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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Denver, Colorado 80225

HYDROLOGIC STUDIES, PROJECT DRIBBLE,
TATUM SALT DOME,
LAMAR COUNTY, MISSISSIPPI

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By

Joe W. Lang

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INTRODUCTION

The principal objective of the U.S. Geological Survey's hydrologic studies is to determine the ground-water situation over and around Tatum dome prior to nuclear testing. If breaching of the salt dome should occur the ion-exchange and immobilizing capacities of the different aquifers and aquicludes, and the rate and direction of ground-water movement must be known in advance so that remedial measures can be taken. Continuous surveillance will be necessary after the detonations. Changes in storage and transmission capacities of the aquifers, that might result from the explosions, must be determined.

There are at least four important fresh-water aquifers (aquifers 1, 2, 3, and 4), several local fresh-water aquifers, and at least one underlying saline-water aquifer (aquifer 5) in the strata surrounding Tatum dome. The three upper aquifers extend across the top of the

dome and the lower two aquifers are interrupted by the dome. The important aquifers are areally extensive although they may be locally offset or interrupted by faults near the dome, especially those that extend across the dome.

If radioactive materials were to escape at the sides of the salt dome they might directly contaminate the aquifers which are interrupted by the dome and, if the confining beds are leaky, contaminated ground water could enter the overlying aquifers.

If radioactive materials were to escape through the top of the dome they might directly contaminate the overlying aquifers, particularly the porous caprock limestone. The limestone apparently is in hydrologic connection with aquifer 3 around the flanks of the dome; the limestone contains cavernous and fractured zones that allow free movement of water depending upon the pattern of the porous zones and direction of slope of the hydraulic head. Should downward leakage occur through semi-confining beds, radioactive contaminants entering any one of the three aquifers above the caprock could, after lateral movement off the dome, enter the lower aquifers indirectly.

In addition to the detailed studies on and adjacent to Tatum dome as described here, a general areal investigation is being conducted to determine hydrologic conditions in the various aquifers for distances of several miles from the dome. This study includes the terrace

deposits consisting of sand of varying thickness that mantles most of the surface and contains water under water-table conditions. Many hundred small domestic and farm water supplies within a radius of 15 miles of Tatum dome are derived from wells in these deposits.

As of November 1, 1961, two wells drilled specifically for hydrologic purposes have been completed at Tatum dome. These are HT-1 and HT-2 on the northeast and southwest flank of the dome, respectively. Each of these wells has two observation wells drilled to the aquifer 3.

HYDROLOGIC TEST DRILLING

The hydrologic test drilling program outlined herein resulted from discussions between the U.S. Atomic Energy Commission (Office of Field Operations, Albuquerque, New Mexico), the Consultants to the Office of Field Operations, and the U.S. Geological Survey, at Hattiesburg, Mississippi, on August 1 and 2, 1961. Table 1 was submitted by the U.S. Geological Survey to the U.S. Atomic Energy Commission and Holmes and Narver in Albuquerque, New Mexico on August 17, 1961 to show the purpose and general specifications for proposed hydrologic test wells at Tatum dome.

The test drilling program includes four principal components, namely: caprock tests, tests on top of dome, tests on southwest flank of dome, and tests on southeast flank of dome.

Table 1.--Purpose and general specifications for proposed hydrologic test wells, Tatum dome, Mississippi
(For location, see plan map)

Note: All wells will be preserved for post-shot observation purposes.

Well No	Approximate location Local coordinate system (ft)	Purpose	Well depth (feet)	Casing			Screen				Cores	Logs	Well development	Pumping tests				Remarks				
				Diameter (inches)	Depth (feet)	Finish	Diameter (inches)	Length (feet)	Depth interval (feet)	Slot (inches)				Pump requirements		Time for test						
														Yield (gpm)	Setting (feet)	Pumping (hr)	Recovery (hr)					
CH-1	E 9,000 N 8,200	Obtain transmissivity, storage, boundary effects, water level, quality of water in porous zone of limestone cap. Information will aid in determining connection with other aquifers.	1,050-1,150	7 5/8	1,050	Cemented bottom to top	None	None, finish open hole through porous zone. 50 to 150 feet thick.	None	None	Side wall 15-20 selected intervals	E log, Gamma-Neutron	Bailed clean	500	350	24	24	Hole can be drilled blind through limestone provided clear water is used. Might consider cable-tool drilling in limestone section.				
CH-2	E 11,150 N 9,600	do.	1,000-1,100	7 5/8	970	do.	None	do.	None	None	do.	do.	do.	500	350	24	24					
CH-3	E 8,500 N 11,000	do.	1,050-1,100	7 5/8	1,000	do.	None	do.	None	None	do.	do.	do.	500	350	48	48	If conditions warrant, pumping may be necessary for 1 week or longer.				
HT-3	E 7,600 N 9,750	Determine transmissivity, storage coefficients and leakance in aquifer 1. Obtain water level and water samples.	400 ±	9 5/8	300±	Cemented bottom to top	6	60	Aquifer test well array on top of dome				Screen and blank pipe in interval from 300-400	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	300	48	48	Finish all pumping wells and observation wells (as necessary) with backpressure valves and seals between casing and screen.
3a	E 7,675 N 10,025	Observation well in aquifer 1 for use in pumping test.	400 ±	6	300±	do.	2	10	5 ft of screen attached to 2-inch pipe to surface placed at 400 ft. Second 5 ft screen placed at 300 ft.	0.01	None	E log	Develop by compressed air.	None	None	None	None	Well finish with two screens and attached pipes to surface to observe head at top and bottom of aquifer. Mud to be placed in well between screens. Bottom screen might be a drive point.				
3b	E 7,800 N 10,400	do.	350 ±	6	300±	do.	4	10	Screen and blank pipe in interval from 300 to 350	0.01	None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None					
3c	E 8,100 N 10,800	do.	350 ±	6	300±	do.	4	10	do.	0.01	None	E log	do.	None	None	None	None					
HT-4	E 7,700 N 10,050	Determine transmissivity storage coefficients and leakance in aquifer 2. Obtain water level and water samples	700	9 5/8	600	Cemented bottom to top	6	60	Screen and blank pipe in interval from 600 to 700		None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	300	48	48	May require pumping 1 week or longer.				
4a	E 7,700 N 10,200	Observation well in aquifer 2 for use in pumping test.	650	6	600	do.	4	10	Screen and blank pipe in interval from 600 to 650		None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None					
4b	E 7,900 N 10,600	do.	650	6	600	do.	4	10	do.		None	E log	do.	None	None	None	None					
HT-5	E 8,000 N 10,600	Determine transmissivity, storage coefficients and leakance in aquifer 3. Obtain water level and water samples.	850-950	9 5/8	800-850	Cemented bottom to top	6	60	Screen and blank pipe in interval from 800-950	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	350	48	24	May require pumping 1 week or longer.				
5a	E 8,000 N 10,700	Observation well in aquifer 3 for use in pumping test.	850-900	6	800-850	do.	4	10	Screen and blank pipe in interval from 800-950	0.01	None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None					
5b	E 8,400 N 11,000	Observation well in aquifer 3 for use in pumping test.	850-900	6	800-850	do.	4	10	do.	0.01	None	E log	do.	None	None	None	None					

Table 1.--Purpose and general specifications for proposed hydrologic test wells, Tatum dome, Mississippi--continued
(For location, see plan map)

Well No.	Approximate location Local coordinate system (ft)	Purpose	Well depth (feet)	Casing			Screen				Cores	Logs	Well development	Pumping tests				Remarks
				Diameter (inches)	Depth (feet)	Finish	Diameter (inches)	Length (feet)	Depth interval (feet)	Slot (inches)				Pump requirements		Time for test		
														Yield (gpm)	Setting (feet)	Pumping (hr)	Recovery (hr)	
Aquifer test well array on southwest flank of dome																		
HT-6	E 6,500 N 5,750	Determine transmissivity, storage coefficients and leakance in aquifer 1A. Obtain water level and water samples.	400	9 5/8	300	Cemented bottom to top	6	60	Screen and blank pipe in interval from 300 to 400	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	200	250	48	48	If conditions warrant, pumping may be necessary for 1 week or longer.
6a	E 6,250 N 5,650	Observation well in aquifer 1A for use in pumping test.	350	6	300	do.	4	10	Screen and blank pipe in interval from 300 to 350	0.01	None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None	Locate on line between HT-6 and the 6-inch supply well near HT-2.
HT-7	E 6,900 N 6,000	Determine transmissivity, storage coefficients and leakance in aquifer 1. Obtain water level and water samples.	700	9 5/8	600±	Cemented bottom to top	6	60	Screen and blank pipe in interval from 600 to 700	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	300	48	48	
7a	E 6,800 N 6,000	Observation well in aquifer 1 for use in pumping test.	650	6	600±	do.	4	10	Screen and blank pipe in interval from 600 to 650	0.01	None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None	
7b	E 6,400 N 5,900	do.	650	6	600±	do.	4	10	do.	0.01	None	E log	do.	None	None	None	None	
HT-8	E 7,000 N 5,800	Determine transmissivity, storage coefficients and leakance in aquifer 2A. Obtain water level and water samples.	1,000±	9 5/8	900±	Cemented bottom to top	6	60	Screen and blank pipe in interval from 900 to 1,000	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	350	48	48	May require pumping 1 week or longer.
8a	E 6,800 N 5,600	Observation well in aquifer 2A for use in pumping test.	950±	6	900±	do.	4	10	Screen and blank pipe in interval from 900 to 950	0.01	None	E log	Bail hole clean, develop slightly to assure contact with aquifer (4 hrs)	None	None	None	None	Present well at HT-2 will serve as the second observation well.
HT-9	E 7,100 N 5,900	Determine transmissivity, storage coefficients and leakance in aquifer 2B. Obtain water level and water samples.	1,200±	9 5/8	1,100±	Cemented bottom to top	6	60	Screen and blank pipe in interval from 1,100 to 1,200	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	350	48	48	May require pumping 1 week or longer.
9a	E 7,200 N 5,900	Observation well in aquifer 2B for use in pumping test.	1,150±	6	1,100±	do.	4	10	Screen and blank pipe in interval from 1,100 to 1,150	0.01	None	None	Develop sufficiently to assure contact with aquifer; bail hole	None	None	None	None	
9b	E 7,500 N 6,100	do.	1,100±	6	1,050±	do.	4	10	Screen and blank pipe in interval from 1,050 to 1,100	0.01	None	E log	do.	None	None	None	None	
HT-10	E 7,100 N 6,050	Determine transmissivity, storage coefficients and leakance in aquifer 3. Obtain water level and water samples.	1,800±	9 5/8	1,300±	Cemented bottom to top	6	150	Screen and blank pipe in interval from 1,300 to 1,800	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (24 hrs)	300	350	48	48	HT-2 well also available for observation of water level in this aquifer. May require pumping longer than 48 hours.
10a	E 7,600 N 6,350	Observation well in aquifer 3 for use in pumping test.	1,500±	6	1,300±	do.	4	30	Screen and blank pipe in interval from 1,300 to 1,500	0.01	None	E log	Develop with surge block and bailing, clean hole free of sand (4 hrs)	None	None	None	None	

Table 1.--Purpose and general specifications for proposed hydrologic test wells, Tatum dome, Mississippi--continued
(For location, see plan map)

Well No.	Approximate location Local coordinate system (ft)	Purpose	Well depth (feet)	Casing			Screen				Cores	Logs	Well development	Pumping tests				Remarks
				Diameter (inches)	Depth (feet)	Finish	Diameter (inches)	Length (feet)	Depth interval (feet)	Slot (inches)				Pump requirements		Time for test		
														Yield (gpm)	Setting (feet)	Pumping (hr)	Recovery (hr)	
Aquifer test well array on southwest flank of dome--continued																		
HT-11	E 8,000 N 6,400	Determine transmissivity, storage coefficients and leakance in aquifer 4. Obtain water level and water samples.	1,800+	9 5/8	1,600+	Cemented bottom to top	6	100	Screen and blank pipe in interval from 1,600 to 1,800	Slotted pipe 1/8-in. openings	Side wall, 15 to 20 at selected intervals	E log, gamma neutron	May require development by surge blocks and bailing; clean hole free of sand (10 hrs)	300	350	24	24	HT-2 well available for observation of water level in this aquifer.
11a	E 7,800 N 6,200	Observation well in aquifer 4 for use in pumping test.	1,700+	6	1,600+	do.	4	130	Screen and blank pipe in interval from 1,600 to 1,700	Slotted pipe 1/8-in. openings	None	E log	May require some development with surge block and bailing; clean hole free of sand (5 hrs)	None	None	None	None	
Water level control wells on southeast flank																		
HT-12	E 12,700 N 6,400	Observation well in aquifer 2 to fix control on slope of water pressure surface in aquifer. Collect water samples.	1,000+	6	900+	Cemented from bottom up 200 feet	4	10	Screen and blank pipe in interval from 900 to 1,000	0.01	None	E log	Develop to assure contact with aquifer; clean sand from hole (4 hrs)	None	None	None	None	Casing should extend 2 feet above ground and be capped for protection.
HT-13	E 12,200 N 7,000	Observation well in aquifer 3 to fix control on slope of water pressure surface in aquifer. Collect water samples.	1,500+	6	1,300+	Cemented from bottom up 200 feet	4	10	Screen and blank pipe in interval from 1,300 to 1,500	0.01	None	E log	Develop to assure contact with aquifer; clean sand from hole (4 hrs)	None	None	None	None	Do.
HT-14	E 11,800 N 5,500	Observation well in aquifer 4 to fix control on slope of water pressure surface in aquifer. Collect water samples.	2,000+	6	1,850+	Cemented from bottom up 200 feet	4	10	Screen and blank pipe in interval from 1,850 to 2,000	0.01	Side wall, 15 to 20 at selected intervals	E log gamma neutron	Clean mud from hole (3 hrs)	None	None	None	None	Do.

Caprock tests

The caprock test wells are designed to determine the hydrologic properties of the caprock limestone. This limestone is known to be porous, cavernous, and to contain large quantities of fresh water. The work point (WP) and dome definition (E) holes (see fig. 1) all penetrated the caprock limestone, but they were drilled for other objectives and do not afford quantitative hydrologic data.

Three proposed caprock hydrology (CH) test wells will explore the caprock limestone:

CH-1, located 300-500 feet southeast of E-2, near access road.

CH-2, located 300-500 feet northeast of E-9, near access road.

CH-3, located 300-500 feet west of E-6, near access road.

Figure 1 shows the approximate location of the CH wells with respect to the salt dome and other test holes that have been drilled on or near the dome. They must be of sufficiently large diameter (7-5/8-inch suggested minimum) to accomodate a turbine pump capable of yielding 500 gallons per minute or more, assuming a pump setting of no more than 350 feet.

The holes should be drilled and cased to the upper part of the limestone. If the rock is cavernous or fractured the casing should be securely cemented to the limestone above the cavernous or fractured zone. After installation of the casing, drilling

should proceed carefully using very light mud or water if possible, until sufficient porous zone has been drilled to allow formation water to enter the well freely. This may require drilling through most or all of the limestone section, which ranges in thickness from about 100 to 150 feet. Pumping tests will be made as necessary. Full use will be made of wells E-2, E-3, and E-6 as observation wells during caprock pumping tests, provided they are available and show normal fluctuations of water levels.

Tests on top of dome

Ten wells are planned to test the hydrologic characteristics of aquifers overlying the caprock limestone on the dome. An array of 10 wells, suggested for installation along the west side of the access road between E-1 and E-6 (see fig. 1), will suffice for observations of leakage between the aquifers during the pumping operations. While fulfilling the needs for the overall requirements, the array of wells will provide ground-water data in the vicinity of the proposed shafts.

For each aquifer, one properly-constructed well for pumping and at least two observation wells are proposed in this plan. The accompanying schematic cross section (fig. 2) shows the tentative spacing and estimated depths for this array of wells. The observation wells can be of inexpensive construction because their prime purpose is only to record changes in water level caused by the pumping. Spot

Figure 2.-- Schematic diagram showing array of hydrologic test wells on top of Tatum dome.

coring will be done at places to be selected by the Geological Survey hydrologist either in HT-3 or HT-5, or both. Provision should be made for either vertical core barrel or sidewall coring. General specifications are given below.

Three 9-5/8-inch diameter wells are needed for pumping, each to have 40 to 60 feet of 6-inch diameter screen of 0.088- or 0.010-inch mesh. Alternating sections of screen and blank pipe may be used opposite the aquifer as determined by the hydrologist. Wells are to be of 9-5/8-inch diameter to the following approximate depths (to be determined accurately from electric log and other observations):

HT-3 - 300 to 325 feet deep.

HT-4 - About 600 feet deep.

HT-5 - 800 to 850 feet deep.

Total casing: about 1,700 feet of 9-5/8-inch casing for three wells.

Total screen: about 160 feet of 6-inch screen for three wells.

Casing should be cemented back to land surface; the water sand should be drilled with about a 7-7/8-inch bit for setting screen. Use only water or very light mud during drilling of sand. Finish with back pressure valve and lead seal. Well should be thoroughly cleaned and developed to standards specified by the Geological Survey hydrologist. Possibly under-reaming and gravel packing of sand section will be needed in the event the sand is very fine; however, this is not necessary if natural formation can be adequately developed.

Seven observation wells 6 inches in diameter will be needed. Six of these will have from 5 to 10 feet of screen 4 inches in diameter and of the same mesh size as in the pumping well. The screen should be securely sealed to the 6-inch casing. One observation well should have 10 feet of 2-inch screen.

Casing 6 inches in diameter should extend to the following approximate depths and be cemented back to surface (or in a way to ensure that the water level will reflect only fluctuations for the screened aquifer):

Aquifer 1: three observation wells, (3a, 3b, and 3c) 300 to 350 feet deep. One of the wells to have 5 feet of 2-inch screen set in the lower one-third of the aquifer and 5 feet in the lower part of upper one-third, each screen attached to a pipe extending to the surface so that water levels may be measured separately. The annular space surrounding the screens should be packed with sand, but the annular space surrounding the blank pipe between the screens should be packed with mud. The bottom screen might be driven into the water sand in the manner of a drive point, thus eliminating the need for sand packing it.

Aquifer 2A and 2B: 2 observation wells, (4a and 4b) about 600 to 620 feet deep.

Aquifer 3: 2 observation wells (5a and 5b) about 800 to 850 feet deep.

Casing total: about 3,800 feet of 6-inch casing.

Screen total: about 10 feet of 2-inch and 60 feet of 4-inch screen.

After cementing the casing, wells should be deepened into the water-bearing sand and screened. Only clean water should be used for this drilling. Each observation well must be thoroughly developed and cleaned up after the screen has been placed, and then should be capped until needed by the Geological Survey

Tests on southwest flank of dome

Fourteen wells are planned for testing the hydrologic properties and continuity of aquifers on the southwest flank of Tatum dome between Hydrologic Test 2 (HT-2) and E-2 (see fig. 1).

The principal fresh-water aquifers in the strata surrounding Tatum dome are artesian and extend for many miles from the dome. Water gets into them mostly in their outcrop belts at distances ranging from only a few miles to 50 miles or more east, northeast, and north of the dome. Some recharge to the upper aquifer, however, may occur in the rim syncline around the dome and slow upward leakage probably occurs from some of the deeper aquifers into overlying ones. The regional hydraulic gradient and the water movement in all of the aquifers is to the south and southwest, which is the general direction of dip of the geologic formations, but locally adjacent to the dome the ground water movement probably is modified by the domal structure.

The following array of wells is planned to determine water level, storage and transmissivity, leakage, and chemical quality of water in the principal aquifers:

1. A well (HT-6) about 400 feet deep to be pumped in testing aquifer 1. Aquifer 1 of Miocene age has been subdivided locally, regionally they are lenticular beds that can not be easily delineated over a large area. It should be of 9-5/8-inch diameter to 300-320 feet, with approximately 60 feet of 6-inch screen (0.010-inch openings) and 20 feet of 6-inch blank pipe, the exact depths and lengths of pipe and screen to be determined from the electric log. One 6-inch observation well (6a) 300-350 feet deep, with 10 feet of 4-inch screen is to be located about 150 feet from the pumped well on a straight line between HT-6 and the supply well near HT-2.

2. A well (HT-7) about 700 feet deep to be pumped in testing aquifer 1. Aquifer properties because of lenticular nature can not be defined with single array of holes. It should be of 9-5/8-inch diameter to be about 620 feet with approximately 60 feet of 6-inch screen (0.010-inch openings) and 20 feet of 6-inch blank pipe. Two 6-inch observation wells (7a and 7b) are to be drilled to a depth of about 650 feet, with 10 feet of 4-inch screen.

3. Four additional wells of 9-5/8-inch diameter are needed for pumping each of aquifers 2A and 2B, 3 and 4. Aquifer 2 of Miocene age has been subdivided into 2A and 2B. In the Tatum dome area, a few domestic wells tap the shallower Miocene aquifer (Hattiesburg Formation). Outside the area, the deeper Pascagoula Formation is used for large withdrawals. The Catahoula Formation has also been subdivided into aquifers 3A and 3B. These wells (HT-8, HT-9, HT-10, and HT-11) should have 6-inch diameter screen with openings no larger than 0.010-inch mesh. For well HT-8, only one observation well (8a) will be necessary, about 900 feet deep, of 6-inch diameter, with about 10 feet of screen. Multiple well (HT-2) already installed will serve as the second observation well. For well HT-9, two observation wells (9a and 9b), of 6-inch diameter will be needed, one about 1,150 feet deep and the other about 1,100 feet deep. For HT-10 and HT-11 only two 6-inch observation wells will be necessary because water levels can also be measured in hydrologic test well HT-2.

The pumping wells and observation wells should be finished with back-pressure valves and adequate seals to prevent sand from entering wells between surface casing and liner and screens.

Tests on southeast flank

Three wells on the southeast flank of the dome, in the vicinity of Humble Hibernia No. 1 (see fig. 1), are planned (HT-12, HT-13, and HT-14). These wells should be of about 6-inch diameter, one in each

of aquifers 2, 3, and 4, for measurement of the artesian heads. Depths and other information are given in table 1. These wells will provide information for ascertaining the slope of the water surface and the direction of ground water movement in the vicinity of the dome.

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