Rehabilitation of wells in the Headquarters Area, White Sands Proving Ground, Dona Ana County, N. Mex.

By

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REHABILITATION OF WELLS IN THE HEADQUARTERS AREA WHITE SANDS PROVING GROUND, DONA ANA COUNTY, NEW MEXICO

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INTRODUCTION

During the recently-completed study of the ground-water resources of the headquarters area at White Sands Proving Ground, New Mexico several pumping tests of wells 10, 11, 12, and 13 were conducted. Data obtained from the pumping tests indicated that the performances of at least some of those wells probably could be improved by cleaning and additional development. However, rehabilitation of wells 10, 11, 12, and 13 could not be undertaken until the new wells 14, 15, and 16 were completed and placed in production in the latter parts of 1953 and 1954.

On October 22, 1954 a conference at White Sands Proving Ground to formulate tentative plans for the rehabilitation of wells 10, 11, 12, and 13 was attended by representatives from the U. S. Army and the U. S. Geological Survey. Specifications were completed in December 1954 by the Corps of Engineers, Albuquerque District, and in January 1955 a contract was let by the Corps of Engineers to the H. P. Doty Drilling Company. Actual rehabilitation of the wells was started in February 1955.

At the outset it was recognized that rehabilitation was experimental and that the exact procedures or results could not be accurately predicted. However, attempts at rehabilitation were believed justified in view of the cost of the improvement expected as contrasted with the cost of another new well that would be needed to offset the decline in production. Further, it was recognized that deterioration of the new wells, 14, 15, and 16, might occur in time and that the knowledge gained in rehabilitation of wells 10,11,12, and 13 would be useful in determining the course of action to be followed in the future with respect to the new wells.

Throughout most of the rehabilitation a representative of the Geological Survey was present to advise on the procedures and to observe the results. The procedures followed and the results obtained at each of the four wells are summarized on the following pages.

WELL 10

Pumping tests conducted on well 10 in 1953 indicated that the well probably was capable of greater yields with little additional work. It is reported that the well had a capacity of 400 gpm (gallons per minute) when it was completed in 1948. In the summer of 1954 the well was yielding about 325 gpm, and in the winter of 1954-55 only about 270 gpm. Some of the later decline in yield probably is due to the increased head caused by pumping the water to the new surface reservoirs completed in the latter part of 1954. As past records of drawdowns are not available, it is not possible to determine definitely to what extent the previous decreases in discharge were the result of a decrease in well capacity. The tests conducted in 1953 indicated that a large part of the decrease in discharge probably was due to a decrease in the efficiency of the pump.

In February 1955 the existing pump was removed from the well so that the well could be test pumped to determine its optimum yield. After the existing pump was removed, it was found that the lower 38 feet (between depths of 45 and 494 feet) of the well was filled with medium to coarse sand. Bailing operations were somewhat difficult because the well is not straight and because pieces of airline tubing were encountered near the bottom of the well. All the accumulated material was finally removed.

A test pump was installed with the bottom of the bowl assembly set at a depth of about 453 feet with an additional 20 feet of suction pipe. Because the well is not straight, the test pump column rested against the casing in several places, and it was impossible to determine water levels by dropping a steel tape between the column and the casing. The nonpumping depth to water was determined to be 357 feet below the top of the concrete pump base by dropping a steel tape down inside the pump column. After pumping started all the water levels were measured with an airline gage.

Procedures and results

On February 26, 1955, the well was pumped at an average rate of 310 gpm for 4 hours. At the end of that pumping period, the depth to water was about 373½ feet, representing a drawdown of 16½ feet. About 4 hours after pumping ceased, the water level had risen to 357 feet, the level prior to pumping.

On February 27 the pump was started at a rate of 450 gpm. Much sand, silt, and clay were pumped, and the water did not clear appreciably. After the well had been pumped for about 3 hours, the gravel pack suddenly dropped about 67 feet. The yield of the pump was decreasing constantly, both before and after the gravel pack slipped, and at the end of 4 hours the water level had declined to about 455 feet, representing a drawdown of about 98 feet. The well was pumped for an additional 2 hours, during which time the water level declined an additional foot, and the yield of the pump declined to about 400 gpm. Much air was being pumped, and the water level was fluctuating noticeably. The pump was stopped for 4 hours, during which time 5 cubic yards of gravel were added to the gravel pack.

The well was then pumped for 3 hours at 300 gpm and for an additional 2 hours at 400 gpm. A considerable amount of sand was pumped during this period, and the drawdown at the end of 5 hours was about 30 feet. An additional 5 cubic yards of gravel were added to the gravel pack.

On February 28 the well was pumped for 8½ hours at rates ranging from 300 to 450 gpm, and much sand and clay were removed. Gravel was added to keep the level of the gravel pack within a few feet of the land surface.

From 9:00 a. m. on March 1 until 4:30 p. m. on March 2 the well was pumped at varying rates up to 500 gpm, and the well was surged frequently by allowing the water in the pump column to drop back into the well. Each surging operation resulted in a large increase in sand content of the water.

On March 2 an additional engine was attached to the pump, and from 9:00 p. m. until 4:00 a. m. on March 3 the well was pumped at varying rates up to 800 gpm with frequent surges. Toward the end of this period very little fine sand and clay, but a large amount of coarse sand was being pumped.

On March 3, after a shutdown period of 8 hours, the water level in the well was at a depth of 359 feet and rising slowly. The well was pumped for 3 hours at a rate of 450 gpm. Very little sand and practically no clay was pumped. At the end of the 3 hours, the depth to water was 387 feet and the pumping rate was increased to 500 gpm. Some sand was pumped when the pumping rate was first increased, but the water cleared in a very few minutes. After the well had been pumped at this higher rate for 3 hours, the depth to water was 395½ feet, representing a total drawdown of about 38 feet. The water contained only a very small amount of coarse sand.

Conclusions and recommendations

It appears that the gravel pack in well 10 had been bridged and had been in an unstable condition for a considerable length of time, possibly since the well was first constructed. During the recent pumping and development operations, the gravel pack dropped about 80 feet, and approximately 12 cubic yards of gravel were added to bring the level of the gravel to the land surface. It is believed that the gravel pack is now continuous and at higher rates of pumping will be considerably more effective than formerly. The life of the well undoubtedly has been increased by dropping the gravel pack and removing a large amount of sand and clay.

The maximum yield of the well is now about 700 gpm, compared to about 400 gpm before these operations, but it would not be advisable to pump the well at this rate because of the large drawdown that would result and the danger of pumping large amounts of sand. The original gravel used in the well is coarse and poorly sorted, and it is likely that the gravel would continue to pass large amounts of coarse sand at high rates of pumping.

Following redevelopment, the well was test pumped on March 3, 1955 for 3 hours at a rate of 450 gpm and for 3 hours at a rate of 500 gpm. At the end of the 6 hours of continuous pumping, the depth to water, as measured by an air gage, was $395\frac{1}{2}$ feet, representing a drawdown of about 38 feet. The water contained a small amount of coarse sand but no fine sand or clay at the higher rate of pumping. The tests indicate that the well probably could be safely pumped at a rate of 500 gpm. However, there will be less danger of moving undesirable amounts of sand, and the drawdown will be at least 20 percent less, if the well is pumped at a rate not exceeding 450 gpm. It would be advisable to set the pump bowls at a depth of about 450 feet to be certain that the pumping water level will still be well above the bowls as the water level declines.

On figure 1 are plotted the drawdown and recovery of the water level

Figure 1.--Drawdown and recovery curves from pumping test of well 10 on March 3, 1955, following rehabilitation.

in well 10 during a pumping test that followed rehabilitation. Figure 2

Figure 2.--Specific capacity curves from pumping test of well 10 before and following rehabilitation.

is a graphic plot of the specific capacity of well 10 before and following the redevelopment operations described above.

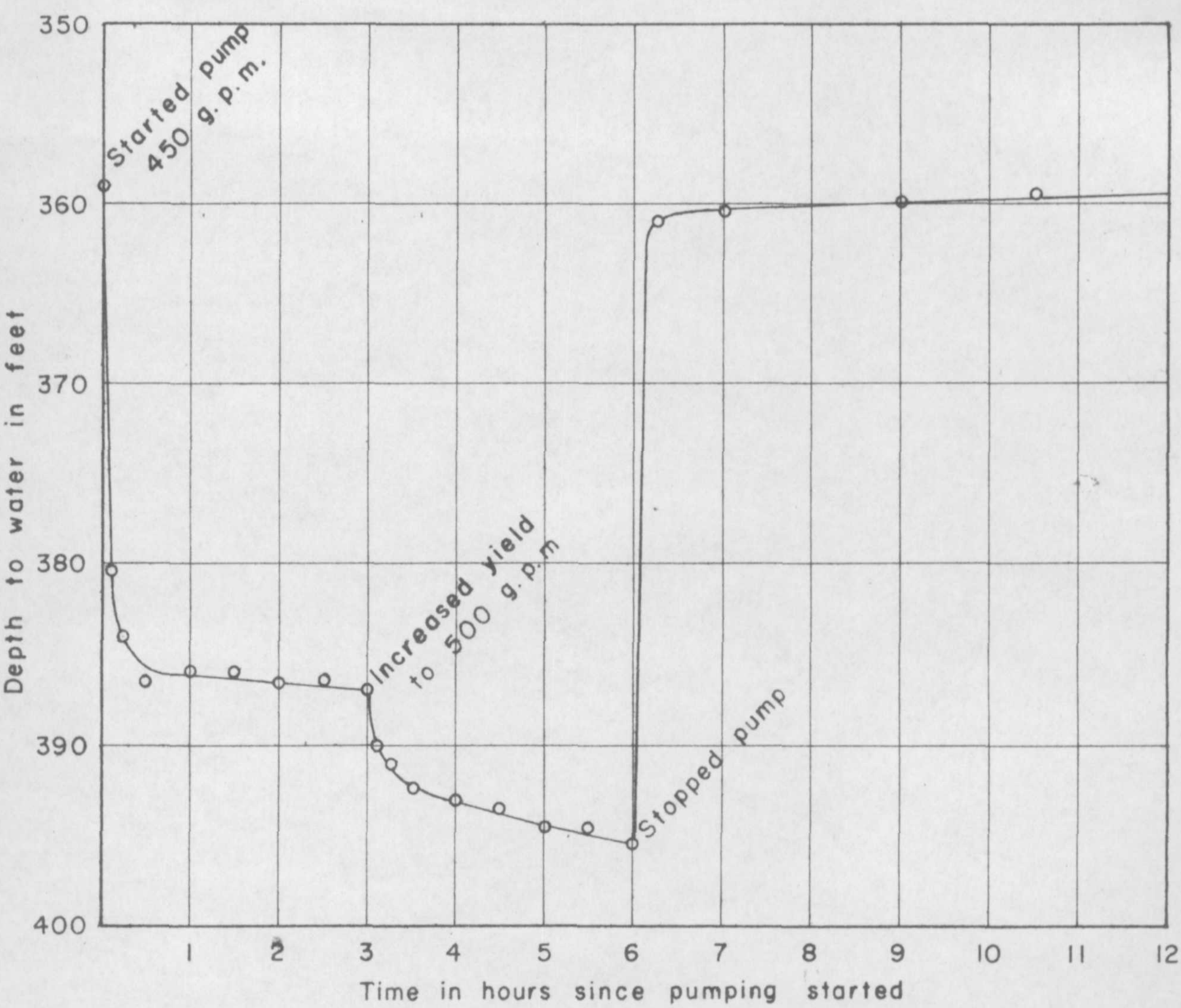


Figure 1.--Drawdown and recovery curves from pumping test of well 10 on March 3, 1955, following rehabilitation

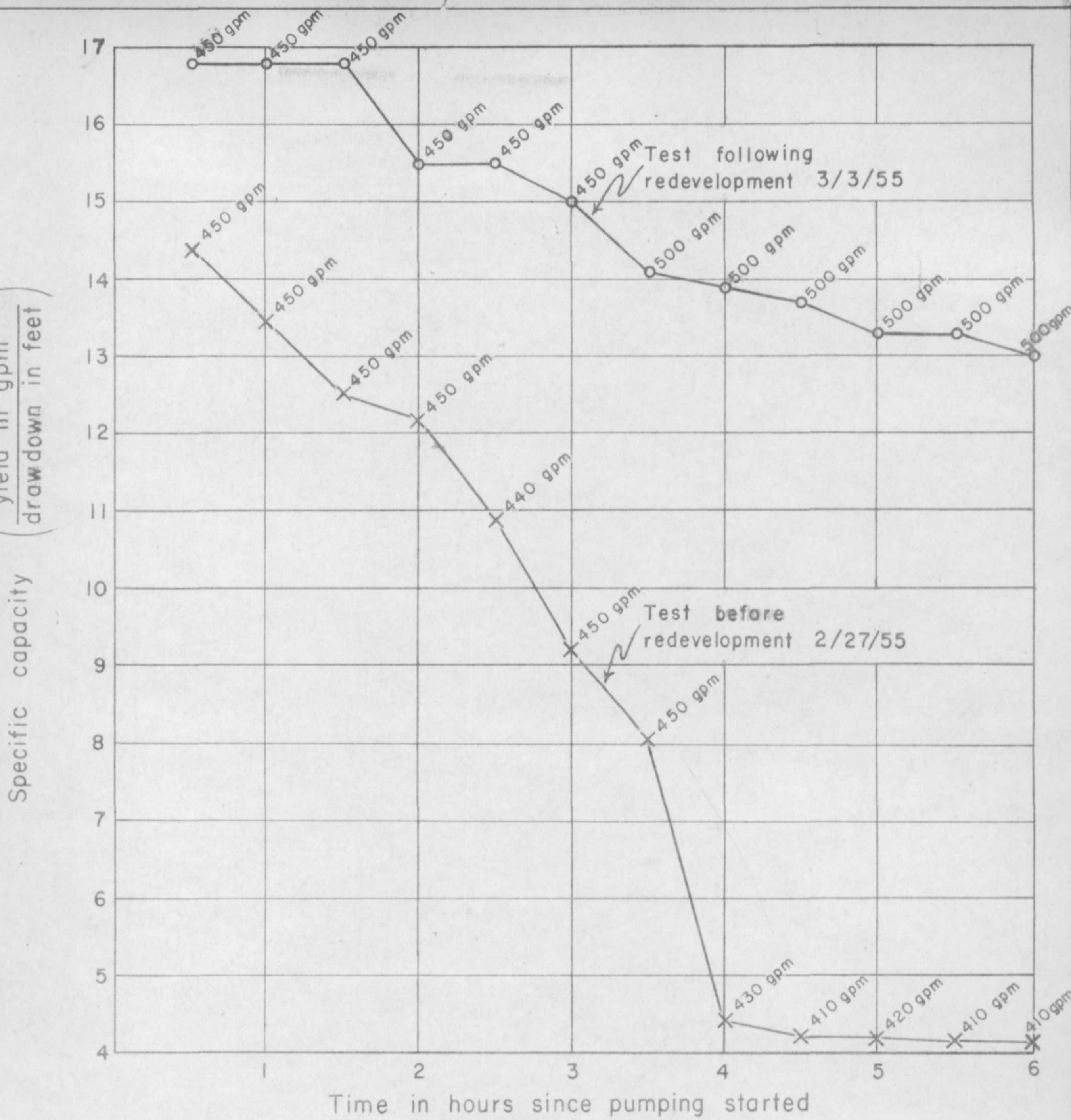


Figure 2.--Specific capacity curves from pumping test of well 10

before and following rehabilitation

WELL 11

Well 11 was drilled in 1950 to a total depth of 523 feet and cased to a depth of 500 feet. The casing is perforated with $\frac{1}{4}$ x 4-inch slots between depths of 380 and 490 feet. The depth to water when the well was completed is reported to have been 291 feet.

It is reported that well 11, when first equipped in 1950, produced 480 gpm with a drawdown of 40 feet. There is no indication of how long the well was pumped, and it is impossible to accurately evaluate and compare the reported data with more recent tests. In August 1953 the well was pumped for $29\frac{1}{2}$ hours at an average rate of 366 gpm. Throughout the pumping period the water level declined at an almost constant rate and had reached the top of the bowl assembly, a drawdown of approximately 60 feet, at the end of that period. In July 1954 the well was producing about 250 gpm. In August 1954 the well suddenly produced a large amount of sand, and it is reported that the pump locked. The well was taken out of service until rehabilitation could be undertaken.

Although the drawdown and recovery curves appeared to be characteristic of a well producing water from a limited aquifer, there were indications that the declining yield probably was partly due to plugged perforations or gravel pack. It is also probable that the efficiency of the pump had declined. In March and April 1955 the following procedures were followed in an attempt to increase the production of the well.

Procedures and results

On March 13, 1955, in an attempt to determine which perforations were admitting water to the well, a current meter was lowered between the pump column and the casing to the bottom of the well. Considerable difficulty was encountered in getting the meter past the bowl assembly. As the well was pumped, the current meter was raised in intervals of 5 feet. There were inconclusive indications of water entering the well at depths of approximately 470, 425, and 390 feet. The pump was then removed, and medium to coarse sand was bailed from the well between depths of 490 and 495 feet.

On March 17 neutron and gamma-ray logs were run. These were compared with the electric log run when the well was first drilled. The neutron and gamma-ray logs indicated that the formation about the well bore was relatively impermeable throughout most of the depth of the well. Although a permeable zone between depths of 470 and 490 feet was indicated on the original electric log, the section between depths of 480 and 490 feet appeared on the neutron and gamma-ray logs to be impermeable. It appeared that most of the gravel pack probably had a low permeability and that the greatest part of the water was entering the well between depths of 470 and 480 feet.

During the afternoon of March 17 the perforated section of the well was swabbed for $5\frac{1}{2}$ hours with a close-fitting surge block, the well was bailed to a depth of 490 feet, and compressed air was pumped through the short air cleanout line. These operations lowered the gravel pack about 8 feet.

On March 18 compressed air was pumped through the short air cleanout line. The long air cleanout line remained plugged and was not free until March 26. In the meantime a test pump had been installed with the bowls set at a depth of approximately 450 feet. On March 29 the well was pumped for short periods at varying rates, and compressed air was pumped through both air cleanout lines alternately while the pump was off. Large amounts of sand and silt were discharged each time the pump was started, but the water cleared in a very few minutes. On March 30 the well was surged at intervals with the pump, and air pressure was applied to the air cleanout lines.

On March 31, 600 pounds of dry Weltone was washed into the well between the pump column and the casing. The well was then surged 12 times with the pump. The chemical was left in the well for 48 hours, during which time the well was surged 10 times every 2 hours during the working hours. Toward the end of that period the gravel pack dropped about 12 feet following a surging operation, and gravel was added to bring the level to the top of the gravel feed line. Soon after this, it was noted that the pump could be moved only with difficulty, probably because sand had accumulated around the bowl assembly.

On April 2 the well was pumped, and large quantities of sand, silt, and clay were removed. The well was surged frequently to keep the sand moving.

On April 3, 600 pounds of Weltone was washed into the well as before. The well was surged with the pump and air pressure applied to both the long and short air cleanout lines at intervals throughout that and the following day.

On April 5 the well was pumped at an average rate of 350 gpm for 1 hour. Large quantities of sand, silt, and clay were removed by the pump and the water level declined more than 100 feet in that period. Throughout the day and the next the well was pumped at varying rates, the well was surged frequently, and air pressure was occasionally applied to the air cleanout lines. As the water cleared there was a steady improvement in the performance of the well.

On April 6 very little sand could be moved by surging and pumping, and a final 4-hour performance test of the well was made. The well was pumped for 4 hours at an average rate of 460 gpm. The total corrected drawdown was 55 feet and the water was clear.

Conclusions and recommendations

It appears from the observations made during these rehabilitation operations that the gravel pack in well 11 contained a large amount of sand, silt, and clay, probably accounting to a large extent for the decline in the yield of the well. Apparently the gravel pack was not bridged. The fact that only a small amount of sand had accumulated in the well tends to support other evidence that prior to rehabilitation a large part of the water probably was entering the well at the lower part of the perforated section of the casing. There are indications in the nature of the drawdown and recovery curves of the final test that the well is still not fully developed to its potential capacity. The lower part of the pump was heavily encrusted with iron oxide and other material, and it is probable that some of the perforations are plugged with these same materials. It is possible that additional sand could be moved and perforations cleaned more completely if additional extensive treatment, including treatment with a mud acid, were undertaken; it is not certain that this would improve the well more than has been accomplished with the operations described above.

The final pumping test, the results of which are given graphically in figures 3 and 4, indicate that the well should safely produce at

Figure 3.--Drawdown and recovery curves from pumping test of well 11 on April 6, 1955, following rehabilitation.

Figure 4.--Specific capacity curve from pumping test of well 11 on April 6, 1955, following rehabilitation.

least 400 gpm compared to 250 gpm before rehabilitation was undertaken. The nonpumping water level is about 305 feet, and if the well is pumped at a rate of 400 gpm the drawdown will be approximately 60 feet. It would be advisable to set the pump bowls at a depth of about 450 feet to keep the lower part of the well free of sand and to be certain that the bowls remain well below the pumping water level as the water level declines.

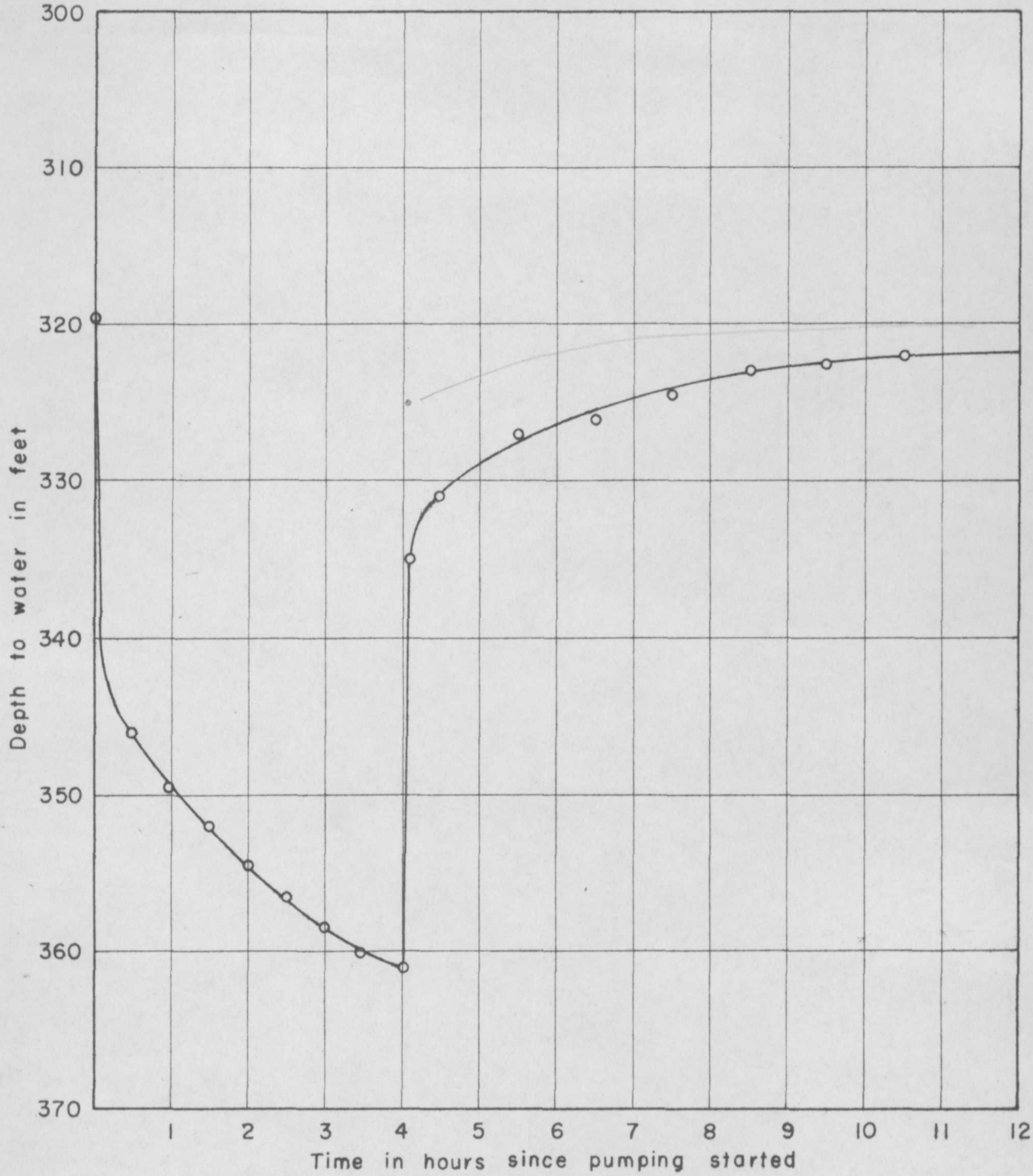


Figure 3.--Drawdown and recovery curves from pumping test of well 11 on April 6, 1955, following rehabilitation

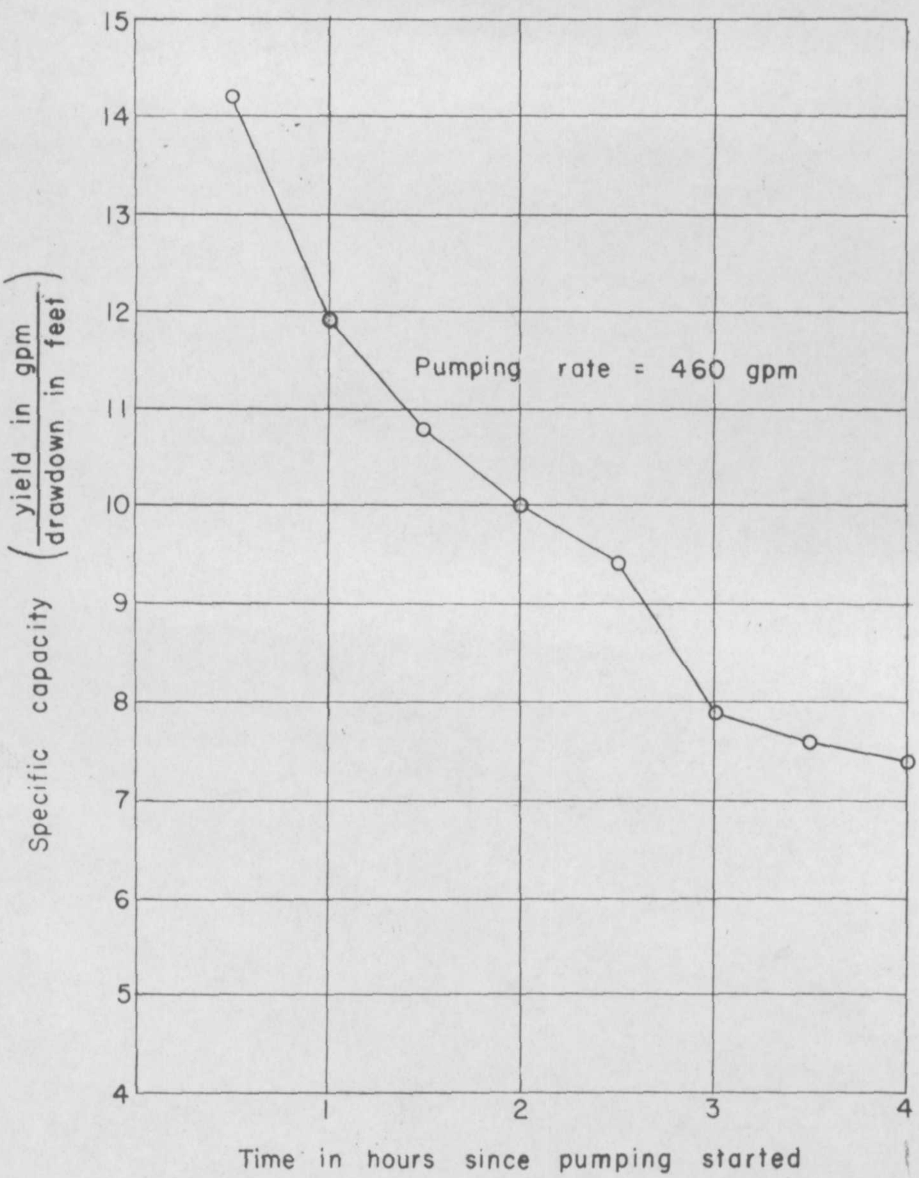


Figure 4.--Specific capacity curve from pumping test of well 11 on April 6, 1955, following rehabilitation

WELL 12

Well 12 at White Sands Proving Ground was completed in January 1952 at a depth of 570 feet. The 12-inch diameter casing was perforated with $\frac{1}{4}$ x 4-inch slots at depths of 330 to 360 feet, 425 to 480 feet, and 500 to 560 feet. The well was gravel packed, and three air cleanout lines were placed to depths of 360, 480, and 560 feet.

It is reported that the depth to water when the well was completed was 291 feet, and the well was pumped at a rate of 330 gpm with a resulting drawdown of 103 feet. Therefore, the specific capacity of the well was computed to be 3.2 gpm per foot of drawdown. However, there is no record of how long the well was pumped during the test. Therefore, it is impossible to evaluate the data accurately or to compare the test with later performance records.

It is reported that in July 1952 the static water level in well 12 declined about 14 feet very suddenly. A decline in the yield of the pump also was reported at that time. One air cleanout line was found to be plugged and could not be opened with 550 psi (pounds per square inch) of compressed air. Although the gravel pack did not drop, it was concluded that the formation had caved and sealed off at least one water-bearing stratum. However, records indicate that the drawdown in the well resulting from pumping decreased from 145 to 50 feet following the supposed caving. This would indicate that the overall performance of the well probably was at least as good as it had been previously. However, the reliability of the records is questionable. The long air cleanout line could have been plugged with only a small accumulation of sand in the bottom of the well, such as would result from normal pumping. The lower end of the air cleanout line was placed at a depth of 560 feet, only 10 feet above the bottom of the well.

Pumping records indicate that the yield of well 12 had declined from about 275 gpm in July 1952, when hour meters were installed on all the wells, to little more than 200 gpm at the end of 1954. In the past it has not been possible to measure the depth to water in the well with a steel tape, and airline determinations of the water level probably are not reliable.

Pumping tests of well 12 have indicated that the transmissibility of the aquifer in the vicinity of the well is relatively low. However, there are indications of considerable well loss, and it appeared that the performance of the well might be improved through redevelopment if the gravel pack could be stabilized. In July and August 1955 the following procedures were followed in an attempt to increase the specific capacity of the well.

Procedures and results

The pump was removed from well 12, and it was found that sand had accumulated to a depth of 552 feet. As this would place the top of the sand 8 feet above the bottom of the long air cleanout line, this would explain why the air cleanout line could not be opened with compressed air. The well was bailed to a depth of 570 feet, and the perforated sections of the casing were then swabbed for 8 hours with a close-fitting surge block, and compressed air was applied to the air cleanout lines. The well was again bailed to a depth of 570 feet. The gravel pack had not been lowered. The depth to water in the well on July 27, following swabbing and bailing, was determined with a steel tape to be about 304 feet below the top of the casing.

A test pump was installed with the top of the bowl assembly and the bottom of the airline at a depth of 440 feet. Two direct-reading airline gages were calibrated to the measured non-pumping water level.

On July 29 the well was pumped at a rate of 200 gpm. However, the yield declined rapidly, and the water level dropped to the bowls within 5 minutes after pumping started. Much heavy green clay, silt, and sand were pumped, and after 2 hours of pumping, the yield of the pump was only about 150 gpm, and the water level was fluctuating at the bowls. On July 30, the well was pumped at rates ranging up to 230 gpm, and the well was surged frequently by stopping and starting the pump. A large quantity of clay and sand was pumped, but the gravel pack could not be lowered.

At 4:00 p. m. on July 30, 600 pounds of dry Weltone was washed into the well between the pump column and the casing. The well was then surged eight times with the pump. The Weltone was left in the well for 48 hours, during which time water was washed down through the gravel pack and the well was surged with the pump eight times every 2 hours during the working hours.

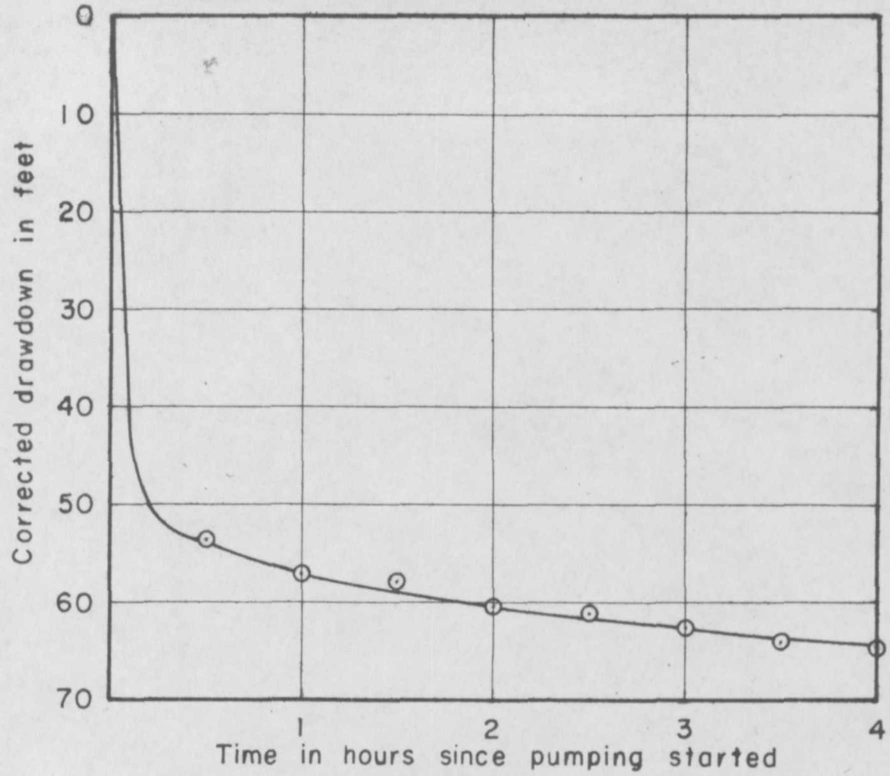
On August 1 and 2 the well was pumped at rates ranging from 150 to 300 gpm, until the water was relatively clear. The well was surged frequently with the pump and water was washed through the gravel pack in order to move as much clay and sand as possible from the gravel pack. The performance of the well improved with continued pumping and surging, but the gravel pack could not be lowered.

At 9:30 a. m. on August 2, 600 pounds of dry Weltone was again washed into the well between the pump column and the casing. The chemical was left in the well for 48 hours; water was washed through the gravel pack; and the well was surged with the pump eight times every 2 hours during the working hours. Frequently during this period compressed air was applied to the two shorter air cleanout lines. The long air cleanout line was plugged, probably by an accumulation of sand in the bottom of the well. These operations did not result in a lowering of the gravel pack.

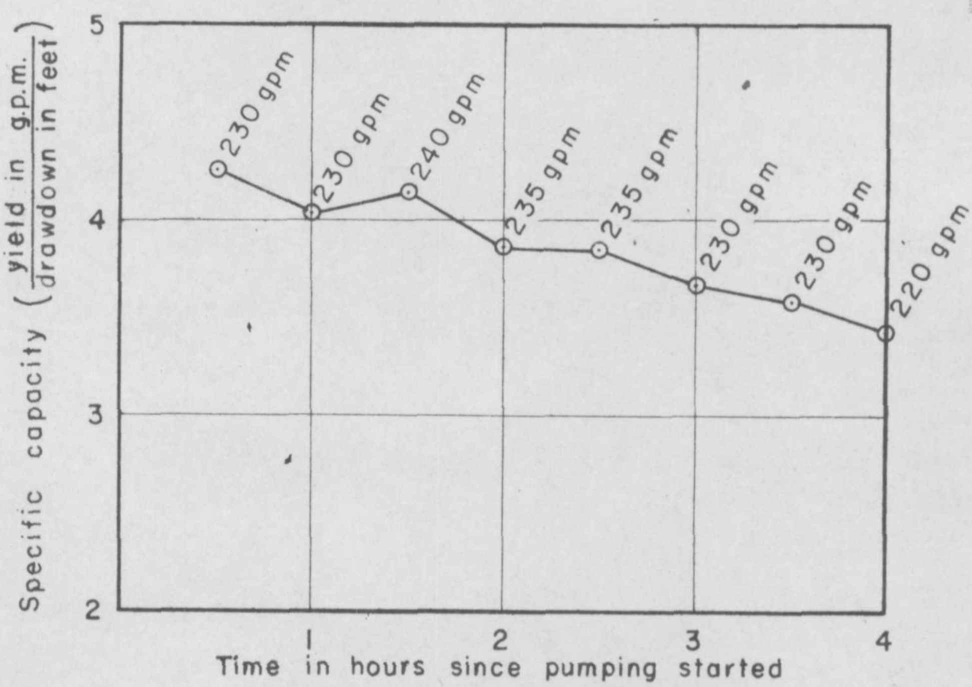
From 12 M on August 4 until 1:30 p. m. on August 6 the well was pumped almost continuously at rates ranging from 150 to 300 gpm. Whenever the water cleared sufficiently, the well was surged several times with the pump, and compressed air was occasionally applied to the air cleanout lines in an attempt to keep the clay and sand moving through the gravel pack. On August 6 the water contained only a trace of fine to medium sand, and surging did not result in the movement of appreciable amounts of sand.

From 1:30 p. m. on August 6 until 9:00 a. m. on August 7, the well was not pumped, and the recovering water level was measured frequently with the airline gage. From 9:00 a. m. until 1:00 p. m. on August 7, the well was pumped at an average rate of about 230 gpm and the depth to water was determined frequently with the airline gage. The results of this pumping test are plotted on figure 5.

Figure 5.--Curves from pumping test of well 12 on August 7, 1955, following rehabilitation.



A.--Drawdown curve



B.--Specific capacity curve

Figure 5.--Curves from pumping test of well 12 on August 7, 1955, following rehabilitation.

Conclusions and recommendations

During the redevelopment of well 12 a large quantity of clay and sand was pumped, but the gravel pack could not be lowered. The gravel used in this well was large and very poorly sorted. It may have been bridged when originally placed and is almost certainly bridged at present. If the bridge is within about 50 feet of the surface, it might be possible to lower the pack by jetting with water. However, this would be a difficult and expensive procedure, as it would be necessary to remove the concrete pump base. The bridge may be at any depth.

The results of the final pumping test on August 7 following redevelopment are given in figure 5. They indicate that the well had a specific capacity of about $3\frac{1}{2}$ gpm per foot of drawdown at the end of 4 hours of pumping at a rate of 230 gpm.

The well should at present produce about 250 gpm with about 75 feet of drawdown for short periods of pumping. The well probably should not be pumped at a rate higher than 250 gpm, as a higher rate of pumping may move large quantities of sand into the gravel pack, thus reducing the specific capacity of the well.

The original pump was set at an adequate depth for the above rate of pumping. The pump bowl assembly should, of course, be carefully examined and thoroughly cleaned before it is replaced in the well. It is impossible to predict how the future capacity of the pump will compare with its capacity prior to rehabilitation of the well. On the basis of the available data the well should yield about as much water as formerly. It would be desirable to conduct a short pumping test, after the permanent pump is re-installed, to determine the value of the redevelopment procedures.

WELL 13

Well 13 was drilled in 1951 to a depth of 534 feet. The 12-inch diameter casing was perforated with $\frac{1}{4}$ x 4-inch slots at depths of 373 to 393 feet and 470 to 534 feet. The well was gravel packed, and air cleanout lines were placed to depths of 390 and 531 feet.

It is reported that the depth to water when the well was completed was 300 feet. It is also reported that the well, when it was first equipped in 1951, was test pumped at a rate of 165 gpm resulting in a drawdown of the water level of 145 feet. As there is no record of how long the well was pumped, it is impossible to accurately evaluate that data.

In the past it has not been possible to determine the depth to water in the well with a steel tape, and airline determinations have not been reliable as the airline leaked. Pumping records indicate that the well was producing about 200 gpm prior to rehabilitation.

It appeared possible from an examination of the driller's log and a comparison with other wells in the area that the performance of well 13 might be improved by redevelopment and cleaning. In April and May 1955 the following procedures were followed in an attempt to increase the production of the well.

Procedures and results

In April 1955 the existing pump was removed, and it was found that sand had accumulated to a depth of 513 feet. The well was bailed to a depth of 536 feet. The perforated sections of the casing were then swabbed for a period of 8 hours with a close-fitting surge block, and compressed air was applied to both air cleanout lines. These operations resulted in an accumulation of sand to a depth of 490 feet. The well was again bailed clean, and the depth to water was determined with a steel tape to be 315 feet below the top of the casing. The gravel pack had not been lowered.

A test pump was installed with the top of the bowl assembly and the bottom of the airline set at a depth of 440 feet. Two direct-reading airline gages were calibrated to the depth to water as determined with the steel tape.

On May 3, 4, and 5 the well was pumped at rates ranging up to 300 gpm. Compressed air was occasionally applied to the air cleanout lines, and the well was surged by stopping the pump frequently which allowed the water to drop suddenly back down the pump column. The water level declined very rapidly to the bowls; therefore, it was impossible to pump the well continuously for more than a few minutes even at a low pumping rate. A considerable quantity of clay and sand were pumped during these operations, but the gravel pack could not be lowered.

On May 6, 600 pounds of dry Weltone were washed into the well between the pump column and the casing. The well was then surged six times with the pump. The chemical was left in the well for 48 hours, during which time the well was surged six times every 2 hours during the working hours.

On May 8 at 8:00 a. m., the pump was started, but the water level declined very rapidly to the bowl assembly and very little sand was removed. Compressed air was applied to the air cleanout lines, and the well was surged in an attempt to increase the flow of water and sand. These operations were not successful, and it was apparent that the gravel pack probably was bridged and plugged with sand and clay.

At 2:00 p. m. on May 8, 600 pounds of dry Weltone were again washed into the well as before, and the well was surged six times. During the night of May 8 the gravel pack dropped 11 feet and on the following day the well was surged six times every 2 hours. Compressed air was occasionally applied to the air cleanout lines. On May 10 the gravel pack suddenly dropped to a depth of 250 feet following a surging cycle. Pumping operations were suspended and additional gravel was placed in the space for the gravel envelope during the remainder of the day. On the morning of May 11 the pump was started, but the water level declined to the bowls in 20 seconds. Compressed air was again applied to the air cleanout lines. Thereafter until May 13, during the working hours, the well was pumped and surged frequently in order to keep the water and large quantities of sand and clay moving as continuously as possible. The gravel pack slipped a few feet occasionally and the performance of the well improved constantly, although frequently the production would temporarily decline, perhaps because clay was caving in at the perforated sections of the casing. On the afternoon of May 13 there had been a pronounced improvement in the performance of the well, and the water had cleared noticeably.

On May 14 the well was pumped continuously for about 7½ hours at an average rate of nearly 300 gpm. At the end of that period the water contained very little sand and the gravel pack was stable. The total drawdown of the water level during that period was less than 100 feet, and it was believed additional pumping or surging would not be profitable.

Conclusions and recommendations

The original gravel used in well 13 was large and poorly sorted. A comparison of the original test data and the performance of the well following rehabilitation procedures indicate that this well was not adequately developed or that the original test data is inaccurate, possibly both. A large quantity of clay and sand was pumped from the well, and it is probable that the gravel pack had been bridged and therefore ineffective for a long time prior to rehabilitation.

The results of the final pumping test on May 14, 1955 are given graphically in figures 6 and 7. They indicate that the well should

Figure 6.--Drawdown curve from pumping test of well 13 on May 14, 1955, following rehabilitation.

Figure 7.--Specific capacity curve from pumping test of well 13 on May 14, 1955, following rehabilitation.

produce 300 gpm with a drawdown of approximately 100 feet. A pumping rate of 250 gpm will, of course, result in a smaller drawdown and will be less likely to move undesirable amounts of sand into the gravel pack. The original pump was set at an adequate depth and, if thoroughly cleaned, should produce somewhat more water than formerly. The life of the well undoubtedly has been increased by stabilizing the gravel pack and by removing large quantities of clay and sand.

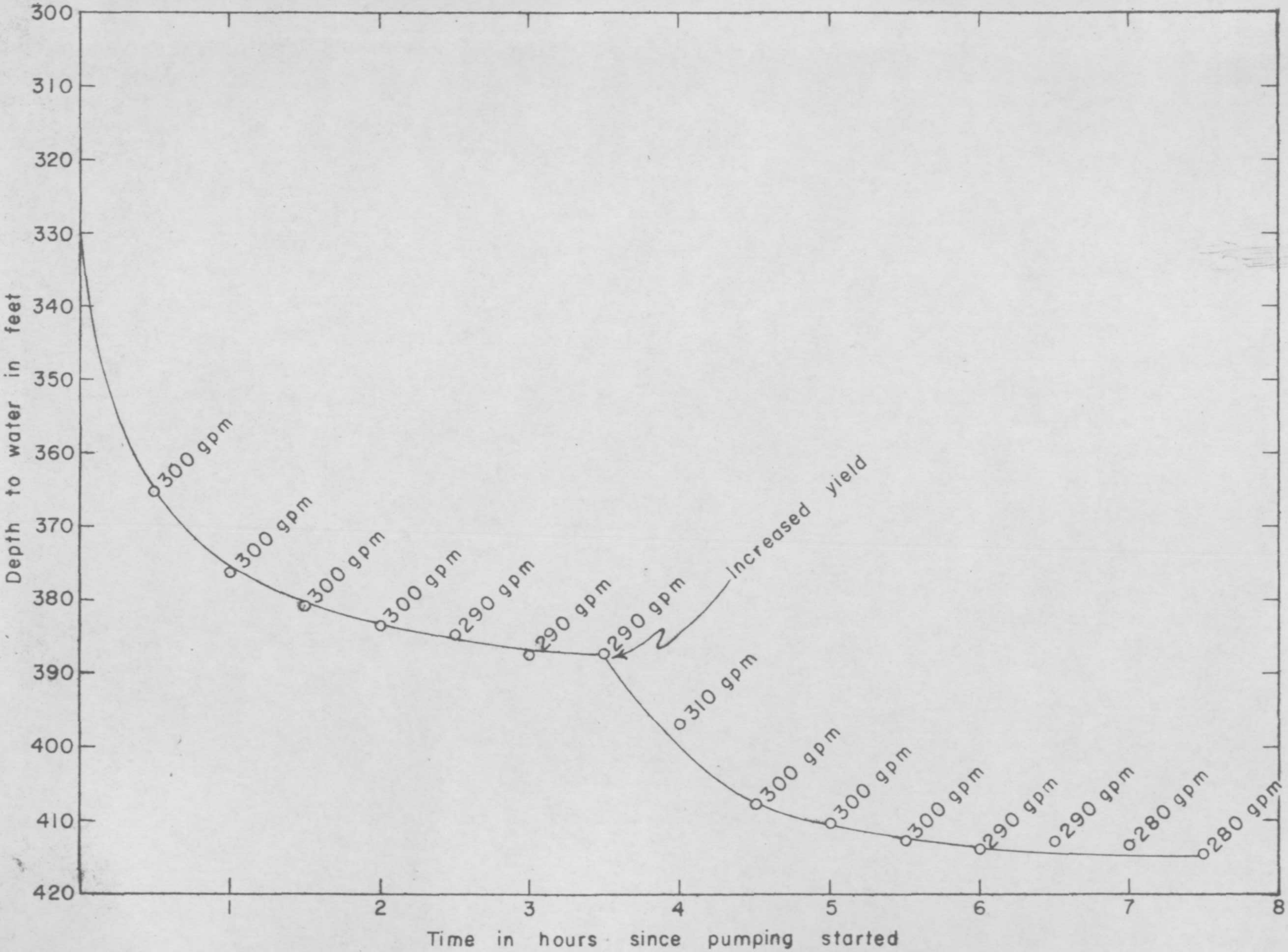


Figure 6.--Drawdown curve from pumping test of well 13 on May 14, 1955, following rehabilitation.

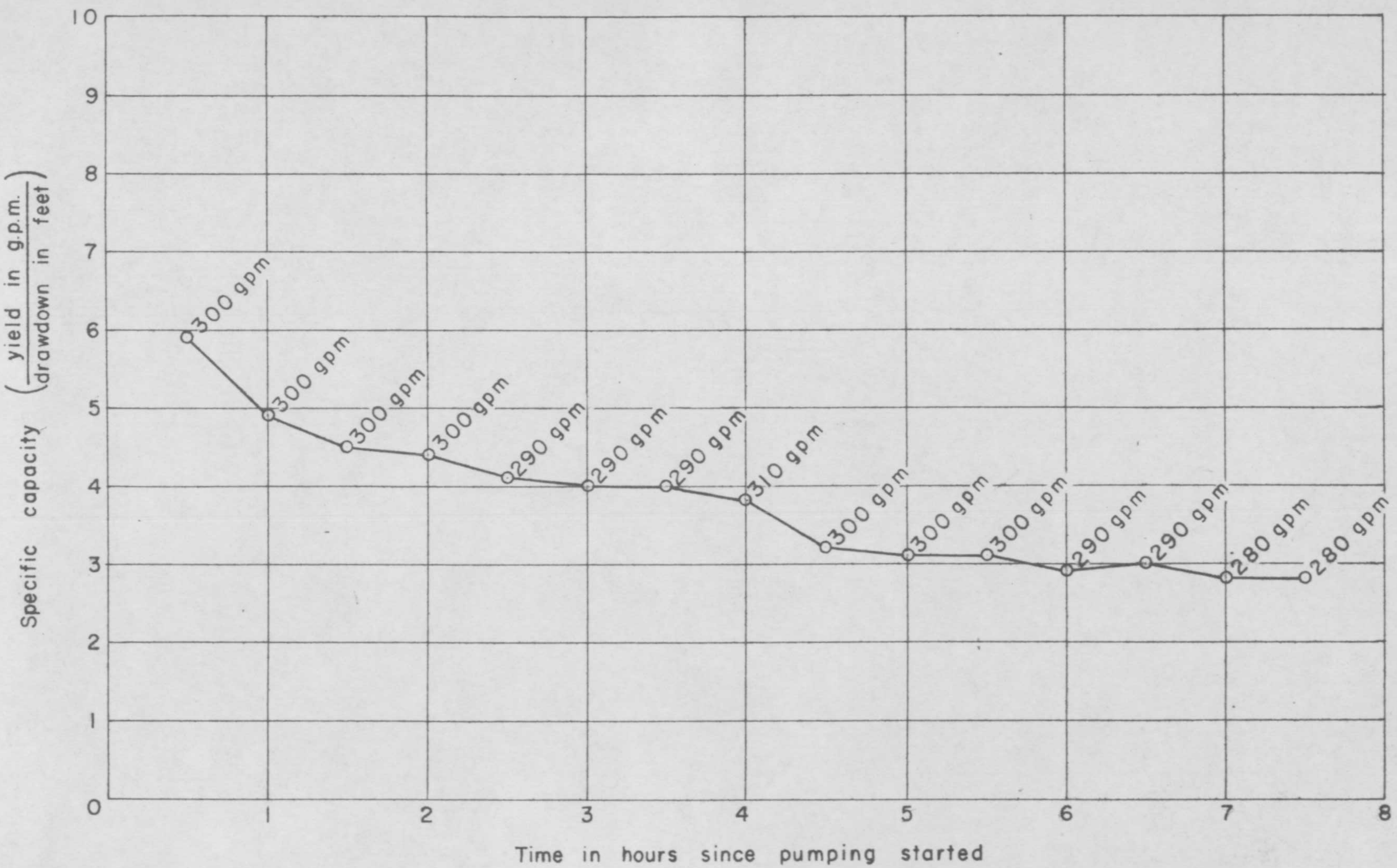


Figure 7.--Specific capacity curve from pumping test of well 13 on May 14, 1955, following rehabilitation.

Table 1.--General summary of results of rehabilitation of wells at White Sands Proving Ground, New Mexico 1/

Well	Well characteristics prior to rehabilitation							Rehabilitation procedures employed							Well characteristics following rehabilitation								
	Non-pumping depth to water 2/		Pumping test data 3/												Non-pumping depth to water 2/		Pumping test data 3/						
	Date measured	Feet below land surface	Date of test	Average yield (gpm)	Hours pumped	Drawdown (feet)	Specific capacity (gpm per ft)	Bailing	Swabbing with surge blocks	Pumping	Surging with pump	Compressed air to air cleanout lines	Weltone	Addition of gravel to gravel pack	Date measured	Feet below land surface	Date of test	Average yield (gpm)	Hours pumped	Drawdown (feet)	Specific capacity (gpm per ft)	Recommended pumping rate (gpm)	Expected drawdown (feet) at recommended pumping rate
			2-26-55	310	4	16½	18.8										3- 3-55	450	3	28½	16.1		
10	2-26-55	353	2-27-55	435	6	99	4.4	X		X	X			X	3-11-55	353	3- 3-55	475	6	38	13.2	450	35
11	3-17-55	300	8-53	366	29½	57	6.4	X	X	X	X	X	X	X	4-25-55	297	1- 6-55	460	4	55	8.4	400	60
12	7-26-55	300	9-53	212	-	-	-	X	X	X	X	X	X		10-20-55	300	8- 7-55	230	4	64	3.6	250	75
13	5- 3-55	300	9-53	209	50	72	2.9	X	X	X	X	X	X	X	5-17-55	287	5-14-55	295	7½	100	3.0	250	80

1/ Data included in this summary are of varying accuracy and are tabulated here to give a generalized summary, supplementing the text.

2/ Non-pumping depths to water in all wells measured by means of steel tape from top of casing, estimated to be approximately 4 feet above land surface.

3/ Drawdowns determined by means of airline gage.