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POLLUTION POTENTIAL IN THE FEED MATERIALS PRODUCTION CENTER OPERATED BY THE NATIONAL LEAD COMPANY OF OHIO, PREPARED BY UNIVERSITY OF CINCINNATI FOR THE NATIONAL LEAD COMPANY OF OHIO - (USED AS A REFERENCE IN THE OU1 RI)

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REPORT

REPORT ON THE GROUND WATER POLLUTION POTENTIAL IN THE FEED MATERIALS PRODUCTION CENTER OPERATED BY THE NATIONAL LEAD COMPANY OF OHIO

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GEOLOGY OF SITE

The geology of the Feed Materials Production Center (FMPC) site has been influenced strongly by the glaciers which extended into the area. According to geologists, the Miami River Valley was once occupied by a much larger stream than the present day Miami River. This larger stream eroded the bedrock to a depth of more than 200 feet below the present surface of the ground. As the glaciers retreated, the deeply eroded valley was filled with a glacial train consisting of sand, gravel, and clay. Since the glacial periods, the Miami River has cut into the glacial deposits and formed the Miami Valley.

Test borings through the earth formations underlying the FMPC site reveal that the sand, gravel, and clay are deposited in a very irregular manner, sometimes appearing as small lenses of a single material and at other places as mixtures of two or more of the constituents. Figure 1 depicts a somewhat idealized vertical section along a north-south line through the plant.

OCCURRENCE OF GROUND WATER

The physical characteristics of the sand and gravel deposits in the Miami Valley in the Ross area have given rise to ground water resources which are of tremendous potential economic value. At the present time, only limited use is being made of the ground water in the vicinity of the FMPC but increased industrial use will undoubtedly be experienced in the next decade.

Test borings for foundation design, well drilling, and waste pit excavations within the confines of the FMPC have demonstrated the existence of many ground water systems. Some of these ground waters are quite localized and result mainly from infiltrated precipitation being trapped by an underlying impervious layer of clay. There are two major water bearing formations (aquifers) in the FMPC site; one is a sand and gravel layer approximately 50 feet in thickness, the top of which is about 80 to 90 feet below the ground surface; the second, and most important, is a sand and gravel formation more than 70 feet in thickness which is found about 140 feet below the ground surface. (See Figure 1.)

NOTE: Ground water is defined as all water below the ground surface.

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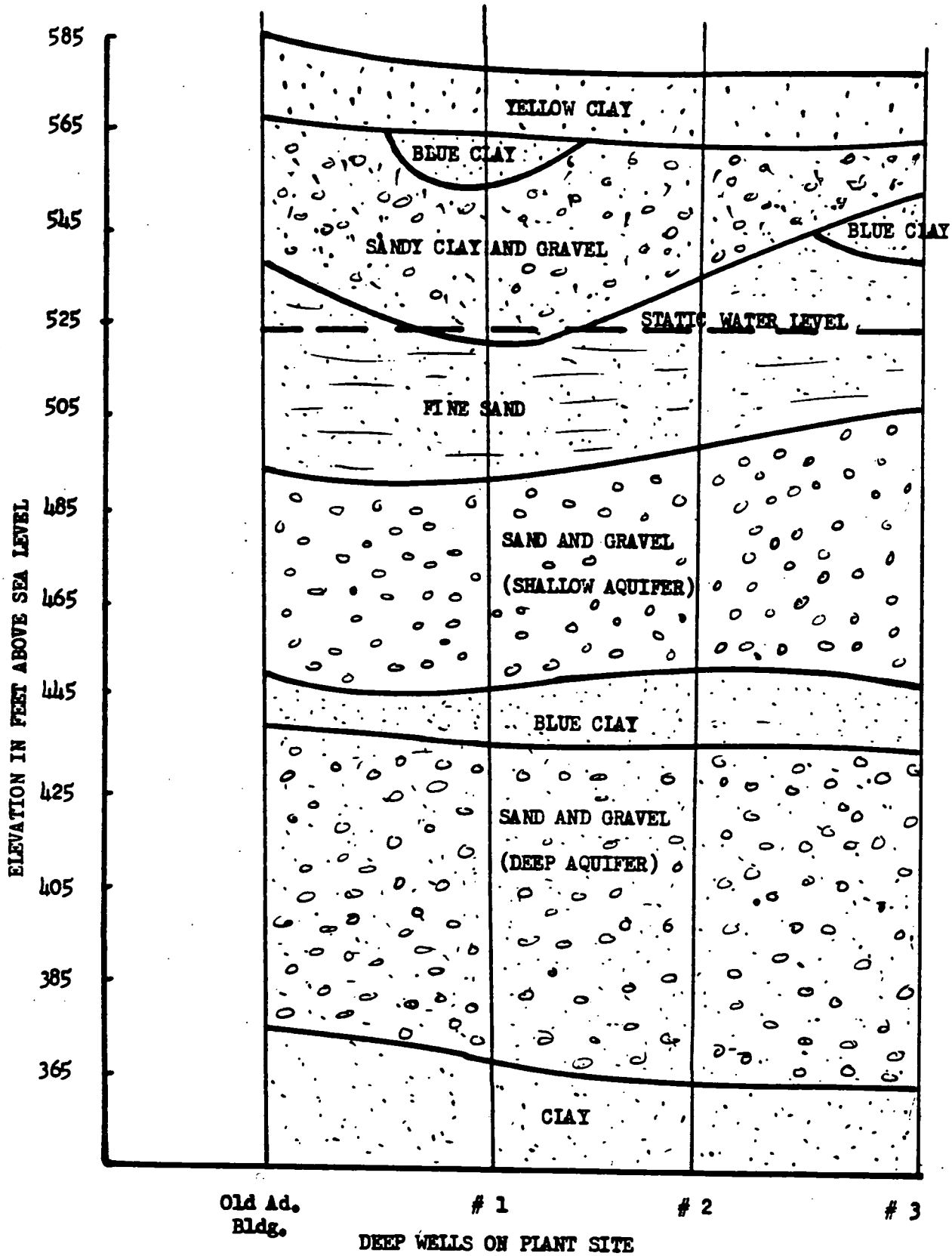

FIGURE 1: NORTH-SOUTH VERTICAL SECTION

These two formations are separated by a layer of impervious blue clay of considerable areal extent. The blue clay formation is sufficiently impervious in the immediate plant area to cause the water contained in the deep formation to be under a considerable hydrostatic head (artesian system). The water contained in the shallow aquifer apparently represents the normal water table (water at atmospheric pressure) for the area and as such is dependent on local rainfall for replenishment. The formations near the ground surface are composed of sand and gravel mixed with varying amounts of clay. For the most part, these surface materials (10 to 20 feet in thickness) contain enough clay to prevent the rapid infiltration of precipitation. The shallow aquifer, therefore, probably would not support a sustained high rate of pumping or withdrawal of water.

The deep aquifer (artesian in the FMPC site) undoubtedly is supplied with water from a much larger recharge area than is the shallow aquifer. It may also contain water which has been accumulating for a long period of time. The precipitation pattern and the surface formation characteristics in the plant site, therefore, will not affect the water producing ability of the deep aquifer to any great extent.

GROUND WATER MOVEMENT

In general, ground water moves from a source to a point of discharge. Since water contained in sand and gravel deposits must move through the interstices between the particles, the rate of flow is dependent on the number and size of the openings (voids) between the particles comprising the formation and on the driving force (head or slope of the piezometric surface). In most instances, the velocity of underground flow is relatively low.

Ground water under normal atmospheric pressure usually will have sufficient head to induce flow, and the direction of flow often coincides with the surface slope for the area.

Ground water under a head greater than atmospheric (artesian system) follows the outlines of the bottom of the confining (impervious) formation and the direction of flow need not follow the natural slope of the ground surface. Many artesian waters do not find a point of discharge, hence water in these aquifers is often the result of accumulations extending over thousands of years.

When wells are drilled into a water bearing formation and water is withdrawn by pumping, the direction of flow in the vicinity of the wells (this may be many miles in extent) is more or less radial and is governed to a large extent by the elevation of the free water surface in the well or wells being pumped. Thus, while the undisturbed or normal flow pattern is in a given direction, this pattern can be changed drastically by the introduction of wells, even miles away.

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SOURCES OF GROUND WATER POLLUTION

The possibilities for contaminating the ground water with the various chemicals used in the FMPC are many and varied. They include the waste disposal system, surface wash from storage pads, accidental spills from vehicles, surface wash from scrap heaps, leaks in pipelines and storage tanks, fallout, and flooding of facilities during periods of heavy precipitation. Process liquids and water soluble solids which are discharged on the ground surface can be carried down into the shallow aquifer by infiltrating precipitation or other surface water. The clay contained in the upper 10 to 20 feet of earth in the plant area tends to make this material rather impervious and the downward movement of water and soluble contaminants will be relatively slow. Nevertheless, this is one avenue by which appreciable amounts of chemical contaminants can enter the ground water over extended periods of plant operation if such contaminants are allowed to accumulate on the surface of the ground in the plant area. The underground agricultural drainage system (tile system), which is located a few feet below the surface, and the gravel filled trenches of the newly constructed water supply system also can transport and spread local contaminants over much of the plant site.

When chemical substances come into contact with certain earth materials there is a tendency for the contaminants to be retained through the process of ion exchange. It is not known if the sub-surface formations in the FMPC will effectively remove the types of pollutants that might be carried by infiltrating water. Even if such removal is effective initially, prolonged application of contaminants eventually will overcome the ion exchange capacity of the sub-surface formation and the pollutants then will move through the earth materials relatively unaffected.

The waste disposal pits form the most serious potential ground water pollution problem. These pits, excavated to a depth of approximately 25 feet, extend below the somewhat impervious surface layers, and in some of these pit excavations lenses or deposits of pure sand and gravel were encountered. The bottom and sides of these pits were sealed initially with a layer of clay but there is no assurance that the seal is still completely continuous and water tight. The inside walls of Pit #3 show evidence of considerable "slipping" or "spalling" and it is likely that some of the clay liner on the sidewalls has been destroyed. If this is the case, pronounced seepage may occur when the water level in the pit rises above these "slip" zones.

The so-called "dry" waste pits likewise are a potential source of ground water pollution. While the materials deposited in these "dry" pits are usually in solid form, water from direct rainfall, surface runoff, equipment washing, and quite likely some ground water accumulates in the depression and dissolves the more soluble chemical compounds contained in the residues. In a more indirect

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manner, therefore, the "dry" waste disposal pits can become a source of ground water pollution in the same way as indicated for Pit No. 3.

POLLUTANTS OF PRIMARY CONCERN

While there are many materials employed in the FMPC operation, the ones of principal concern from a ground water pollution standpoint are: the uranium and thorium products and their accompanying radioactivity; chlorides; nitrates; and fluorides. Of these, the chlorides, nitrates, and fluorides are the most likely contaminants. Chlorides and nitrates are present in the wastes in high concentrations (in the 1,000's of parts per million by weight). The chlorides and nitrates are extremely soluble and the fluorides relatively soluble. The uranium products are only slightly soluble and as such are probably of secondary significance in a consideration of ground water pollution in the area.

The thorium residues stored in drums on a concrete storage pad pose the most serious threat in terms of radioactive materials. As long as the drums are intact and no spillage occurs, the thorium presents no particular hazard. It was observed, however, that many of the storage containers have deteriorated to a point where the contents are spilling out onto and over the edges of the pad. Redrumming operations are required from time to time. Rain-water and surface runoff from the pad can carry exposed thorium residues into the surface drainage system from whence it may gain entrance into the sub-surface waters.

The K-65 Area and the concrete trench leading to it form another important source of potential radioactive contamination for the ground water. Leakage from the concrete storage tanks may ultimately find its way into ground water either directly through the drain tile or by backing up into the trench. In both instances this material is exposed to direct rainfall, sub-surface seepage, and at times to surface runoff.

PROBABLE RESULTS OF POLLUTION OF THE GROUND WATER

1. If pollution of the ground water by chemicals from the plant should occur, the cost and difficulty of treating the water to make it suitable for use will be greatly increased even though the degree of pollution is small.

2. If the concentration of contaminants should become excessive it is possible that the water from the production wells could not be treated to render it suitable for plant use.

3. Wells other than those owned by the Government can be rendered unfit for use, thereby creating serious legal and public relations problems.

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4. The ground water in the entire area can be rendered unusable for a very long period of time because the contaminants can only be removed by eliminating the source and then removing all of the polluted water from the aquifers. This would be a gigantic task if pollution accumulated for a long period of time before it was discovered.

SPECIAL FIELD STUDIES TO EVALUATE GROUND WATER POLLUTION POTENTIAL

During the summer and autumn of 1960, a special study was carried out for the purpose of evaluating the ground water pollution potential in the FMPC site. The investigation included: a series of pumping tests on the production wells; chemical analyses of water samples withdrawn from the production wells, from Test Wells Nos. 1 and 5, and from the well at the old Administration Building (See Figure 2); a visual inspection of the entire plant site with particular attention being given to the leak from waste Disposal Pit #3 into Paddy's Run Creek; a field survey of Paddy's Run Creek and analyses of samples collected therefrom; the collection and analyses of approximately 100 soil samples from the plant area; and a detailed study of the analysis of water samples collected over a two year period from excavations and storm sewers in the plant. No consideration was given to the methods of waste treatment and disposal or to the effects of FMPC wastes on the Miami River water quality because these items warrant detailed studies which are beyond the scope of the present investigation.

The pumping tests were carried out over a period of three weeks at pumping rates of 1.5, 2.75 and 3.85 million gallons daily for weeks one, two and three respectively. An additional test was made on Well #2 in which the well was pumped at a rate of 420 gallons per minute for several hours, followed by a rate of 1100 gallons per minute for an additional period of time. The main objective in performing these pumping tests was to determine the probable productivity of the deep aquifer and the area of influence of the pumping wells.

The pumping tests indicate that the three production wells are capable of delivering only a small fraction of the water available in the deep aquifer. The main limitation on the three production wells is the fact that only the bottom 20 feet of the casing of each well is perforated whereas the wells extend through the aquifer which is at least 70 feet in thickness. The amount of water that can be withdrawn therefore is controlled by the perforated area of the casing rather than by the hydraulic characteristics of the aquifer.

Drawdown measurements taken in the three production wells at the maximum possible pumping rate show that the area of influence is quite limited. (Tables I and II).

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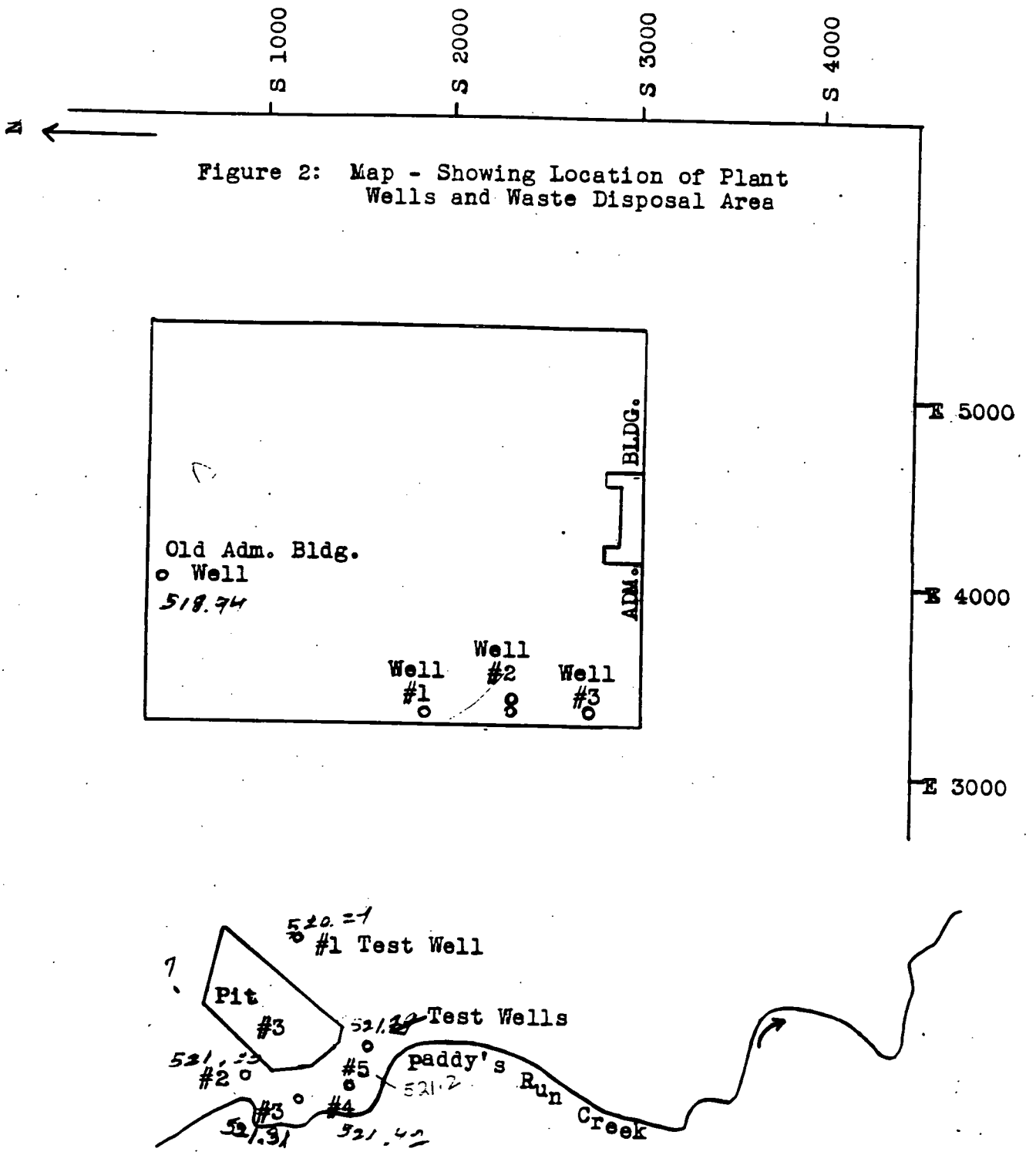

Figure 2: Map - Showing Location of Plant Wells and Waste Disposal Area

TABLE I

SPECIAL PUMPING TESTS OF MAIN PRODUCTION WELLS

DATE	TIME	PUMPING RATES GPM			DISTANCE FROM TOP OF CASING TO WATER SURFAC					
		#1	#2	#3	#1	#2	#3	1 Test	5 Test	Old Adm. Bldg.
6-27-60	0830	--	890	--	60.5	114.5	60.5	63.7	--	69.6
	1300	--	1035	--	61.2	125.0	61.5	64.1	--	69.8
	2100	--	1030	--	60.3	124.0	60.3	64.0	--	69.5
6-28-60	0830	--	1035	--	60.8	124.2	61.3	63.8	--	69.8
	1300	--	1035	--	60.9	124.0	61.0	63.8	--	69.7
	2100	--	1040	--	61.2	124.0	61.2	64.1	33.3	68.9
6-29-60	0830	--	1035	--	60.9	123.3	61.1	63.8	33.2	69.5
	2100	--	1040	--	61.1	123.7	61.1	64.3	33.3	68.9
6-30-60	0830	--	1035	--	60.9	123.3	61.1	63.8	33.2	69.7
	2100	--	1035	--	60.8	122.8	61.1	64.0	33.3	69.5
7- 1-60	0831	--	1021	--	60.8	122.3	61.1	63.9	33.3	69.6
	2100	--	1040	--	60.9	122.8	60.8	63.9	33.3	69.5
7- 2-60	0830	--	1040	--	61.2	123.3	61.3	64.2	33.3	69.6
	2100	--	1035	--	61.3	123.0	60.8	63.8	33.3	69.4
7- 3-60	0900	--	1040	--	60.8	123.5	61.2	63.9	33.1	69.7
	2100	--	1040	--	60.8	123.6	61.3	64.0	33.3	69.7
7- 4-60	0900	--	1040	--	61.6	124.6	61.5	63.9	33.2	69.5
	2100	--	1040	--	61.6	123.9	61.7	64.0	33.3	69.7
7- 5-60	0900	--	1040	--	61.3	124.5	61.4	63.9	33.3	69.9
7- 6-60	0900	808	1006	--	96.6	121.3	61.8	63.9	33.3	69.9
7- 7-60	0900	808	1006	--	96.6	121.0	62.8	64.3	33.4	70.5
7- 8-60	0900	800	1058	--	96.0	119.8	61.9	64.3	33.3	69.7
7- 9-60	0900	---	----	--	59.1	59.6	59.7	64.3	33.5	69.6
7-10-60	0900	850	1056	--	94.8	114.6	61.7	64.0	33.3	69.3
7-11-60	1300	850	1068	700	96.3	117.0	105.0	64.0	33.3	69.5
7-12-60	0900	850	1068	700	96.5	117.7	106.4	64.2	33.3	69.5
7-13-60	0900	850	1068	700	96.4	117.9	106.8	64.1	33.3	69.4
7-14-60	0900	850	1068	700	96.7	118.3	107.0	64.3	33.5	69.7
7-15-60	0900	850	1068	700	97.3	118.3	107.5	64.4	33.4	69.8
7-16-60	0900	850	1068	700	97.4	118.3	107.2	64.4	33.4	69.7
7-17-60	0900	850	1068	750	97.5	118.3	107.4	64.5	33.4	69.9
7-18-60	0900	850	1068	750	97.4	118.3	107.6	64.4	33.3	70.0
	1240	850	1068	750	97.4	118.3	107.5			
	1241	---	1068	750	68.9	118.3	107.5			
	1242	---	1068	750	62.9	118.3	107.5			
	1245	---	1068	750	60.4	118.3	107.5			
	1250	---	1068	750	59.9	118.3	107.5			
	1300	---	1068	---	---	118.3	107.5			
	1308	---	1068	---	---	118.3	60.3			
	1325	---	1068	---	---	118.3	---			
	1327	---	---	---	---	71.9	---			
	1328	---	---	---	---	64.9	---			
	1341	---	---	---	---	59.3	---			
	1350	---	---	---	---	58.4	---			

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TABLE II

SPECIAL PUMPING TEST ON WELL NO. 2

TIME	PUMPING RATE gpm	DISTANCE FROM TOP CASING TO WATER SURFACE #2	#2 Recording Well	#1 Well
0750	0	59'2"	59'2"	59'5"
Start 0807	440	79'5"	62'9"	60'
0810	440	79'5"	62'9"	60'
0820	440	86'	64'9"	60'
0830	420	87'4"	65'2"	60'
0840	420	87'5"	65'2"	60'
0850	420	87'5"	65'2"	60'
0900	420	87'2"	65'	60'1"
0910	420	87'2"	65'	60'2"
0940	420	86'4"	65'	60'2"
1015	420	86'4"	64'11"	60'2"
1115	420	86'	64'11"	60'2"
1140	580	92'	65'3"	--
1144	636	105'7"	66'	61'
1154	1100	120'	67'9"	61'
1204	1100	121'	69'11"	61'
1214	1100	121½'	70'9"	61'2½"
1224	1100	121½'	71'2"	61'4"
1234	1100	121'4"	71'3"	61'4"
1244	1100	121'4"	71'3"	61'4"
1254	1100	121'4"	71'3"	61'4"
1330	1100	121'3"	71'3"	61'4"
1400	1100	121'3"	71'3"	61'4"
1400	Off			
1410	--	59'5½"	61'8"	60'8"
1420	--	59'2"	60'9"	60'0"
1430	--	Recovered	60'	59'5"
1445	--	Recovered	Recovered	Recovered

REMARKS

The distance from #2 production well to #2 recording well is 24½'.

Base elevations of #1 and #2 wells are: #1-578.66
#2-579.16
#3-579.36

Date of Test 8/22/60

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The static water level in the production wells and in the well at the Old Administration Building are approximately the same thereby indicating that the deep and shallow aquifers are interconnected. Chemical analyses of water samples from both deep and shallow wells indicate that the deep and shallow ground water are of the same general composition, a further indication of direct interchange between the two systems (Table III). It is quite possible that the layer of blue clay separating the two water bearing formations is in places discontinuous thereby permitting water to flow from one aquifer to the other. Since the two aquifers are undoubtedly interconnected, any accumulation of pollutants in the shallow ground water can in turn contaminate the plant water supply.

In the FMPC plant site, the water in the shallow formation appears to be flowing in a south-easterly direction toward the Miami River. The static water levels in Test Wells Nos. 2, 3, 4, and 5 located on the west side of the waste disposal area are higher than the water level in Test Well No. 1 on the east side of the waste disposal area. This difference in elevation indicates that the shallow ground water in the vicinity of the waste disposal pits is moving from Paddy's Run toward the main production wells (Table IV and Figure 3).

The data listed in Table III and Table V prove conclusively that there is some leakage from Pit #3 into Test Well #5. While the amount of leakage is undoubtedly small, it is nevertheless moving in the general direction of the production wells.

It can be argued that even though pollution is entering the shallow aquifer, the velocity of flow will be so low, because of the limited area of influence of the main wells, that it will take many years for it to reach the production wells. While this concept is undoubtedly true, the fact remains that if pollution does reach the main wells many years of pumping will be required to eliminate the accumulated contaminants even if the source of pollution can be blocked.

The inspection of the production area revealed many potential sources of surface contamination, with the chemicals used in processing reactor fuel elements. The points of major concern are: the overflow of liquids from process areas, tanks, and sumps onto gravel courtyards or into the storm drainage system; wash water and storm water from concrete storage pads; spillage of solids from vehicles and from storage pads; and exposed surplus and scrap materials stored in certain areas. While it is not known what loss of chemicals occurs from these sources, samples of water taken from various excavations on the FMPC site show a high concentration of chlorides, nitrates, fluorides and uranium, (Table VI). As indicated in an earlier section of this report, the agricultural drain tile and the water system trenches can transport contaminants from one part of the plant over much of the plant area thereby in-

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TABLE III

CHLORIDE AND NITRATE CONTENT OF GROUND WATER
FROM WELLS ON THE FMPC SITE

		TEST WELL NO. 1		TEST WELL NO. 5		PROD. WELL NO. 1		PROD. WELL NO. 2		PROD. WELL NO. 3		OLD ADM. BLDG. WELL	
		Cl^-	NO_3^-	Cl^-	NO_3^-	Cl^-	NO_3^-	Cl^-	NO_3^-	Cl^-	NO_3^-	Cl^-	NO_3
6/27/60	0900	17	0.1	-	-	18	0.3	21	0.5	11	<0.1	16	0.4
	1300	17	<0.1	-	-	16	0.1	21	0.1	-	-	16	0.2
	2200	19	0.4	-	-	21	0.4	23	0.4	-	-	17	0.4
6/28/60	0800	18	0.3	-	-	16	0.4	16	0.3	19	0.3	16	0.4
	1300	21	0.2	-	-	17	0.6	18	0.5	16	0.1	16	0.4
	2100	19	0.1	340	500	18	0.1	21	0.2	16	0.1	17	0.4
6/29/60	0800	24	0.4	555	920	18	0.1	18	0.1	14	0.1	16	0.4
	2100	21	0.1	570	830	17	0.1	20	0.1	12	0.1	16	0.3
6/30/60	0800	26	2.6	630	940	18	0.1	19	0.1	11	0.1	16	0.4
	2100	21	0.2	11	0.4	15	0.4	19	0.4	11	0.1	16	0.1
7/ 1/60	0800	27	6.2	660	1030	18	<0.1	17	<0.1	10	<0.1	16	0.4
	2100	22	0.2	690	863	17	0.2	18	0.1	11	<0.1	12	0.3
7/ 2/60	0900	21	0.2	680	1140	17	<0.1	18	0.7	10	<0.1	15	0.7
	2100	22	0.1	680	1140	16	<0.1	18	0.1	9	<0.1	16	0.3
7/ 3/60	0930	22	0.1	670	800	17	0.1	19	0.1	11	0.1	16	0.2
	2100	23	0.1	740	860	17	<0.1	19	<0.1	10	0.1	15	0.4
7/ 4/60	0930	22	0.1	640	750	17	<0.1	20	<0.1	10	0.1	15	0.3
	2100	24	0.5	740	1000	17	<0.1	18	0.1	10	0.1	15	0.1
7/ 5/60	0930	23	0.4	740	870	17	0.2	19	0.1	11	0.1	16	0.4
	2030	23	0.3	680	780	16	0.6	-	-	-	-	-	-
7/ 6/60	1000	25	0.8	710	870	18	1.1	18	0.1	11	0.1	16	0.5
7/ 7/60	1000	23	0.3	660	550	17	0.4	18	0.1	11	0.1	15	0.5
7/ 8/60	1000	22	0.6	670	850	16	0.4	17	0.1	10	0.1	15	0.4
7/ 9/60		No samples											
7/10/60	0930	24	0.2	710	880	17	<0.1	16	0.1	9	<0.1	16	0.7
7/11/60	1400	22	0.2	720	760	19	0.2	17	0.4	10	0.1	15	0.6
7/12/60	0900	24	0.2	770	1000	18	0.4	16	0.4	10	0.2	15	0.7
7/13/60	0900	22	0.4	800	1700	16	1.6	17	1.3	10	0.3	16	0.7
7/14/60	0900	25	0.3	840	830	18	0.6	17	0.4	10	0.3	15	0.4
7/15/60	0830	23	0.8	820	1250	20	0.6	18	0.4	8	0.2	16	0.6
7/16/60	No time given	22	0.4	820	1110	20	0.2	19	0.4	8	0.3	16	0.6
7/17/60	No time given	22	0.7	800	1110	22	0.4	18	0.2	10	0.1	15	0.7
7/18/60	No time given	23	0.2	800	1050	20	0.2	19	0.1	9	0.2	16	0.5

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TABLE IV

STATIC WATER LEVELS IN TEST WELLS
DRILLED INTO THE SHALLOW AQUIFER

TEST WELL	ELEVATION FEET ABOVE SEA LEVEL
No. 1	520.29
No. 2	521.00
No. 3	521.31
No. 4	521.42
No. 5	521.20
Old Adm. Bldg.	518.94

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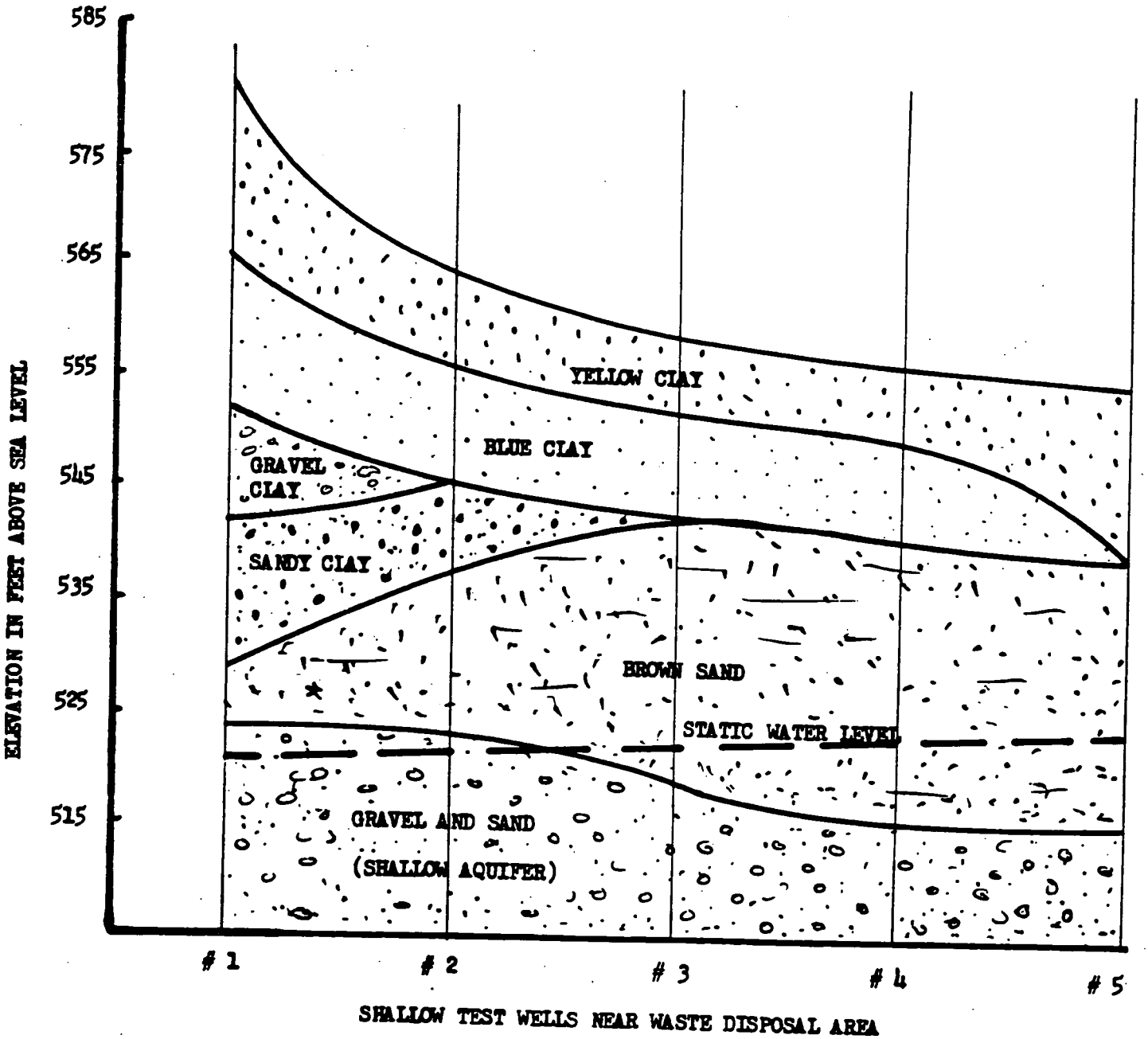

FIGURE 3: VERTICAL SECTION THROUGH TEST WELLS

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TABLE V

FLUORIDE, CHLORIDE AND NITRATE CONTENT OF WATER PUMPED FROM TEST WELLS #4 AND #5

#4 Test Well - 4/24/60

DURATION OF PUMPING	FLUORIDE ppm F^-	NITRATE ppm NO_3^-	CHLORIDE ppm Cl^-
After 15 min.	.54	4	12
" 24 hrs.	.34	8	11
" 2 days	.08	5	13
" 3 days	.44	6	13.5
" 4 days	.32	10	14
" 5 days	.4	13	11
" 6 days	.4	6	14
" 7 days	.52	7	14
" 8 days	.5	6	13
" 9 days	.38	7	13
" 10 days	.3	6	13.5
" 11 days	.6	10.5	13
" 12 days	.3	8	15
" 13 days	.2	10	13
" 14 days	.3	17	14
" 15 days	.08	7	13
" 16 days	.54	6	15
" 17 days	.66	7	15
" 18 days	.12	6	13
" 19 days	nd*	4.1	13
" 20 days	nd	6	13
" 21 days	nd	4	14
" 22 days	.16	7	14
" 23 days	.04	5	13
" 24 days	nd	7	14
" 25 days	.06	4	14

#5 Test Well - 3/24/60

DURATION OF PUMPING	FLUORIDE ppm F^-	NITRATE ppm NO_3^-	CHLORIDE ppm Cl^-
Start	nd	292	282
After 1 day	.14	257	282
" 2 days	.16	272	260
" 3 days	.08	261	245
" 4 days	.2	212	200
" 5 days	.24	206	195
" 6 days	.24	206	207
" 7 days	.2	164	170
" 8 days	.12	177	177
" 9 days	.12	173	170
" 10 days	.16	168	172
" 11 days	.2	175	172
" 12 days	.2	184	175
" 13 days	.2	144	165
" 14 days	.08	.57	170
" 15 days	.22	147	190
" 16 days	.06	148	177
" 17 days	.16	148	152
" 18 days	.26	162	165
" 19 days	.24	157	165
" 20 days	.24	150	170
" 21 days	.03	151	170
" 22 days	.06	155	145
" 23 days	.20	166	165
" 24 days	.02	162	160
" 25 days	.70	135	132
" 26 days	.17	148	150
" 27 days	.16	159	162
" 28 days	.26	102	165
" 29 days	.24	126	135
" 30 days	.08	128	152
" 31 days	.22	139	167

*non-detectable

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TABLE VI

ANALYSIS OF MISCELLANEOUS WATER SAMPLES
COLLECTED ON FMPC SITE

DATE	SAMPLE LOCATION	NO_3^- ppm	Cl^- ppm	F^- ppm	U ppm
9/22/60	Storm Sewer Line from Tech. Lab.	1328	1217	38	8.9
9/ 3/60	Elevated Tower Trench	66	25	0.5	8.0
9/28/60	Fire Line Trench	-	28	0.5	5.5
10/28/60	Fire Line Trench	-	490	3.0	1.3
10/30/60	Ditch N. of Pit #3	1.0	22	1.2	1.1
6/24/60	Puddle North Side of Plant #8	443	8125	56	41.5
6/26/60	MH-123 from Plant #8	7	100	23	2.0
6/29/60	Surface Water from Plant #8	20	188	6	8.5
7/17/60	Overflow from Slop Tank Plant #8	490	66,400	2,500	14
7/20/60	Water into MH-23	1230	330	280	9.5
7/15/60	New Elevated Tower Excavation	19	61	15	1.3
7/18/60	Retaining Wall East of Tank Farm	-	88	10,000	275
6/29/60	Ground W. of Pit #5	5	27	4.8	12
7/23/60	MH East of Plant #6	4	18	10	70
7/18/60	Hole at A and 2nd Sts.	2.2	-	5.4	18.5
8/ 3/60	Catch Basin-Storm Sewer Outfall	18	62	8.6	9.9
7/21/60	Test Hole-N Tech. Lab.	1	17	2.3	6.5
1/26/60	Waste Line from Pilot Plant	-	340	-	64.5
2/ 5/60	Water from Storage Pad	16	8	4.5	4.9
2/ 5/60	Water from Storage Pad	16	16.5	3.5	6.9
2/18/60	Drainage Ditch by #5 Test Well	51	1600	9.8	0.32
2/18/60	Plant # 8 Line Break at #1 Test Well	498	19,000	170	56.5
4/11/60	To Storm Sewer from Tank Farm Sump	293	9250	85	0.65
4/13/60	To Storm Sewer from Tank Farm Sump	24	1500	800	1.55
5/ 6/60	Hole Tech. Lab Court Yard	27	22	8	3.5
6/ 8/60	Excavation for Pit #4	14	30	12.4	120
1/22/60	To CB-93 from Garden Hose	11	150	2.8	4.75
1/28/60	Water to Storm Sewer from Plant #8	11	110	8.3	3.95
1/28/60	To Storm Sewer from Plant #6	2	5000	-	30.3
1/29/60	Thick Fluid at MH-117	18	33	240	86,750
1/31/60	Leakage from Tank No. F3E7	5977	82	49	144
2/ 7/60	Water at MH-166	8245	63	7.3	12.4
2/26/59	Overflow from K-65 Trench	1107	-	-	29.1
4/ 8/59	Ground Water in Ditch at K-65	1273	-	7.4	16.7
6/11/59	Excavation W. of Plant #1	0.59	-	1.2	2.14
6/22/59	Creek Behind Pilot Plant	1107	-	-	22.3
11/ 4/59	Surface Water to MH Plant #8	60	37	9.8	98
11/ 4/59	From Pit at R R Track	102	40	5.6	837
11/19/59	To Storm Sewer at General Sump	184	21,000	2220	32
12/11/59	Barrel Loading Pad-B Street	22	6	1.5	25.2

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creasing the possibility of a ground water pollution hazard.

In September 1960, a limited survey was made of the reach of Paddy's Run Creek from the New Haven bridge below the plant to the head of the stream. At the time of the inspection, the section of Paddy's Run Creek from the waste disposal area to a point below the Willey Road bridge was completely dry. There was a limited flow in the creek above the waste disposal area and also below the Willey Road bridge. Samples of water were collected at several points and analyzed for chlorides, fluorides, nitrates, radium, uranium and radioactivity. The results of the analyses indicated little change in chemical constituents of the water of Paddy's Run Creek between the upper and lower reaches sampled (Table VII).

There was a small amount of waste seeping through the stream bank just west of Pit #3. While the chloride and nitrate content of this waste was high (See Sample #5, Table VII) the quantity was so small that it did not affect appreciably the quality of Paddy's Run water. Since the September study, the leak into Paddy's Run has stopped almost completely. It is not known if solids accumulating in Pit #3 have blocked the seepage or if the wastes leaking from the pit are finding another outlet.

Since there was visual evidence of chemical contamination of the ground surface at various points in the plant site, a detailed soil sampling study was made. The entire production and K-65 areas were divided into blocks approximately 200 feet square. The east-west and north-south coordinate lines of the plant area formed boundaries of the blocks and the corners of the blocks were used as soil sampling points. By selecting the sampling points on a uniform basis for the entire plant without regard to the location of individual process areas it is believed that the results obtained are unbiased. The main disadvantage to this method of selecting sampling points was the fact that some of them were inaccessible or else the point fell on a paved area. In the event that a sampling point fell so close to an individual process operation that abnormal results might have been obtained, the sample was not taken.

The sampling method consisted of driving a special soil sampler into the ground approximately 12" and withdrawing a core. A section was cut lengthwise from each core and pulverized before being sent to the laboratory for analysis. The data obtained from the soil study (Table VIII) show a wide variation in total uranium content from area to area in the plant. The high concentrations of total uranium are somewhat localized in certain process areas and along roadways. In general, the samples taken from the production area are higher in total uranium than those from the K-65 area (Figure 4).

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TABLE VII

ANALYSES OF WATER AND ALGAE
SAMPLES COLLECTED FROM PADDY'S RUN CREEK

	Cl^-	F^-	NO_3^-	RADIUM uug/ml	U^-	ALPHA d/m/ml	BETA d/m/ml
*P.R. Bridge N of State Route 126	15	0.14	nd	0.113	0.021	0.20	0.09
P.R. Bridge on State Route 126	15	.38	nd	.005	.023	.18	.02
Tributary to P.R. (¼ mi. S of Sample 2)	10	.14	8	.093	.012	.07	.04
100 ft. N of Spur Line Bridge	11.5	.12	0.4	.064	.021	.02	nd
Waste leakage from project (just below Spur Line Bridge)	1415	.07	1948	-	.090	.12	.16
P.R. at point just above Waste Pits	13	.14	0.4	.024	.012	.01	.06
Point just above leak from Waste Pit to P.R.	15	.28	0.6	.012	.014	.14	nd
Point below leak from Waste Pit	13	.20	1.4	.036	.20	.19	.08
Upstream from ford S of Willey Bridge	23	1.0	0.4	.088	2.4	3.73	7.69
Tributary between Willey Road and New Haven Bridge	75	nd**	0.6	.022	.006	nd	.02
Effluent from Virginia Carolina Chemical Plant	27.5	.06	0.4	.078	.018	nd	.05
New Haven Bridge	265	nd*	1.3	nd	.040	.11	.14
Sample of Algae at New Haven Bridge	1.0 mg Uranium/sample						
S of New Haven Bridge	9	.06	0.3	nd	.13	.19	.12
Bridge N of By Pass 50	230	.70	0.3	.003	.019	.02	.06
Sample of Algae at Bridge N of By Pass 50	0.38 mg Uranium/sample						

Date of Sampling: September 13, 1960
* P.R. (Paddy's Run)
** nd (non-detectable)

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TABLE VIII

FLUORIDE AND URANIUM CONTENT OF
SOIL SAMPLES FROM FMPC SITE

SAMPLE LOCATION COORDINATES	FLUORIDE ppm F^-	SOLUBLE URANIUM ppm U	TOTAL URANIUM ppm U
S3100 - E5400	50	0.33	22
5200	33	.45	89
5000	40	.40	59
4830	33	.63	21
S3090 - E4600	28	.30	42
4400	30	.30	11
4200	125	.32	15
4000	130	2.0	31
3800	78	.47	34
3600	58	.90	44
3400	60	.08	11
5230	108	2.4	26
S2900 - E4800	113	.16	39
4600	83	.10	27
4200	80	.21	15
3750	45	.28	40
S2890 - 3300	240	12.8	345
S2700 - E5400 (Surface Sample)	173	1.5	90
5200	103	.36	241
S2700 - E4800	125	.31	90
4320	198	0.44	106
4000	165	.12	20
3700	125	.60	31
S2500 - E5400	123	.56	21
5200	75	.09	53
S2420 - 4930	65	.11	49
4800	148	.96	30
4600	48	.44	119
3340	113	.22	19
S2300 - E5450	25	.15	39
S2330 - E5280	190	3.6	450
4960	85	.44	54
2280 - 4810	123	6.0	18
4600	55	.32	210
3400	178	1.5	44
5200	28	3.6	690
4970	138	.40	70
4800	28	.18	290
4600	38	.32	130
S1900 - E5400	108	5.2	90
5200	165	2.5	150
1960 - 5000	163	2.0	190
1960 - 4800	48	.16	208
S1950 - E4600	98	2.4	379
1850 - 3420	78	.16	-
S1700 - E5400	85	.16	22
5200	150	2.0	13
1750 - 4150	108	.60	44
3330	-	2.8	147

TABLE VIII (Cont'd)

SAMPLE LOCATION COORDINATES	FLUORIDE ppm F⁻	SOLUBLE URANIUM ppm U	TOTAL URANIUM ppm U
S1500 - E5400	185	2.2	31
5200	155	.52	60
4800	70	2.0	69
4600	95	.44	34
4400	175	1.6	43
4150	158	.36	40
3500	85	2.0	80
3330	85	.11	22
S1300 - E5400	155	1.3	27
5000	145	.80	22
4800	143	.68	34
S1300 - E4600	206	0.36	23
4150	63	.08	16
3520	133	.32	23
3400	58	4.8	35
S1100 - E5400	70	1.0	19
5200	138	1.4	39
4930	228	3.2	-
4800	35	.32	31
4600	95	.16	22
4400 (Wet)	33	1.1	80
4150	258	.14	29
3520	115	.21	149
3400	183	.36	19
S 900 - E4800	55	.18	44
4600	113	.56	139
4400	140	6.8	149
920 - 4000 4080	85	.68	29
3800	23	.09	290
3400 3520	65	1.2	129
S 800 - E3300	83	0.16	12
S1000 - E2900	78	.09	80
S1200 - E3300	160	.28	50
S1400 - E2900	103	.03	70
S1200 - E2400	45	.44	47
S1400 - E2100 (50' from Test Well #1)	270	.11	9
S1600 - E3300	188	.20	24
S1800 - E2900	63	.92	11
S1600 - E2500	140	.14	7
S1800 - E2100	75	.06	7
S1600 - E1700	225	.12	11
S2000 - E3300	190	.20	9
S2200 - E2900	250	.13	37
S2000 - E2500	35	.20	14
S2200 - E2100	163	.32	12
S2000 - E1700	98	.14	16
S2400 - E3300	165	.48	35
S2400 - E2500	73	.28	10
S2400 - E1700	140	.36	21

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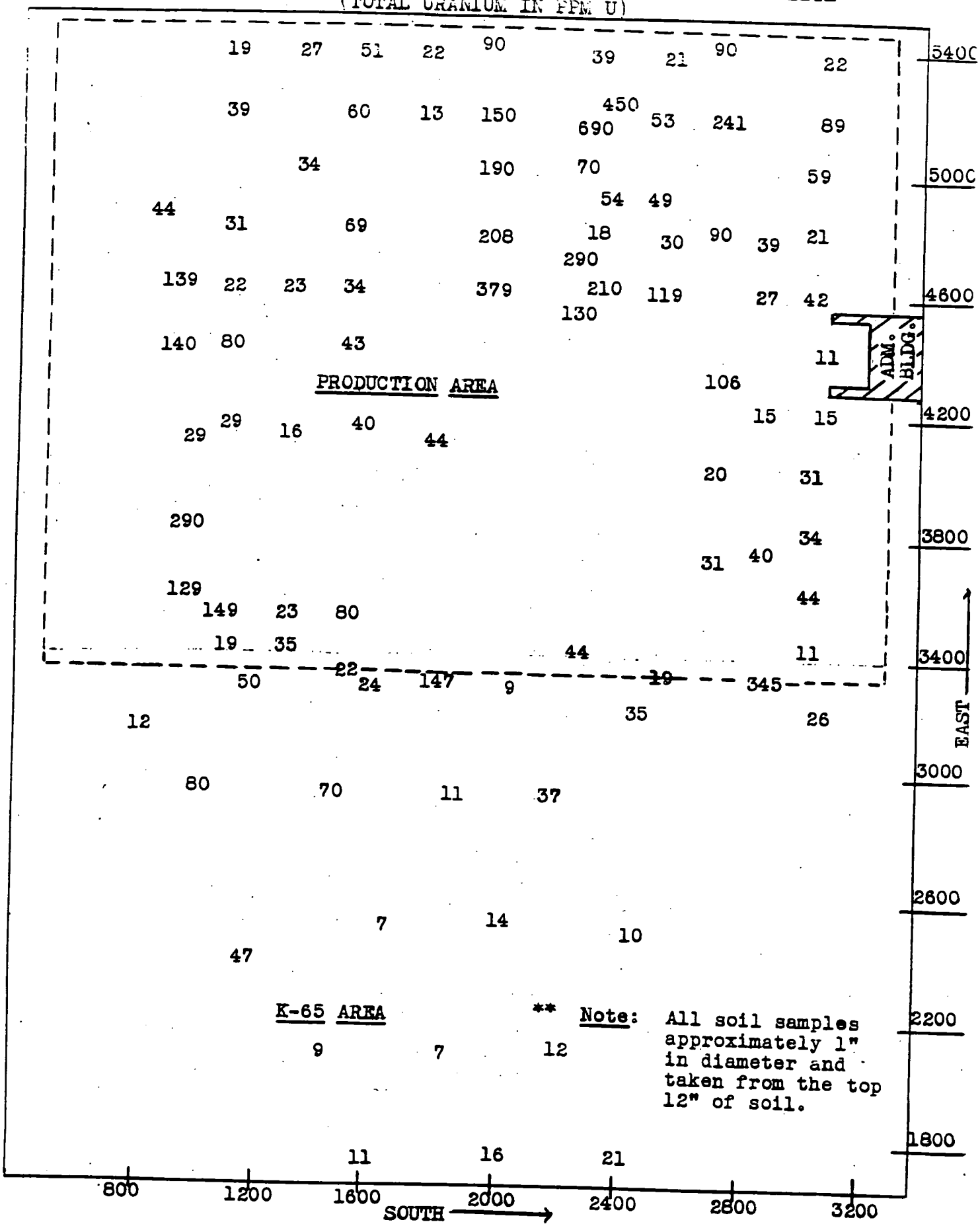
Figure 4: URANIUM CONTENT OF SOIL SAMPLES FROM PLANT SITE**
(TOTAL URANIUM IN PPM U)



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The fluorides likewise show variation from point to point but there does not appear to be a significant difference between the Production and K-65 areas.

The soluble uranium contained in the soil samples is simply the residual that was not removed by infiltrating precipitation and surface runoff and as such is indicative only of the fact that process materials can be dissolved and carried into the ground water. The high fluoride, nitrate, chloride and uranium levels found in the seepage water in ditches and excavations also support this conclusion.

CONCLUSIONS:

1. The pumping tests of the main production wells did not cause a significant drawdown in the test wells or in the well at the old Administration Building. This indicates that at the maximum pumping rates possible, the area of influence of the production wells is quite limited.

2. The deep aquifer can supply considerably more water than can be withdrawn from the present wells.

3. The static water levels in the deep wells and in the shallow wells are approximately the same thereby indicating that the deep and shallow aquifers are interconnected.

4. Analyses of samples from the deep and shallow wells show that the chemical content is essentially the same; a further indication of a direct interchange of water between the two aquifers. Contamination reaching the shallow ground water therefore can be carried into the deep aquifer.

5. The water in the shallow aquifer is moving from Paddy's Run Creek toward the production wells. This conclusion is supported by the higher water levels in Test Wells Nos. 2, 3, 4, and 5 as compared with Test Well No. 1.

6. While the main production wells do not influence the normal direction of ground water flow appreciably, except in the immediate vicinity of the wells, the construction of additional wells or increased withdrawal from existing wells can cause a significant change in the direction of ground water movement.

7. There is definitely some leakage from Pit #3 into #5 Test Well because the chloride and nitrate content of samples from this well is much higher than from other wells in the plant.

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8. A small amount of seepage from Pit #3 is entering Paddy's Run Creek.

9. Analysis of water samples collected from trenches and excavations throughout the plant site show that production chemicals are finding their way into the subsurface waters of the plant.

10. The soil sample analyses gave evidence of rather widespread surface contamination in the Production Area and along some of the major roadways.

11. Rather high concentrations of chemicals accumulate at times in the lower portion of the K-65 trench and in the sump at the concrete storage silos in the K-65 area.

12. Surface runoff from the storage pads carries appreciable concentrations of process materials onto the ground surface and into the storm drainage system.

13. The quality of water in Paddy's Run Creek is not affected appreciably by the FMPC operations except possibly during periods of heavy rainfall.

14. The wet and dry pits in the K-65 Area form the greatest potential hazard from a ground water pollution standpoint, and also with respect to potential pollution of Paddy's Run Creek.

RECOMMENDATIONS:

It is specifically recommended that the following steps be initiated immediately, to lessen the ground water pollution potential in the FMPC plant area:

1. Test well #1 should be extended to the bottom of the shallow aquifer, but not through the blue clay layer separating the two aquifers, and equipped with a suitable screen and pump to permit water to be withdrawn at a rate of at least 100 gallons per minute.

   Pumping tests on this well will give direct evidence of leakage or non-leakage from the waste disposal pits. If leakage is occurring, the contaminants from the pits will be moved into Test Well #1 after a short period of heavy pumping. In this manner, leaks can be detected before appreciable quantities of ground water have been polluted.

   If a leak is found, then it will be absolutely necessary to seal the leak or to contain the leakage within the

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waste disposal area by intercepting the contaminants below the bottom of the pits before they can reach the shallow ground water.

2. After Test Well #1 is operative, the well should be pumped continuously at the maximum rate possible for a period of three days. Drawdown measurements must be taken at 10-minute intervals until no further drop in water level is observed; thereafter, the water level should be checked every eight hours for the duration of the pumping test. Water samples are to be collected at 2-hour intervals and analyzed immediately for chlorides, and as soon as possible for nitrates, fluorides and uranium. Drawdown measurements are to be made in Test Well #5 and in the old Administration Building Well at 2-hour intervals during the pumping test on Test Well #1.

   Subsequent tests should be made on Test Well #1 in June and October of each year. These pumping tests will be carried out under the direct supervision of the Health and Safety Division and the Engineering Division.

3. The waste disposal pits should be protected from surface runoff by the construction of clay dikes around the perimeter of the pits. The dikes should be high enough to keep surface water from the surrounding area out of the pits. In the event that the dry waste pit is covered, the cover should be made of clay which is thick enough and compacted sufficiently well to be impervious. The clay cover and dikes should be inspected thoroughly every month so that any necessary repairs or revisions can be made without delay.

   A drain line should be installed to carry any accumulated liquids from the dry pits into Pit #3. This drain line must be kept above the high water level in Pit #3 so that backflow does not occur.

4. All areas where chemicals are used and stored, or where there is a possibility of process chemicals being spilled, should be paved and curbed to prevent surface water from flowing over the areas and also to contain materials which are spilled accidentally. These paved and curbed areas should be provided with drains which discharge into recovery sumps which in turn discharge into Pit #3. Under no circumstances should process chemicals be discharged into the storm sewerage system, accidentally or otherwise.

5. When agricultural drain tiles are encountered in excavations, they should be reported to the Health and Safety Division or to the Engineering Division so that appropriate sealing procedures can be initiated.

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6. Samples should be collected from all subsurface waters encountered in excavations to determine the levels of contaminants present.

7. A soil sampling program as carried out in this investigation should be performed annually to determine if a build-up of surface contamination is occurring. It is recommended that such sampling be done in late August or early September.

8. Special attention should be given to the K-65 trench to make sure that wastes do not accumulate therein. When wastes are found in this trench they must be pumped to Pit #3 or back into the K-65 storage tanks.

9. The storm drainage system should be investigated thoroughly to ascertain if it presents a possible pollution potential for Paddy's Run Creek during periods of storm flow. If it is found that Paddy's Run Creek might be polluted through storm water discharged from the plant, corrective measures should be carried out. Recommendation No. 4 if carried out will reduce the chance of Paddy's Run being contaminated through surface runoff from the plant.

10. Continuous monitoring of Paddy's Run Creek in the vicinity of the K-65 Area is necessary so that leakage from the waste disposal pits can be detected.

11. A comprehensive study of the sources, types, and quantities of wastes produced in the FMPC area is needed so that maximum recovery of materials can be achieved and so that the various waste streams can be properly blended before going to the waste treatment system. A study also should be made of the waste treatment procedures to determine if more appropriate methods can be developed. The basic reason for this recommendation is to prolong the useful life of the present waste pits, particularly Pit #3 because the ground water pollution potential will increase as the number of waste disposal pits increases. It is imperative therefore that the existing pits be used as long as they are capable of providing the storage time and treatment necessary for meeting effluent standards.

12. The actual amount of water discharged from Pit #3 to the Miami River each day should be correlated directly with river flow so that the amount of wastes retained always will be at an absolute minimum. In this way, reserve storage will be available when waste discharge must be curtailed because of low river flows.

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