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CONDITIONS GOVERNING THE OCCURRENCE OF GROUNDWATER IN THE FERNALD AREA, OHIO, WITH REFERENCE TO THE POSSIBILITIES OF CONTAMINATION BY DISPOSAL OF CHEMICAL WASTES, USGS, GROUNDWATER BRANCH, COLUMBUS, OHIO (USED AS A REFERENCE IN OU1, 2, 4 & 5 RI REPORTS)

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REPORT

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CONDITIONS GOVERNING THE OCCURRENCE OF

[redacted] IN THE FERNALD AREA, OHIO, WITH

REFERENCE TO THE POSSIBILITIES OF CONTAMINATION BY

DISPOSAL OF CHEMICAL WASTES

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U. S. Geological Survey
Ground Water Branch

Columbus, Ohio

September 1951

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Conditions governing the occurrence of gr
water in the Fernald area, Ohio, with reference to the possibilities of contamination by disposal of chemical wastes

by George D. Dove and Stanley E. Norris

Introduction

This report describes ground-water conditions in the vicinity of Fernald in southwest Ohio in Hamilton County. It was prepared at the request of the Atomic Energy Commission to aid in the design of waste disposal and water supply facilities for a uranium-processing plant now being constructed by the Atomic Energy Commission in the Fernald area. A knowledge of ground-water conditions is needed for design of these facilities because the refining process will require disposal in some manner of wastes which would be injurious to public health if allowed to contaminate ground-water supplies. The danger exists that the plant's water supply, if developed locally, might be rendered unfit for use and that other water supplies in the area might be damaged if the wastes are not handled carefully.

The field work on which this report is based was done in May, August, and September 1951 by George D. Dove and Stanley E. Norris, geologists, of the Columbus office of the Ground Water Branch, U. S. Geological Survey, working under the direction of E. J. Schaefer, District Engineer. Most of the interpretations of the basic data given in this report were made by Mr. Dove who is the principal author. The local geology was studied, well drillers and well owners were interviewed, and a survey was made of most of the water wells in the area. Water-level measurements were made in wells wherever possible and the elevations of the water level were estimated from the U. S. Geological Survey topographic map for the area, with the exceptions of the water levels for wells 41 and 48 which were determined by instrumental leveling. The

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water-level elevations given for many wells in table 1 are based on reported depths to water because the water level could not be measured at the time of the investigation. Some of these reported depths are somewhat discordant among themselves and can be regarded, therefore, as being only very approximate.

Water samples were collected from many of the wells surveyed. These samples are being retained by the Atomic Energy Commission for comparison, if deemed desirable, with samples to be collected after the new plant is put into operation.

The Fernald area is located near the Hamilton-Butler County line, about six miles southwest of Hamilton and ten miles northwest of Cincinnati. As shown by the map, plate 1, three small villages in the area, located with reference to Fernald, are New Baltimore, two miles southeast, Venice (Ross post office), six miles northeast, and Shandon, about eight miles northwest. These are small communities, each having a population of less than 200, and none have public water supplies. All are in the Miami River Valley west of the river.

There are no large ground-water supplies being pumped near the Fernald area at this time. A Ranney water collector is at present being built for the Southwest Ohio Water Company approximately one mile east of the site of the Atomic Energy Commission plant on the opposite side of the Miami River. The location of the collector is shown on plate 1. When completed it is anticipated that the collector will yield in excess of 15 million gallons a day. The water will be piped to industries in the Mill Creek Valley immediately north of Cincinnati.

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Geology and Ground-Water Conditions

The Miami valley is more than two miles wide in the Fernald area. This broad lowland was not eroded by the Miami River, but represents the former course of a much larger stream which, prior to glaciation, had cut its channel into the consolidated rocks to a level more than 200 feet below that of the present stream. Glacial meltwaters filled the valley to its present level chiefly with layers of sand and gravel, called valley train deposits, into which the Miami River has cut its present course. There is a well-defined terrace, which is prominently developed along the eastern edge of the proposed plant site, shown on Plate 1, that marks the boundary between the floodplain of the present stream and the original level of the valley train deposits

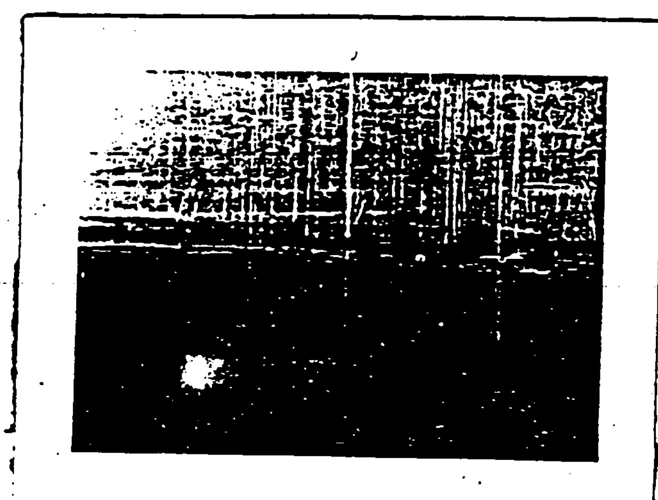

Plate 2. View of the plant site showing very flat topography. Photograph was taken from Route 126 at N.E. corner of plant site.

In some places the valley train deposits are interstratified by generally thin and irregular layers of clay-like till. The permeability of the till is low and in some areas produces artesian conditions by confining water below it under hydrostatic pressure. Where this occurs there are generally two recognizable aquifers, that found in the shallower deposits where the ground-water level represents the true water table, and that found at depth under artesian conditions. In wells drilled to the artesian aquifer the water level rises above the top of the aquifer after the confining layer has been penetrated. In the area of this investigation the artesian level was generally lower than the water table.

The upper 10 to 25 feet of the valley train deposits consist of river alluvium and soil, developed during several thousand years since glacial times. In the flood plain of the present Miami River the soil and alluvium are generally less than 10 feet in thickness as seen in exposures along the river. The soil of the lowland areas is very fertile and it supports some of the richest farms in Ohio. This is in sharp contrast to conditions in the bordering upland areas where soils are thin and much less fertile, and the consolidated rocks are generally covered by only a few feet of glacial drift.

The consolidated rocks, which are exposed in numerous places on the uplands, consist of shales and interbedded limestones of Ordovician age. These strata are almost everywhere impermeable and are a negligible source of ground water. Upland farms depend for their water supplies mainly on dug wells in the glacial drift, springs, and cisterns. In prolonged dry periods farmers often haul water from lowland farms or from the river.

Ground water of good quality is generally available in the Miami River valley lowlands. Along the Miami River most farmers simply drive a perforated pipe 20 or 25 feet into the ground, attach a pitcher pump, and a well is complete. Because of the comparatively low cost of such wells most farms have several, located at convenient places. Farms located beyond the present floodplain, at the higher levels of the valley train deposits, generally have shallow dug wells which range in depth from 20 to 30 feet on the average. A few farms in these areas have drilled wells, generally 4 inches in diameter and from 30 to 60 feet deep.

As shown by the data presented in table 1, the average depth of the drilled wells in Venice is approximately 42 feet; most of the driven wells there average 23 feet in depth. The largest single water user in Venice is the Meadowbrook swimming pool which has a capacity of 500,000 gallons, and is drained and refilled each week in the summer time.

Most of the residents of New Baltimore obtain water from cisterns, which suggests that the alluvial and glacial deposits in that area are not as permeable in their upper part as they are at Venice.

As shown on plate 1 the site of the proposed refining plant includes an area of approximately 1.75 square miles, centering about one mile west of the Miami River at the mean elevation of 580 feet. The records of test holes, table 2, drilled by the U. S. Army Corps of Engineers, and the Layne-Ohio Company, show that the thickness of the glacial deposits underlying the plant site is slightly more than 200 feet. The upper 20 or 30 feet of these deposits consist chiefly of alluvial sand and silt, containing sufficient clay to make the whole of relatively low permeability. Some water is obtained from these deposits from dug wells but the best supplies in the plant site area are obtained from drilled wells tapping the more permeable gravel deposits found at greater depths.

The measurements of water levels (table 1) made in the shallow wells in

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the area surveyed show that the slope of the water table corresponds closely to the surface topography. There is, therefore, a ground-water divide which corresponds roughly to the topographic divide marked approximately by the 600-foot contour at the eastern side of the new plant site. West of the divide the shallow ground water flows to Paddy's Run (plate 3) and east of the divide it flows to the Miami River. East of the divide water levels in shallow wells as measured or reported seem to correspond with those in deep wells, leading to the conclusion that the shallow and deep deposits form a single aquifer. West of the divide there are pronounced differences between water levels measured or reported in the deep wells as compared to water levels in the shallow wells, the water levels in the shallow wells being higher than in nearby deep wells.

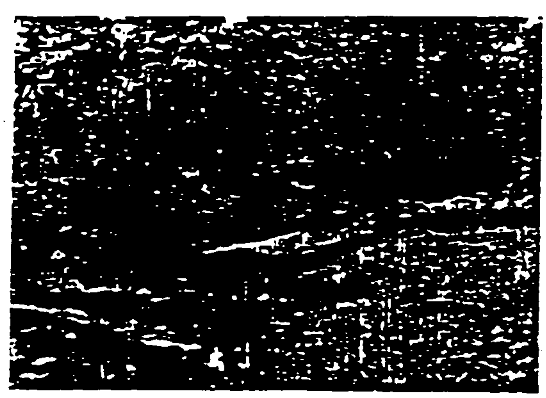

Plate 3. View of Paddy's Run about 3,000 feet north of proposed plant site

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Possibilities of Ground Water Contamination

Although the upper 20 or 30 feet of the glacial and alluvial materials underlying the proposed plant site are of low permeability, the fact that dug wells are developed in these materials indicates that wastes discharged on the ground would very probably infiltrate to the water table. Depending upon its relationship to the ground-water divide, the contaminant either would flow westward to Paddy's Run, eastward to the Miami River, or it might percolate through the upper and less permeable material to the more permeable sands and gravels of the lower aquifer. In the latter case it would also move, in response to the hydraulic gradient of the area, to the Miami River because the shallow and deep gravels as previously stated apparently become a single aquifer east of the plant site. Because wells normally intercept a portion of the ground-water flow in an area, local contamination of the ground-water aquifers would almost certainly result in the eventual contamination of nearby water supplies.

Paddy's Run, which is shown on plate 3, is probably a source of water for stock. Any toxic materials discharged into the stream either by surface drainage or by ground-water flow, could cause harm to animals watering there. Flow of contaminated ground water into the Miami River would also be undesirable unless the amount of dilution offered by the relatively high flow of the river is sufficient in dry periods to cut the concentration of dangerous wastes to amounts not considered harmful.

In view of the potential hazards it is not considered advisable to allow harmful wastes to enter the surface drainage or to be discharged onto the ground where it may infiltrate to water-bearing gravels and eventually reach surface streams by underground flow.

Available Ground Water Supply

Without conducting detailed pumping tests of the gravel deposits that underlie the proposed plant site it is not possible to make a close quantitative estimate of the amount of water that can be pumped or what effect such pumping would have on ground-water levels in the area. However, the possibilities can be roughly judged on the basis of the knowledge of geologic conditions gained during the investigation, and on detailed investigations made in areas where geologic conditions are similar.

The largest ground-water supplies in Ohio are obtained from highly permeable deposits of sand and gravel, similar to those which underlie the Miami Valley at Fernald. Where wells are located so as to cause the infiltration of stream flow into the ground-water aquifers, large yields are sustained. It is this method of inducing stream recharge that is expected to make possible the withdrawal of approximately 15 million gallons of water a day from the collector being built for the Southwest Ohio Water Company. This very large yield is not expected to cause ground-water levels, except in the proximity of the collector along the east side of the river, to be lowered a large amount. This is because of the very high minimum flow of the Miami River (lowest on record 100 cubic feet per second) which should provide abundant recharge at the proposed rate of withdrawal into the highly permeable glacial deposits underlying the Miami River. The largest water supplies, therefore, in the general area of the proposed Atomic Energy Commission plant can probably be obtained from wells located on the flood plain of the Miami River, close enough to the river to induce stream flow into the aquifer.

Wells constructed farther from the Miami River, in the immediate plant site area, would not encounter conditions as favorable as those which prevail

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near the river chiefly because recharge conditions would not be as good. Drawdowns in pumping wells would be greater because a much more extensive cone of depression would result for any particular rate of pumping before a condition of steady flow is attained. In spite of these handicaps it is believed that two or three million gallons of water a day can be obtained in the area without extreme lowering of ground-water levels. If larger amounts of water are desired, controlled pumping tests should be conducted to provide a means for estimating the effects of pumping on water levels in the surrounding area.

Quality of the Ground Water

Only one chemical analysis of ground water from the proposed plant area is available. It was a bailer sample taken by a representative of the Atomic Energy Commission during the drilling of a deep well (No. 69), located near the center of the site. This sample was analyzed by the Quality of Water Branch, U. S. Geological Survey, Columbus, Ohio. The analysis is presented as follows:

	Parts per million		
Silica (SiO_2)	10	Carbonate (CO_3)	0
Iron (Fe) See below		Bicarbonate (HCO_3)	374
Calcium (Ca)	88	Sulfate (SO_4)	8.4
Magnesium (Mg)	27	Chloride (Cl)	78
Sodium (na)	37	Fluoride (F)	.0
Potassium (K)	7.7	Nitrate (NO_3)	.1
Manganese (Mn)	.00		
Dissolved solids	431	pH value	7.6
Total hardness as $CaCO_3$	334	Oxygen consumed:	
		unfiltered	___
Suspended matter		filtered	___
Color	2	Specific conductance at 25° C (micromhos)	795

Fe

In solution when analyzed	.01	
In sediment and solution	2.3	a/

a/ Sample turbid with some sediment when collected

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The ground water, as shown by this analysis, is hard (334 p.p.m. as $CaCO_3$) but not much harder than most other ground waters in Ohio. Unfortunately the water sample was collected by bailer before the test well was fully developed. As a result the sample was turbid and the accuracy of the analysis of the iron content of the sample is therefore in doubt. This is explained by W. L. Lamar, District Chemist, as follows: "It should be noted that this sample was not clear when collected. We are, therefore, unable to determine the amount of iron in solution at the time of collection. In order to determine the amount of iron in solution at the time of collection the sample should have been clear or filtered clear when collected. Since a clear sample was not collected it is difficult to evaluate the significance of the iron analysis." The iron in solution at the time of analysis was 0.01 p.p.m. but, when that contained in the sediment was added, the total amounted to 2.3 p.p.m. The latter is high and would make the water unsuitable for some purposes unless some method of treatment is provied to remove the iron.

Table 1

Records of wells investigated in the vicinity of Fernald, Ohio

Well No.	Owner	Type well	Depth of well (Ft.)	Static level (Ft. below land surface)	Elev. of water level (Ft. above sea level)	Date data collected
1	Lois Weaver	Dug	12.5	8.7	569	5/8/51
2	C.M. Morris	Dug	16.5	5.9	576	do
3	do	Drilled	150*	-	-	do
4	Almer Francis	Dug	18	13.0	577	do
5	F.M. Francis	Drilled	45*	-	-	do
6	C. M. Morris	Dug	12.8	6.4	575	do
7	Mrs. J. Williams	Drilled	-	-	-	do
8	Formerly B. Irwin, Now USA	Drilled	93	59.0	530	do
9	Formerly H. Horace, New USA	Drilled	66	39.0	531	do
10	U.S. Gov't	Dug	-	10.2	553	do
11	P.A. Farmer	Dug	-	5.4	555	do
12	B. Butterfield	Dug	-	-	-	5/9/51
13	Unknown	Drilled	62	44.0	524	do
14	C.H. Knollman,	Dug	-	-	-	do
15	do	Drilled	-	-	-	do
16	do	Dug	10	6.5	574	do
17	U.S. Gov't	Dug	15	4.5	566	do
18	A.P. Sachs	Drilled	100*	-	-	do
19	do	Dug	17	4.5	558	do
20	Leo Hayob	Drilled	88*	48*	519	do
21	H. [illegible]	Drilled	100*	40*	530	do
22	W.S. Schmied	Drilled	72*	54*	509	do
23	do	Drilled	98*	72*	530	do
24	S.D. Lewis	Drilled	[illegible]	20*	530	do
25	B. Butterfield	Driven	[illegible]	10*	535	do
26	Unknown	Driven	-	-	-	do
27	[illegible]	Driven	20*	-	-	do
28	Clara [illegible]	Driven	[illegible]	-	-	do
29	[illegible]	Driven	[illegible]	-	-	do
[illegible]	Formerly C. Morris	Driven	15*	27*	530	do
[illegible]	[illegible]	Drilled	[illegible]	27*	531	do
[illegible]	[illegible]	Dug	[illegible]	3.5	575	5/10/51
[illegible]	Unknown	Dug	13	6.0	617	do
[illegible]	[illegible]	Dug	[illegible]	24.0	536	do
[illegible]	[illegible]	Dug	[illegible]	-	-	do
[illegible]	[illegible]	Dug	13	8.1	611	do
[illegible]	[illegible]	Drilled	[illegible]	-	-	do
[illegible]	[illegible]	Dug	-	-	-	do
[illegible]	[illegible]	Dug	-	8.2	580	do
[illegible]	[illegible]	Dug	-	4.0	579	do
[illegible]	[illegible]	Drilled	[illegible]	17.3	522	5/12/51

* Indicates reported depths of wells and water levels

[redacted]

Table 1 (Cont.)

Record of wells investigated in the vicinity of Fernald, Ohio

Well No.	Owner	Type well	Depth of well (Ft.)	Static level (Ft. below land surface)	Elev. of water level (Ft. above sea level)	Date data collected
42	Game Prot'n Assn.	Drilled	125*	43.5	650	7/12/51
43	Geo. Gisler	do	100*	-	-	do
44	Ed Klinger	do	114*	30*	582	do
45	R. Cormican	do	122*	50.1	560	do
46	Venice P'byn Ch.	do	41*	23.5*	534	do
47	John O'Brien	do	41*	24*	526	7/11/51
48	H. Williamson	do	41*	28.8	526	7/12/51
49	H. T. Hilton	do	35*	20*	531	7/11/51
50	A. Hardert	do	60*	-	-	do
51	Formerly H.T. Hilton now A.E. Bayse	do	42*	21*	537	do
52	Merrit McKee	do	44.6*	29*	526	do
53	E.C. Huddleston	do	40*	25*	520	do
54	Robert Wada	Driven	36*	23*	522	7/30/51
55	Chas. Gisle	Drilled	41*	21*	536	7/11/51
56	Mrs. O. Butterfield	do	41*	21*	526	do
57	Phillip Toffer	do	44*	30*	526	do
58	Marion Keller	do	49*	29*	529	do
59	Leon Johnson	do	44*	30*	528	do
60	Edwin Brater	do	50*	30*	528	do
61	Formerly Stan Schultz now Workman	do	85*	-	-	do
62	A. R. Robinson	do	71*	22*	583	do
63	Brown Sisters	do	50*	37*	525	do
64	Formerly Butter-field now Elliott	do	42*	23*	522	do
65	U.S. Engr. Test Hole #4	do	80*	-	-	5/10/51
66	U.S. Engr. Test Hole #17	do	50*	-	-	do
67	U.S. Gov't Test Well #2	do	218*	67*	528	
68	Robert Busch	Driven	35*	2*	548	7/30/51
69	U.S. Gov't Test Well #3	Drilled	213*	59*	519	8/21/51
70	U.S. Gov't Test Well #1	do	138*	64*	531	do
71	U.S. Engr. Test Hole #21	do	215*	-	-	5/10/51
72	Southwest Ohio Water Co.	Water collector	137*	20*	520	9/28/51
73	Procter and Gamble Co.	Drilled test well	151	-	-	9/28/51

Table 2

Well Logs

Well No. 65. Test hole #4, drilled by U.S. Army, Corps of Engineers

	Depth in Feet From	To
Gray-brown clay	0	6
Gray-brown sandy clay	6	37.5
Gray silty sand	37.5	45
Gray silty-gravelly sand	45	55
Gray silty sand	55	60
Gray silty-sandy gravel	60	65
Gray silty-gravelly sand	65	70
Brown sand	70	75
Gray silty-gravelly sand	75	80

Well No. 66. Test hole #17, drilled by U.S. Army, Corps of Engineers

	From	To
Brown clay	0	5
Gray-brown clay	5	10
Brown silty sand	10	12
Brown clay	12	15
Gray clay	15	19
Gray sandy clay	19	21.6
Brown silt	21.6	23.6
Brown silty sand (cemented)	23.6	31
Brown silty sand	31	35
Brown silty sand (cemented)	35	40
Brown silty-sandy gravel	40	43
Brown silty sand	43	45
Brown silty-sandy gravel	45	50

Well No. 67. Test well #2, drilled by Layne-Ohio Company

	From	To
Soil	0	3
Yellow sandy clay	3	40
Hard dirty yellow clay	40	80
Brown sand	80	85
Coarse gravel	85	90
Coarse brown sand	90	100
Brown sand and gravel	100	120
Gray gravel	120	130
Coarse gravel	130	140
Gray clay	140	150
Sand and water	150	155
Muddy gravel	155	165
Sand and gravel	165	170
Coarse brown sand	170	180
Brown sand and gravel	180	200
Brown sand	200	205
Brown sand and gravel	205	216
Brown sand	216	218
Gray shale	218	

Table 2 (Cont.)

Well Logs

Well No. 69. Test well #2, drilled by Layne-Ohio Company

	Depth in Feet From	To
Soil	0	3
Yellow clay	3	18
Dirty sand	18	27
Dirty gravel	27	29
Gray clay	29	43
Fine brown sand	43	46
Sand and gravel	46	50
Brown sand and gravel	50	60
Coarse gray sand	60	65
Grey sand and gravel	65	70
Brown sand and gravel	70	75
Gray sand and gravel	75	100
Gray fine sand	100	125
Sand and gravel	125	127
Blue clay	127	132
Gray sand and clay	132	140
Fine brown sand	140	145
Gray sand and gravel	145	160
Brown sand	160	175
Coarse sand	175	185
Sand and gravel	185	195
Brown sand	195	200
Sand and gravel	200	205
Brown sand and gravel	205	211
Gray clay	211	213

Well No. 71. Test hole #21, drilled by U. S. Army, Corps of Engineers

	From	To
Top soil	0	5
Gray-brown clay	5	10
Brown clay	10	15
Gray sandy-clay	15	24
Gray silty sand (cemented)	24	75
Gray silty-sandy gravel	75	125
Gray silty-gravelly sand	125	150
Gray silty-sandy gravel	150	178
Brown sand	178	202
Gray silty-sandy gravel	202	204
Gray soft shale	204	215

Well No. 73. Test well drilled by Layne-Ohio Co. for Procter and Gamble Co.

	From	To
Soil	0	4
Sand and gravel	4	25
Blue clay	25	28
Sand and gravel	28	151
Shale	151	

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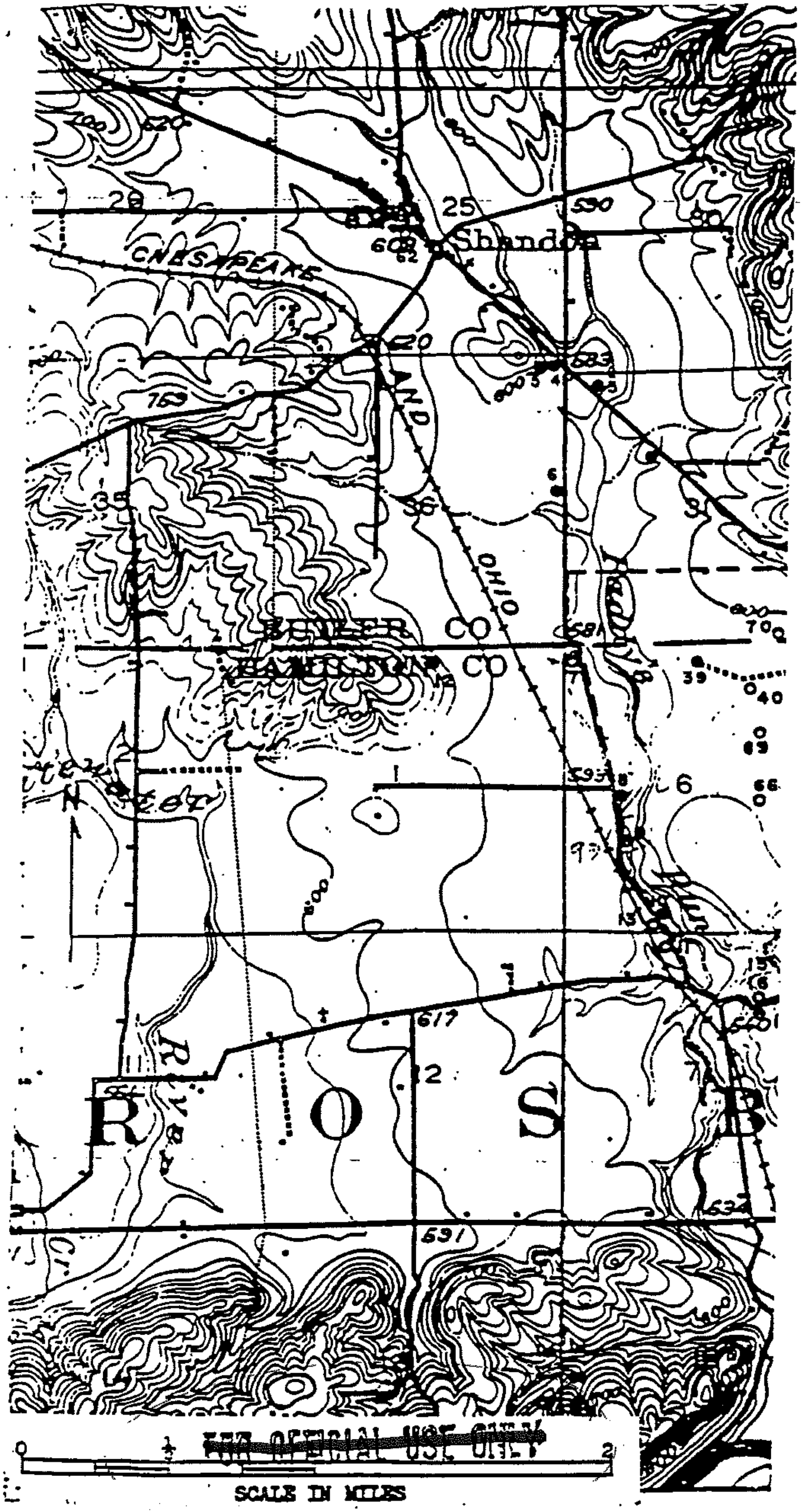

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