses can be found in publications by Hendron (1, 3-4) and Walters (6).

THIRD INVESTIGATION

The survey data indicate that the subsidence in the vicinity of the two sinkholes continued throughout the period of the investigation. The results from the exploratory drilling program indicate that sagging shale beds were resting on the roof-fall rubble pile in the well 57 solution cavity; owing to the similarity and proximity of the two wells it was inferred that the well 50 cavity roof was resting on the roof-fall rubble pile in the well 50 cavity. The behavior of the subsidence around the two sinkholes was therefore most likely a result of the gradual settling of the sagging shale beds that was caused by the continued consolidation of the rubble piles on which the shale beds rested. As the rubble piles gradually compacted, the overlying strata responded with a gradual downward deflection into the rubble-filled cavities. If the consolidation processes ceased, the subsidence would also gradually cease; however, the subsidence was not halted, implying that consolidation was still occurring in the two collapsed cavities at the end of the investigation. It is logical to assume that the consolidation processes occurring in the rubble piles will, at some point in time, be completed, and subsidence still occurring after the completion of the investigation will eventually decrease and stop.

The characteristics of the subsidence occurring over the two failed cavities indicate that gradual yet significant settlement of the ground surface can be expected after the initial collapse of a solution cavity and the formation of a sinkhole. This conclusion is further supported by the continued settling of other major sinkholes in the region; the area around the 1952 Barton sinkhole, for example, is still experiencing some minor deformations (6). It is also logical to assume that a larger volume cavity with accompanying sinkhole will experience surface deformations of greater magnitude than a smaller volume cavity; a larger volume cavity will contain a larger rubble pile, and thus experience more initial collapse and eventual consolidation. This is evidenced by comparing the deformations occurring above the well 50 cavity and the smaller well 57 cavity.

The symmetry of the ground surface deformations around the two sinkholes was due to the geometries of the underlying cavities, since the subsidence areas were similar in plan to the probable cavity geometries. The subsidence around well 50 was found to extend approximately 190 ft on the north and west sides of the sinkhole. The area east of the sinkhole was affected by a drainage canal that runs north-south in the vicinity of well 50 (fig. 9); the canal and its effects on the subsidence around the well 50 sinkhole are explained later in this section. The well 57 sinkhole, however, did not have a similar ground surface deformation pattern. The subsidence around the well 57 sinkhole was elongated in the northeast-southwest direction and had a total span of approximately 570 ft. The span of subsidence in the southeast direction was about the same as the dimensions for the well 50 sinkhole subsidence pattern. This could have been the result of a cavity extending in the northeast-southwest direction, elongated by hydraulic connections to other brine

well 56 cavity to have a smaller roof span than the well 50 or well 57 cavities, it is apparent that smaller horizontal cavity dimensions were responsible for creating stable cavity conditions for well 56.

CONCLUSIONS

The four investigations performed by the Bureau in cooperation with the SMRI were designed to determine the characteristics and parameters of sinkhole formation over solution-mined salt cavities. The results from the exploratory drilling and coring investigations indicated that the Cargill sinkhole, the Barton sinkhole, and the two Carey sinkholes all were the result of solution-cavity roof failures caused by large, unsupported roof spans and deteriorating shale roof rock. In the case of the Cargill sinkhole, the cavity roof rock was completely breached, forming a chimney that piped approximately 90,000 yd^3 of surface soil into its interior. The overlying shales of the Barton and the two Carey solution cavities did not completely fail, resulting in these beds sagging and resting on the rubble piles in the solution cavities. The solution cavity of well 56 in the Carey brinefield appeared to be stable in that no sagging or major deterioration of the overlying shales had occurred.

The results of the surveying programs that monitored the ground surface around wells 50, 57, and 56 in the Carey brinefield indicated a relationship between cavity size and subsidence geometry. It was inferred from the drilling and coring program that the postfailure subsidence was due to the consolidation of the rubble piles on which the sagging shale beds rested.

It is evident after evaluating the surface monitoring and the drilling and coring data that the large, unsupported roof spans that ultimately failed were the result of the well completion and mining operation procedures used for each collapsed solution cavity. These methods allowed salt dissolution near the roofs of the cavities, creating the large, unsupported spans that eventually failed. The methods used for salt dissolution in the area have now been changed to prevent salt dissolution near the top of solution cavities so as to limit the dimensions of the cavity roofs. The resulting cavity configurations should be more stable.

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APPENDIX A.--FINAL VERTICAL CONTROL SURVEY OF CAREY BRINEFIELD

(Positive values correspond to downward movement)

Subsidence monument	Movement, ft[1]	Subsidence monument	Movement, ft[1]	Subsidence monument	Movement, ft[1]
M-1	0.02	R-19	NA	S-2	0.02
M-2	.00	R-20	0.22	S-3	.03
M-3	-.01	R-21	.13	S-4	.03
M-4	-.04	R-22	.11	S-5	.04
M-5	-.03	R-23	NA	S-6	.07
M-6	-.01	R-24	.11	S-7	NA
M-7	-.01	R-25	.09	S-8	NA
M-8	.00	R-26	.09	S-9	.75
M-9	.01	R-27	.16	S-10	NA
MV-1	.04	R-28	.10	S-11	1.44
MV-2	.01	R-29	.12	S-12	1.81
MV-3	-.01	R-30	.15	S-13	.20
MV-4	.02	R-31	.12	S-14	NA
MV-5	-.01	R-32	.14	S-15	.15
MV-6	NA	R-33	.16	S-16	NA
MV-7	.04	R-34	.18	S-17	.09
N-1	-.01	R-35	.29	S-18	.08
N-2	-.02	R-36	.23	S-19	.04
N-3	-.02	R-37	.23	S-20	.04
N-4	-.04	R-38	.26	S-21	.03
N-5	-.02	R-39	.24	T-1	.04
N-6	-.04	R-40	.49	T-2	.04
N-7	-.01	R-41	.42	T-3	.05
N-8	-.01	R-42	.32	T-4	.05
N-9	-.02	R-43	.30	T-5	.04
N-10	-.02	R-44	.30	T-6	.05
R-4	NA	R-45	.27	T-7	.01
R-5	.03	R-46	NA	T-8	.02
R-6	NA	R-47	NA	T-9	NA
R-7	.03	R-48	NA	T-10	.08
R-8	.05	R-49	.07	T-11	.14
R-9	.13	R-50	.04	T-12	.23
R-10	.37	R-51	NA	T-13	.34
R-11	.52	R-52	.02	T-14	.21
R-12	.74	R-53	.03	T-15	.15
R-13	1.03	R-54	.03	T-16	.10
R-14	1.31	R-55	.02	T-17	.05
R-15	1.58	R-56	.01	T-18	NA
R-16	.18	R-57	.01	T-19	.02
R-17	NA	R-58	.01	T-20	NA
R-18	NA	S-1	-.02		

NA Not available.

[1]Movement is elevation change between initial and final surveys.

NOTE.--Survey accuracy is ±0.04 ft. The error limits were determined by statistically averaging the standard deviations of stable subsidence monuments for all surveys.

APPENDIX B.--FINAL HORIZONTAL CONTROL SURVEY OF CAREY BRINEFIELD

(Positive values correspond to increasing easting or northing)

Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft	Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft
M-1	-0.17	0.04	R-19	NA	NA
M-2	-.19	.02	R-20	0.22	-0.20
M-3	-.06	.05	R-21	.11	-.09
M-4	-.14	.04	R-22	.23	1.61
M-5	-.20	.01	R-23	NA	NA
M-6	-.16	.02	R-24	.20	.17
M-7	-.06	.10	R-25	.14	.18
M-8	-.06	.11	R-26	.19	.03
M-9	-.04	.14	R-27	-.11	.49
MV-1	.09	.03	R-28	.17	-.02
MV-2	.07	.03	R-29	NA	NA
MV-3	.06	.03	R-30	.31	.09
MV-4	.11	.23	R-31	.13	-.03
MV-5	NA	NA	R-32	.20	-.08
MV-6	NA	NA	R-33	NA	NA
MV-7	.01	.04	R-34	.27	-.08
N-1	-.07	.05	R-35	-.02	.87
N-2	-.29	.00	R-36	.25	-.05
N-3	-.16	.03	R-37	.22	-.08
N-4	-.18	.02	R-38	.29	-.13
N-5	.01	.08	R-39	.05	-.04
N-6	-.22	-.01	R-40	-.22	.09
N-7	-.11	.05	R-41	.06	.07
N-8	-.16	.02	R-42	.04	.14
N-9	-.03	.12	R-43	.08	.13
N-10	-.12	.05	R-44	.14	.16
R-4	.26	.02	R-45	NA	NA
R-5	NA	NA	R-46	.15	.11
R-6	.26	.01	R-47	NA	NA
R-7	.22	-.04	R-48	NA	NA
R-8	.17	-.18	R-49	.26	.05
R-9	.22	-.40	R-50	.28	.01
R-10	.13	-.57	R-51	NA	NA
R-11	.17	-.62	R-52	.28	.06
R-12	.26	-.82	R-53	.28	.04
R-13	.01	-1.00	R-54	.61	.26
R-14	.13	-.97	R-55	.33	.08
R-15	NA	NA	R-56	.31	-.02
R-16	NA	NA	R-57	.20	.00
R-17	NA	NA	R-58	.25	.00
R-18	NA	NA	S-1	.26	.04

See footnotes at end of appendix.

(Positive values correspond to increasing easting or northing)

Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft	Subsidence monument	ΔEasting, ft[1]	ΔNorthing, ft
S-2.....	0.31	0.13	T-1.....	0.34	-0.15
S-3.....	.26	.09	T-2.....	.34	-.15
S-4.....	NA	NA	T-3.....	.33	-.15
S-5.....	.27	-.02	T-4.....	.21	-.27
S-6.....	.36	.08	T-5.....	.28	-.09
S-7.....	.45	.06	T-6.....	.30	-.12
S-8.....	NA	NA	T-7.....	.23	-.05
S-9.....	.85	.09	T-8.....	.26	-.07
S-10.....	.97	.30	T-9.....	NA	NA
S-11.....	NA	NA	T-10.....	.31	.04
S-12.....	1.12	-.09	T-11.....	.32	.00
S-13.....	-.04	-.11	T-12.....	.30	.02
S-14.....	-.06	-.46	T-13.....	.04	-.19
S-15.....	.01	-.17	T-14.....	.08	-.06
S-16.....	NA	NA	T-15.....	.06	.04
S-17.....	.14	-.15	T-16.....	.04	.06
S-18.....	.17	-.13	T-17.....	-.70	-.14
S-19.....	.17	-.07	T-18.....	NA	NA
S-20.....	.13	-.14	T-19.....	.05	.04
S-21.....	.13	-.12	T-20.....	NA	NA

NA Not available.

[1]Movement is change in horizontal coordinates between initial and final surveys.

NOTE.--Survey accuracy is ±0.35 ft. The error limits were determined by statistically averaging the standard deviations of stable subsidence monuments for all surveys.

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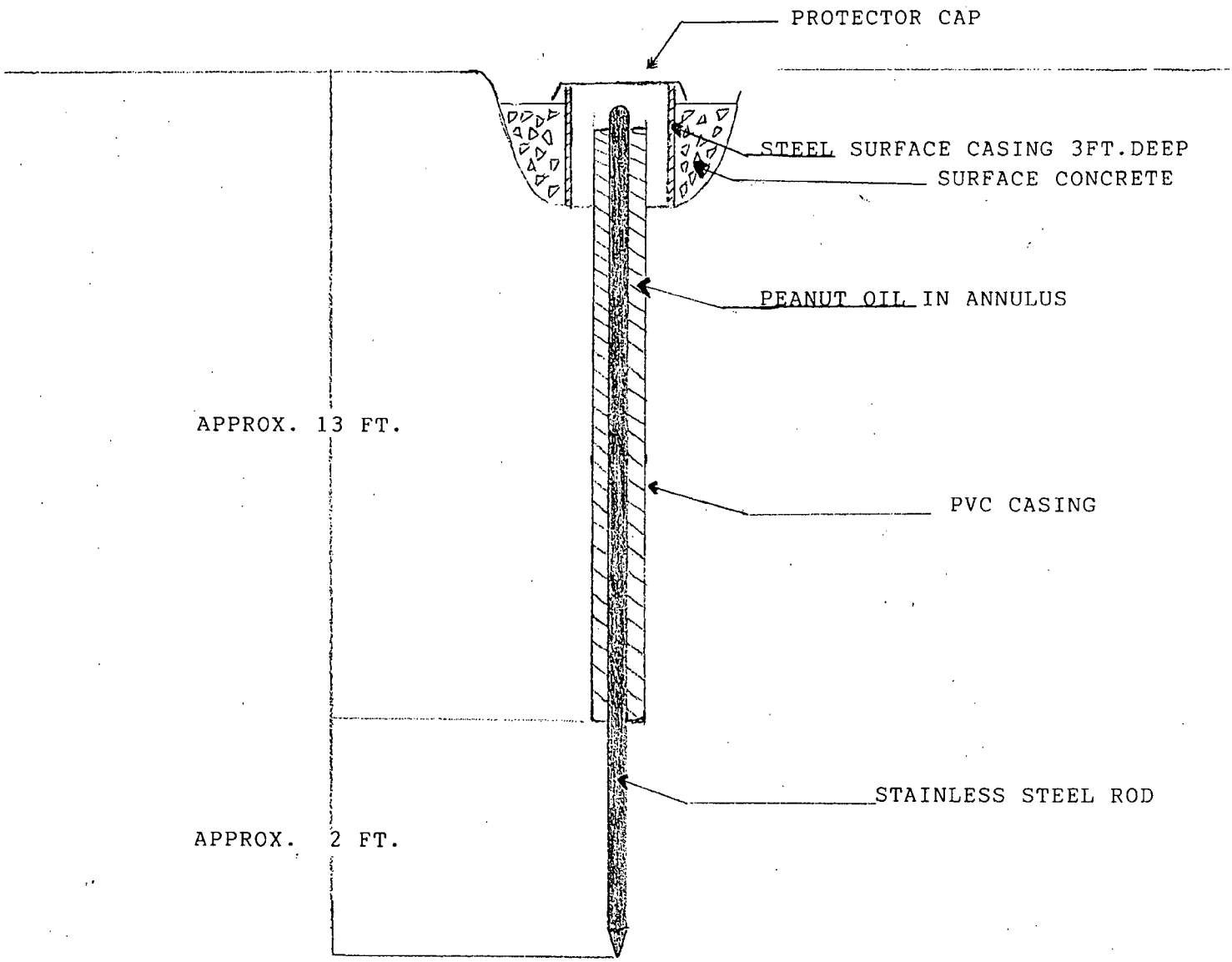
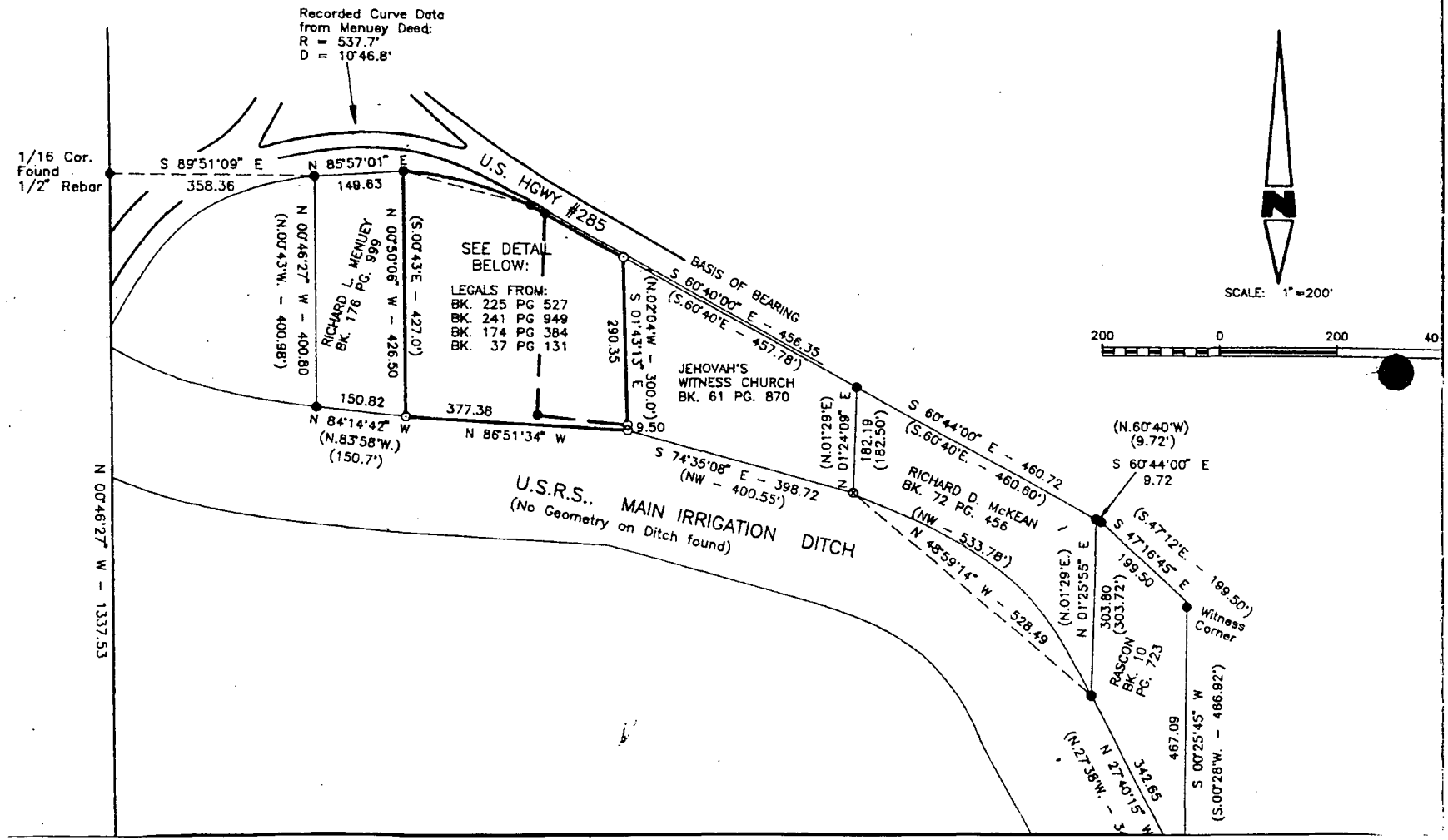
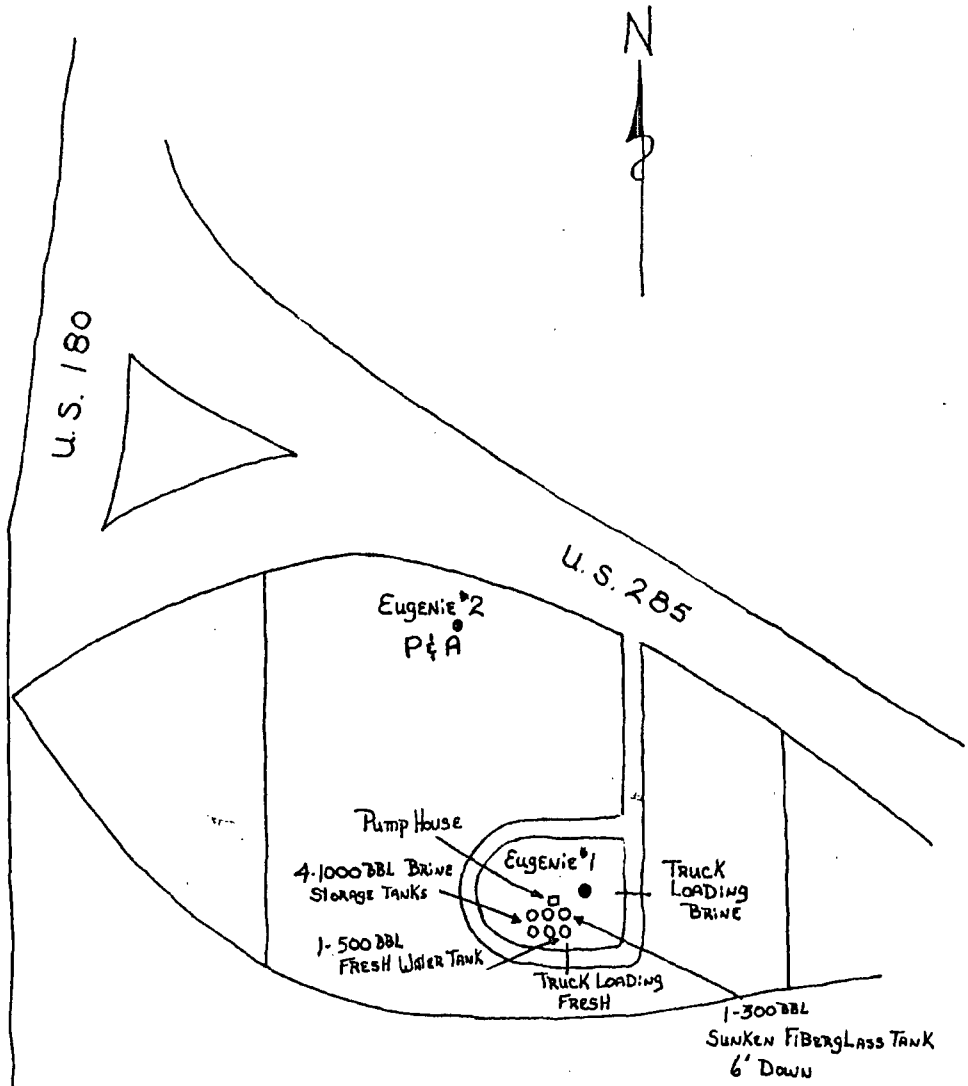


I & W, INC.
CARLSBAD, NM.
EUGENIE BRINE STATION

2.26.02

SECTION 17, TOWNSHIP 22 SOUTH, RANGE 27 EAST, N.M.P.M.,
EDDY COUNTY, NEW MEXICO

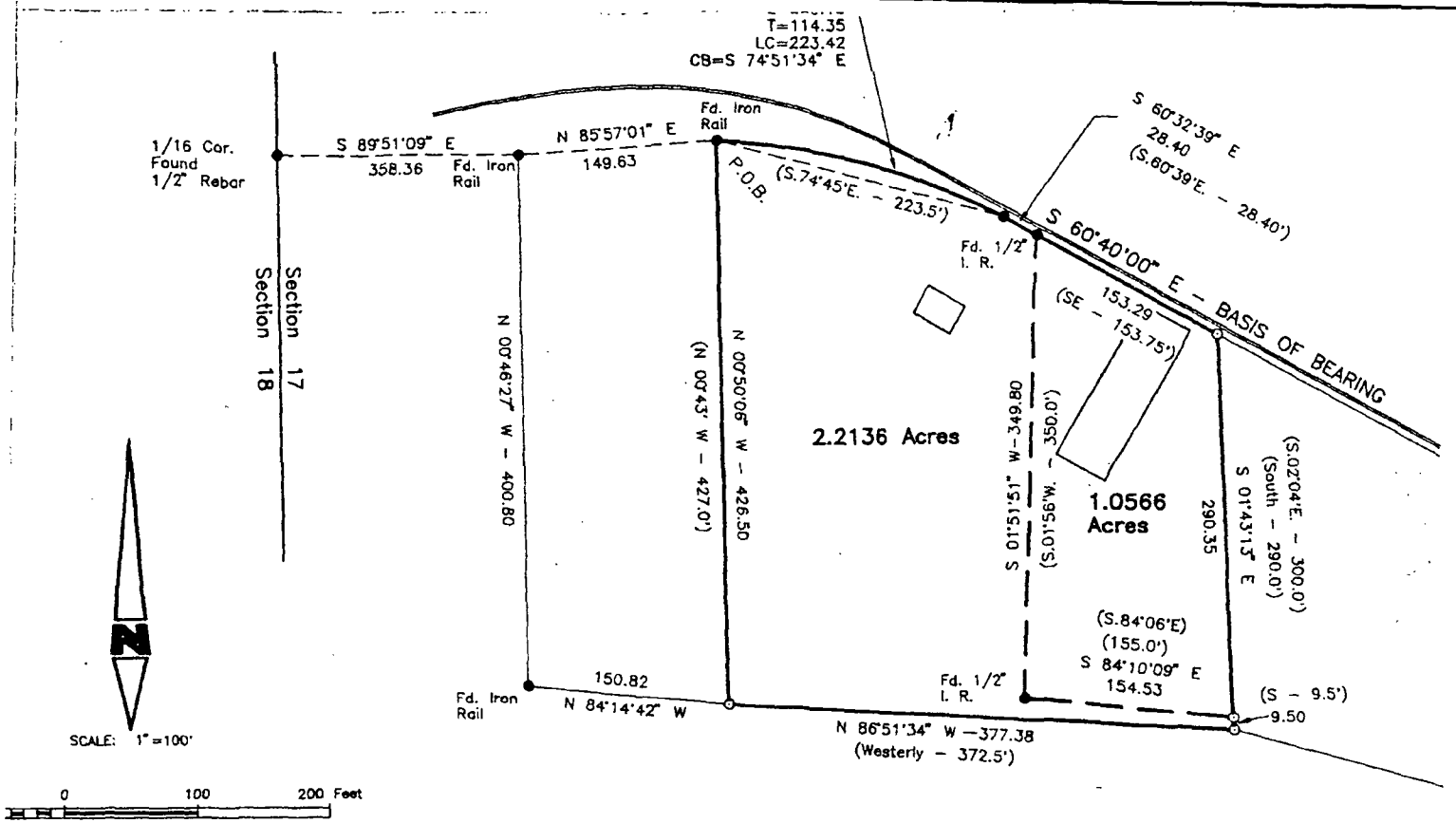




Facility Plot Plan

Map A

I & W Inc.		
Eugenie #1 - Eugenie #2 Brine Station SW/4 - SW/4 Sec. 17 Rge. 27 E Twp. 22 S		
Date 1/29/01	Gene Pruitt	Revised Drawing #2



LEGAL DESCRIPTION:

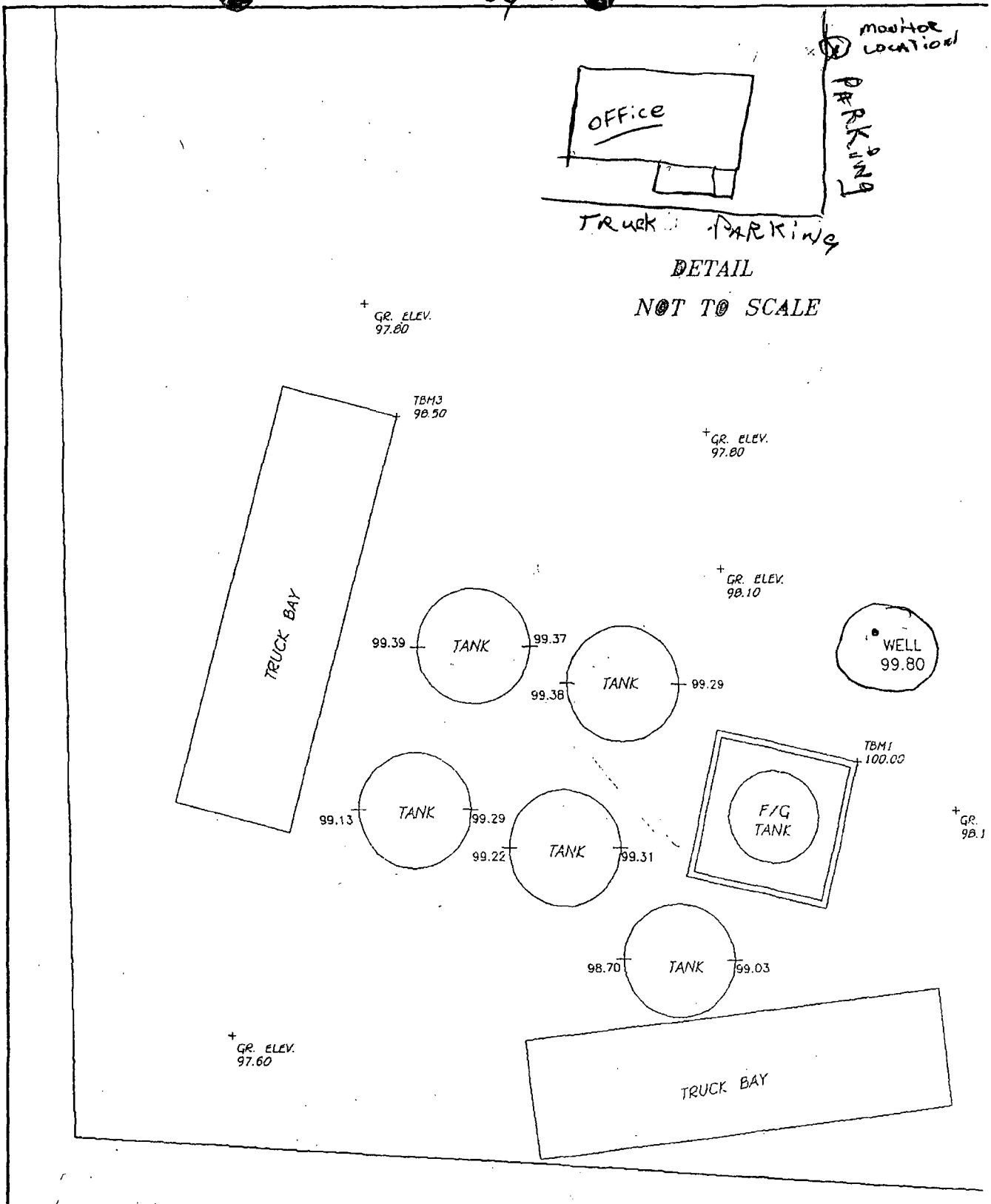
A tract of land located in the Southwest quarter of the Southwest quarter of Section 17, Township 22 South, Range 27 East, NMPM, Eddy County, New Mexico and being more particularly described as follows:

Beginning at the Northwest corner of this tract, a point being on the South Right of Way line of State Highway No. 285 and a point being S.89°51'09"E., 358.36 feet and N.85°57'01"E., 149.63 feet from a half inch rebar accepted as the Northwest corner of

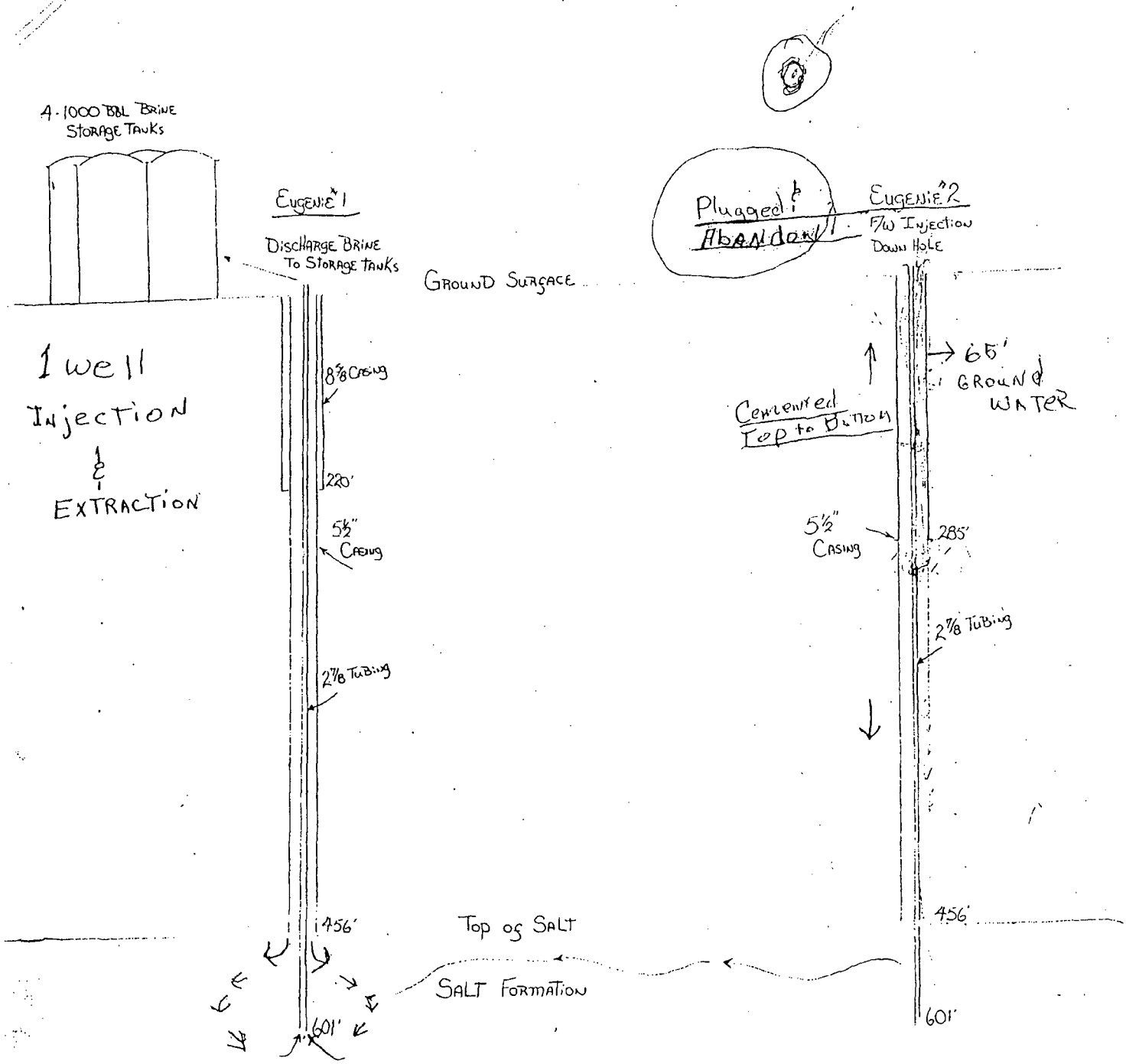
LEGEND:

- ⊗ Calculated Corner (Not found or set)
- ● Found Corner

Hwy 287


monitor location
OFFICE
PARKING
TRUCK PARKING
DETAIL
NOT TO SCALE
GR. ELEV. 97.80
TBM3 98.50
GR. ELEV. 97.80
GR. ELEV. 98.10
TRUCK BAY
99.39
TANK
99.37
99.38
TANK
99.29
WELL 99.80
TBM1 100.00
99.13
TANK
99.29
99.22
TANK
99.31
F/G TANK
GR. 98.1
98.70
TANK
99.03
GR. ELEV. 97.60
TRUCK BAY
U.S.R.S. MAIN IRRIGATION DITCH

3991



663'

Depth, Diameter Casing & Tubing Specs

Map B

SUB-SURFACE SCHEMATIC DRAWING OF EUGENIE #1 & SOUTH Y CARLSBAD N.M. 88220

DATE 1/30/00

I & W INC

QUANTITIES

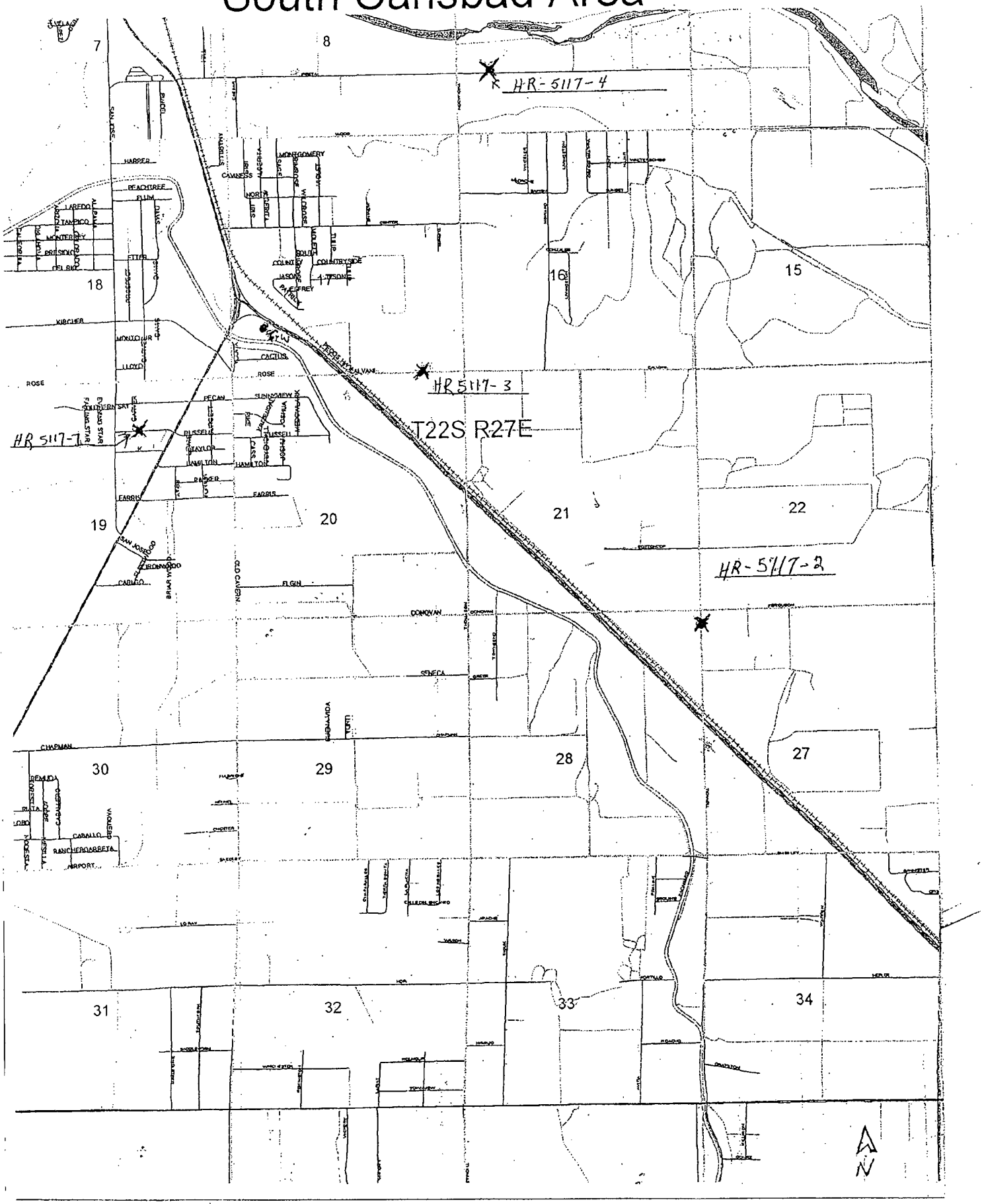
SOURCE: EUGENIE #1 EXTRACTION FACILITY

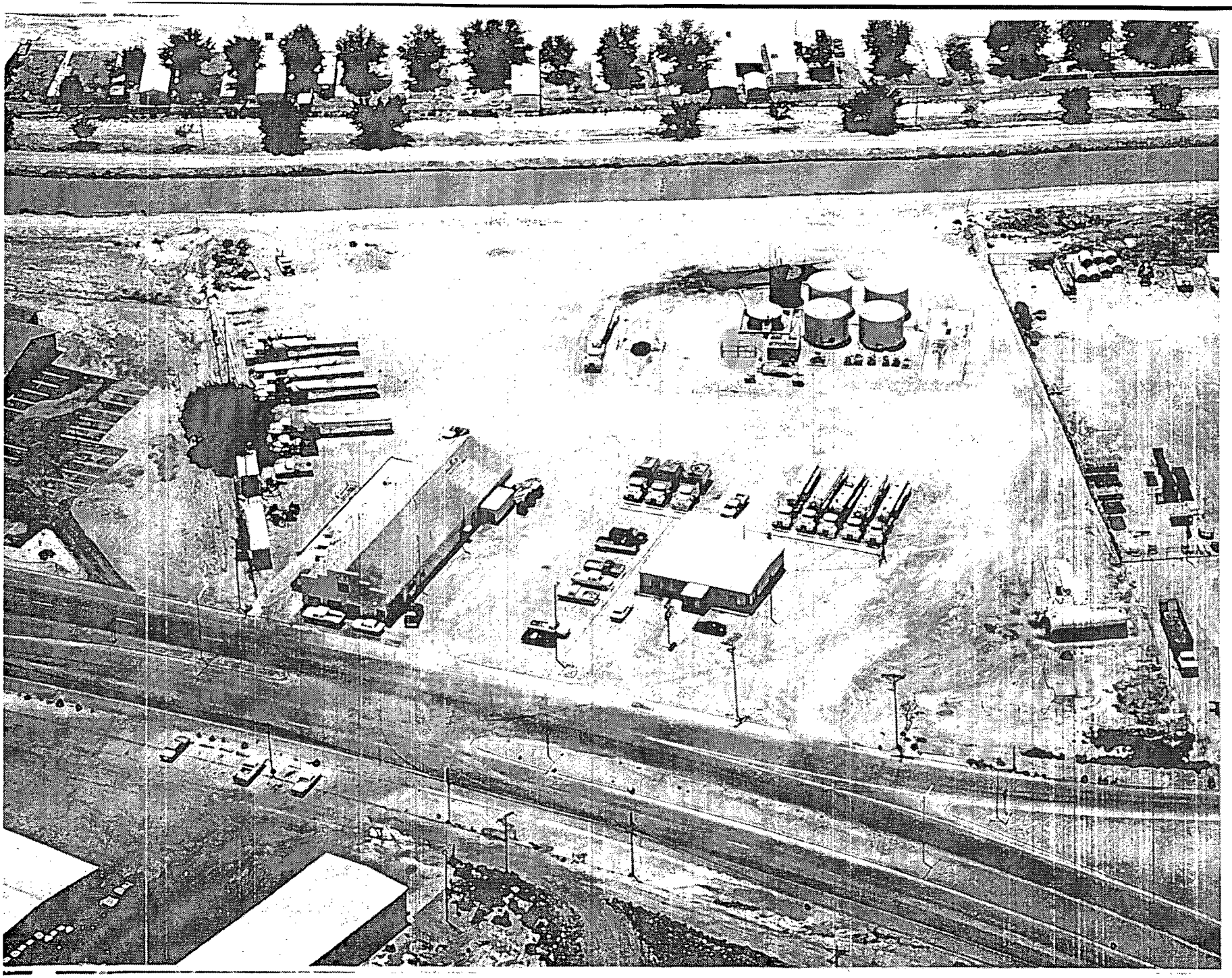
AVERAGE DAILY VOLUME PRODUCED: 200 BBLS/DAY

ESTIMATED VOLUME STORED: 4000 BBLS

TYPE OF CONTAINERS: 4 X 1000 BBL-STEEL TANKS

South Carlsbad Area





Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 11, 2007 10:01 AM
To: 'Lisa Rice'
Cc: Price, Wayne, EMNRD; Sanchez, Daniel J., EMNRD
Subject: RE: BW-6 Subsidence Monument Monitoring Program Information for Brine Cavern

Mr. Wilson:

Re: I & W Inc. Eugenie #1: API# 30-015-22574 & Eugenie #2: API# 30-015-23031

Good morning. As a follow up to the recent OCD letter and telephone conversation this morning. Please find attached a subsidence monitoring report that may assist you in understanding the scope of the issues and concerns associated with shallow brine caverns. The report contains subsidence monument monitoring information that may assist you with the subsidence monitoring at your facility.

Please review the monitoring information (i.e., Fig. 9, 12, etc.). My Supervisor, Mr. Wayne Price seems to recall that there was a monitor well that was being surveyed to address this provision of the permit. Based on the attached report, I recommend at least five monitoring points at ~ 200 ft. spacing, including ground and top of casing elevations at both of the Eugenie BWs, and a subsidence monument at mid-point (if possible) between the brine wells. The other subsidence monuments should be selected based on best professional judgment of a certified surveyor. A monitor well drilling company may offer advice and the means for physically installing subsidence monuments. It would seem that swale areas away from the brine well network may be appropriate locations for the other monitor points. The survey elevations should be monitored on a semi-annual basis for the first couple of years (and as needed) and then annual monitoring (and as needed) may be appropriate thereafter. You will need to setup a format for your monitoring information to be made available at the request of the OCD and/or when subsidence monitoring warrants notification to the OCD.

Please provide the OCD with an update on your progress on or before May 4, 2007 and as events transpire thereafter. The *shallow nature of the brine cavern is the reason why the OCD is concerned about subsidence in the vicinity of your facility and* of course public health and safety in the area.

Please contact me if you have questions. Thank you.

From: Lisa Rice [mailto:iwcarlsbad@plateautel.net]
Sent: Wednesday, April 11, 2007 8:27 AM
To: Chavez, Carl J, EMNRD
Subject: Subsidence Monitoring Program information

Dear Mr. Chavez

This is Kevin Wilson Operation Manager for I & W, Inc. We are in need of any information you may have to assist us in setting up the Subsidence monitoring Program on our Eugenie Brine station. I will be contacting survey companies for further information & we will keep you updated as to our progress. However any information or help you may have in assisting us in this matter would be greatly appreciated.

Sincerely,
Kevin Wilson
Operation Manager