THE GENERAL GEOLOGY OF BLACK HAWK COUNTY AND ADJACENT AREAS

prepared by

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SUMMER FIELD TRIP

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GUIDEBOOK 26

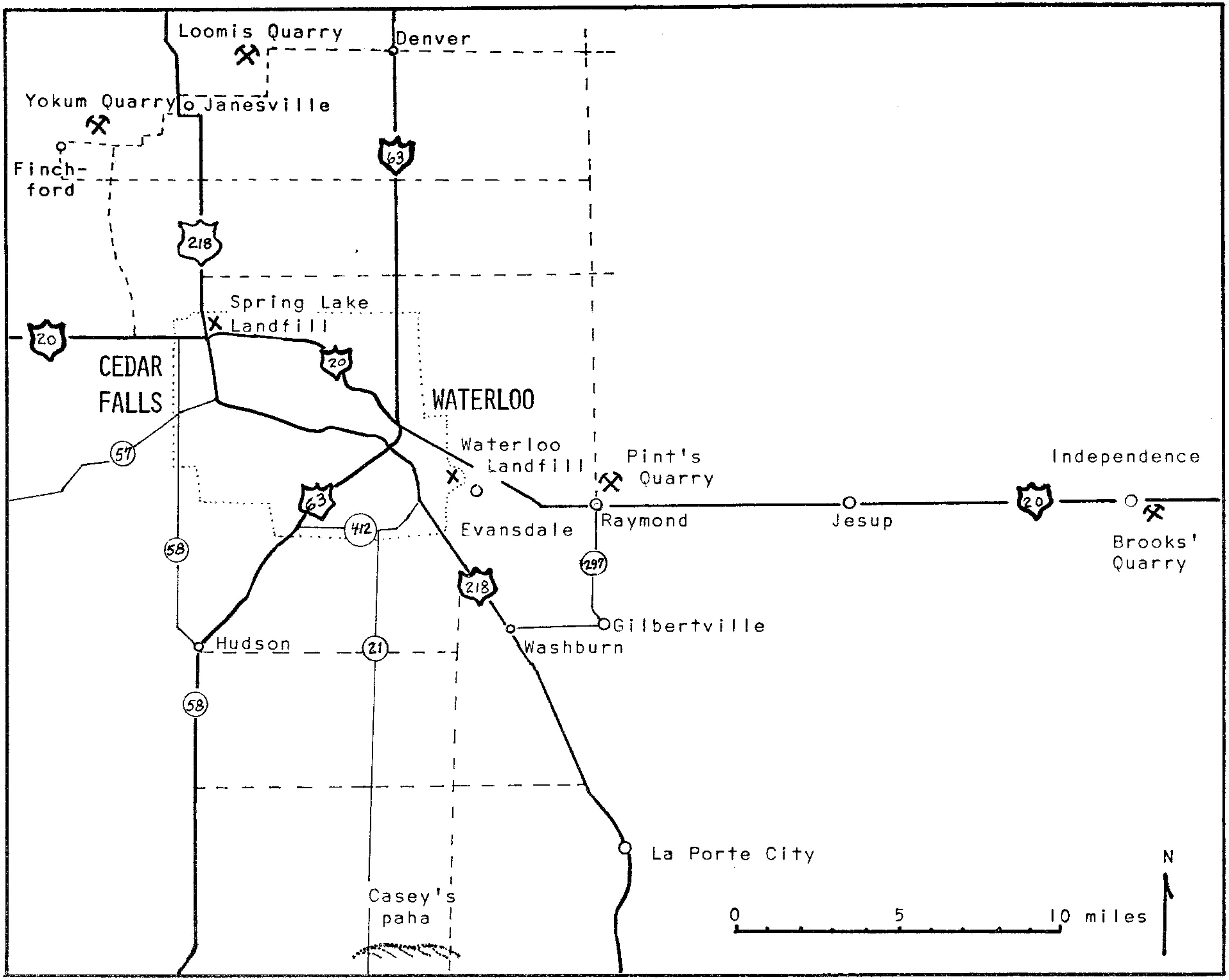

Figure I. Locality map showing field trip stops. Certain paved county roads are shown by dashed lines. The approximate boundary of Cedar Falls & Waterloo is shown by dotted lines.

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ACKNOWLEDGEMENTS

Several former students contributed data for this report. Charles Ashland provided background information on the Loomis Quarry. Dale Elifrits compiled data on the Spring Lake and Waterloo landfills. Mary Ann Smith provided information on the fossils from the Brooks' Quarry.

Ed Kettenbrink of the University of Iowa prepared the report on Pint's Quarry. James Urban of the University of Texas at Dallas provided information on the "Independence" shale exposures at Brooks' Quarry and Pint's Quarry. Stanley Grant of the University of Northern Iowa provided some background information on Casey's paha.

Mary Evans typed the manuscript and helped prepare the diagrams. The University of Northern Iowa provided partial support for this study under research project number 302-100.

SPRING LAKE SITE

General description. The site is located in the flood plain of the Cedar River, SE¼ Sec. 1, T.89N., R.14W. It is bounded on the east and south sides by an old stream channel, on the north and west sides by an abandoned railroad bed (see Figure 2). The surface of the site slopes gently to the south or southeast and is protected from direct current of the Cedar River in times of flood by the abandoned railroad grade. Distance from the present river channel is about 2000 feet.

Geology "The generalized geologic section at the site consists of (a) surficial alluvial sediments of fifteen to twenty feet thickness. These sediments range in grain size from clay to coarse sand. The details of stratigraphy are unknown, but it is a fair assumption that in this Lithotope, alluvial sediments were formed into lenticular bodies. (b) Fractured bedrock of the Cedar Valley Limestone Formation immediately underlies the alluvial sediments. This formation is in a significant aquifier" (Tuthill, 1970, p. 1). At the time of this report, data about site geology has indicated that Tuthill's description of the area is correct. (See cross sections in Figure 3.) The refuse cells are covered with sediments obtained from nearby excavations. Both the excavations to obtain the cover material and a limited drilling program indicate that lenticular bodies of sand, silt and clay overlie the Cedar Valley Formation in the Spring Lake area.

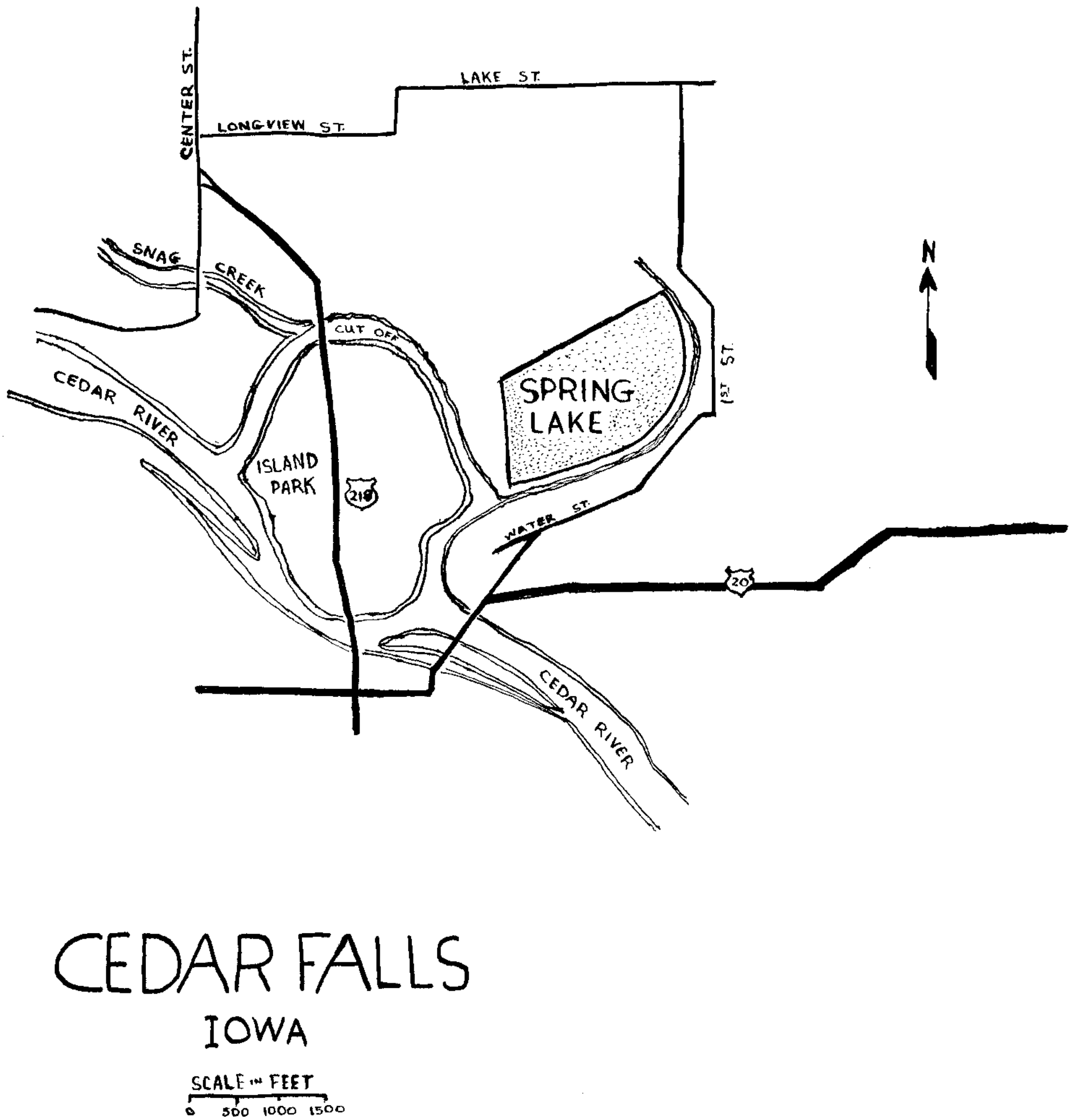

Figure 2. Location map showing the Spring Lake landfill site.

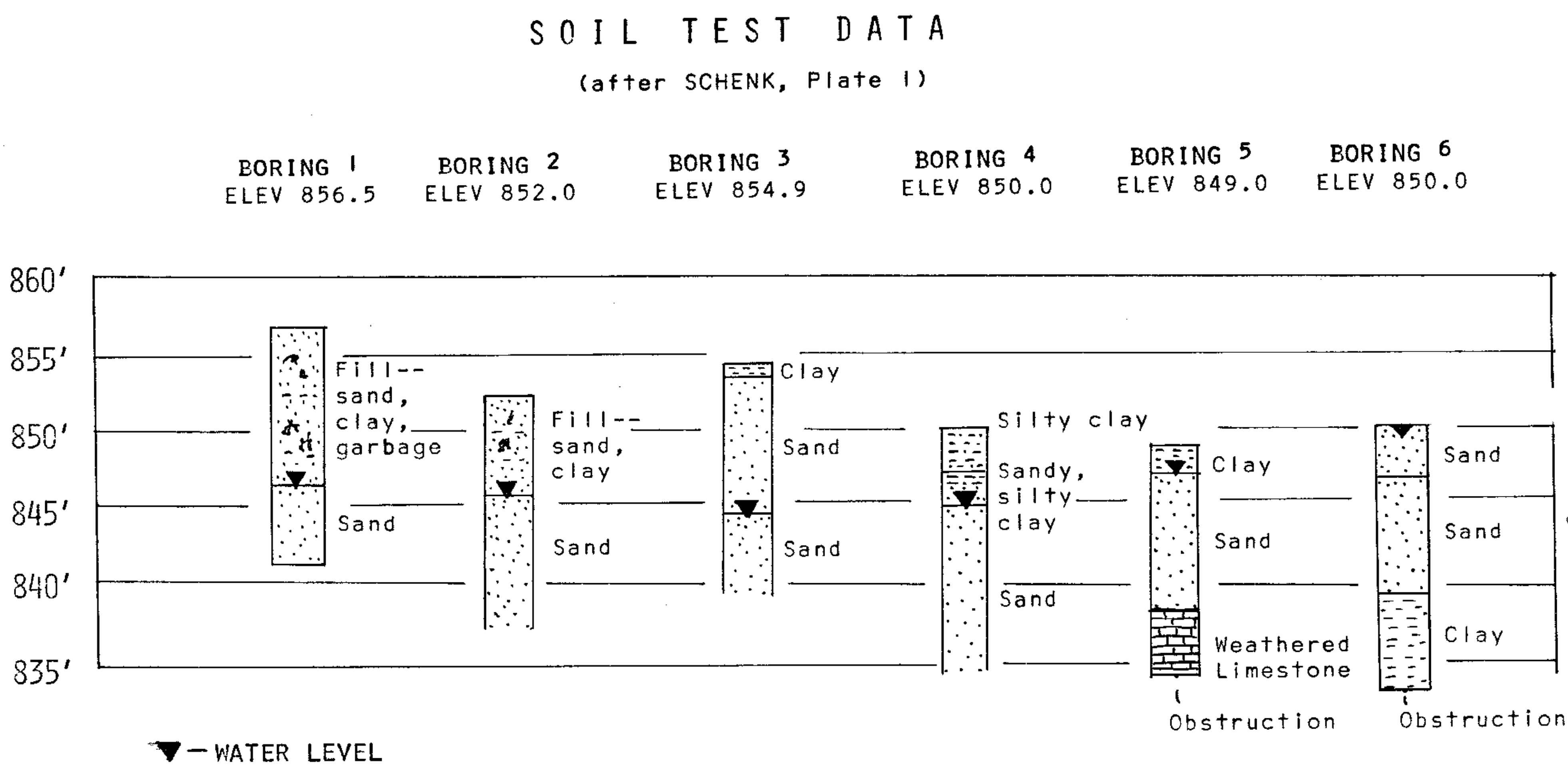

Figure 3. Soil test data from the Spring Lake landfill site. Location of borings is shown on Figure 4. (from Schenk Engineering Company, Waterloo).

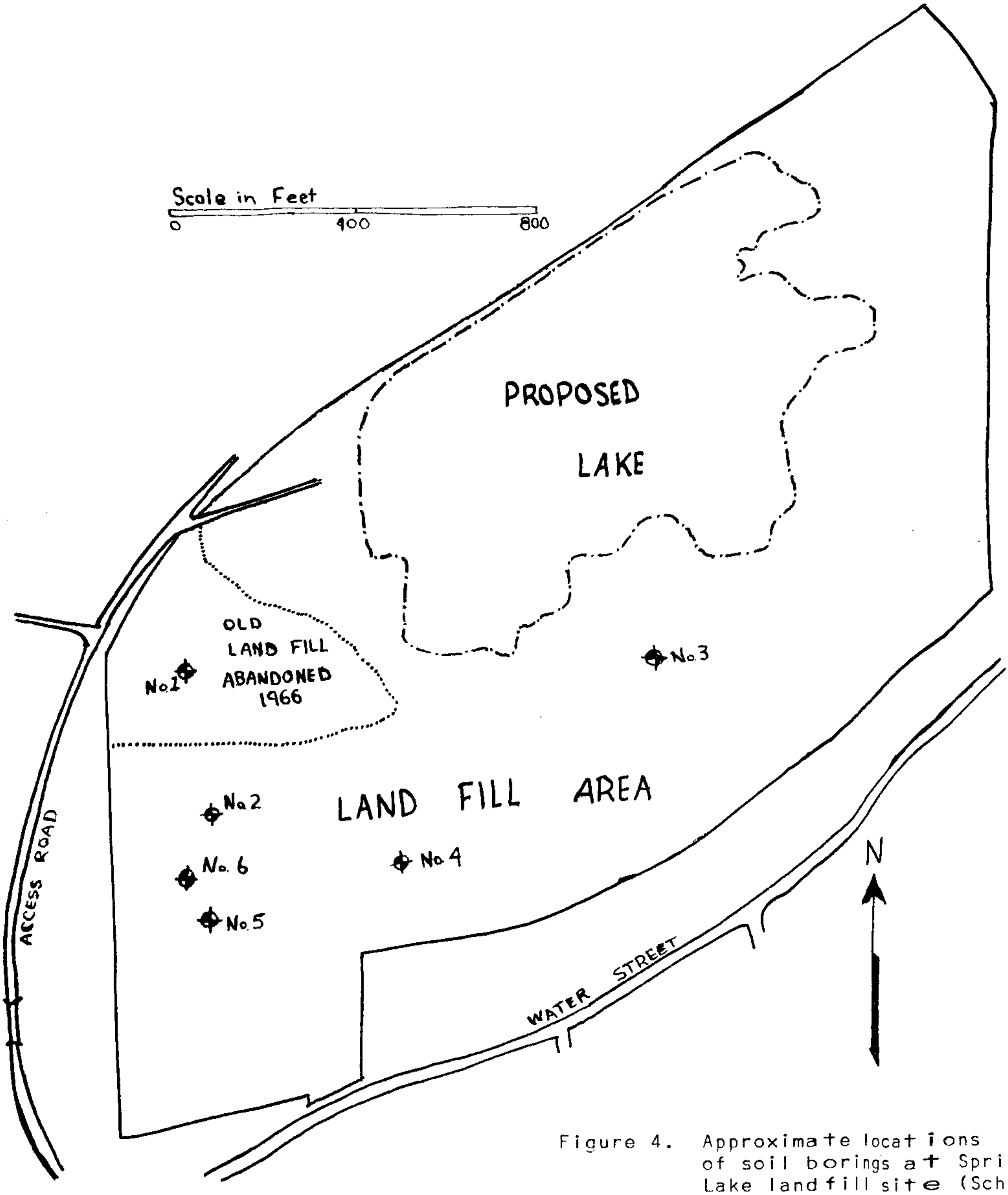

Figure 4. Approximate locations of soil borings at Spring Lake landfill site (Schenk Engineering Company, Waterloo).

Hydrology The hydrological conditions in the Spring Lake area are affected by three factors: (1) precipitation on the site, (2) surface runoff that moves into areas near the site (the old river channel to the east and south of the site), and (3) the stage of the Cedar River. The relationship between these factors and the movement of the leachate-born contaminates into the Cedar Valley Formation, which is a aquifier for individuals and communities in fifty-three Iowa counties (Tuthill, 1970, p.1), is not definite at this time. However, data is being collected from a system of monitoring wells on the perimeter of the site to determine the movement of waters away from the fill areas.

Rises in the state of the Cedar River have caused one major problem: at a stage of fourteen feet on the United States Geological Survey meter at Waterloo, the present fill areas are inaccessible. This occurred on 2-3 April, 1971, and resulted in a reduction in operation, with trenching of materials on higher ground for a period of three days. As the river receded, water withdrew from the fill areas and no refuse which had been compacted and covered was eroded away from fill areas. It seems likely that the leachate production of the fill was increased by such an advanced wetting front, but no quantitative measure of this is available.

Precipitation on the site and surface runoff into the area appear to have an accelerating effect on leachate production. However, by using cover material of an impermeable nature and grading to divert water away from the fill cells, this has been minimized.

Monitoring system A series of wells has been placed on the perimeter of the landfill area (see Figure 5 for location). Samples have been collected and analyzed by the State Hygienic Laboratory, Des Moines Branch. The results of these analyses (as available to date) are shown on Table I. The last available data is from samples collected on July 13, 1971. It is my understanding that more recent data may be available from Dr. Lyle V. A. Sendlein, Mr. Gib Klefstad and Mr. John Peckenpaugh, Department of Earth Science, Iowa State University, Ames, Iowa (see Table 2 for specific conductivity data by Lyle Sendlein).

Site operations The Spring Lake site is operated by the Heath Brothers, Joseph and Richard. The property on which the site is developed has been in the Heath family for years. This general area of the flood plain has been a sand and gravel pit and "dump" area on an intermittent basis for over forty years.

A variation of the area method of landfill operation is used at the Spring Lake site. In the area method a bulldozer or other similar equipment spreads out and compacts solid waste on the original ground surface. Cover material is placed over the day's fill of refuse on a daily basis. At the Spring Lake site, cells of refuse are built up, side by side and above the existing ground surface. The refuse is then compacted and covered.

The operation involves sixty to two hundred yards of refuse per day. Haulers are billed on a per load or per yard basis. Haulers are private citizens and businesses primarily. The city of Cedar Falls has contracted with another operator for the disposal of the city's solid wastes. The contract is let to a private concern on a low bid basis.

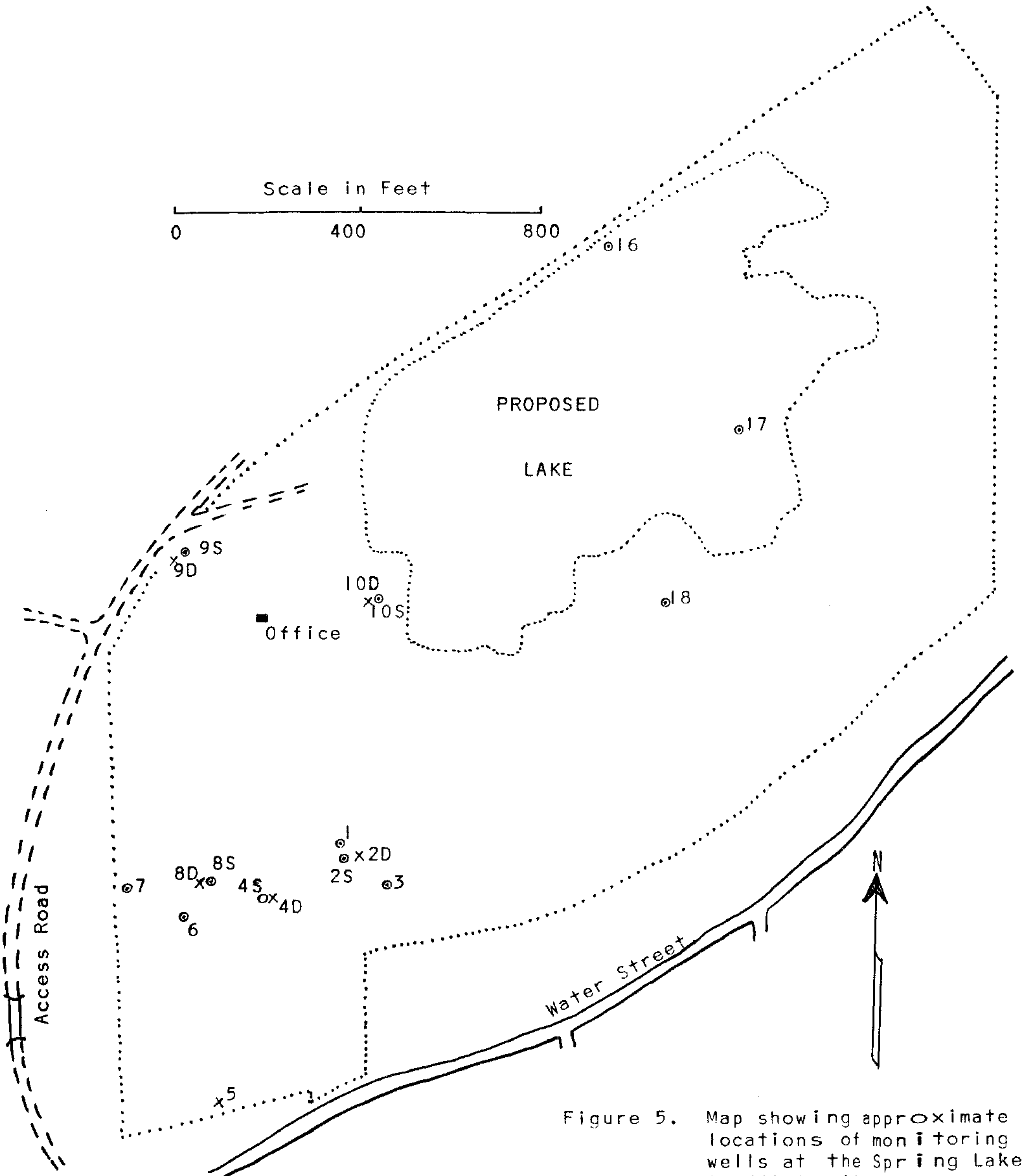

Figure 5. Map showing approximate locations of monitoring wells at the Spring Lake landfill site.

SPRING LAKE LANDFILL

MINERAL ANALYSIS (PARTS PER MILLION)

	#1		#2D		#3D	#4D	#5D	#6D		#7D	#8D
	6/11	7/14	6/11	7/14	7/14	7/14	7/14	6/11	7/14	7/14	7/14
Dissolved Solids	348	344	558	396	395	444	644	792	720	1560	1400
Total Solids	348		558		444		681	792			
Soluble Iron (Fe)	6.0		18		0.48		0.08	39			
Silica (SiO_2)	14		17		21		25	14			
Total Iron (Fe)	6.0		18		10		18	39			
pH	7.1		7.0		7.2		7.6	7.0			
Positive Ions											
K^+	6.6		15		12		3.7	2.0			
Na^+	14		23		11		17	46			
Ca^{++}	80.8		109		80.0		168	140			
Mg^{++}	22.3		27.2		17.5		31.6	46.2			
Mn^{++}	0.56		3.5		1.5		3.6	2.9			
Al^{++}											
Negative Ions											
NO_3^-	0.5	<0.1	0.9	0.5	1.1	<0.1	<0.1	1.1	2.5	2.5	1.8
F^-	0.1		0.1		0.15		0.15	<0.1			
Cl^-	15	14	16	14	16	21	26	38	37	84	93
SO_4^{--}	13		110		54		47	19			
HCO_3^-	378		420		303		630	749			
CO_3^{--}											
Trace Metals											
Arsenic	<0.01		<0.01		<0.01		<0.01	<0.01			
Cadmium	<0.01		<0.01		<0.01		<0.01	<0.01			
Chromium	<0.01		<0.01		<0.01		<0.01	<0.01			
Copper	<0.01		<0.01		<0.01		<0.01	0.07			
Lead	<0.01		<0.01		<0.01		<0.01	0.11			
Zinc	0.02		0.02		0.29		0.02	0.65			
Mercury	<0.01		<0.01		<0.01		<0.01	<0.01			

Table I.

(Samples collected May 6, 1971)

	#1	#2	#6	#8D	#7	#4S	#9S
Organic Nitrogen As N	0.28	0.37	0.71	0.89	0.01	0.24	0.52
Ammonia Nitrogen As N	3.9	16	21	24	15	7.7	1.5
Nitrite Nitrogen As N	0.008	0.008	.007	0.010	0.010	0.1	0.1
Total Nitrogen As N	0.1	0.1	0.1	0.1	0.1	0.1	0.1
COD	24.7	26.7	49.4	187	45.3	24.7	32.9
Chloride				51	35	22	11
Sulfate				16	17	15	15
Conductance	650	980	1400	1400	1340	900	520

Table 1. (continued)

Chemical analyses of samples from the Spring Lake monitoring wells (State Hygienic Laboratory, Des Moines Branch).

The following represent specific conductivity, which is equivalent to the total dissolved solids of NaCl, measured in parts per million for the wells located on the Spring Lake Map (see Figure 5).

Date	Wells 1	2s	2d	3	4s	4d	5	6	7
9-2-71	140	410	355	310			480	855	
10-8-71	170	390	360	350	405	430	535	1150	
11-20-71	205			475		550		1200	
12-31-71	265			475		480		890	
2-4-72	310	540	370	445		680		890	800
3-25-72	455	760	555	485	1800	545	445	880	850
5-5-72	335	615	435	445	1550	1450		820	915
6-17-72	305	470	595	440	870	915		935	1050

Date	Wells 8s	8d	9s	9d	10s	10d	16	17	18
9-2-71	640	700	240	325			150	145	180
10-8-71	775	915	235	310			170	240	180
11-20-71	980	900	240	255			170	280	245
12-31-71		725	165	215			160	230	190
2-4-72		925	180	200			200	235	215
3-25-72	950	880		200	180		225	250	210
5-5-72	960	980	215	180	135		205	240	215
6-17-72	1025	1200		185	165	165	195	240	220

Table 2.

Specific conductivity data from monitoring wells at the Spring Lake landfill site (provided by Lyle Sendlein, Iowa State University).

The type of refuse at the Spring Lake site is basically domestic with some rubble and wastes from light industries and businesses of the area. Long range plans developed by the Schenk Engineering Company of Waterloo propose that the area be developed and landscaped into a lake and campsite. The fill would result in an elevation of the land surface reducing the flood problems of the area. The excavations for cover for the refuse would result in the construction of a lake in the area.

At present it does not appear as if this goal will be reached. The operators estimate that it will take 15-20 years at the present rate of operation to realize the objectives of their long range plans. Economic considerations may result in the closing of the site in the near future according to one of the operators.

References cited:

Schenk Engineering Company, 1970, Unpublished Report on the Spring Lake sanitary landfill, Cedar Falls, Iowa: prepared by Schenk Engineering Company, Waterloo.

Tuthill, Samuel J., 1970, Report of the state geologist to the Iowa Natural Resources Council on the geologic and hydrologic conditions at the Heath landfill site: Iowa Natural Resources Council.

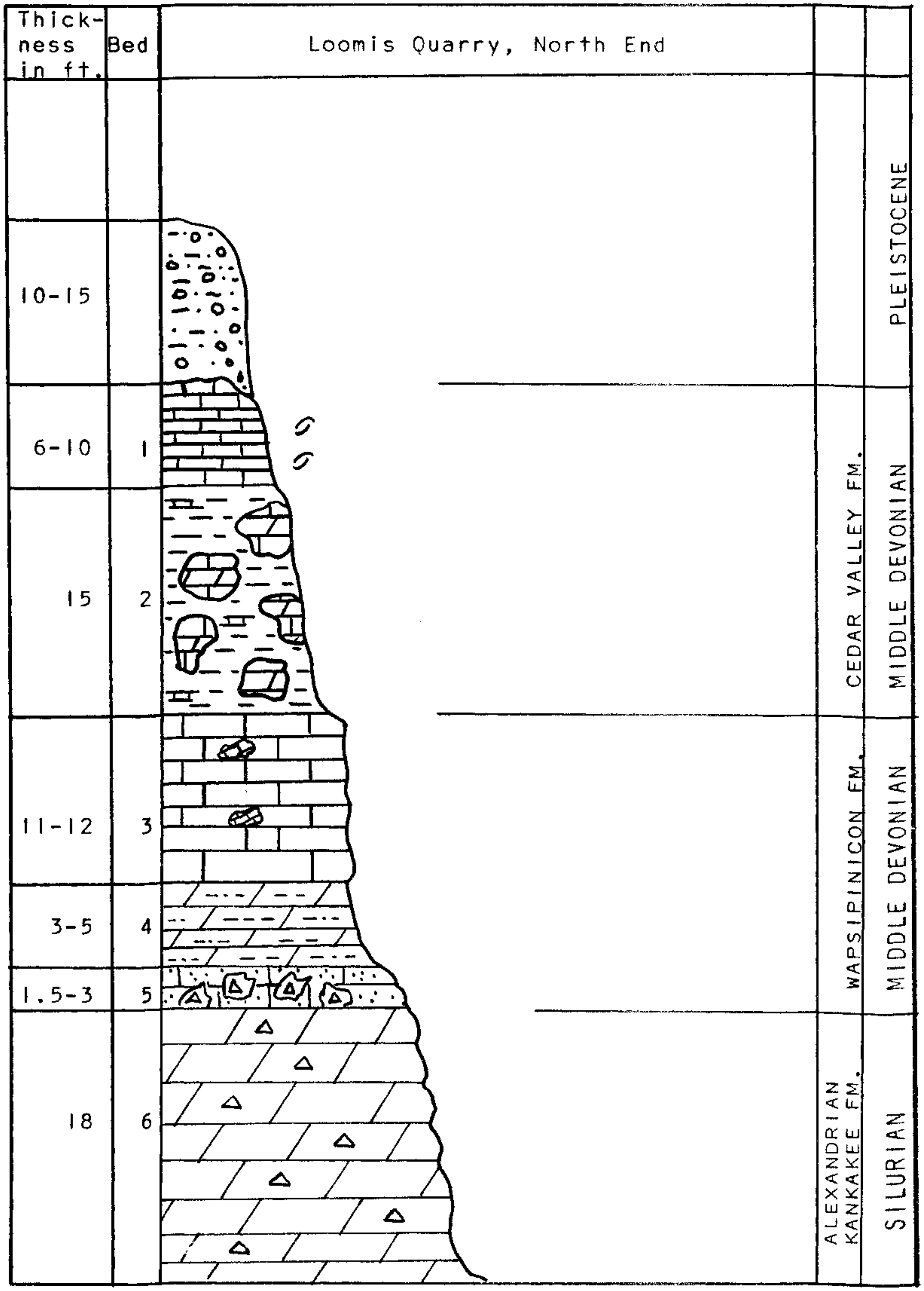

Figure 6. Stratigraphic section, north end, Niemann's Loomis Quarry.

Niemann's Loomis Quarry

Stratigraphic section as measured in the north end of the Loomis Quarry, Denver, Iowa. NW¼ Sec. 29, T.91N., R.13W., Bremer County.

Bed No.		Thickness (feet)
Pleistocene		
	Loess and Till (presumably Wisconsin loess and Kansan till)	10-15
Devonian System Cedar Valley Formation		
1.	Limestone: grayish orange (10 YR 7/4) to very pale orange (10 YR 8/2); medium grained; beds 2"-6" thick with platy weathering; numerous brachiopod fragments (<u>Atrypa</u> sp.) and a few crinoid stem sections; MnO_2 dendrites; unit highly weathered and slumped; overlain by glacial drift	6-10
2.	Breccia composed of fragments of grayish orange (10 YR 7/4) calcareous dolomite in a matrix of shale; poorly preserved brachiopods; unit highly weathered and poorly exposed	15
Wapsipinicon Formation		
3.	Limestone: very pale yellowish brown (10 YR 7/2) to yellowish gray (5 Y 7/2); fine grained; brecciated in places; thick-bedded to massive; thin laminations in places; unit shows effects of solution	11-12
4.	Dolomite: pale yellowish orange (10 YR 8/6); fine to medium grained; friable; silty and argillaceous; weathers to a structureless slope. . .	3-5
5.	Limestone and Chert Breccia: grayish yellow (5 Y 8/4) to very pale orange (10 YR 8/2); coarse grained; fragments of limestone and chert; quartz sand; chert was apparently derived from the Alexandrian Series of the Silurian.	1.5-3

Silurian System (Alexandrian Series)
Kankakee Formation

6. Dolomite: very pale orange (10 YR 8/2) to grayish orange (10 YR 7/4); medium grained; massive bedding; nodules of chert elongated parallel to bedding; color of chert varies from yellowish gray (5 Y 7/2) to very light gray (N 8) and light gray (N 7); patches of calcite crystals; bedding somewhat irregular and weathers with a nodular appearance; silicified tabulate corals present; lower part of unit covered by overburden that has been dumped into the north end of the quarry. 18

Discussion: Dorheim and Koch described the Loomis Quarry exposures in some detail in their 1962 paper in the Proceedings of the Iowa Academy of Science. The quarry has been worked nearly continuously since the time of their report and the nature of the exposures have changed. The stratigraphic section described in this report is similar to the stratigraphic section described by Dorheim and Koch (1962, p. 343-345). Overburden has been dumped into the north end of the quarry in recent years and this partly conceals the exposures in the north end of the quarry. If you go to the extreme north end of the quarry and walk up the pile of overburden you should be able to observe the section as described in this report.

Note that the Wapsipinicon Formation rests directly on the Alexandrian Series of the Silurian in the north end of the quarry. The Niagaran Series of the Silurian is absent at this particular spot (extreme north end of the quarry).

Beds 1 and 2 of this section contain fossil brachiopods that are representative of the Solon Member of the Cedar Valley Formation according to Dorheim and Koch (1962, p. 346).

Bed 3 is a fine grained limestone (micrite) that has been brecciated and affected by solution. The lithologies represented in this unit are characteristic of the Davenport Member of the Wapsipinicon Formation. Bed 5 is a breccia with angular fragments of light gray chert. Blocks of this breccia can be observed at various places in the quarry. The chert fragments were probably derived from a weathered residium developed on the cherty dolomites of the Alexandrian Series of the Silurian. The majority of the chert fragments are quite angular and probably were transported only a short distance.

Bed 6 is a cherty dolomite typical of the Alexandrian Series of the Silurian System. It is assigned to the Kankakee Formation in this report.

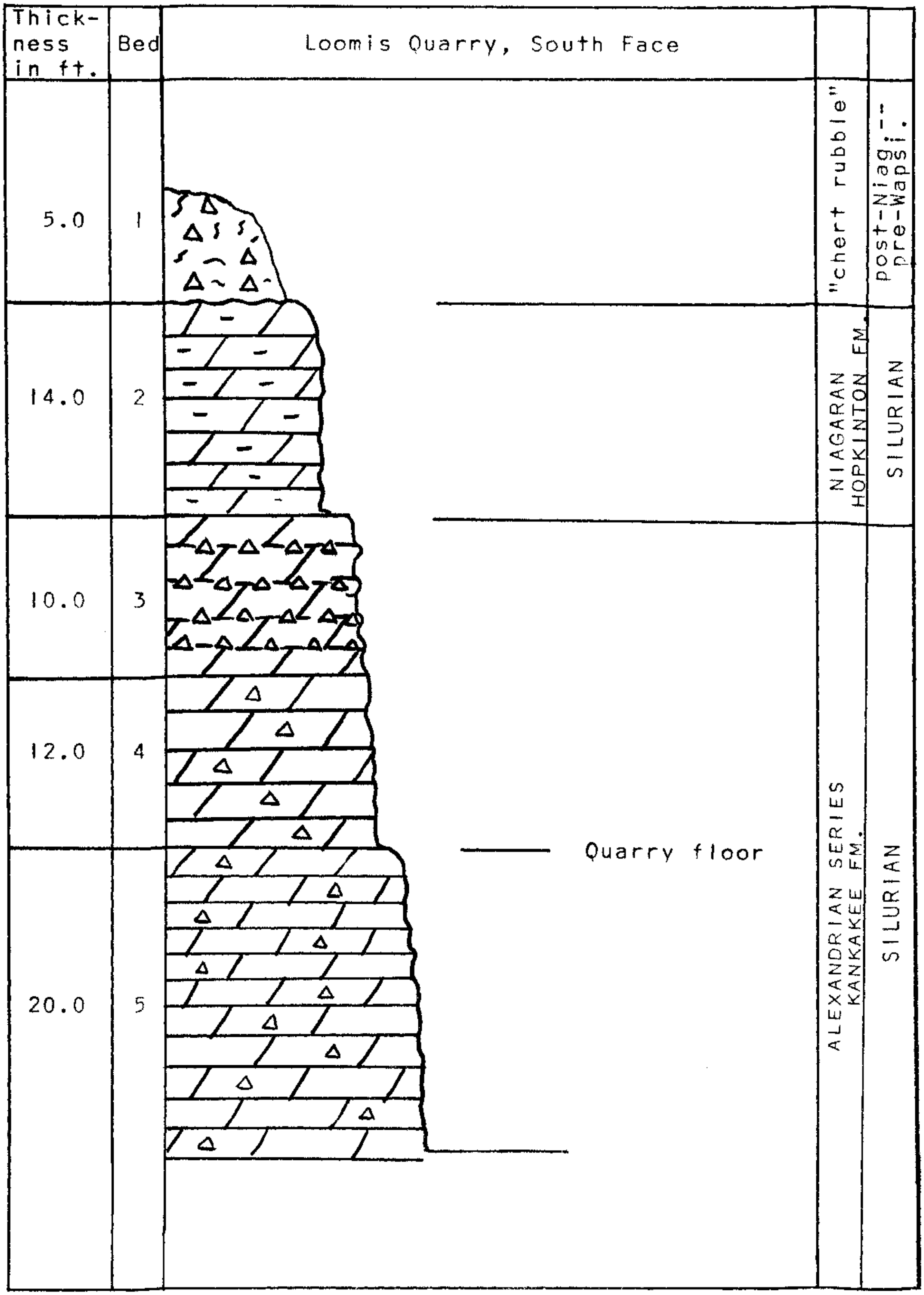

Figure 7. Stratigraphic section, south face, Niemann's Loomis Quarry.

Niemann's Loomis Quarry

Stratigraphic section as measured in the southwest end of the Loomis Quarry, Denver, Iowa. NW¼ Sec. 29, T.91N., R.13W., Bremer County.

Bed No.		Thickness (feet)
	Post-Niagaran--pre-Wapsipinicon (chert rubble)	
1.	Chert rubble in clay matrix: clay matrix ranges in color from pale yellowish orange (10 YR 7/6) to pale red purple (5 RP 6/2); chert fragments and weathered chert nodules range in color from dusky red (5 R 6/2) to light gray (N 8); the chert is probably a residium from weathering and solution of the cherty dolomites of the Alexandrian Series.	5-20
	Silurian System (Niagaran Series) Hopkinton Formation	
2.	Dolomite: light gray (N 7) to very light gray (N 8) on fresh surface, yellowish gray (5 Y 7/2) on the weathered surface; medium grained; contains small pockets of yellowish brown clay (10 YR 5/4 to 10 YR 7/4); massive bedding; scattered nodules of light gray chert; this unit is more weathered and contains less chert than the underlying unit.	14
	Alexandrian Series Kankakee Formation	
3.	Dolomite: light gray (N 7) to very light gray (N 8) on the fresh surface, yellowish gray (5 Y 7/2) on the weathered surface; medium grained; abundant chert nodules and stringers spaced at .5 to 1.0 ft. intervals; chert varies in color from yellowish gray (5 Y 7/2) to light gray (N 8) and very light gray (N 7); massive bedding; shaly partings near top of unit; silicified tabulate corals. . .	10
4.	Dolomite: light gray (N 7) to very light gray (N 8) on the fresh surface, yellowish gray (5 Y 7/2) on the weathered surface; medium grained; massive bedding; contains light gray chert nodules; silicified tabulate corals, horn corals, stromatoporids,	

porous where small fossil fragments have been dissolved; patches of calcite crystals; limonite weathering stains; base of unit is at the level of the main floor of the quarry 12

5. Dolomite: light gray (N 7) on fresh surface, yellowish gray (5 Y 7/2) on weathered surface; medium grained; nodules and stringers of light gray chert; thick-bedded; porous where small fossil fragments have been dissolved; limonite weathering stains; a few horn corals; patches of calcite crystals; unit measured in lower level of quarry starting at water level 20

Discussion: The chert rubble described here as unit I is interpreted as a product of weathering of Alexandrian strata. The weathered material (chert rubble) lies on the eroded surface of the Niagaran Series and below the Wapsipinicon Formation (see Figure 8). The chert rubble is apparently post-Niagaran and pre-Wapsipinicon in age.

The Niagaran Series is distinguished from the Alexandrian Series primarily on the basis of chert content. The Alexandrian Series contains abundant chert whereas the chert content of the Niagaran Series is minor. The upper surface of the Niagaran is an erosional surface and is quite irregular. On the west wall of the quarry the Niagaran dolomite forms a large hummock. Beds of the Wapsipinicon Formation lie on the eroded surface of the Niagaran adjacent to this hummock (see Figure 9). The hummocky Silurian surface is also displayed elsewhere in the quarry (see Figure 8). Exposures in this quarry provide a good opportunity to study the irregular contact of the Silurian-Devonian unconformity.

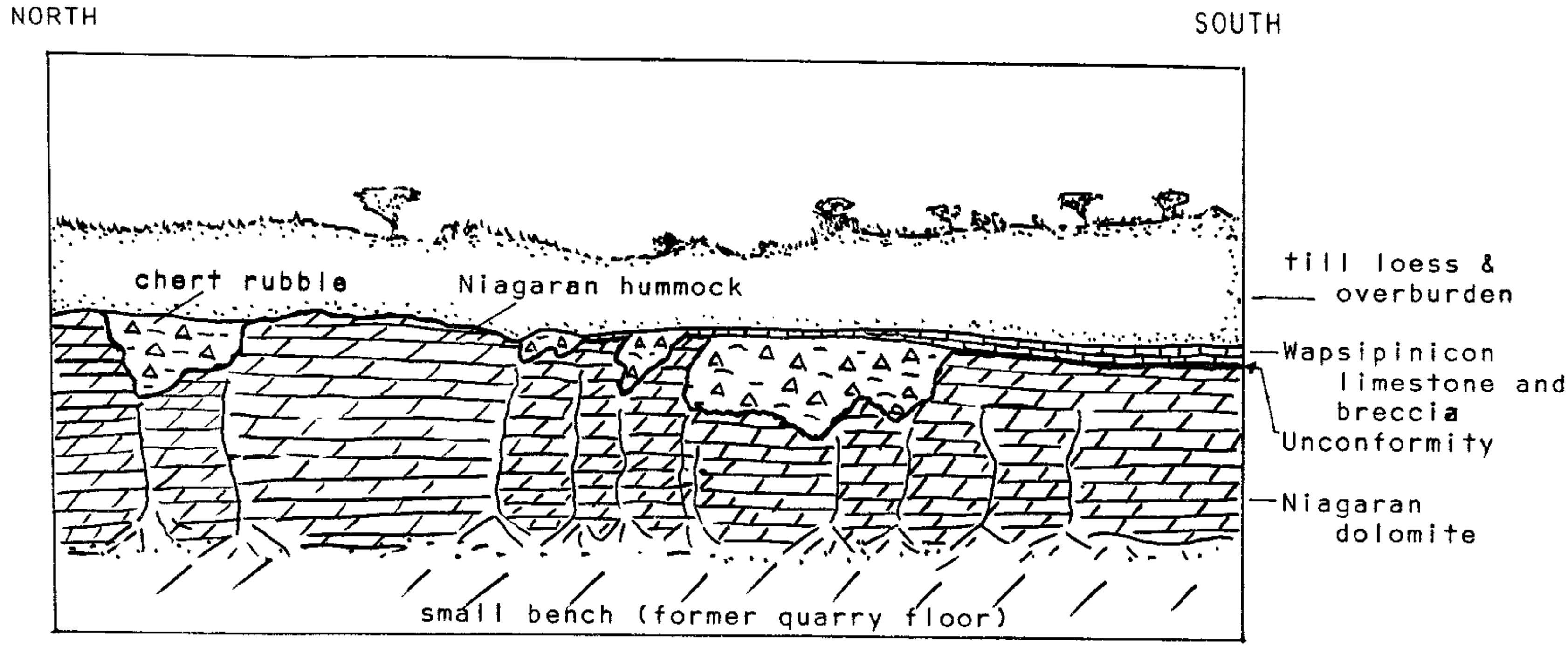

Figure 8. Niagaran hummocks on east wall showing chert rubble pockets. Note Wapsipinicon lithology overlies chert rubble on right side of the figure. Figure drawn from a photograph taken October, 1970. The quarry has been deepened since the photograph was taken. Scale: 1 inch = approximately 20 feet.

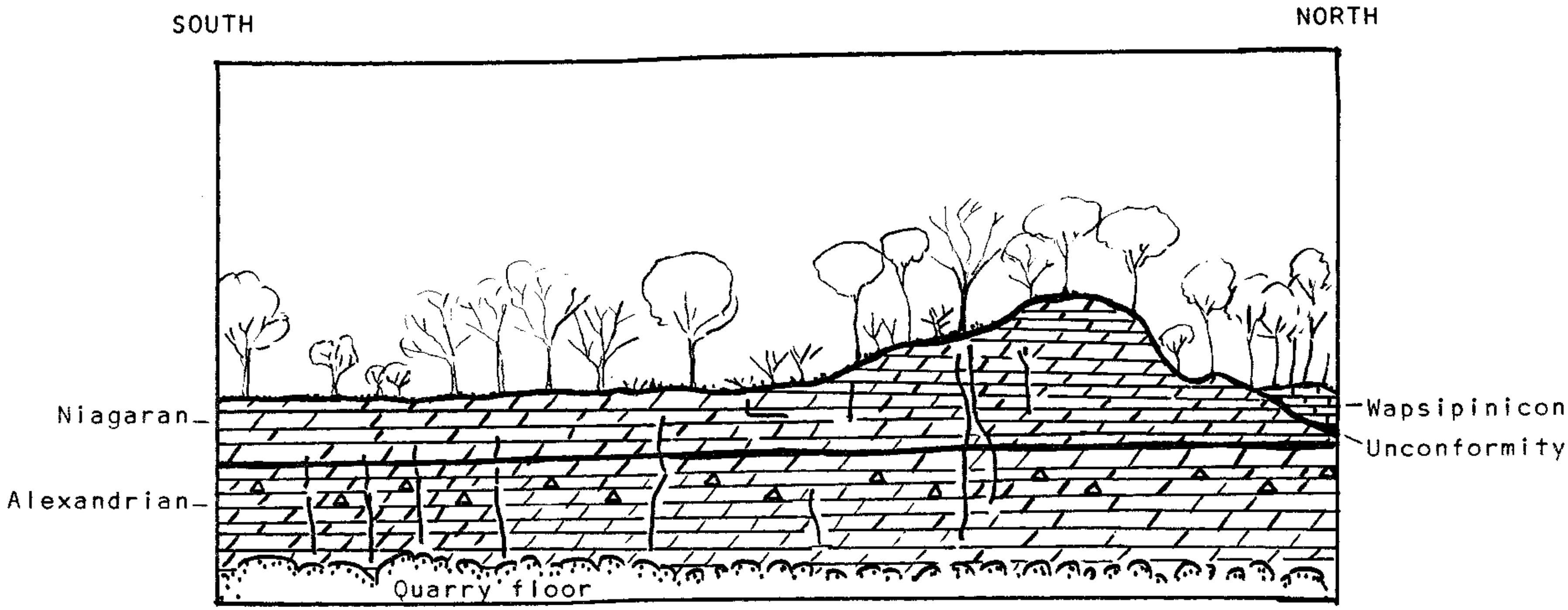

Figure 9. Niagaran hummock on west face of quarry. Limestone of the Wapsipinicon Formation is exposed on the north side of the hummock. Scale: 1 inch = approximately 20 feet.

Core information from the Iowa State Highway Commission indicates that the Ordovician Maquoketa Shale is encountered at a depth of approximately 55 feet below the main floor of the quarry.

References cited:

Dorheim, Fred H., and Koch, Don L., 1962, Unusual exposure of Silurian-Devonian unconformity in Loomis Quarry near Denver, Iowa: Proceedings of the Iowa Academy of Science, v. 69, p. 341-350.

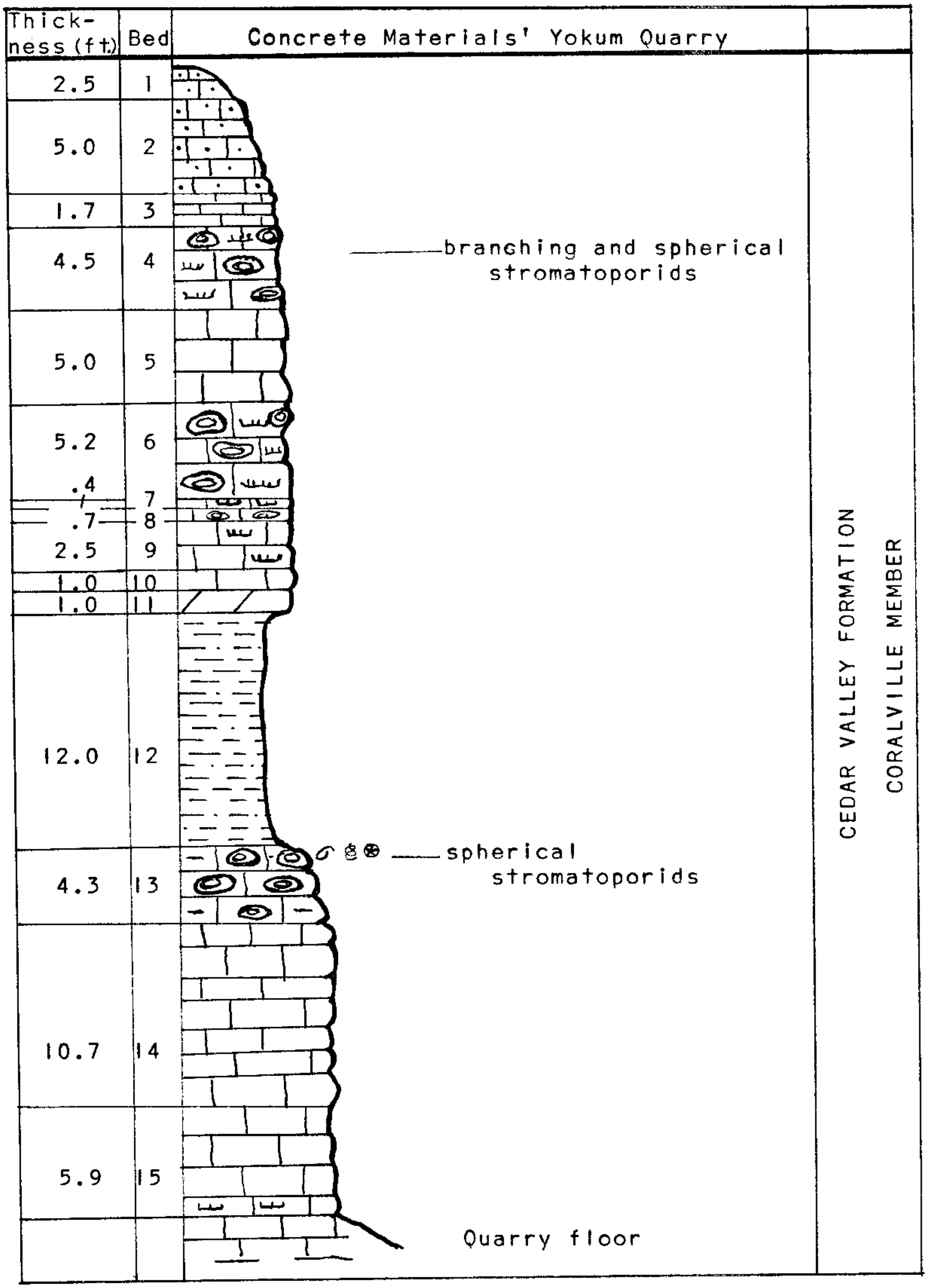

Figure 10. Stratigraphic section, Concrete Materials' Yokum Quarry.

Concrete Materials' Yokum Quarry

Description made of exposures at south end of quarry, southwest of the weigh station, October 1971, field checked July of 1972. SW¼ Sec. 4, T.90N., R.14W., Black Hawk County, Iowa.

Bed No.		Thickness (feet)
	Cedar Valley Formation	
	Coralville Member	
	Overburden: sandy till	8.0
1.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; medium-bedded with numerous shaly partings; birdseye-type structure; traces of quartz silt	2.5
	(Mud cracks have been observed in beds equivalent to units 1-3 in an inactive part of the quarry, approximately ¼ mile to the west.)	
2.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); clastic texture with limestone clasts (½-2 mm) in a fine grained matrix, some clasts appear to be broken stromatoporids; medium-bedded with numerous shaly partings; birdseye-type structure; quartz sand and silt present.	5.0
3.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; thin- to medium-bedded with shaly partings	1.7
4.	Limestone (biostrome): very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; thin- to medium-bedded; numerous branching stromatoporids (*Amphipora* sp.) and spherical stromatoporids (*Actinostroma* sp.).	4.5
5.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; medium-bedded; Shaly in upper 8"; scattered spherical and branching stromatoporids	5.0
6.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; thin-bedded to medium-bedded; branching stromatoporids (*Amphipora* sp.) and spherical stromatoporids (*Actinostroma* sp.); scattered recrystallized gastropods.	5.2

7.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; medium-bedded; branching stromatoporids (Amphipora sp.)	0.4
8.	Limestone: very pale orange (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained matrix with spherical stromatoporids and limestone pellets (¼ - 2 mm)	0.7
9.	Limestone: very pale brown (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; medium-bedded; scattered branching stromatoporids; manganese dioxide dendrites.	2.5
10.	Limestone: very pale brown (10 YR 8/3) to grayish orange (10 YR 7/3); fine grained; thick-bedded .	1.0
11.	Dolomite: very pale brown (10 YR 8/3) to pale yellow (10 YR 7/3); fine to medium grained; argillaceous; medium-bedded; weathered blocks appear to contain poorly preserved mud cracks.	1.0
12.	Shale: light olive-gray (5 Y 6/2); silty, calcareous; scolecodonts found in residues	12.0
13.	Limestone (biostrome): very pale brown (10 YR 8/3); fine grained; argillaceous limestone matrix with numerous spherical stromatoporids (Actinostroma sp.), the brachiopods Cranaena sp. and Atrypa sp. are common in the upper layers; a few gastropods, Stroparollus sp., crinoid fragments	4.3
14.	Limestone: very pale brown (10 YR 8/3); fine grained; medium- to thick-bedded.	10.7
15.	Limestone: very pale brown (10 YR 8/3); fine grained; medium-bedded; branching stromatoporids in lower 1.5 feet	5.9
	Total	62.4 ft.

Discussion: The Coralville Member of the Cedar Valley Formation is exposed at this stop. The predominant rock type is fine grained limestone (micrite) and reflects deposition in quiet, shallow water.

Stromatoporids are abundant in the quarry and two well developed biostromes of stromatoporids are recognizeable (bed 4 and bed 13). The lower biostrome is overlain by about 12 feet of shale. Stromatoporids weather out of this bed and can be collected in abundance in many areas of the quarry. The weathered specimens show good skeletal detail. Brachiopods and crinoid fragments are abundant in many of the irregular depressions associated with the top of the biostrome and can be found on the weathered slopes at the contact of beds 12 and 13. Apparently the influx of mud, now represented by the shale, terminated the growth of the stromatoporid colonies. The upper biostrome is overlain by fine grained limestones (micrites) that contain a considerable amount of quartz sand and silt grains. Limestone clasts, possibly stromatoporid fragments, are found in some of the beds (bed 2 for example).

The upper limestone beds (1 and 2) contain birdseye structure which is an indication of tidal or supratidal deposition. Mudcracks have been observed in these beds also which would further indicate tidal or supratidal depositional conditions.

Core information from the Iowa Highway Commission indicates that the Coralville Member is approximately 120 feet thick in this location.

This quarry was visited by the 1951 Tri-State Field Conference.

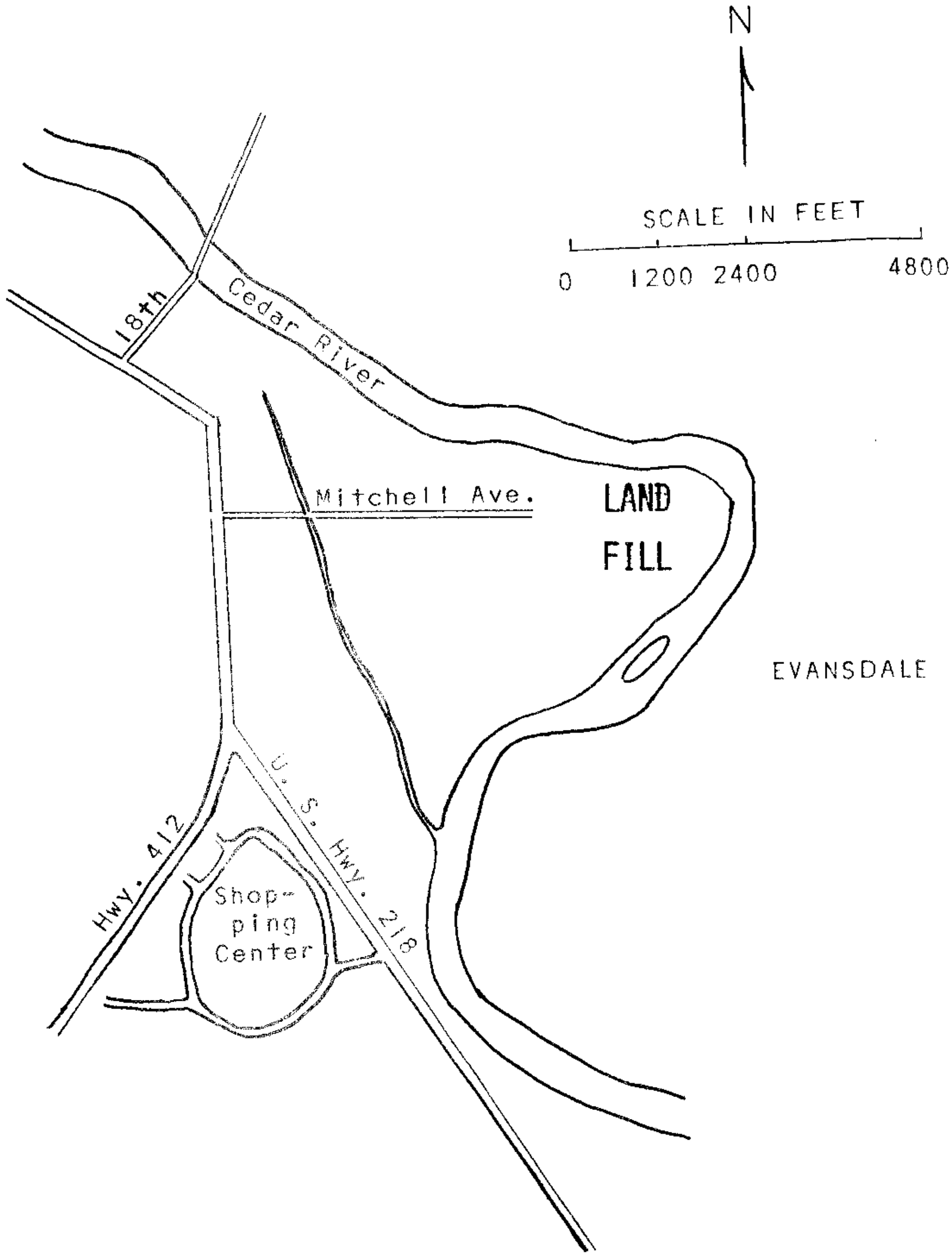

Figure II. Location map showing the Waterloo Municipal landfill site.

WATERLOO MINICIPAL SITE

General description The present operating site is located on the flood plain of the Cedar River, SW 1/4, Sec. 32, T. 89N., R. 12W. The fill area is a progressive face which has advanced along the landward side of the flood protection levee of the west bank of the Cedar River. The initial stages of the fill were made at the Eighteenth Street bridge in Waterloo and in some fifteen or sixteen years the landfill operation has advanced to the present location (on site coordinator, personal communication, 1971). Escavating is done in front of and to the landward side of the advancing face of the landfill in order to obtain cover material for daily operation. The distance between the river and the actual fill area varies from the width of the levee (fifty to seventy-five feet) to as much as approximately 300 feet at the present location. Ground surface around the present fill is nearly flat and poorly drained.

The area surrounding the present working site of the landfill is sparcely populated. To the southeast of the site is located the city of Evansdale, and to the southwest is the Waterloo Sanitary Sewer Plant.

Geology The generalized geologic section in the vicinity of the present Waterloo site consists of (A) surficial alluvial sediments of unknown thickness, and (B) the Cedar Valley Limestone Formation, underlying. The details of the stratigraphy are uncertain, except for the first twelve to thirteen feet of the sediments. These sediments are visible in the excavation area and consist of three to four feet of silt and eight to ten feet of sand. At the time of the spring snow melt in late March and early April the water level in the sand section is near the top of the section.

Hydrology The hydrological conditions of the Waterloo site are affected by the same factors as the Spring Lake site. The groundwater of the alluvial sand at the base of the landfill operation is frequently in direct contact with the refuse of the landfill operation. During times when the groundwater level is high, operations are hampered because the sand that is excavated for cover material is saturated with water. The higher water level also advances the wetting front in the landfill area and presumably increases leachate production.

Monitoring system No monitoring program is being conducted at the Waterloo site. Two water samples were taken by Dale Elifrits in April 1971 and sent to the State Hygienic Laboratory to be analyzed. The results are shown in Table 3.

Site operations The ramp method of operation is used at the Waterloo site. The material used for cover is removed from the surface as the ramp face of the fill advances. Depending on the water level below the fill in the sands, the excavation is up to twelve feet deep. This excavation is back-filled with refuse as the face advances, and the fill is continued upward, above the surface, to an elevation equal to that of the top of the standard project flood levee, all in one ramp face. On the landward side of the fill and back of the advancing face, old appliances are stockpiled for salvage and, at length, compacted

WATERLOO SITE GROUND AND SURFACE WATER

CHEMICAL COMPOSITION[1]

Element	Ground Water Concentration (mg/l)	Surface Water Concentrations (mg/l)
Zinc	o.10	o.79
Copper	0.01	0.11
Chromium	0.01	0.11
Nickel	0.04	0.13
Iron	2.0	5.0

[1]Ground water sample was taken from the cover material excavation around the face of the fill area on 22 April, 1971.
Surface water sample was taken from standing surface water on the river side of the levee across from the face of the fill on 22 April, 1971.

Table 3.

Chemical analyses of water samples from the Waterloo landfill site.

and covered in that location.

The types of materials disposed of at the Waterloo site are domestic refuse and garbage, business and industry wastes, and construction scraps and rubble. Based on the rate of advance of the fill face and number of truck loads in a given period of observation, the per day quantity of material handled is estimated to be 300 to 600 cubic yards.

Control of wind-blown paper and plastics is often a problem at the site. The standing water around the fill face at the base of the landfill is an obvious odor problem. Odors from the landfill site are noticeable across the river in Evansdale.

The site is not well suited for use as a sanitary landfill. Hopefully the operation will be closed in the near future. At present a county site is being selected and will be proposed by November of 1972.

Pint's Quarry

Welp and McCarten, Inc. operate so-called Pint's Quarry, just north of U. S. Highway 20, Raymond Iowa in the SE¼, Sec. 36, T.89N., R.12W., Black Hawk County. All three members of the Cedar Valley Formation are exposed here. This quarry is a favorite collecting spot for local mineral collectors. Good crystals of calcite, fluorite, barite, pyrite, and marcasite can be found in the lower levels of the quarry in the Solon Member. Abundant fish fragments can also be found in the Solon Member in the lower part of the quarry.

Ellipsoidal structures, possibly algal oncolites, are present in the Rapid Member. An unusual "ripple bed" can be observed near the top of the Rapid Member.

The upper portion of the quarry is in the Coralville Member. An exposure of greenish-gray shale, the so-called "Independence Shale", can be seen in a fissure in the Coralville Member in the upper part of the quarry. This shale contains Upper Devonian conodonts similar to those described by Müller and Müller (1957) from the Independence Formation and its equivalents.

James Urban, University of Texas at Dallas, was sent a sample of this shale for palynologic studies. He reports (personal communication) that the sample contained palynologic fossils indicative of an Upper Devonian age and other palynologic fossils indicative of a Mississippian age. This seems

Formation	Bed Number	Cumulative Thickness	Thickness	Description
CORALVILLE	24	102.0	10.3	dololutite/calcilutite, lower part similar to bed 23, but without calcite, abrupt change in middle to thinly laminated dololutite, top few feet which is poorly exposed is a laminated/thin-bedded calcilutite with scattered intraclasts and fossils.
CORALVILLE	23	91.7	4.2	dololutite, dark brown, soft to "earthy" with cavities up to several inches filled with single crystals of dark brown calcite. Top of bed forms third prominent bench.
CORALVILLE	22	87.5	4.1	dololutite, similar to beds 20 and 21, but darker and with more iron staining, possible dessication (?) features near top.
CORALVILLE	21	83.4	3.7	dololutite, similar to bed 20, but with fewer recognizable fossils.
CORALVILLE	20	79.7	1.5	dololutite, similar to bed 19, recrystallized corals produce "blotchy" mottling, concentration of recrystallized brachiopods and crinoid fragments near middle of bed.
CORALVILLE	19	78.2	4.6	dololutite, buff, massive, no bedding features, calcite lined vugs present, this ledge forms the second prominent bench in quarry.
CORALVILLE	18	73.6	1.2-3.4	dololutite, argillaceous with intraclasts of underlying bed, calcite void filling, much variation in composition, texture,
CORALVILLE	17	70.2	1.0	calcilutite, laminated/thin bedded, light color, hard, dense, composed of 90% micritic pellets, no dolomite present.
RAPID	16	69.2	1.5	dololutite, argillaceous, calcitic, light brown, weathered, undeformed.
RAPID	15	67.7	10.6	dololutite, argillaceous, similar to bed 14, but finer laminations and more pyrite upper 3 feet contain deformed bedding, some of which closely resemble ripplemarks.
RAPID	14	57.1	10.4	dololutite, argillaceous, thinly laminated, scattered horizontal and vertical burrows, small "cut and fill" structures, prominent iron stained zone at top.
RAPID	13	46.7	6.0	dololutite, argillaceous, similar to bed 11, no distinct laminations, discontinous layer of chert nodules near top in a prominent iron stained horizon.
RAPID	12	40.7	0.3	dololutite, very argillaceous, less resistant unit, contains flat calcite nodules and chert.
RAPID	11	40.4	7.3	dololutite, argillaceous, fine pyrite laminations-but not very distinct, more crystal lined vugs in lower half of bed, a few scattered chert nodules near top.
RAPID	10	33.1	4.3	dololutite, calcitic, light gray, transitional Rapid lithology, coarser grained than overlying dololutites, lag concentration of phosphatic (fish) fossils and glauconite pellets on disconformity, abundant silicified corals, crystal lined vugs, and silicified "oncolites", top of bed is lowest bench in quarry.
SOLON	9	28.8	1.5	dololutite, calcitic, light brown, fewer vugs and fossils, top of bed is burrowed disconformity with 6 to 8 inches relief and marks the Solon-Rapid contact, distinct color change at contact.
SOLON	8	27.3	4.7	dololutite, calcitic, similar to units 5, 6 & 7, but with fewer crystal lined vugs, shaley parting at top of bed.
SOLON	7	22.6	4.0	dololutite, calcitic, similar to beds 5 and 6, but with fewer crystal lined vugs, shaley partings at top of bed.
SOLON	6	18.6	2.0	dololutite, calcitic, similar to bed 5, fluorite in vugs first noted here.
SOLON	5	16.6	5.4	dololutite, calcitic, similar to beds below, abundant scattered vugs in lower part, more abundant solitary corals in upper part, recrystallized corals produce "blotchy" mottling.
SOLON	4	11.2	1.5	dololutite, calcitic, similar to beds 2 and 3, but lighter in color.
SOLON	3	9.7	0.8	dololutite, calcitic, similar to bed 2.
SOLON	2	8.9	4.0	dololutite, calcitic, similar to unit 1, but with fewer bituminous partings, and more vugs, abundant horizontal burrows.
SOLON	1	4.9	4.9	dololutite, calcitic, thick-bedded to massive, dark brown, numerous discontinous bituminous partings particularly near the top, abundant crystal lined vugs, a few discontinous calcite veins parallel to bedding, a few scattered fossil fragments and solitary corals.

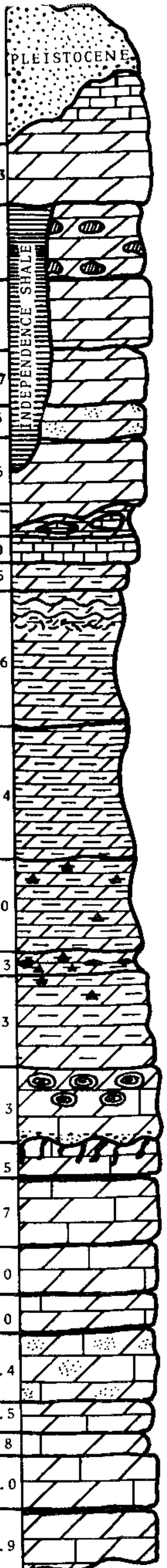

Figure 12. Stratigraphic section of the Cedar Valley Formation

to be consistent with his findings in other areas (see discussion of Brooks' Quarry section).

The stratigraphic section for Pint's Quarry included in this guidebook was measured and described by E. C. Kettenbrink, geology department, University of Iowa. The following discussion was prepared by Mr. Kettenbrink.

The Stratigraphic Section at Pint's Quarry

E. C. Kettenbrink
University of Iowa

Approximately 102 feet of the Cedar Valley Formation is exposed at Pint's Quarry. This includes all of the Rapid Member (41 feet), a portion of the Solon Member (28 feet), and part of the Coralville Member (33 feet). The upper part of the Coralville Member has been removed by erosion and is overlain by Pleistocene till. A core log from the Iowa State Highway Commission indicates that another 42 feet of Solon is present below the quarry floor so the total thickness of the Solon Member at this site is approximately 70 feet. This represents an increase in thickness for the Solon Member from 6 feet in the vicinity of the Mississippi River and 15-20 feet in the type area in Johnson County to approximately 70 feet in Black Hawk County. The greater thickness of the Solon to the north probably represents deposition in a more rapidly subsiding portion of the basin rather than deposition in deeper water. The total thickness of the Rapid Member varies little over the outcrop area from the Mississippi River (50 feet) through the Johnson County type area (52 feet) to Black Hawk County (41 feet).

Diagenesis is a striking feature of the rocks at Pint's Quarry. Recrystallization of calcite and dolomitization is extensive. Few beds in the quarry have escaped extensive dolomitization. Silicification, although less abundant, is pervasive. Vugs, ranging from ½ inch to 6 inches in diameter and lined with calcite crystals are conspicuous features throughout the formation. Additional mineralization of these vugs with pyrite, marcasite, sphalerite, barite, fluorite, and other minor minerals have made this quarry a favorite with mineral collectors. Fluorite is perhaps the most unusual and noteworthy for the size of individual crystals (up to 1 inch in diameter).

Solon--The Solon rocks are dark brown, with bedding thick to massive. Irregularly spaced, discontinuous bituminous partings are common. Concentration of more closely spaced partings (forming "shaly" seams up to 1 inch thick) mark the top of most beds in the Solon Member. Horizontal, unbranched, sinuous burrows are particularly common in the lower part of the quarry exposure. The burrows, averaging 3/8 to 1/2 inch in diameter, have been traced up to 12 inches, and are particularly well displayed on bituminous partings. In cross-section, these burrows appear as an ellipse with the major axis parallel to bedding and with a slightly different texture and color than the surrounding matrix. The most distinct feature of the burrow cross-sections is their peculiar "swirled" texture.

All of the Solon Member at this locality consists of calcite and dolomite in varying proportions. Some beds are dolomitic limestones and others are calcitic dolostones. This variability in composition may be exhibited by a single bed. Thin section analysis reveals an interesting calcite-dolomite replacement relationship. Most of the dolomite crystals are in various stages of replacement by calcite. Dolomite occurs as euhedral to subhedral crystals, 75 to 100μ in longest direction. The calcite spar occurs as irregular to euhedral cores in partially replaced dolomite crystals, as recrystallized fossils, and as a cement (or groundmass). The calcite spar is characterized by its purity and relatively large crystal size (several times larger then the crystal size of the dolomites).

The Solon Member contains 10 to 25 percent recognizable fossils and is not as fossiliferous at Pint's Quarry as at some other Solon sections in the area. Rugose corals are the most abundant fossils in the Solon at this locality. Favositid corals are also common. Stromatoporoids, brachiopods, bryozoans, and crinoid fragments are also found, but are definitely scarcer at Pint's Quarry than at most Solon localities. A notable exception to the general scarcity of fossils at Pint's Quarry is the abundant fish fauna.

In thin section a few more percent of recrystallized fossil fragments can be recognized. The only invertebrate microstructure that has survived has been preserved in silica.

Apparently, silicification preceded recrystallization and dolomitization. The almost complete obliteration of favositid corals in some beds in the upper part of the Solon results in a "blotchy" mottling, best perceived by slight textural and color differences.

Of the many crystal-lined vugs in the Solon, most give no indication as to their origin. However when silicification was included in the mineralization of these structures, the origin is apparent. Silicification around the outer margin of these vugs has preserved the skeletal structure of various corals. Silicification of the outer part of these corals was followed by solution of the remaining carbonate skeletons of the corals leaving voids. Following calcite emplacement in the voids, selective mineralization of individual vugs produced the mineral suites now found.

Rapid--The Solon-Rapid contact can be placed at a prominent burrowed disconformity. This contact is several feet below the lowest bench in the quarry. A lag concentration of phosphatic fossils and glauconite pellets occurs on this contact and it is accompanied by a slight, but distinct change in lithology between members. A distinct color change from medium yellowish brown (10 YR 5/2) in the Solon Member to medium greenish gray (5 GY 5/1) in the Rapid Member exists at this contact. The basal several feet of the Rapid Member is more dolomitic than the underlying Solon. The basal Rapid is also coarser grained and more fossiliferous than the rest of the overlying Rapid and it represents a transitional lithology between the two members. This basal transitional lithology of the Rapid has one of the largest concentrations of mineralized vugs of any bed in the quarry. Large silicified corals are also abundant in this transitional lithology. Of particular interest is the occurrence of possible silicified oncolites. These "oncolites" are round to ellipsoidal in shape, dark brown in color, and possess a thin white surface rind. Individual "oncolites" range from 1/2 inch to 7 inches in diameter. Larger specimens are due to the coalescence of smaller "oncolites" forming larger compound structures. The strongest evidence of an algal origin of the "oncolites" is the overlapping festoon laminae that all of the specimens exhibit. In thin section there is a definite textural and mineralogical difference between these festoon laminae and surrounding portions of the "oncolite". Some laminae show possible borings or burrows. The "oncolites" may or may not show a distinct nucleus. The orientation of skeletal material within the "oncolite" structures is a problem. One would expect to see more of a tangential alignment of elongated fragments in true oncolites that have rolled on the sea floor than is seen in the Pint's Quarry material. The loss of much structural detail due to the combined effects of recrystallization, dolomitization, and silicification present serious problems in the interpretation of these structures.

The remaining Rapid consists of light gray pyrite-rich dololutite. The Rapid is quite argillaceous and has been characterized by Bisque and Lemish (1959) as having a total insoluble residue content greater than 10%, most of which is illite. The dolomite is in the form of euhedral crystals, 15 to 75 μ in longest direction, with the average size near 25μ. Bedding ranges from massive (due to bioturbation) to thinly laminated. Laminations are due to alternating layers of slightly different texture which are commonly separated by thin films of pyrite. Boundaries between some layers are erosional. Small amounts of calcite (up to 20% in the most abundant examples) exist as cement in these rocks. The calcite occurs as small scattered patches in the bioturbated beds and as alternating calcite-rich and calcite-poor layers in the thinly laminated units. The calcite exhibits an interstitial pore filling texture between euhedral dolomite crystals.

Fossils are quite scarce, with the exception of local concentrations in several thin discontinuous chert layers. In thin sections the rocks are almost totally devoid of skeletal debris. The few fossils recovered have been partially silicified brachiopods, with only faint impressions of the dissolved calcitic shell preserved as a mold in the dololutite, and phosphatic fish fossils.

Abundant crystal-lined vugs characterize the Rapid Member as its most conspicuous feature. These vugs are perhaps more regularly elliptical than those in the Solon Member. Evidence is lacking (except in the beds of the transitional Rapid lithology) which would suggest an organic origin for these vugs, similar to the vugs in the Solon. Although skeletal fossils are uncommon in the Rapid, vertical and horizontal burrows are a relatively common feature, with the number of horizontal burrows being greatest. Bioturbated beds exhibiting a "churned" texture occur in the lower part of the Rapid Member. Progressing upward stratigraphically, burrowing in the Rapid becomes less abundant and pyrite laminae become less disrupted and spaced closer together. Vertical burrows, usually exhibit a delicate meniscus backfilling and are more common in the upper part of the Rapid.

Some of the laminated dololutites preserve erosional surfaces and small scale "cut and fill" structures, indicating that the Rapid environment did experience at least short-term strong currents. Recognition of some of these structures may be difficult due to later superimposed deformation and faulting. Contorted and deformed bedding of the laminated dololutites occur within the top few feet of the Rapid Member. In areas of less pronounced deformation, the bedding superficially resembles current ripples in both plan and cross section views. The wavelengths of "ripples" vary from 1/2 to 12 inches, with the majority of the wave lengths measuring approximately 2 inches. Preservation of equally spaced pyrite laminations and lack of cross bedding preclude a ripple (primary) origin for these structures. The "ripples" are interpreted as being caused by the deformation of soft sediment, possibly due to intrastratal folding of weakly consolidated carbonate mud. These contorted and deformed beds were cut by still later micro-normal faults with displacements up to 1 cm. This deformation may have resulted from gravitational slippage of mud layers.

Above the deformed zone there is approximately 1 1/2 feet of undeformed Rapid below the Coralville Member. Fine pyrite laminations, current produced structures, a sparse fauna, burrow orientation, and stratigraphic position suggest that the Rapid was deposited in a shallow subtidal environment, generally unfavorable to life, to a low intertidal environment.

Coralville--The base of the Coralville Member is marked by a thinly laminated, light colored calcilutite. This bed is much harder and denser than the underlying dololutites of the Rapid Member. In thin section the rock is made up of slightly elongated micritic pellets, which are probably fecal in origin. The pellets are of a uniform size (100-120μ). The rock also contains a few percent of scattered, unidentified, thin-shelled fossil fragments. It is noteworthy that this lithology is completely devoid of dolomite. Directly above this pellet limestone occurs a zone of variable thickness (2 to 4 feet) which forms the second prominent bench in the quarry. This zone consists of material ripped up from the bed directly below. It includes angular fragments and rounded intraclasts within a variable amount of argillaceous dololutite. Abundant spar-filled voids and fractures are also present. This bed is quite variable laterally even over a few tens of feet. The bulk of the Coralville Member consists of thick-bedded to massive, light to dark brown dololutites, with varying amounts of sparry calcite as recrystallized fossils, void filling, and cement. Again recrystallization and dolomitization has been intense, destroying much original fabric. Ghost fossils, mainly favositid corals almost completely obliterated by diagenesis, produce a "blotchy" mottling pattern similar to that found in the upper Solon beds. The petrology of the massive Coralville dololutites is very similar to that of the Solon Member, except that the Coralville beds do not contain bituminous partings and have fewer brachiopods and other fossil fragments than do the Solon beds.

A very soft to "earthy" dark brown dololutite mottled with large single crystals of dark brown calcite occurs in the upper third of the Coralville. Single crystals of calcite, up to several inches in diameter, occur in the dololutite beds. The large calcite crystals break along cleavages, and are very prominent because of their reflection of sunlight. It appears that the crystals started as void filling and proceeded to replace the dololutite as indicated by a transition zone along the margin of crystals.

Several beds contain numerous irregular spar-filled fissures which may represent dessication cracks (?). Unequivocal dessication polygons have been found at about the same stratigraphic position at other localities in the area. In the top six feet of the section there is an abrupt change from thick-bedded dololutites, to laminated/thin-bedded calcilutites. These limestones are very fine grained and contain scattered intraclasts and a very few fossil fragments.

The lower part of the Coralville is thought to represent deposition in a normal shallow marine environment dominated by a favositid coral and stromatoporoid fauna. The lower pellet limestone may represent a "lagoonal" facies. The environment became shallower with deposition moving into the intertidal environment as indicated by dessication features and the very fine grained calcilutite which was probably deposited on a tidal flat.

Independence Shale--An exposure of the "Independence Shale" as a stratigraphic leak within the Cedar Valley can be seen in the upper part of the quarry. Here it occurs in two prominent fissure fillings, three to four feet wide in the Coralville Member. The age and stratigraphic position of the Independence has long been a controversy. It is now generally considered to be Upper Devonian and younger than the Cedar Valley in age and generally to occur as cavern and fissure fillings (Collinson et al., 1967).

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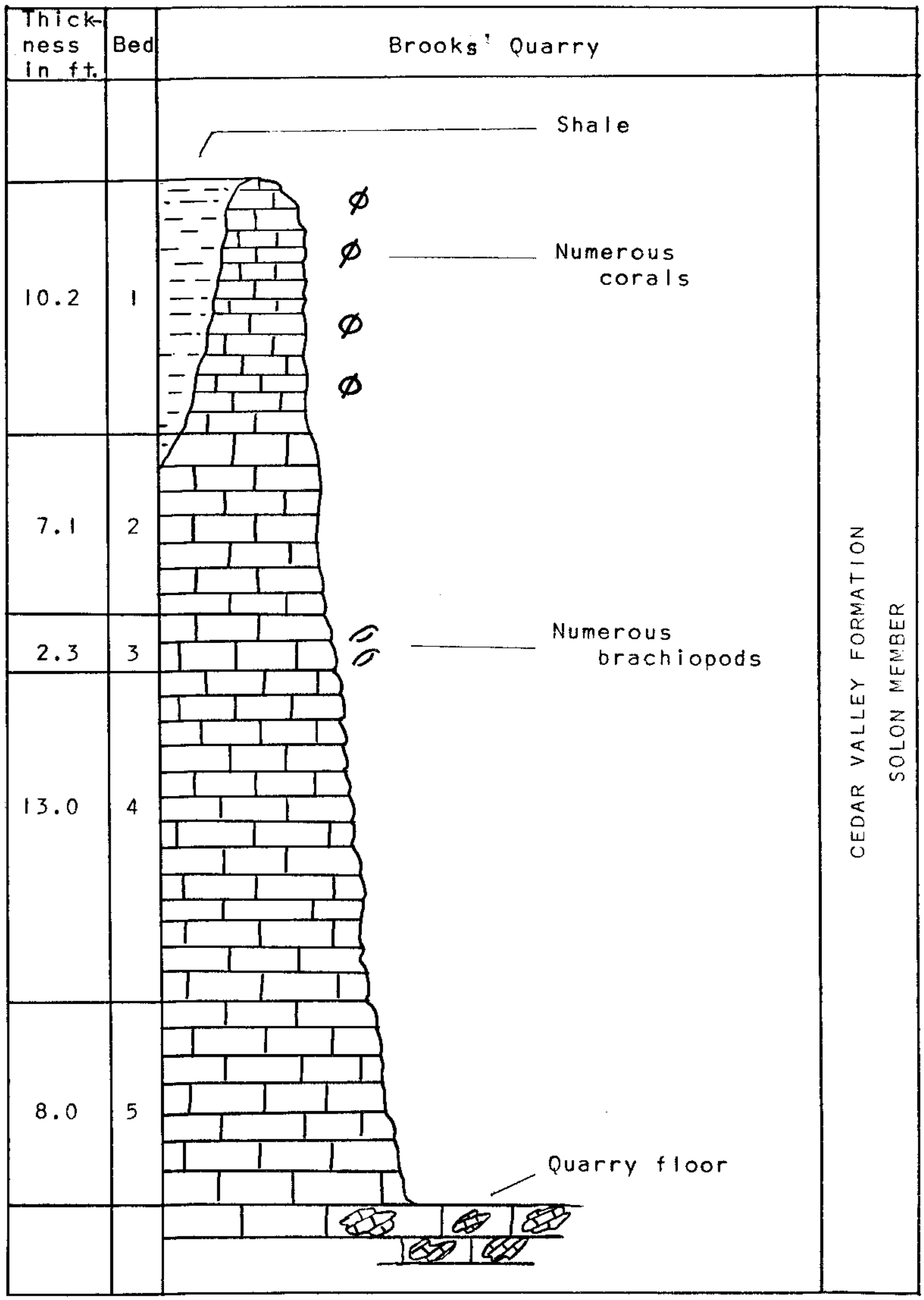

Figure 13. Stratigraphic section, Brooks' Quarry.

Brooks' Quarry

The stratigraphic section was measured in the northeast corner of the active quarry approximately ¼ mile south of U. S. Highway 20 in Independence, Iowa. NW¼ Sec. 2, T.88N., R.9W., Buchanan County, Iowa.

Bed No.		Thickness (feet)
Devonian System		
Cedar Valley Formation		
Solon Member		
1.	Limestone (biostrome): light yellowish gray (2.5 Y 7/2); medium grained; thin- to medium-bedded; platy weathering; highly fractured; limonite weathering stains; MnO_2 dendrites; patches of secondary calcite; numerous horn corals, tabulate corals and colonial Rugose corals, (*Hexagonaria* sp., *Billingsastrea* sp., "*Cystiphyllum*" sp., *Zaphrentis* sp.); the horn corals are compressed and flattened parallel to the bedding; crinoid stem fragments; occasional brachiopods.	10.2
2.	Limestone: light yellowish gray (2.5 Y 7/2); fine grained; medium-bedded; highly fractured with many fractures filled with secondary calcite deposits; patches of calcite; limonite weathering stains; MnO_2 dendrites; scattered fossils--crinoid stem fragments, bryozoa, horn corals, brachiopods (*Atrypa independensis*, *Platyrachella iowensis*).	7.1
3.	Limestone: light yellowish gray (2.5 Y 7/2); fine grained; medium-bedded; fractured; secondary calcite; abundant MnO_2 stains; numerous brachiopods (*Atrypa independensis*, also a spiny variety of *Atrypa*, *Platyrachella iowensis*), crinoid stem fragments.	2.3
4.	Limestone: light yellowish gray (2.5 Y 7/2) on the weathered surface, very light gray (N 8) on the unweathered surface; fine grained; thick-bedded; highly fractured; a few scattered brachiopods in the upper 8" of the unit (*Atrypa* sp. and *Platyrachella* sp.)	13.0

5. Limestone: very light gray (N 8); fine grained; thick-bedded; highly fractured; similar to overlying bed except for color; covered by talus at level of quarry floor 6.0-8.0

Total thickness 40.6

Discussion: Additional lithologic units are present in the quarry. Several exposures of light gray to dark gray shale can be seen in the quarry on the east, south and west walls. The shales lie in solution cavities on and within the Solon Member of the Cedar Valley Formation. James Urban (personal communication), University of Texas at Dallas, has recovered palynomorphs from some of these shales which contain both Upper Devonian and Late Mississippian (Chester) species. He concludes that the shale (the so-called "Independence Shale"), was derived from erosion of the Upper Devonian Lime Creek Formation during Chester time. He states the Upper Devonian fossils have been flattened while the Chester fossils are virtually undistorted, indicating that the Devonian forms have been reworked.

Solution breccias are well developed in the Solon exposures on the south wall of the quarry. The breccias are composed of limestone fragments within a limestone matrix. The breccias appear to owe their origin to solution and collapse. Slickenside-like markings are prevalent along the south wall of the quarry and are apparently related to the solution and collapse associated with the formation of the breccias.

A second type of breccia is visible in the lower few feet of the west face of the quarry and in blocks on the floor of the quarry. This breccia contains angular fragments of pale yellow and olive gray limestone (micrite) in a matrix of light gray (2.5 Y 8/1), fine grained limestone. The limestone fragments are typical of lithologies associated with the Davenport Member of the Wapsipinicon Formation.

Core information from the Iowa State Highway Commission indicates that the Davenport Member of the Wapsipinicon Formation lies at or a few feet below the level of the quarry floor. The Highway Commission logs indicate the total thickness of the Wapsipinicon Formation is approximately 50 feet at this locality.

The upper beds of the quarry (beds 1-3) are very fossiliferous and contain a wide variety of fossils. Gilbert Klapper (personal communication), University of Iowa, has recovered a well preserved conodont fauna from the Solon limestones at this locality. A partial faunal list of fossils recovered from Brooks' Quarry follows:

Porifera
- *Astraeospongia* sp.

Stromatoporoidea

Rugose corals
- "*Cystiphyllum*" sp.
- *Zaphrentis* sp.
- *Heliophyllum* sp.
- *Hexagonaria* sp.
- *Billingsastrea* sp.

Tabulate corals
- *Favosites* sp.
- *Striatopora* sp.

Bryozoa
- *Fenestrellina* sp.
- *Cryptostomata* types

Brachiopoda
- *Platyrachella iowensis*
- *Atrypa independensis*
- a spiny species of *Atrypa*

Trilobites
- *Proetus* sp.

Pelecypods
- *Paracyclas* sp.

Gastropods
- *Straparollus* sp.

Echinodermata
- assorted crinoid stem fragments

Miscellanea
- *Tentaculites* sp.
- conodonts

The Solon Member at this locality reflects subtidal marine deposition in a shallow inland sea.

The 1951 Tri-State Geology Field Conference visited the abandoned quarry, approximately 1/4 mile north of the present active quarry.

Casey's paha, Sections 10, 11, 12, 13, 14, and 15, T.88N., R.13W., Tama County, Iowa.

The Iowan Problem and Casey's Paha

The term "paha" was used by McGee (1891, p. 255) for constructional ridges of wind-blown silt and clay in the area of the so-called "Iowan glaciation" of northeastern Iowa. The stratigraphy of the interiors of the paha is similar to that of the Kansan drift region of Iowa according to Scholtes (1955). Scholtes suggested that the "Iowan" ice did not override the high areas on the pre-Wisconsin landscape. Instead, the thin "Iowan" ice was diverted around the high areas which were composed of Kansan till. "Iowan" till was deposited against the flanks of the topographic highs and on the low lying plains surrounding the highlands.

Scholtes further suggested that vegetation on the pre-Wisconsin soil of the high areas served as a catchment for loess and permitted a thick accumulation of loess on the ridges. He reasoned that the loess was much thinner on the lower-lying "Iowan" till plain because the loess could not be deposited in this area until the "Iowan" ice had melted.

Ruhe and others (1965, p. 12) presented evidence for an erosional origin both of the paha cores and the lower lying "Iowan" surface. Much of their evidence was based on data from a drilling program that traced the Pleistocene stratigraphy from known Kansan drift areas in southern Tama County across the Iowan-Kansan boundary and onto the so-called "Iowan" drift surface of northern Tama County. A drilling traverse was also conducted from the paha areas onto the adjacent "Iowan" plain.

Ruhe and his co-workers concluded that the cores of the paha were composed of paleosols and tills that represent erosional remnants that stand above the "Iowan" surface at interstream divides. They further concluded that the "Iowan" drift does not exist and that the "Iowan" plain is an erosion surface cut into Kansan and/or Nebraskan tills. Ruhe (1969, pl. 1) indicates that the Iowan erosion surface in this area formed 18,000 to 30,000 years ago.

The erosion surface encroached on the paha areas from all directions but did not completely destroy them. As remnants, these areas received the full deposition of loess in contrast to the lower-lying erosion surface which received a thinner cover of loess (Ruhe and others, 1965).

At the northwest end of Casey's paha along the east side of Highway 21, NW¼, SE¼, Sec. 10, T.86N., R.13W., there is a good exposure of the so-called gumbotil of Iowa. The gumbotil, a Yarmouth-Sangamon paleosol, extends from north to south through the road cut as a nearly level layer. The paleosol is sharply truncated on the north and south ends of the road-cut by the pre-loess erosion surface. Thick loess buries the paleosol and flanking erosion slopes (Ruhe and others, 1965, p. 16).

Ruhe and others (1965, p. 28a) reported the following section from a drill hole at this locality (see Figure 14):

Soil	4.0 ft.
Wisconsin loess	16.1 ft.
Kansan till	52.3 ft.

Ruhe reports that a sample of organic carbon was collected from the base of the loess deposits just above the paleosol from nearby Hayward's paha. The age of the sample from carbon 14 analysis was 25,000 ± 2,500 years.

If you climb to the top of the paha here you will get a good view of the lower-lying plain to the west and north. This was the "Iowan-drift" plain of early workers. Ruhe and others (1965, p. 16) considers the plain to be the Iowan erosion-surface complex cut in Kansan till.

At the east end of Casey's paha, along county road X in the vicinity of the SE¼, SE¼, Sec. 12, T.86N., R.13W., Ruhe and others (1965, p. 31a) reported the following section from a drill hole (see Figure 14):

Soil	4.0 ft.
Wisconsin loess	12.5 ft.
Sand	2.5 ft.
Late Sangamon paleosol	2.5 ft.
Kansan till	29.0 ft.
Nebraskan till	12.0 ft.

Ruhe reported that the oxidized and weathered Nebraskan till was penetrated at a depth of 50 feet below the top of the roadcut at an elevation of approximately 920 feet and that the lower till (Nebraskan) was penetrated in other holes in this vicinity at similar elevations.

The lower-lying roadcut to the north has loess over stone line on till. Subsurface studies show that the till beneath the stone line is the lower till (Nebraskan). A series of cores showed that the Sangamon paleosol was truncated northward

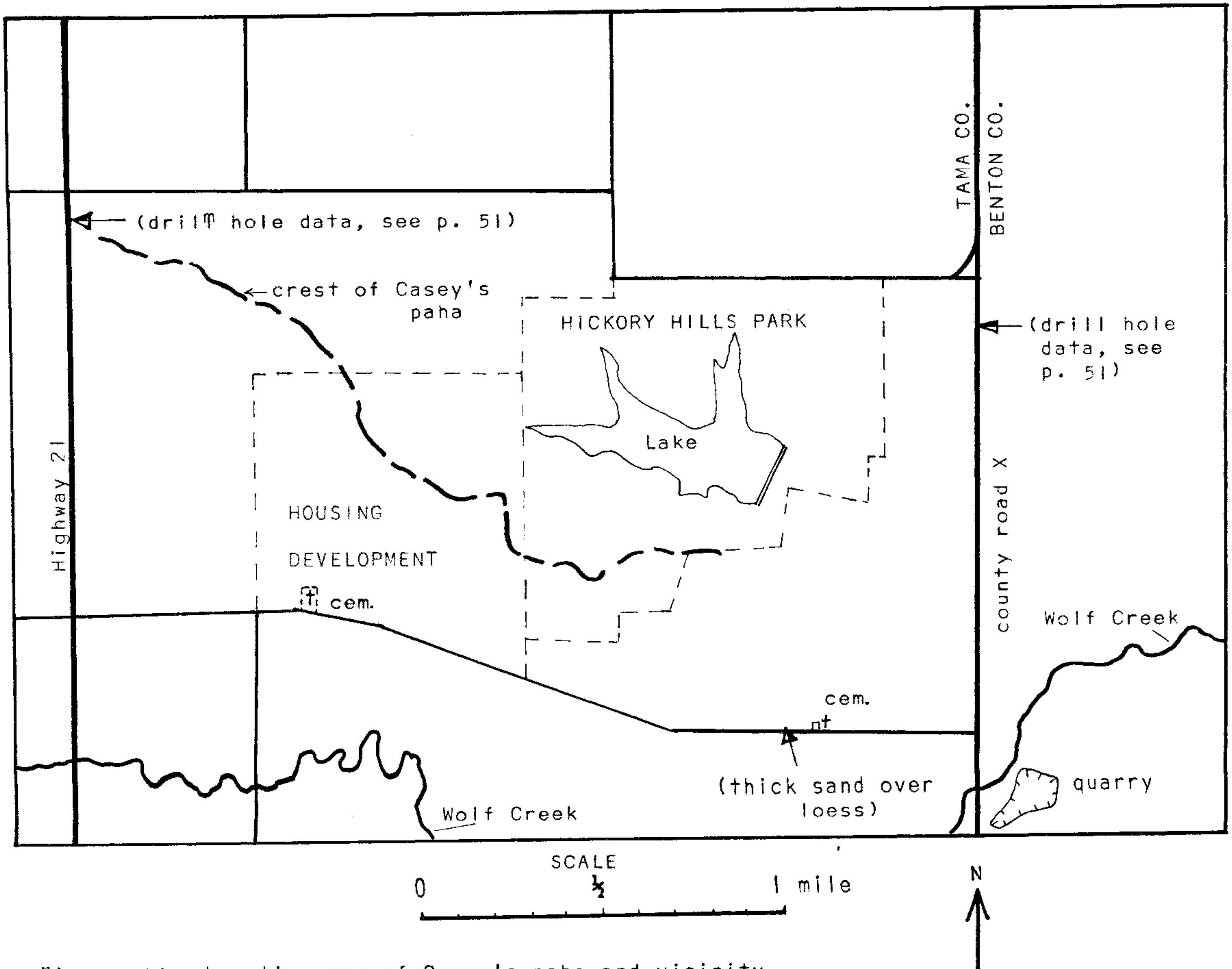

Figure 14. Location map of Casey's paha and vicinity.

from this locality (Ruhe and others, 1965, p. 19).

Land use controversy: Approximately 500 acres of Casey's paha was purchased by Black Hawk County and developed into Hickory Hills Park. As far as is known, this is the first time in Iowa that one county has owned land in another county. The Black Hawk County Conservation Board has developed a small lake with beach area, a 40-unit camping area, a picnic area and a ski area in the park. Long range plans called for some expansion of the park area as additional funds and land became available.

Recently (winter of 1972) a Waterloo developer purchased the land to the west and southwest of the park for a proposed housing development. Approximately 130 lots of one acre or larger size are planned for the first phase of the development. Additional units may be developed later.

The Black Hawk County Board of Supervisors and the Black Hawk County Conservation Board objected to the housing development for several reasons: (1) the development would block any further expansion of the park; (2) the construction would likely increase the potential for pollution and siltation of the lake in the Hickory Hills park; and (3) the housing development would likely alter the ecological setting of the area adjacent to the park.

Their objections were to no avail however as the Tama County Board of Supervisors allowed the area to be rezoned and construction is scheduled to begin in late summer of 1972.

The developer may well encounter some engineering problems by building homes on loess underlain by paleosol and glacial till on relatively steep slopes. According to the U. S. Department of Agriculture Soil Conservation Service Map of the soils of Tama County, two soil types are prominent on Casey's paha: The Lindley Series and the Fayette Series. Fayette soils are present over most of the area of the proposed housing addition and moderate to severe erosion can be expected on these soils, especially on slopes greater than 5 per cent. Slopes in the area are consistently greater than 8 per cent.

Along the south side of Casey's paha several roadcuts show sections of loess over Kansan till. Near the Hill Cemetery (see Figure 14) a thick deposit of sand is visible, overlying Wisconsin loess. The sand was apparently blown from the floodplain of Wolf Creek.

Limestone bedrock is exposed in a quarry just south of Wolf Creek in Benton County (see Figure 14). The Coralville Member of the Cedar Valley Formation is exposed in the quarry and contains some well developed mud cracks, indicators of supratidal or intertidal environments. Glacial scour and striations can be observed on the upper surface of the bedrock. The fresh cuts of the quarry excavation formerly exposed a good section of the Pleistocene stratigraphy of the area but weathering and erosion have modified the exposures a great deal and at present the Pleistocene sequence is not well exposed in the quarry.

Hayward's paha, the ridge to the south of Casey's paha and Wolf Creek, has a stratigraphic sequence similar to that found in Casey's paha. Ruhe and others (1965) reported the following stratigraphic sequence from a drill hole on Hayward's paha:

40 feet of loess
Yarmouth-Sangamon paleosol
Kansan till
Aftonian paleosol
Nebraskan till

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Ruhe, R. V., Dietz, W. P., Fenton, T. E., and Hall, G. F., 1965, The Iowan problem: guidebook for the 16th annual meeting of the Midwest Friends of the Pleistocene, 66 p.

Ruhe, R. V., 1969, Quaternary landscapes in Iowa: The Iowa State University Press, 255 p.

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EXPLANATIONS

Terms used in rock descriptions

Texture	
coarse grained	> 2 mm
medium grained	1/16 - 2 mm
fine grained	< 1/16 mm

Bedding	
massive	> 2 ft.
thick-bedded	1 - 2 ft.
medium-bedded	4 in. - 1 ft.
thin-bedded	1 in. - 4 in.

(Symbols)