HARD HAT SERVICES™
Engineering, Construction and Management Solutions

932 N. Wright Street, Suite 160, Naperville, IL 60563
Phone (877) 630-7428
www.hardhatinc.com

VIA EMAIL

October 5, 2020

Mr. Jeffrey Maxted
Alliant Energy – Environmental Services Manager
4902 North Biltmore Lane
Madison, WI 53718-2148

Re: Unstable Areas Determination CCR Surface Impoundments - §257.64
Interstate Power and Light Company (IPL)
Ottumwa Generating Station
Ottumwa, Iowa

Mr. Jeffrey Maxted,

This Unstable Areas Determination has been prepared in accordance with the requirements of the United States Environmental Protection Agency (USEPA) published Final Rule for Hazardous and Solid Waste Management System – Disposal of Coal Combustion Residual (CCR) from Electric Utilities (40 CFR Parts 257 and 261, also known as the CCR Rule) published on April 17, 2015 (effective October 19, 2015) and subsequent amendments. This letter assesses the factors of both CCR units at Interstate Power and Light Company (IPL), Ottumwa Generating Station (OGS) in Ottumwa, Iowa in accordance with the CCR Rule §257.64 Unstable Areas. For purposes of this Report, "CCR unit" refers to an existing or inactive CCR surface impoundment.

Background Information

In accordance with the requirements set forth in §257.64 of the CCR Rule a CCR unit must not be located in an unstable area. The owner or operator must consider all the following factors:

- On-site or local soil conditions that may result in significant differential settling,
- On-site or local geologic or geomorphologic features; and,
- On-site or local human-made features or events (both surface and subsurface).

Facility Specific Information

The OGS is located at 20775 Power Plant Road, Ottumwa, IA 52501. Figure 1 provides both a topographic map and an aerial of the OGS facility location, with the approximate property boundary of the facility identified. Figure 2 identifies each CCR Unit. OGS has one existing and one inactive CCR surface impoundment, which are identified as follows:

- OGS Ash Pond (existing)
- OGS Zero Liquid Discharge Pond (inactive)

Differential Settling

The embankment soils at OGS were documented by SCS Engineers[1] boring logs MW-304 and MW-305, Figure 2. The results indicate that the embankments of both impoundments are constructed of stiff compacted clay from the site overlying the medium stiff native clay which overlies very dense sand of the Des Moines River. The boring logs are shown in Exhibit A.

During the design phase, before the plant was constructed, a 1974 subsurface investigation was completed which included borings and testing of the native soils. These borings showed that the native clay was sampled and tested for Atterberg limits, unconfined compressive strength and both consolidated undrained (CU) and unconsolidated undrain (UU) triaxial strength. The test results are shown in Exhibit B and indicated that the native clay under the embankments is a low plasticity clay (CL) with unconfined compression values from 1,500 to 2,500 psf. Triaxial UU tests indicated a range of 750 to 2,000 psf for cohesion and the CU tests indicated 29˚ to 34˚ for friction angle and 0 to 600 psf cohesion. The CU test results imply the clay is normally consolidated.

Information on the compacted clay and river valley sand is available from the SCS soil boring standard split spoon (SPT) blowcount information, Exhibit A. The Terzaghi and Peck relationship of SPT blowcount to clay cohesion for the average blowcounts in each clay layer yields a value of cohesion of 1,000 psf for the native clay and 1,600 psf for the embankment clay, Exhibit C. The very dense sand is assigned a friction angle of 38˚, based on the correlation of cohesionless soil strength to density provided in NAVFACs DM-7[2] , Appendix C.

The analysis of slope stability for the CCR embankments was completed with a cohesion value of 1,600 psf for the embankment clay, 1,000 psf for the native clay and a friction angle of 38˚ for the very dense sand. Soil borings show the soil conditions are consistent under the entire area of the two CCR ponds.

Based on the known geotechnical information, both the OGS Ash Pond and the OGS Zero Liquid Discharge Pond are not susceptible to significant differential settlement. Additionally, annual inspections of the embankments for the last 4 years have indicated no observable areas of differential settlement on the embankments.

[1] SCS Engineers, "Ottumwa Generating Station – Monitoring Well Construction Documentation", April 15, 2016
[2] Naval Facilities Engineering Command, Soil Mechanics, Foundations, and Earth Structures, Figure 3-7, NAVFAC DM-7, January 1971

Geologic and Geomorphologic Features

The Bedrock Geologic Map of Iowa (Exhibit D) shows that the site contains up to four types of bedrock including the Lower Cherokee, Raccoon Creek, St. Louis, and Pella formations. The formations are comprised of dolomite, shale, and sandstone. The Bedrock Topography of Southeast Iowa by Robert. E Hansen from 1973 shows that the elevation of the bedrock in the general area of the facility varies between 600 and 650 feet. The 1974 boring logs (Exhibit B) on Section E-E show the bedrock near the CCR impoundments varies between 630 to 655 feet in elevation.

While there are karst formations known to exist in Iowa, they are predominately in the northeast part of the state, see Exhibit E. Additionally, an Iowa Department of Natural Resources map of known and potential karst terrain and/or paleosinks (sinkholes) near OGS has also been included in Exhibit E. This map shows that the OGS is in an area potentially susceptible to karst formations although there are no known paleosinks near the facility.

Several figures and tables have been included in Exhibit F from the OGS Selection of Remedy[3]. This document illustrates that the local groundwater direction is generally east toward the Des Moines River. Additionally, the nested well water elevation data for MW-305 and MW-305A suggests that a downward gradient exists. At this location limestone is located 35 feet below the bottom of the impoundment and the water recharging this area is likely at or above a pH of 7. As result, there is little risk for the formation of paleosinks.

Human-made Features or Events

Based on the information provided herein, both the OGS Ash Pond and the OGS Zero Liquid Discharge Pond are not susceptible to anthropogenic activities that could exist in this area, which could include a large dam failure, failure due to improper cut and fill during construction, excessive drawdown of groundwater, extreme fluctuations in flooding from human-made changes, or failure due to underground mines.

Unstable Areas Determination

After review of the reasonably and readily available documentation, the following CCR Units are not located in unstable areas:

- OGS Ash Pond
- OGS Zero Liquid Discharge Pond

[3] SCS Engineers, "Selection of Remedy", September 11, 2020

Qualified Professional Engineer Certification

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer attesting that the documentation as to whether a CCR unit meets the requirements 40 CFR 257.64(b).

To meet the requirements of 40 CFR 257.64(c), I Mark W. Loerop hereby certify that I am a licensed Professional Engineer in the State of Iowa; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in 40 CFR 257.64.

LICENSED PROFESSIONAL ENGINEER
MARK W. LOEROP
22197
IOWA

By: [signature]

Name: Mark Loerop

Date: October 5, 2020

cc: Tony Morse, Alliant Energy

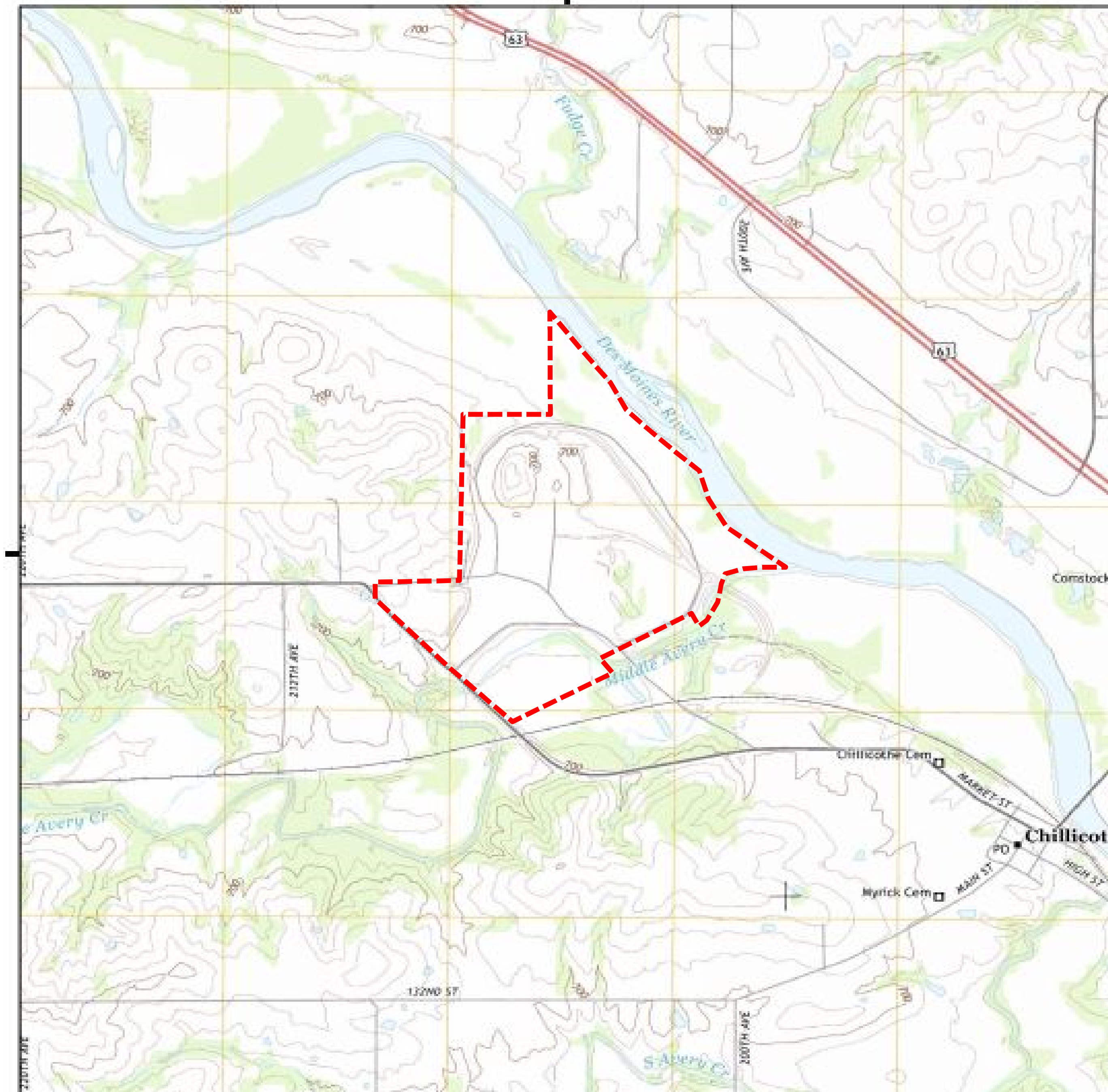
att: Figure 1 – Site Location
Figure 2 – Location of Critical Cross Sections
Exhibit A – 2016 Soil Boring
Exhibit B – 1974 Soil Laboratory Results
Exhibit C – Conversion of Blowcount to Soil Strength
Exhibit D – Bedrock Maps
Exhibit E – Karst Formation Maps
Exhibit F – OGS Local Groundwater Information

MWL/tjh/MWL
Z:\Shared\Projects\154 - Alliant Energy\154.018 - CCR Projects\022 - 2020 OGS & COL Unstable Conditions Determination\001 - OGS UCD\Unstable Area Determination\OGS Unstable Areas - FINAL.doc

FIGURES

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Historical Topo Map 2013



Miles 0.25 0.5 1 1.5

This report includes information from the following map sheet(s).

NW N NE
W E
SW S SE

TP, Chillicothe, 2013, 7.5-minute

SITE NAME: Ottumwa Generating Station
ADDRESS: 20775 Power Plant Road
Ottumwa, IA 52501
CLIENT: Environmental Site Assessors

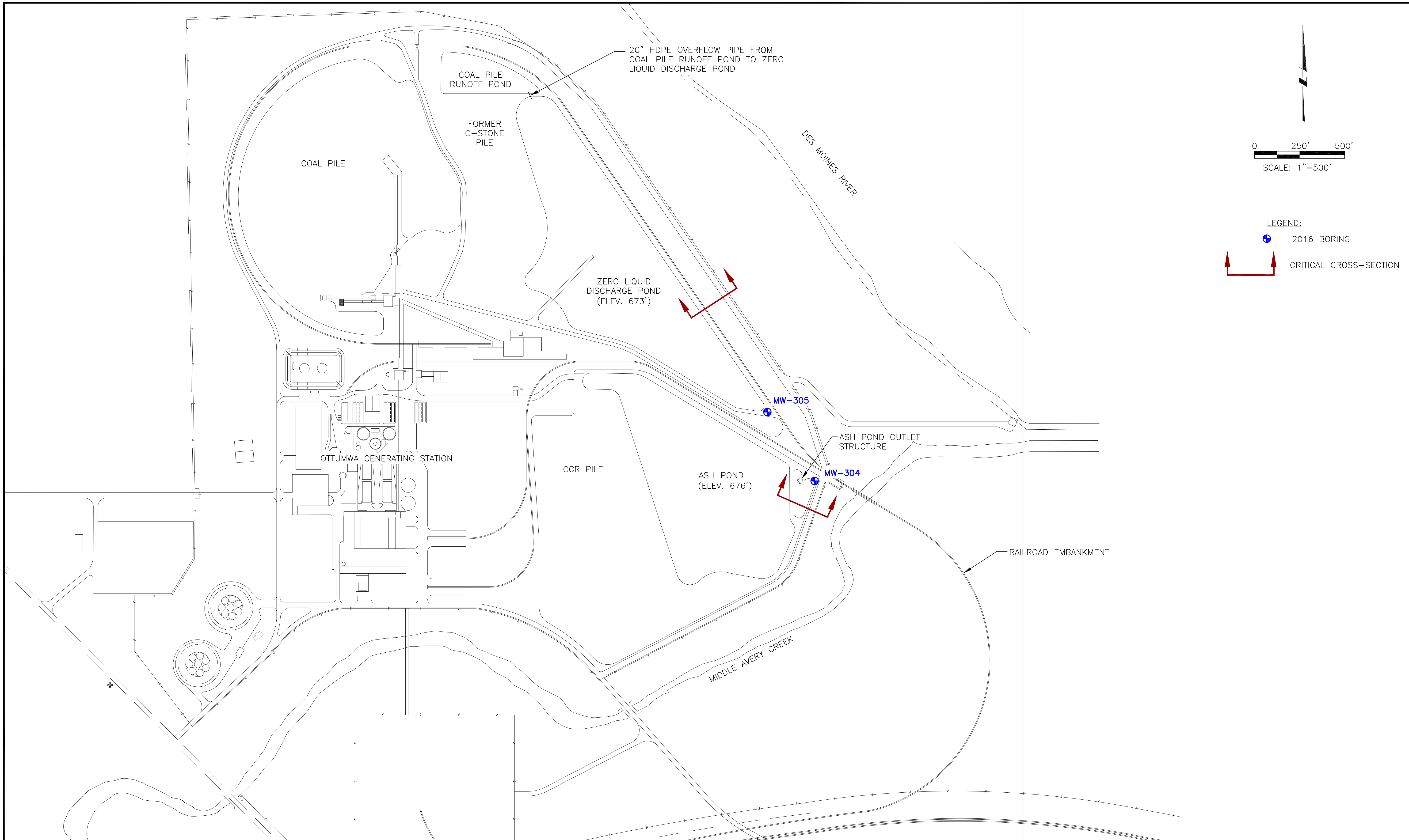
N

4555570 - 5 page 4

Historical Aerial Photo 4/13/2016

Approximate Property Boundary

HARD HAT SERVICES™ Engineering, Construction and Management Solutions	Site Location Ottumwa Generating Station Intersate Power and Light Company	Drawing Figure 1 Date 7/12/2016



REV	DATE	BY	DESCRIPTION
5			
4			
3			
2			
1			

hard hat™ SERVICES
solutions and action

SCALE:	AS SHOWN
DATE:	8-29-16
DRAWN BY:	JFD
CHKD BY:	THJ
APRVD BY:	MWL

CLIENT / LOCATION
INTERSTATE POWER AND LIGHT (IPL)
OTTUMWA GENERATING STATION
OTTUMWA, IA

DRAWING DESCRIPTION
SAFETY FACTOR ASSESSMENT
CRITICAL CROSS–SECTION LOCATION

JOB 154.018.002.003
SHT. FIGURE 2
DWG. 154.018.002.003–D2

EXHIBIT A – 2016 SOIL BORINGS

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL- Ottumwa Generating Station SCS#: 25215135.40		MW-304

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Todd Schmalfeld Cascade Drilling	11/11/2015	11/11/2015	4-1/4 hollow stem auger

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW-304	Feet	680.1 Feet	8.5 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 401,152 N, 1,903,287 E S/C/N
SE 1/4 of NE 1/4 of Section 26, T 73 N, R 15 W
Lat ___° ___' ___"
Long ___° ___' ___"
Local Grid Location ☐ N Feet ☐ S ☐ E Feet ☐ W

Facility ID	County	Civil Town/City/ or Village
	Wapello	Ottumwa

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–1	TOPSOIL.	TOPSOIL									
			1–12.5	FAT CLAY, black (10YR 2/1).	CH									
S1	23	4 5 4 5	~11							M				
			12.5–15	FAT CLAY, yellowish brown (10YR 5/4).	CH									
S2	19.5	4 4 5 5	~13.5							M				
			15–16	FAT CLAY, yellowish brown (10YR 3/4).	CH									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature] for Kyle Kramer

Firm: SCS Engineers
2830 Dairy Drive Madison, WI 53718
Tel: (608) 224-2830
Fax:

Boring Number MW-304

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
S3	12	3 3 4 5		FAT CLAY, yellowish brown (10YR 3/4). *(continued)*						M				
			17											
			18											
S4	22	4 3 7 12	19							M				
			20											
S5	23	2 7 8 9	21							M				
			22											
			23											
S6	23	3 4 8 6	24							M				
			25		CH									
S7	23	5 11 15 11	26							M				
			27											
			28											
S8	15	4 4 5 6	29							M				
			30											
S9	18	4 6 9 9	31							M				
			32											
			33											
S10	24	4 6 7 6	34							M				
			35	FAT CLAY, DARK OLIVE BROWN (2.5Y 3/3).										
S11	16	2 2 4 6	36							M				
			37											
			38											
S12	24	4 3 5 5	39		CH					M				
			40											
S13	18	2 3 3 3	41							M				
			42											

Boring Number MW-304

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			43	FAT CLAY, DARK OLIVE BROWN (2.5Y 3/3). *(continued)*	CH									
S14	24	3 4 9 14	44	SANDY SILT, very dark gray.	ML					W				
				POORLY GRADED SAND, medium grained, gray (5Y 6/1), (weathered bedrock).										
			45											
S16	15	30 50/.4	46							W				
			47											
			48		SP									
S17	5	33 50/.2	49							W				
			50											
S18		50/.4	51							W				
			52	End of Boring at 52 feet bgs.										

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name: IPL- Ottumwa Generating Station SCS#: 25215135.40	License/Permit/Monitoring Number:	Boring Number: MW-305	
Boring Drilled By: Name of crew chief (first, last) and Firm: Todd Schmalfeld, Cascade Drilling	Date Drilling Started: 12/7/2015	Date Drilling Completed: 12/8/2015	Drilling Method: 4-1/4 hollow stem auger
Unique Well No.: / DNR Well ID No.: / Common Well Name: MW-305	Final Static Water Level: Feet	Surface Elevation: 681.5 Feet	Borehole Diameter: 8.5 in
Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒ State Plane 401,473 N, 1,903,023 E S/C/N; SE 1/4 of NE 1/4 of Section 26, T 73 N, R 15 W	Lat ° ' " Long ° ' "	Local Grid Location: Feet ☐ N ☐ S; Feet ☐ E ☐ W	
Facility ID: / County: Wapello	Civil Town/City/ or Village: Ottumwa		

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				TOPSOIL	TOPSOIL									
			1	GRAVEL	GP									
			2–9	FAT CLAY	CH									
S1	18	3 6 9 11	10–12	FAT CLAY, very dark grayish brown (10YR 3/2).						W				
S2	22	3 7 14 22	13–14	same as above except, brown (10YR 4/3).						W				
			15–16											

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature] for Kyle Kramer

Firm: SCS Engineers, 2830 Dairy Drive Madison, WI 53718 Tel: (608) 224-2830 Fax:

Boring Number MW-305

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
S3	22	5 15 14 15	17	FAT CLAY *(continued)*										
S4	20	3 5 13 15	18–19		CH									
S5	24	4 5 7 11	20–22	FAT CLAY WITH SILT, dark gray (10YR 4/1).						M				
S6	20	7 11 15 20	23–24	same as above except, very dark brown (10YR 2/2).						M				
S7	24	4 8 11 12	25–27	same as above except, very dark gray (10YR 3/1).	CH					M				
S8	24	8 12 16 21	28–29							M				
S9	13	4 4 7 12	30–32							M				
S10	24	5 6 9	33–34	LEAN CLAY, very dark brown (10YR 2/2).						W				
S11	24	4 4 5 7	35–37		CL					W				
S12	22	2 2 3 5	38–40	same as above except, very dark grayish brown (10YR 3/2).						W				
S13	6	3 9 11	41–42	POORLY GRADED SANDY GRAVEL, fine, brown (10YR 4/3).	GPS					W				water @ 41.0 ft bgs.

Boring Number MW-305

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
			43	POORLY GRADED SAND, medium grained, yellowish brown (10YR 5/4), (weathered bedrock). *(continued)*	SP									
S14	22	23 50	44							S				
			45											
S15	6	5 10 50	46		SP					S				
			47											
			48											
S16	6	50	49							S				
			50	End of Boring at 50 ft bgs.										

EXHIBIT B – 1974 SOIL LABORATORY RESULTS

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination

APPENDICES

APPENDIX A MAPS

Vicinity Map (Figure 1)
Plan of Borings (Figure 2)

APPENDIX B PROFILES

Generalized Soil and Rock Profiles (Figures 3, 4, 5, 6, 7)

APPENDIX C LABORATORY TESTING PROGRAM

Discussion of Laboratory Investigation
Table C-1 Summary of Laboratory Test Results-Split Spoon Samples
Table C-2 Summary of Laboratory Test Results-Undisturbed Samples
Table C-3 Summary of Compression Test Results-Rock Samples
Table C-4 Summary of Tests on Limestone

APPENDIX D CONSWLIDATION TESTS

Table D-1 Summary of Consolidation Test Results
Void Ratio vs. Log Vertical Effective Stress Curves
Table D-2 Coefficient of Consolidation Summary

APPENDIX E TRIAXIAL TESTS

Table E-1 Summary of Consolidated-Undrained Triaxial Test Results
Consolidated-Undrained Triaxial Test Data and Curves
Table E-2 Summary of Unconsolidated-Undrained Triaxial Test Results
Unconsolidated-Undrained Triaxial Test Data and Curves

APPENDIX F GRADATION TESTS

Table F-1 Summary of Sieve Analysis Results
Gradation Curves

APPENDIX G COMPACTION TESTS

Table G-1 Summary of Compaction Test Results
Moisture Content vs. Dry Density Curves

APPENDIX H PERMEABILITY TESTS

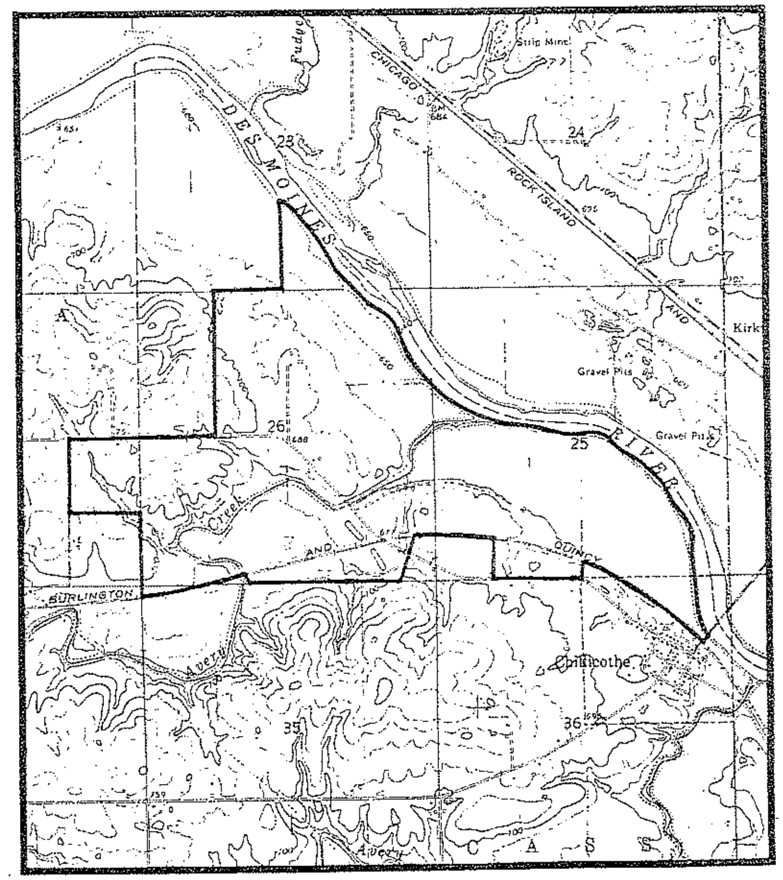
Table H-1 Summary of Permeability Test Results

APPENDIX I FIELD INVESTIGATION

Discussion of Field Investigation
Boring Logs
Table I-1 Summary of Piezometer Locations and Water Level Measurements June 19 and October 11, 1975
Field Classification System

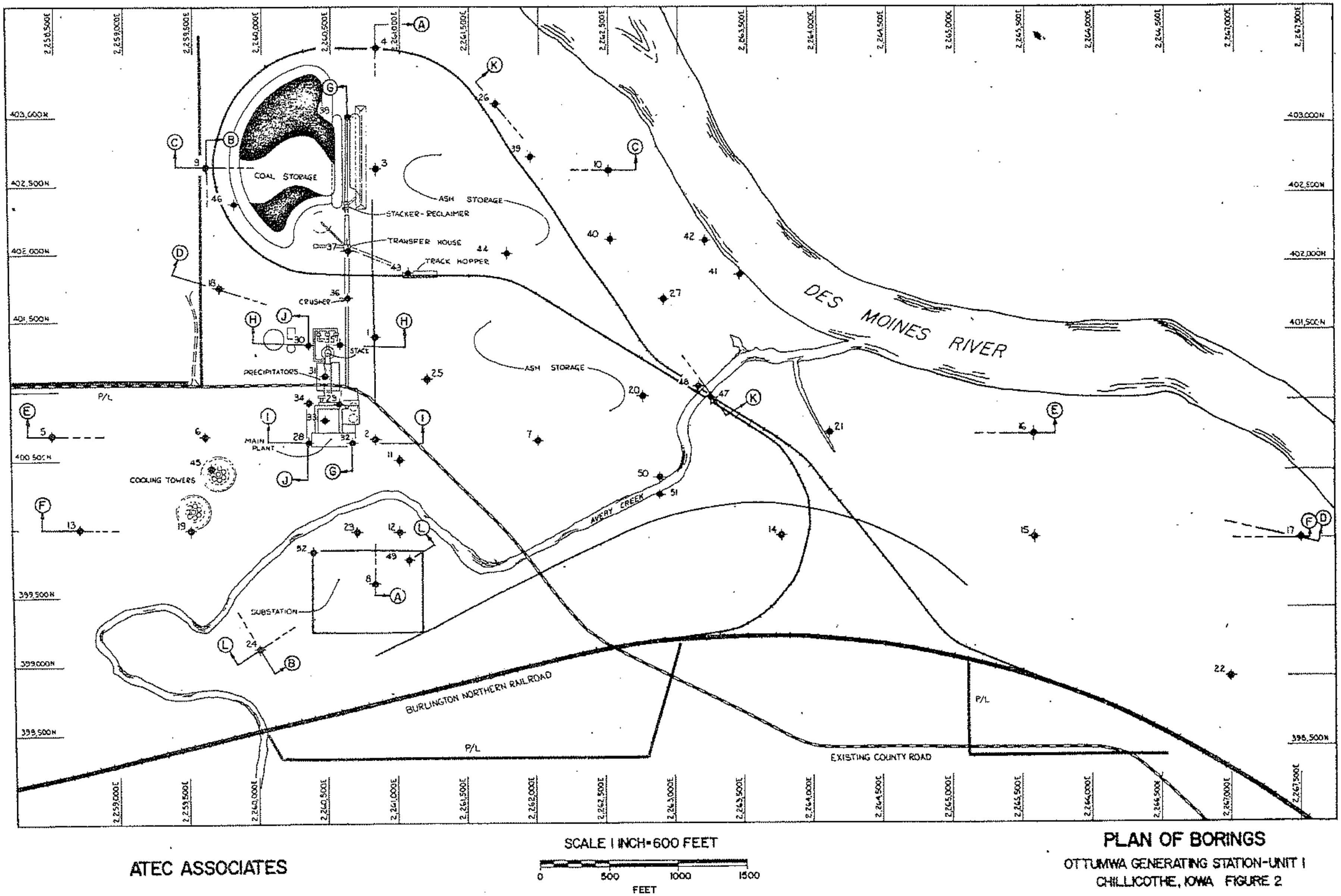
APPENDIX A

MAPS



VICINITY MAP
OTTUMWA GENERATING STATION-UNIT I
CHILLICOTHE, IOWA

FIGURE I

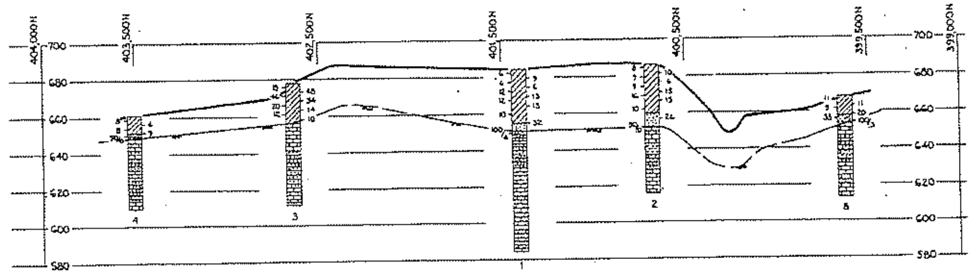


ATEC ASSOCIATES

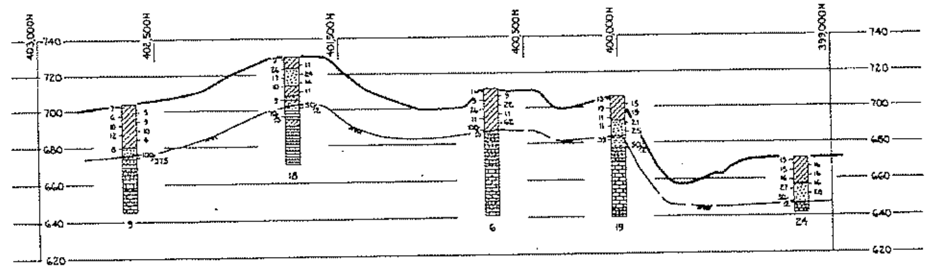
PLAN OF BORINGS

OTTUMWA GENERATING STATION-UNIT I

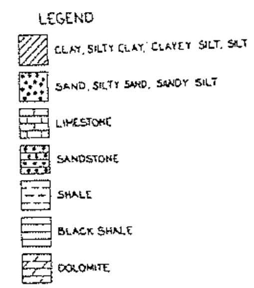
CHILLICOTHE, IOWA FIGURE 2

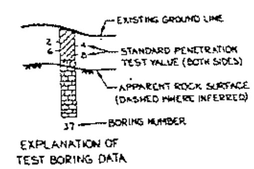


SECTION A-A

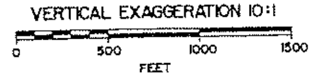


SECTION B-B





HORIZONTAL SCALE 1 INCH=600 FEET
VERTICAL EXAGGERATION 10:1

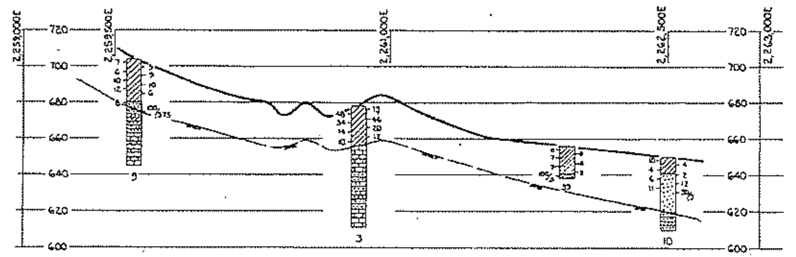


ATEC ASSOCIATES

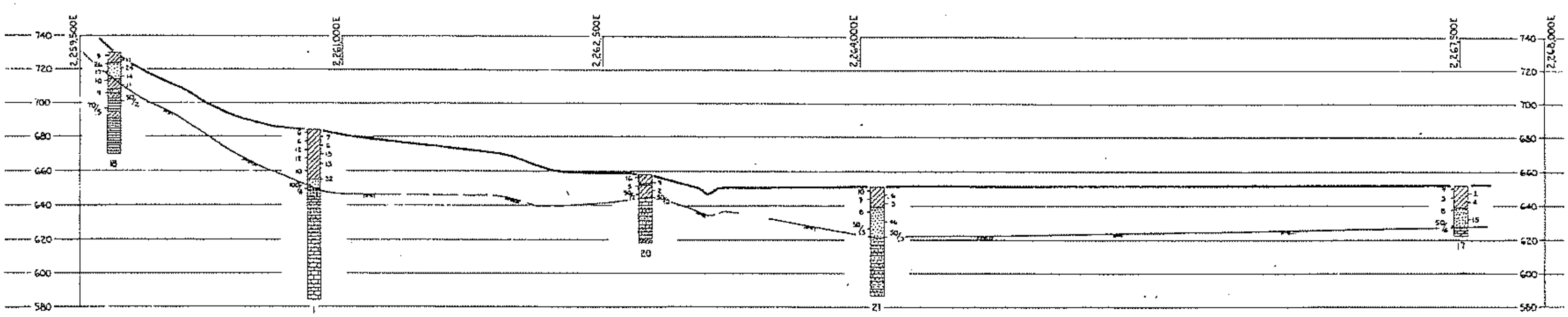
GENERALIZED SOIL AND ROCK PROFILES

OTTUMWA GENERATING STATION-UNIT I
CHILLICOTHE, IOWA

FIGURE 3



SECTION C-C



SECTION D-D

HORIZONTAL SCALE 1 INCH=600 FEET
VERTICAL EXAGGERATION 10:1

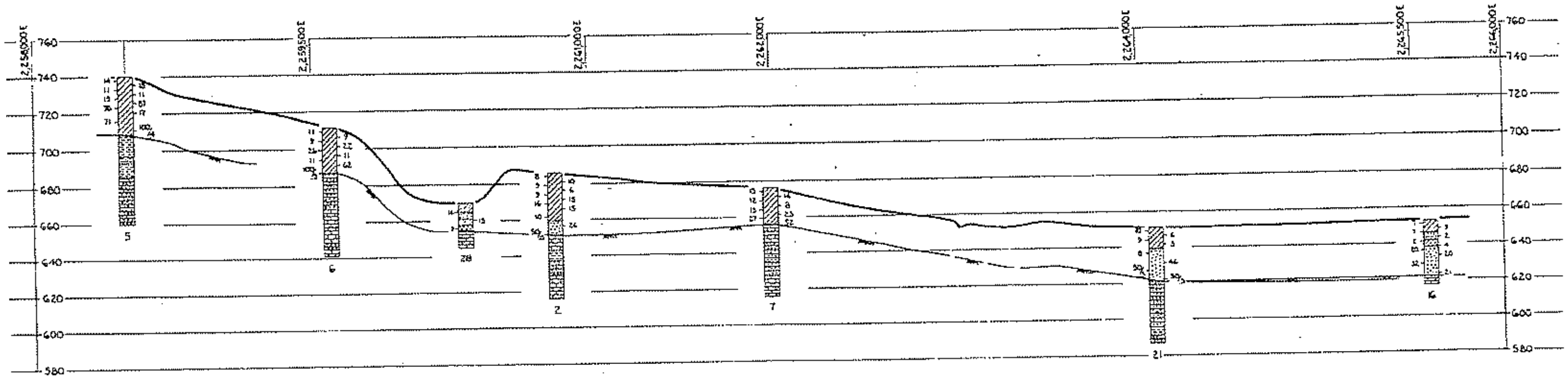
0 500 1000 1500
FEET

ATEC ASSOCIATES

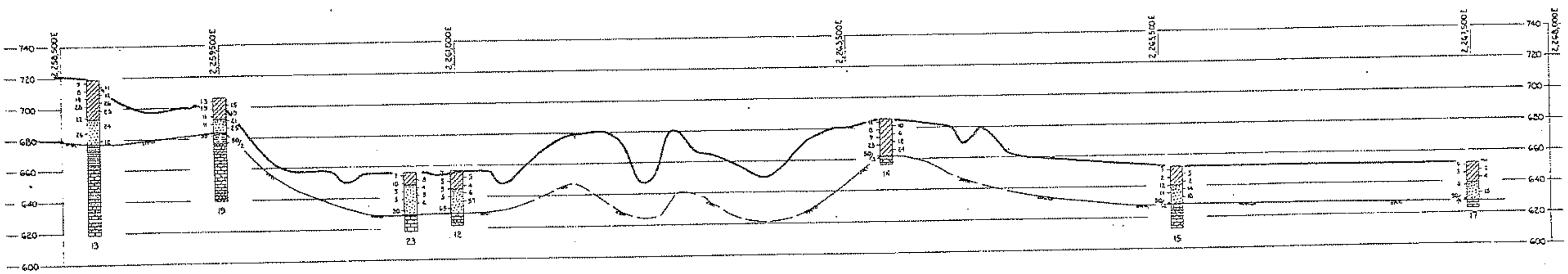
GENERALIZED SOIL AND ROCK PROFILES

OTTUMWA GENERATING STATION-UNIT I
CHILLICOTHE, IOWA

FIGURE 4



SECTION E-E



SECTION F-F

HORIZONTAL SCALE 1 INCH=600 FEET
VERTICAL EXAGGERATION 10:1

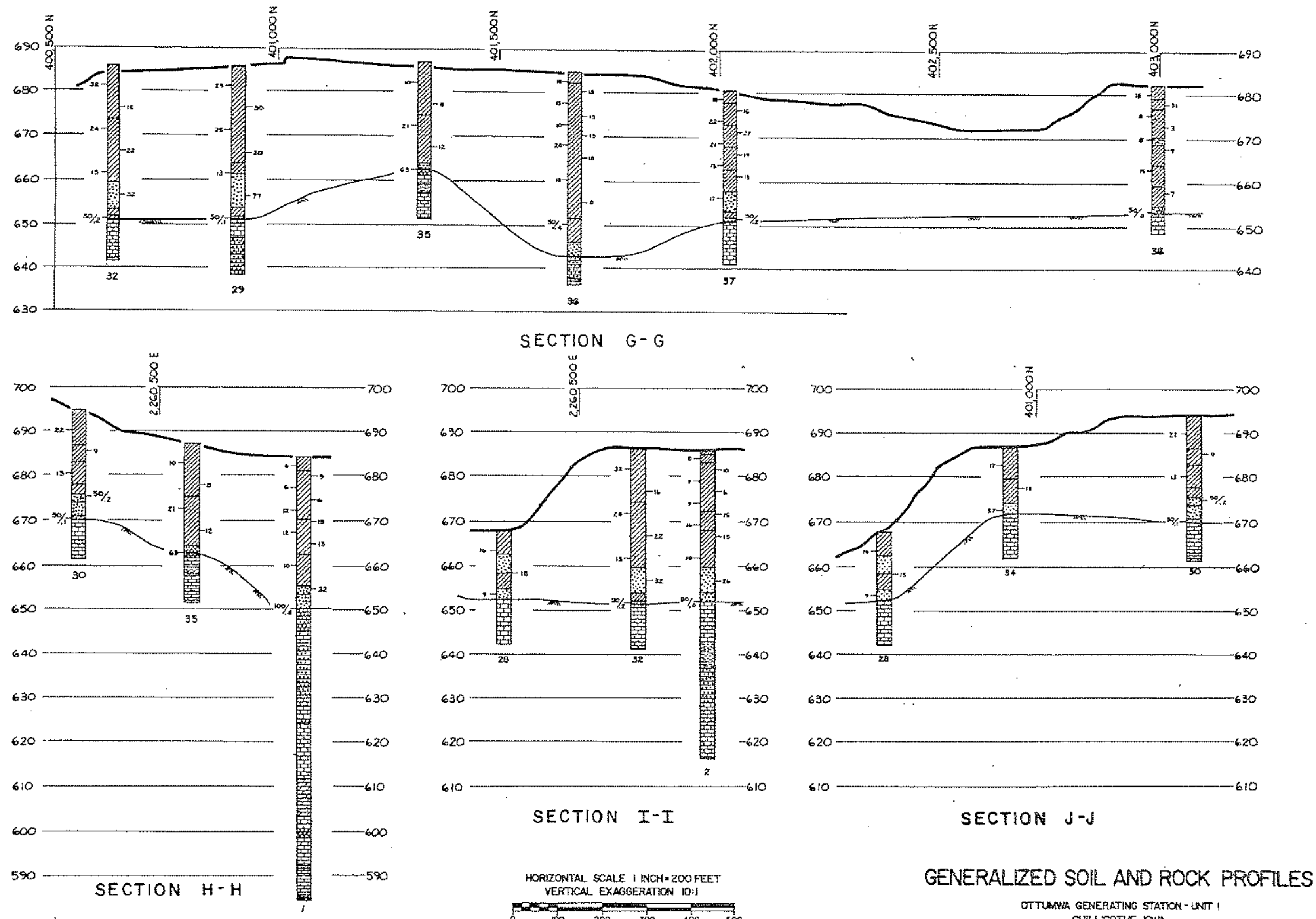
0 500 1000 1500
FEET

GENERALIZED SOIL AND ROCK PROFILES

OTTUMWA GENERATING STATION-UNIT 1
CHILLICOTHE, IOWA

FIGURE 5

ATEC ASSOCIATES

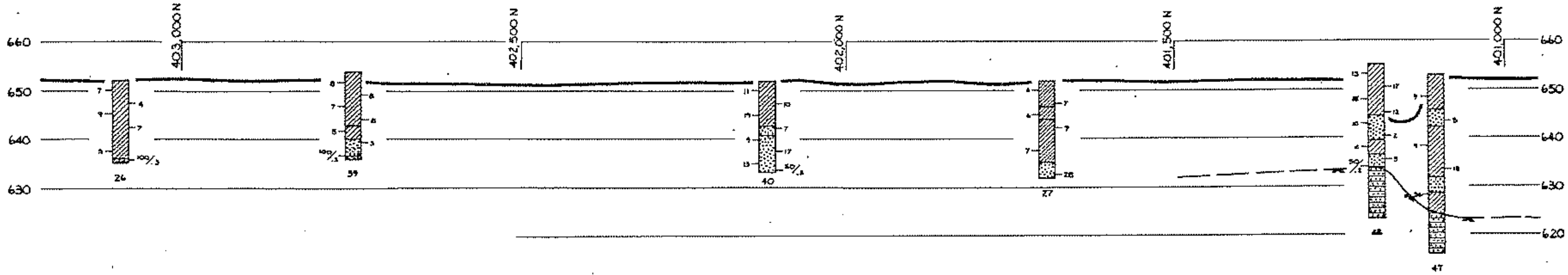


ATEC ASSOCIATES

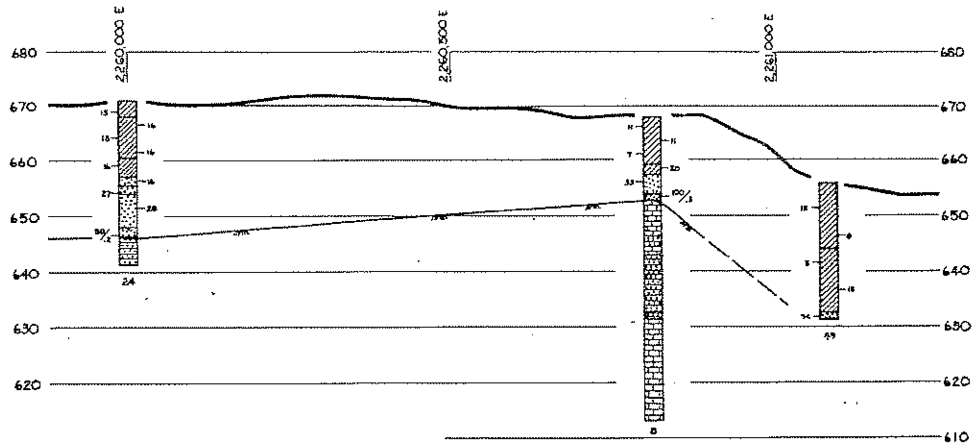
GENERALIZED SOIL AND ROCK PROFILES

OTTUMWA GENERATING STATION - UNIT 1
CHILLICOTHE, IOWA

FIGURE 6



SECTION K-K



SECTION L-L

ATEC ASSOCIATES

HORIZONTAL SCALE 1 INCH = 200 FEET
VERTICAL EXAGGERATION 10:1
0 100 200 300 400 500

GENERALIZED SOIL AND ROCK PROFILES

OTTUMWA GENERATING STATION - UNIT 1
CHILLICOTHE, IOWA
FIGURE 7

APPENDIX C

LABORATORY TESTING PROGRAM

Discussion of Laboratory Investigation

The split spoon samples were inspected and classified in accordance with the Unified Classification System and the field boring logs were edited as necessary. To aid in classifying the soils and to determine general soil characteristics, natural moisture and density determinations, Atterberg limits tests and sieve analyses were performed on selected samples. The organic contents of some samples were estimated from loss-on-ignition tests.

The undisturbed Shelby tube samples were extruded from the tubes, classified, and natural moistures and densities determined. Atterberg limits tests were performed on selected Shelby tube samples. In order to determine compressibility characteristics, twelve consolidation tests were performed on samples selected to be critical based on probable locations of structures and the results of field and laboratory tests. The conventional load increment ratio of two was employed throughout each test.

To provide undrained shear strength estimates, unconfined compression tests and unconsolidated-undrained triaxial tests were performed on some of the undisturbed samples. Consolidated-undrained triaxial tests (with pore pressure measurements) were performed to determine effective strength parameters. All consolidated-undrained triaxial samples were saturated prior to consolidation.

Compaction tests (according to both ASTM D-698 and ASTM D-1557) were performed on selected bag samples taken from potential on-site borrow areas. Strength and permeability tests were conducted on recompacted samples.

Unconfined compression tests were performed on certain of the rock core samples. Abrasion, soundness and chemical tests were conducted on some of the limestone samples from the eastern portion of the site.

The results of all tests are included in the remainder of Appendix C and Appendices D, E, F, G, H and I.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1

SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
1	1.0-2.5		37.3				4.8
1	3.5-5.0	93.5	29.7				
1	6.0-7.5		28.9				
1	8.5-10.0		28.5	37	25	12	
1	11.0-12.5		25.0				
1	13.5-15.0		26.7				
1	16.0-17.5	106.3	22.6	49	23	16	
1	18.5-20.0		22.5				
1	23.5-25.0		20.9	32	20	11	
2	1.0-2.5		22.8				
2	3.5-5.0		30.0				
2	6.0-7.5		28.1				
2	8.5-10.0	98.3	30.0	41	25	16	
2	11.0-12.5		20.2				
2	13.5-15.0		21.5				
2	16.0-17.5	108.2	20.2				
2	18.5-20.0		25.9				
2	23.5-25.0		26.8				
3	1.0-2.5		23.6				
3	3.5-5.0		16.4				
3	6.0-7.5		13.2				
3	8.5-10.0		17.5				
3	11.0-12.5	113.2	17.0	45	23	19	
3	13.5-15.0		22.2				
3	16.0-17.5		20.9				
3	18.5-20.0		23.0				
4	1.0-2.5		21.3				2.8
4	3.5-5.0		24.2				
4	6.0-7.5	104.1	23.5	30	21	9	
5	1.0-2.5		21.0				
5	3.5-5.0		22.5				
5	6.0-7.5		27.3				
5	8.5-10.0		16.7				
5	11.0-12.5		13.4				
5	13.5-15.0		14.9				
5	16.0-17.5		10.3				
5	18.5-20.0		24.1				

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples (ccnt.d)

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
6	1.0-2.5		17.8				
6	3.5-5.0		20.6				
6	6.0-7.5		25.1				
6	8.5-10.0		13.0				
6	11.0-12.5		14.0				
6	13.5-15.0		53.3	90	33	57	
7	1.0-2.5		29.9				
7	3.5-5.0		28.9				
7	6.0-7.5		27.6				
7	8.5-10.0		26.5	33	20	13	
7	11.0-12.5		25.8				
7	13.5-15.0		25.8				
7	16.0-17.5		25.2				
8	1.0-2.5		16.7				
8	3.5-5.0		24.6				
8	6.0-7.5	98.8	27.1	37	25	12	
8	8.5-10.0		10.9				
8	11.0-12.5		11.5				
9	1.0-2.5		28.7				
9	3.5-5.0		36.8				
9	6.0-7.5		26.7	61	20	41	
9	8.5-10.0		23.9				
9	11.0-12.5		26.7				
9	13.5-15.0		18.8				
9	16.0-17.5		21.4				
9	18.5-20.0		22.6	56	21	35	
10	1.0-2.5		28.0				1.5
10	3.5-5.0		30.0				4.2
10	6.0-7.5		28.7	56	25	31	
10	8.5-10.0		36.0				
11	1.0-2.5		21.2				
11	3.5-5.0		26.1				
11	6.0-7.5		27.1				
11	8.5-10.0		21.2				
11	11.0-12.5		21.8				
11	13.5-15.0		21.5				
11	16.0-17.5		19.2				
11	18.5-20.0		20.0				

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples(cont'd.)

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
12	1.0-2.5		18.1				
12	3.5-5.0		19.7				
12	6.0-7.5		24.4				
12	8.5-10.0		22.6				
12	11.0-12.5		23.0				
12	13.5-15.0		21.8				
13	1.0-2.5		27.2				
13	3.5-5.0		26.1				
13	6.0-7.5		19.8				
13	18.5-20.0		18.3	57	18	39	
14	1.0-2.5		19.8				
14	3.5-5.0		23.1				
14	6.0-7.5		20.7	44	21	23	
14	8.5-10.0		26.1				
14	11.0-12.5		25.9				
14	13.5-15.0		19.5				
15	1.0-2.5		31.8				
15	3.5-5.0		26.3				
15	6.0-7.5		27.0				
15	8.5-10.0		33.2				
16	1.0-2.5		23.9				
16	3.5-5.0		27.1				
16	11.0-12.5		28.6				
16	13.5-15.0		29.4				
17	1.0-2.5		24.1				
17	3.5-5.0		22.0				
17	6.0-7.5		34.1				
17	8.5-10.0		31.2				
18	1.0-2.5		24.7				
18	3.5-5.0		24.6	57	18	39	
18	6.0-7.5		24.8				
18	16.0-17.5		18.0				
18	18.5-20.0		22.9	47	24	23	

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples (cont'd.)

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
19	1.0-2.5		19.3				
19	3.5-5.0		15.8				
19	6.0-7.5		22.0				
19	8.5-10.0		16.9				
19	13.5-15.0		17.4				
19	16.0-17.5		18.5				
20	1.0-2.5		23.0				
20	3.5-5.0		20.7				
21	1.0-2.5		22.2				
21	3.5-5.0		28.5				
21	6.0-7.5		26.1				
21	8.5-10.0		34.6				
22	1.0-2.5		33.2				
22	3.5-5.0		32.1				
22	6.0-7.5		30.0				
22	8.5-10.0		33.4	38	23	15	
24	1.0-2.5		23.8				
24	3.5-5.0		25.2				
24	6.0-7.5		28.3	44	22	22	
24	8.5-10.0		22.6				
25	1.0-2.5		22.2				
25	3.5-5.0		25.1				
25	6.0-7.5		29.3				
25	8.5-10.0		26.5				
26	1.0-2.5		28.2				5.3
26	3.5-5.0		27.9				3.0
26	6.0-7.5		29.3				
26	8.5-10.0		30.3				
26	13.5-15.0		31.8	54	27	27	
27	1.0-2.5		30.5				4.1
27	3.5-5.0		30.9	51	24	27	4.5
27	6.0-7.5		33.9				
27	8.5-10.0		26.0	51	28	23	
27	11.0-12.5		29.8				

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
28	3.5-5.0		18.5				
29	13.5-15.0		22.0	60	20	40	
30	3.0-5.0		26.2				
30	8.5-10.0		25.3	35	21	14	
30	13.5-15.0		19.3				
31	3.5-5.0		28.7				
31	8.5-10.0		24.4				
32	3.5-5.0		22.5				
33	23.5-25.0		29.8	57	21	36	
34	3.5-5.0		23.0				
35	3.5-5.0		27.6				
35	8.5-10.0		27.6				
36	1.0-2.5		20.7				3.1
36	3.5-5.0		25.3				
36	6.0-7.5		24.2				
36	8.5-10.0		24.2				
36	11.0-12.5		23.8	36	16	20	
36	13.5-15.0		25.5				
36	28.5-30.0		22.7				
37	1.0-2.5		21.4				
37	3.5-5.0		21.0				
37	6.0-7.5		23.4				
37	8.5-10.0		21.5				
37	11.0-12.5		20.2				
37	13.5-15.0		20.7				
37	16.0-17.5		17.5				
37	18.5-20.0		22.3				
38	1.0-2.5		18.6				
38	3.5-5.0		21.1				
38	6.0-7.5		27.7				
38	8.5-10.0		27.3				
38	11.0-12.5		25.8				
38	13.5-15.0		43.2				
38	23.5-25.0		29.2	43	22	21	

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
39	1.0-2.5		28.7				5.6
39	3.5-5.0		32.8				
39	6.0-7.5		26.5				
39	8.5-10.0		29.5				
39	11.0-12.5		35.9				
39	13.5-15.0		35.2				
39	16.0-17.0		11.4				
40	1.0-2.5		29.0				
40	3.5-5.0		31.5	56	18	38	
40	6.0-7.5		27.2				
40	8.5-9.0		27.4				
41	1.0-2.5		21.3				4.2
41	3.5-5.0		16.1				
41	6.0-7.5		22.2				
41	8.5-10.0		23.7				
41	11.0-11.8		25.3				
42	1.0-2.5		20.4				
42	3.5-5.0		19.9				
42	6.0-7.5		20.3				
42	8.5-10.0		26.2				
42	11.0-12.5		25.7				
43	3.5-5.0		25.4				
43	8.5-10.0		26.1				
43	13.5-15.0		21.0				
43	18.5-20.0		24.3				
44	1.0-2.5		11.9				5.0
44	3.5-5.0		11.3				
44	16.0-17.5		23.3				
45	3.5-5.0		17.0				
45	8.5-10.0		18.3				
45	13.5-15.0		18.9				
45	18.5-20.0		20.4				
45	23.5-25.0		23.2				
46	1.0-2.5		25.0				3.3
46	3.5-5.0		27.2				
46	6.0-7.5		27.4				
46	8.5-10.0		25.2	32	13	19	

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-1 SUMMARY OF LABORATORY TEST RESULTS
Split-Spoon Samples

Boring No.	Depth ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Loss-on-Ignition %
46	11.0-12.5		23.8				
46	13.5-15.0		25.4				
46	16.0-17.5		22.5				
46	18.5-20.0		27.0				
47	3.5-5.0		25.2				
47	13.5-15.0		24.2				2.8
47	18.5-20.0		30.9	40	22	18	
48	1.0-2.5		22.9				
48	3.5-5.0		25.0				
48	6.0-7.5		25.4				
48	8.5-10.0		24.6				
48	16.0-17.5		40.4				
49	3.5-5.0		22.5				
49	8.5-10.0		25.2				
49	13.5-15.0		31.2				
49	18.5-20.0		32.1				
50	3.5-5.0		18.8				
50	8.5-10.0		17.9				
50	13.5-15.0		24.3				
50	18.5-20.0		30.6				
51	3.5-5.0		13.5				
51	8.5-10.0		16.5				
51	13.5-15.0		24.1				
51	18.5-20.0		28.0	32	17	15	
52	1.0-2.5		24.4				
52	3.5-5.0		24.1	37	18	19	

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-2 SUMMARY OF LABORATORY TEST RESULTS
Undisturbed Samples

Boring No.	Depth, ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Atterberg Limits % LL	PL	PI	Unconfined Compressive Strength,tsf
1A	6.0-8.0	96.4	28.2				0.71
1A	8.0-10.0	98.4	26.6				0.96 *
4A	3.0-5.0	100.2	24.8				0.63
4A	6.0-8.0	101.9	23.6				
8A	5.0-7.0	95.2	28.2				*
8A	7.0-9.0	99.5	25.2				1.15
9A	4.0-5.0	79.8	39.7				
9A	5.0-6.0	94.6	29.2				
9A	6.0-6.5		46.3				
9A	6.5-8.0	100.5	26.3				1.88
9A	13.0-14.5	106.5	22.5				**
9A	18.0-19.0	96.4	27.6				
9A	19.0-20.0	110.0	19.6				0.75
9A	22.0-24.0	99.9	25.7				0.42
10A	3.0-5.0	90.8	30.0				*
10A	5.0-7.0	94.4	28.5				**
10A	7.0-9.0	97.5	26.4				* **
12A	2.0-4.0	93.1	31.0				
12A	4.0-6.0	100.6	23.3				
12A	7.0-9.0	104.4	22.6				
14A	4.0-6.0	94.5	29.3				
14A	8.0-10.0	94.6	28.5				
14A	10.0-12.0	98.5	27.9				
15A	2.0-4.0	94.7	28.8				
15A	5.0-7.0	93.4	28.9				
15A	8.0-10.0	88.4	33.7				
15A	10.0-12.0	95.7	25.5				
18A	3.0-5.0	101.0	25.0				1.20
18A	19.0-21.0	107.8	20.6				**
26A	3.0-5.0	88.8	31.9				0.14
26A	9.0-9.5		34.4				
26A	9.5-11.0	97.3	26.9				0.97
26A	13.0-15.0	87.6	33.6				0.36 *
27	6.0-8.0	90.5	31.2				0.74 *
27A	13.0-15.0	92.6	30.9				0.91

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-2 SUMMARY OF LABORATORY TEST RESULTS
Undisturbed Samples

Boring No.	Depth, ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Atterberg Limits % LL	PL	PI	Unconfined Compressive Strength,tsf
36	10.0-12.0	101.4	22.5				0.81
36	12.0-14.0	104.9	22.1				
36	18.0-20.0	103.3	24.1				
36	23.0-25.0	104.7	20.3				
36	28.0-29.9	95.2	27.4				1.11
38	7.0-8.9	93.3	28.5	37	20	17	0.66 *
38	9.0-11.0	88.1	30.5				
38	14.0-15.9	97.2	30.9				1.18
38	18.0-20.0	103.3	23.3				
38	23.0-25.0	107.1	19.6				
39	3.0-5.0	85.7	32.4	52	25	27	0.70 *
39	11.0-13.0	89.5	29.3				
39	13.0-15.0	82.0	38.8	42	25	17	* **
40	3.0-5.0	87.5	31.9				1.24
41	3.0-5.0	105.1	15.0				
41	8.0-10.0	99.3	22.3	41	16	25	**
42	2.0-4.0	102.1	20.1				
42	10.0-12.0	96.5	26.6	34	22	12	
43	3.0-5.0	98.3	20.8				2.89
43	8.0-10.0	99.0	26.7				1.00 **
43	13.0-15.0	104.0	23.1				1.07
43	18.0-20.0	104.1	22.1	32	15	17	**
44	3.0-5.0	106.2	12.7	29	16	13	
45	3.0-5.0	98.8	20.0				
45	9.0-11.0	111.4	17.0	35	11	24	0.97 **
45	11.0-13.0	111.9	19.5				
45	18.0-19.8	105.3	21.2				
45	28.0-30.0	109.8	19.3				
46	3.0-4.8	98.6	22.0				
46	10.0-12.0	104.3	22.9				
46	18.0-19.9	102.6	23.3				1.04 **
46	28.0-30.0	102.7	23.8				

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-2 SUMMARY OF LABORATORY TEST RESULTS
Undisturbed Samples

Boring No.	Depth, ft	Natural Dry Density, lbs/cu.ft	Natural Moisture Content,%	Atterberg Limits % LL	PL	PI	Unconfined Compressive Strength,tsf	
48	8.0-10.0	96.5	25.4				0.81	
48	16.0-17.9	82.9	37.7	53	23	30		* **
49	8.0-10.0	99.2	24.1				0.46	
49	13.0-15.0	96.5	27.5	38	18	20	0.76	*
49	18.0-20.0	96.9	28.0					
50	8.0-10.0	108.7	18.1				1.32	
50	19.0-21.0	86.5	34.5	49	25	24	0.62	* **
51	8.0-10.0	103.3	21.5				0.72	
51	19.0-21.0	96.6	23.3					
52	3.0-5.0	94.8	24.4				.85	
52	6.0-8.0	108.3	16.2					
52	8.0-10.0	111.5	15.4					

* See Appendix D for Consolidation Test Results

** See Appendix E for Triaxial Test Results

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-3 SUMMARY OF COMPRESSION TEST RESULTS
Rock Samples

Boring No.	Depth ft	Sample Height, in.	Sample Diameter, in.	Unconfined Compressive Strength,psi	Rock Description
1	36.1	2.75	2.00	1350	Gray Sandstone
1	43.0	4.38	2.03	2460	Gray Sandstone
2A	38.6	4.67	2.06	14070	White Limestone
2A	44.3	4.25	2.06	7030	Gray Sandy Shale and Limestone
2A	51.3	4.44	2.06	5990	Gray Sandstone
2A	57.7	4.44	2.06	12720	White Limestone
4	20.0	4.88	2.00	1070	Green Sandstone
4	29.4	3.88	2.06	13170	White Limestone
4	46.3	4.53	2.06	5160	Gray Sandstone
6	25.0	4.97	2.03	2500	Dark Gray Shaly Sandstone
7	27.5	4.44	2.06	14520	Gray Limestone
19	29.5	3.44	1.88	2670	Gray Sandstone
23	29.4	4.88	1.88	9270	White Limestone
28	18.7	4.63	2.06	14790	Gray Limestone
29	36.1	3.69	2.06	19150	Gray Limestone
29	42.8	6.00	2.06	16970	Gray Sandstone
30	25.0	5.94	2.06	14540	White Limestone
31	29.5	6.00	2.00	8000	Gray Limestone
32	38.5	5.63	2.06	16490	Gray Limestone
33	28.7	5.25	2.06	15030	Gray Sandstone
33	36.0	4.38	2.06	5820	Gray Sandstone
34	15.7	5.69	2.06	6550	Gray Shaly Limesto
35	26.7	4.38	2.06	12850	Gray Limestone
35	28.2	6.00	2.06	16730	Green Shale
35	30.0	6.00	2.06	17460	White Limestone
41	31.8	6.00	2.06	14000	Green Sandstone
43	41.0	3.88	2.00	5150	Gray Sandstone
43	57.9	6.00	2.06	6788	White Limestone
47	31.0	4.69	2.00	6750	Gray Sandstone
48	22.0	4.13	2.06	5820	Gray Sandstone
50	26.2	5.38	2.06	4850	Gray Sandstone
51	30.5	5.06	2.06	5820	Gray Sandstone

Ottumwa Generating Station-Unit 1
(E-7566)

Table C-4 SUMMARY OF TESTS ON LIMESTONE

1. Test for Determining the Soundness of Coarse Aggregate by Freezing and Thawing
(ISHC Test Method No 211-Method A)

Sample: Boring No 15, 24.2 to 26.4 ft depth
Boring No 15, 29.9 to 31.9 ft depth
Boring No 15, 31.9 to 39.6 ft depth
Boring No 16, 31.0 to 32.4 ft depth
Boring No 16, 32.4 to 36.0 ft depth
Boring No 17, 24.3 to 29.3 ft depth
Boring No 22, 25.6 to 30.3 ft depth

Results: Loss - 16.8%

2. Resistance to Abrasion of Coarse Aggregate by use of the Los Angeles Machine (AASHTO T 96)

Sample: (Same as above)

Results: Loss - 27.8%

3. Analysis of Limestone (ASTM C 25)

Sample: Boring No 15, 31.9 to 40.0 ft depth

Results:

Insoluble matter	1.29%
Total neutralizing value in terms of $Ca\ CO_3$	98.25%
Calcium Carbonate ($Ca\ CO_3$)	97.00%
Magnesium Carbonate ($Mg\ CO_3$)	1.25%

APPENDIX D

CONSOLIDATION TESTS

Ottumwa Generating Station-Unit I
(E-7566)

Table D-1 SUMMARY OF CONSOLIDATION TEST RESULTS

Boring No.	Depth, ft	Existing Effective Overburden Pressure, tsf	Compression Index	Initial Moisture Content, %	Initial Void Ratio	Initial Dry Density, lbs/cu.ft
1A	8.5	0.529	0.211	27.8	0.848	94.3
8A	6.0	0.821	0.218	26.7	0.821	90.7
10A	4.0	0.246	0.258	32.1	0.962	88.7
10A	7.5	0.462	0.261	34.9	0.971	85.1
26A	13.5	0.556	0.205	30.9	0.864	91.4
27A	7.0	0.416	0.238	31.0	0.958	88.6
38A	8.5	0.501	0.282	28.2	0.888	81.9
39A	4.5	0.262	0.235	27.8	0.875	91.2
39A	14.5	0.819	0.184	32.9	0.937	89.7
48A	17.5	0.915	0.369	37.5	1.077	84.5
49A	14.0	0.795	0.257	29.1	0.861	94.0
50A	20.0	0.945	0.304	37.1	1.064	84.8

Ottumwa Generating Station-Unit 1
(E-7566)

Table D-2 COEFFICIENT OF CONSOLIDATION SUMMARY

Boring No.	Depth, ft	Load Increment, tons/sq.ft	Coefficient of Consolidation $cm^2/sec.$	Coefficient of Compressibility, cm^2/kg	Average Void Ratio	Estimated Coefficient of Permeability, cm/sec
1A	8.5	0.25 to 0.5	1.69×10^{-3}	0.024	0.839	2.2×10^{-4}
1A	8.5	0.5 to 1.0	5.18×10^{-3}	0.030	0.829	0.85×10^{-4}
1A	8.5	1.0 to 2.0	3.78×10^{-3}	0.031	0.806	0.65×10^{-4}
1A	8.5	2.0 to 4.0	3.43×10^{-3}	0.027	0.764	0.51×10^{-4}
1A	8.5	4.0 to 8.0	4.26×10^{-3}	0.016	0.706	0.40×10^{-4}
8A	6.0	0.25 to 0.5	1.05×10^{-3}	0.016	0.816	0.92×10^{-5}
8A	6.0	0.5 to 1.0	1.31×10^{-3}	0.018	0.810	1.29×10^{-5}
8A	6.0	1.0 to 2.0	1.47×10^{-3}	0.017	0.797	1.38×10^{-5}
8A	6.0	2.0 to 4.0	1.25×10^{-3}	0.017	0.772	1.16×10^{-5}
8A	6.0	4.0 to 8.0	0.98×10^{-3}	0.015	0.725	0.86×10^{-5}
10A	4.0	0.25 to 0.5	3.95×10^{-4}	0.084	0.934	1.71×10^{-5}
10A	4.0	0.5 to 1.0	4.99×10^{-4}	0.066	0.907	1.72×10^{-5}
10A	4.0	1.0 to 2.0	3.67×10^{-4}	0.050	0.875	0.97×10^{-5}
10A	4.0	2.0 to 4.0	4.48×10^{-4}	0.035	0.805	0.86×10^{-5}
10A	4.0	4.0 to 8.0	3.35×10^{-4}	0.020	0.731	0.37×10^{-5}
10A	7.5	0.25 to 0.5	1.0×10^{-4}	0.156	0.916	8.1×10^{-6}
10A	7.5	0.5 to 1.0	0.9×10^{-4}	0.110	0.869	5.2×10^{-6}
10A	7.5	1.0 to 2.0	1.0×10^{-4}	0.069	0.807	3.8×10^{-6}
10A	7.5	2.0 to 4.0	1.0×10^{-4}	0.039	0.733	2.2×10^{-6}
10A	7.5	4.0 to 8.0	0.9×10^{-4}	0.020	0.576	1.1×10^{-6}
26A	13.5	0.25 to 0.5	1.60×10^{-4}	0.120	0.807	1.06×10^{-5}
26A	13.5	0.5 to 1.0	1.84×10^{-4}	0.084	0.771	0.85×10^{-5}
26A	13.5	1.0 to 2.0	2.01×10^{-4}	0.051	0.725	0.57×10^{-5}
26A	13.5	2.0 to 4.0	2.84×10^{-4}	0.029	0.671	0.47×10^{-5}
26A	13.5	4.0 to 8.0	2.83×10^{-4}	0.015	0.602	0.26×10^{-5}

cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

COEFFICIENT OF CONSOLIDATION SUMMARY

Table D-2

Boring No.	Depth, ft	Load Increment, tons/sq.ft	Coefficient of Consolidation $cm^2/sec.$	Coefficient of Compressibility, cm^2/kg	Average Void Ratio	Estimated Coefficient of Permeability, cm/sec
27A	7.0	0.25 to 0.5	1.55×10^{-3}	0.060	0.931	4.81×10^{-5}
27A	7.0	0.5 to 1.0	0.84×10^{-3}	0.050	0.912	2.19×10^{-5}
27A	7.0	1.0 to 2.0	0.81×10^{-3}	0.037	0.881	1.58×10^{-5}
27A	7.0	2.0 to 4.0	1.03×10^{-3}	0.028	0.834	1.48×10^{-5}
27A	7.0	4.0 to 8.0	0.78×10^{-3}	0.018	0.771	0.79×10^{-5}
38A	8.5	0.25 to 0.5	5.73×10^{-3}	0.032	0.881	3.45×10^{-4}
38A	8.5	0.5 to 1.0	7.41×10^{-3}	0.028	0.869	1.11×10^{-4}
38A	8.5	1.0 to 2.0	3.38×10^{-3}	0.026	0.848	0.48×10^{-4}
38A	8.5	2.0 to 4.0	2.42×10^{-3}	0.031	0.805	0.42×10^{-4}
38A	8.5	4.0 to 8.0	1.91×10^{-3}	0.021	0.735	0.23×10^{-4}
39A	4.5	0.25 to 0.5	2.9×10^{-4}	0.036	0.867	0.55×10^{-5}
39A	4.5	0.5 to 1.0	7.3×10^{-4}	0.054	0.848	2.13×10^{-5}
39A	4.5	1.0 t- 2.0	7.6×10^{-4}	0.035	0.817	1.46×10^{-5}
39A	4.5	2.0 to 4.0	7.9×10^{-4}	0.027	0.772	1.20×10^{-5}
39A	4.5	4.0 to 8.0	6.0×10^{-4}	0.017	0.711	5.9×10^{-5}
39A	14.5	0.25 to 0.5	6.43×10^{-3}	0.064	0.908	2.2×10^{-4}
39A	14.5	0.5 to 1.0	6.29×10^{-3}	0.048	0.889	1.6×10^{-4}
39A	14.5	1.0 to 2.0	5.42×10^{-3}	0.033	0.861	0.9×10^{-4}
39A	14.5	2.0 to 4.0	7.78×10^{-3}	0.022	0.822	0.9×10^{-4}
39A	14.5	4.0 to 8.0	6.31×10^{-3}	0.013	0.773	0.5×10^{-4}
48A	17.5	0.25 to 0.5	0.65×10^{-3}	0.040	1.067	1.25×10^{-5}
48A	17.5	0.5 to 1.0	1.20×10^{-3}	0.042	1.052	2.45×10^{-5}
48A	17.5	1.0 to 2.0	0.63×10^{-3}	0.049	1.017	1.52×10^{-5}
48A	17.5	2.0 to 4.0	0.47×10^{-3}	0.050	0.942	1.21×10^{-5}
48A	17.5	4.0 to 8.0	0.32×10^{-3}	0.028	0.837	0.48×10^{-5}

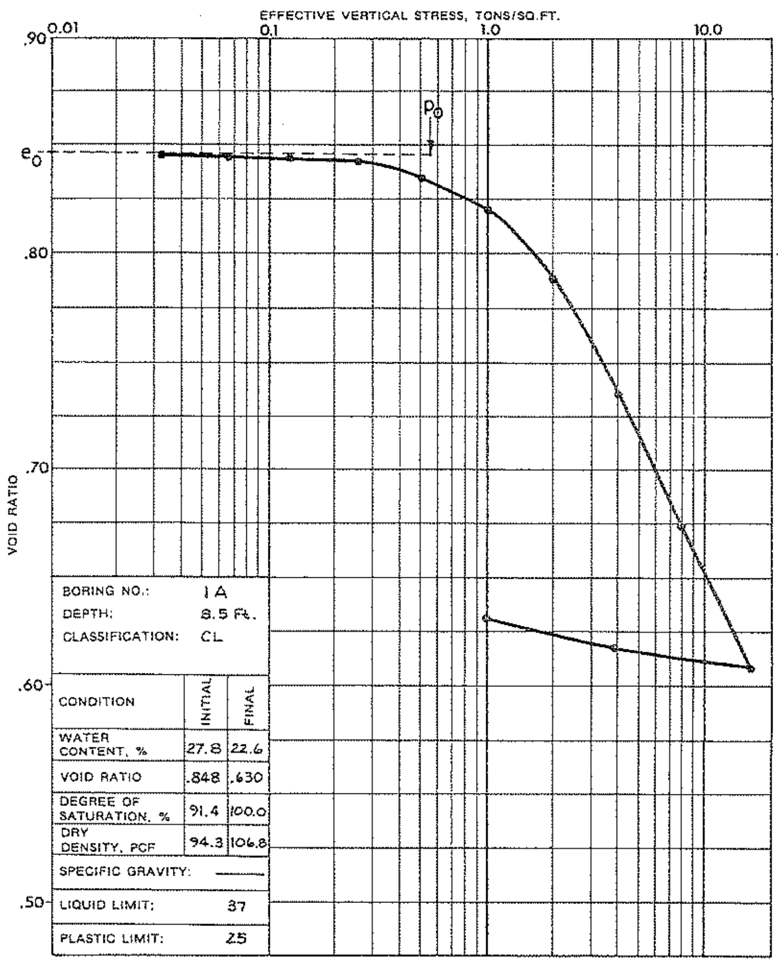
cont'd.

Ottumwa Generating Station-Unit 1
(E-7566)

COEFFICIENT OF CONSOLIDATION SUMMARY

Table D-2

Boring No.	Depth, ft	Load Increment, tons/sq.ft	Coefficient of Consolidation $cm^2/sec.$	Coefficient of Compressibility, cm^2/kg	Average Void Ratio	Estimated Coefficient of Permeability, cm/sec
49A	14.0	0.25 to 0.5	3.30×10^{-3}	0.056	0.847	1.00×10^{-6}
49A	14.0	0.5 to 1.0	4.27×10^{-3}	0.042	0.830	0.98×10^{-6}
49A	14.0	1.0 to 2.0	4.15×10^{-3}	0.029	0.805	0.67×10^{-6}
49A	14.0	2.0 to 4.0	4.36×10^{-3}	0.029	0.767	0.72×10^{-6}
49A	14.0	4.0 to 8.0	2.36×10^{-3}	0.016	0.713	0.22×10^{-6}
50A	20.0	0.25 to 0.5	5.78×10^{-3}	0.076	1.042	2.15×10^{-4}
50A	20.0	0.5 to 1.0	7.26×10^{-3}	0.062	1.017	2.23×10^{-4}
50A	20.0	1.0 to 2.0	3.25×10^{-3}	0.055	0.945	0.92×10^{-4}
50A	20.0	2.0-4.0	1.82×10^{-3}	0.043	0.905	0.40×10^{-4}
50A	20.0	4.0 to 8.0	2.76×10^{-3}	0.023	0.816	0.35×10^{-4}

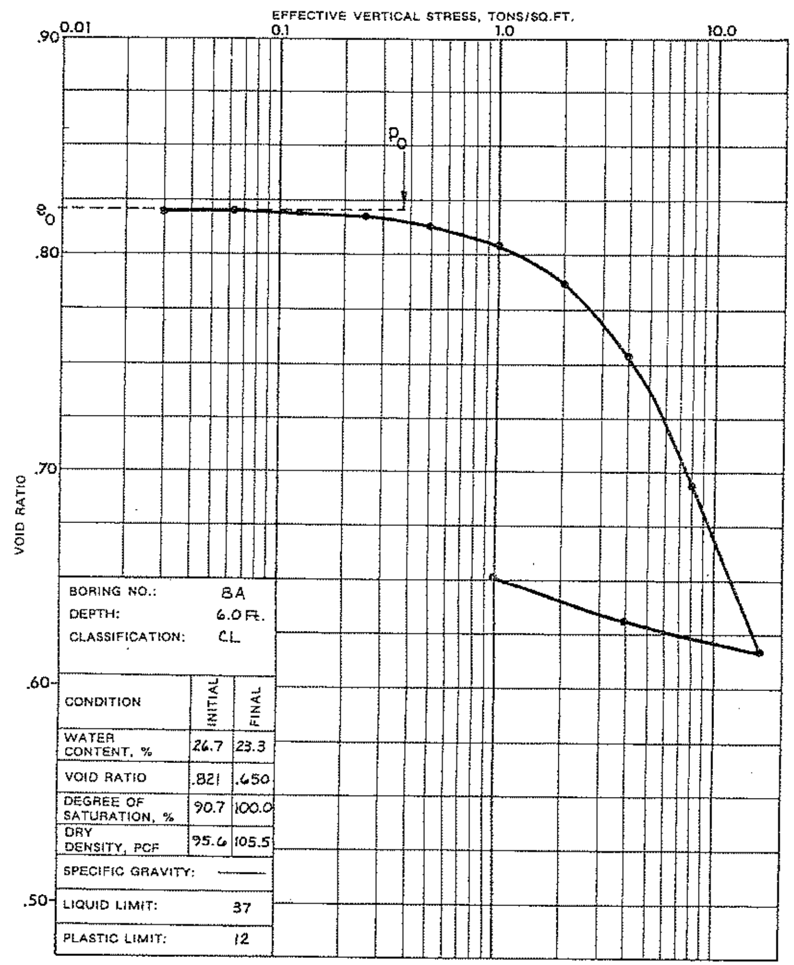


BORING NO.:	1 A
DEPTH:	8.5 Ft.
CLASSIFICATION:	CL

CONDITION	INITIAL	FINAL
WATER CONTENT, %	27.8	22.6
VOID RATIO	.848	.630
DEGREE OF SATURATION, %	91.4	100.0
DRY DENSITY, PCF	94.3	106.8
SPECIFIC GRAVITY:	—	
LIQUID LIMIT:	37	
PLASTIC LIMIT:	25	

CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES CN-1

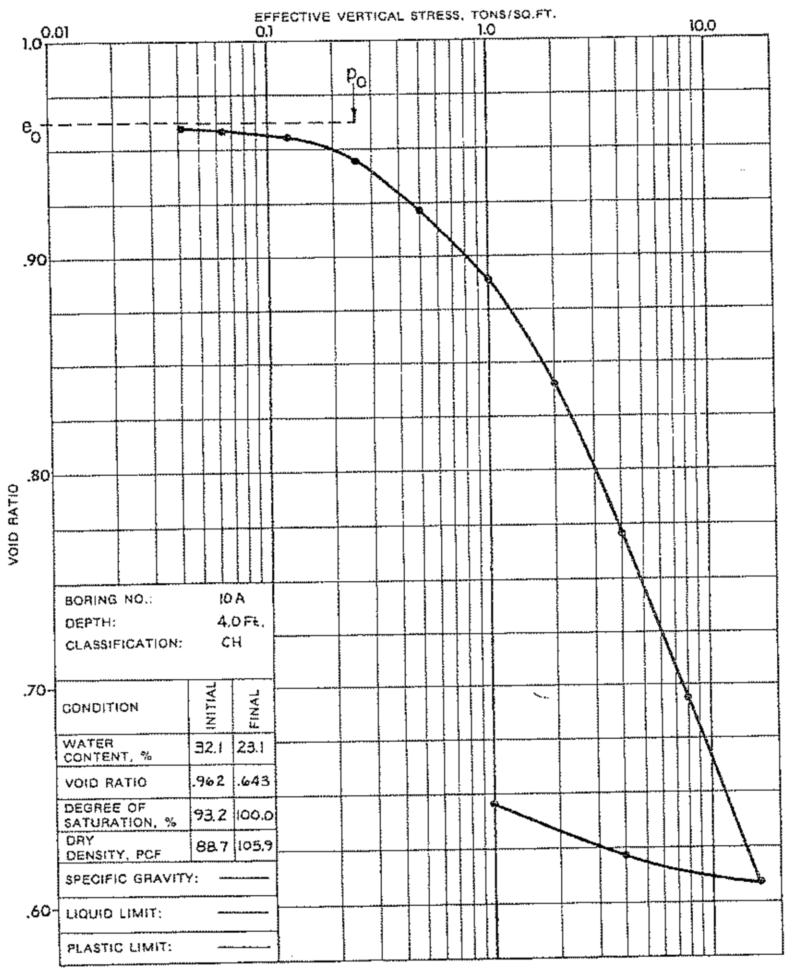


BORING NO.:	8A
DEPTH:	6.0 Ft.
CLASSIFICATION:	CL

CONDITION	INITIAL	FINAL
WATER CONTENT, %	26.7	23.3
VOID RATIO	.821	.650
DEGREE OF SATURATION, %	90.7	100.0
DRY DENSITY, PCF	95.6	105.5
SPECIFIC GRAVITY:	—	
LIQUID LIMIT:	37	
PLASTIC LIMIT:	12	

CONSOLIDATION TEST RESULTS

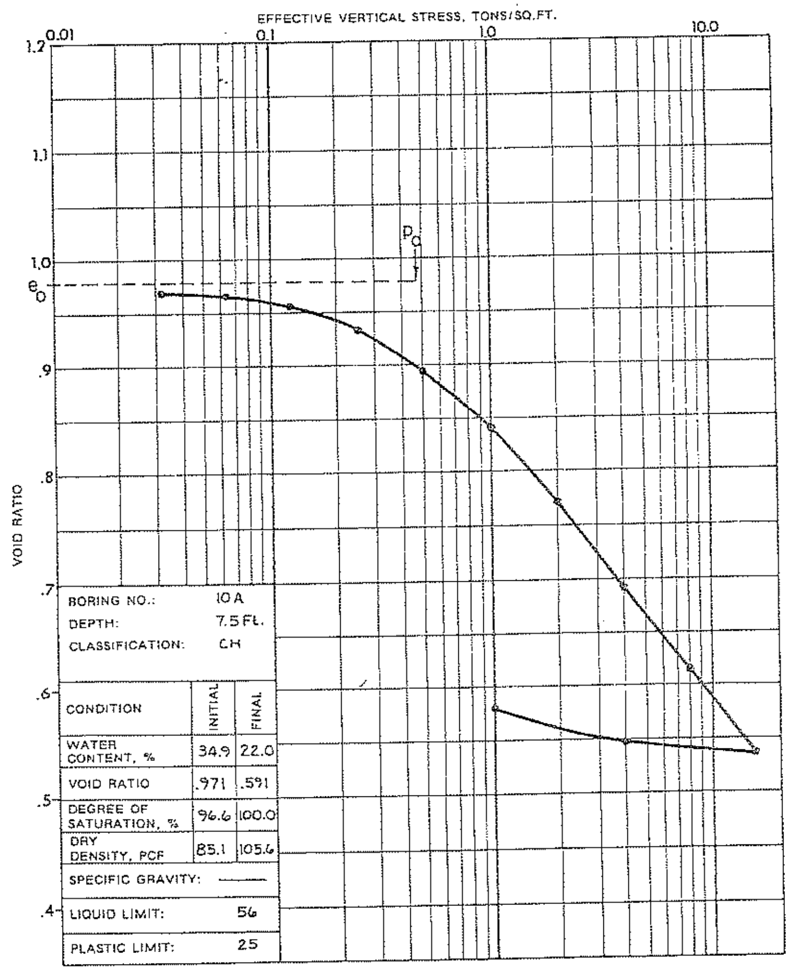
ATEC ASSOCIATES CN-1



BORING NO.:	10 A	
DEPTH:	4.0 Ft.	
CLASSIFICATION:	CH	
CONDITION	INITIAL	FINAL
WATER CONTENT, %	32.1	23.1
VOID RATIO	.962	.643
DEGREE OF SATURATION, %	93.2	100.0
DRY DENSITY, PCF	88.7	105.9
SPECIFIC GRAVITY:	——	
LIQUID LIMIT:	——	
PLASTIC LIMIT:	——	

CONSOLIDATION TEST RESULTS

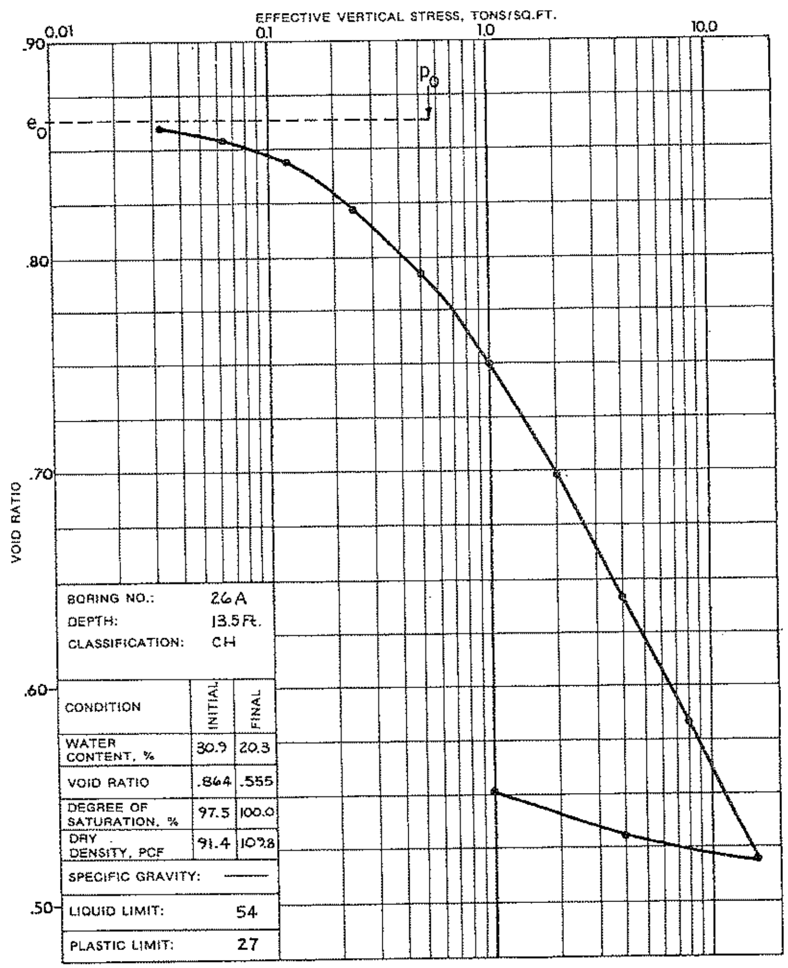
ATEC ASSOCIATES CN-1



BORING NO.:	10 A	
DEPTH:	7.5 Ft.	
CLASSIFICATION:	CH	
CONDITION	INITIAL	FINAL
WATER CONTENT, %	34.9	22.0
VOID RATIO	.971	.591
DEGREE OF SATURATION, %	96.6	100.0
DRY DENSITY, PCF	85.1	105.6
SPECIFIC GRAVITY:	——	
LIQUID LIMIT:	56	
PLASTIC LIMIT:	25	

CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES CN-1

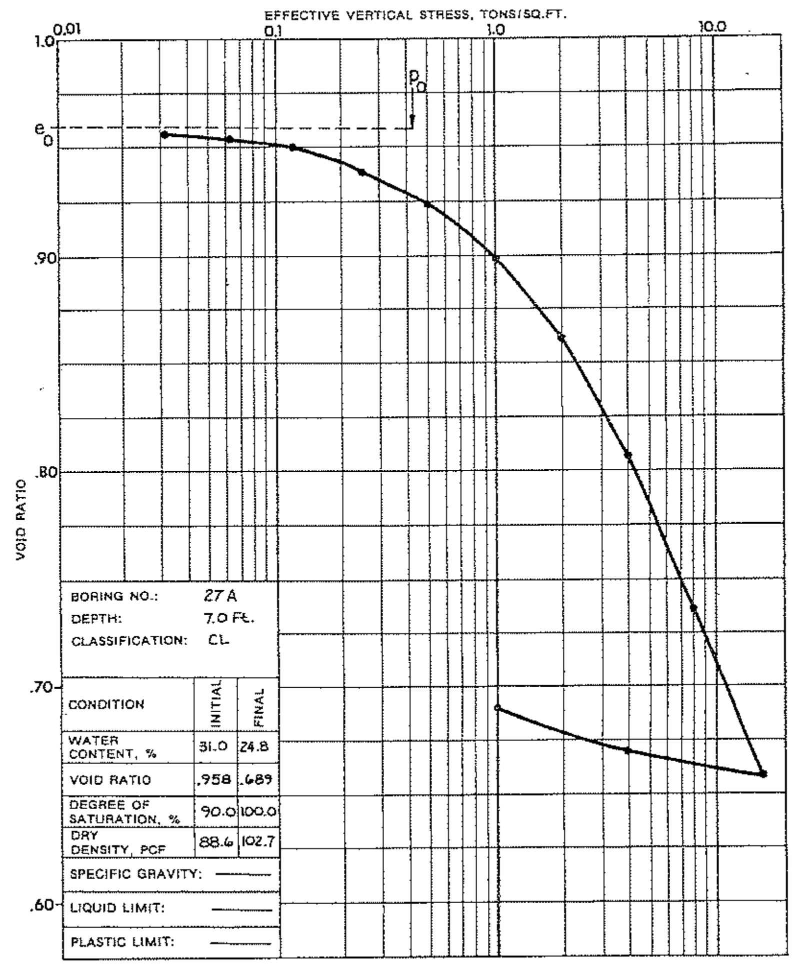


BORING NO.:	26A	
DEPTH:	13.5 Ft.	
CLASSIFICATION:	CH	
CONDITION	INITIAL	FINAL
WATER CONTENT, %	30.9	20.3
VOID RATIO	.864	.555
DEGREE OF SATURATION, %	97.5	100.0
DRY DENSITY, PCF	91.4	102.8
SPECIFIC GRAVITY:	——	
LIQUID LIMIT:	54	
PLASTIC LIMIT:	27	

CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES

CN-1

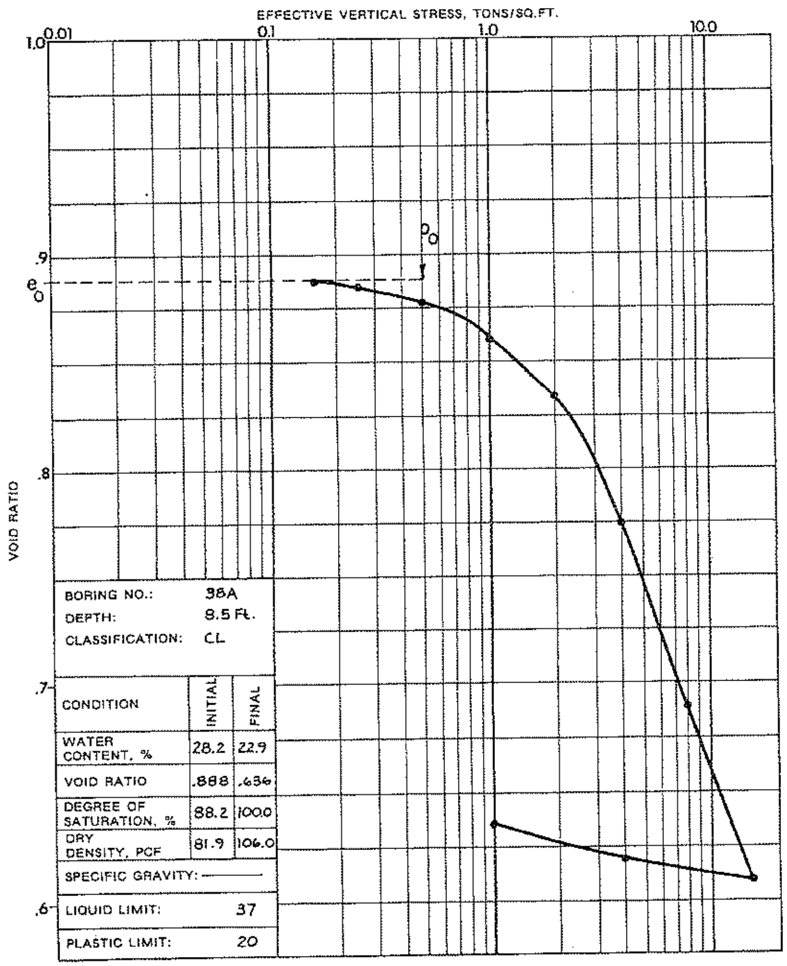


BORING NO.:	27A	
DEPTH:	7.0 Ft.	
CLASSIFICATION:	CL	
CONDITION	INITIAL	FINAL
WATER CONTENT, %	31.0	24.8
VOID RATIO	.958	.689
DEGREE OF SATURATION, %	90.0	100.0
DRY DENSITY, PCF	88.6	102.7
SPECIFIC GRAVITY:	——	
LIQUID LIMIT:	——	
PLASTIC LIMIT:	——	

CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES

CN-1



BORING NO.: 38A
DEPTH: 8.5 Ft.
CLASSIFICATION: CL

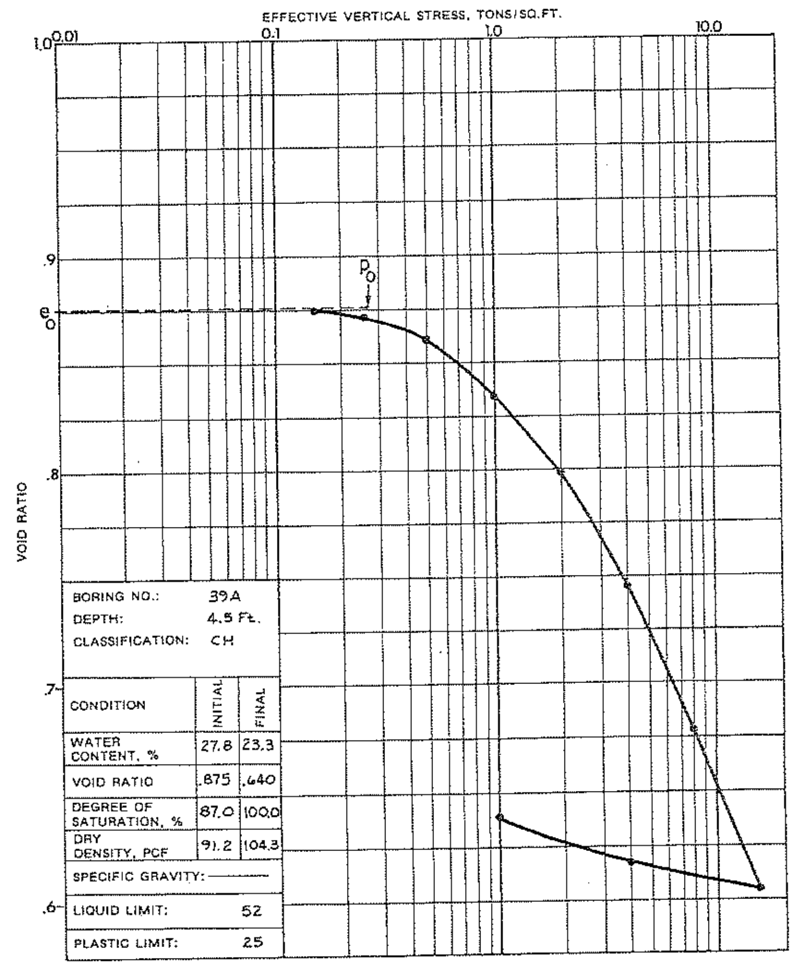
CONDITION	INITIAL	FINAL
WATER CONTENT, %	28.2	22.9
VOID RATIO	.888	.636
DEGREE OF SATURATION, %	88.2	100.0
DRY DENSITY, PCF	81.9	106.0

SPECIFIC GRAVITY: ——
LIQUID LIMIT: 37
PLASTIC LIMIT: 20

CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES

CN-1



BORING NO.: 39A
DEPTH: 4.5 Ft.
CLASSIFICATION: CH

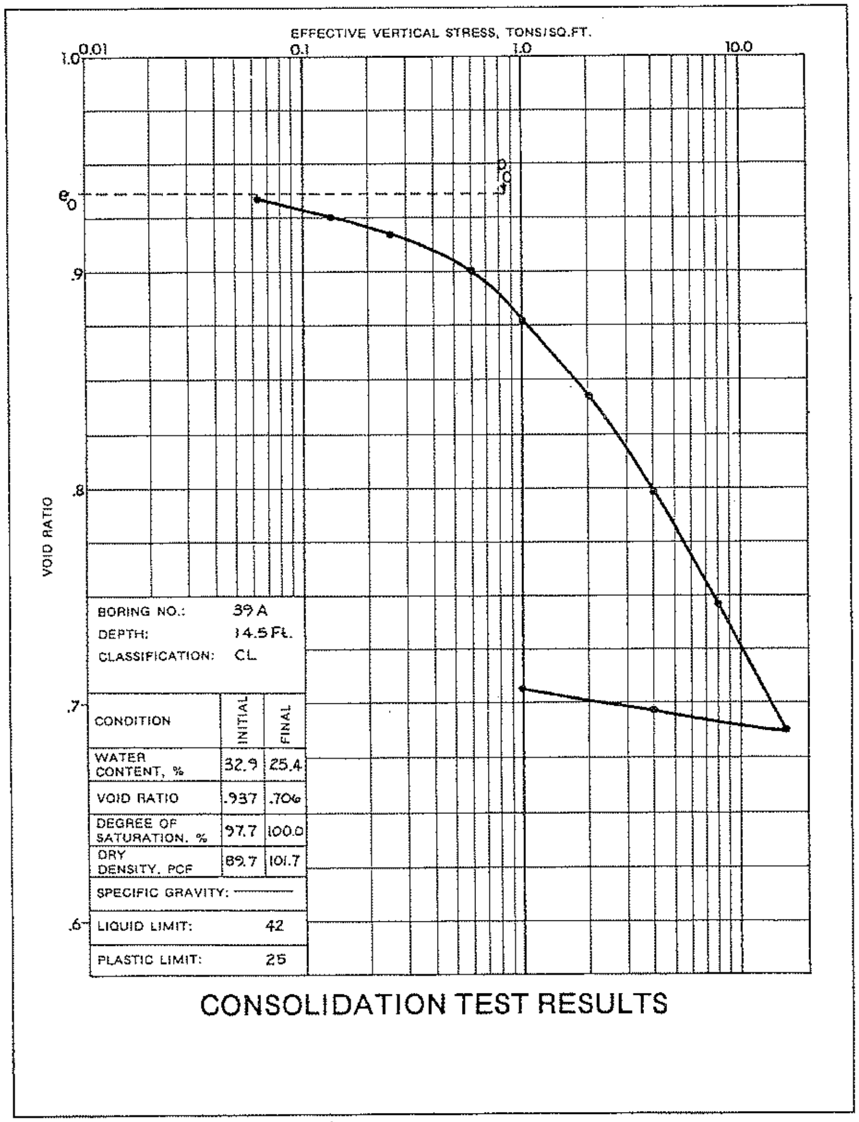
CONDITION	INITIAL	FINAL
WATER CONTENT, %	27.8	23.3
VOID RATIO	.875	.640
DEGREE OF SATURATION, %	87.0	100.0
DRY DENSITY, PCF	91.2	104.3

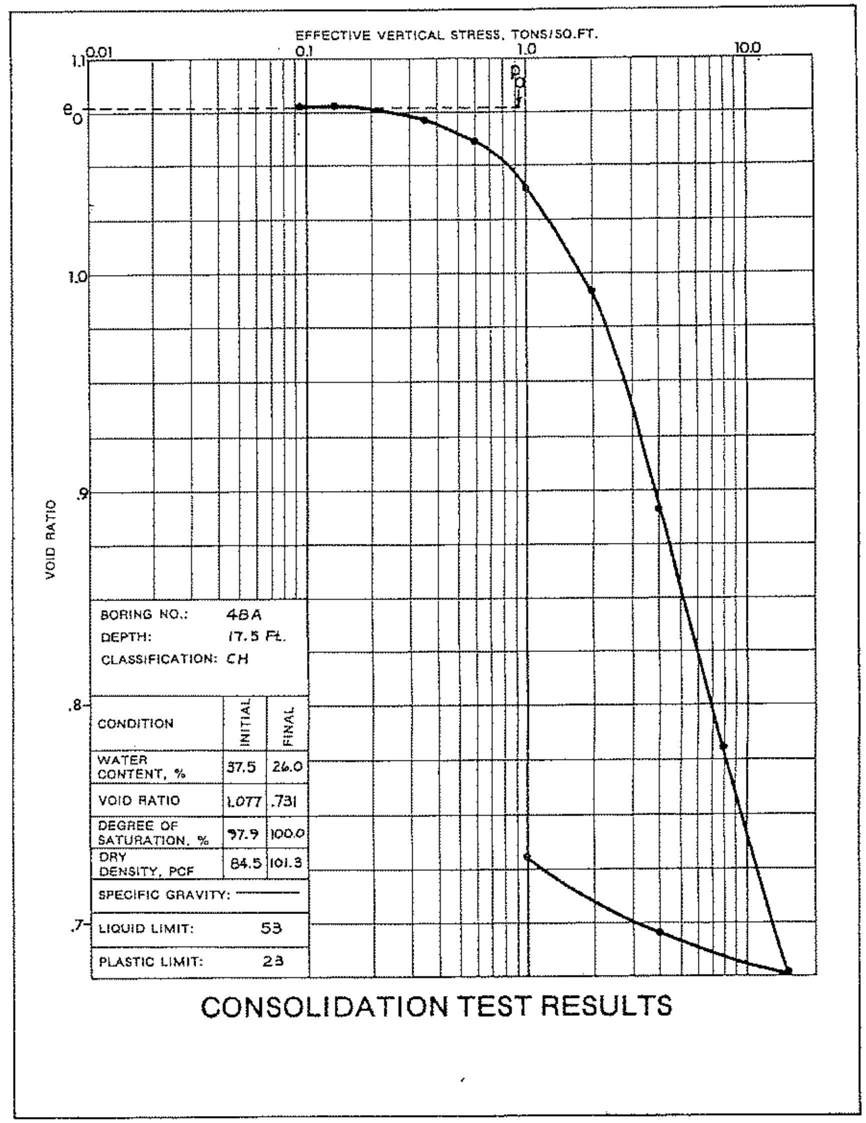
SPECIFIC GRAVITY: ——
LIQUID LIMIT: 52
PLASTIC LIMIT: 25

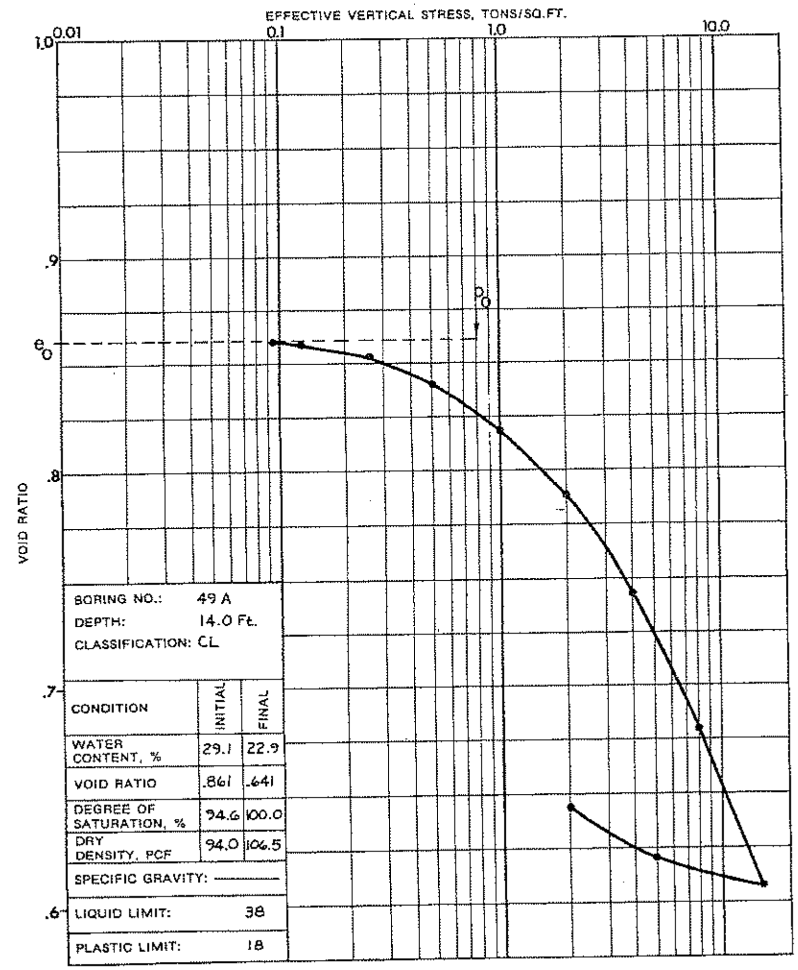
CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES

CN-1

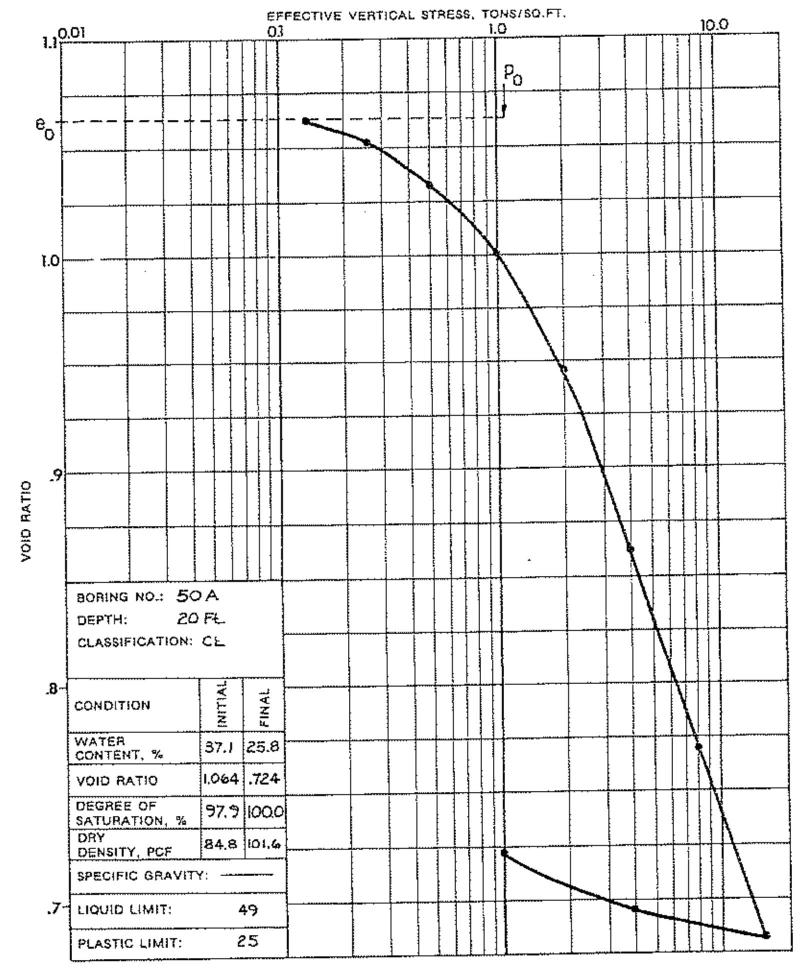

EFFECTIVE VERTICAL STRESS, TONS/SQ.FT.
0.01
0.1
1.0
10.0
VOID RATIO
1.0
.9
.8
.7
.6
e_0
P_0
BORING NO.: 39 A
DEPTH: 14.5 Ft.
CLASSIFICATION: CL
CONDITION | INITIAL | FINAL
WATER CONTENT, % | 32.9 | 25.4
VOID RATIO | .937 | .706
DEGREE OF SATURATION, % | 97.7 | 100.0
DRY DENSITY, PCF | 89.7 | 101.7
SPECIFIC GRAVITY: ———
LIQUID LIMIT: 42
PLASTIC LIMIT: 25
CONSOLIDATION TEST RESULTS
ATEC ASSOCIATES
CN-1


EFFECTIVE VERTICAL STRESS, TONS/SQ.FT.
0.01
0.1
1.0
10.0
VOID RATIO
1.1
1.0
.9
.8
.7
e_0
P_0
BORING NO.: 48A
DEPTH: 17.5 Ft.
CLASSIFICATION: CH
CONDITION | INITIAL | FINAL
WATER CONTENT, % | 37.5 | 26.0
VOID RATIO | 1.077 | .731
DEGREE OF SATURATION, % | 97.9 | 100.0
DRY DENSITY, PCF | 84.5 | 101.3
SPECIFIC GRAVITY: ———
LIQUID LIMIT: 53
PLASTIC LIMIT: 23
CONSOLIDATION TEST RESULTS
ATEC ASSOCIATES
CN-1



CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES CN-1



CONSOLIDATION TEST RESULTS

ATEC ASSOCIATES CN-1

APPENDIX E

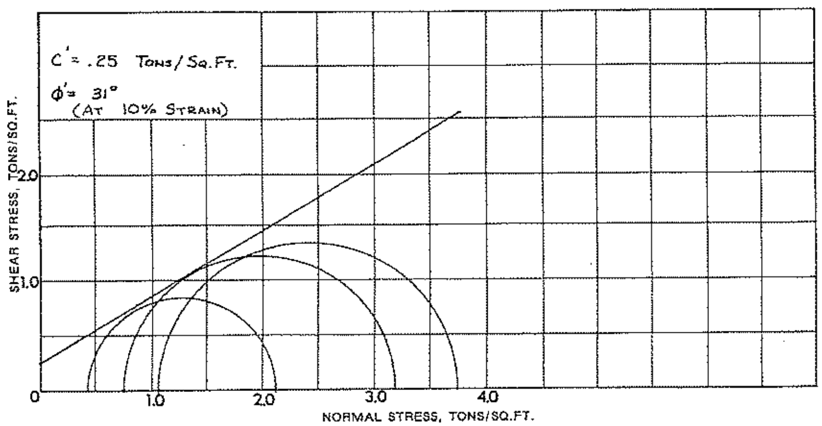
TRIAXIAL TESTS

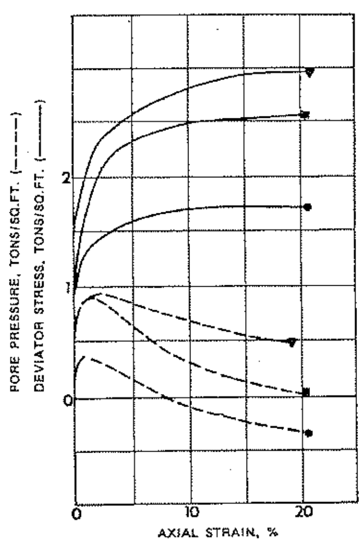
Ottumwa Generating Station-Unit 1
(E-7566)

Table E-1 SUMMARY OF CONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS

Boring No.	Depth, ft	c' kg/cm^2	ø' degrees	Effective Confining Pressures tsf	Dry Densities, lbs/cu.ft	% Final Water Contents	Strain Rate %/min
9A	13.0-14.5	0.25	31	.35	101.2	26.2	
				1.06	107.7	20.4	1.0
				1.76	101.1	23.8	
10A	5.0-7.0	0.30	34.5	1.41	94.4	25.8	1.0
				1.82	91.6	27.0	
10A	7.0-9.0	0.30	29	1.06	91.3	27.7	
				2.11	88.1	28.5	1.0
				3.17	96.3	22.8	
18A	19.0-21.0	0.20	34	0.70	107.8	22.2	
				1.41	104.5	19.9	0.5
				2.11	105.7	21.3	
39A	13.0-15.0	0	34	1.06	89.1	30.0	
				2.11	82.9	29.4	.074
				3.17	90.0	27.1	
43A	18.0-20.0	0.3	31	0.35	104.1	23.6	
				1.06	105.3	22.3	0.5
				1.76	105.0	21.6	
48A	16.0-17.9	0	31	1.06	88.3	31.0	
				2.11	88.1	28.9	.071
				3.17	85.2	30.2	
32A *	0.0-7.0	0	40	0.70	109.2	23.1	.071
				1.41	109.6	21.5	
				2.11	109.7	22.0	

* Samples recompacted from disturbed bag sample to approximately 95 percent of modified Proctor maximum dry density.

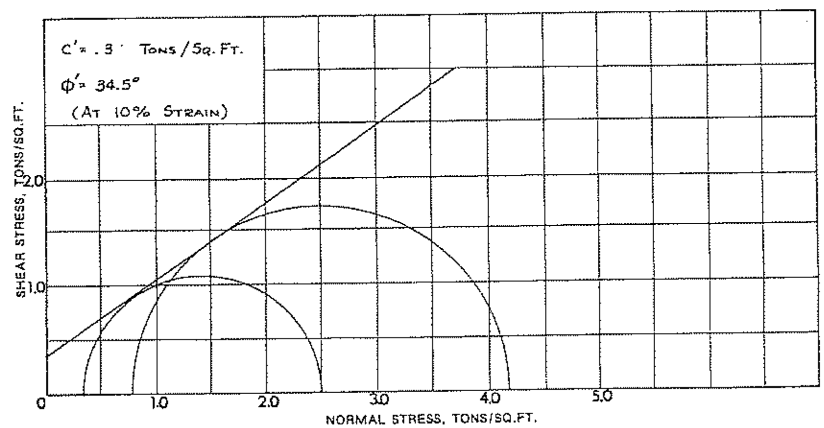


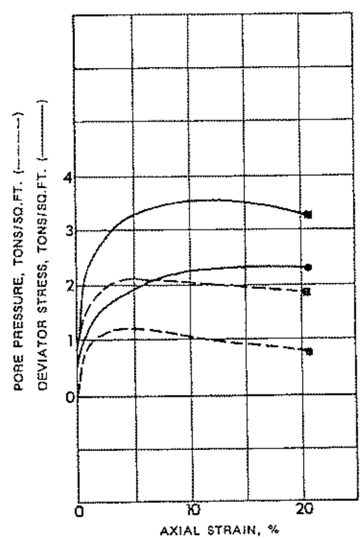


PROJECT NO.: E-7566					
BORING NO.: 9A		DEPTH: 13.0-14.5			
LIQUID LIMIT: ——		PLASTIC LIMIT: ——			
SOIL CLASSIFICATION: CH					
TYPE OF TEST: Consolidation - Undrained					
RATE OF STRAIN: 1.0 % / Min.					
TEST DESIGNATION		●	■	▼	○
INITIAL	WATER CONTENT, %	24.9	21.0	24.9	
	DRY DENSITY, PCF	101.2	107.7	101.1	
	SAMPLE HEIGHT, IN.	2.80	2.80	2.80	
	SAMPLE DIAMETER, IN.	1.40	1.40	1.40	
FINAL BACK PRESSURE, TSF		1.97	4.08	1.62	
TOTAL CONSOLIDATION PRESSURE, TSF		2.32	5.14	3.38	
EFFECTIVE CONFINING PRESSURE, TSF		0.35	1.06	1.76	
FINAL WATER CONTENT, %		26.2	20.4	23.8	
REMARKS:					

TRIAXIAL TEST RESULTS

ATEC ASSOCIATES TX-1

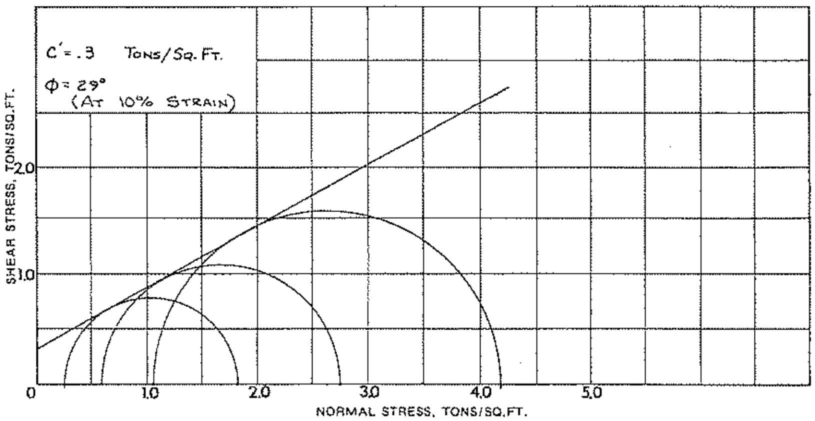


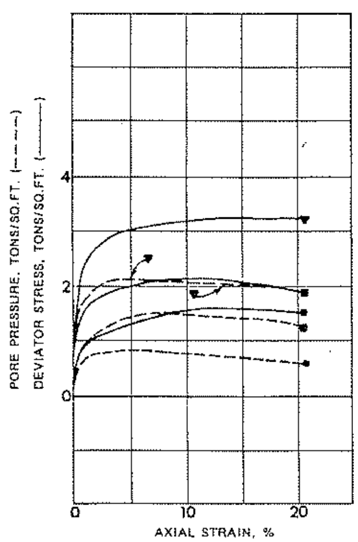


PROJECT NO.: E-7566					
BORING NO.: 10A		DEPTH: 5.0-7.0			
LIQUID LIMIT: 56		PLASTIC LIMIT: 25			
SOIL CLASSIFICATION: CH					
TYPE OF TEST: Consolidated - Undrained					
RATE OF STRAIN: 1.0 % / Min.					
TEST DESIGNATION		●	■	▼	○
INITIAL	WATER CONTENT, %	28.5	30.7		
	DRY DENSITY, PCF	94.4	91.6		
	SAMPLE HEIGHT, IN.	2.80	2.80		
	SAMPLE DIAMETER, IN.	1.40	1.40		
FINAL BACK PRESSURE, TSF		1.62	1.97		
TOTAL CONSOLIDATION PRESSURE, TSF		3.03	4.79		
EFFECTIVE CONFINING PRESSURE, TSF		1.41	2.82		
FINAL WATER CONTENT, %		25.8	27.0		
REMARKS:					

TRIAXIAL TEST RESULTS

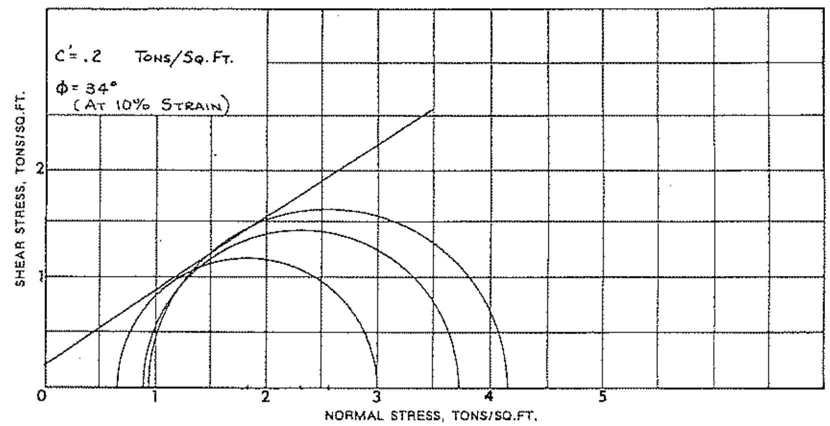
ATEC ASSOCIATES TX-1

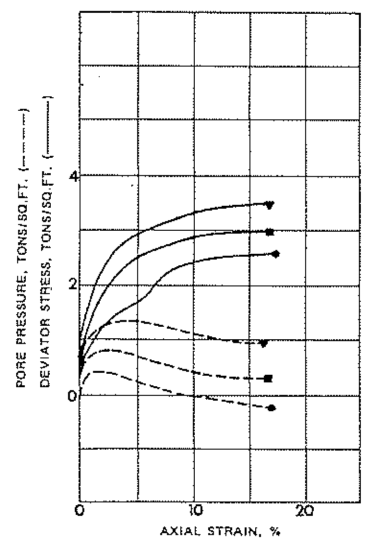




PROJECT NO.: E-7566					
BORING NO.: 10 A		DEPTH: 7.0 - 9.0			
LIQUID LIMIT: 56		PLASTIC LIMIT: 25			
SOIL CLASSIFICATION: CH					
TYPE OF TEST: Consolidated - Undrained					
RATE OF STRAIN: 1.0 %/Min.					
TEST DESIGNATION		●	■	▼	○
INITIAL	WATER CONTENT, %	32.1	32.7	27.5	
	DRY DENSITY, PCF	91.3	88.1	96.3	
	SAMPLE HEIGHT, IN.	2.80	2.80	2.80	
	SAMPLE DIAMETER, IN.	1.40	1.40	1.40	
FINAL BACK PRESSURE, TSF		2.32	2.68	1.62	
TOTAL CONSOLIDATION PRESSURE, TSF		3.38	4.79	4.79	
EFFECTIVE CONFINING PRESSURE, TSF		1.06	2.11	3.17	
FINAL WATER CONTENT, %		27.7	28.5	22.8	
REMARKS:					

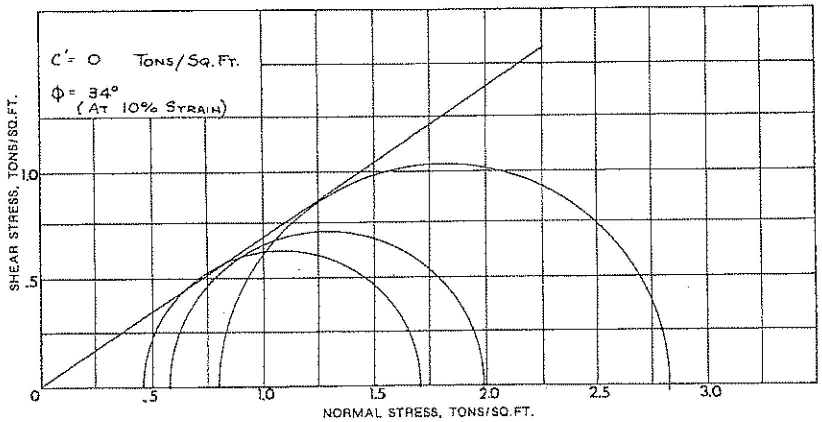
TRIAXIAL TEST RESULTS

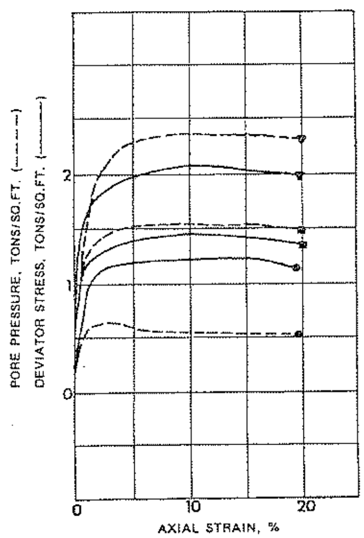




PROJECT NO.: E-7566					
BORING NO.: 18 A		DEPTH: 19.0 - 21.0			
LIQUID LIMIT: 47		PLASTIC LIMIT: 24			
SOIL CLASSIFICATION: CL					
TYPE OF TEST: Consolidated - Undrained					
RATE OF STRAIN: 0.5%/Min.					
TEST DESIGNATION		●	■	▼	○
INITIAL	WATER CONTENT, %	20.6	23.0	20.9	
	DRY DENSITY, PCF	107.8	104.5	105.7	
	SAMPLE HEIGHT, IN.	5.60	5.60	5.60	
	SAMPLE DIAMETER, IN.	2.86	2.87	2.87	
FINAL BACK PRESSURE, TSF		1.62	1.62	2.68	
TOTAL CONSOLIDATION PRESSURE, TSF		2.32	3.03	4.79	
EFFECTIVE CONFINING PRESSURE, TSF		0.70	1.41	2.11	
FINAL WATER CONTENT, %		22.2	19.9	21.3	
REMARKS:					

TRIAXIAL TEST RESULTS



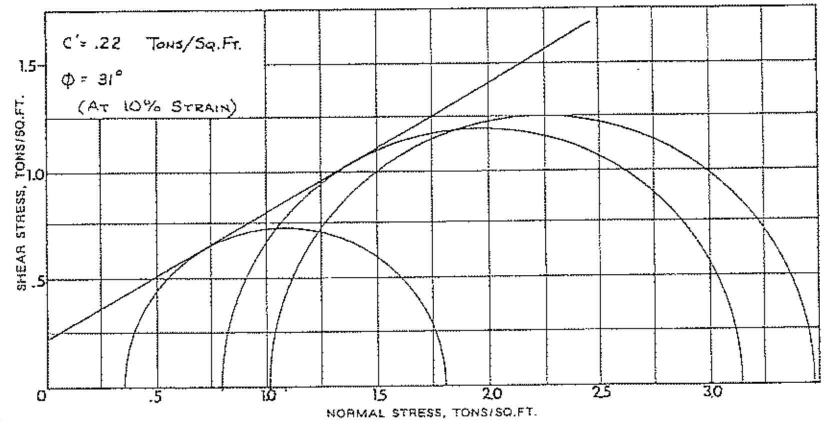


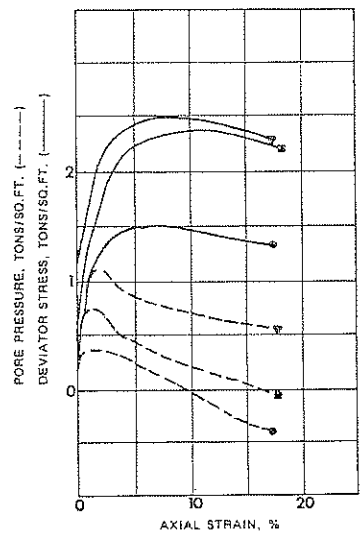
PROJECT NO.: E-7566				
BORING NO.: 39A	DEPTH: 13.0 - 15.0			
LIQUID LIMIT: 42	PLASTIC LIMIT: 25			
SOIL CLASSIFICATION: CL				
TYPE OF TEST: CONSOLIDATED - UNDRAINED				
RATE OF STRAIN: 0.074% / MIN.				
TEST DESIGNATION	●	■	▼	○
INITIAL — WATER CONTENT, %	32.8	38.4	33.9	
INITIAL — DRY DENSITY, PCF	89.1	82.9	90.0	
INITIAL — SAMPLE HEIGHT, IN.	2.80	2.80	2.80	
INITIAL — SAMPLE DIAMETER, IN.	1.40	1.40	1.40	
FINAL BACK PRESSURE, TSF	1.97	1.27	1.62	
TOTAL CONSOLIDATION PRESSURE, TSF	3.03	3.38	4.79	
EFFECTIVE CONFINING PRESSURE, TSF	1.06	2.11	3.17	
FINAL WATER CONTENT, %	30.0	29.4	27.1	
REMARKS:				

TRIAXIAL TEST RESULTS

ATEC ASSOCIATES

TX-1



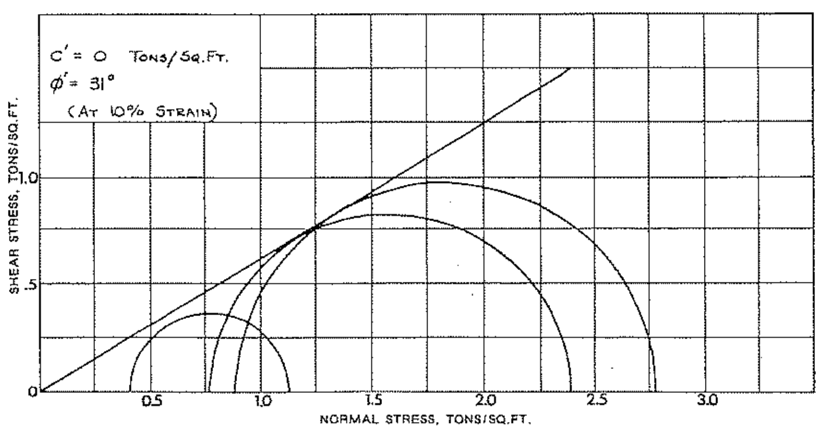


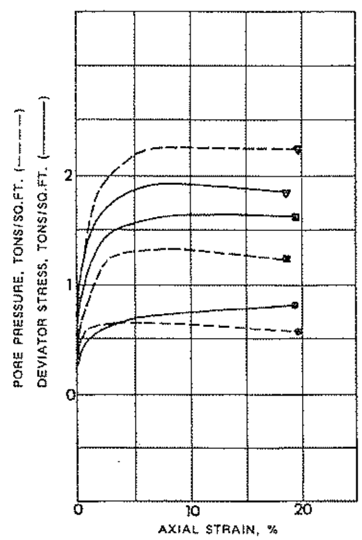
PROJECT NO.: E-7566				
BORING NO.: 43A	DEPTH: 18.0 - 20.0			
LIQUID LIMIT: 32	PLASTIC LIMIT: 15			
SOIL CLASSIFICATION: CL				
TYPE OF TEST: CONSOLIDATED - UNDRAINED				
RATE OF STRAIN: 0.5% / MIN.				
TEST DESIGNATION	●	■	▼	○
INITIAL — WATER CONTENT, %	22.2	22.2	21.1	
INITIAL — DRY DENSITY, PCF	104.1	105.0	105.3	
INITIAL — SAMPLE HEIGHT, IN.	5.60	5.37	5.60	
INITIAL — SAMPLE DIAMETER, IN.	2.87	2.87	2.86	
FINAL BACK PRESSURE, TSF	1.27	1.97	2.32	
TOTAL CONSOLIDATION PRESSURE, TSF	1.62	3.03	4.06	
EFFECTIVE CONFINING PRESSURE, TSF	0.35	1.06	1.76	
FINAL WATER CONTENT, %	23.6	22.3	21.6	
REMARKS:				

TRIAXIAL TEST RESULTS

ATEC ASSOCIATES

TX-1



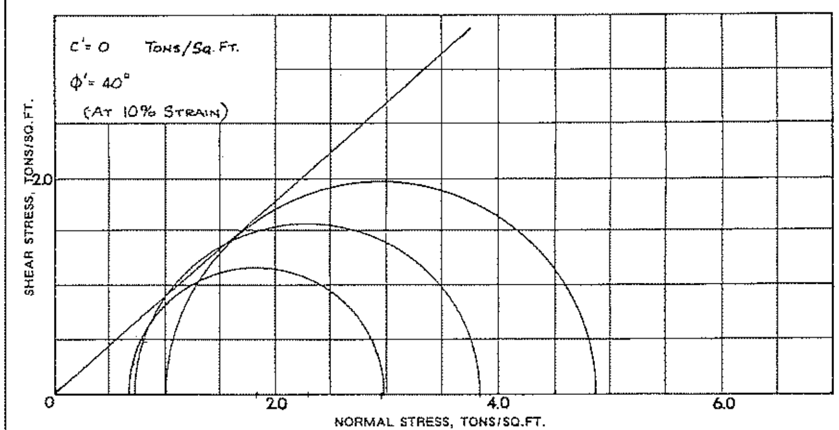


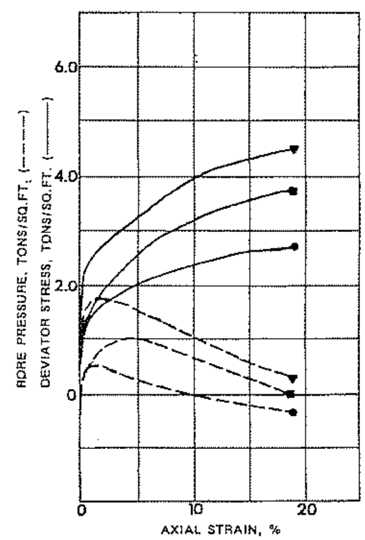
PROJECT NO.: E-7566				
BORING NO.: 48A	DEPTH: 16.0-17.9			
LIQUID LIMIT: 53	PLASTIC LIMIT: 23			
SOIL CLASSIFICATION: CH				
TYPE OF TEST: Consolidated-Undrained				
RATE OF STRAIN: 0.071%/Min.				

TEST DESIGNATION	●	■	▼	○
INITIAL WATER CONTENT, %	33.4	33.4	36.3	
INITIAL DRY DENSITY, PCF	88.3	88.1	85.2	
INITIAL SAMPLE HEIGHT, IN.	2.80	2.80	2.80	
INITIAL SAMPLE DIAMETER, IN.	1.40	1.40	1.40	
FINAL BACK PRESSURE, TSF	1.62	2.32	2.32	
TOTAL CONSOLIDATION PRESSURE, TSF	2.68	4.43	5.49	
EFFECTIVE CONFINING PRESSURE, TSF	1.06	2.11	3.17	
FINAL WATER CONTENT, %	31.0	28.9	30.2	

REMARKS:

TRIAXIAL TEST RESULTS





PROJECT NO.: E-7566				
BORING NO.: 32	DEPTH: 0-7.0 *			
LIQUID LIMIT: —	PLASTIC LIMIT: —			
SOIL CLASSIFICATION: CL				
TYPE OF TEST: Consolidated - Undrained				
RATE OF STRAIN: 0.07%/Min.				

TEST DESIGNATION	●	■	▼	○
INITIAL WATER CONTENT, %	19.5	19.5	19.5	
INITIAL DRY DENSITY, PCF	109.2	109.6	109.7	
INITIAL SAMPLE HEIGHT, IN.	2.80	2.80	2.80	
INITIAL SAMPLE DIAMETER, IN.	1.40	1.40	1.40	
FINAL BACK PRESSURE, TSF	2.32	3.38	4.44	
TOTAL CONSOLIDATION PRESSURE, TSF	3.02	4.79	6.55	
EFFECTIVE CONFINING PRESSURE, TSF	0.70	1.41	2.11	
FINAL WATER CONTENT, %	23.1	21.5	22.0	

REMARKS: * Sample Recompacted From Disturbed Bag Sample To Approx. 95% Of Modified Proctor Maximum Dry Density.

TRIAXIAL TEST RESULTS

Ottumwa Generating Station-Unit 1
(E-7566)

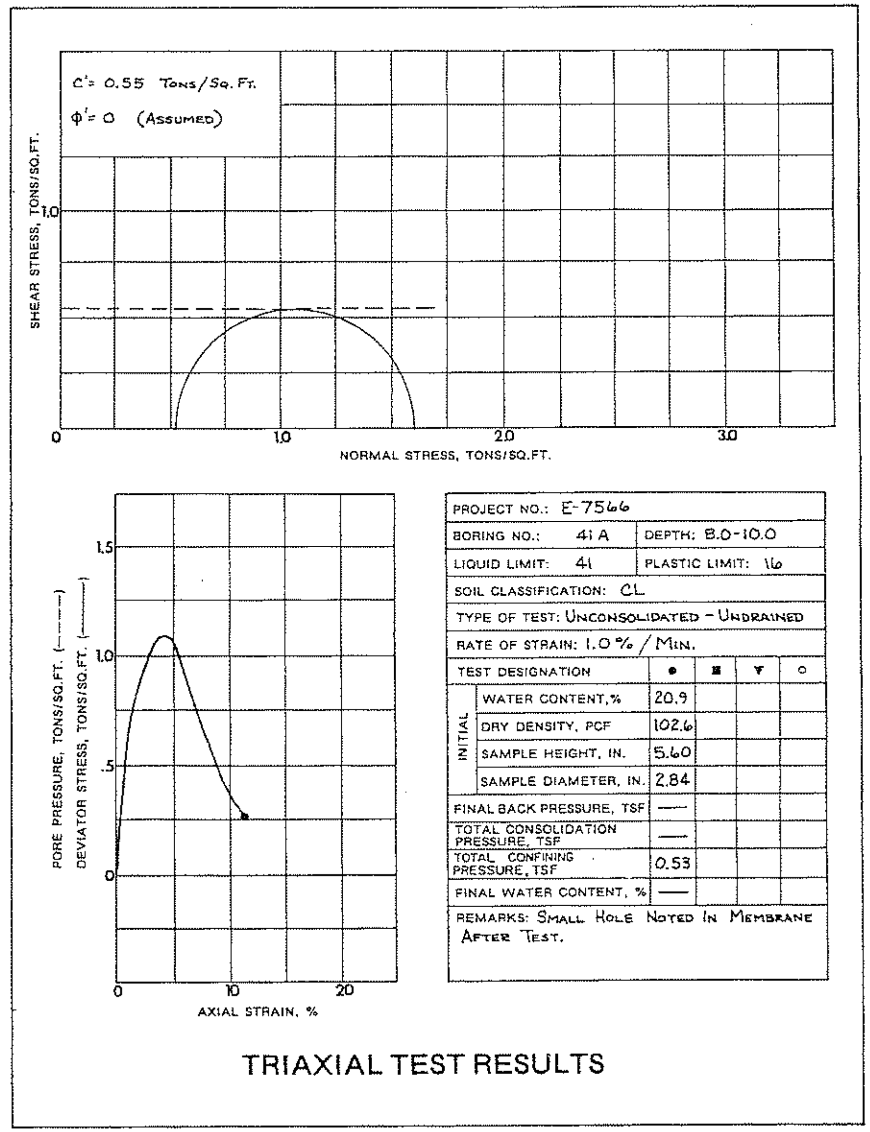
Table E-2 SUMMARY OF UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS

Boring No.	Depth, ft	Total Confining Pressure, tsf	Dry Density, lbs/cu.ft	Moisture Content, %	c (For Ø=0), tons/sq.ft	Remarks
41A	8.0-10.0	0.53	102.6	20.9	0.55	Small hole noted in membrane after test
43A	8.0-10.0	0.53	98.1	25.6	0.54	
45A	9.0-11.0	0.60	113.1	16.9	1.05	
46A	18.0-19.9	0.95	96.8	26.6	0.56	
50A	19.0-21.0	0.90	88.6	34.1	0.37	
32	0.0-7.0	1.41	104.6	19.3	0.85	Sample recompacted from disturbed Bag Sample at approx. 90% of modified Proctor maximum dry density
32	0.0-7.0	1.41	109.5	14.9	8.85 *	Sample recompacted from disturbed Bag Sample at approx. 95% of modified Proctor maximum dry density
32	0.0-7.0	1.41	108.5	20.1	3.38 **	Sample recompacted from disturbed Bag Sample at approx. 95% of modified Proctor maximum dry density

Note: All tests performed at a strain rate of approximately 1.0 percent per minute.

* Unconfined compressive strength for similarly recompacted sample - 10.49 tons/sq.ft

** Unconfined compressive strength for similarly recompacted sample - 5.37 tons/sq.ft



ATEC ASSOCIATES TX-1

EXHIBIT C – CONVERSION OF BLOWCOUNT TO SOIL STRENGTH

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination

nt and procedure

ocedure of ASTM D-1586
revisions:
th 20-in.-long split bar-
g 30 blows per foot, 12-
of drive is permissible.
ch 6 in. of penetration.
ith water or drilling

s pumped from a central
d while the drawdown or
g from the well is ob-
piezometers or obser-
le 3 to 5 observation
easing intervals along
arated by 90° central

is raised or lowered
position and readings
vels at periodic inter-
equilibrium. Observa-
ead and time elapsed
n in Figure 4-3.

cased, open-end bore-
orehole with double
ch water flows out of
constant head is meas-
and procedures of

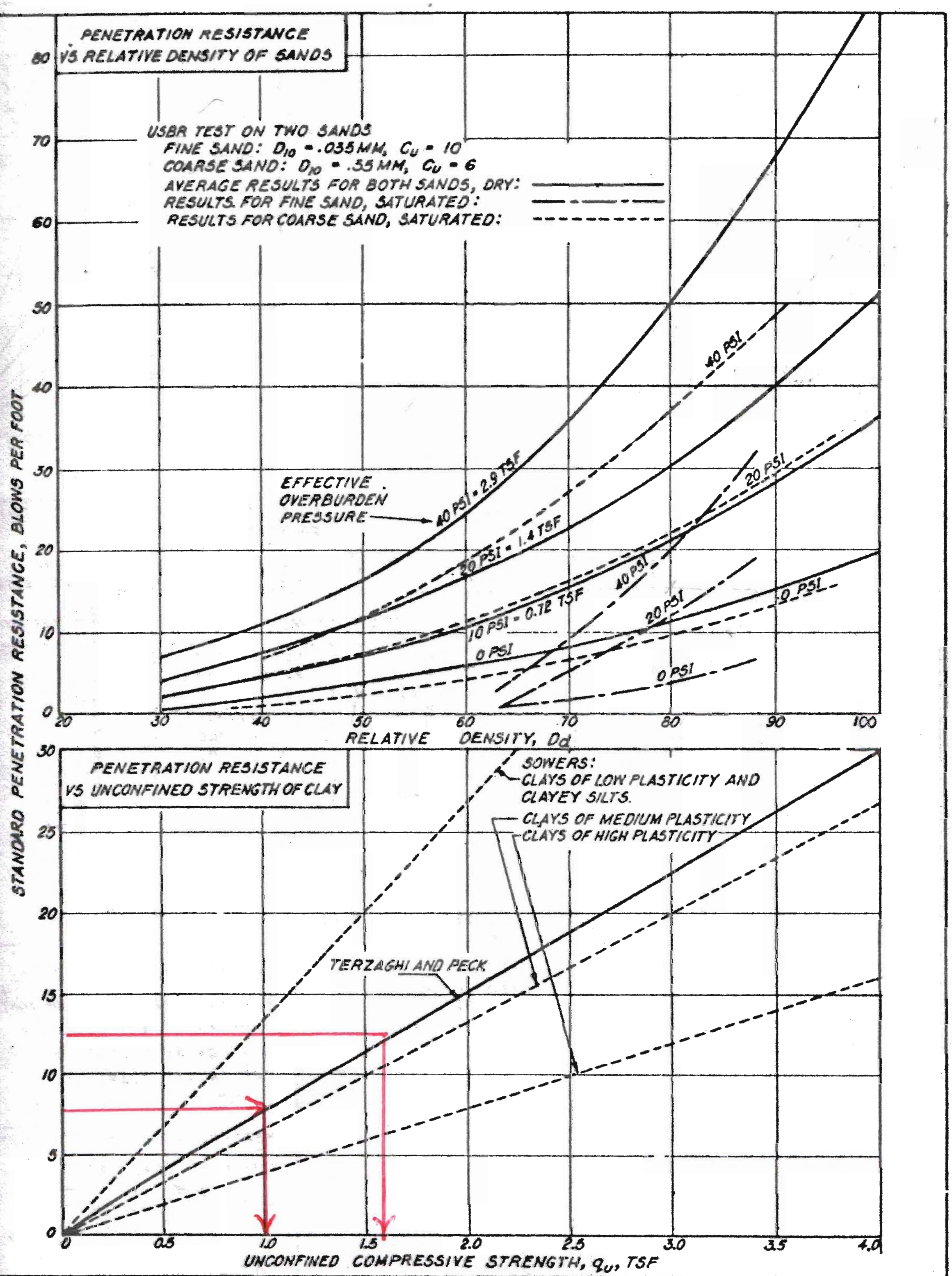
ws out of the uncased
taining a constant wa-
Use equipment and
ethod E-19.

sture content of soil
avated hole is deter-
me of hole by sand
uipment and proce-
0-45-302, Appendix

sture content is deter-
ed from a thin-wall
pressed into the
nd procedure of USCE
dix III.

ncased boreholes.

hole to determine
ctangular test pits



NATIVE CLAY SPT 8
EMBANKMENT CLAY SPT 12

FIGURE 4-2
Correlations of Standard Penetration Resistance

isticated shear tests a
satisfactorily approxi-
ication (Table 1-3 and
ction can be obtained
the laboratory. As fo
l conditions, triaxial

disturbed samples pro-
en as one-half the unc
n made between uncon
t (Section 3, Chapter
y disturbed in samplin
further useful when th

se soils are not well f
load. A practical,
cohesion is substantia
can be treated as a
shear tests. The acti
minations. Where the
rformed under drainag
rine deposits, the
gth and its increase

nployed in determining
ohesionless soils.

t compaction control.
l borrow materials.

ed base course or a
us earthwork, when
isture content that,

t free draining cohesi
than those provided b
niversally accepted.

s classified in the

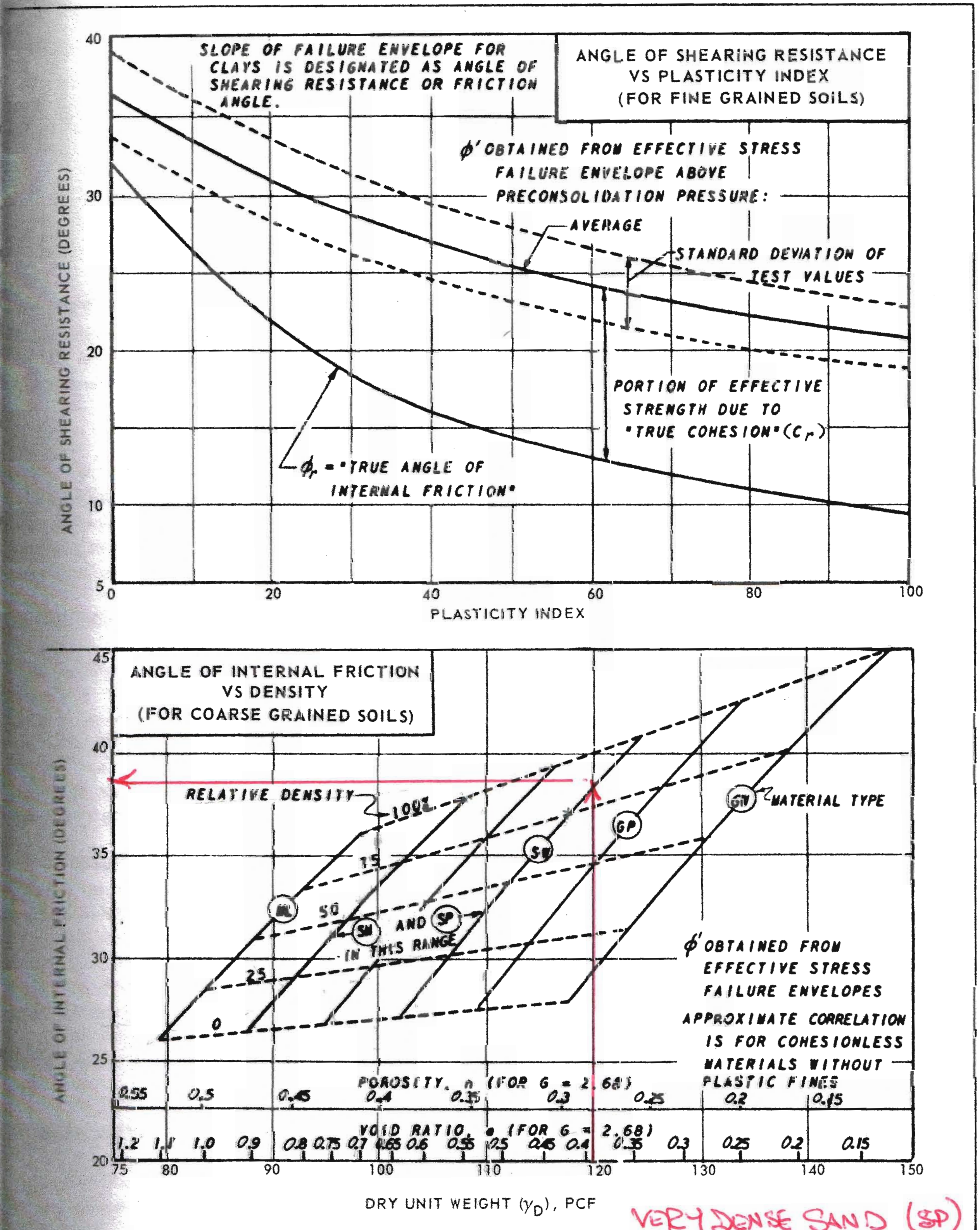


FIGURE 3-7

Correlations of Strength Characteristics

EXHIBIT D – BEDROCK MAPS

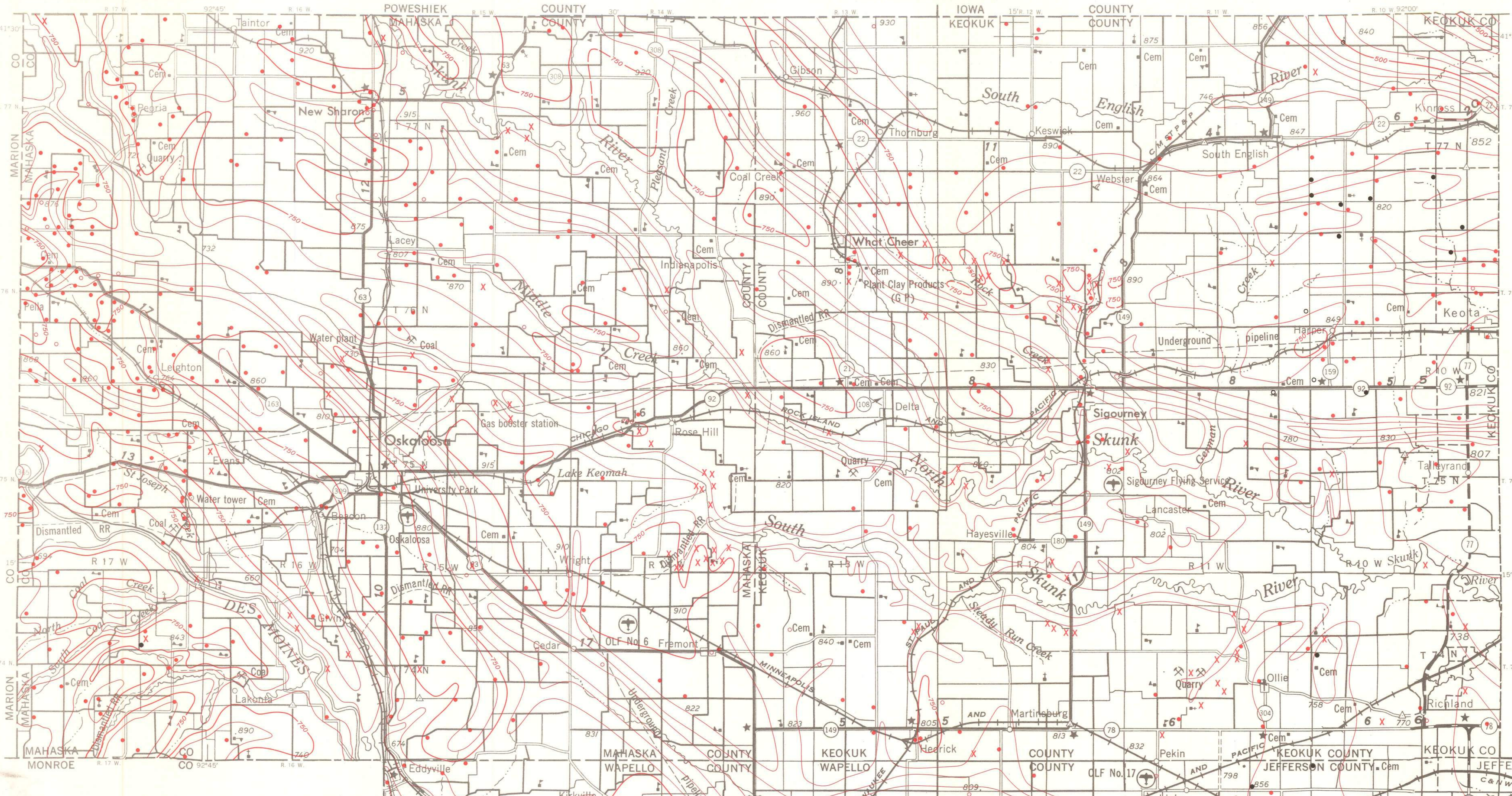
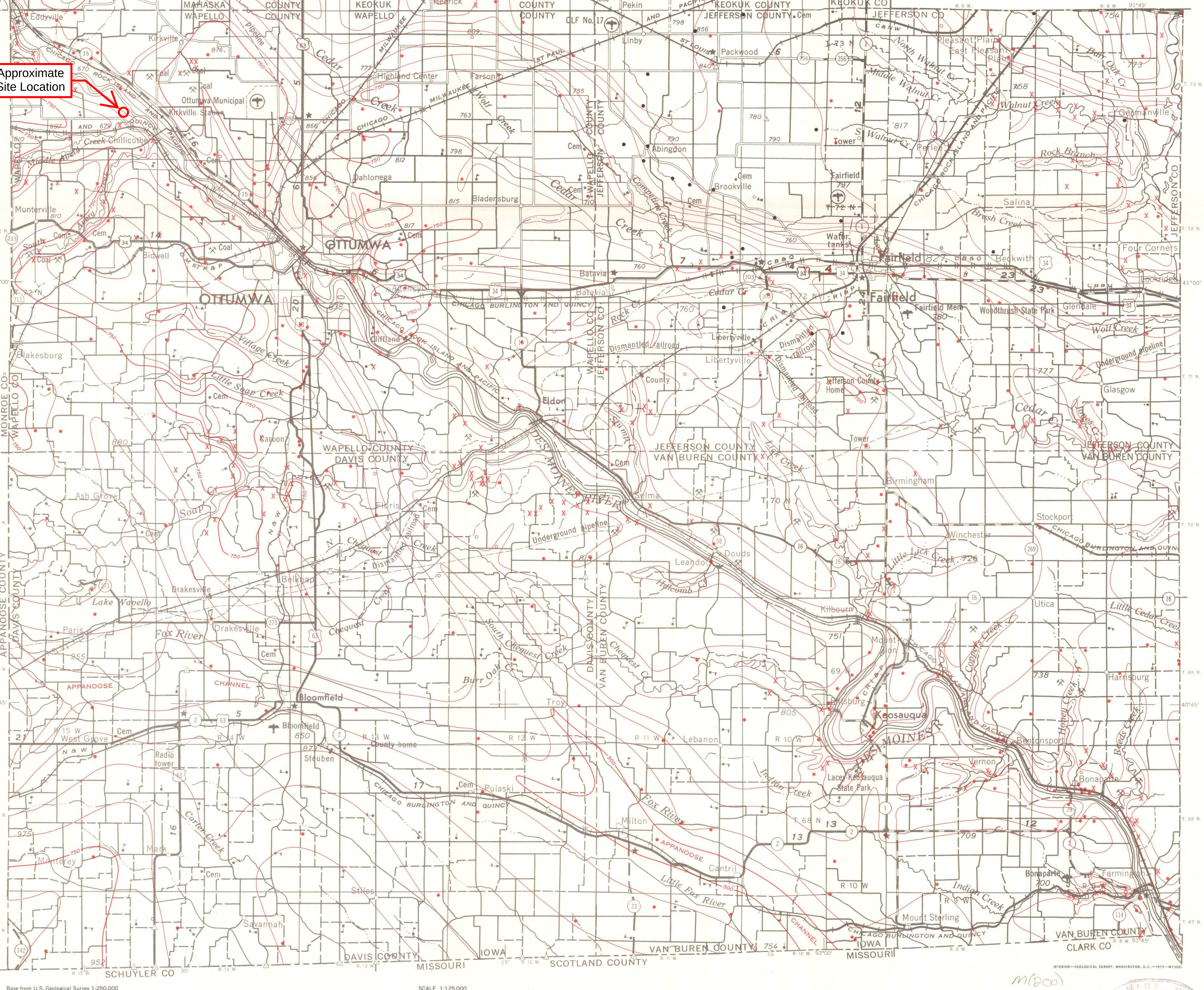
Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
IOWA GEOLOGICAL SURVEY

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-808 (SHEET 1 OF 2)

EXPLANATION

Log data
Bedrock penetrated

Log data
Bedrock not penetrated

Published data
Bedrock penetrated

Published data
Bedrock not penetrated

Quarry or outcrop

750

Bedrock contours
Show altitude of bedrock surface. Dashed where approximately located. Contour interval is 50 feet. Datum is mean sea level

INTRODUCTION

The bedrock in Iowa is covered nearly everywhere by unconsolidated deposits of glacial drift and alluvium, which range in thickness from less than 1 foot to more than 400 feet, and from less than 1 foot to about 60 feet, respectively. The configuration of the bedrock surface is the result of a complex system of ancient drainage courses which were developed during a long period of preglacial erosion and during shorter, but more intense, periods of interglacial erosion.

BEDROCK TOPOGRAPHY

Primary control for the map is geological log data and information from quarries and outcrops. Published data (Norton, 1912) provide additional control, but they are not as precise as the log data and are used principally in areas where primary control is limited and to support the contouring of major features such as the bedrock channels. Much of the available published data for the area cannot be used because locations are too general to assign land-surface altitudes with reasonable accuracy. More detailed information about the control data is available in the cooperative files of the Iowa Geological Survey and the U.S. Geological Survey, Iowa City, Iowa.

The accuracy of the map is related to the density of control points; the greater number of points there are in a given area, the more exact is the placement of the contours. In several instances dashed contours were used where it seemed reasonable to continue a ridge or valley, but where no control point was available to confirm the contours.

The principal features of the map are the deeply buried bedrock channels along the eastern border and the present-day bedrock-incised stream valleys in the northwestern part of the area. The Udden and Gordon channels are a part of the master drainage line for a network of channels that are cut into the predominantly carbonate bedrock of eastern Iowa (Hershey, 1969). In southeastern Iowa, tributaries to the master channel are characteristically narrow and steep-walled. In contrast, the broad channel with gently-sloping walls in Van Buren and Davis counties is characteristic of channels which are cut into bedrock that is dominantly shale. These features indicate that the bedrock topography reflects both the erosional history of the bedrock surface and the lithology of the underlying rock.

The northwestern part of the map area illustrates a part of the bedrock surface that has been sculptured primarily by present-day streams. These streams have incised the bedrock uplands which consist of shale and sandstone, and have extended their valleys by headward erosion. Generally, the bedrock-incised valleys tend to be narrow and steep walled. Occasionally, the present-day streams occupy valleys that are situated over buried channels and relatively broad valleys have developed.

USES OF MAP

The bedrock map, when used in conjunction with land-surface altitudes, is a vital tool for studying hydrologic, environmental, and geologic problems.

Hydrology. – The map is an aid in locating supplies of ground-water. The areas that are most favorable for the development of ground-water supplies are the buried-bedrock channels and the alluvial valleys of present-day streams. In areas that are underlain by shale the bedrock channels often are the principal source of potable water for private domestic and stock wells and a few small towns. Though not all channels contain sand and gravel aquifers, the larger, more extensive channels in the eastern part of the map area contain aquifers that supply many farm and rural-domestic needs. Recorded yields generally range from 10 to 30 gpm (gallons per minute) but yields as high as 100 gpm have been reported.

The alluvial deposits range in thickness up to about 60 feet and contain sand and gravel aquifers that will yield from 10 to 40 gpm to individual wells. Because few wells have been completed in the alluvium and information is limited, a program of test drilling is recommended, especially when attempting to develop a large supply of water.

The map will help the drilling contractor when planning the construction of a well. By determining the depth to bedrock, the contractor can estimate casing needs and prepare more accurate cost estimates. And, where overburden is particularly thick, the contractor can be better prepared for any problems attendant to drilling this material.

Other uses for the map are in river basin hydrology studies and in determining surface-water and ground-water relationships at selected locations.

Environment. – The bedrock information is particularly valuable to State, regional, and local planners concerned with environmental problems such as the location of landfill sites. The thickness of overburden, which can be determined with the aid of this map, is an important factor to consider for the protection of ground-water supplies from potential contamination.

Geology. – The bedrock map shows the location of bedrock highs, which are of interest to quarry operators and to construction engineers concerned with foundation problems. The map also aids in the interpretation of drainage changes caused by glacial advances and in mapping the areal distribution of consolidated rocks.

ACKNOWLEDGMENTS

Particular recognition is made to the present and past members of the Iowa Geological Survey who, over a period of many years, have collected and analyzed drill-hole samples, determined land-surface altitudes, and compiled other information necessary to the preparation of this map. Further acknowledgment is made to the many well drilling contractors who have voluntarily collected drill cuttings and have provided other well data.

SELECTED REFERENCES

Arey, M. F., 1909, Geology of Davis County: Iowa Geol. Survey Ann. Rept., v. 20, p. 487-524.
Bain, H. F., 1894, Geology of Keokuk County: Iowa Geol. Survey Ann. Rept., v. 4, p. 255-311.
________1894, Geology of Mahaska County: Iowa Geol. Survey Ann. Rept., v. 4, p. 313-380.
________1895, Geology of Washington County: Iowa Geol.Survey Ann. Rept., v. 5, p. 113-173.
Beveridge, T. R., 1947, Subdrift valleys of southeastern Iowa: Unpublished M.S. thesis, State Univ. of Iowa.
Cagle, J. W., Bedrock topography of south-central Iowa: U.S. Geol. Survey Misc. Geol. Inv. Map I-763 (in print).
Coble, R. W., 1971, The water resources of southeast Iowa: Iowa Geol. Survey, Iowa Geol. Survey Water Atlas no. 4, p. 36.
Gordon, C. H., 1893, Buried river channels in southeastern Iowa: Iowa Geol. Survey Ann. Rept., v. 3, p. 237-255.
________1894, Geology of Van Buren County: Iowa Geol. Survey Ann. Rept., v. 4, p. 197-254.
Hansen, R. E., 1972, Bedrock topography of east-central Iowa: U.S. Geol. Survey Misc. Geol. Inv. Map I-717.
Hershey, H. G., 1969, Geologic map of Iowa: Iowa Geol. Survey.
Jones, R. G. and Highland, J. D., 1971, Soil Survey of Keokuk County, Iowa, U.S. Dept. Agriculture, S.C.S., in cooperation with Iowa Agri. Exper. Station.
Kay, G. F., and Apfel, E. T., 1929, The pre-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey Ann. Rept., v. 34, 304 p.
Kay, G. F., and Graham, J. B., 1943, The Illinoian and post-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey Ann. Rept., v. 38, 262 p.
Keyes, C. R., 1893, Geology of Lee County: Iowa Geol. Survey Ann. Rept., v. 3, p. 305-407.
________1893, Geology of Des Moines County: Iowa Geol. Survey Ann. Rept., v. 3, p. 409-492.
Leonard, A. G., 1901, Geology of Wapello County: Iowa Geol. Survey Ann. Rept., v. 12, p. 439-499.
Leverett, Frank, 1942, Shiftings of the Mississippi River in relation to glaciation: Geol. Soc. America Bull., vol. 53, p. 1283-1298.
Norton, W. H., and others, 1912, Underground water resources of Iowa: U.S. Geol. Survey Water-Supply Paper 293, p. 514-618.
________1912, Underground water resources of Iowa: Iowa Geol. Survey Ann. Rept., v. 21, p. 618-748.
Savage, T. E., 1901, Geology of Henry County: Iowa Geol. Survey Ann. Rept., v. 12, p. 237-302.
Udden, J. A., 1900, Geology of Louisa County: Iowa Geol. Survey Ann. Rept., v. 11, p. 55-126.
________1901, Geology of Jefferson County: Iowa Geol. Survey Ann. Rept., v. 12, p. 355-437.

Base from U.S. Geological Survey 1:250,000
Centerville, and Des Moines, 1954;
Burlington and Davenport, 1958
Roads as of 1969

SCALE 1:125 000

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973—W73081

BEDROCK TOPOGRAPHY OF SOUTHEAST IOWA

By
Robert E. Hansen

1973

For sale by U.S. Geological Survey, price $1.00 per set

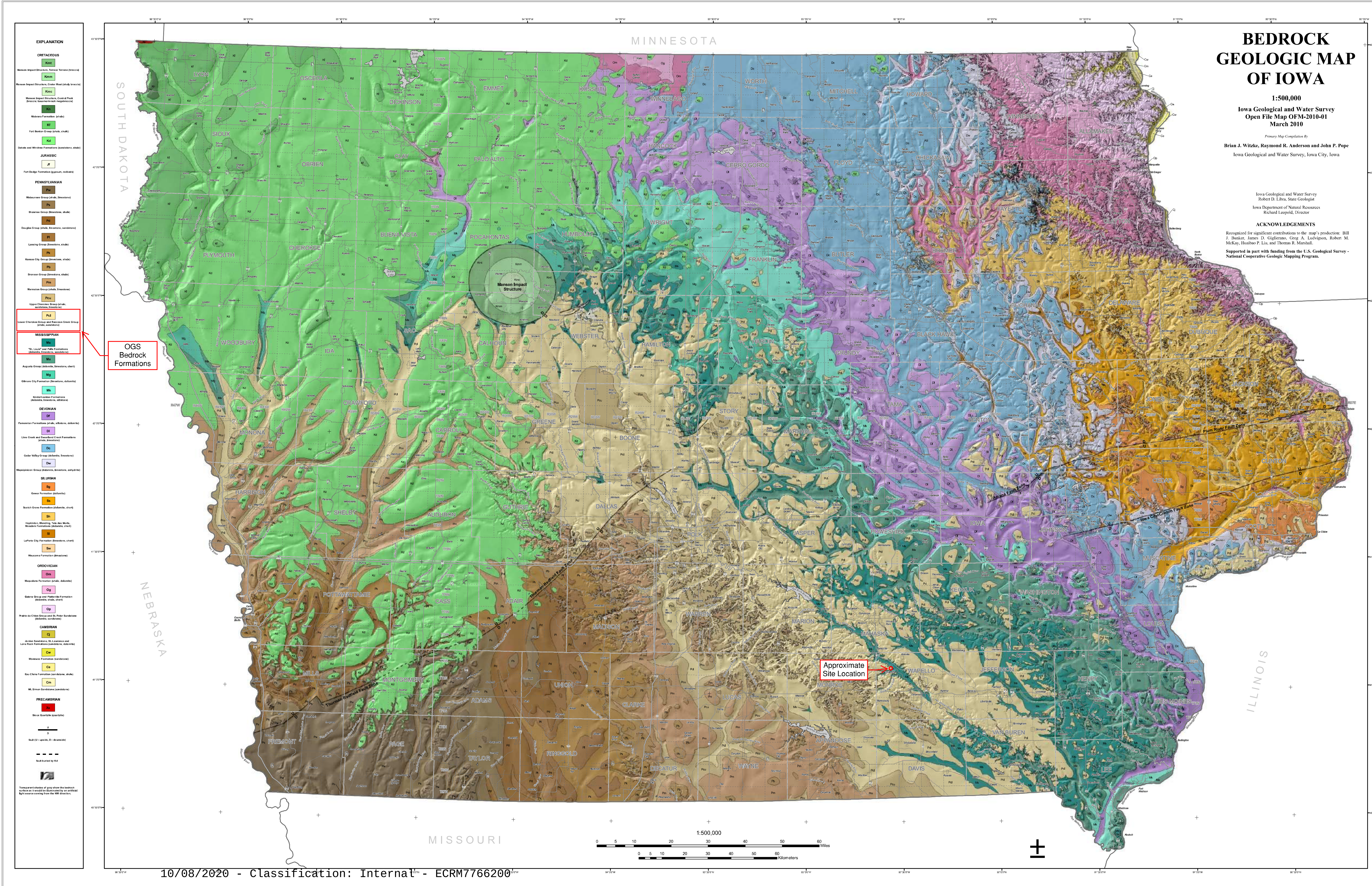
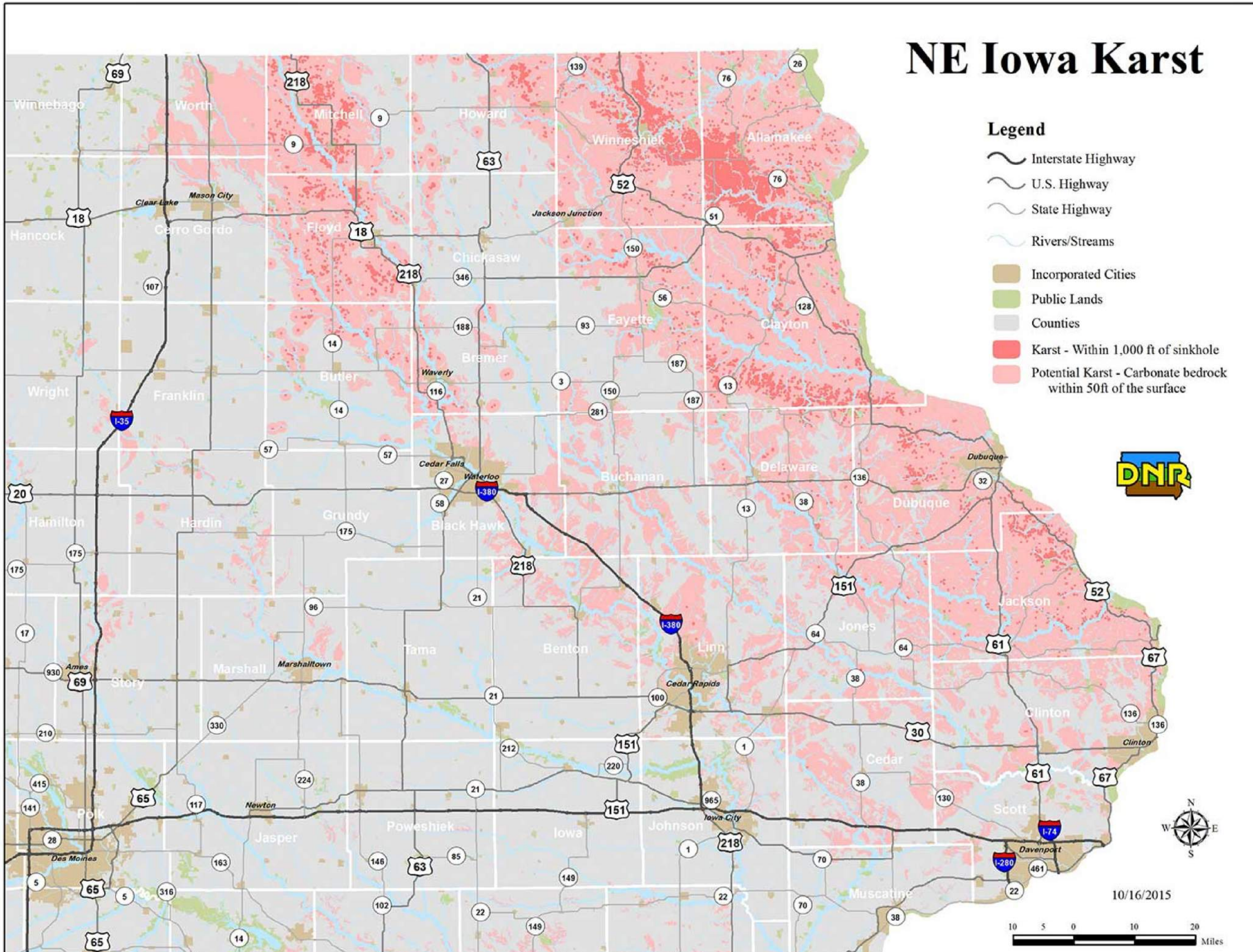

BEDROCK GEOLOGIC MAP OF IOWA
1:500,000
Iowa Geological and Water Survey
Open File Map OFM-2010-01
March 2010
Primary Map Compilation By
Brian J. Witzke, Raymond R. Anderson and John P. Pope
Iowa Geological and Water Survey, Iowa City, Iowa
Iowa Geological and Water Survey
Robert D. Libra, State Geologist
Iowa Department of Natural Resources
Richard Leopold, Director
ACKNOWLEDGEMENTS
Recognized for significant contributions to the map's production: Bill J. Bunker, James D. Giglierano, Greg A. Ludvigson, Robert M. McKay, Huaibao P. Liu, and Thomas R. Marshall.
Supported in part with funding from the U.S. Geological Survey - National Cooperative Geologic Mapping Program.
EXPLANATION
CRETACEOUS
JURASSIC
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
OGS Bedrock Formations
Approximate Site Location
Manson Impact Structure
MINNESOTA
SOUTH DAKOTA
NEBRASKA
MISSOURI
ILLINOIS
Thurman-Redfield Fault Zone
Plum River Fault Zone
Iowa City Fault Zone
1:500,000
Miles
Kilometers

EXHIBIT E – KARST FORMATION MAPS

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination


NE Iowa Karst
Legend
Interstate Highway
U.S. Highway
State Highway
Rivers/Streams
Incorporated Cities
Public Lands
Counties
Karst - Within 1,000 ft of sinkhole
Potential Karst - Carbonate bedrock within 50ft of the surface
DNR
10/16/2015
10 5 0 10 20
Miles
N
S
E
W
Winnebago
Worth
Mitchell
Howard
Winneshiek
Allamakee
Hancock
Cerro Gordo
Floyd
Chickasaw
Fayette
Clayton
Wright
Franklin
Butler
Bremer
Buchanan
Delaware
Dubuque
Hamilton
Hardin
Grundy
Black Hawk
Jackson
Jones
Tama
Benton
Linn
Marshall
Story
Clinton
Cedar
Scott
Polk
Jasper
Poweshiek
Iowa
Johnson
Muscatine
Clear Lake
Mason City
Jackson Junction
Waverly
Cedar Falls
Waterloo
Dubuque
Ames
Marshalltown
Cedar Rapids
Iowa City
Newton
Des Moines
Davenport
Clinton

IOWA
DEPARTMENT OF NATURAL RESOURCES

Basemaps ▾ Measure Bookmarks ▾ Mail Map Info

Map layers | Legend

- ☑ AFO Siting Data
  - ☑ Sinkholes
  - ☑ Ag Drainage Well
  - ☐ Wells
  - ☑ Animal Feeding Operation
    - Active, Confined/Open
    - Active, Confinement
    - Active, Open Feedlot
    - Inactive
  - ☐ Public Drainage Infrastructure
  - ☑ Drainage Districts
  - ☐ High Qty Wtr Resource (Rivers)
  - ☐ High Qty Wtr Resource (Waterbody
  - ☐ Major Water Source (Rivers)
  - ☐ Major Water Source (Lake)
  - ☐ Surface Water
  - ☐ Public Land
  - ☐ Public Land Survey (PLSS)
  - ☑ Designated Wetland
    - Designated Wetland
    - Wetland Buffer(2500ft)
  - ☑ Sinkhole or Potential Karst
    - Sinkhole w/ 1000 ft radius
    - Karst and Potential Karst
  - ☐ 100 Year Flood Plain
  - ☐ Alluvial Soils

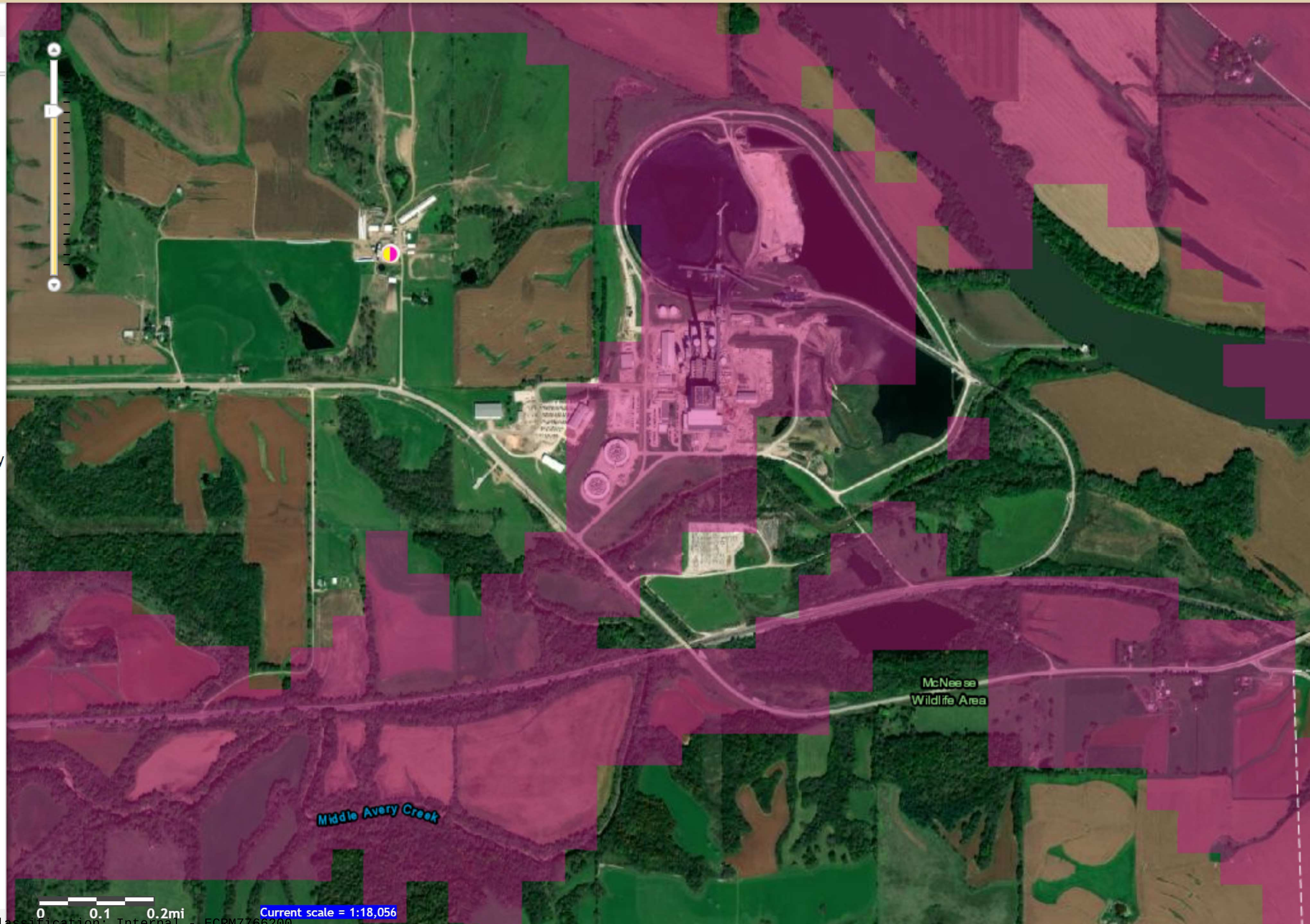
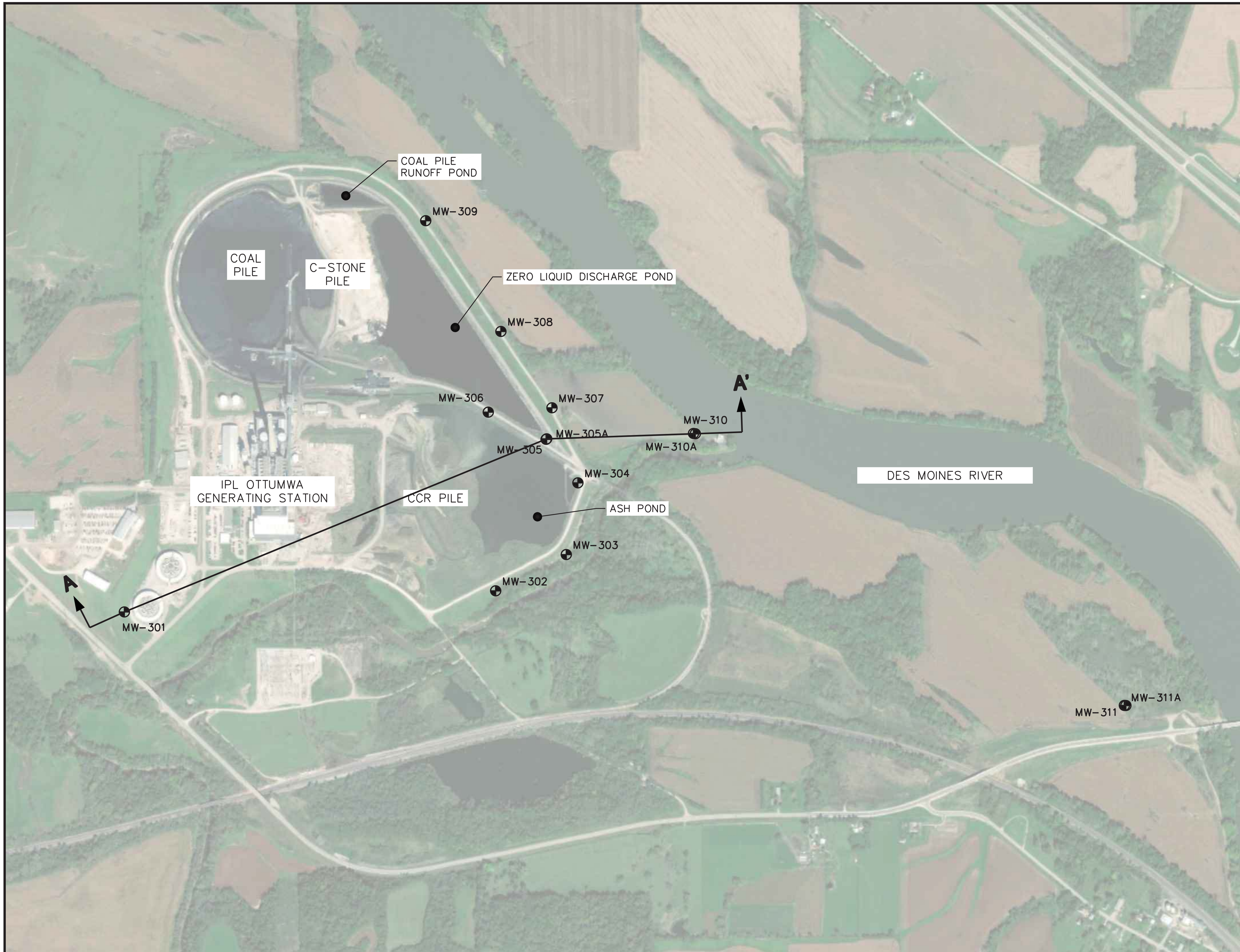


EXHIBIT F – OGS GROUNDWATER MAP

Alliant Energy
Wisconsin Power and Light Company
Ottumwa Generating Station
Ottumwa, Iowa

Unstable Area Determination



LEGEND

MONITORING WELL

GEOLOGIC CROSS SECTION

NOTES:

1. 2014 AERIAL PHOTOGRAPH SOURCES: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, USDA FSA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.
2. MONITORING WELLS MW-301, MW-302, AND MW-304, WERE INSTALLED BY CASCADE DRILLING, LLP. UNDER THE SUPERVISION OF SCS ENGINEERS FROM NOVEMBER 11-12, 2015.
3. MONITORING WELLS MW-303 AND MW-305 WERE INSTALLED BY CASCADE DRILLING LLP. UNDER THE SUPERVISION OF SCS ENGINEERS ON DECEMBER 7-8, 2015.
4. MONITORING WELLS MW-307, MW-308, AND MW-309 WERE INSTALLED BY CASCADE DRILLING, LLP. UNDER THE SUPERVISION OF SCS ENGINEERS FROM OCTOBER 25-27, 2016.
5. MONITORING WELLS MW-310 AND MW-311 WERE INSTALLED BY ROBERTS ENVIRONMENTAL DRILLING ON AUGUST 27, 2019.
6. MONITORING WELLS MW-305A, MW-310A, AND MW-311A WERE INSTALLED BY ROBERTS ENVIRONMENTAL DRILLING BETWEEN FEBRUARY 27, 2020 AND MARCH 3, 2020.

N

800 0 800

SCALE: 1" = 800'

PROJECT NO.	25220083.00	DRAWN BY:	BSS
DRAWN:	11/15/2019	CHECKED BY:	MDB
REVISED:	05/11/2020	APPROVED BY:	EJN 9/11/2020

ENGINEER: SCS ENGINEERS, 2830 DAIRY DRIVE MADISON, WI 53718-6751, PHONE: (608) 224-2830

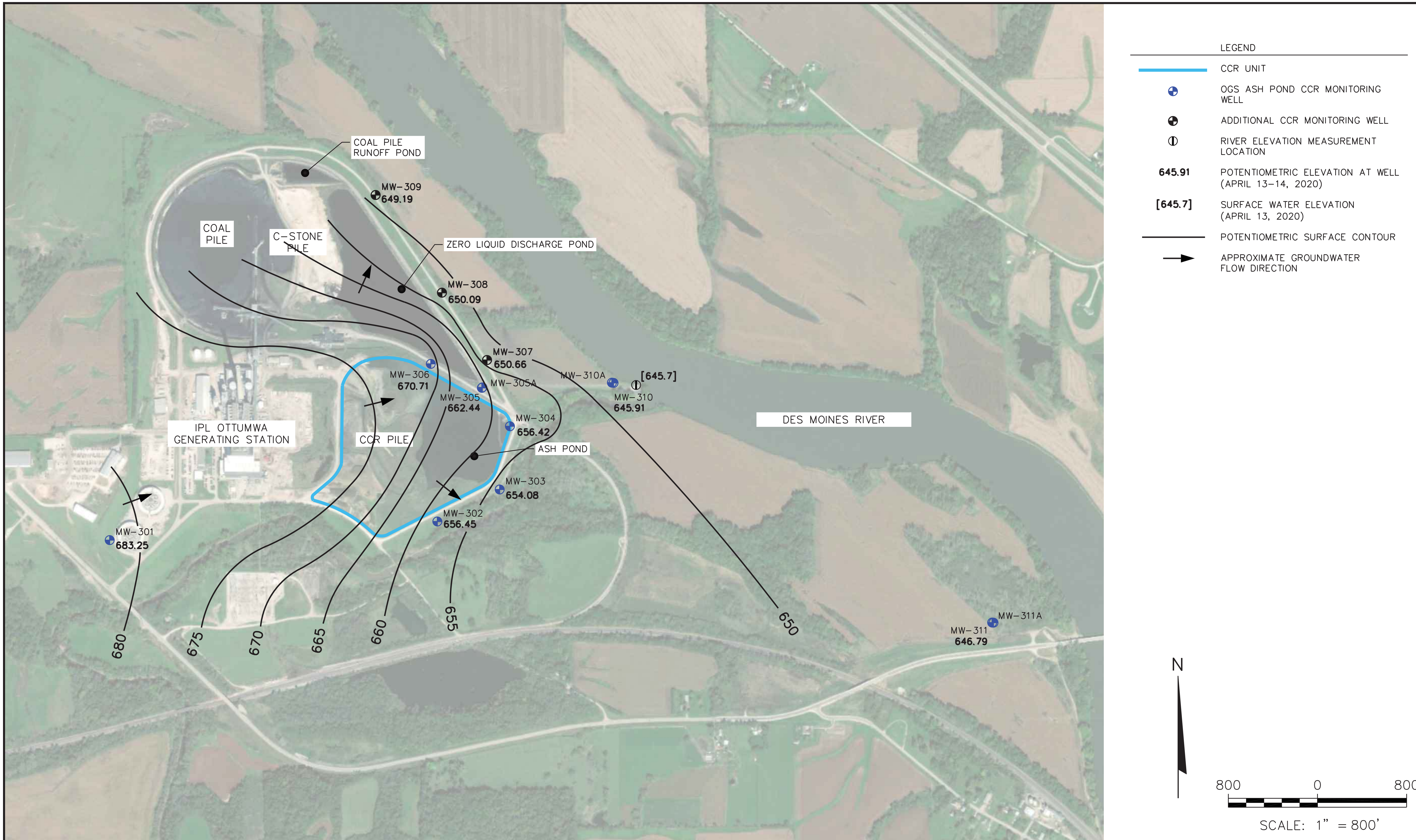
CLIENT: INTERSTATE POWER AND LIGHT CO., 20775 POWER PLANT ROAD, OTTUMWA, IA 52501

SITE: ALLIANT ENERGY, OTTUMWA GENERATING STATION, OTTUMWA, IOWA

SITE PLAN AND MONITORING WELL LOCATIONS

FIGURE 2

I:\25220083.00\Drawings\Site Plan and Monitoring Well Locations.dwg, 5/11/2020 7:55:48 AM



PROJECT NO.	25220072.00	DRAWN BY:	KP/BSS/RJG
DRAWN:	04/28/2020	CHECKED BY:	NDK/SCC
REVISED:	07/30/2020	APPROVED BY:	EJN 9/11/2020

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

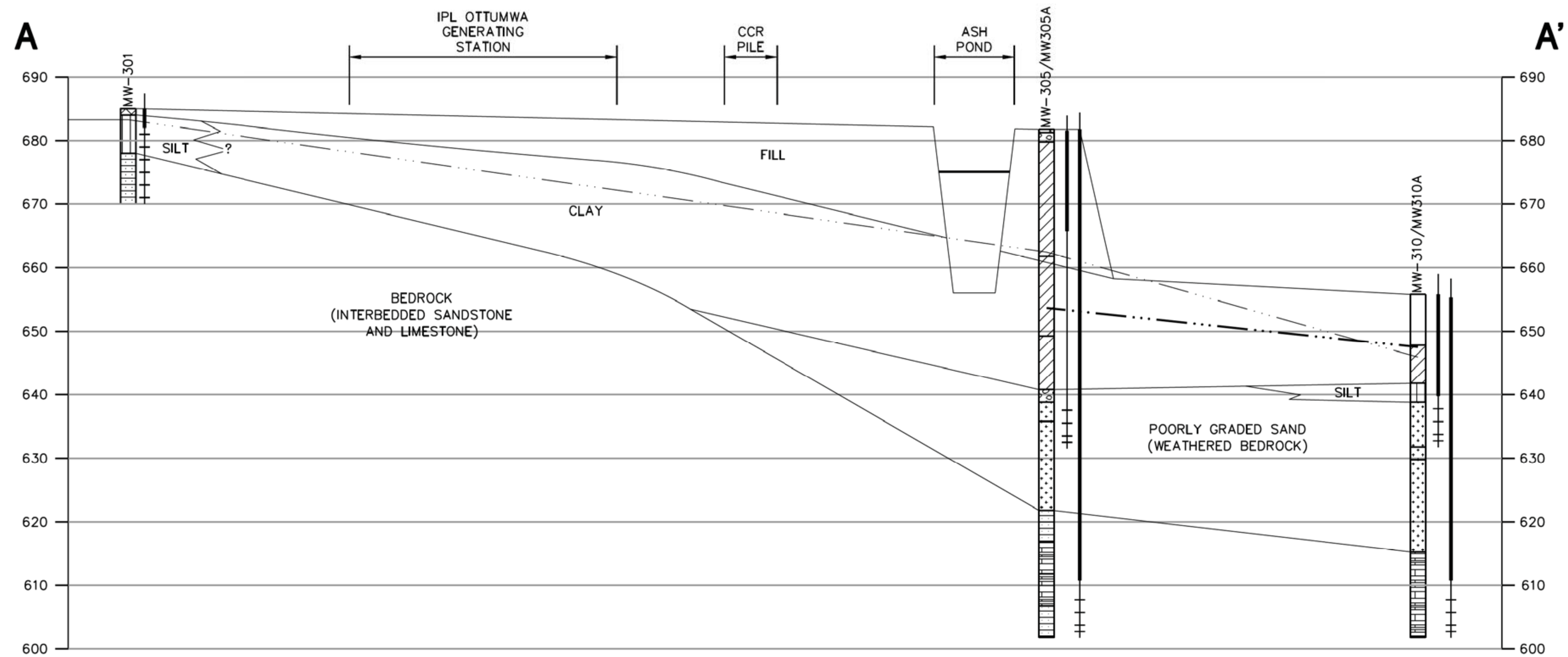
CLIENT: INTERSTATE POWER AND LIGHT CO.
20775 POWER PLANT ROAD
OTTUMWA, IA 52501

SITE: ALLIANT ENERGY
OTTUMWA GENERATING STATION
OTTUMWA, IOWA

SHALLOW POTENTIOMETRIC SURFACE
APRIL 13-14, 2020

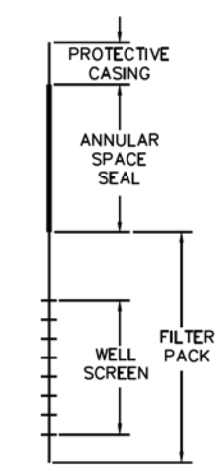
FIGURE 5

I:\25220072.00\Drawings\ otentiometric Sur ace 2020.dwg, 7/ 0/2020 2:12: 6 M



LEGEND

- TOPSOIL/FILL
- SAND, POORLY GRADED (SP)
- SILT, WITH SAND AND GRAVEL (ML)
- CLAY
- GRAVEL, POORLY GRADED, LITTLE OR NO FINES (GP)
- SANDSTONE
- LIMESTONE
- DEEP POTENTIOMETRIC SURFACE MEASURED APRIL 13–14, 2020
- SHALLOW POTENTIOMETRIC SURFACE MEASURED APRIL 13–14, 2020
- POND SURFACE ELEVATION MEASURED JUNE 10–11, 2019



WELL DETAIL

0 500

HORIZONTAL SCALE: 1" = 500'
VERTICAL SCALE: 1" = 20'
VERTICAL EXAGGERATION = 25X

NOTES:

1. MW-305 AND MW-305A WERE HYDROVACED TO APPROXIMATELY 8.5'. MW-310 AND MW-310A WERE HYDROVACED TO APPROXIMATELY 8.0'. HYDROVACING IS PERFORMED TO DETERMINE IF UNDERGROUND UTILITIES ARE PRESENT. HIGH PRESSURE WATER AND A VACUUM ARE USED TO CLEAR THE BOREHOLE AND GEOLOGIC SAMPLES ARE NOT COLLECTED. NATIVE SOIL IN THE VICINITY OF MW-307 IS CLAY.
2. ASH POND BOTTOM ELEVATION IS BASED ON THE EMBANKMENT CREST ELEVATION (681 FEET) AND INTERNAL STORAGE DEPTH (25 FEET) REPORTED IN THE HISTORY OF CONSTRUCTION REPORT ISSUED SEPTEMBER 29, 2016, BY HARD HAT SERVICES.

PROJECT NO. 25220083.00	DRAWN BY: BSS/KP	ENGINEER	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE: (608) 224-2830	CLIENT: INTERSTATE POWER AND LIGHT CO. 15300 130th STREET OTTUMWA, IA 52501	SITE: OTTUMWA GENERATING STATION 20775 POWER PLANT ROAD OTTUMWA, IOWA	GEOLOGIC CROSS SECTION A–A'	FIGURE 4
DRAWN: 07/03/2019	CHECKED BY: NDK/MDB						
REVISED: 05/13/2020	APPROVED BY: EJN 9/11/2020						

I:\25220083.00\Drawings\Geologic Cross Section.dwg, 5/13/2020 8:28:34 AM

Table 1. Water Level Summary
IPL - Ottumwa Generating Station / SCS Engineers Project #25220083.00

Depth to Water in feet below top of well casing/reference elevation															
Raw Data	**MW-301**	**MW-302**	**MW-303**	**MW-304**	**MW-305**	**MW-305A**	**MW-306**	**MW-307**	**MW-308**	**MW-309**	**MW-310**	**MW-310A**	**MW-311**	**MW-311A**	**River at Intake**
Measurement Date															
April 26, 2016	3.83	18.27	8.65	27.47	22.24	NI	12.61				NI	NI	NI	NI	NI
June 23, 2016	4.05	18.25	8.18	26.31	21.55	NI	12.83				NI	NI	NI	NI	NI
August 9, 2016	4.36	18.38	9.31	29.05	23.13	NI	13.12				NI	NI	NI	NI	NI
October 26-27, 2016	4.59	18.23	8.90	27.81	22.54	NI	13.26				NI	NI	NI	NI	NI
January 18-19, 2017	4.96	18.44	9.33	28.34	23.04	NI	13.58	8.75	7.97	8.28	NI	NI	NI	NI	NI
April 19-20, 2017	4.48	17.55	6.50	25.36	20.64	NI	12.78	3.94	4.30	4.78	NI	NI	NI	NI	NI
June 20-21, 2017	4.72	18.25	8.65	28.09	22.65	NI	13.53	7.71	7.13	7.34	NI	NI	NI	NI	NI
August 21-23, 2017	5.35	18.77	10.49	30.45	24.91	NI	14.70	11.78	12.27	13.12	NI	NI	NI	NI	NI
November 8, 2017	5.09	18.50	9.73	29.81	24.15	NI	14.43	10.19	10.40	10.74	NI	NI	NI	NI	NI
April 18, 2018	5.10	18.19	8.60	27.29	22.92	NI	14.55	7.90	7.48	7.29	NI	NI	NI	NI	NI
May 30, 2018	NM	NM	NM	NM	NM	NI	NM	5.11	4.34	3.96	NI	NI	NI	NI	NI
June 28, 2018	NM	NM	NM	NM	NM	NI	NM	4.69	3.96	3.47	NI	NI	NI	NI	NI
July 18, 2018	NM	NM	NM	NM	NM	NI	NM	5.29	4.72	4.25	NI	NI	NI	NI	NI
August 14-15, 2018	5.72	17.85	8.50	26.49	22.35	NI	14.81	NM	NM	NM	NI	NI	NI	NI	NI
August 29, 2018	5.54	18.01	6.00	25.02	NM	NI	NM	NM	NM	NM	NI	NI	NI	NI	NI
October 16, 2018	4.13	16.99	4.90	24.64	20.54	NI	13.23	3.43	NM	3.33	NI	NI	NI	NI	NI
January 8, 2019	4.41	17.87	6.42	26.56	21.78	NI	13.63	NM	NM	NM	NI	NI	NI	NI	NI
April 8, 2019	3.94	16.67	5.52	23.51	19.90	NI	12.51	2.66	1.69	1.39	NI	NI	NI	NI	NI
August 28, 2019	NM	NM	NM	NM	NM	NI	NM	NM	NM	NM	17.65	NI	12.08	NI	NI
October 23-24, 2019	3.56	13.76	7.21	25.13	20.70	NI	12.19	5.67	4.08	3.66	9.32	NI	6.38	NI	NI
December 11, 2019	NM	NM	NM	NM	NM	NI	NM	7.97	8.00	7.70	NM	NI	NM	NI	NI
February 5, 2020	3.33	NM	NM	NM	NM	NI	NM	7.68	5.27	6.60	13.92	NI	9.18	NI	NI
March 12-13, 2020	3.81	NM	NM	NM	22.50	32.39	NM	NM	NM	NM	13.18	40.09	10.00	29.43	NI
April 1, 2020	3.36	16.9	5.18	24.27	23.32	28.98	12.34	3.8	3.51	3.71	7.54	8.77	4.83	5.27	6.6
April 13-14, 2020	3.38	17.45	6.99	26.42	21.47	30.34	12.76	6.90	5.30	5.75	12.72	10.43	7.39	5.12	10.6
June 30, 2020	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	5.81	NM

Ground Water or Surface Water Elevation in feet above mean sea level (amsl)															
Well Number	**MW-301**	**MW-302**	**MW-303**	**MW-304**	**MW-305**	**MW-305A**	**MW-306**	**MW-307**	**MW-308**	**MW-309**	**MW-310**	**MW-310A**	**MW-311**	**MW-311A**	**River at Intake**
Top of Well Casing Elevation / Surface Water Reference Elevation (feet amsl)	686.63	673.90	661.07	682.84	683.91	684.03	683.47	657.56	655.39	654.94	658.63	657.93	654.18	653.54	656.31
Screen Length (ft)	10.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	NA
Total Depth (ft from top of casing)	17.0	25.8	17.5	52.3	51.5	81.91	36.6	28.0	25.0	27.5	25.9	55.55	17.9	47.68	NA
Top of Well Screen Elevation (ft)	679.63	653.10	648.57	635.54	637.41	607.12	651.87	634.56	635.39	632.44	637.76	607.38	641.24	610.86	NA
Measurement Date															
April 26, 2016	682.80	655.63	652.42	655.37	661.67	NI	670.86				NI	NI	NI	NI	NI
June 23, 2016	682.58	655.65	652.89	656.53	662.36	NI	670.64				NI	NI	NI	NI	NI
August 9, 2016	682.27	655.52	651.76	653.79	660.78	NI	670.35				NI	NI	NI	NI	NI
October 26-27, 2016	682.04	655.67	652.17	655.03	661.37	NI	670.21				NI	NI	NI	NI	NI
January 18-19, 2017	681.67	655.46	651.74	654.50	660.87	NI	669.89	648.81	647.42	646.66	NI	NI	NI	NI	NI
April 19-20, 2017	682.15	656.35	654.57	657.48	663.27	NI	670.69	653.62	651.09	650.16	NI	NI	NI	NI	NI
June 20-21, 2017	681.91	655.65	652.42	654.75	661.26	NI	669.94	649.85	648.26	647.60	NI	NI	NI	NI	NI
August 21-23, 2017	681.28	655.13	650.58	652.39	659.00	NI	668.77	645.78	643.12	641.82	NI	NI	NI	NI	NI
November 8, 2017	681.54	655.40	651.34	653.03	659.76	NI	669.04	647.37	644.99	644.20	NI	NI	NI	NI	NI
April 18, 2018	681.53	655.71	652.47	655.55	660.99	NI	668.92	649.66	647.91	647.65	NI	NI	NI	NI	NI
May 30, 2018	NM	NM	NM	NM	NM	NI	NM	652.45	651.05	650.98	NI	NI	NI	NI	NI
June 28, 2018	NM	NM	NM	NM	NM	NI	NM	652.87	651.43	651.47	NI	NI	NI	NI	NI
July 18, 2018	NM	NM	NM	NM	NM	NI	NM	652.27	650.67	650.69	NI	NI	NI	NI	NI
August 14-15, 2018	680.91	656.05	652.57	656.35	661.56	NI	668.66	NM	NM	NM	NI	NI	NI	NI	NI
August 29, 2018	681.09	655.89	655.07	657.82	NM	NI	NM	NM	NM	NM	NI	NI	NI	NI	NI
October 16, 2018	682.50	656.91	656.17	658.20	663.37	NI	670.24	654.13	NM	651.61	NI	NI	NI	NI	NI
January 8, 2019	682.22	656.03	654.65	656.28	662.13	NI	669.84	NM	NM	NM	NI	NI	NI	NI	NI
April 8, 2019	682.69	657.23	655.55	659.33	664.01	NI	670.96	654.90	653.70	653.55	NI	NI	NI	NI	NI
August 28, 2019	NM	NM	NM	NM	NM	NI	NM	NM	NM	NM	640.98	NI	642.10	NI	NI
October 23-24, 2019	683.07	660.14	653.86	657.71	663.21	NI	671.28	651.89	651.31	651.28	649.31	NI	647.80	NI	NI
December 11, 2019	NM	NM	NM	NM	NM	NI	NM	649.59	647.39	647.24	NM	NI	NM	NI	NI
February 5, 2020	683.30	NM	NM	NM	NM	NI	NM	649.88	650.12	648.34	644.71	NI	645.00	NI	NI
March 12-13, 2020	682.82	NM	NM	NM	661.41	651.64	NM	NM	NM	NM	645.45	617.84	644.18	624.11	NI
April 1, 2020	683.27	657.00	655.89	658.57	660.59	655.05	671.13	653.76	651.88	651.23	651.09	649.16	649.35	648.27	649.71
April 13-14, 2020	683.25	656.45	654.08	656.42	662.44	653.69	670.71	650.66	650.09	649.19	645.91	647.50	646.79	648.42	645.71
June 30, 2020	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	647.73	NM
Bottom of Well Elevation (ft)	669.63	648.10	643.57	630.54	632.41	602.12	646.87	629.56	630.39	627.44	632.76	602.38	636.24	605.86	--

Notes:
NM = not measured
NI= not installed

Created by: KAK Date: 5/1/2017
Last rev. by: NDK Date: 7/22/2020
Checked by: AJR Date: 7/22/2020
Proj Mgr QA/QC: EJN Date: 9/11/2020

I:\25220083.00\Data and Calculations\Tables\[wlstat_OGS.xls]levels

Table 4. Vertical Hydraulic Gradients at Well Clusters
Ottumwa Generating Station / SCS Engineers Project #25220083.00

Well Pair		Vertical Hydraulic Gradient (feet/foot)[1,2]	
Shallower Well	**Deeper Well**	**April 1, 2020**	**April 13-14, 2020**
MW-305	MW-305A	-0.183	-0.289
MW-310	MW-310A	-0.064	0.052
MW-311	MW-311A	-0.036	0.054

Notes:
(1) A negative value indicates a downward gradient; a positive value indicates an upward gradient.

Created by: MDB Date: 5/14/2020
Last rev. by: MDB Date: 5/14/2020
Checked by: LMH Date: 5/14/2020
Proj Mgr QA/QC: TK Date: 5/15/2020

I:\25220083.00\Data and Calculations\Tables\[4_Vertical Gradients_OGS.xls]Gradients