EXPLORATION AND DEVELOPMENT
OF GROUND WATER
NORTHUMBERLAND PROJECT
MILL SITE

Prepared for:

CYPRUS MINES CORPORATION

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1.0 SUMMARY AND CONCLUSIONS

1. Five ground-water exploration holes were drilled at the Northumberland Project mill site.

2. Data derived from exploration drilling indicate that ground water is confined and that artesian pressure heads range from about 50 to 90 feet above the tops of the aquifers. Depth to ground water beneath the mill site ranges from about 250 feet to 441 feet below ground level.

3. Two hydrostratigraphic units, the Northumberland and Hoodoo tuffs, were encountered. The aquifers do not appear to be hydraulically connected in the vicinity of the mill site.

4. A process water supply of 400 gpm is available from two production wells, each capable of long-term yields of 200 gpm. A domestic water supply of 75 gpm is available from a third well.

5. Chemical quality of the ground water is fair and is acceptable for process water supply. The water is hard to very hard. Domestic water supply is marginal and will require "softening" for general use and advanced treatment for culinary use.

6. Permits to Appropriate Public Waters of the State of Nevada have been granted for four points of diversion (wells) in Big Smoky Valley.

   Applications for change in the Point of Diversion and Place of Use for these permits have been filed with the office of the State Engineer to transfer the water right to the wells completed at the mill site and a fourth, as yet undrilled, point of diversion north of the mill site.

7. Clean out and testing of existing wells near the crusher and pit sites have not resulted in adequate water supply in that area. Locating a reliable water supply at that locale will requite exploration drilling and testing to establish the potential for deriving a water supply.

2.0 INTRODUCTION

In January, 1979, WILLIAM E. NORK, INC., was contacted by CYPRUS MINES CORPORATION to investigate the potential for developing ground water as a source of water supply for CMC'S Northumberland Canyon Project. Initial program involved selection of potential ground-water exploration drilling sites in Monitor Valley near the mouth of Water Canyon. The program expanded shortly thereafter to include the selection of exploration drilling sites in Big Smoky Valley. Applications for Permit(s) to Appropriate... Waters...were filed on a total of eight points of diversion — four in Monitor Valley and four in Big Smoky Valley — in March 1979.

Due to uncertainty as to the hydrogeologic characteristics of the geologic materials in the vicinity of the proposed gold mining and milling facility, an exploration drilling and testing program was developed. Bid proposals were distributed to a number of water well drilling contractors licensed in the State of Nevada. A total of five bid estimates were returned and W. L. McDonald and Company, Sparks, Nevada, was selected as drilling contractor in May 1979. Actual drilling commenced March 18, 1980.

The Northumberland Project is located about 43 miles southeast of Austin, Nevada, on an alluvial fan adjacent to the western flank of the Toquima Range (Figure 1). Access to the project site is east from State Highway 376, at a point three miles south of the Nye County line, a distance of approximately 10 miles.

The exploration drilling program focused on a one mile square area centered at the section corner common to Section 21, T. 14 N., R. 45 E.; Section 36, T. 14 N., R. 44 E.; Section 1, T. 13 N., R. 44 E.; and Section 26, T. $13\frac{1}{2}$ N., R. $44\frac{1}{2}$ E. (Figure 1). Exploration drilling was to be multi-purpose: 1) to determine availability of ground-water supplies at the mill site and 2) to serve as mill site condemnation holes. For this reason the exploration hole sites were selected by Noranda Exploration, Inc., with the understanding that Noranda would relinquish lode claims at CYPRUS'S proposed mill site, if exploration drilling and subsequent gamma logging did not confirm the presence of economically significant mineral deposits. Drilling sites were not located at optimum sites for groundwater exploration purposes. The cost of the multi-purpose drilling program was expected to be somewhat greater than the original groundwater exploration program. However, the cost of separate condemnation and groundwater exploration would have been even more costly.

Due to the remote location of the mill site from equipment and materials

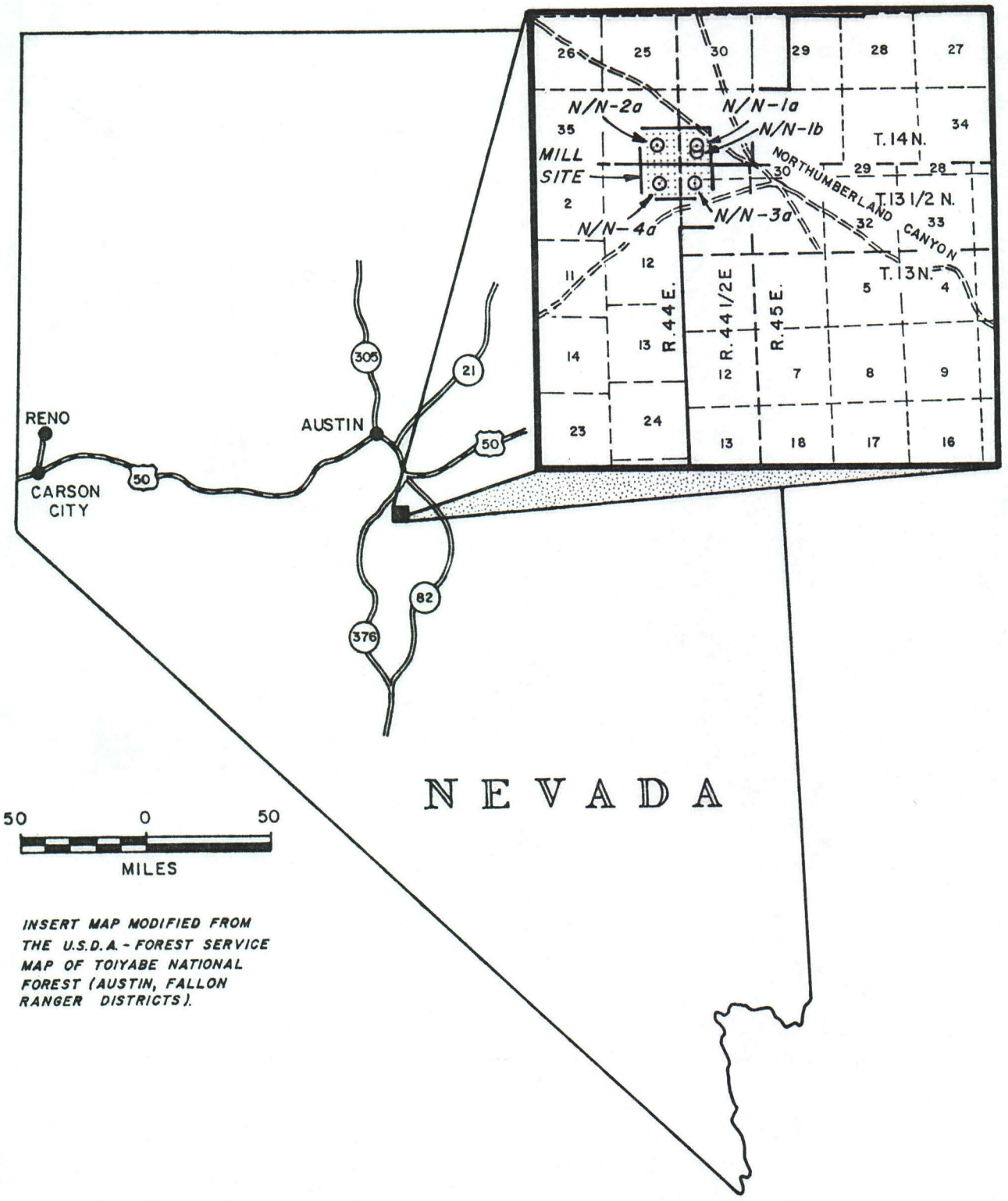

Figure 1. Northumberland Canyon Project Index Map.

supply, and the lack of nearby accommodations, on-site living quarters, support equipment, and anticipated materials were all mobilized to the site prior to commencing drilling operations. Equipment was essentially mobilized March 17, 1980, and drilling commenced March 18.

A total of five groundwater exploration holes, designated Exploration holes N/N-1a, -1b, -2, -3, and -4, were drilled at the proposed mill site — four by the air-rotary method and one by the mud-rotary method. Air rotary drilling was the preferred method of drilling. It provided information regarding the depth at which ground water is first encountered, approximate yield of a well at the exploration hole location, and allowed collecting a water sample for chemical analysis while drilling. Mud-rotary was resorted to only when downhole conditions were not compatible with air-rotary drilling.

The exploration holes penetrated 150 to 250 feet of alluvial-fan deposits and several hundred feet of Tertiary age pyroclastic rocks and associated sedimentary rocks. The Paleozoic sedimentary rocks which underlie younger geologic materials were not encountered in any of the holes. No ground water was encountered in alluvial-fan deposits. Ground water in the holes was derived from the Hoodoo tuff, Northumberland tuff, and interflow sediments. The hydrostratigraphic units are under artesian pressure and ground water levels in exploration holes rose by as much as 50 to 90 feet after water was first encountered.

All of the exploration holes were cased with steel well casing and subsequently tested to determine aquifer properties and yield of production wells constructed at the exploration well sites. Of the five holes two, N/N-1a and -2, were capable of producing approximately 200 gallons per minute (gpm) each and a third, N/N-1b, approximately 75 gpm.

In order to expedite completion of production water-supply wells, CYPRUS requested that N/N-1a and -2 be completed as production water-supply wells and N/N-1b be completed as a domestic water-supply well. Ideally, high efficiency water-supply production wells would have been constructed at the site. All five exploration holes were constructed in accordance with State of Nevada water well construction regulations, including N/N-3 and -4 which are to serve solely as monitoring wells. Water samples for chemical analysis were collected from all of the exploration holes.

3.0 HYDROGEOLOGY

3.1 GEOLOGY

Significant geologic materials in the vicinity of the Northumberland Project mill site are — from oldest to youngest — Paleozoic sedimentary rocks, the Northumberland tuff and associated sedimentary rocks, the Hoodoo tuff, and alluvial-fan deposits (Figure 2). The Paleozoic rocks include chert, shale, limestone and sandstone. They are not present at the mill site but crop out to the east and south of the mill site in the Toquima Range.

The Tertiary age Northumberland tuff unconformably overlies the Paleozoic sedimentary rocks. The tuff is mostly rhyolitic welded tuff with some tuff breccia and minor lava flows. Interbedded with the tuff are thin sedimentary strata of sandstone and chert pebby conglomerate.

Overlying the Northumberland tuff is the Tertiary age Hoodoo tuff. The Hoodoo is a biotite-rich welded tuff. All of the consolidated rocks are overlain by alluvial-fan deposits along the western flank of the Toquima Range. These deposits are poorly sorted clay, silts, sands, cobbles and boulders.

All of the aforementioned geologic materials contribute to the alluvial-fan deposits. Thickness of the alluvial-fan deposits ranges from about 150 feet beneath the eastern portion of the mill site to greater than 350 feet beneath the west.

3.2 EXPLORATION DRILLING

Due to uncertainty as to the hydraulic characteristics of the geologic materials in the vicinity of the mill site, an exploratory drilling program was selected. Production well sites were to be selected on the basis of successful exploration hole results. A total of five ground-water exploration holes were drilled (Table 1). These holes also functioned as mill site condemnation holes to release NORANDA lode claims at the mill site.

W. L. McDonald and Company, Sparks, Nevada, mobilized drilling and support equipment to the Northumberland Project mill site March 17 and 18, 1980. Four drill sites were selected by Sandra Powers, the geologist-in-charge for Noranda Exploration, Inc. These were designated N/N-1, -2, -3, and -4, located in the centers of SW$\frac{1}{4}$ Section 31, T. 14N., R. 45 E.; SE$\frac{1}{4}$ Section 36,

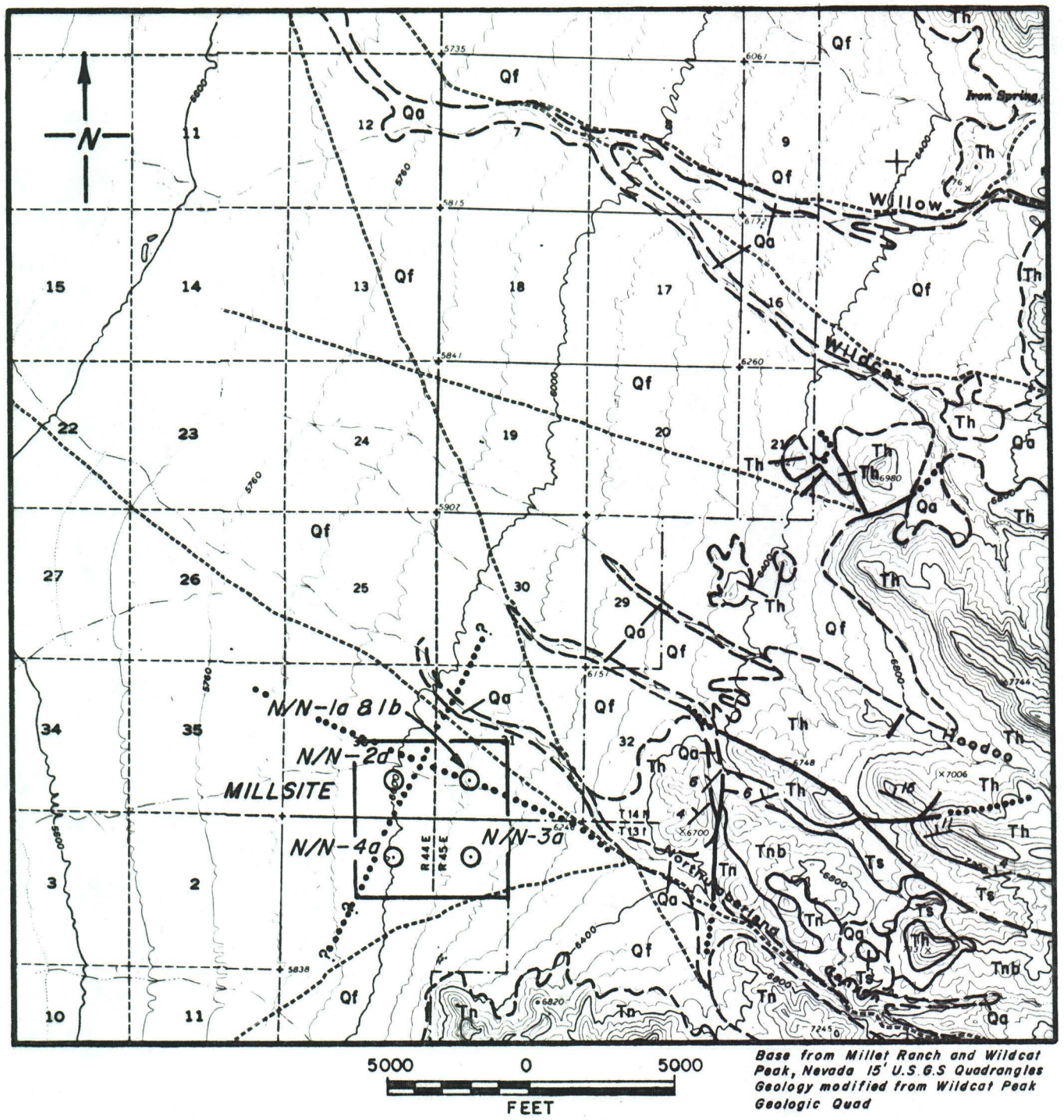

Figure 2. Geologic Map, Northumberland Canyon Project Mill Site and vicinity.

Table 1. Exploration Well Construction Summary

Exploration Hole Number	1/4, Sec., T., R.	Nevada State Coordinates	Exploration Hole Depth (feet)	Casing Depth (feet)	Perforations	Remarks
N/N-1a	SW 31 - 13N/45E.	1,556,465.007M 413,836.306E	281	281	260 to 278	Derives ground water from Hoodoo tuff.
N/N-1b	SW 31 - 13N/45E.	1,556,441.299M 413,832.698E	531	531	240 to 280 388 to 459 and 481 to 531	Derives ground water from Northumberland tuff.
N/N-2	SE 36 - 12N/44E.	1,556,381.079M 411,372.633E	700	500	440 to 500	Derives ground water from interflow sediments in Northumberland tuff.
N/N-3	26 - 12½N/44½E	1,553,891.604N 413,838.895E	700	373	303 to 373	Ground water derived from interflow sediments in Northumberland tuff.
N/N-4	NE 1 - 12N/44E	1,553,743.749N 411,290.129E	540	540	440 to 540	Derives very little ground water from Northumberland tuff.

7.
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T. 14 N., R. 44 E; NW$\frac{1}{4}$ Section 36, T. 13$\frac{1}{2}$ N., R. 44$\frac{1}{2}$ E., and NE$\frac{1}{4}$ Section 1, T. 13 N., R. 44 E., respectively (Figure 1).

Drilling of exploration hole N/N-1a by the rotary-air method commenced March 18, 1980. Total depth of 281 feet was reached March 20. The hole was cased with 6-4/8-inch O.D. x 0.250 inch sidewall casing March 21 and gamma-logged by Noranda Exploration, Inc. No significant gamma anomolies were noted.

Exploration hole N/N-1a penetrated approximately 150 feet of alluvial-fan deposits and 131 feet of Hoodoo welded tuff. Ground water was first encountered at about 250 feet depth. Significantly fractured rocks were penetrated between 270 and 281 feet depth. A lithologic log of N/N-1a is as follows:

Depth interval (feet)	Lithologic description	Formation
0-157	light brown to yellow color poorly sorted sand, gravel, cobbles and occasional boulders of crystalline tuff, chert, and limestone; up to 10% silt and clay.	Alluvial-fan deposits Qal
157-281	pink, orange and white welded tuff with quartz and biotite phenocrysts. Highly fractured below 270 ft.	Hoodoo tuff Th

N/N-1a was terminated at 281 feet due to sloughing of the fractured formation material. Continuing would have required changing to mud-rotary. Without an on-site water supply, mud-rotary drilling was not feasible. N/N-1a was equipped with a pump to serve as a drilling water supply and a new exploration hole, designated N/N-1b, commenced March 27, 1980, by the mud-rotary method. Total depth of 531 feet was reached April 15 and the hole gamma-logged by Noranda Exploration, Inc. No gamma anomalies were noted. A brief lithologic log of N/N-1b is as follows:

Depth interval (feet)	Lithologic description	Formation
0 to 157	light brown to yellow color poorly sorted sand, gravels, cobbles, and occasional boulders of crystalline tuff, chert, and limestone; up to 10% silt and clay.	Alluvial-fan deposits Qal

Depth interval (feet)	Lithologic description	Formation
157 to 260	pink to white color welded tuff contains qtz and biotite phenocrysts, and chert fragments.	Hoodoo tuff Th
260 to 280	white volcanic ash.	Northumberland tuff Tn
280-400	Predominantly white crystalline tuff contains chert fragments.	Northumberland tuff Tn
400 to 531	Predominantly white to pink welded tuff, white volcanic ash, interbedded with chert conglomerate (T_s).	Northumberland tuff Tn and Sedimentary rocks Ts

Exploration holes N/N-1a and -1b, although only 20 feet apart, penetrated significantly different geologic materials 250 to 281 feet depth. N/N-1a encountered highly fractured crystalline tuff in this interval while N/N-1b penetrated unwelded tuff or ash.

Drilling of Exploration hole N/N-2 commenced March 22, 1980. It was drilled to a total depth of 700 feet by the air-rotary method March 27. Noranda Exploration, Inc., gamma-logged the hole and detected no significant anomaly. Casing was installed to 500 feet depth. The lithologic log is as follows:

Depth interval (feet)	Lithologic description	Formation
0 to 372	light brown to yellow color poorly sorted sand, gravel, cobbles and occasional boulders, of tuff, chert, and limestone up to 15% clay and silt.	Alluvial-fan deposits Qal
371 to 462	yellow, pink, and white colored lithic crystalline tuff - quartz and white phenocrysts and chert lithic fragments.	Hoodoo tuff Th
462 to 481	sands, gravels, cobbles and red clay or ash.	Interflow sediments

Depth interval (feet)	Lithologic description	Formation
481 to 565	Yellow and pink crystalline, lithic tuff - no biotite.	Northumberland tuff Tn
565 to 575	very fine-grained sandstone.	T_s
575 to 700	Yellow crystalline, lithic, welded tuff.	Northumberland tuff Tn

Ground water was first encountered in the hole at 441 feet depth, in Hoodoo Formation rocks. Significant ground water appears to be derived mainly from interflow sediments or contacts between individual Northumberland tuff flows referred to as cooling breaks. Well casing was installed in N/N-2 for later aquifer testing.

Exploration hole N/N-3 drilling commenced April 2, 1980. Total depth of 700 feet was reached April 8. Ground water in significant amounts was not encountered in this hole. A lithologic log of N/N-3 is as follows:

Depth interval (feet)	Lithologic description	Formation
0 to 160	poorly to moderately sorted sand, gravel, cobbles and boulders consisting of welded tuff, chert and limestone.	Alluvial-fan deposits
160 to 290	Green colored crystalline to vitric tuff.	Northumberland tuff Tn
290 to 300	Coarse sand to gravel of welded tuff.	Interflow sediments T_s
300 to 405	Pink and white welded tuff - occasional biotite.	Tn
405 to 415	Medium to coarse gravel sand - predominantly quartz and weathered glass.	T_s
415 to 440	Grey-green poorly welded tuff with some glass and quartz crystals, little to no biotite.	Tn

Depth interval (feet)	Lithologic description	Formation
440 to 470	Medium to coarse-grained sands and gravels of tuff and chert.	Ts
470 to 630	Grey-green welded tuff as above; contains grey ash bed.	T_n
630 to 700	Complex sequence of welded tuff, ash, sedimentary rocks and thin rhyolite flows.	Tn and Ts

Exploration hole N/N-4 was drilled April 12-15, 1980. Ground water in significant amounts was not encountered the entire 540 feet depth. An abbreviated lithologic log is as follows:

Depth interval (feet)	Lithologic description	Formation
0 to 150	light brown to yellow, poorly to moderately sorted sand, gravel, cobbles and boulders of welded tuff, limestone, and chert.	Alluvial-fan deposits. Qal
150 to 540	white, pink, orange and grey welded tuff.	Northumberland tuff T_n

Gamma logging of N/N-4 by Noranda Exploration, Inc., detected no gamma anomaly in the formation material at this site. The hole was cased to total depth for later testing and use as a monitoring well for the heap leach operation.

Each of the exploration holes was later test-pumped to determine aquifer characteristics beneath the mill site and enable selection of suitable production well sites.

3.3 HYDROLOGY

Recharge to the groundwater system tributary to the Northumberland Project mill site occurs as precipitation in the form of rain and snow in the Toquima range east of the mill site. Precipitation ranges between 8 and 20 inches per year, depending on elevation and orientation to major storm track patterns. As much as 25 per cent of this is available as recharge to the groundwater system. In the vicinity of Northumberland Canyon (west) ground water generally moves westward and is discharged to the atmosphere at the playa west of the mill site.

Two hydrostratigraphic units have been identified beneath the mill site on the basis of exploration drilling and aquifer testing. The alluvial-fan deposits beneath the mill site are not saturated with ground water. Ground water in both aquifers beneath the mill site is under artesian pressure. Depth to ground water varies between 250 feet below G.L. (ground level) in the Hoodoo tuff aquifer (in N/N-1a) and 441 feet in the Northumberland tuff aquifer (in N/N-2). Water levels rose 43 feet in N/N-1a to 207 feet below G.L. and 84 feet in N/N-2 to 357 feet below G.L. after it was first encountered.

Little to no hydraulic connection exists between the two aquifers beneath the mill site. This is evidenced by the extreme difference between water levels in N/N-1a — 207 feet below T.O.C. (top of casing) — and N/N-1b — 290 feet below T.O.C. — a mere 20 feet apart, and no measurable response in N/N-1a during testing of N/N-1a.

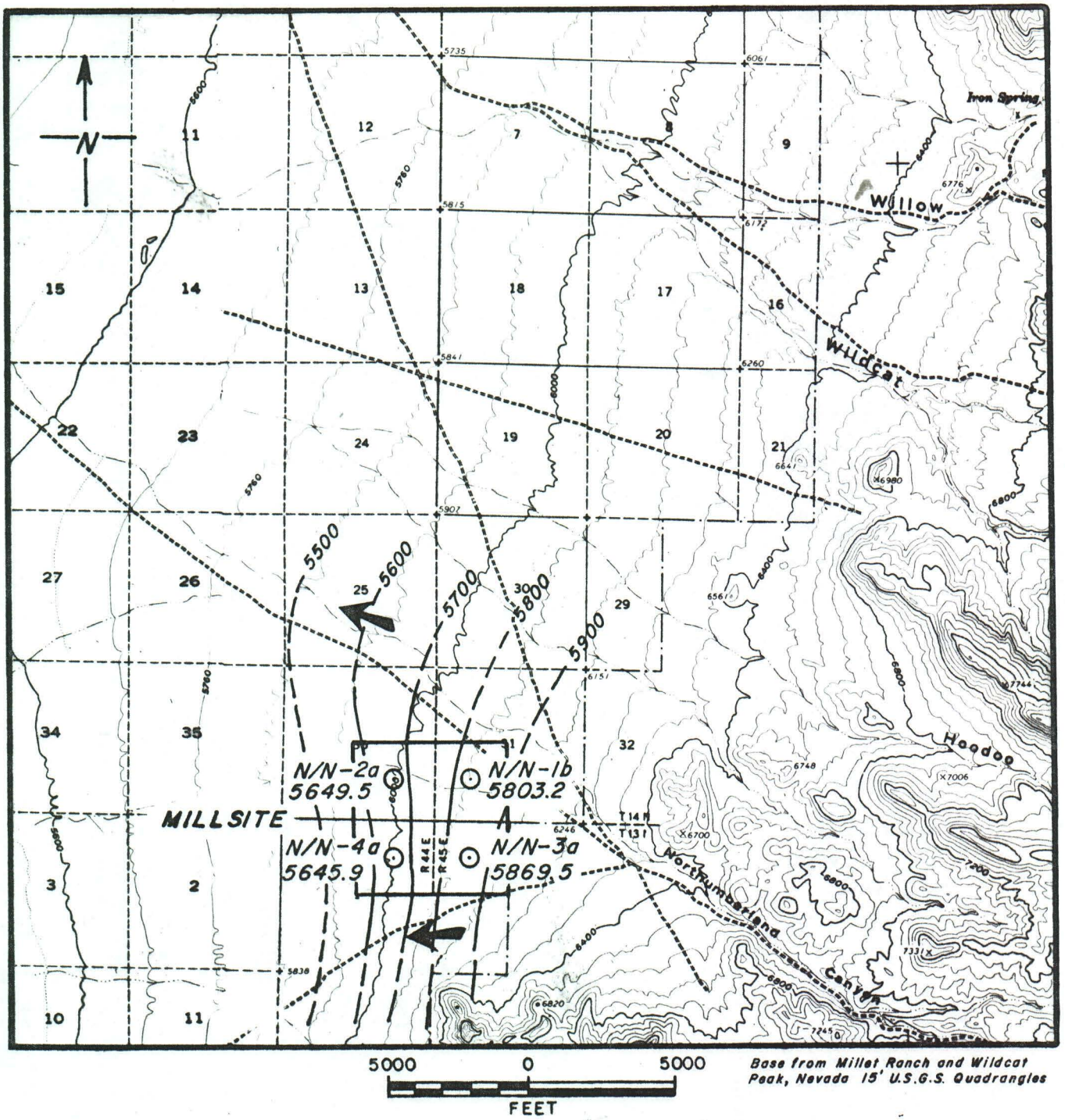
Water level data from exploration holes was N/N-1b, -2, -3, and -4 all completed in the Northumberland tuff aquifer indicate that ground water is flowing west to west-northwest beneath the mill site (Figure 3). Groundwater flow gradient is 0.050 to 0.067. Flow direction of the Hoodoo tuff aquifer is presumed to be the same.

3.4 TEST PUMPING RESULTS

Pumping tests to determine aquifer characteristics were conducted on all of the completed exploration holes to determine aquifer characteristics and potential long-term yield of production wells at these sites.

Exploration hole N/N-1a

Test pump set at 276 feet below G.L. Static water level prior to testing was 206.96 feet. Testing commenced 0930 hours 04/17/80. Drawdown at end of Step I was 3.16 feet (a depth of 210.12 feet) at a pumping rate of 25 gpm after 3 hours (180 minutes). Drawdown at end of Step II (end of test) was



⊙ 5803.2 Ground water exploration holes with indicated water level elevation.

Northumberland Tuff aquifer water level contour, dashed where approximate.

Flow direction

Figure 3. Ground Water Contour Map, Northumberland Canyon Project and vicinity.

5.08 feet (depth of 212.04) at a pumping rate of 33 gpm. Testing was terminated at 1530 hrs. 04/17/80.

Constant-discharge testing commenced 1000 hours 04/19/80. Pre-pumping water level was 207.04 feet below T.O.C. Drawdown at end of testing was 6.46 feet (pumping water level of 213.50 feet below T.O.C.). Testing terminated 1000 hours 04/20/80 at end of 24 hours (Figure 4). Water levels recovered quickly, approximately 75 per cent within three hours (Figure 5).

Exploration hole N/N-2a

Test pump set at 420 feet below T.O.C. Static water level prior to testing was 357.70 feet below T.O.C. Testing commenced 1115 hrs. 04/30/80. Pumped at 10 gpm for 360 minutes (six hours). Drawdown at end of testing was 0.74 (358.44 feet below T.O.C.) (Figure 6). Testing terminated at 1715 hours 04/30/80. Recovery was instantaneous. Water sample for chemical analysis was collected at end of test.

Higher capacity test pump set at 420 feet below T.O.C. Static water level prior to testing was 357.43 feet below T.O.C. Testing commenced 1400 hours 05/11/80. Pumped at 37.8 gpm for 780 minutes (13 hours). Drawdown at end of testing was 4.71 feet, a pumping water level of 362.12 feet below T.O.C. (Figure 7). Recovery was rapid, 80 per cent within 10 minutes. (Figure 8).

Exploration hole N/N-3a

Test pump set at 305 feet below T.O.C. Static water level prior to testing was 237.53 feet below T.O.C. Testing commenced 1830 hrs. 05/12/80. Pumped at 11.29 gpm for 47 minutes. Drawdown at end of test was 61.11 feet, a pumping water level of 298.64 feet below T.O.C. (Figure 9). Recovery was rapid, 92 per cent within 70 minutes (Figure 10).

Exploration hole N/N-4a

Test pump set at 440 feet below T.O.C. Static water level prior to testing was 360.10 feet below T.O.C. Testing commenced 1245 hrs. 05/13/80. Pumped at about 10 gpm for 38 minutes. Drawdown prior to end of test was 80.29 feet, a pumping water level of 440.39 feet below T.O.C. Testing terminated at 1323 hours 05/13/80 (Figure 11). Recovery of water levels in the well was extremely slow, only 37 per cent within 24 hours (Figure 12).

Exploration hole N/N-1b

Test pump set at 471 feet below T.O.C. Static water level prior to testing was 271.22 feet below T.O.C. Testing commenced 1530 hours 05/14/80.

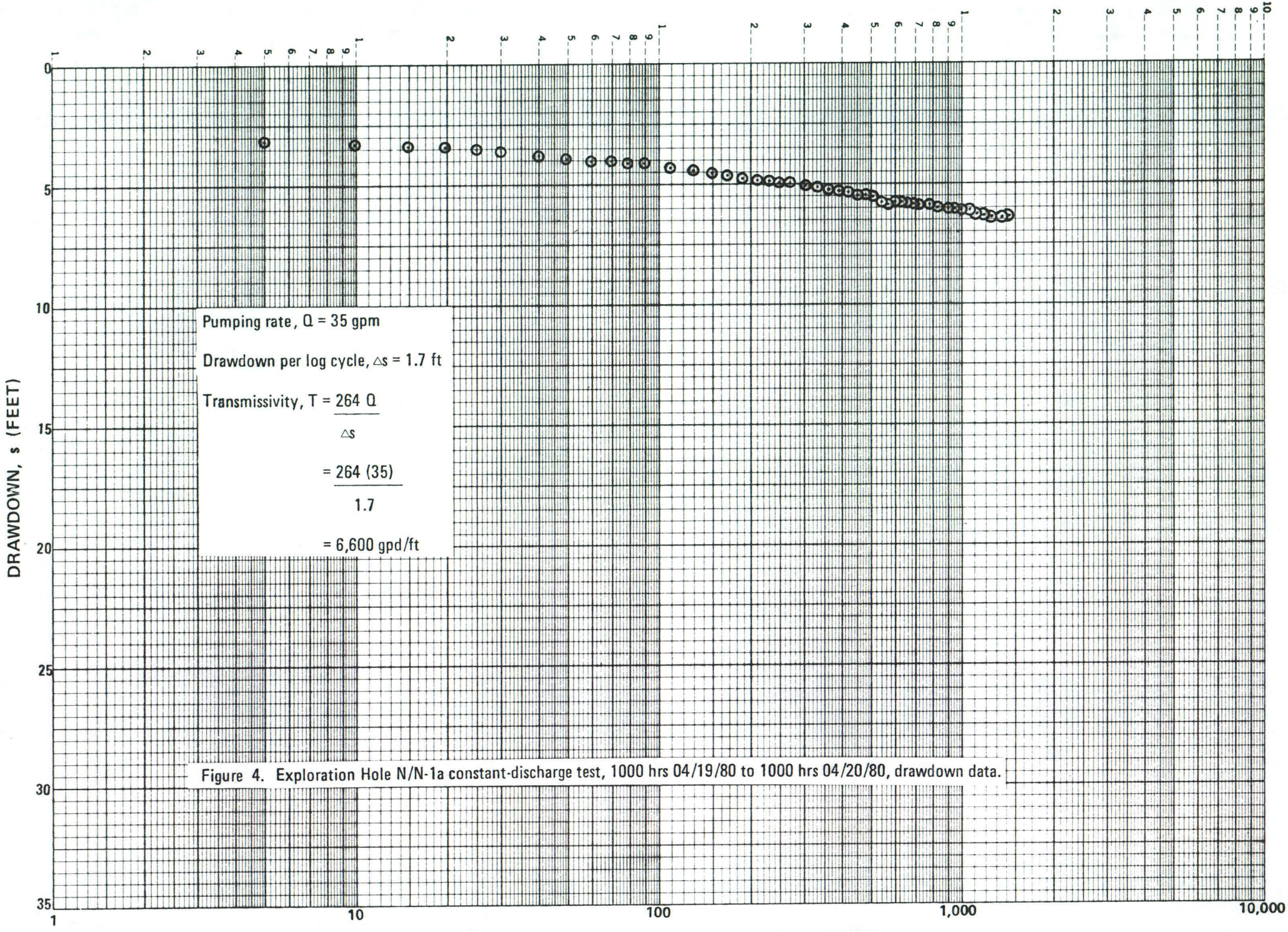


Figure 4. Exploration Hole N/N-1a constant-discharge test, 1000 hrs 04/19/80 to 1000 hrs 04/20/80, drawdown data.

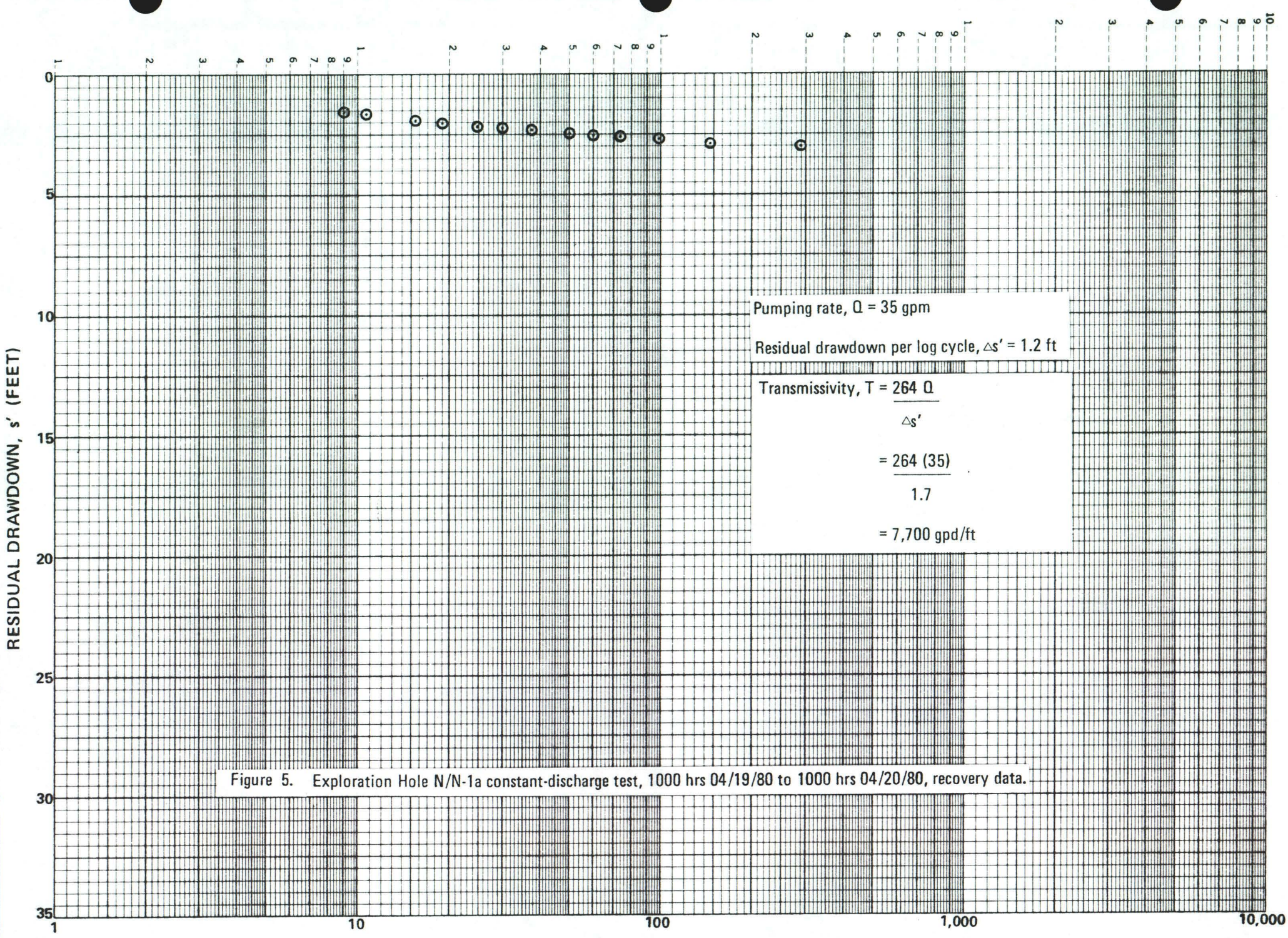


Figure 5. Exploration Hole N/N-1a constant-discharge test, 1000 hrs 04/19/80 to 1000 hrs 04/20/80, recovery data.

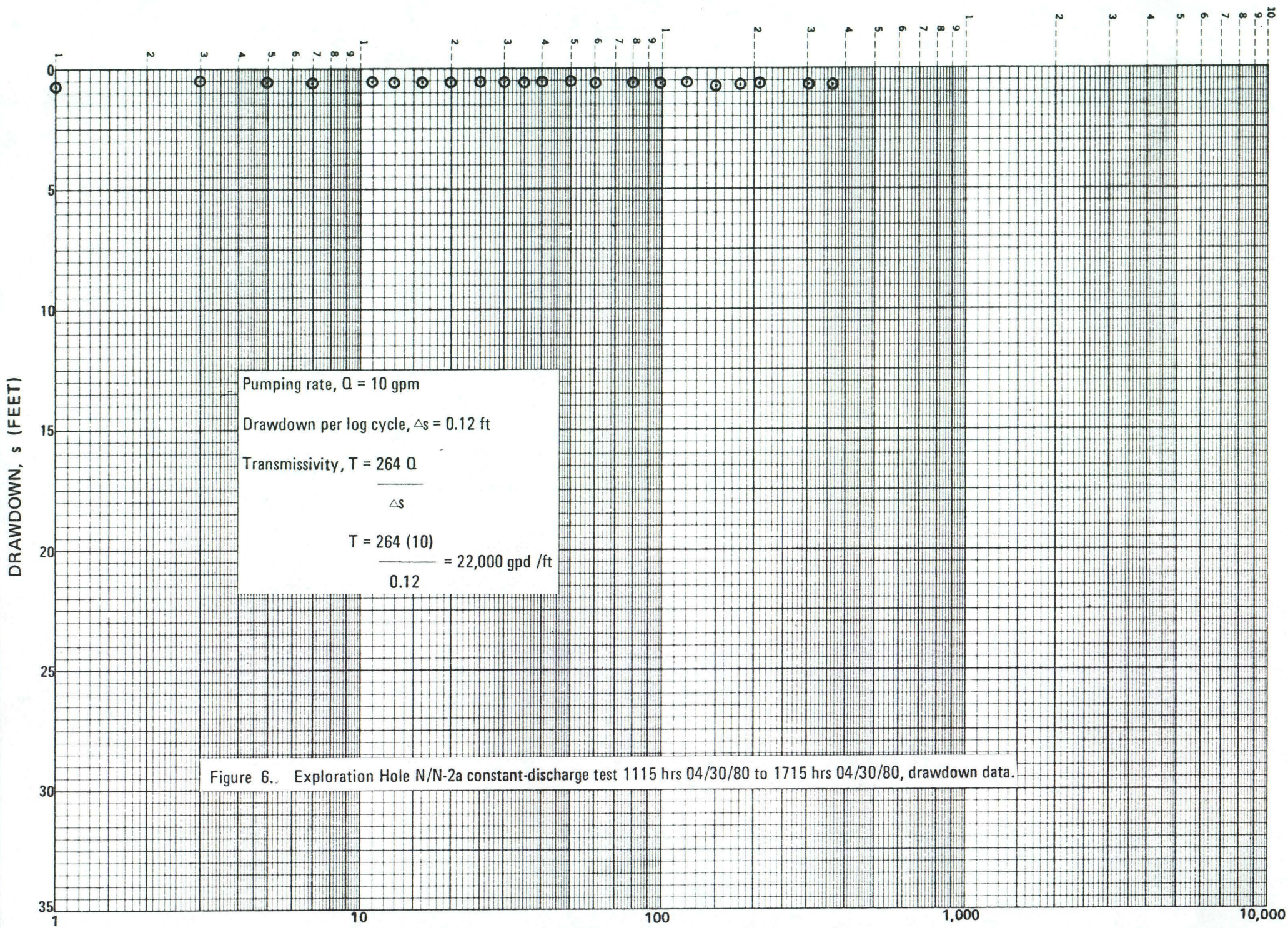


Figure 6. Exploration Hole N/N-2a constant-discharge test 1115 hrs 04/30/80 to 1715 hrs 04/30/80, drawdown data.

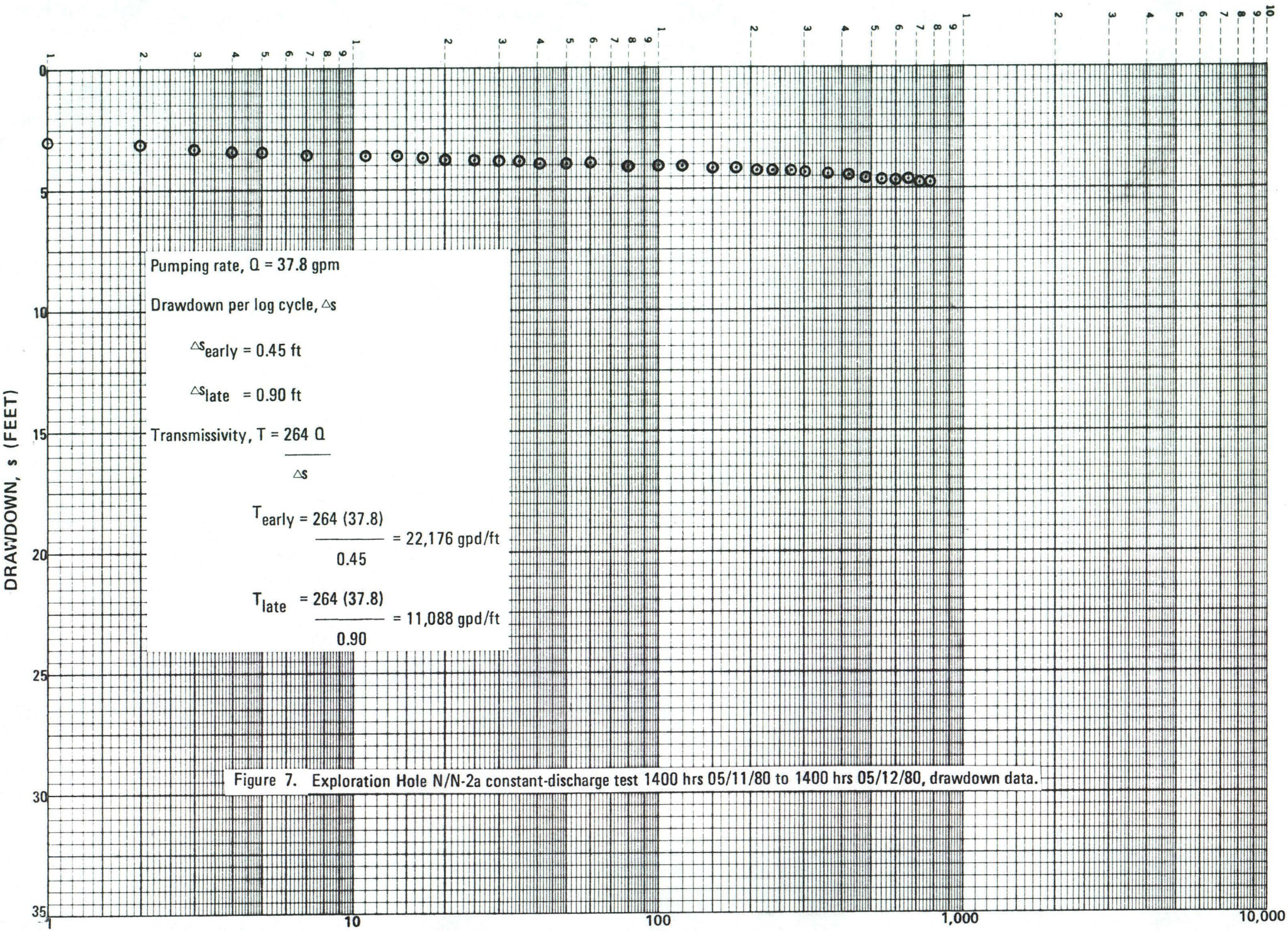


Figure 7. Exploration Hole N/N-2a constant-discharge test 1400 hrs 05/11/80 to 1400 hrs 05/12/80, drawdown data.

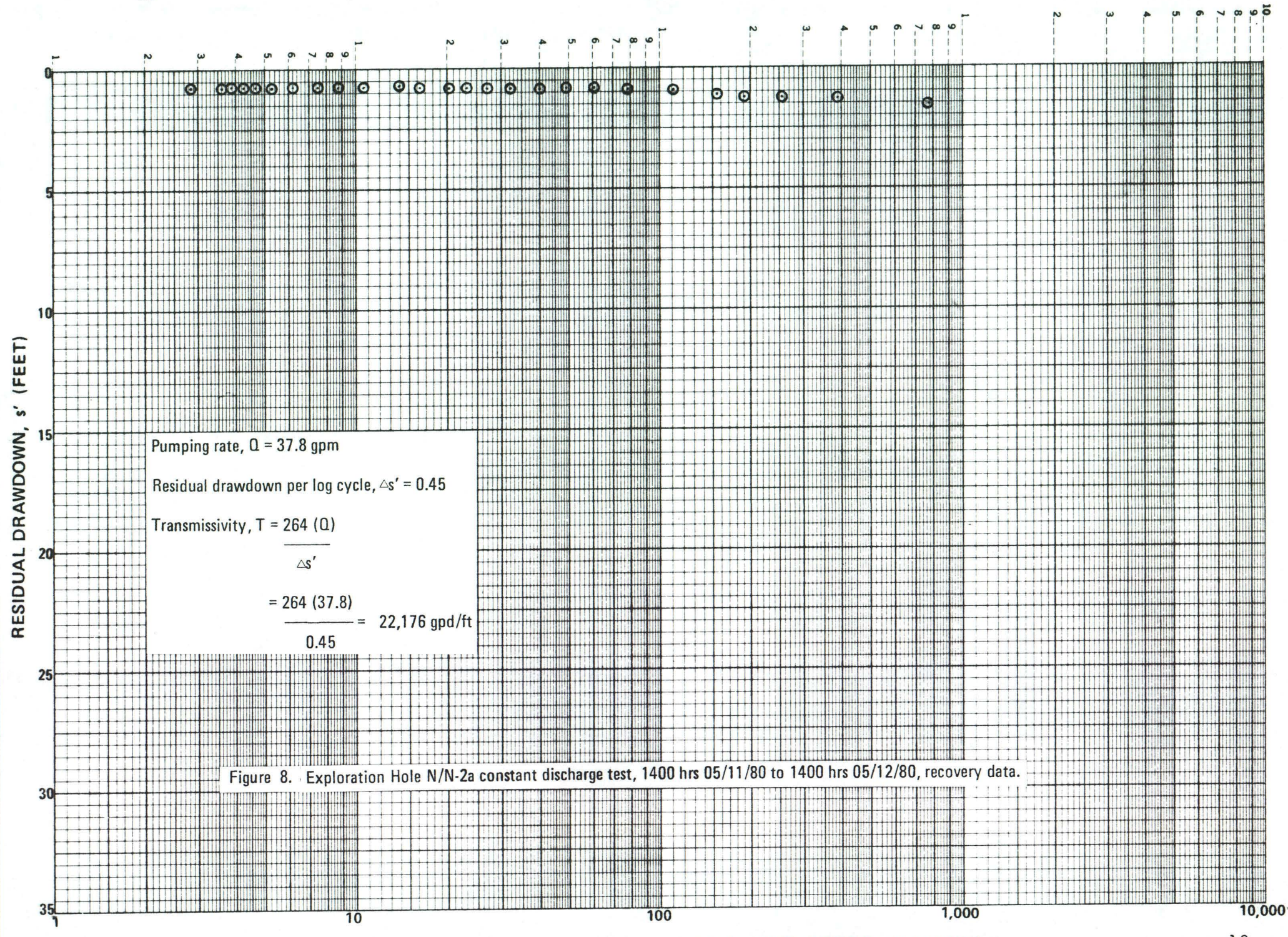


Figure 8. Exploration Hole N/N-2a constant discharge test, 1400 hrs 05/11/80 to 1400 hrs 05/12/80, recovery data.

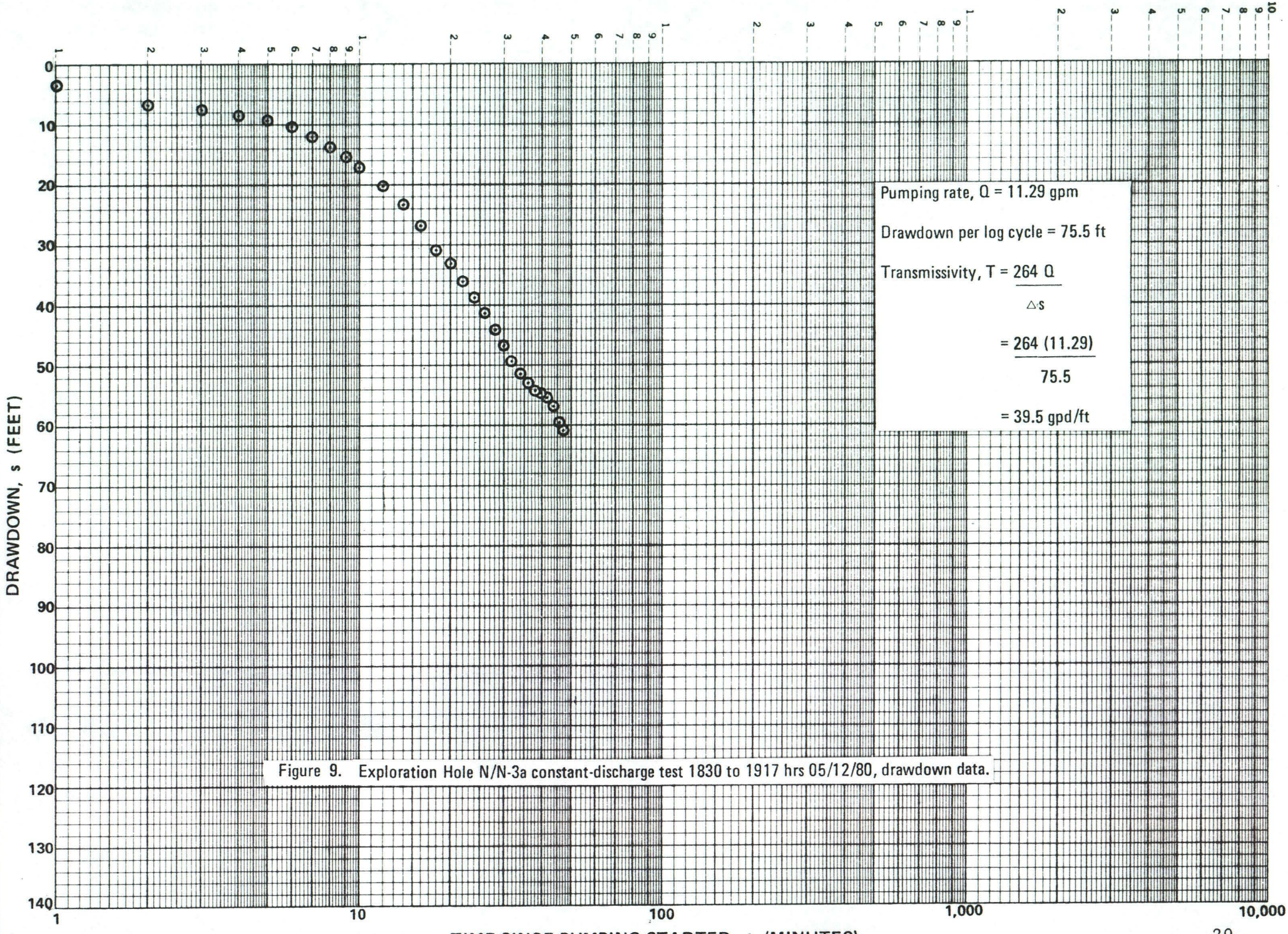


Figure 9. Exploration Hole N/N-3a constant-discharge test 1830 to 1917 hrs 05/12/80, drawdown data.

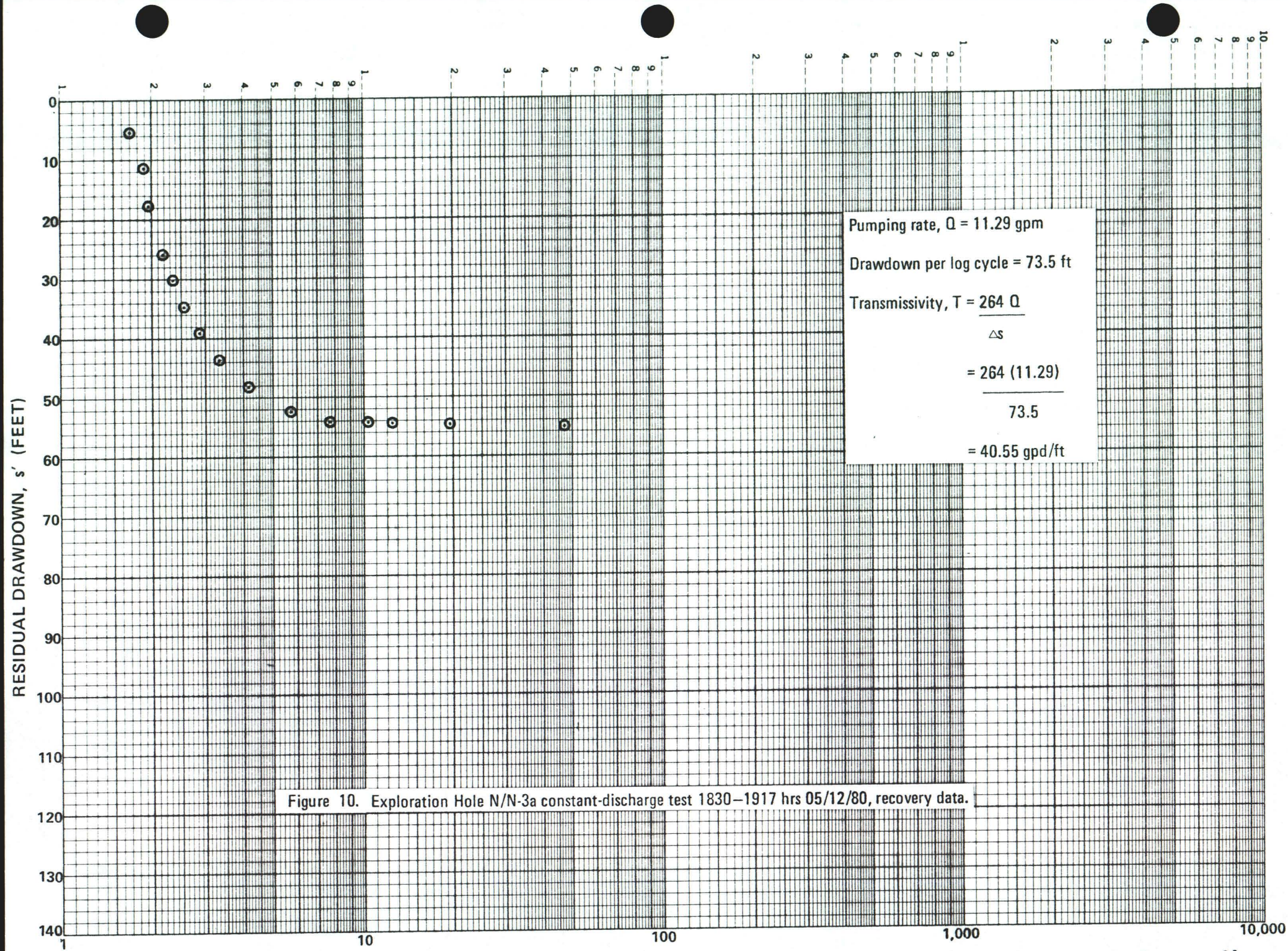


Figure 10. Exploration Hole N/N-3a constant-discharge test 1830–1917 hrs 05/12/80, recovery data.

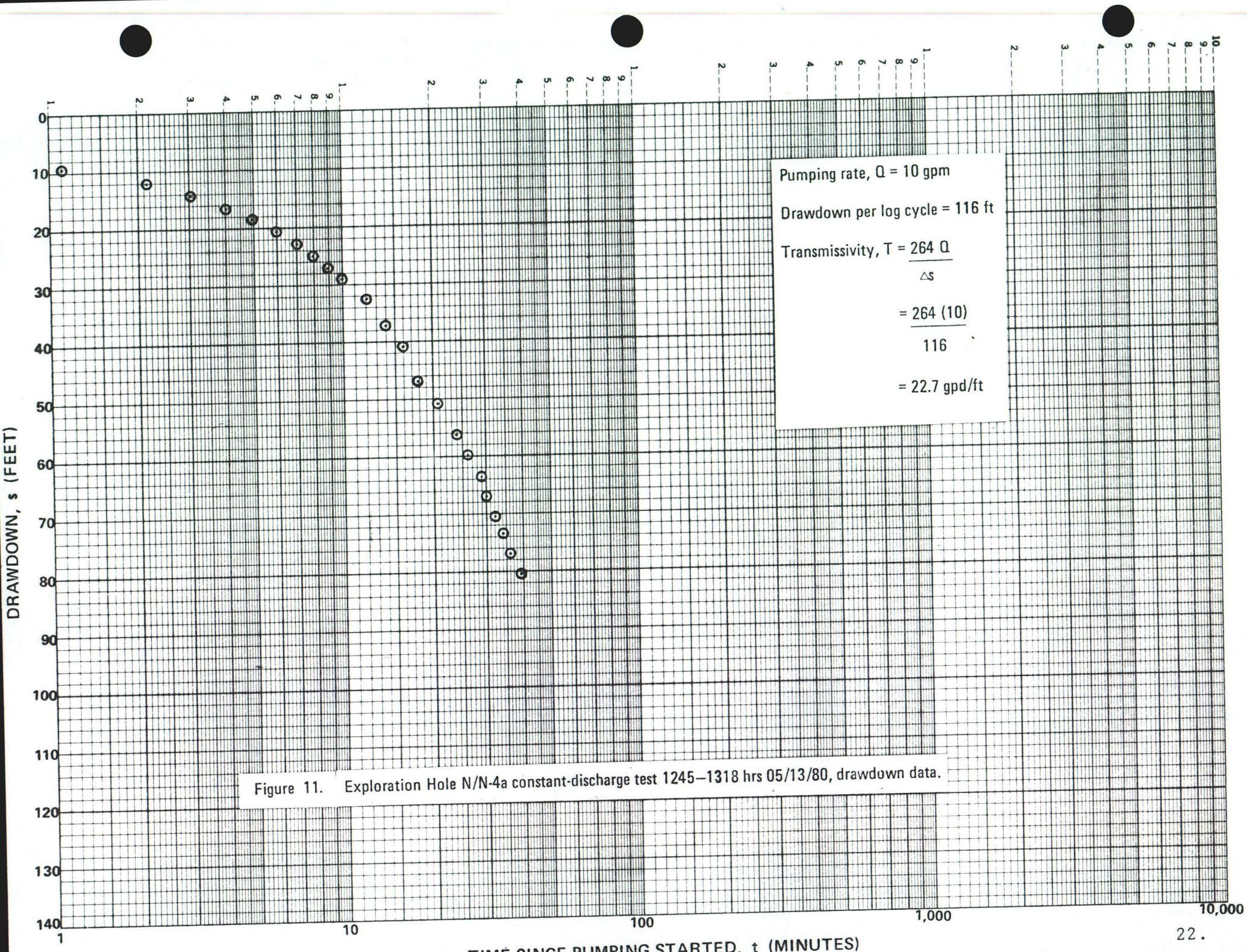


Figure 11. Exploration Hole N/N-4a constant-discharge test 1245–1318 hrs 05/13/80, drawdown data.

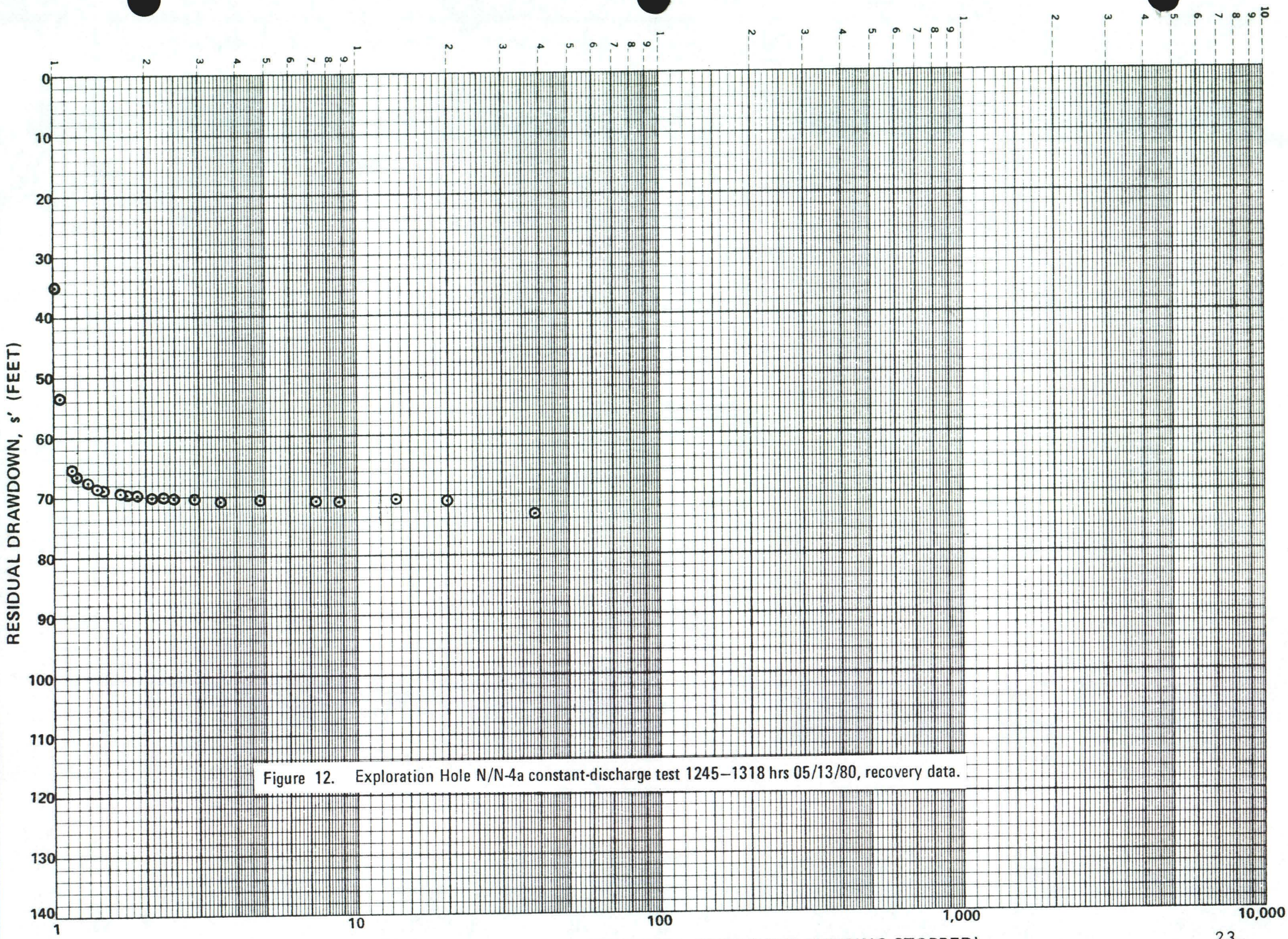


Figure 12. Exploration Hole N/N-4a constant-discharge test 1245–1318 hrs 05/13/80, recovery data.

Pumped at 21.88 gpm for 24 hours (1440 minutes). Drawdown prior to terminating testing was 61.39 feet (pumping water level of 332.61 feet below T.O.C.) (Figure 13). Testing terminated at 1530 hours 05/18/80. Recovery was moderate, about 77 per cent within 15 hours (Figure 14).

Additional physical/chemical well development was performed 05/22-28/80 in order to increase the yield of the well. N/N-1b was retested following the development.

Test pump reset to 471 feet depth. Static water level prior to testing was 290.77 feet below T.O.C. Testing commenced 0915 hours 5/29/80. Pumped at an average of 40 gpm for 24 hours (1440 minutes). Drawdown at conclusion of testing was 76.80 feet (a pumping water level of 367.57 feet below T.O.C.). Pumping terminated 0915 hours 05/20/80 (Figure 15). Recovery was moderate, 53 per cent within one hour and 77 per cent within 24 hours (Figure 16).

Physical/chemical development procedures resulted in a 40 per cent increase in the specific capacity.

Pumping test data was analyzed by the Theis method and transmissivity, the overall ability of the formation to transmit ground water, was calculated for each test (Figures 4 through 16). The values of transmissivity determined from the tests are summarized in Table 2.

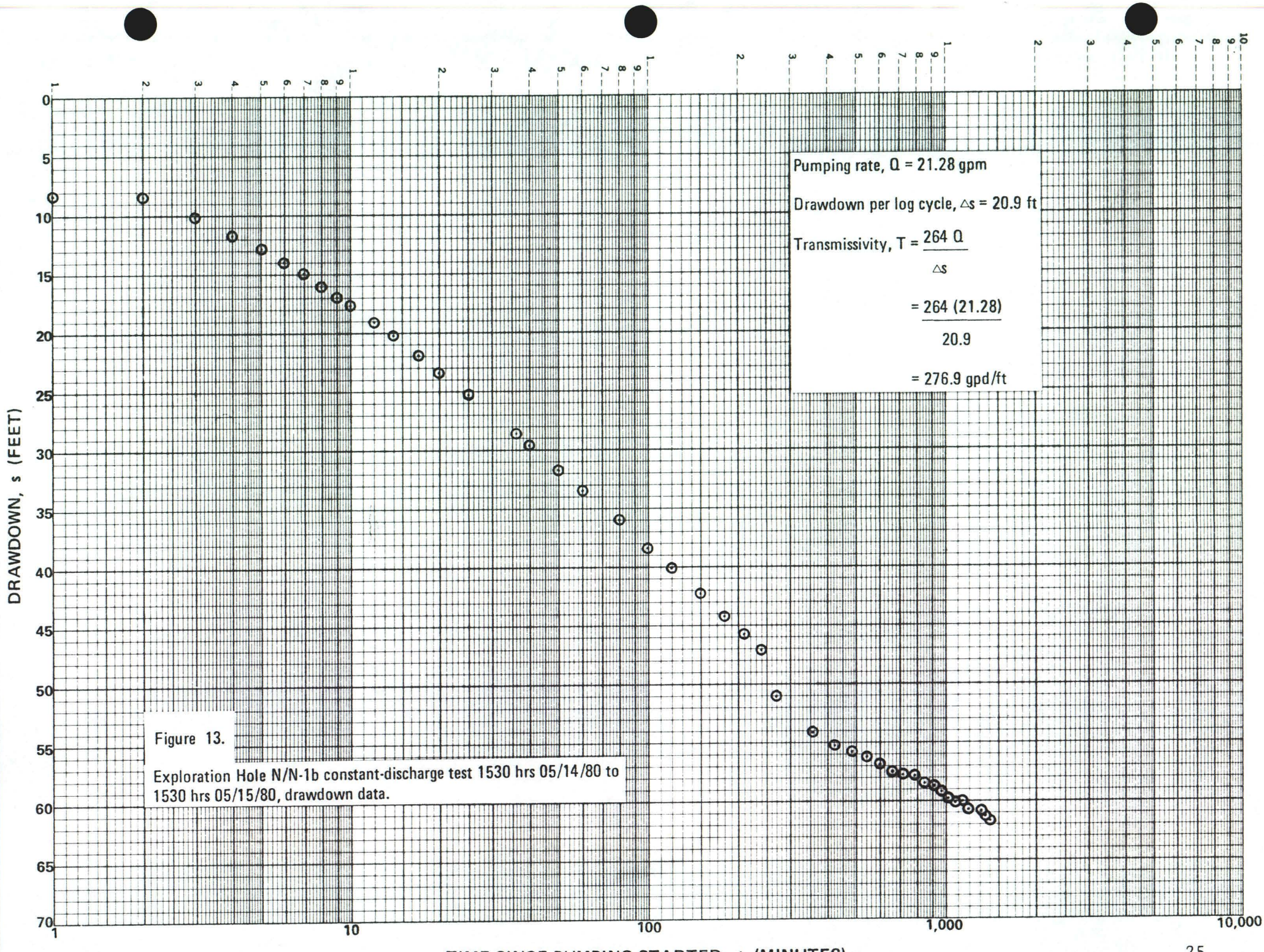


Figure 13.

Exploration Hole N/N-1b constant-discharge test 1530 hrs 05/14/80 to 1530 hrs 05/15/80, drawdown data.

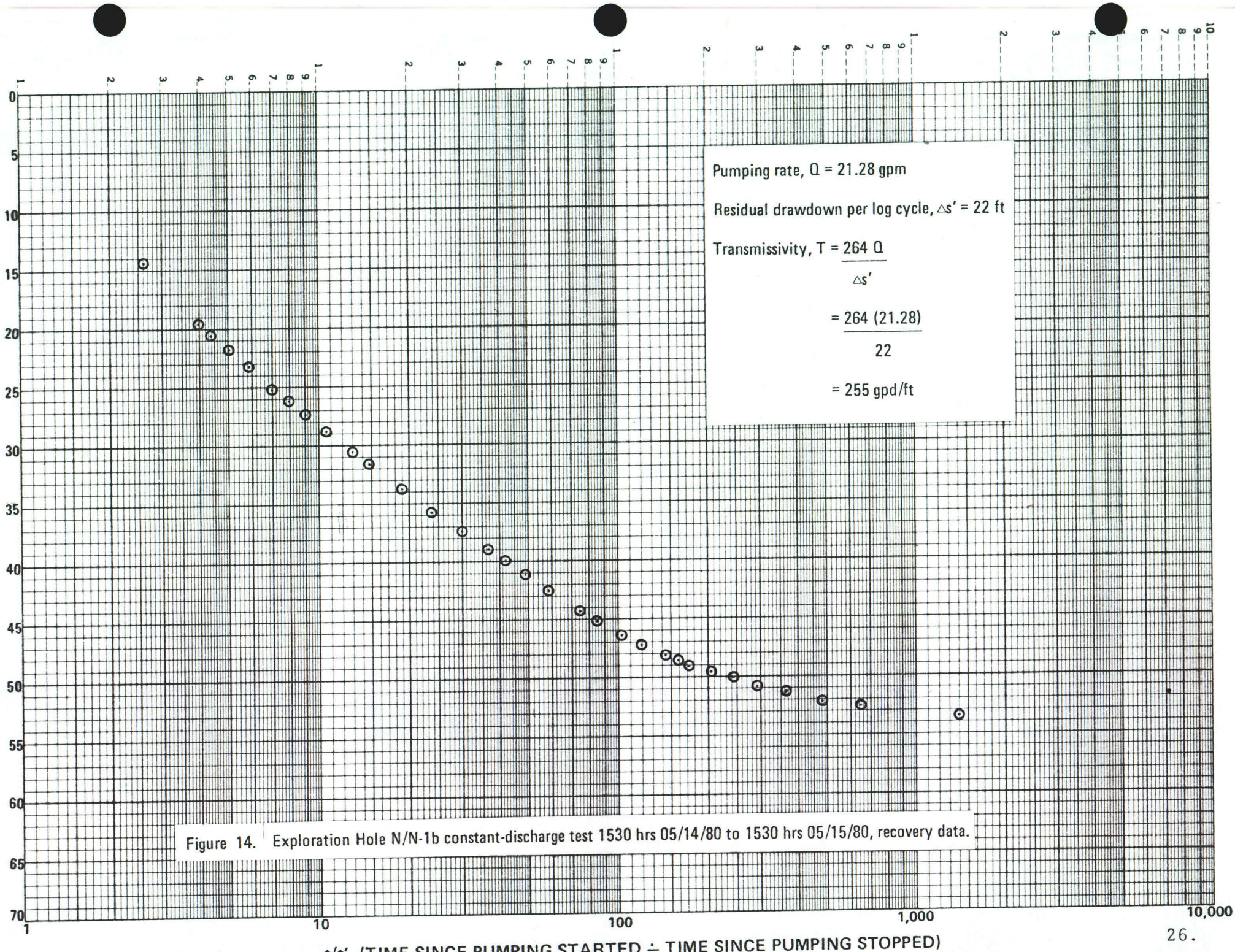


Figure 14. Exploration Hole N/N-1b constant-discharge test 1530 hrs 05/14/80 to 1530 hrs 05/15/80, recovery data.

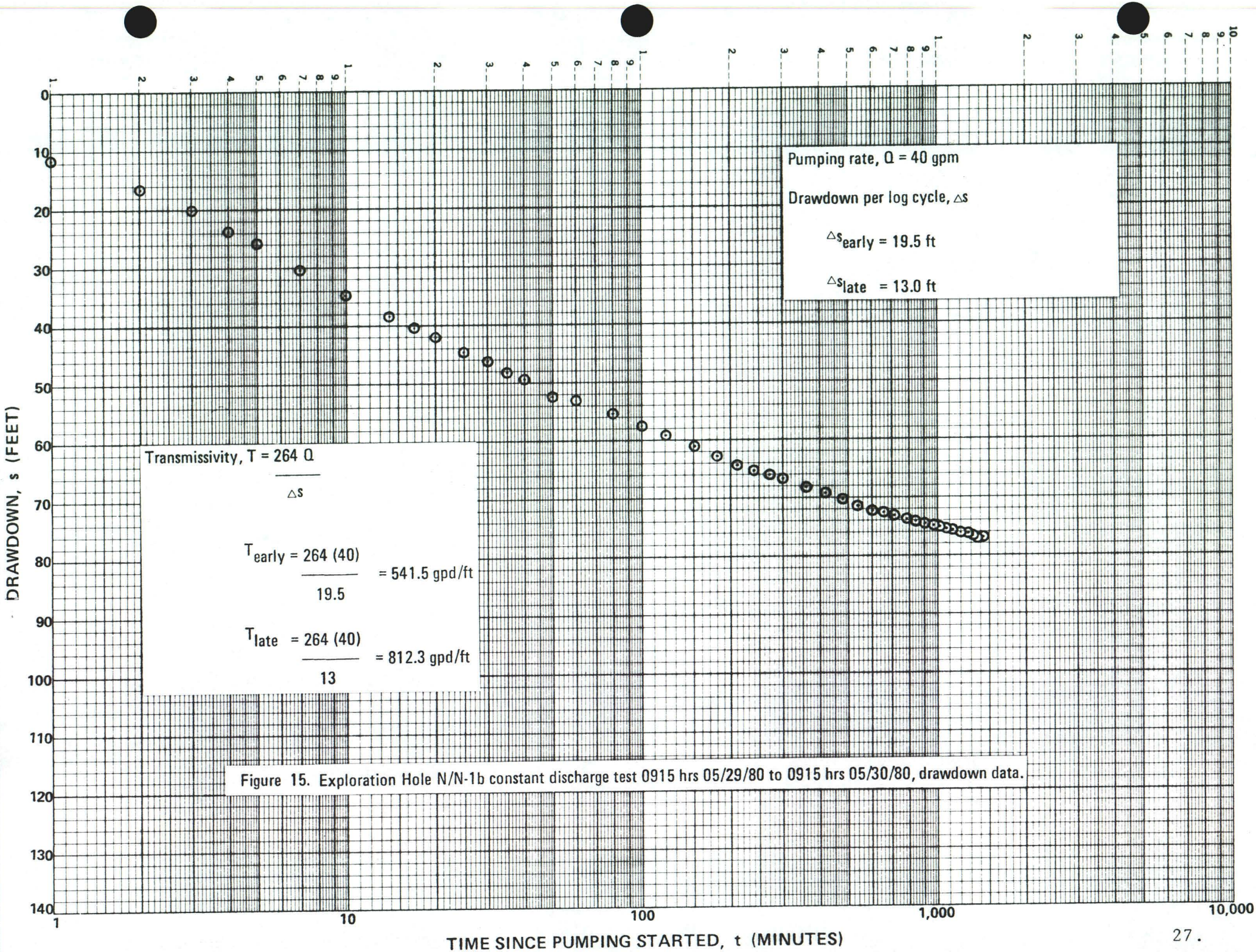


Figure 15. Exploration Hole N/N-1b constant discharge test 0915 hrs 05/29/80 to 0915 hrs 05/30/80, drawdown data.

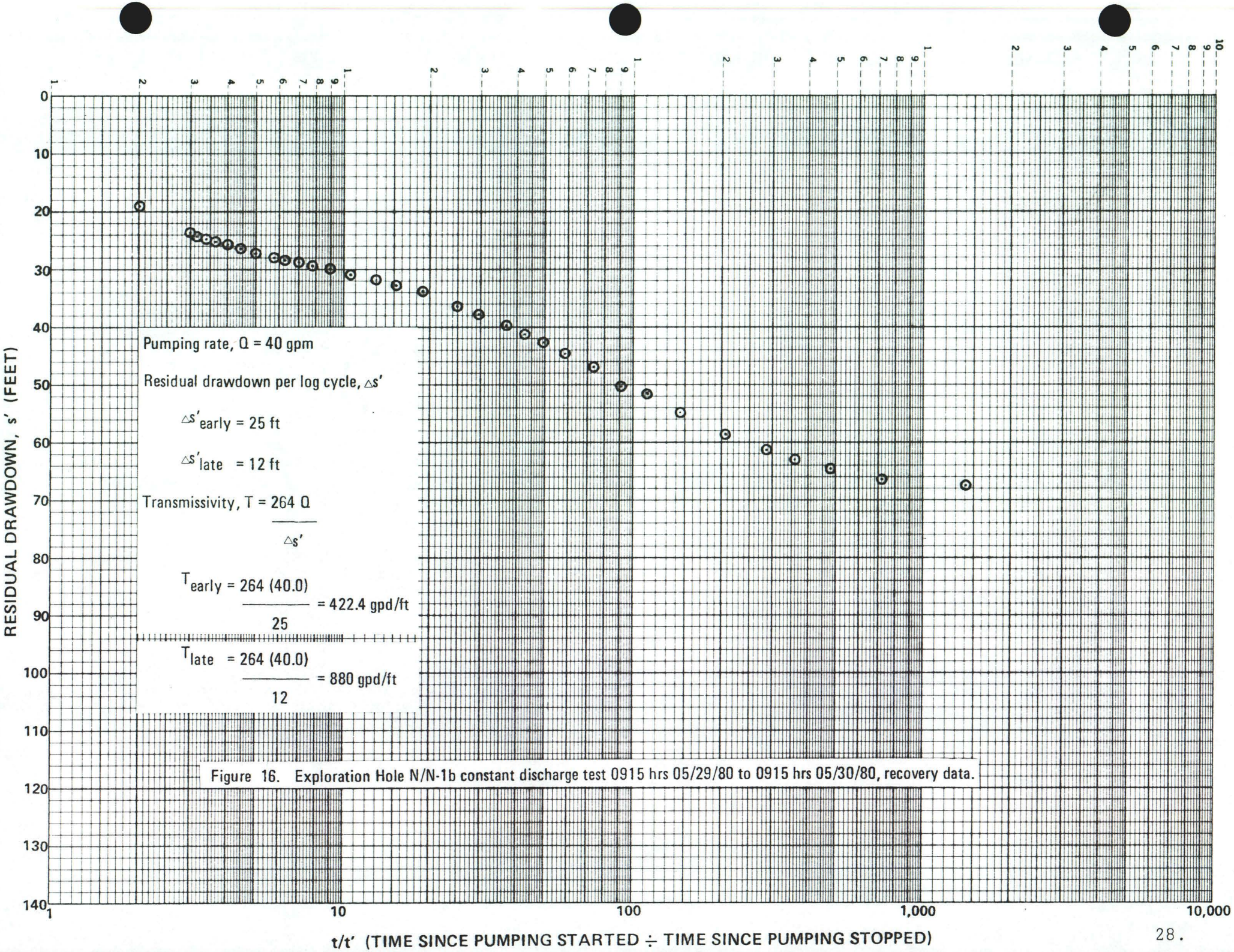


Figure 16. Exploration Hole N/N-1b constant discharge test 0915 hrs 05/29/80 to 0915 hrs 05/30/80, recovery data.

Table 2. Transmissivity values determined from Northumberland Project Pumping Tests.

Exploration Hole number	Aquifer	Transmissivity (gallons per day per foot) Drawdown	Recovery	Remarks
N/N-1a	Hoodoo	6,600	7,700	
N/N-1b	Northumberland	276.9	255	
N/N-1b	Northumberland and Hoodoo	541.5 (early)	422.4 (early)	Preceded by chemical/ physical development and perforating opposite Hoodoo tuff.
		812.3(late)	880(late)	
N/N-2	Northumberland	22,000	-	
N/N-2	Northumberland	22,176(early) 11,088(late)	22,176	
N/N-3	Northumberland	39.5	40.55	
N/N-4	Northumberland	22.7	-	

4.0 PRODUCTION WELL COMPLETION

Exploration drilling efforts were geared to securing a 200 to 400 gpm process water supply for the heap leach operation and a 50 gpm domestic water supply for mill personnel. Testing results (section 3.4) indicated that approximately 200 gallons per minute of ground water could be derived from wells constructed at Exploration hole N/N-1a and -2a sites to meet the estimated peak demand of 400 gpm. Ideally, high efficiency production wells should have been constructed at these locations. However, as a cost-saving measure, WILLIAM E. NORK, INC., was instructed to complete the exploration holes as production wells and secure the installation of pumping equipment capable of satisfying the projected demand. Exploration hole N/N-1b, capable of producing approximately 75 gpm, was completed to serve as the domestic water-supply well.

To comply with State of Nevada regulations for construction of water wells, 50 feet cement sanitary seals were installed in all of the exploration holes June 3-6, 1980. Cement pads, measuring three feet square and one foot thick were poured at the surface in conjunction with the sanitary seals. The sanitary seals were installed in N/N-3 and -4 so they might serve as monitoring wells to detect any leakage into the ground-water system. Final well construction is illustrated in Figure 17.

4.1 WELL MONITORING AND MAINTENANCE

Results of chemical analyses of the ground water derived from the wells at the mill site indicate the ground water to be potentially incrusting. Well performance records should be maintained to assess any change in well performance and diagnose problems early in order that remedial measures, such as chemical treatment or rehabilitation, may be undertaken before irrevocable damage to the wells occur. The relevant data for this purpose are pumping and non-pumping water levels, pumping rates and the time since pumping commenced or ceased. Data should be collected on a regular basis and should be reviewed periodically. Should incrustation become a reoccurring problem, relatively simple chemical treatment programs can be prescribed to rehabilitate the wells.

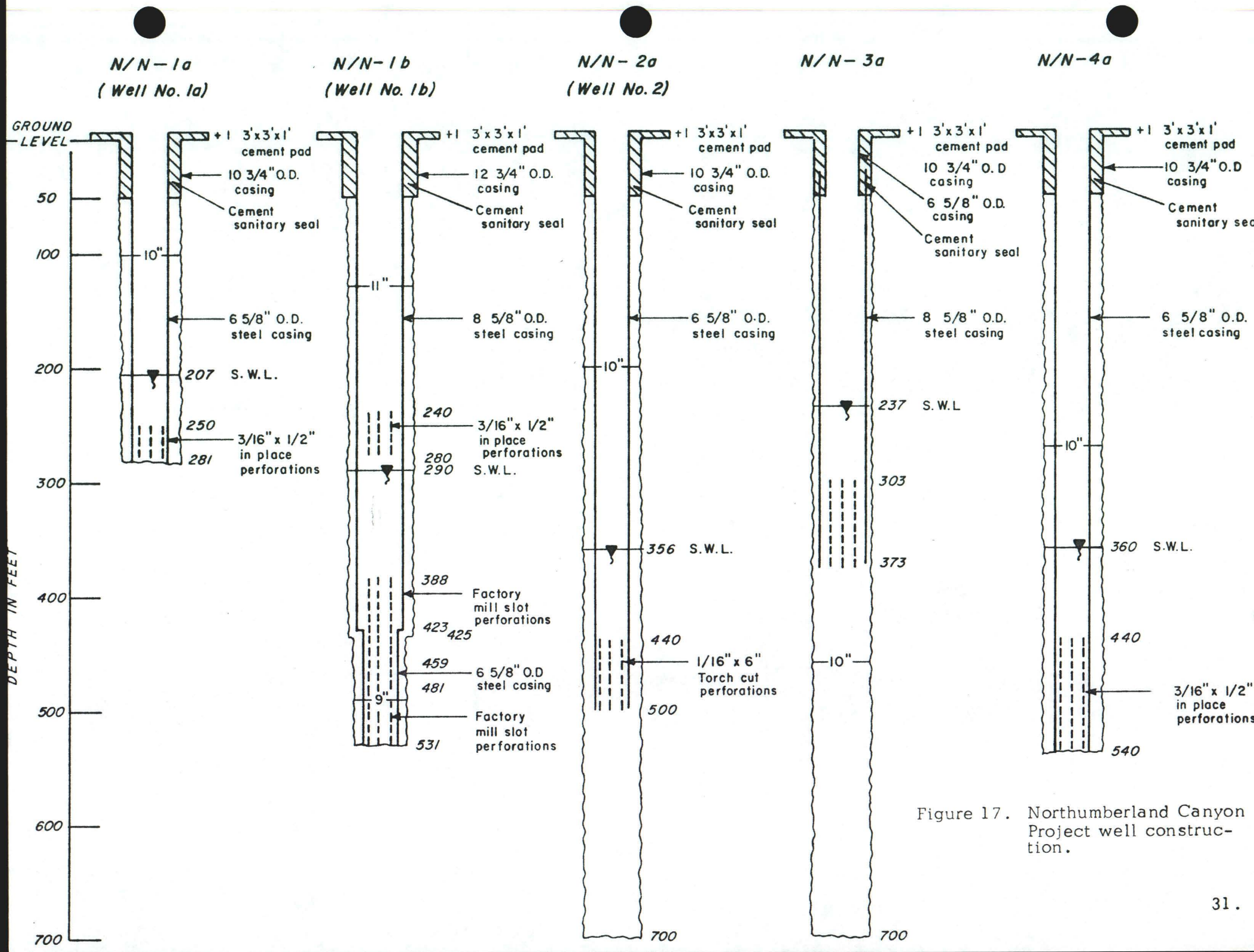


Figure 17. Northumberland Canyon Project well construction.

5.0 WATER QUALITY

Numerous water samples for chemical analysis were collected from springs, streams, and wells prior to startup of the drilling program (Appendix C). Results of analyses served as input to the Environmental Impact Statement. Additional water samples were collected from the exploration holes during drilling and/or testing. These data are given in Table 3 and Figure 18.

Inspection of the data indicate that the ground waters are of mixed types. Predominant ground water type beneath the eastern portion of the mill site is a calcium-magnesium-bicarbonate water. To the west the water becomes a sodium-bicarbonate type. Note that the sulfate levels in sample NG-217 may result from residual drilling fluid.

The change from calcium-magnesium-bicarbonate to sodium-bicarbonate type results from ion exchange of sodium for calcium occurring along the flow path or different sources of the ground water. Chloride also increases from east to west along the flow path.

The ground water can be characterized as hard to very hard with hardness (reported as mg/l $CaCO_3$) ranging from 131 (N/N-4a) to 715 (N/N-1b). The hardness may contribute to incrustation on fixtures, such as toilets, sprinkler heads and cooking utensils.

Total dissolved solids (TDS) vary widely from hole to hole. Values determined by the residue method range from 598 to 1250 mg/l. Those determined by summing the individual constituents range between 524 and 972 mg/l (Table 3). The discrepencies between TDS determinations by the residue and calculated methods is likely the result of failure to completely dehydrate the residue. "It is not uncommon for water high in calcium and sulfate concentrations to yield a residue after drying for an hour at 180°C that exceeds the computed dissolved solids by several hundred milligrams per liter." Since the waters derived from the Northumberland Project exploration holes are all relatively high in calcium and sulfate, the calculated TDS is probably the more accurate. However, EPA Secondary Drinking Water Standards specify the residue method.

For use as a domestic water supply, the ground waters derived from N/N-1b should be softened to reduce its extreme hardness — reported as 688 to 715 mg/l $CaCO_3$. A standard Na/Ca ion exchange water softening unit will be used.

Table 3. Results of Chemical Anaysis of Ground Water Derived from Northumberland Project Groundwater Exploration Holes.

Exploration Hole Number	N/N-1a	N/N-2	N/N-3	N/N-4	N/N-1b	N/N-1b
Sample Number	NG-213	NG-215	NG-216	NG-217	NG-218	NG-219
Date	03/23/80	05/12/80	05/12/80	05/13/80	05/15/80	05/30/80
Depth (feet)	281	700	700	540	535	535
Temperature °C	19	34	20	26	25	25.5
TDS (calculated)	973	742	897	524	1027	972
TDS (residue)	1150	882	943	598	1145	1250
E.C. μMHD/cm (field)	1150	1350	1200	850	1250	1800
pH (field)	7.13	6.92	7.5	8.2	7.3	5.7
pH (lab)	7.5	7.5	7.9	8.3	7.7	6.9
Alkalinity (HCO_3^-)	213	400	169	212	217	178
Hardness ($CaCO_3$)	709	291	512	131	688	715
Na	70	170	61	130	60	110
Ca	159	74	132	28	162	82
Mg	75	29	50	15	82	79
Fe	0.64	0.17	1.4	4.3	0.12	0.10
Mn	0.28	0.06	0.02	0.21	0.14	1.5
SO_4	466	223	466	204	533	380
P	8.7	0.02	0.03	0.07	1.4	0.40
NO_3	0.4	0.4	1.9	0.2	0.4	0.30
Cl	33	37	41	30	30	153
F	0.4	3.2	0.2	2.9	0.4	19.2
CN	<0.005	-	-	-	-	-
SiO_2	55	8.6	60	5.5	51	59
As	0.13	0.009	0.009	0.005	0.06	0.02
Se	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Hg	<0.005	<0.0005	<0.0005	<0.005	<0.0005	<0.0005
Cr	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ba	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ag	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Au	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

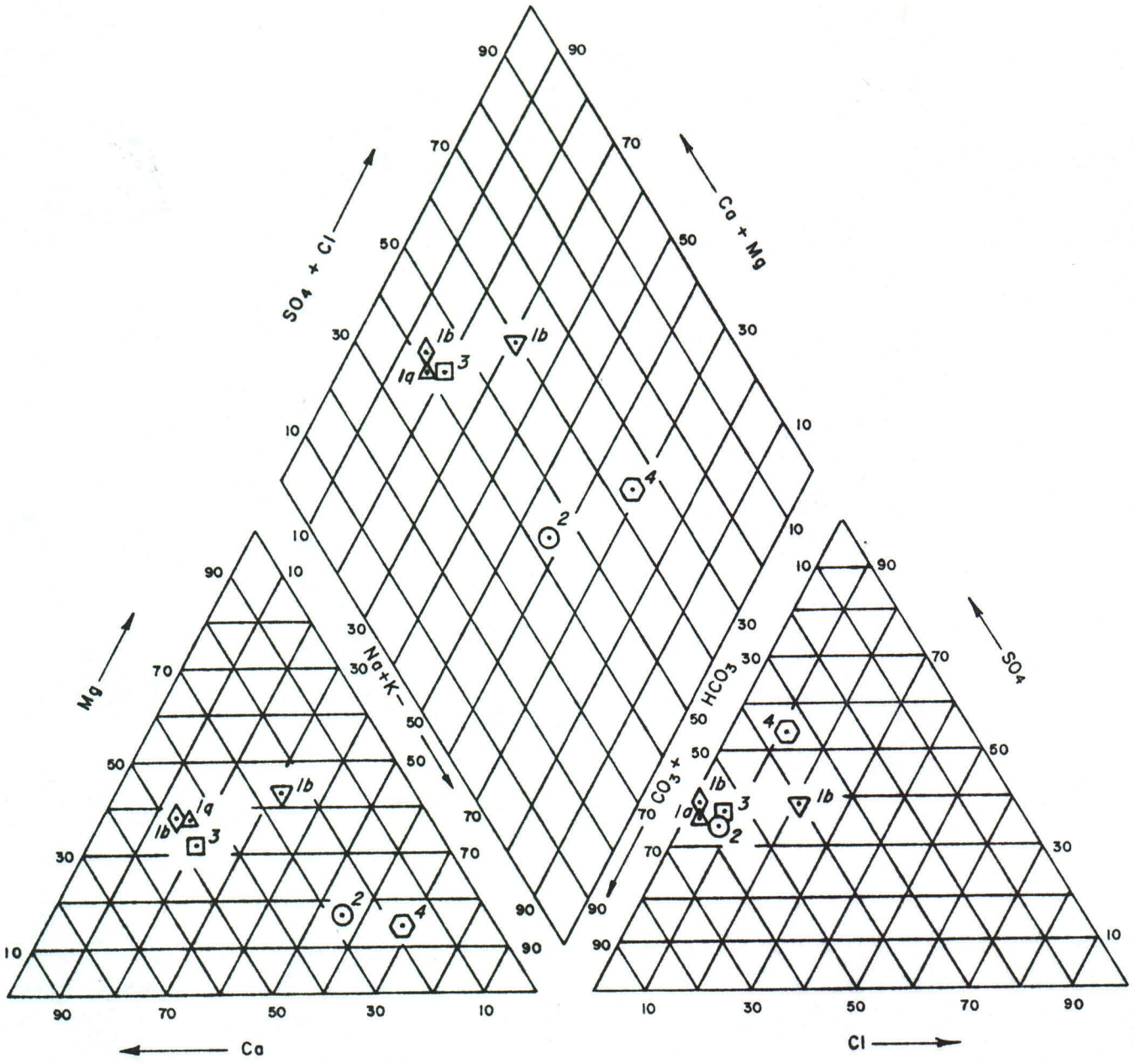


Figure 18. Ground-water Chemistry, Northumberland Canyon Project, Mill Site.

The most recent — 05/30/80; Table 3 — indicates that the ground water from Well No. 1b does not meet EPA Primary Drinking Water Standards. It is advisable to treat culinary use water supply by reverse osmosis or other advanced treatment to make the drinking and cooking water acceptable. Treatment can be accomplished by small individual units installed in each of the living quarters and change facilities at the mill.

6.0 POTENTIAL FOR POLLUTION

The potential for contamination of aquifers by leachate solutions from the heap leach operation is remote even though water-supply wells are located within the confines of the heap leach operation. The aquifers are separated from the surface by 150 to 350 feet of poorly sorted alluvial-fan deposits, the Hoodoo and Northumberland aquifers are under 50 to 90 feet of artesian head, the upper 50 feet of the wells have been fitted with cement sanitary seals, and the heap leach pads will be constructed to contain leachate fluids.

7.0 WATER RIGHTS

At the onset of WILLIAM E. NORK, INC.'s involvement in the ground-water exploration and development program for the Northumberland Project, the exact mill site and haul road locations were not known. In addition, hydrogeologic properties of litholigic units were virtually unknown. Consequently, eight potential sites for exploration drilling were selected on the basis of available hydrogeolgic data. Permits to Appropriate ... Waters ... were filed at these locations by WILLIAM E. NORK, INC., on behalf of CYPRUS MINES CORPORATION (see APPENDIX D and Water Right Survey Map prepared by the Spink Corporation) to secure low serial numbers for the applications.

Of the eight permit applications, four were filed in Monitor Valley. These are Serial Nos. 37414, -16, -17, and -20, were approved on March 20, 1980, and the four holes commenced for permit purposes on April 27, 1980. Proofs of commencement were filed to maintain the good standing of the permits in the event CYPRUS needs additional water supply for Monitor Valley or chooses to sell the water rights.

The four permit applications, Serial Nos. 37415, -18, -19, and -21, filed in Big Smoky Valley, were approved August, 1980. Changes in the Place of Use and Point of Diversion have been filed (see APPENDIX) to account for mill site expansion and transfer water rights to the completed production well sites.

8.0 CRUSHER WATER-SUPPLY AVAILABILITY

The water-supply capability of six existing wells located near the crusher and open pit mine site were investigated. Of the six, three were cleaned out with a drilling rig air compressor April 26 and 28, 1980, in order to develop the wells and ascertain individual suitability for testing. A single hole designated Np-5, located about one-half mile southeast of the proposed crusher site was determined to be suitable for testing.

8.1 PUMPING TEST SUMMARY

Well depth approximately 93 feet. Test pump installed to 67 feet depth. Static water level prior to testing was 30 - 30 feet below T.O.C. Step-drawdown test commenced 1615 hours 5/06/80. Pumped at approximately 44.5 gpm for one hour. Drawdown at end of Step I was 6.05 feet. Step II commenced at 1715 hours. Pumped at 47.25 gpm for two hours. Drawdown at end of Step II was 8.62 feet. A third step was attempted but was not attainable with the existing test pumping equipment. Testing was terminated at 1835 hours 5/06/80.

Constant-discharge testing commenced 1145 hours 5/07/80. Static water level prior to testing was 31.00 feet below T.O.C. Pumped at 47.25 gpm for 45 hours (2700 minutes). Testing terminated at 0845 hours 5/09/80. Pumping water level was 57.26 feet below T.O.C., a drawdown of 26.26 feet (Figure 18). Recovery was slow, 53 per cent within 24 hours (Figure 19).

8.2 PUMPING TEST RESULTS

Analysis of both drawdown and recovery water level data indicate that ground water derived from Np-5 likely originates from the shallow strip of alluvial-fill materials in upper Northumberland (east) Canyon. Data also suggests that these materials are in poor hydraulic connection with the Paleozoic sedimentary rocks in the vicinity.

Transmissivity, the overall ability of the aquifer to transmit ground water, was calculated on the basis of drawdown and recovery data to be 780 gpd/ft. and 709 gpd/ft., respectively (Figures 19 and 20).

Probable long-term yield of the well is 10 to 15 gpm maximum.

The alluvial-fill deposits comprising the valley fill deposits in Northumberland Canyon do not appear very promising as a long-term source of water supply for crusher, open pit mining dust control, equipment shop and security guard's residence. Carbonate Paleozoic sedimentary rocks in this vicinity offer greater potential and should be explored.

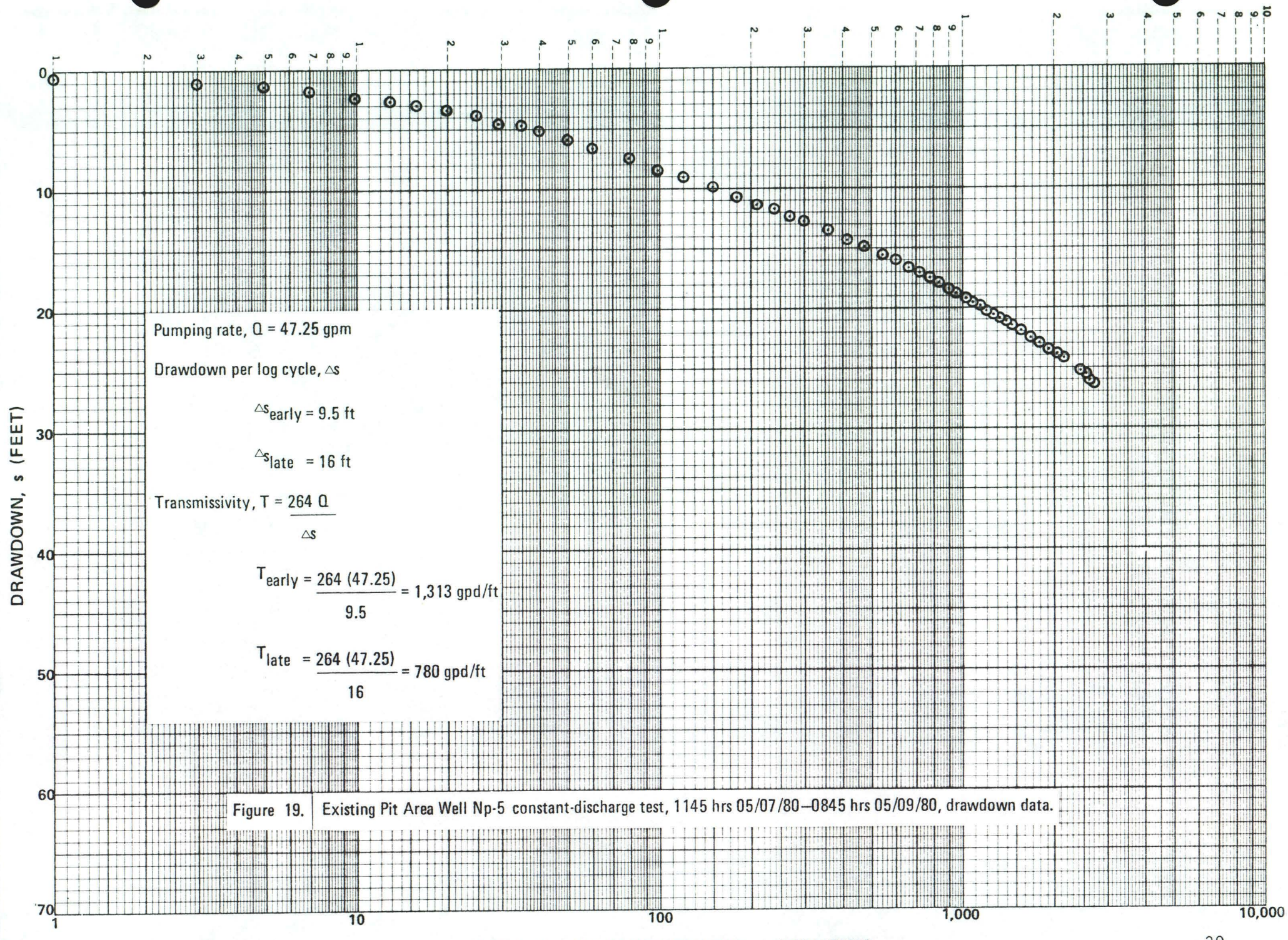


Figure 19. Existing Pit Area Well Np-5 constant-discharge test, 1145 hrs 05/07/80–0845 hrs 05/09/80, drawdown data.

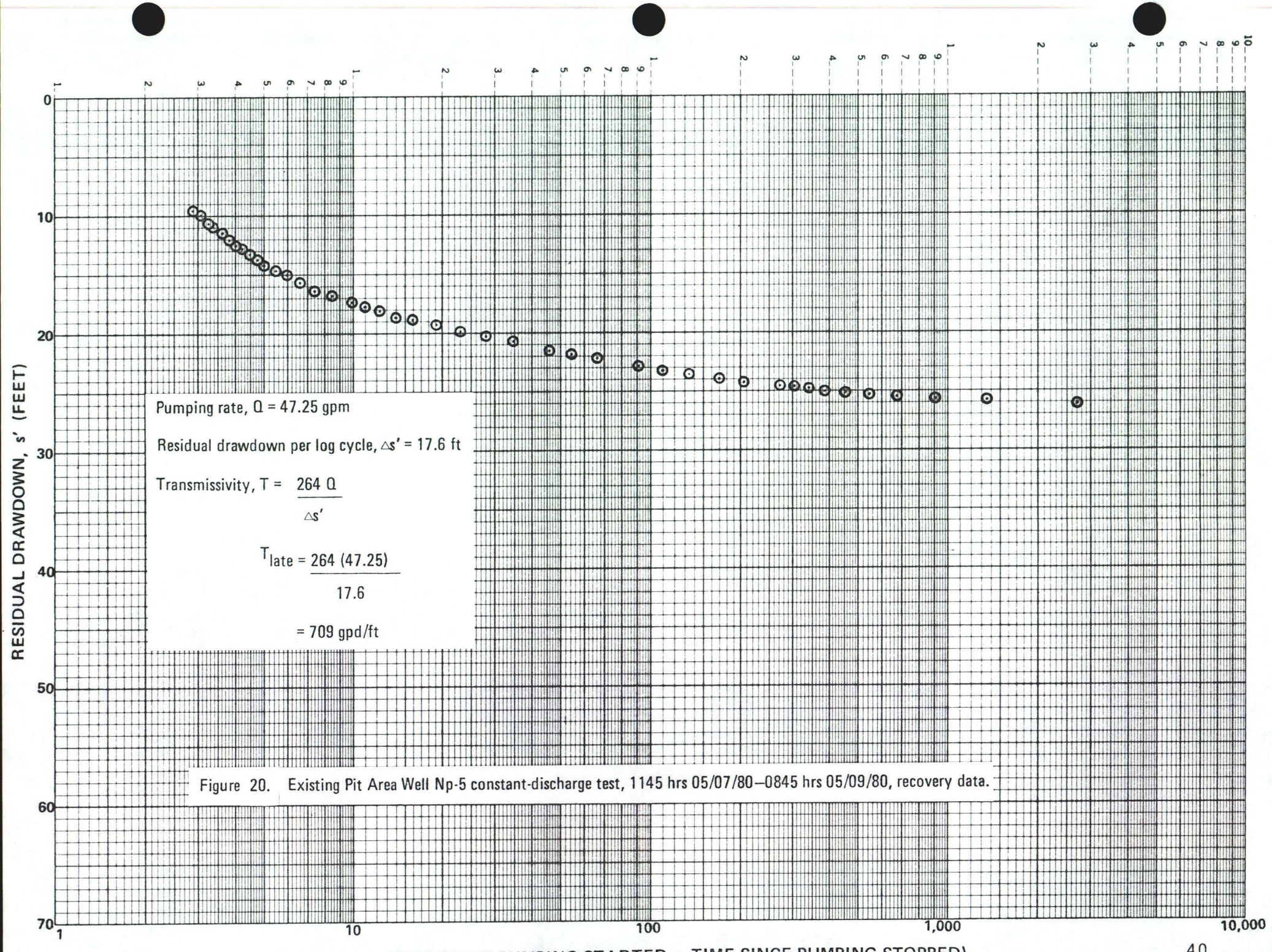


Figure 20. Existing Pit Area Well Np-5 constant-discharge test, 1145 hrs 05/07/80–0845 hrs 05/09/80, recovery data.

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Personal Communication

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