APPENDIX C

SOIL AND FOUNDATION INVESTIGATION

SOIL AND FOUNDATION INVESTIGATION

TOWER RESOURCES
COAL HANDLING FACILITIES

HELPER, UTAH

April 1982

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

1435 WEST 820 NORTH, P. O. BOX 711, PROVO, UTAH 84603
TELEPHONE 374-5771

RBG

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April 1982

ROLLINS, BROWN AND GUNNELL, INC.
Professional Engineers
1435 West 820 North, P.O. Box 711
Provo, Utah 84603

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

April 2, 1982

Tower Resources, Inc.
P.O. Box 1027
Price, UT 84501

ATTN: Mike Glasson

Gentlemen:

A soil and foundation investigation has been completed at the proposed site for the Tower Resources, Inc. coal handling facilities near Helper, Utah. The investigation was performed to define the characteristics of the subsurface material throughout the soil profile so that satisfactory substructures could be designed to support the facilities contemplated in this area. The work has been performed in a manner to accomplish the basic objective, and the results of the investigation, along with pertinent recommendations for foundation design, are outlined in the following sections of this report.

The information contained in the report is discussed under the following headings: (1) Existing Site Conditions, (2) Subsurface Soil and Water Conditions, (3) Foundation Considerations and Recommendations, (4) Site Preparation, Compacted Fill Requirements and Lateral Earth Pressures, and (5) Results of Field and Laboratory Tests.

1. EXISTING SITE CONDITIONS

The proposed site is located approximately 3.8 miles west of U.S. Highway 50 near Helper, Utah. The general layout of the facilities contemplated throughout the site is presented in Figure No. 1. The subsurface materials throughout this area are alluvial deposits laid down by streamflow through the area.

The topography of the site slopes to the east and south, and the area is dissected by a number of small drainage channels. Except for a substantial amount of coal fill which has been placed in the vicinity of Sites 1, 2 and 3, no man-made fill appears to exist throughout the area.

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No major structures are located in the immediate vicinity of the proposed site from which foundation performance in this area can be inferred.

No water conveyance facilities or other water bodies are located in the immediate vicinity of the site which would affect the groundwater level in this area.

Other than the information provided above, no environmental factors appear to exist at this site which would adversely affect foundation performance.

2. SUBSURFACE SOIL AND WATER CONDITIONS

The characteristics of the subsurface material throughout the area were defined by drilling eight test borings to depths of between 20 and 45 feet below the existing ground surface. The logs for the eight test holes are presented in Figures 2 through 5, and it will be observed that the subsurface material generally consists of cohesive soils underlain by a gray shale. In the vicinity of Test Holes 1 and 2, coal fill exists for a depth of between 9 and 12 feet below the existing ground surface.

During the subsurface investigation, sampling was performed at 3-foot intervals throughout the upper 15 feet of the soil profile and at 5-foot intervals thereafter. Both disturbed and undisturbed samples were obtained during the field investigations. Disturbed samples were obtained by driving a 2-inch, split-spoon sampling tube through a distance of 18 inches, using a 140-pound weight dropped from a distance of 30 inches. The number of blows to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value.

The standard penetration value provides a reasonable indication of the in-place density of sandy-type materials; however, the standard penetration value only provides an indication of the relative stiffness of cohesive soils, since the penetration resistance of this material is a function of the moisture content.

Undisturbed samples were obtained at various locations throughout the soil profile at the site by pushing a 2.5-inch, thin-walled shelby tube into the subsurface material using the hydraulic pressure on the drill rig. The locations at which undisturbed samples were obtained are presented on the boring logs.

Each test hole was extended until shale was encountered, and the hole was advanced in the shale for several feet using a rock bit or by coring. An attempt was made to sample the shale using the standard split spoon sampler. However, at essentially all locations refusal was encountered when an attempt to sample was performed.

Each sample obtained in the field was classified in the laboratory according to the Unified Soil Classification System. The symbol designating the soil type according to this system is presented on the boring logs. A description of the Unified Soil Classification System is presented in Figure No. 6, and it will be noted that the cohesive material throughout the soil profile generally classifies as an ML or a CL-ML type soil. A few areas were encountered, however, where CL-1 type material exists. It is concluded, therefore, that all of the overburden materials throughout the proposed site are low plasticity silts and clays.

In penetrating the shale layer throughout the subsurface profile at this site, it was necessary to use water as the drilling fluid. The use of the water makes an accurate determination of the groundwater level in this area uncertain during the period of time when the drilling was performed. It is our opinion, however, that the groundwater level throughout the site is at a substantial distance below the existing ground surface and groundwater will not be a problem throughout the area.

In order to determine if groundwater actually exists throughout the site, observation wells extending to a depth of 50 feet below the ground surface were installed at the locations shown in Figure No. 1. It is recommended that these wells be monitored at frequent intervals to determine if a static groundwater level exists at an elevation which would influence foundation performance and construction throughout the site.

3. FOUNDATION CONSIDERATIONS AND RECOMMENDATIONS

As of the preparation of this report, no details are available on any of the structures contemplated throughout the area, and recommendations outlined below for foundation design must be considered of a preliminary nature. The following recommendations will be expanded when more information is available as to the type of facility, the size of the structures and the anticipated structural loads.

A. Truck Dump Facilities

It is anticipated that the truck dump facilities will include an earth fill ramp and a truck dump hopper. The characteristics of the subsurface material in the vicinity of the truck dump facilities is defined by Test Hole 1, and it will be observed that the subsurface material throughout the profile consists of a surface coal layer underlain by approximately 20 feet of brown sandy silt. The subsurface silts throughout the general area do not appear to be highly compressible; however, it can be expected that several inches of settlement will occur due to the fill loads.

Since the subsurface soils are silty-type materials, it is expected that the time delay associated with the consolidation of these materials will be relatively small and that consolidation will be essentially complete by the time the fill has been placed.

It will be noted from Test Hole 1 that coal exists in the upper 9 feet of the soil profile at this location. Coal is not capable of supporting the truck dump hopper, and we recommend that the coal be excavated and replaced with compacted fill material. If a source of granular material is available, we recommend that the granular material be used as compacted fill to support the truck dump hopper. If a source of granular material is not readily available, the on-site sandy silt can be used as compacted fill in this area. If the sandy silt is densified in accordance with recommendations outlined in the subsequent section of this report, we recommend that the foundations for the truck dump hopper be proportioned using an allowable soil bearing pressure of 2,500 pounds per square foot, provided the major portion of the zone of significant stress for the foundations is in the fill material.

The exact elevation of the foundations for the truck dump hopper is not known as of the preparation of this report. If the elevation of the foundations for the truck dump hopper is located such that a significant portion of the zone of significant stress for the foundations exists within the natural material, we recommend that the foundations be proportioned using an allowable soil bearing pressure of 1,500 pounds per square foot.

In order for compacted fill beneath structural foundations to be effective, the width of the compacted fill should be at least equal to twice the width of the footing.

B. Crusher and Screening Building

As indicated earlier in this report, the size of the building contemplated for this area and the characteristics of the crusher are not known as of the preparation of this report. It is assumed, however, that the structural loads for the building will be relatively small, and that column loads will not likely exceed 75 kips and wall loads will not likely exceed 3 to 4 kips per lineal foot.

Test Hole 2 defines the characteristics of the subsurface material in the vicinity of the crusher and screening building. It is apparent from the log for Test Hole 2 that coal fill extending to a depth of approximately 13 feet exists at this location. The coal is not capable of supporting structural foundations, and either the coal should be removed and replaced with compacted fill, or drilled caissons extending to the gray shale layer in the vicinity of 20 feet below the ground surface should be used to support the structures for this facility.

The on-site sandy silt may be used as compacted fill to support the structures for the building throughout this area provided it is densified in accordance with recommendations outlined in a subsequent section of this report. If compacted fill is used to support the crusher building, we recommend that the foundations be proportioned using an allowable soil bearing pressure not exceeding 2,500 pounds per square foot.

Since the crusher and screening facilities will transmit vibratory loads to the subsurface material, it may desirable to support the foundations for these facilities on drilled caissons extending to the gray shale. Recommended caisson capacities for caissons extending to the gray shale are tabulated below:

Caisson Tip Diameter (feet)	Caisson Capacity (kips)
2	122
3	183
4	244

If the foundations for the facilities at this location are provided in accordance with the above recommendations, the maximum settlement of any footing should not exceed 1 inch and differential settlement throughout the structure should not exceed 0.5 inches, which in our opinion will be satisfactory for the proposed facilities.

C. Train Load-Out Facilities

It is anticipated that the facilities at this location will consist of elevated bins equipped to discharge coal into the freight cars. The detailed nature of these facilities, along with the structural loads, is not known as of the preparation of this report.

The characteristics of the subsurface material in the vicinity of the load-out facility is defined by Test Hole 3, and it will be observed that the subsurface material in this area consists of a 6-foot layer of coal fill underlain by a brown sandy silt and silty clay extending to a depth of about 41 feet below the existing ground surface, at which point shale was encountered. The coal fill located in the upper 6 feet of the soil profile at this site is not capable of supporting structural foundations and should be replaced with compacted fill material.

The allowable soil bearing pressure of the natural brown sandy silt is about 1,500 pounds per square foot at this location, and if the structural loads for the proposed facility are relatively small, it may be possible to support the proposed facility using spread foundations on the natural material. It is our opinion, however, that since the coal fill must be removed the most desirable foundation type for this structure will be to use spread foundations on compacted fill.

The natural sandy silt existing throughout the area can be used as compacted fill provided it is densified in accordance with recommendations outlined in the following sections of this report.

If the depth of the compacted fill beneath the structural foundations at this location is at least equal to the width of the footing, the foundations for the proposed facilities may be proportioned using an allowable soil bearing pressure of 2,500 pounds per square foot.

An alternate to supporting the proposed facility using spread foundations on compacted fill would be to use drilled caissons extending to the shale layer. Since the depth to the shale layer is over 40 feet, foundations of this type will likely be considerably more expensive than spread foundations on compacted fill. If, however, the structural loads for the proposed facility are of such a magnitude that drilled caissons will be required, we are prepared to provide allowable caisson capacities at this location.

D. Facilities in the Vicinity of Test Hole 4

The type of facility contemplated in the vicinity of Test Hole 4 is not known as of the preparation of this report. It appears as if the facility at this location will be some component of a conveyor system. The subsurface material at this location is defined by the log associated with Test Hole 4, and it will be observed that the subsurface material consists of approximately 20 feet of silt and clay overlying the shale.

The results of laboratory tests performed on the subsurface material at this location indicates that the cohesive materials are in a medium-dense state and are capable of supporting 1,500 to 2,000 pounds per square foot, and we recommend that spread foundations on the natural material be used to support any structure located at this site.

E. Clean Coal Pile

It will be noted that the characteristics of the subsurface material throughout the alignment of the clean storage pile is defined by Test Holes 5, 6, 7 and 8. It will be noted from the boring logs for these test holes that the overburden material consists predominantly of silty-type soil and that shale was encountered at depths of between 15 and 35 feet below the existing ground surface. The bottom of the shale appears to dip in a southerly direction.

We understand that either a concrete tunnel or a steel multi-plate tunnel accomodating transfer facilities will be located beneath the clean coal pile. The size of the underground structure at this location is not known; however, it is possible that the bottom of the tunnel in the northerly end of the pile may be relatively close to the shale surface, while a substantial amount of overburden material will be located beneath the bottom of the tunnel and the top of the shale towards the southerly end of the tunnel. This situation could lead to several inches of differential settlement between the north and south ends of the tunnel under the loads associated with the clean coal pile.

If differential settlement is not a problem, the tunnel may be located directly on the existing silt and clay material. If differential settlement throughout the area is critical, excavation and replacement of a portion of the natural overburden material in the southerly end of the site may be required to reduce the magnitude of the differential settlement.

It is recommended that further consideration be given to foundation performance in this area when the exact details of the proposed facility at this location are known.

4. SITE PREPARATION, COMPACTED FILL REQUIREMENTS AND FLEXIBLE PAVEMENT DESIGN

As indicated earlier in this report, a substantial amount of excavation, backfilling and grading will likely be required throughout the site to accomodate the proposed facilities. The coal fill in the vicinity of Test Holes 1, 2 and 3 is not capable of supporting structural foundations and should be replaced with compacted fill. If possible, the compacted fill placed throughout the area should be a well-graded granular material with a maximum size less than 4 inches and with not more than 10 to 15 percent passing a No. 200 sieve.

It is recognized that granular fill is relatively scarce in the Price-Helper area, and the existing site material may be used as compacted fill to support structural foundations provided it is densified to an in-place unit weight equal to 95 percent of the maximum laboratory density as determined by ASTM D 1557-78.

If embankments are contemplated in the area where the truck dump facilities will be located, we recommend that all material placed within the dump embankments be densified to an in-place unit weight equal to 95 percent of the maximum laboratory density as indicated above. The on-site sandy silt or silty clay can be used in the truck dump embankments.

It is recommended that either a tamping-type roller or rubber-tired rollers be used to densify the sandy silts or silty clays used for compacted fill throughout the site. Since the compacted fill will support structural foundations, it is imperative that appropriate quality control be performed to insure that the compacted fill is densified in accordance with the specifications indicated above.

It is anticipated that an excavation 10 to 12 feet deep will be required in the area where the clean coal pile will be located. Since the subsurface materials in this area are cohesive-type soils and since no groundwater table was encountered in the area, it is not anticipated that any difficult excavation problems will be encountered.

If a portion of the subsurface material in the southerly end of this facility is excavated and replaced with compacted fill to reduce the likelihood of differential settlement for structures in this area, we recommend that the compacted fill be densified in accordance with the recommendations outlined above.

In areas where driveways or haul roads are located, we recommend that the upper 3 to 4 inches of the natural material be stripped to remove any organic matter which may exist in the soil profile at this location. Following the stripping operations, we recommend that the upper 10 inches of the natural material be scarified and redensified to an in-place unit weight equal to 90 percent of the maximum laboratory density specified herein.

The thickness of flexible pavement recommended for driveways and haul roads has been calculated using the following equation developed by the Corps of Engineers:

$$t = (23.1 \text{ Log } C + 14.4) \sqrt{P\left(\frac{1}{8.1 \text{ CBR}} - \frac{1}{p\pi}\right)}$$

Where: C = Number of coverages
P = Wheel load
p = Tire pressure
CBR = California Bearing Ratio

It will be noted from the above equation that the thickness of the flexible pavement is a function of the wheel load, the number of coverages, the tire pressure and the CBR value. No CBR tests were performed during this investigation; however, based upon the results of tests performed on similar materials, it is not anticipated that the CBR value of these materials will exceed 3 to 5 percent.

The number of coverages and the wheel loads contemplated on haul roads and driveways are also not known as of the preparation of this report, and certain assumptions have been made relative to these parameters. The recommended thickness of flexible pavement is based upon the following assumptions:

A. Number of coverages = 50,000

B. Wheel load = 14,000 pounds

C. CBR value = 3 percent

D. Tire pressure = 70 psi

Substituting the above parameters into the flexible pavement equation indicates a total flexible pavement thickness of 28 inches. Fifteen inches of the flexible pavement may consist of bankrun sand and gravel, while the remainder of the pavement should consist of untreated granular base, unless an asphalt surface course is contemplated.

All base material should be densified to an in-place unit weight equal to 90 percent of the maximum laboratory density indicated above, and the gradation of the untreated granular base should conform to the following specifications:

Sieve Size	Percent Passing
1"	100
.5"	70 - 100
No. 4	41 - 68
No. 16	21 - 41
No. 50	10 - 27
No. 200	4 - 13

If an asphalt surface course is contemplated for any of the driveways or haul roads, we recommend that it have a minimum thickness of 3 inches and that the flexible pavement under these conditions consist of 3 inches of an asphalt surface course plus 10 inches of untreated granular base and 15 inches of bankrun sand and gravel. The mineral aggregates in the untreated granular base should conform to Section 402 of the standard specifications of the Utah State Department of Transportation. Mixing, placing and densification of all asphalt materials should also conform to State standards.

5. RESULTS OF FIELD AND LABORATORY TESTS

Field and laboratory tests performed during this investigation included standard penetration tests, in-place unit weight, natural moisture content, Atterberg limits, mechanical analyses and consolidation tests. A summary of all tests performed during the investigation, with exception of the consolidation tests, is presented in Table No. 1, Summary of Test Data.

It will be observed from Table No. 1 that the natural moisture content of the subsurface material is very dry and is generally several percentage points below the plastic limit. It will also be noted that most of the materials throughout the profile at this site classify as ML or CL-ML type materials. With exception of one or two tests, the in-place unit weight of the subsurface material is generally in excess of 95 pounds per cubic foot.

Cores obtained from the shale in Test Holes 5 and 6 indicate that the shale material has a high unit weight. It will also be noted from the results of the Atterberg limits that the plastic index is generally less than 6 percent, and in some cases, the silty material is nearly non-plastic.

The compressibility characteristics of the overburden material throughout the site were evaluated by performing ten consolidation tests on representative samples obtained from Test Holes 1, 2, 4, 6 and 8; while the compressibility characteristics of the shale material were evaluated by performing two consolidation tests on representative samples obtained from Test Holes 5 and 6. The results of the consolidation tests are presented in Figures 7 through 18. It will be observed that most of the consolidation tests performed on the overburden material indicate that this material is quite highly overconsolidated, and settlement will be relatively small for load intensities less than 1,500 to 2,000 pounds per square foot.

It should be noted that during the consolidation tests, each sample was permitted to absorb water during the loading sequence, in order to determine the affect of moisture on the compressibility characteristics of the subsurface material. It should be noted from the consolidation tests performed on samples of the shale material that the sample obtained at a depth of 19 feet below the existing ground surface in Test Hole 5 indicated some swell potential, while the sample obtained at a depth of 20 feet below the existing ground surface in Test Hole 6 did not swell on the addition of water. The rebound portion of the consolidation curve on this sample, however, indicates that some swell potential may exist.

The conclusions and recommendations presented in this report are based upon the results of the field and laboratory tests which, in our opinion, define the characteristics of the subsurface material throughout the site in a satisfactory manner. If during construction conditions are encountered which appear to be different than those presented herein, it is requested that we be advised in order that appropriate action may be taken.

Very truly yours,

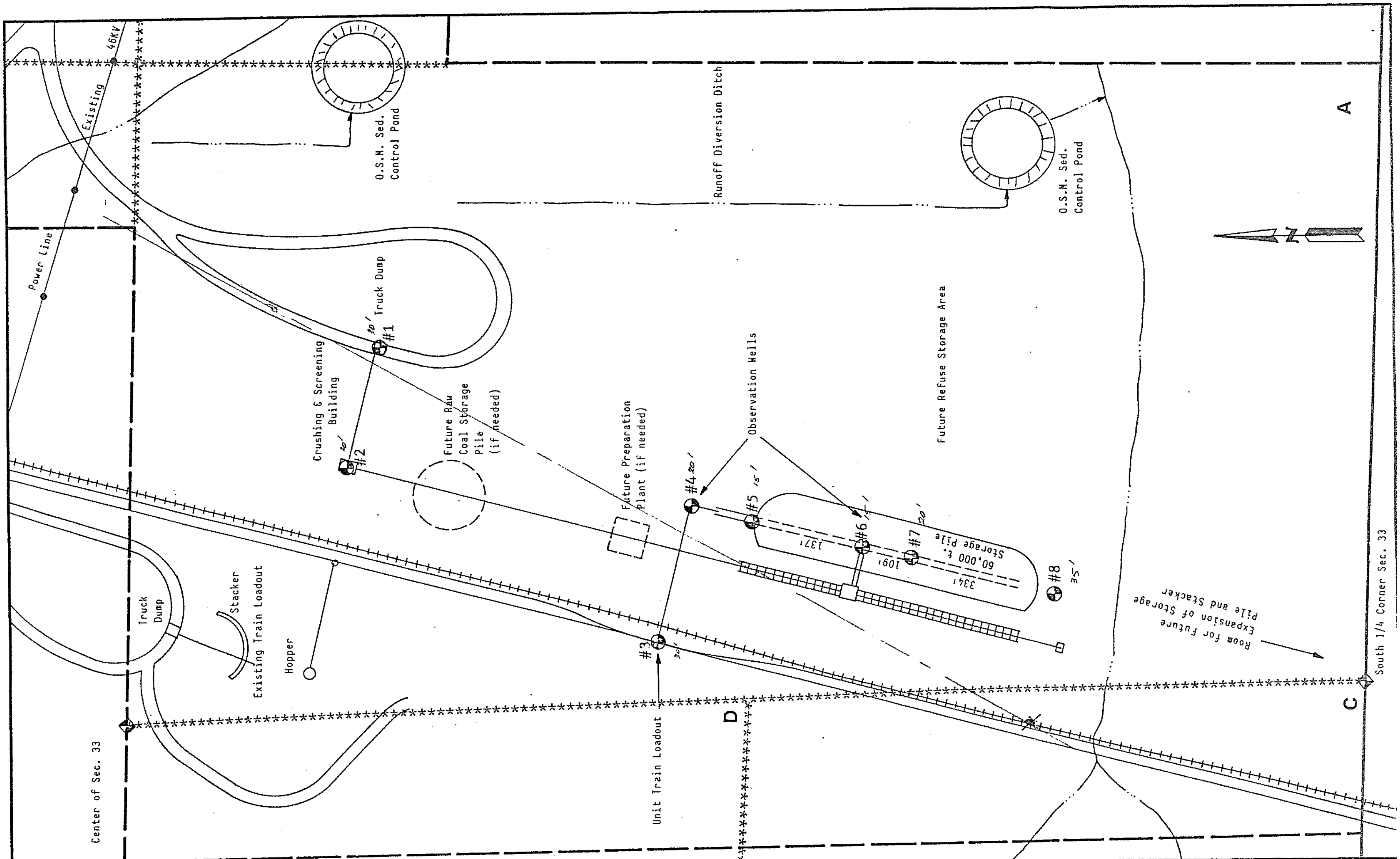
ROLLINS, BROWN AND GUNNELL, INC.

Ralph Hollins

Ralph L. Rollins

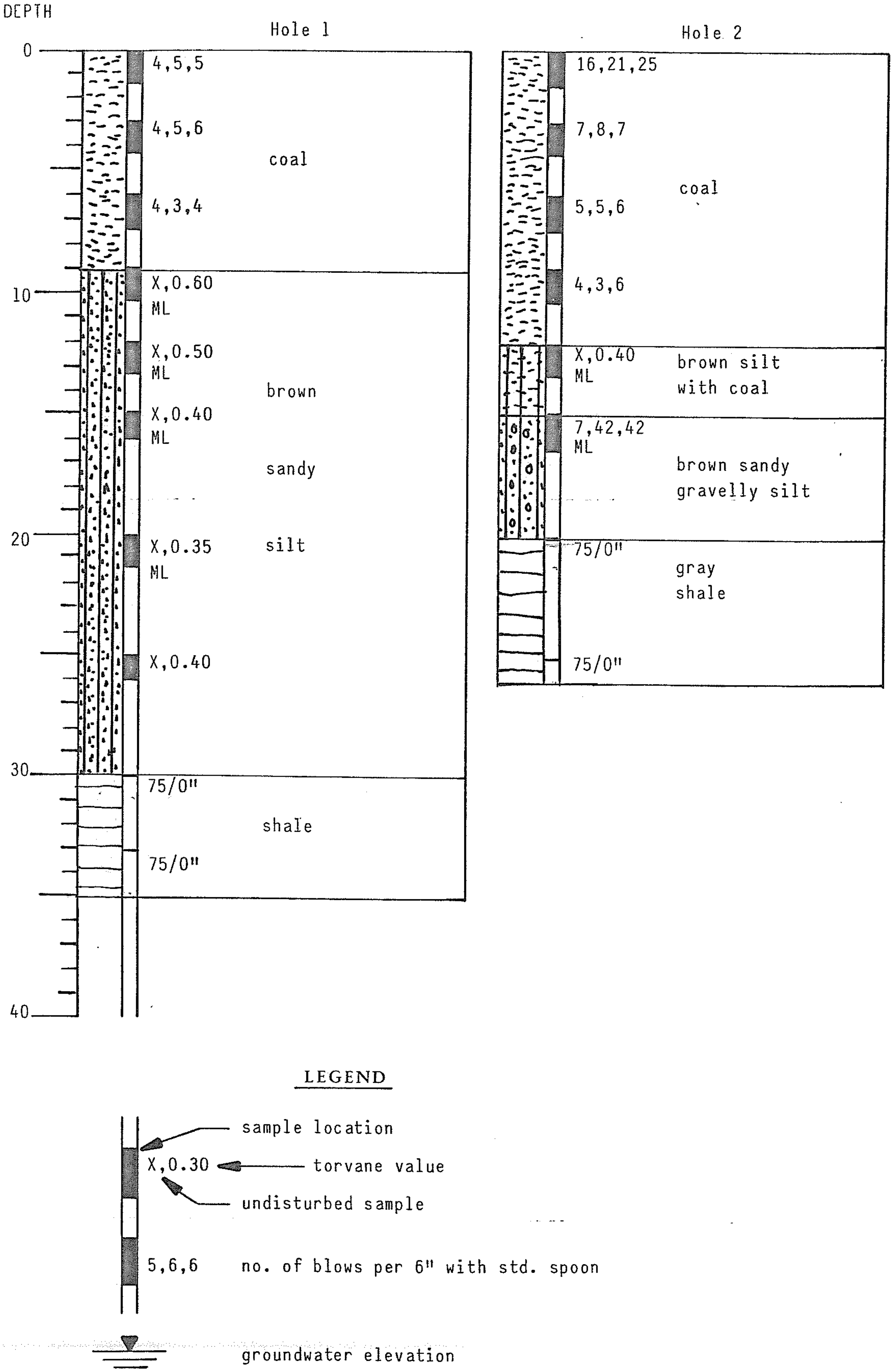
lw

enc.



SCALE ______ DESIGNED ______ CHECKED ______ DRAWN ______ DATE ______ APPROVED ______ LICENSE NO. ______	**ROLLINS, BROWN & GUNNELL, Inc.** CONSULTING ENGINEERS	LOCATION OF TEST HOLES TOWER RESOURCES COAL HANDLING FACILITIES	FIGURE NO. 1

Bruning "500"



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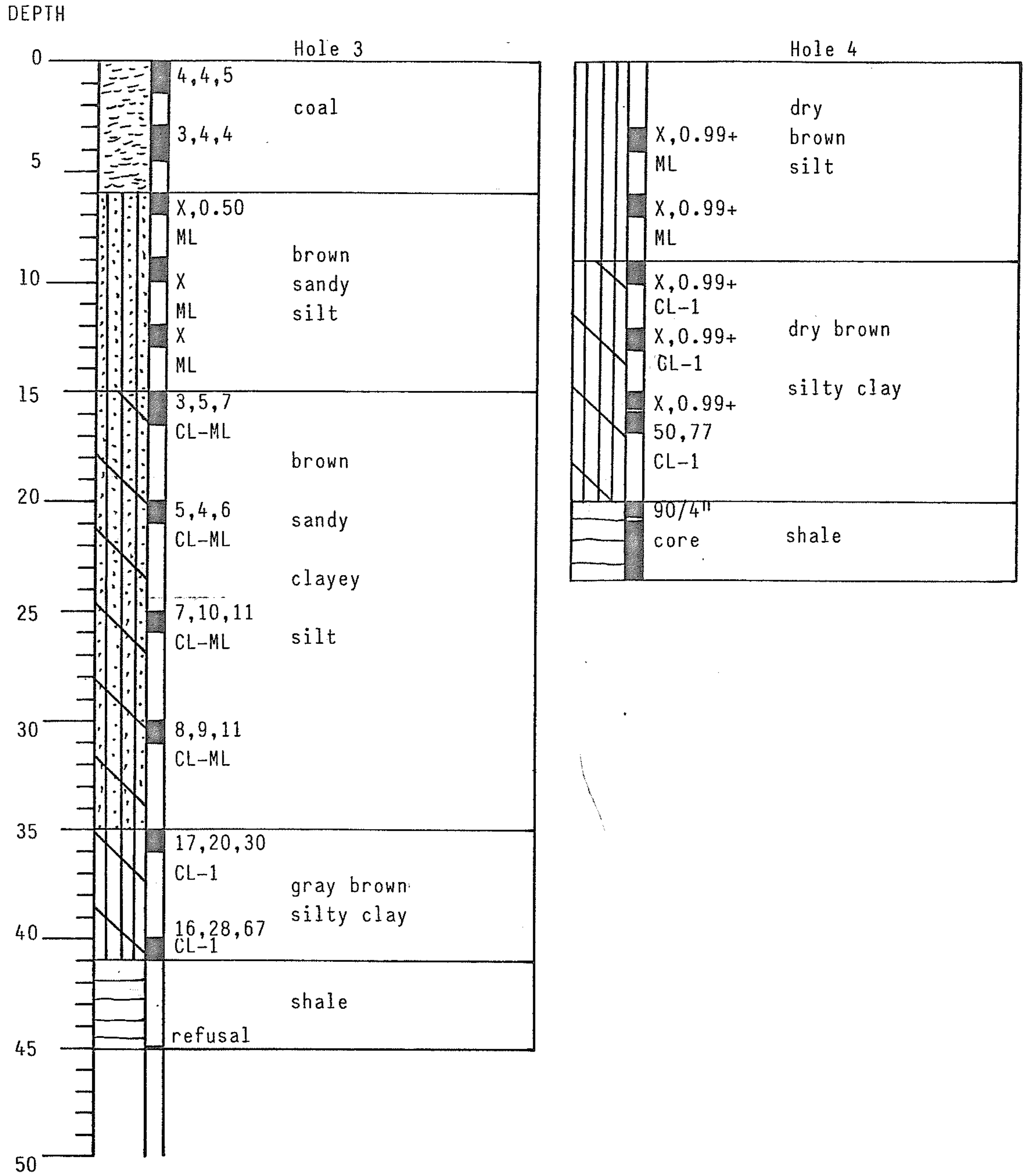
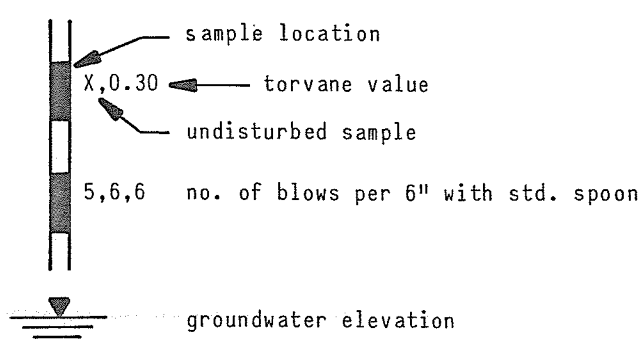
Log of Borings for:
Tower Resources

Figure No. 2



LEGEND



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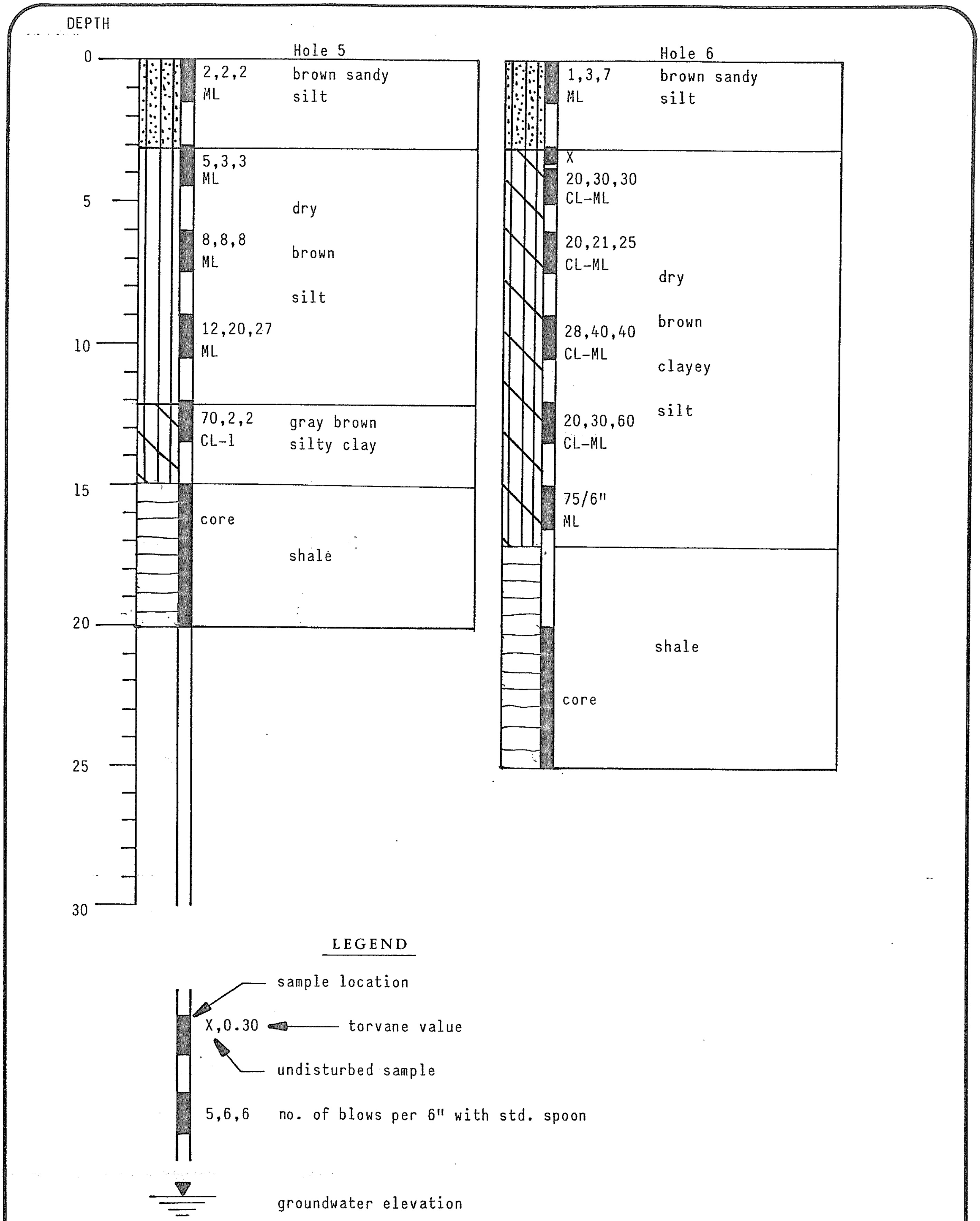
Log of Borings for:

Tower Resources

Figure No. 3



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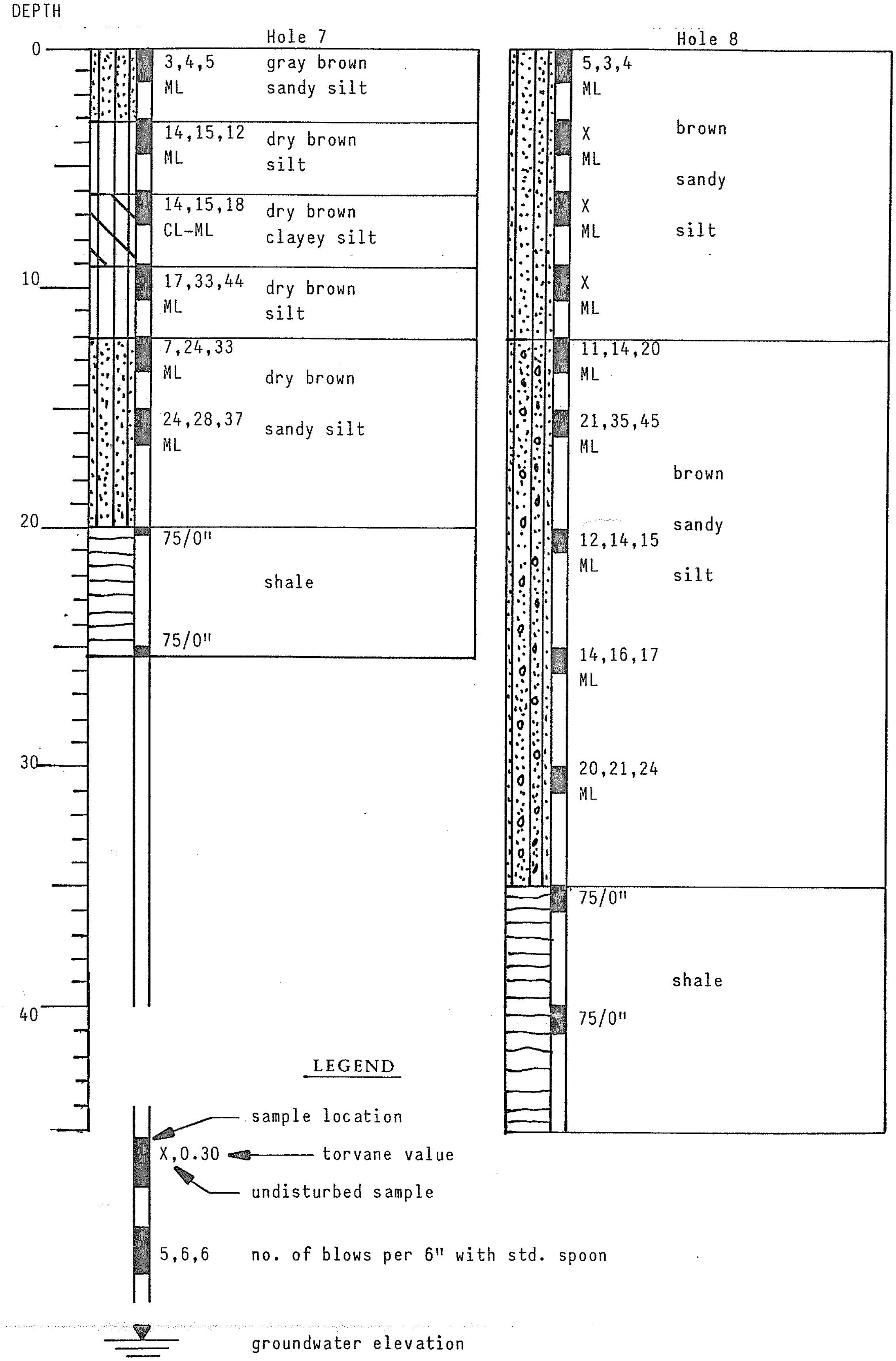
Log of Borings for:
Tower Resources

Figure No. 4



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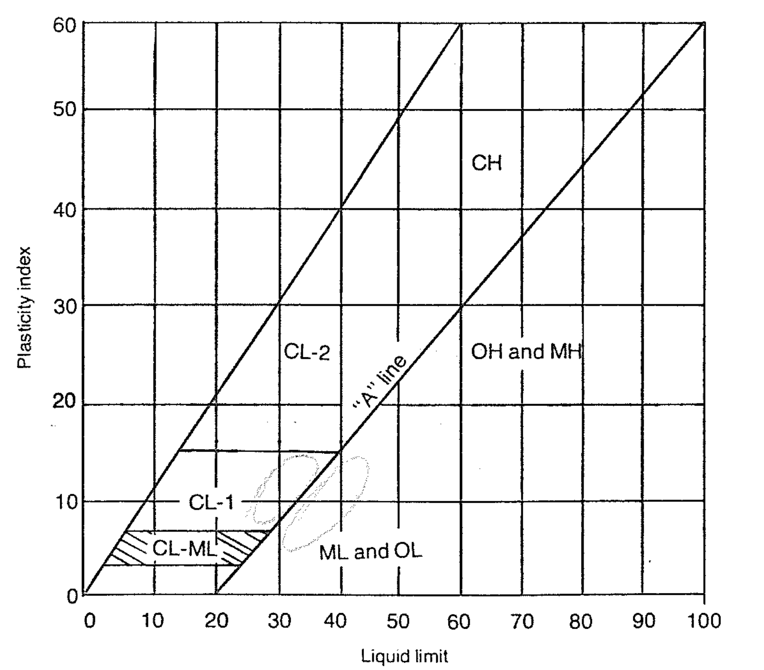
Log of Borings for:
Tower Resources

Figure No. 5

Figure No. 6

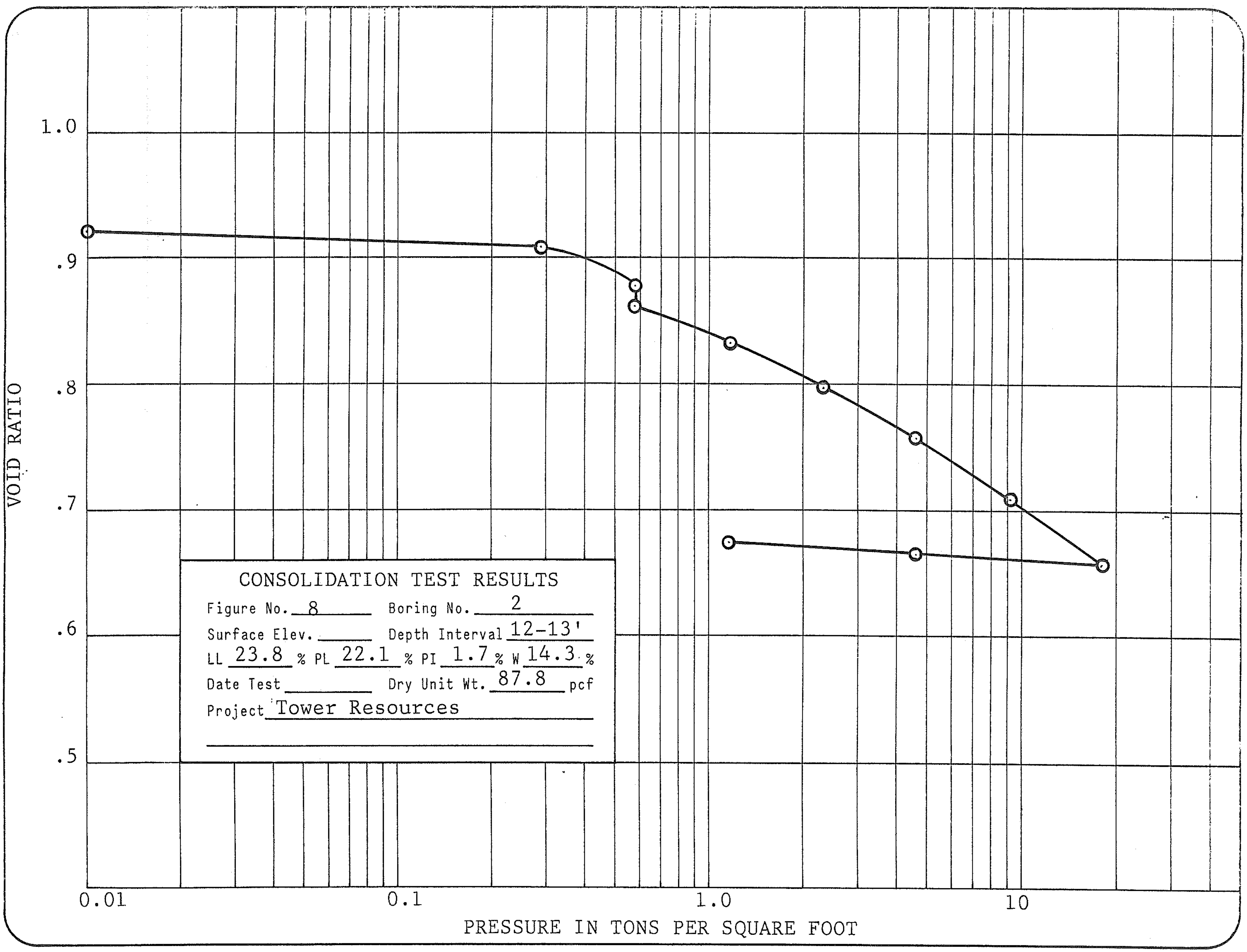
Unified Soil Classification System

Major divisions			Group symbols	Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent .... GW, GP, SW, SP; More than 12 percent .... GM, GC, SM, SC; 5 to 12 percent .... Borderline cases requiring dual symbols**	$Cu = \frac{D_{60}}{D_{10}}$ greater than 4, $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM* d/u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$Cu = \frac{D_{60}}{D_{10}}$ greater than 6, $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM* d/u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual sysbols.
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. less than 7	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL 1/2	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
Highly organic soils			Pt	Peat and other highly organic soils			

Plasticity Chart

*Division of GM and SM groups into subdivisions of d and u for roads and airfields only. Subdivision is based on Atterberg limits, suffix d used when L. L. is 28 or less and the P.I. is 6 or less, the suffix u used when L. L. is greater than 28.

** Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.



CONSOLIDATION TEST RESULTS

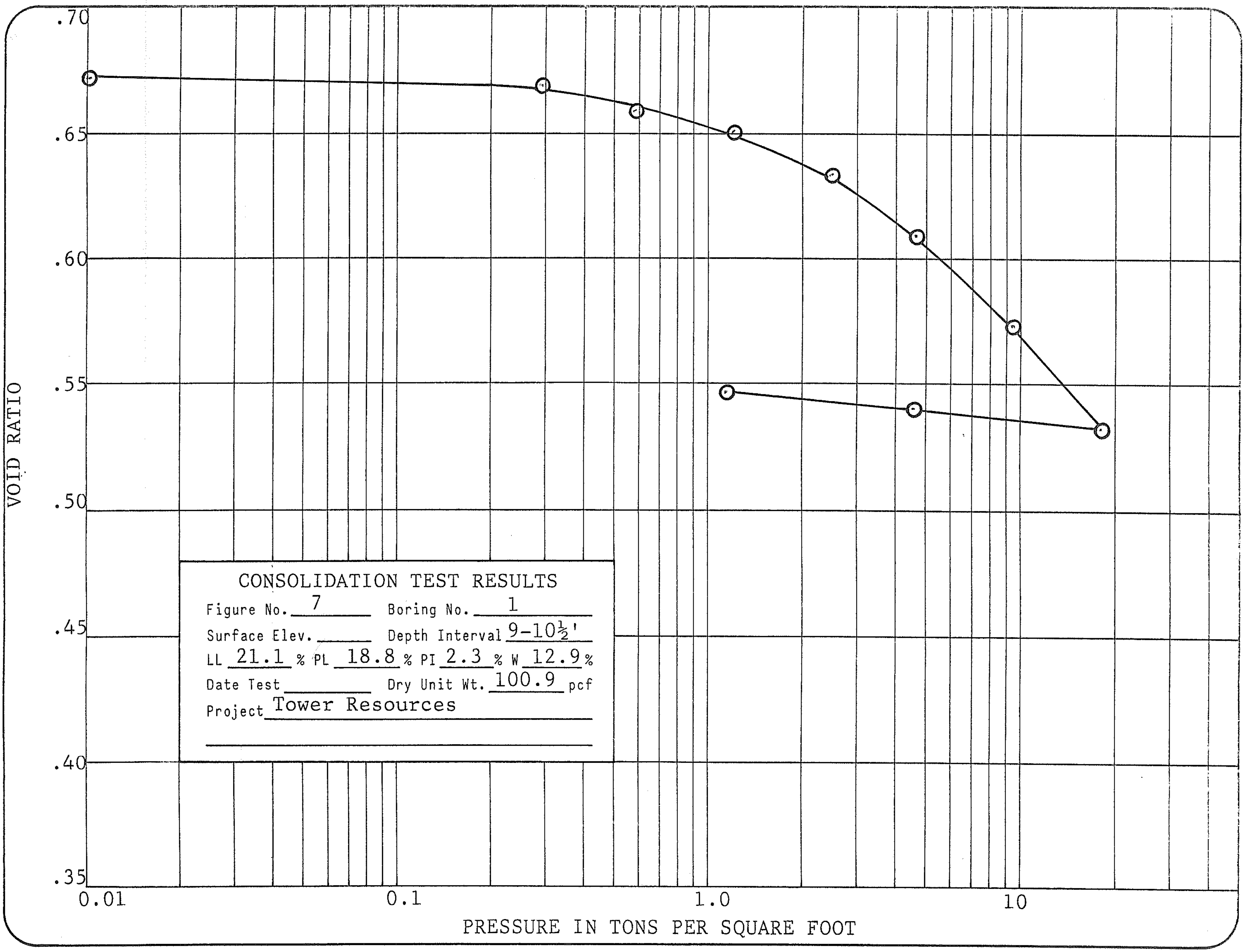
Figure No. 8 Boring No. 2

Surface Elev. ______ Depth Interval 12-13'

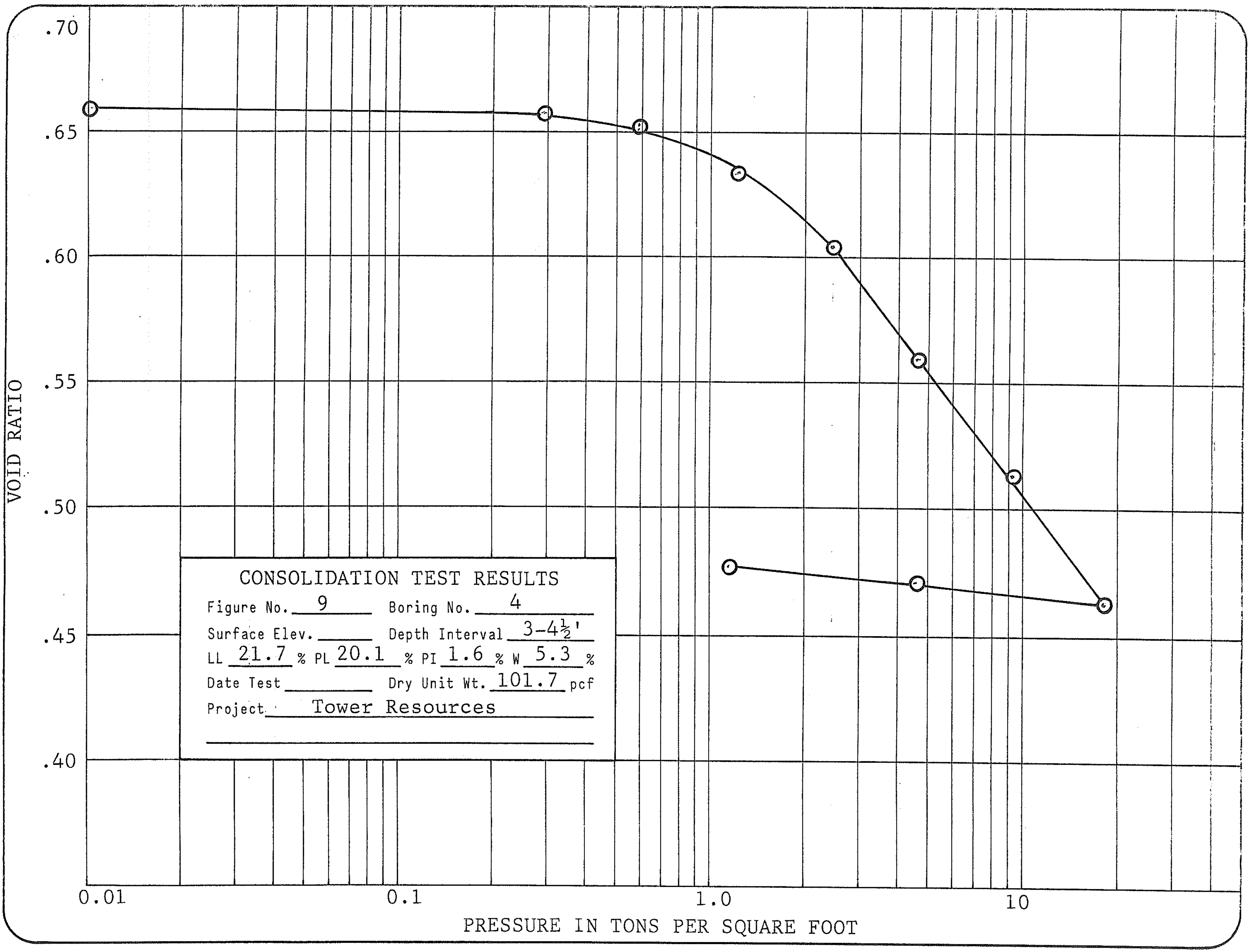
LL 23.8 % PL 22.1 % PI 1.7 % W 14.3 %

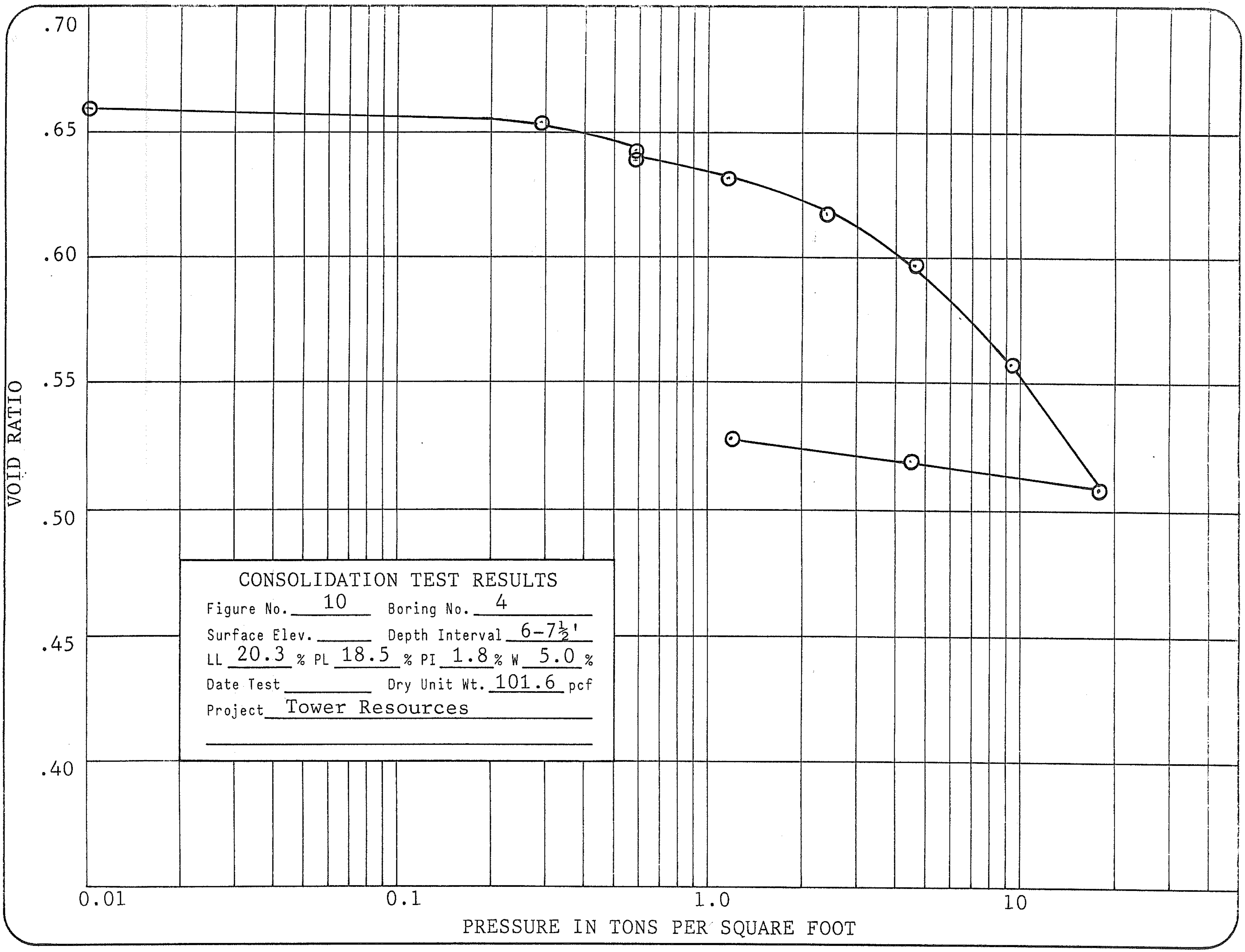
Date Test ______ Dry Unit Wt. 87.8 pcf

Project Tower Resources

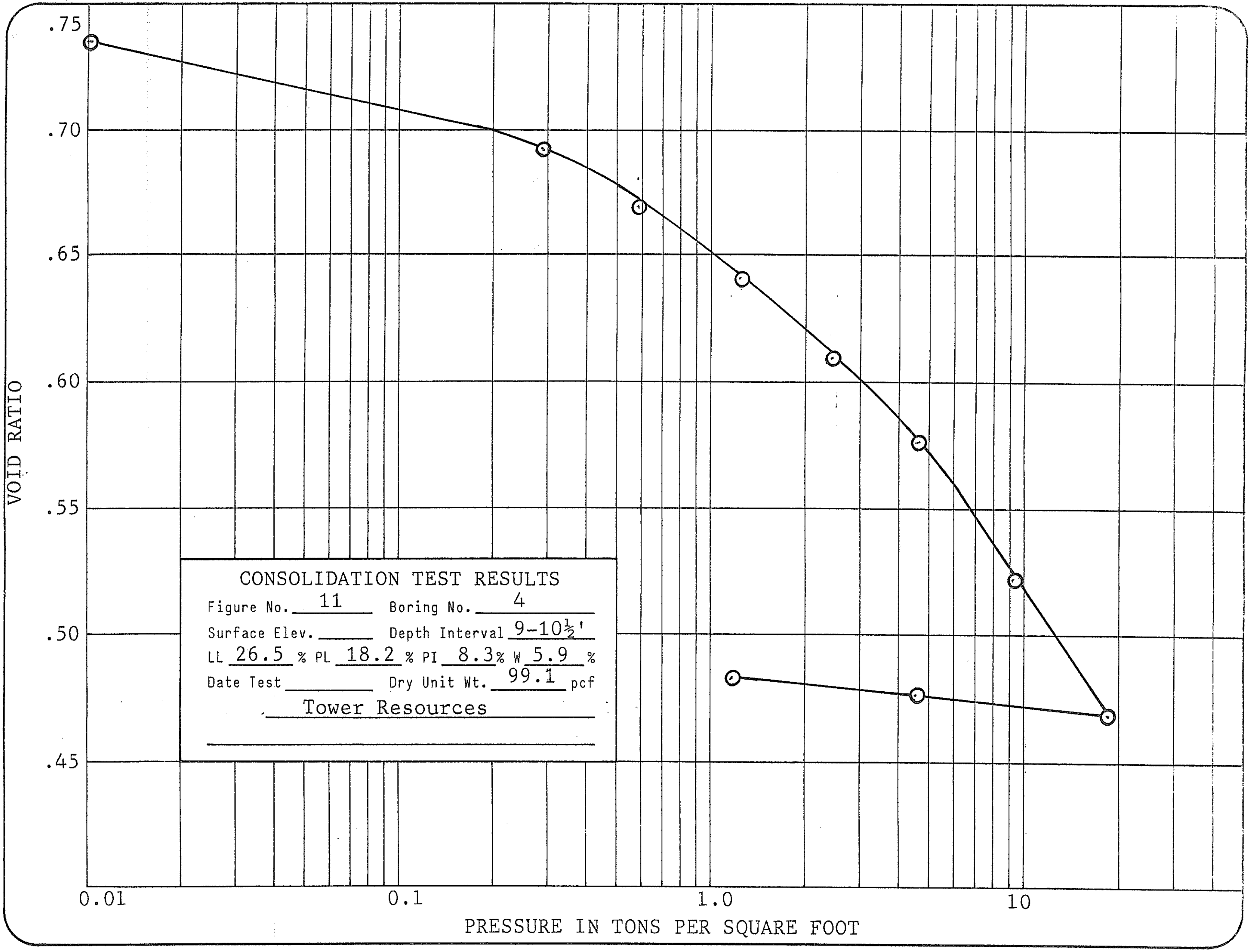


.70
.65
.60
.55
.50
.45
.40
.35
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 7
Boring No. 1
Surface Elev.
Depth Interval 9-10½'
LL 21.1 % PL 18.8 % PI 2.3 % W 12.9 %
Date Test
Dry Unit Wt. 100.9 pcf
Project Tower Resources

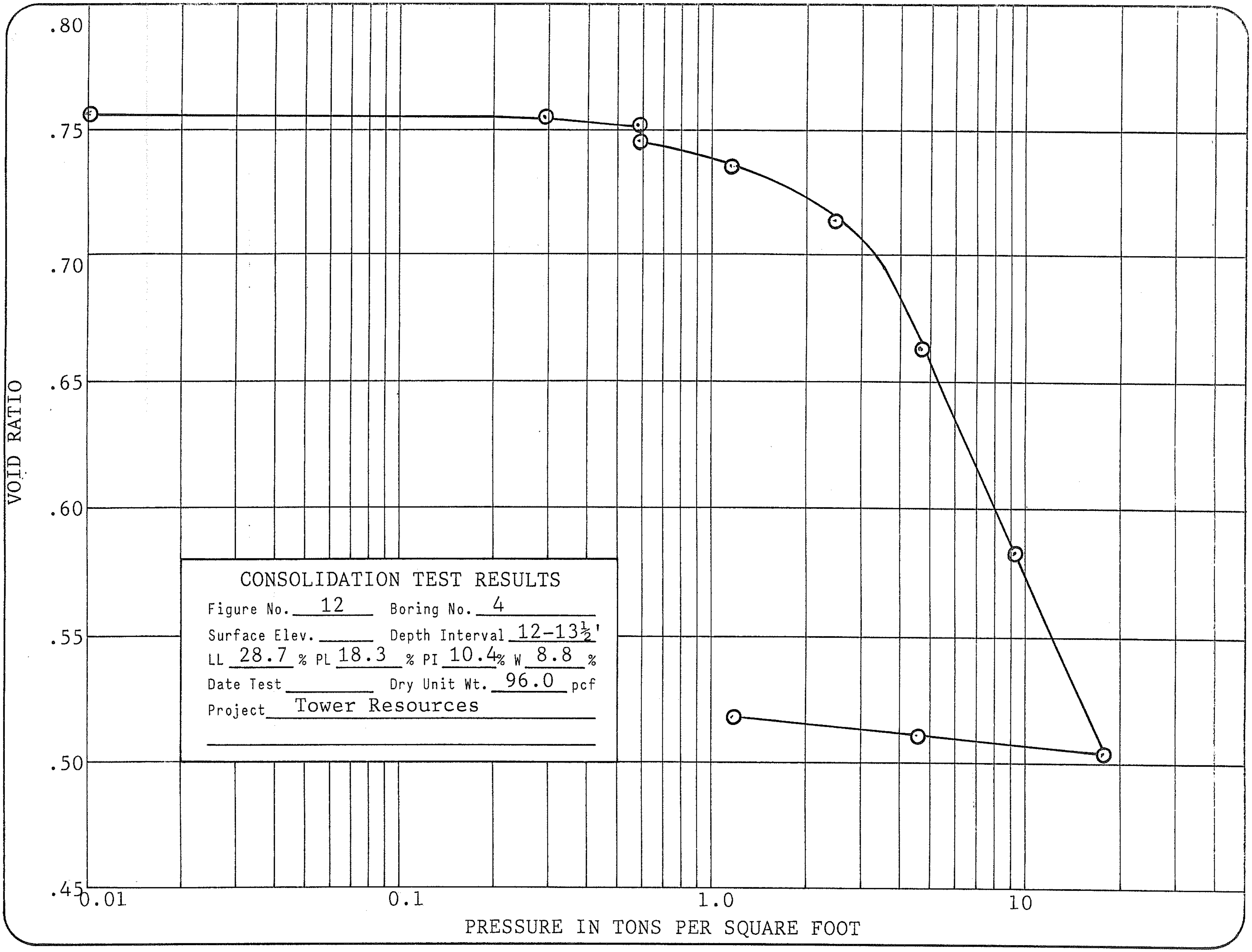

VOID RATIO
.70
.65
.60
.55
.50
.45
.40
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 9 Boring No. 4
Surface Elev. ___ Depth Interval 3-4½'
LL 21.7 % PL 20.1 % PI 1.6 % W 5.3 %
Date Test ___ Dry Unit Wt. 101.7 pcf
Project Tower Resources



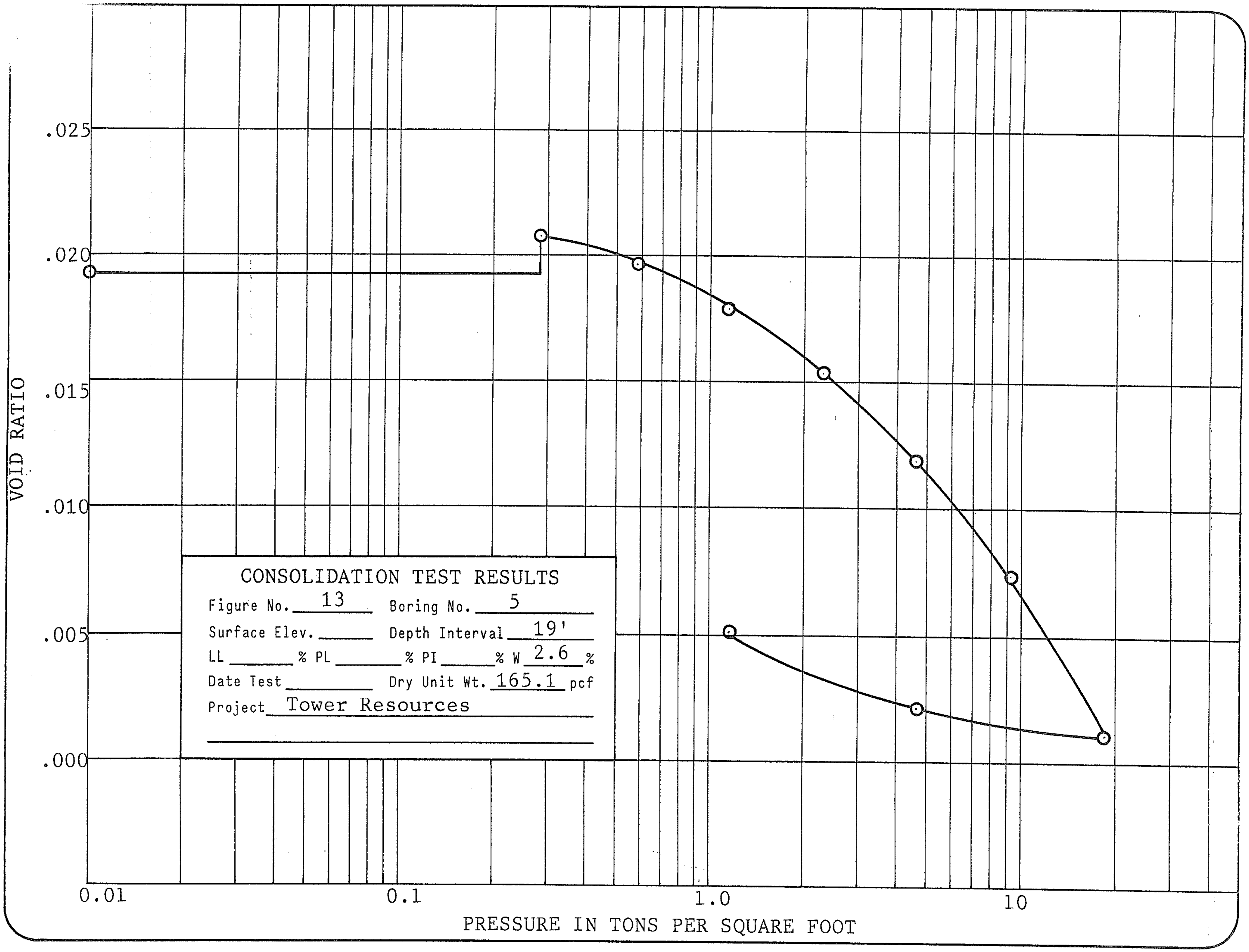
.70
.65
.60
.55
.50
.45
.40
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 10 Boring No. 4
Surface Elev. ____ Depth Interval 6-7½'
LL 20.3 % PL 18.5 % PI 1.8 % W 5.0 %
Date Test ____ Dry Unit Wt. 101.6 pcf
Project Tower Resources

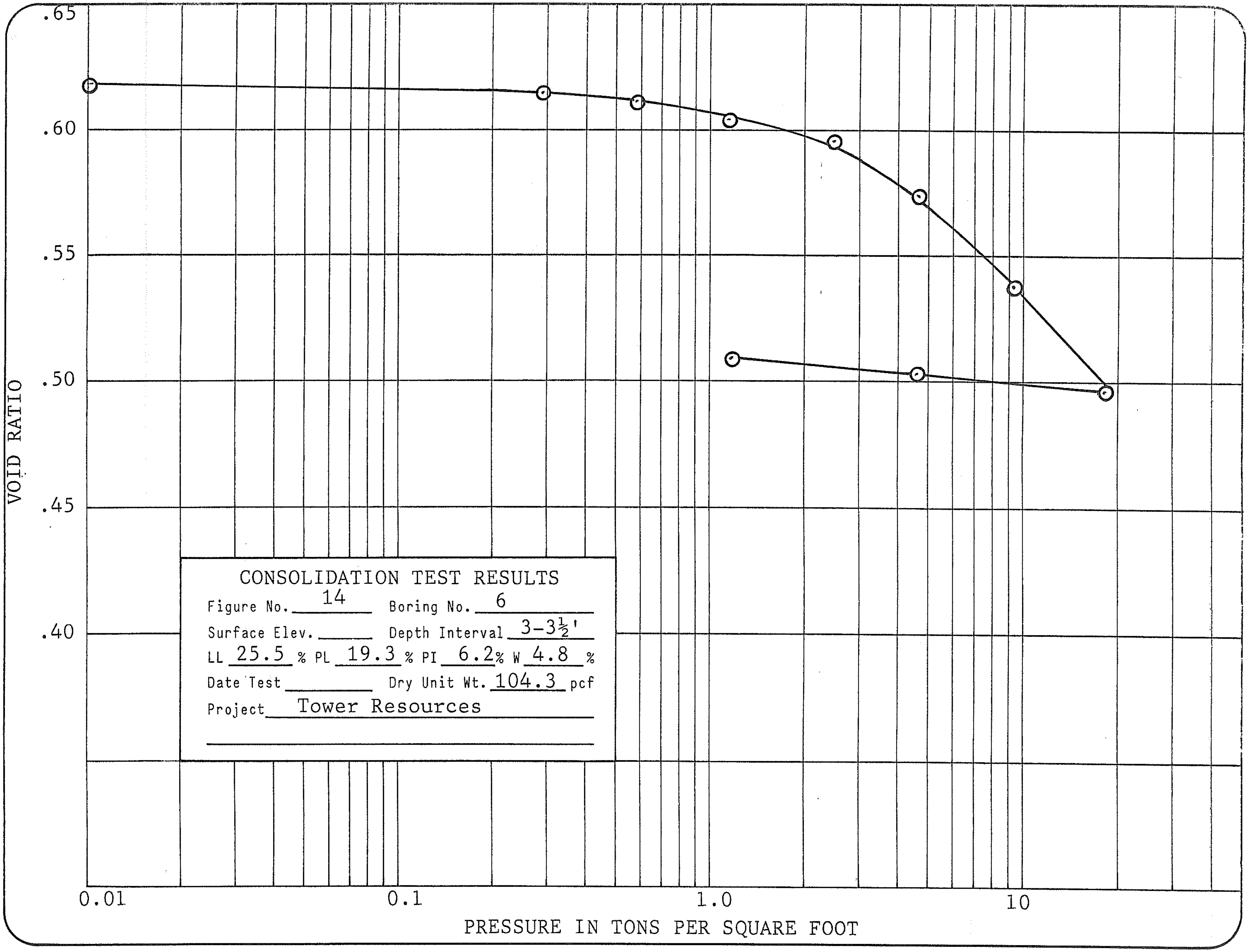


.75
.70
.65
.60
.55
.50
.45
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 11 Boring No. 4
Surface Elev. Depth Interval 9-10½'
LL 26.5 % PL 18.2 % PI 8.3% W 5.9 %
Date Test Dry Unit Wt. 99.1 pcf
Tower Resources

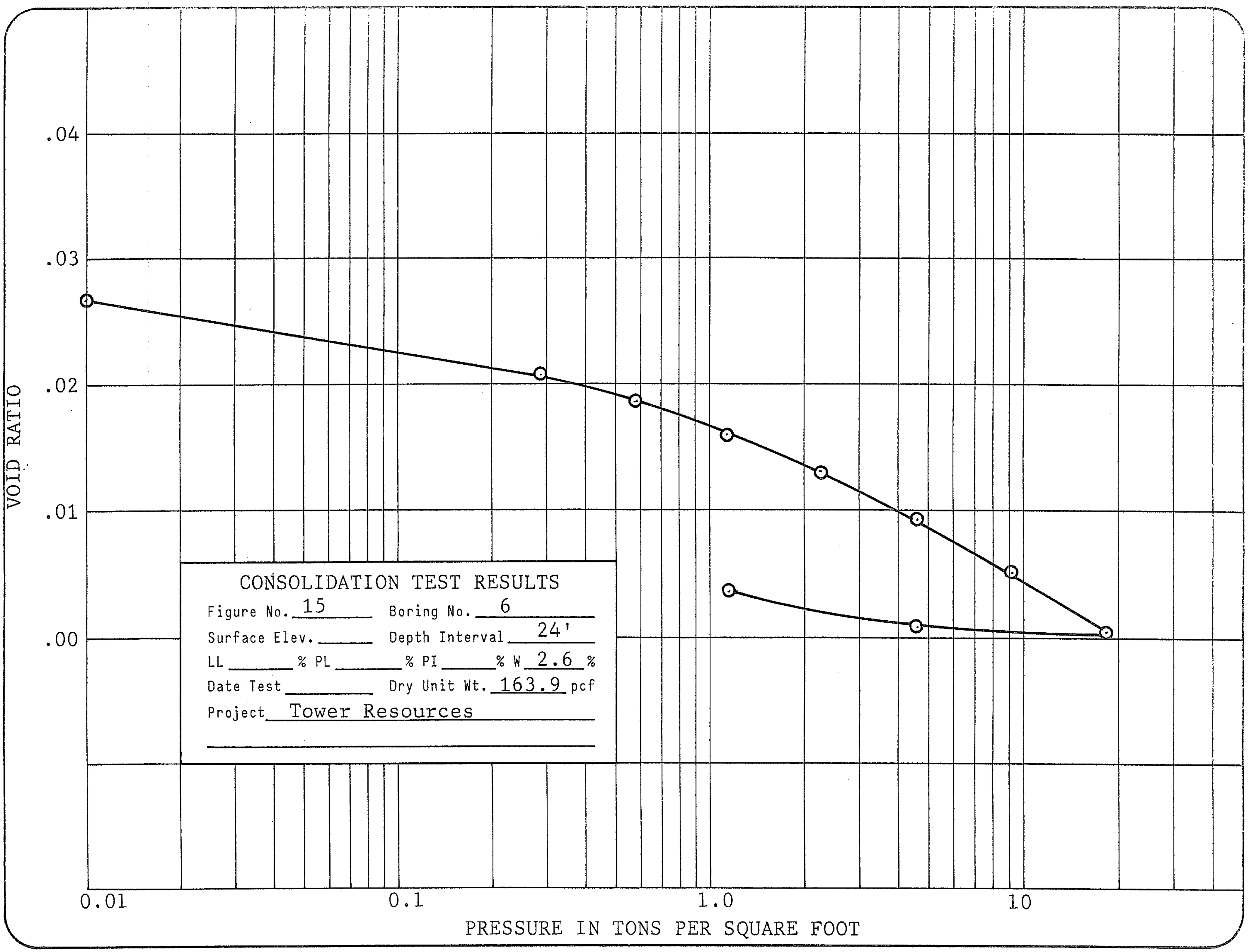


.80
.75
.70
.65
.60
.55
.50
.45
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 12 Boring No. 4
Surface Elev. ____ Depth Interval 12-13½'
LL 28.7 % PL 18.3 % PI 10.4% W 8.8 %
Date Test ____ Dry Unit Wt. 96.0 pcf
Project Tower Resources

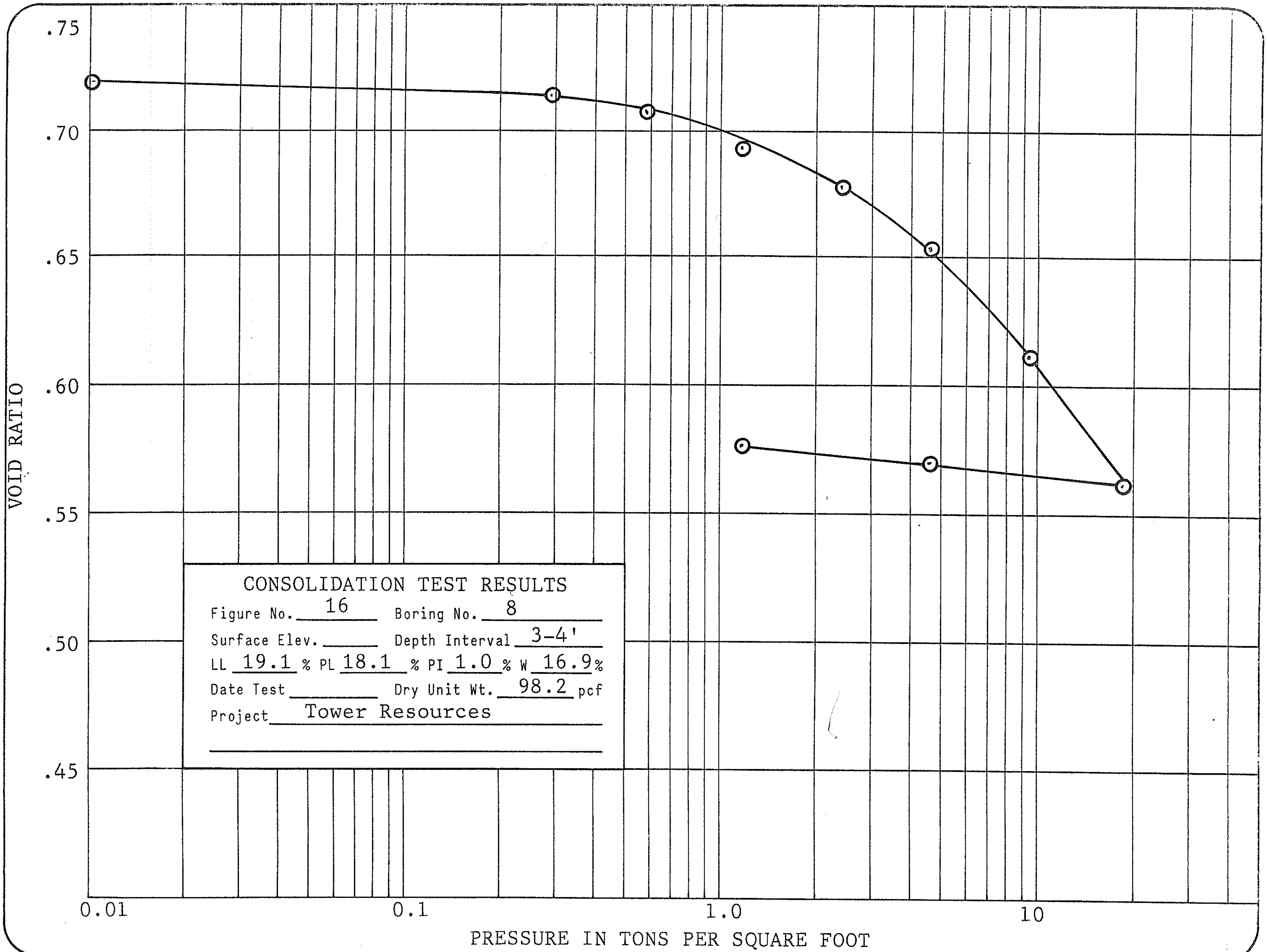

CONSOLIDATION TEST RESULTS
Figure No. 13
Boring No. 5
Surface Elev.
Depth Interval 19'
LL % PL % PI % W 2.6 %
Date Test
Dry Unit Wt. 165.1 pcf
Project Tower Resources
VOID RATIO
.025
.020
.015
.010
.005
.000
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT

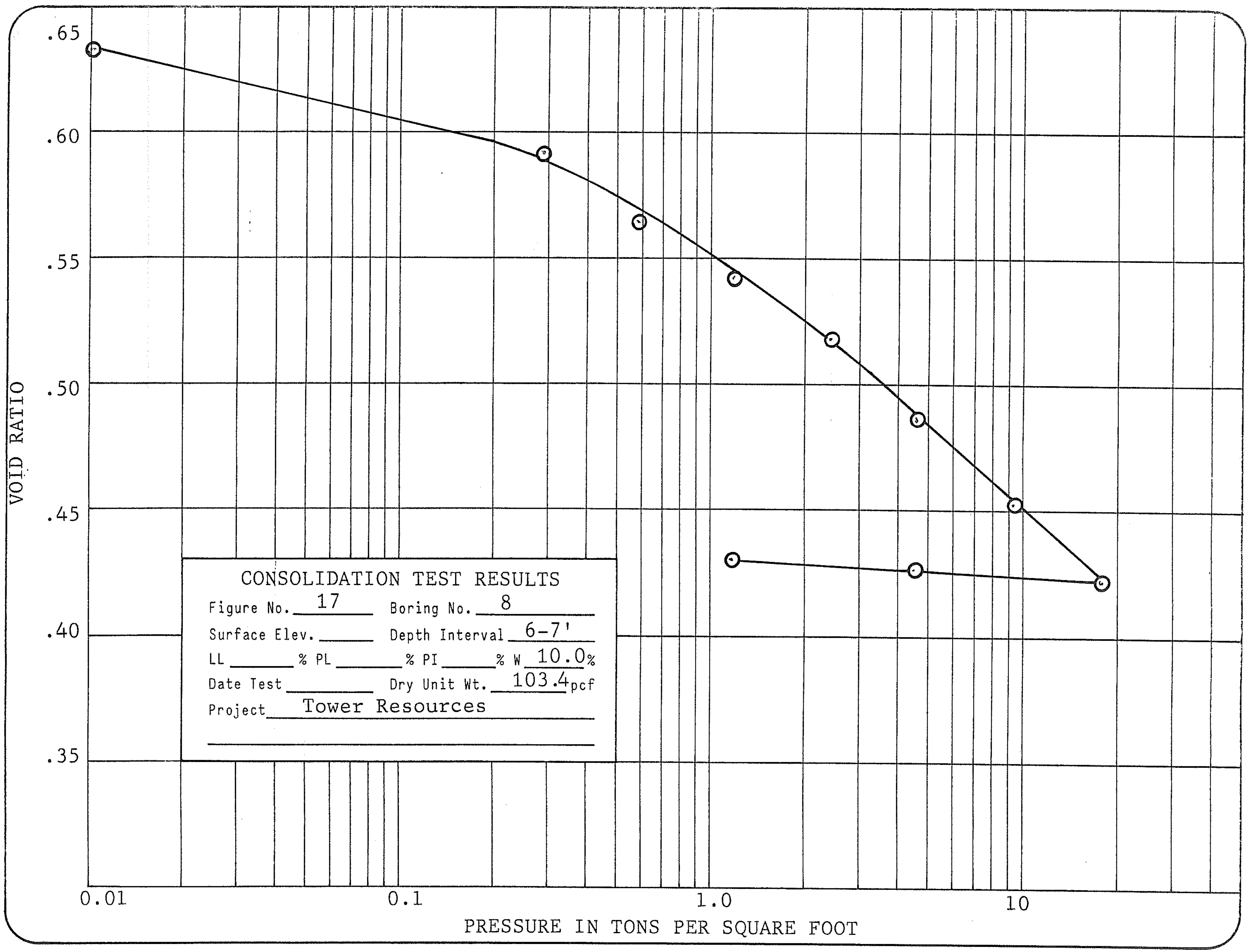


.65
.60
.55
.50
.45
.40
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 14
Boring No. 6
Surface Elev.
Depth Interval 3-3½'
LL 25.5 % PL 19.3 % PI 6.2% W 4.8 %
Date Test
Dry Unit Wt. 104.3 pcf
Project Tower Resources

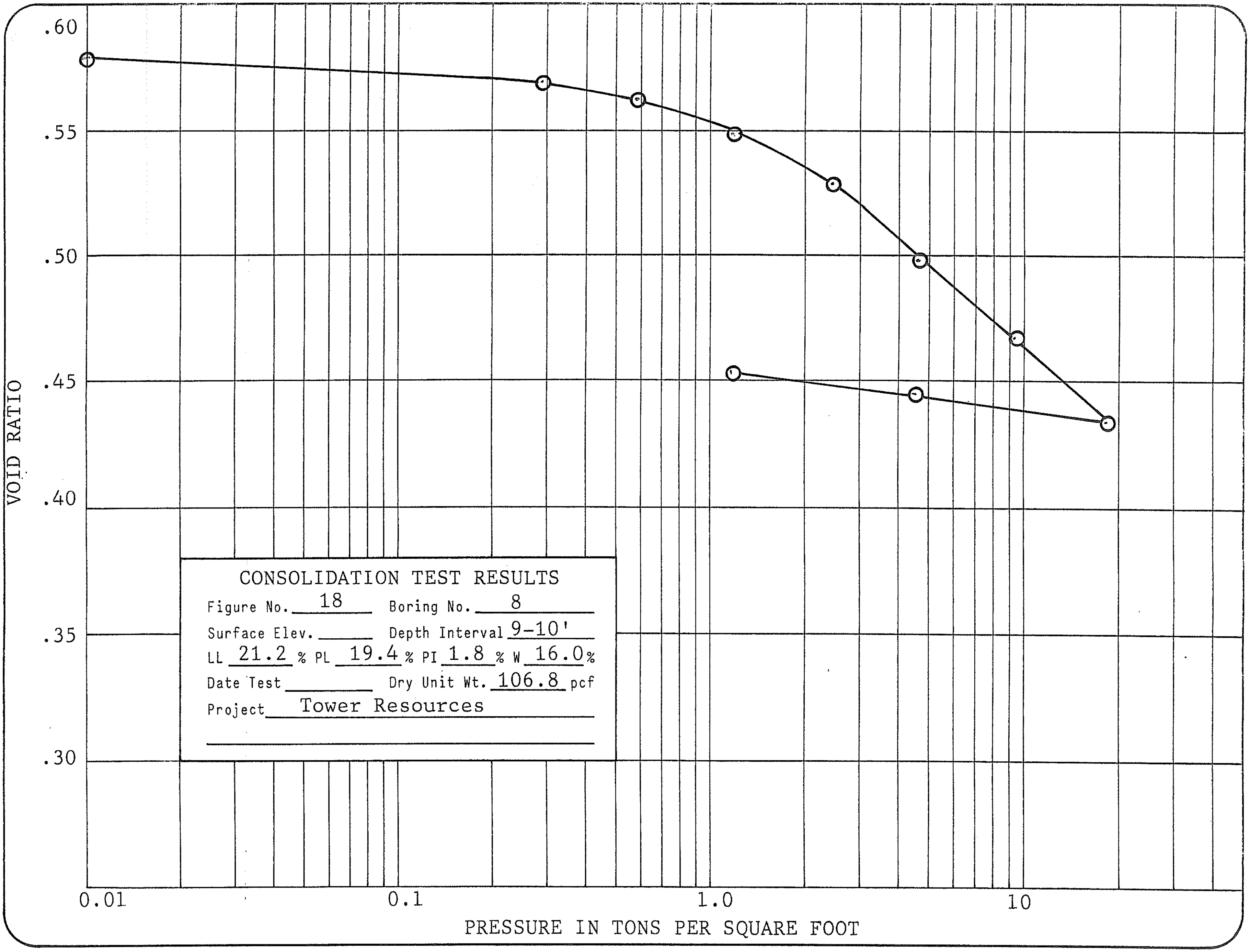


VOID RATIO
.04
.03
.02
.01
.00
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 15
Boring No. 6
Surface Elev.
Depth Interval 24'
LL % PL % PI % W 2.6 %
Date Test
Dry Unit Wt. 163.9 pcf
Project Tower Resources


.75
.70
.65
.60
.55
.50
.45
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 16 Boring No. 8
Surface Elev. ____ Depth Interval 3-4'
LL 19.1 % PL 18.1 % PI 1.0 % W 16.9 %
Date Test ____ Dry Unit Wt. 98.2 pcf
Project Tower Resources



.65
.60
.55
.50
.45
.40
.35
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 17
Boring No. 8
Surface Elev.
Depth Interval 6-7'
LL % PL % PI % W 10.0%
Date Test
Dry Unit Wt. 103.4pcf
Project Tower Resources



.60
.55
.50
.45
.40
.35
.30
VOID RATIO
0.01
0.1
1.0
10
PRESSURE IN TONS PER SQUARE FOOT
CONSOLIDATION TEST RESULTS
Figure No. 18 Boring No. 8
Surface Elev. Depth Interval 9-10'
LL 21.2 % PL 19.4 % PI 1.8 % W 16.0%
Date Test Dry Unit Wt. 106.8 pcf
Project Tower Resources

TABLE NO. 1 SUMMARY OF TEST DATA

PROJECT Tower Resources FEATURE Foundations LOCATION Helper, Utah

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT^2	FRICTION ANGLE ϕ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM
			UNIT WEIGHT LB/FT^3	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
1	9-10½'	shelby	100.9	12.9				21.1	18.8	2.3				ML
	12-13'	shelby						NON-PLASTIC			4.7	39.6	55.7	ML
	15-16'	shelby						21.3	19.8	1.5				ML
	20-21'	shelby						20.9	16.7	3.3				ML
	25-26'	shelby						20.2	19.0	1.2				ML
2	12-13'	shelby	87.8	14.3				23.8	22.1	1.7				ML
4	3-4½'	shelby	101.7	5.3				21.7	20.1	1.6				ML
	6-7½'	shelby	101.6	5.0				20.3	18.5	1.8				ML
	9-10'	shelby	99.1	5.9				26.5	18.2	8.3				CL-1
	12-13'	shelby	96.0	8.8				28.7	18.3	10.4				CL-1
	15-15½'	shelby						32.6	19.1	13.5				CL-1
5	19'	core	165.1	2.6										
6	3-3½'	shelby	104.3	4.8				25.5	19.3	6.2				CL-ML
	6-7½'	46	100.7	10.1				23.9	19.9	4.0				CL-ML

TABLE NO. 1 SUMMARY OF TEST DATA

PROJECT Tower Resources FEATURE Foundations LOCATION Helper, Utah

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT^2	FRICTION ANGLE ϕ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM
			UNIT WEIGHT LB/FT^3	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
6	9-10½'	80						27.0	20.1	6.9				CL-ML
	12-13½'	90	108.3	14.5				21.9	17.8	4.1				CL-ML
	24'	core	163.9	2.6										
8	3-4'	shelby	98.2	16.9				19.1	18.1	1.0				ML
	6-7'	shelby	103.4	10.0				NON-PLASTIC			6.0	38.4	55.6	ML
	9-10'	shelby	106.8	16.0				21.2	19.4	1.8				ML

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

December 31, 1981

Received
JAN 04 1982
Tower Resources Inc.

Tower Resources, Inc.
P.O. Box 1027
Price, UT 84501

ATTN: Mike Glasson

Gentlemen:

In accordance with your request, we have examined the depth of topsoil in the area where the proposed coal handling facilities will be located near Helper, Utah. The soil profile in this area is poorly developed and the depth of the topsoil is very thin. The depth of topsoil has been determined for Test Holes 1 through 8, as shown on the attached figure.

The approximate depth of the topsoil for Test Holes 4 through 8 are tabulated below as follows:

Hole No.	Depth of Topsoil (Inches)
4	4
5	3
6	3
7	3
8	3

Refuse from a coal washing operation has been deposited in the area where Test Holes 1 and 2 are located, and no topsoil exists in this area. Test Hole 3 is located along the tracks where coal has been deposited for shipping purposes during past periods of time. Approximately 2 feet of fine coal exists in this area, and no topsoil is in evidence.

The topsoil in the vicinity of Test Holes 4 through 8 is generally a silty sand to sandy silt.

1435 WEST 820 NORTH, P. O. BOX 711, PROVO, UTAH 84603 TELEPHONE 374-5771

We anticipate moving into the area to complete the foundation investigation for the drill holes during the middle of next week. Please advise us if we can be further assistance to you on this project.

Yours truly,

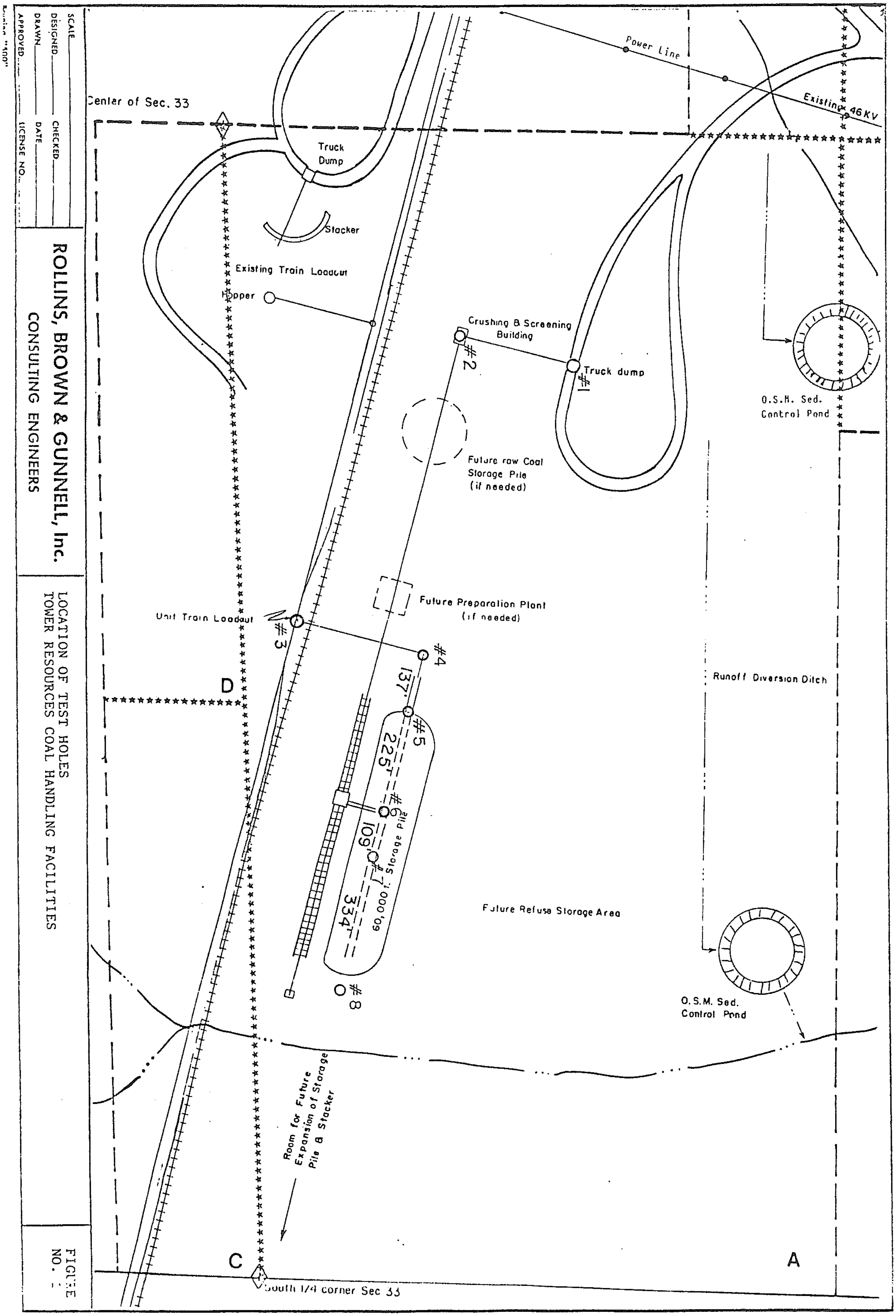
ROLLINS, BROWN AND GUNNELL, INC.

Ralph L. Rollins

Ralph L. Rollins

lw

enc.


ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS
LOCATION OF TEST HOLES
TOWER RESOURCES COAL HANDLING FACILITIES
FIGURE NO. 1
SCALE
DESIGNED
CHECKED
DRAWN
DATE
APPROVED
LICENSE NO.
Center of Sec. 33
Power Line
Existing 46 KV
Truck Dump
Stacker
Existing Train Loadout
Hopper
Crushing & Screening Building
#2
Truck dump
#1
Future raw Coal Storage Pile (if needed)
O.S.M. Sed. Control Pond
Future Preparation Plant (if needed)
Unit Train Loadout
#3
#4
137
#5
225
#6
109
#7
334
60,000 T Storage Pile
#8
D
Runoff Diversion Ditch
Future Refuse Storage Area
O.S.M. Sed. Control Pond
Room for Future Expansion of Storage Pile & Stacker
C
A
South 1/4 corner Sec 33