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HYDROGEOLOGIC DATA RELATED TO ESTABLISHMENT OF A PUMPING STATION IN THE EVERGLADES NATIONAL PARK, FLORIDA

By

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CONTENTS

ILLUSTRATIONS

TABLES

HYDROGEOLOGIC DATA RELATED TO ESTABLISHMENT OF A PUMPING STATION IN THE EVERGLADES NATIONAL PARK, FLORIDA

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INTRODUCTION

Water-control works constructed north of the Everglades National Park since its establishment have changed the amount and seasonal distribution of water replenishment to the Park from the north. A long period of below average rainfall on the Park since 1961, superimposed on the effects of the man-made works has resulted in hydrologic conditions that the U.S. National Park Service considers detrimental to the plant and animal life in the Park.

The feasibility of maintaining certain hydrologic conditions by artificial development and control of water at selected areas in the Park is now being studied by the U.S. National Park Service. One plan under consideration involves furnishing water at the rate of 100 cfs (cubic feet per second) to the upper part of the Shark River Slough in the northeast area of the Park during critical dry periods. In connection with this study the National Park Service requested the U.S. Geological Survey to determine if a proposed water-collection gallery, about 4000 feet long near the northeast corner of the Park (fig. 1),

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could yield water at a rate of 100 cfs continuously for as long as 100 days.

Figure 1.--Map of southern Florida showing Everglades National Park and the locations of the sites to be considered for a water collection gallery.

The 100-cfs rate is equal to about 4 times the minimum monthly surface-water inflow toward the Park, and about one-third the average annual surface flow toward the Park as determined from discharge measurements made before construction of control works immediately north of the Park.

The site at the northeast corner of the boundary of the Park was selected because it was presumed that most of the water pumped from a gallery there would receive replenishment by ground-water flow from Conservation Area 3A (fig. 1) where the water levels are generally higher than those in the Park. However, core holes and other information furnished by the Corps of Engineers indicated that the transmissibility of the water-table aquifer at the northeast corner of the Park might not be adequate to permit sufficient quantities of water to be induced to a gallery of reasonable dimensions from Conservation Area 3A. Thus, the National Park Service requested the U.S. Geological Survey also to investigate an alternate site (fig. 1) along the eastern boundary of the Park 8 to 10 miles south of the Tamiami Canal. The alternate site was selected because preliminary tests, by the Corps of Engineers, along the eastern boundary indicated that the transmissibility of the water-table aquifer is relatively low from the Tamiami Canal southward for about 8 miles and then increases considerably, southward.

This report presents the results of hydrogeologic tests at the proposed site at the northeast corner of the Park and at the alternate site along the eastern boundary. It gives estimates of the length of gallery that would be required at each site to obtain the sustained yield of 100 cfs for as long as 100 days. Estimates are made concerning the effect that pumping from a gallery along the eastern Park boundary might have on the water levels in the aquifer in the area surrounding the gallery.

RESULTS OF HYDROGEOLOGIC TESTS ALONG NORTH PARK BOUNDARY

Eighteen exploratory holes were drilled along old U.S. Highway 41 to determine the thickness and hydraulic characteristics of the materials that would be penetrated by a gallery 20 feet deep. Seventeen of the holes were drilled along the northern boundary of the Park (fig. 2). The eighteenth hole was drilled 7 miles east of the Park

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Figure 2.--Caption on next page (belongs near here).

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boundary where it was known that the Biscayne aquifer is present and is highly permeable. The holes were drilled 9 inches in diameter by rotary method and rock cuttings were brought to the surface by forcing compressed air through the bottom of the drill pipe. The drilling fluid used was water picked up from the aquifer during the course of drilling the hole. The relative permeability of the different sections was observed by noting the increase in the quantity of water brought to the surface by the compressed air as each well was being drilled.

Figure 2.--Map showing the location of exploratory holes drilled along the northern Park boundary.

Drilling began with a series of closely-spaced holes extending westward from the northeastern corner of the Park, because this was the preferred area for the pumping installation. It was apparent from the outset that the limestone material composing the water-table aquifer at that location was not of sufficient permeability to yield the required 100 cfs from a 4,000-foot gallery. The uppermost 10 to 12 feet of materials, extending to depths slightly below sea level, failed to yield large quantities of water under compressed-air drilling. Drilling continued westward on a wider spacing to determine if any high permeability material could be located that would be capable of yielding 100 cfs from a collection gallery.

A generalized subsurface section showing the thickness and relative permeability of the limestone of the shallow aquifer along U.S. Highway 41 is presented in figure 3. During the drilling of each of

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Figure 3.--Caption on next page (belongs near here).

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the 17 holes along the north boundary little or no water was yielded until 10 or more feet of limestone was penetrated. The bottom 2 to 5 feet proved to be the only section that would yield enough water to bring rock cuttings to the surface by air lift. In general, the water yield increased to the west owing to the fact that the bottom section of high permeability increased in thickness from 2 feet to about 5 feet. The yield of each hole during drilling was less than 250 gpm (gallons per minute).

Information from well 18N, 7 miles east of the Park boundary, showed that the rock there was similar in character to highly permeable sections of the Biscayne aquifer in the Miami area farther east. Highly permeable limestone was penetrated about 5 feet below the land surface, and the water yield continued to increase to the bottom of the limestone material, a depth of 35 feet. At that depth the well was yielding about 2,000 gpm.

Figure 3.--Generalized section of the near-surface aquifer along U.S. Highway 41 showing the thickness of the zones of different relative permeabilities.

Pumping tests were made on 10 of the 17 wells drilled along the north Park boundary. The other 7 wells could not be tested because surface fill caved into the holes. Each of the tested wells was pumped at a constant rate and water levels were measured in the well until the water level had stabilized. Pumping rates ranged from 150 gpm to 210 gpm. Stabilization of the water levels in each test occurred after about 30 minutes of pumping. Drawdowns of water level ranged from 1.6 feet to 6.3 feet. From the drawdowns and pumping rates, computations were made to determine the specific capacity of each well. The specific capacity is expressed as gallons per minute yielded by the well for each foot of drawdown of water level in the well. The specific capacity of a well is indicative of the water-bearing characteristics of the aquifer from which it obtains its yield. A high specific capacity indicates a relatively high transmissibility for an aquifer, whereas, a low specific capacity indicates a relatively low transmissibility.

The specific capacities of the test wells along the north boundary, excluding well 4, ranged from 24 gpm/ft to 53 gpm/ft, and averaged about 35 gpm/ft. of drawdown (fig. 2). The specific capacity of well 4 was 120 gpm/ft. The relatively high specific capacity of well 4 represents a local condition that probably reflects the effects of heavy blasting and rock excavation during construction of the nearby floodway of the S-12D control structure.

Well 18N, 7 miles east of the Park boundary, was pumped at a rate of about 325 gpm. One minute after pumping began the water level in the well had stabilized and the drawdown was measured at 0.35 foot. The value for specific capacity was computed to be 930 gpm/ft, or 26 times the average specific capacity that characterized the wells along the northern boundary of the Park.

The coefficient of transmissibility of a homogeneous areally extensive aquifer can be estimated from the specific capacity of a well after any pumping period if the coefficient of storage of the aquifer is known. Although the coefficient of storage of the water-table aquifer along the north park boundary has not been determined exactly, the functional relationship between specific capacity, transmissibility, and the storage coefficient is such that relatively large errors in the estimated coefficient of storage result in comparatively small errors in the coefficient of transmissibility estimated from specific capacity data. Based on the known geologic conditions and water-level fluctuations in response to rainfall in this area, a coefficient of storage of 0.15 is assumed for the aquifer, for the purpose of estimating transmissibility from the specific capacity data.

Based on the specific capacity data and the assumed storage coefficient the following estimates of the transmissibility were made of the limestone section of the aquifer along the northern Park boundary. (fig. 4).

Figure 4.--Caption on next page (belongs near here).

Well Number (see fig.4)	Estimated coefficient of transmissibility gpd/ft
1 N	46,000
3 N	20,000
4 N	145,000
10 N	55,000
16 N	30,000

The average coefficient of transmissibility of the limestone section of the aquifer along the northern Park boundary is estimated to be between 35,000 and 50,000 gpd/ft, whereas, that estimated from the specific capacity of 18N, 7 miles east of the Park boundary, is about 1,400,000 gpd/ft.

Figure 4.--Map showing the transmissibility of the limestone section of the Biscayne aquifer at selected sites in and near the Everglades National Park.

A pumping test also was made at the rockpit near the S-12B control structure near the 7-Mile Road (fig. 2). The approximate dimensions of the rockpit are shown in figure 5. The pit is 18 feet deep and probably completely penetrates the aquifer. The pit was pumped for 4 days, and

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water-level measurements were made to determine the drawdown in the pit. The maximum pumping rate was 1800 gpm, but, because of breakdowns and frequent servicing and adjustments, the average rate was estimated at about 1400 gpm. Water was pumped from the northwest corner of the pit and discharged across the road in order to reduce the return of surface flow.

Figure 5.--Map showing location and configuration of the rockpit near 7-Mile Road at which a pumping test was conducted.

After the pit was pumped for 14 hours at the rate of 1800 gpm (drawdown 0.6 foot), the pumping rate was reduced to 400 gpm for a 12-hour interval in order to make repairs on the suction pipe. Throughout the 12-hour interval the water level stabilized (at 0.6 foot drawdown) indicating that 400 gpm was the approximate ground-water inflow to the pit. The total drawdown measured in the pit after 4 days of pumping was 3.62 feet. During the final 5 hours of pumping the water level was being drawn down at a constant rate of about 0.05 foot per hour. The relation of the water level drawdown with the pumping suggests that the aquifer transmissibility is relatively low.

Because the amount of water taken from aquifer storage is not known, a definite value of the aquifer transmissibility could not be determined. Nevertheless, the rate of change of the drawdown during the test strongly suggests that the sustained yield of the pit would be less than 1500 gpm with a drawdown in the pit of 7 feet. Considering the relatively large area of aquifer exposed in the pit (perimeter of about 4000 feet) and its performance during the pumping test, the aquifer transmissibility is probably about the same order of magnitude as estimated for the area along the north Park boundary.

If the average coefficient of transmissibility of the limestone along the northern Park Boundary were as high as 50,000 gpd/ft, the amount of underseepage from Conservation Area 3 to a gallery 4,000 feet long would be far less than the desired amount based on the following computations. For this computation it was assumed that the flow from the Tamiami Canal, between Conservation Area 3A and the old U.S. Highway 41 (fig. 2), to the gallery would be negligible because of the relatively low permeable materials that line the canal bottom in many places.

It is estimated that no more than an 8,000-foot section of Conservation Area 3 parallel to the gallery would contribute flow to the north side of a 4,000-foot gallery located 600 feet to the south. The flow into the north side of the gallery from this part of the Conservation area would be given approximately by:

$Q = TIL$, where

Q = Quantity of underseepage, in gpd, moving from the 8,000-foot section of Conservation Area 3 to the Gallery,

T = Coefficient of transmissibility, in gpd/ft

I = Average hydraulic gradient, between Conservation Area 3 and the gallery in ft/ft

L = Average of the length of the gallery and the length of the section of the Conservation Area contributing flow, in feet.

and, in particular

$$Q = (50{,}000)\left(\frac{8}{600}\right)\left(\frac{4000 + 8000}{2}\right) = 4{,}000{,}000 \text{ gpd or } 6.2 \text{ cfs}$$

The 8-foot difference in head is based on the assumption that the water level in Conservation Area 3 will remain at a constant elevation of 8 feet above msl (mean sea level) and the water level in the gallery would be maintained at msl by pumping.

The flow from the other sections of Conservation Area 3 to the ends and to the south side of the gallery from the Park would be at most an estimated 1,500,000 gpd. Thus, a maximum of about 5,500,000 gpd or 8.5 cfs could be withdrawn from a gallery 4000 feet long located 600 feet south of Conservation Area 3 in response to a head difference of 8 feet.

The Tamiami Canal, adjacent to the old U.S. Highway 41, could be used as the infiltration gallery, rather than constructing one, if provisions were made to assure good hydraulic connection between the canal and the aquifer. It was computed that if a gallery were formed by closing off the canal at the east Park boundary and at about 3 miles west of 40-mile Bend (fig. 3), to prevent surface inflow, about 33,000,000 gpd (50 cfs) could be induced to the gallery from Conservation Area 3A. This computation also assumed a coefficient of transmissibility of 50,000 gpd/ft and a head difference of 8 feet between Conservation Area 3A and the gallery. Flow into the gallery from other areas would occur, but would amount to but a small fraction of that obtained from Area 3A. Algal growth in the canal would have to be controlled to assure unobstructed flow in all sections of the canal. The yield from this canal would be increased considerably if water were allowed to flow freely from L-29 Canal, L-67A Canal, and L-28 Canal (See figure 3 for locations.) to the Tamiami Canal. The largest contribution would be from L-29 and L-67A Canals.

RESULTS OF HYDROGEOLOGIC TESTS ALONG EAST PARK BOUNDARY

The Biscayne aquifer increases in thickness and permeability along U.S. Highway 41 to the east of the Park boundary (See figure 3.). Data from core borings and tests made several years ago by the Corps of Engineers indicate the aquifer thickens to the south and increases in permeability (See figure A-1 of Survey-Review Report on Central and Southern Florida Project Southwest Dade County, October 15, 1963.). Recharge tests made in 3 core holes indicate the permeability of the limestone section of the water-table aquifer 13 and 20 miles south of U.S. Highway 41 is considerably greater than at 8 miles. Quantitative estimates of the permeability at these sites are not available but the tests suggest that a sufficient thickness of highly permeable materials may be present less than 13 miles south of U.S. Highway 41 to provide the desired yield to a gallery of reasonable length.

Recent Coring and Testing

Six core holes were drilled along the east boundary of the Everglades National Park between 7 and 12 miles south of U. S. Highway 41 in 1965 (See fig. 4.). The borings were made by the U.S. Army Corps of Engineers and hydrologic data were collected by the Geological Survey. The cores were taken using a 5-foot core barrel and a diamond bit. Core recovery in zones of moderate permeability was nearly 100 percent whereas recovery in zones containing relatively high percentages of sand or highly porous rock was small. Samples that contained principally sand were taken using a 2-inch drive sampler.

The section penetrated generally consists of fossiliferous limestone becoming increasingly sandy with depth. The part of the Biscayne aquifer that would have the most significant influence on the performance of a gallery is above the depth where the sandy materials predominate. The depths below the land surface at which the sandy materials dominate are as follows (See fig. 4 for locations):

Well Number	Depth in feet
1E	28
2E	29
3E	26
4E	32
5E	32
6E	36

The procedure followed in testing along the east boundary consisted of alternately core drilling 5-foot intervals of the aquifer and performing recharge and/or discharge tests at each interval. Recharge tests were made by pumping water into the test hole at a rate sufficient to build up a head of 5 feet above the initial water level for the zone tested. Inaccuracies developed both in recharge and discharge tests because of leakage around the casing in most instances. In cases where leakage apparently was small, a discharge test was made, which consisted of pumping water from the test hole at a known rate and measuring the drawdown of the water level.

After four of the sites were drilled and tested a packer device was used to obtain better results in testing isolated parts of the cored holes to reduce leakage around the casing. Testing procedures were as follows: (1) Casing was inserted 3 feet into each hole and was cemented at the land surface; (2) The packer was inserted and inflated 5 feet below the bottom of the casing to separate the core hole above from that below the packer; (3) A discharge test was made by pumping from the section of hole above the packer, and water-level measurements were made until the drawdown stabilized; (4) At completion of pumping then the packer was lowered at 5-foot intervals and each interval was tested until the bottom of the hole was reached. Determinations of the coefficient of transmissibility for the limestone part of the aquifer were made which gave an indication of the relative permeability of each of the zones.

The following table gives the estimated coefficient of transmissibility at the 6 core-hole sites along the east Park boundary.

Core hole Number	Coefficient of transmissibility, mgd/ft
1 E	0.03
2 E	0.22
3 E	0.05
4 E	0.30
5 E	1.80
6 E	0.75

Although the limestone section thickens southward, the large variation in transmissibility primarily reflects permeability differences.

If the part of the aquifer from which water is discharged is less than about 60 percent of the total aquifer thickness, the coefficient of transmissibility computed from the observed specific capacity is less than the actual coefficient of transmissibility. A method developed by Jacob (1963, p. 273) was used to adjust for this partial aquifer penetration.

Table 1 gives estimates of the coefficients of transmissibility at each site, based on selected tests of different parts of the aquifer. The relative values for various penetrations in a given well give an indication of permeability in different zones. For example, the test results for core hole 1E suggest that the average permeability of the bottom half of the limestone section is about twice that of the upper half. The decrease in the estimated coefficients of transmissibility with increase in discharge rate shown for the tests on at least 90 percent of the aquifer at core hole 5 E is believed to be due to turbulent flow in and adjacent to the hole. The value of transmissibility associated with the lowest discharge rate is considered most representative of the aquifer at that site.

Table 1.--Estimates of coefficients of transmissibility based on selected specific capacity tests made on different parts of the limestone section.

ore le (see fig. 4)	Zone tested, in ft. below land surface	Discharge rate in gpm	Estimated transmissibility in mgd per foot (corrected to account for partial penetration of tested) zone
1 E	0 - 10.5	46	0.016
1 E	0 - 10.5	46	0.014
1 E	0 - 28.0 1/	91	0.028
2 E	0 - 10.5	47	0.32
2 E	0 - 15.6	48	0.29
2 E	0 - 29.0 1/	92	0.22
4 E	0 - 18.7	47	0.022
4 E	0 - 23.7	50	0.10
4 E	0 - 32.0 1/	51	0.30
5 E	0 - 10.5	120	1.00
5 E	0 - 15.5	86	0.70
5 E	0 - 20.5	90	1.30
5 E	0 - 25.5	90	0.90
5 E	0 - 29.5 1/	70	1.80
5 E	0 - 32 1/	180	1.20
5 E	0 - 32 1/	350	0.60
6 E	0 - 10	48	0.16
6 E	0 - 14.3	50	0.10
6 E	0 - 16.3	57	0.42
6 E	0 - 32 1/	92	0.45
6 E	0 - 32 1/	170	0.75

1/ Zone represents at least 90 percent penetration.

One of the assumptions in the development of the method to estimate transmissibility using specific capacity data is that the pumped water comes from storage in the aquifer. Water was above the land surface at all sites except 6 E during most of the tests. The order of magnitude of the error introduced by the ponded-water condition is believed to be small because at most of the sites the material within about 3 feet of land surface was relatively dense and probably of low permeability. If so, this would limit appreciably the effect of the ponding on the drawdown in the core hole required to obtain any given yield.

The increase in the estimated coefficient of transmissibility with increase in discharge for the tests on 32 feet of the aquifer at core hole 6 E probably indicates that the velocity at the higher discharge rate was sufficient to remove fine-grained material from solution holes in the vicinity of the core hole, thus increasing the permeability.

AREAL VARIATIONS IN AQUIFER TRANSMISSIBILITY

The coefficients of transmissibility estimated from the tests along the north and the east boundaries of the Park are shown on figure 4 along with other determinations of transmissibility in the vicinity. The data suggest that the transmissibility of the aquifer within the Park area is relatively low between U.S. Highway 41 and 10 miles to the south. The data also suggest that the transmissibility increases eastward and probably exceeds 1,000,000 gpd/ft in an area 3 or 4 miles east of the northeast corner of the Park.

Quantitative data on the aquifer transmissibility south of the southernmost core hole along the east Park boundary are lacking (See figure 4.). Results of recharge tests obtained earlier by the Corps of Engineers on a cored well 20 miles south of U.S. Highway 41 indicate a transmissibility comparable to that obtained at well 5 E. This suggests that the aquifer transmissibility is relatively uniform from 11 to 20 miles south of U.S. Highway 41 along the boundary. Because of the relatively high aquifer transmissibility, the area about 11 to 13 miles south of U.S. Highway 41 is considered as a site for the proposed infiltration gallery.

GALLERY DIMENSIONS

The dimensions of a gallery to provide a given quantity of water for an appreciable period of time is governed in part by the transmissibility of the aquifer system. At the alternate site (See fig. 1.), the variation of aquifer transmissibility is large. The problem of analyzing the performance of a gallery in an aquifer of nonuniform transmissibility is quite difficult without use of electronic computer facilities, whereas, the performance of a gallery in an aquifer of uniform transmissibility equal to about the average aquifer transmissibility is much less difficult to analyze and would give a reasonable approximation of gallery length required to obtain 100 cfs for as long as 100 days. As a first approximation it is assumed that the aquifer transmissibility near the alternate site is effectively uniform and is between 1 and 2 mgd/ft.

Because the gallery would be used primarily during periods of drought it is assumed that the aquifer would receive no replenishment from rainfall. The nearest hydrologic recharge boundaries to the aquifer are Conservation Area 3 to the north and the Levee 31 Canal to the east, which are about 10 miles distant. Replenishment to the aquifer from those boundaries during a period of pumping for no more than 100 days would be quite small compared to the amount pumped. Thus, assuming no rainfall, practically all of the water pumped from a gallery during a 100-day period at the alternate site would be water from aquifer storage, causing water levels in and around the gallery to decline continuously. Some water may be salvaged from evapotranspiration due to lowering of the water level by the pumping but this has been neglected for the purpose of computation of gallery dimensions.

Engineers from the Everglades National Park have indicated that a gallery 20 feet wide and 20 feet deep would be most practical to construct and a drawdown not to exceed 8 feet would be acceptable. Such a gallery would have in available storage about 1.2 million gallons per 1000 feet of length. It is assumed that a maximum feasible gallery length is 20,000 feet with available storage of about 24 million gallons. The amount of water from gallery storage after 100 days of pumping would be less than half of 1 percent of the total water withdrawn. Thus, gallery storage can be ignored in determining the gallery length needed to produce 100 cfs with 8-foot lowering in 100 days.

The authors know of no general method of determining the maximum yield that can be obtained from a gallery of given length after a given period of pumping where the maximum drawdown in the gallery is specified. In the special case where the gallery length is not large relative to gallery width, a fairly accurate approximation can be obtained by using formulas developed for flow to a pumping well.

Formulas developed for linear flow to an infinitely long drain or stream give an approximation for the flow to a gallery of finite length that has better accuracy where the gallery length is very large. It was determined that neither approach would yield a sufficiently accurate approximation for this particular case.

A method was developed which consists of approximating the gallery performance by that of a line of equally spaced wells having diameters equal to the gallery width. Using this method of gallery simulation by wells it is estimated that a 20,000-foot gallery would be required to provide a sustained yield of 100cfs with a drawdown of no more than 8 feet for 100 days if the aquifer storage and transmissibility are 0.15 and 2,000,000 gpd/ft. If the transmissibility is 1,000,000 gpd/ft, a 20,000-foot gallery would yield only about 65 cfs.

EFFECT OF GALLERY DISCHARGE

The estimated drawdowns that would occur in the vicinity of a 20,000-foot gallery assuming no recharge from rainfall and no evapotranspiration losses are shown in figure 6. Also assume that the

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Figure 6.--Caption on next page (belongs near here).

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coefficient of transmissibility of 2,000,000 gpd/ft is areally uniform, the coefficient of storage is 0.15, and the water discharged from the gallery was not recirculated.

The drawdown contours around the gallery would be distorted somewhat from the symmetrical pattern shown on figure 6 because the aquifer transmissibility is not uniform. Water-level studies in this area suggest that during droughts the water table near the alternate site generally slopes southward. Much of this flow normally would be discharged to drainage canals or go to evapotranspiration in areas to the south. Thus, equal quantities of water would not enter the gallery from the north and from the south, as suggested by figure 6. Water entering the gallery would be intercepted flow that otherwise would drain to the south or water that would otherwise be lost by evapotranspiration in the vicinity of the gallery.

Figure 6.--Estimated drawdowns in the vicinity of a 20,000-foot gallery after pumping at 100 cfs for 100 days.

The water pumped for 100 days in a drought, in the amount of 20,000 acre feet, is assumed as having been extracted from storage in the aquifer. It represents a discharge from the system which is additional to that which would have occurred naturally. It resembles a borrowing of water from future supplies if the depletion of storage from the aquifer is to be replaced during an ensuing wet period when excess water presumably will be available.

The lowering of water level by pumping, of more than 1 foot over about 50 square miles, and less than 1 foot over an infinitely larger area, would accentuate drought conditions and would probably result in a reduction of evapotranspiration. The amount of reduction may be significant but is undetermined and would represent salvage of water. The effects of such pumping upon ecologic conditions of the Park and adjacent areas may be significant and need to receive further consideration before the pumping scheme is instituted.

REFERENCES

Jacob, C. E., 1963, Correction of drawdowns caused by a pumped well tapping less than the full thickness of an aquifer, in Bentall, Ray, (Compiler), Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 272-282.

U. S. Army Corps of Engineers, October 15, 1963, Survey-review report on Central and Southern Florida Project, Southwest Dade County. (Mimeographed report).

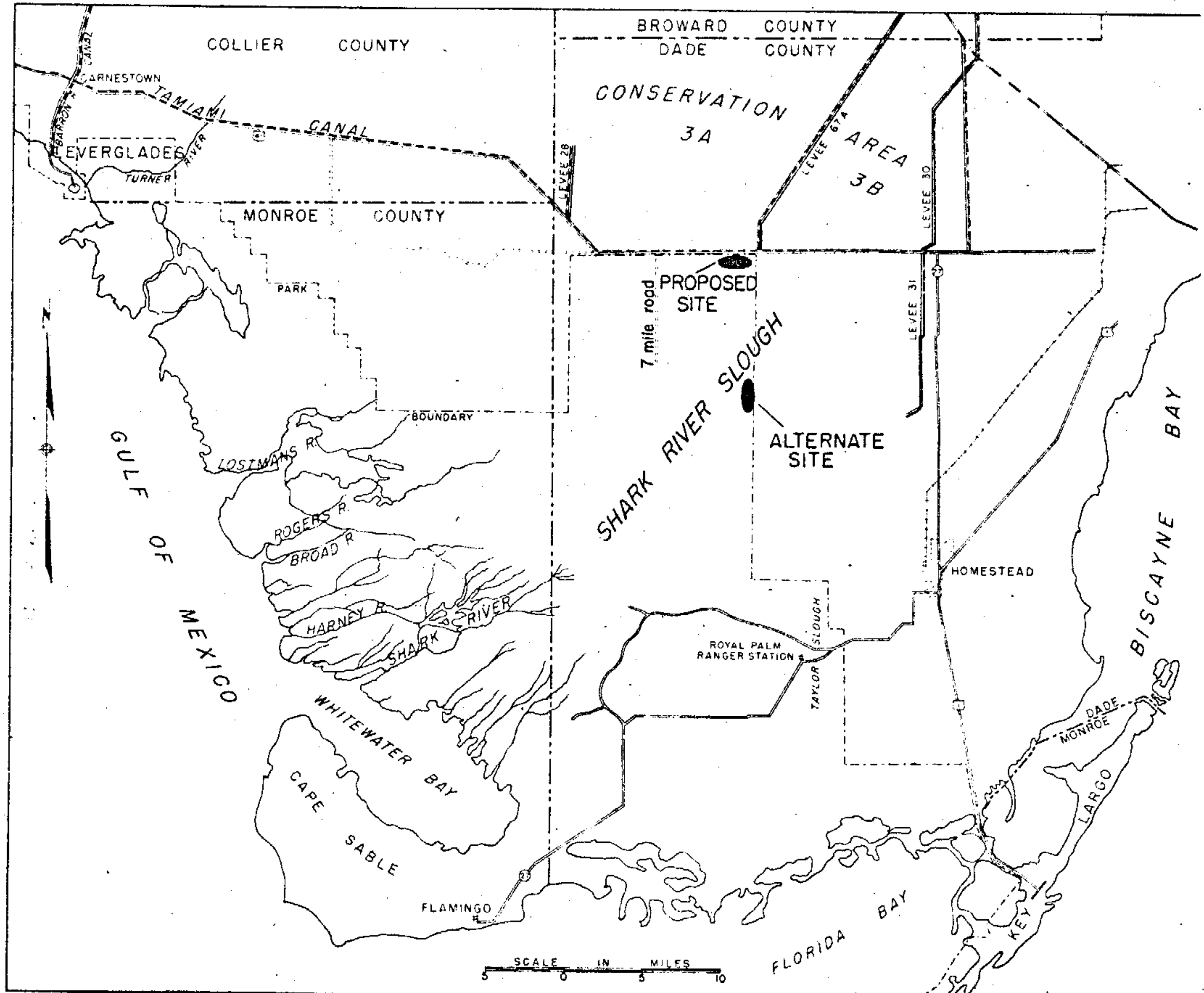

Figure 1.--Map of southern Florida showing Everglades National Park and the locations of the sites to be considered for a water-collection gallery.

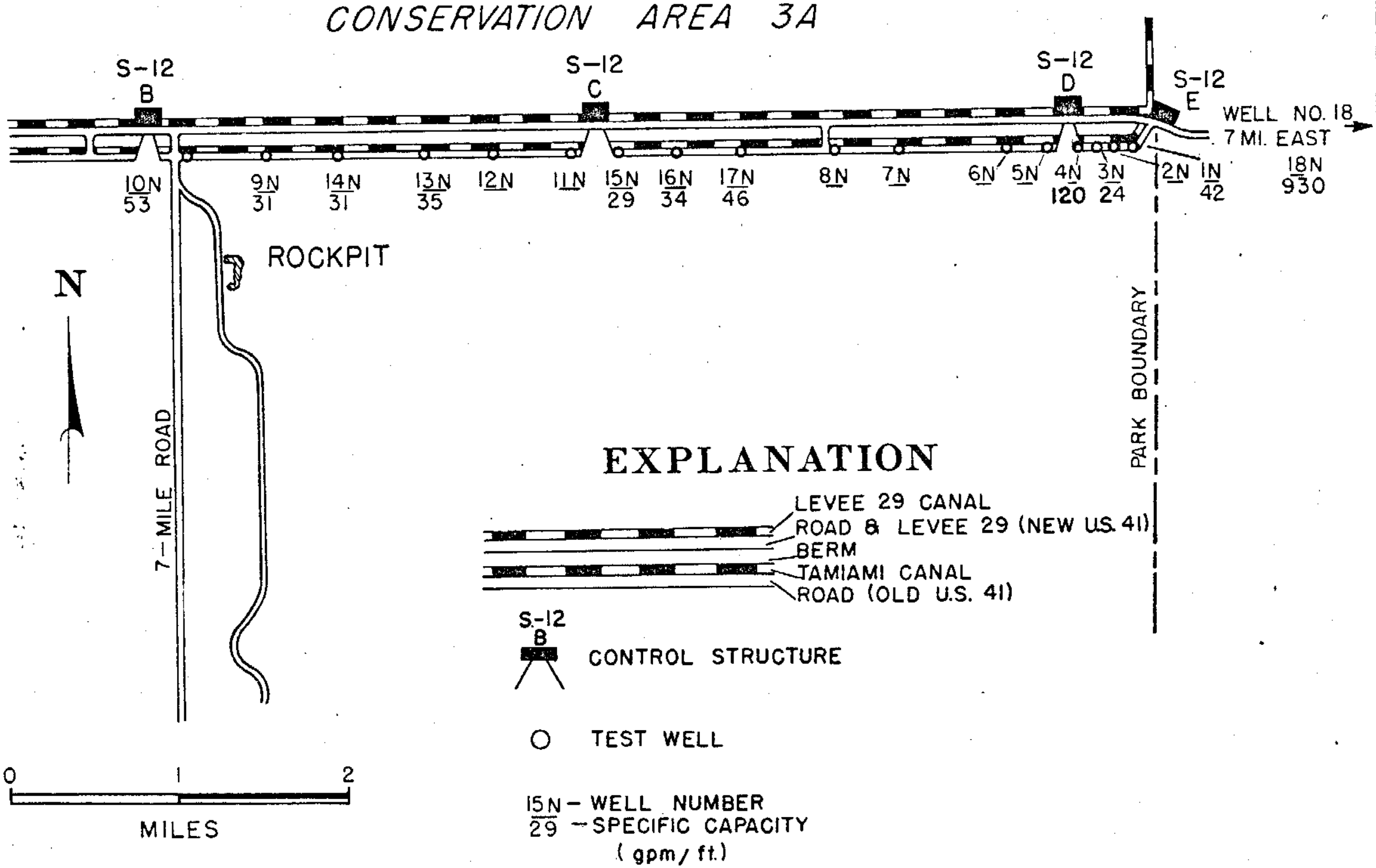

Figure 2.--Map showing the location of exploratory holes drilled along the northern Park boundary.

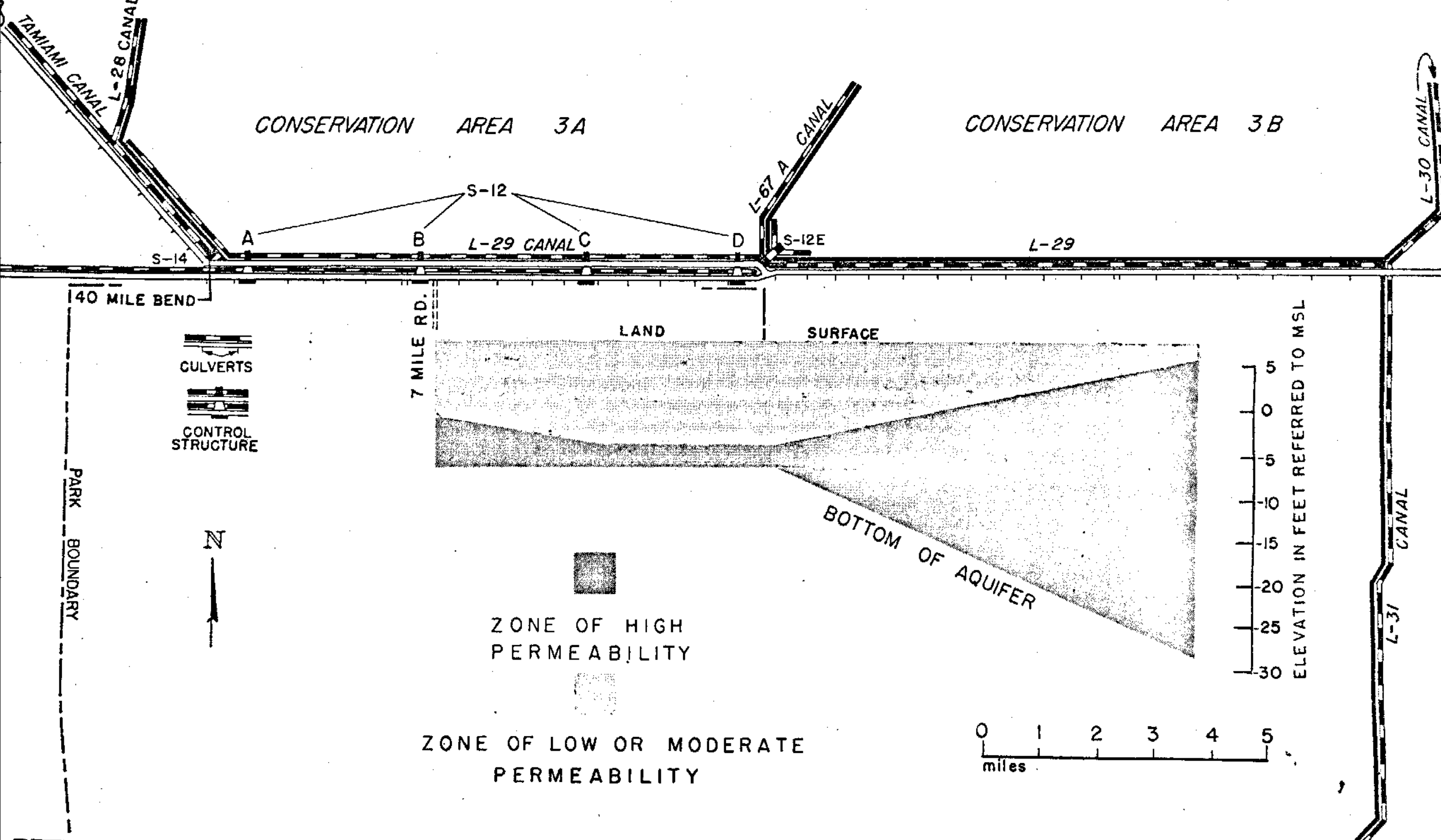

Figure 3.--Generalized section of the near-surface along U.S. Highway 41 showing the thickness of the zones of different relative permeabilities.

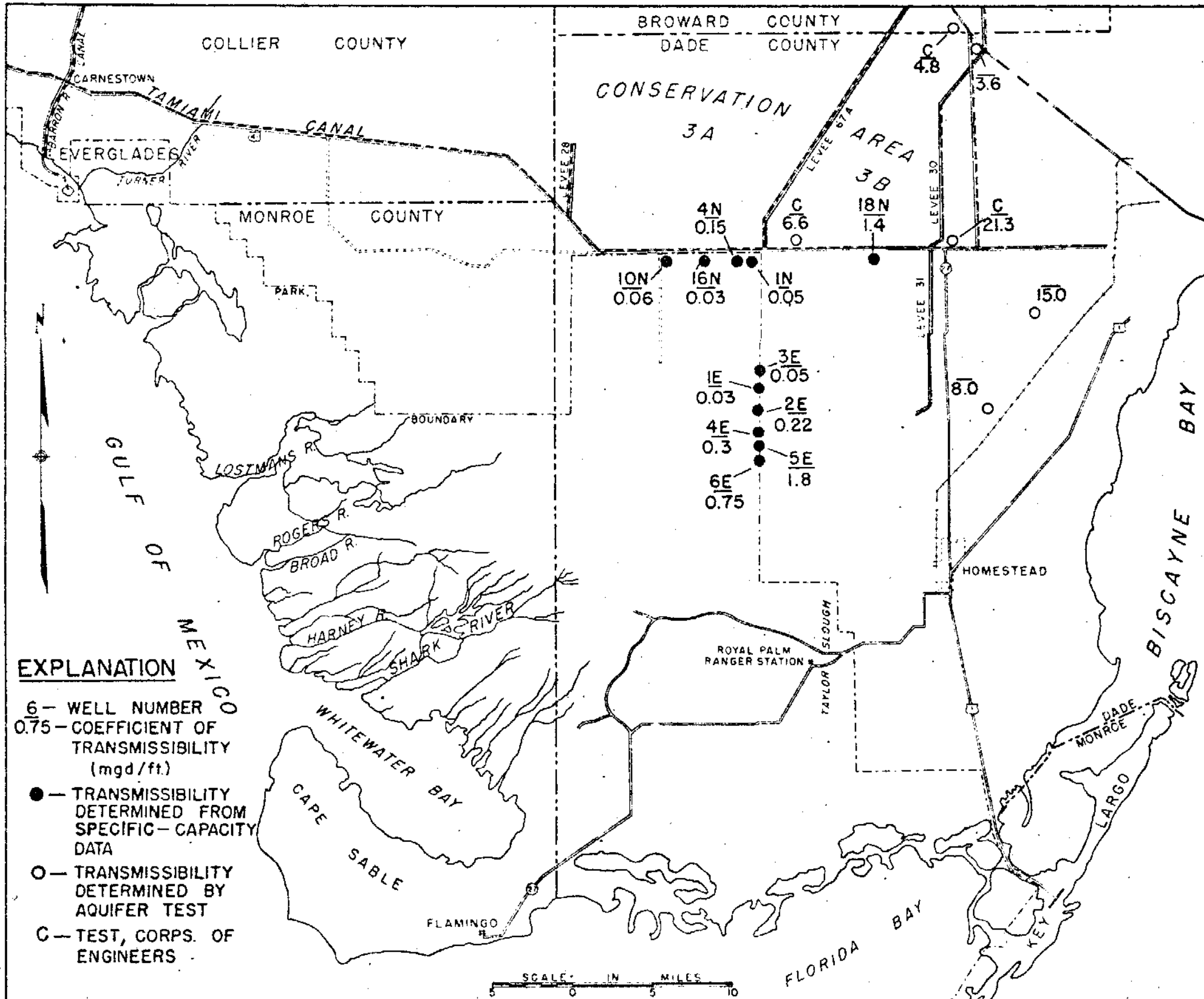

Figure 4.--Map showing the transmissibility of the ... stone section of the Biscayne aquifer at selected sites in and near the Everglades National Park.

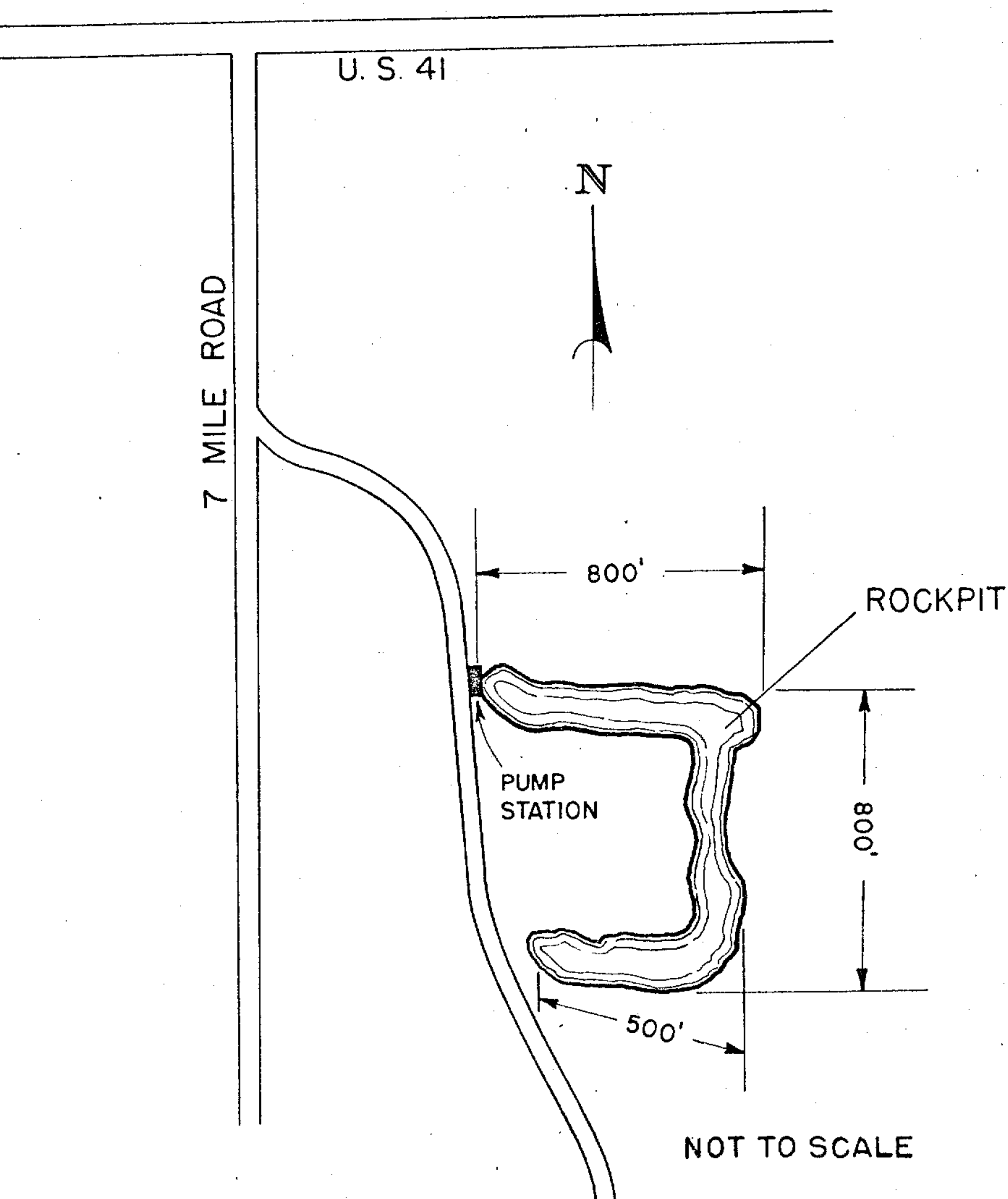

Figure 5.--Map showing location and configuration of the rockpit near 7-Mile Road at which a pumping test was conducted.

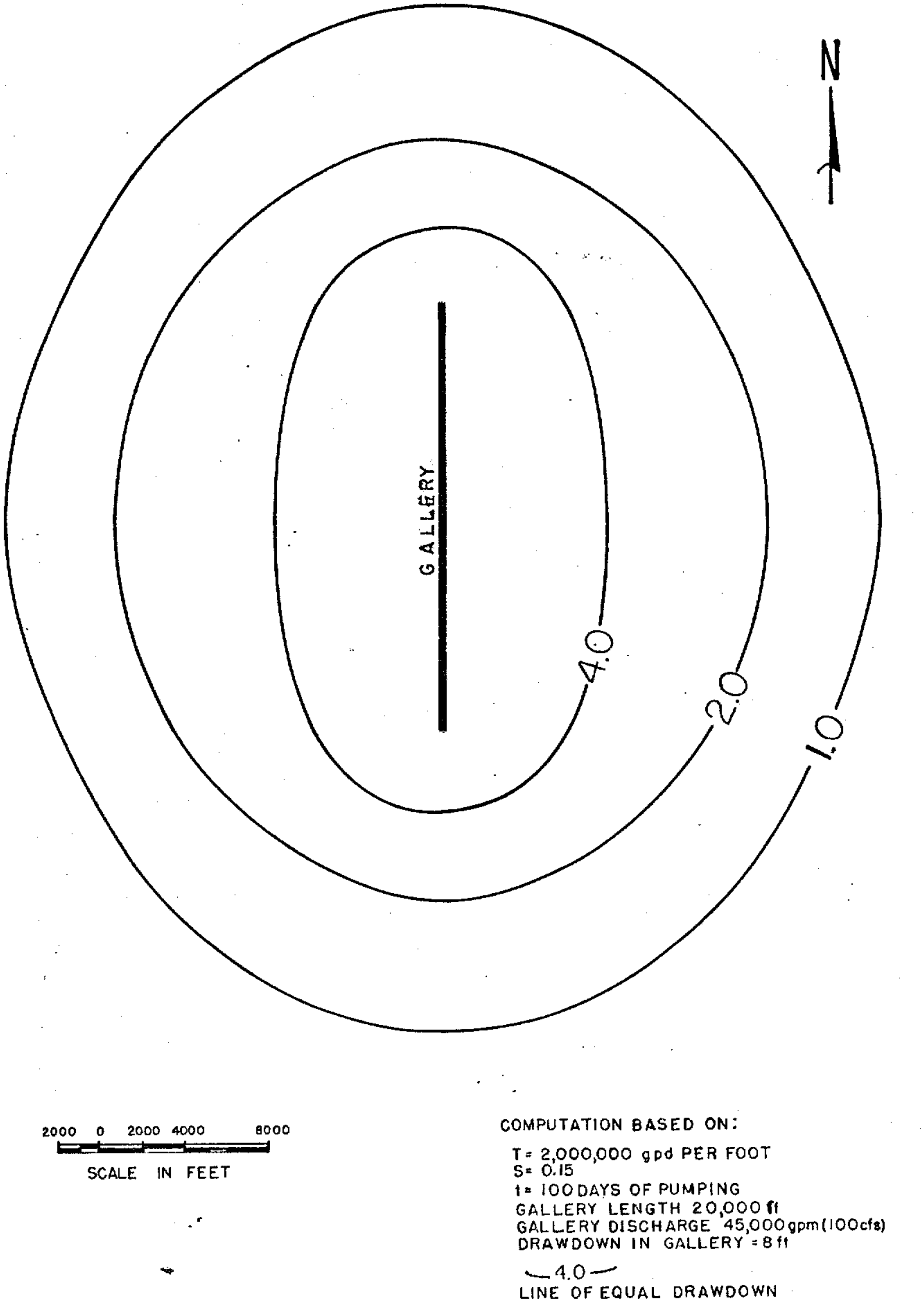

Figure 6.--Estimated drawdown in the [illegible] of a 20,000-foot [illegible] after pumping at 100 cfs for 100 days