JERRY F.

TRUAX LANDFILL

LEACHATE MIGRATION

STUDY

JANUARY, 1984

Prepared by:

City Engineering Division

City of Madison, Wisconsin

JEROME FRANKLIN

Department of Public Works
City Engineering Division

City of Madison

Arnold E. Milke, P.E., City Engineer

May 23, 1984

Floyd Stautz
Assistant District Director
Department of Natural Resources
Southern District Headquarters
3911 Fish Hatchery Rd.
Madison, WI 53713

Delbert Maag
Water Supply Unit Supervisor
Department of Natural Resources
Southern District Headquarters
3911 Fish Hatchery Rd.
Madison, WI 53713

Gentlemen:

Enclosed is a copy of a report drafted by the City of Madison Department of Engineering which compiles and discusses various leachate indicator parameters which have been detected in the groundwater monitoring wells near the Truax landfill site.

These wells are routinely monitored by the Engineering and Health Departments as part of the City's water quality maintenance and review program.

This report has been provided to Dane County, owner of the Truax site and Oscar Mayer Foods Corporation, which maintains private wells near the site. By copy of this letter, the report is also being provided to the owners of the former Burke sewerage treatment site.

If you have any questions regarding the report, please contact Jill Schmidt of the Health Department or David Benzschawel of my staff.

Very truly yours,

Arnold E. Milke

Arnold E. Milke,
City Engineer

AEM:DLB:map

cc: First Wisconsin National Bank c/o
Vernon J. Martin, Personal Representative
& Trustee of Henry E. Reynolds Estate
William Mundt, Murphy, Stolper, Brewster &
Desmond, Attorneys for Reynolds Estate
Jonathan Barry, Dane County Executive
Jack Spohn , Vice President and Madison Plant Manager,
Oscar Mayer Foods Corporation
City Staff

City-County Building
210 Monona Avenue, Room 115
Madison, Wisconsin 53710
608 266 4751

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	
	A. Background	1
II.	EXISTING GROUNDWATER TABLE	
	A. Summary of Upper and Lower Acquifer from "Water-level Declines in the Madison Area."	2
	B. Historical Data on Groundwater Table in the Madison Area.	4
	C. Summary of R.F. Kaufman's Report on "Hydrogeology of Solid-Waste Sites in Madison, Wisconsin"	4
	D. Historical Data on Groundwater Flow Rates and Directions in Upper Aquifer at Truax	4
III.	GROUNDWATER QUALITY	
	A. Truax Landfill Leachate	9
	B. Burke Sewage Treatment Plant Leachate	11
	C. Leachate Movements	12
IV.	PROPOSED MONITORING PROGRAM	
	A. Leachate Parameters of Concern	18
	B. Burke Monitoring Program	20
	C. Truax Monitoring Program	21
V.	BIBLIOGRAPHY	23

Report prepared by: David Benzschawel

David Benzschawel
Civil Engineer

Approved by: Arnold E Milke

Arnold E. Milke, City Engineer

APPENDIX

FIGURE 1	Head Declines in Lower Aquifer
FIGURE 2	Head Declines in Upper Aquifer
FIGURE 3	Leachate Plumes and Cones of Depression at Truax Landfill
FIGURE 4	Vertical Groundwater Flow Under Landfill. 1970
FIGURE 5	Groundwater Isotherms Under Landfill Area. 1970.
FIGURE 6	Geologic Section at Truax Landfill
FIGURE 7	Typical Chloride Ion Plume in Sandy Aquifer
	Water Supply Well Analysis

I. INTRODUCTION

The Truax Landfill has been operated as an open-burning dump and sanitary landfill by two owners since the low area adjacent to the Starkweather Creek wetlands was first filled back in the 1930's. Commercial wastes were first disposed at the site in the late 1940's by the Oscar Mayer Company. It is assumed that a wide variety of wastes were disposed at the site by Oscar Mayer who apparently operated all or part of the site as an open-burning dump. Oscar Mayer probably disposed of both office and commercial wastes at the site. The City of Madison took over operations in 1953, and continued to use the area as a burning dump through 1960. Sanitary landfill operations began in 1961 and ended when the site was closed in 1972. Since the site was operational prior to the state legislation enacted in 1973 which required stricter environmental controls and long-term care, the State of Wisconsin Department of Natural Resources (DNR) has not required groundwater monitoring.

The landfill and the surrounding city-owned land was transferred to the County in 1973.

The Policy of the DNR for the "grandfathered" landfill sites which do not contain hazardous wastes is to reactivate groundwater monitoring and completely review the groundwater quality when signs of harmful groundwater contamination are evident. So at this time, the DNR does not require Dane County to perform any groundwater monitoring at Truax.

Currently the City is monitoring Truax water quality on its own because the City Engineering Division and the City Health Department have agreed that the rising levels of leachate indicator parameters being detected in the groundwater monitoring wells are a cause for concern.

The City Engineering Division is involved at Truax because it is acting as engineering consul to the City Streets Division which is the licensee for all City landfills.

The City Health Department has an interest in the Truax Landfill because they are charged with protecting the environment of the City of Madison according to City Ordinance Sec. 7.46 and 7.47 which includes ground and surface waters.

II. THE EXISTING GROUNDWATER TABLE

The Upper and Lower Aquifers

The United States Geological Survey prepared a report in cooperation with the City of Madison Water Utility on the upper and lower groundwater aquifers titled "Water Level Declines in the Madison Area, Dane County, Wisconsin." The report was drafted because of the concern for the dramatic drop in the lower aquifer levels due to municipal and industrial pumping in this aquifer by high capacity wells. The groundwater flow system under Madison is classified as a two-aquifer system composed of a confined lower sandstone aquifer underlain by a relatively impermeable bedrock and overlain by a leaky unconfined upper aquifer composed of glacial soils.

Monitoring of the aquifers has shown that the upper aquifer is recharging the lower aquifer at an increasing rate as the lower sandstone aquifer is being drawn down.

This change in traditional groundwater flow patterns has resulted in a reduction of the groundwater discharge to wetlands, lakes and streams.

These findings particularly apply to the Truax-Oscar Mayer area as this area is situated adjacent to the wetlands of the east branch of Starkweather Creek and the area is surrounded by eight wells which pump about 8 million gallons of water per day from the lower sandstone aquifer.

Contours of the groundwater levels in the upper and lower aquifers are shown in Figures #1 and #2 in the Appendix. The figures show that one of the worst areas in the City for the channelization of flow from the upper to the lower aquifers is at the Truax Landfill area.

The Dane County Regional Planning Commission studied the Starkweather Creek drainage basin and determined groundwater pumpage at the high-capacity wells around Truax Landfill to be a major cause of the decline of flow in the creek. Figure No. 8 in the Appendix is a plan of the Dane County Regional Planning Commission's estimate of groundwater contours that have resulted from the heavy pumping of Oscar Mayer's wells.

THE CITY OF MADISON'S CITY-WIDE DATA

The City of Madison's groundwater measurements confirm the draw-downs predicted by 1978 USGS report. Monitoring wells at Sycamore and Green Tree Landfills, both in areas of large groundwater depressions which have been monitored since 1973 to the present, show that the upper aquifer is being depleted by the local water wells.

The significance of this is that the leachate from Truax Landfill and the sludge beds will be drawn more quickly towards the adjacent water wells as the lower groundwater table drops.

The high capacity wells near Truax, installed by the City of Madison Water Utility and Oscar Mayer, have a cone of depression which extends about 2,600 feet from each well. Oscar Mayer has installed five wells on their property and it is estimated that the combined cone of depression from the wells would extend out from the wells about 3,500 feet on the average. These cones of depression are not uniform and are influenced by the permeability of the layered aquifers. The groundwater below the Truax Landfill appears to be strongly influenced by the cones of depression from the Oscar Mayer wells and the City of Madison Well #7 on Sherman Avenue at Schlimgen Avenue. These cones are shown on Figure #3 in the Appendix.

SUMMARY OF GROUNDWATER FLOW STUDY AT TRUAX LANDFILL, 1970

The "Hydrogeology of Solid Waste Sites in Madison, Wisconsin" included a study of the effect of Truax Landfill on the local groundwater system.

It was written by R.J. Kaufman, a University of Wisconsin graduate student in geology as part of his doctoral requirements.

His data concerning the flow patterns between the upper and lower aquifers is in agreement with the assumptions used by the USGS five years later when they computer-modeled the groundwater flow patterns in Dane County. Kaufman's data from the first year of the study showed that the upper groundwater flow pattern was westward under the landfill and that the vertical gradients were downward for most of the area, including the area immediately adjacent to Starkweather Creek and its ditches. This included the undisturbed marsh areas and the man-made sewage sludge irrigation fields. The shallow groundwater flow patterns are shown in Figure #4 of the Appendix.

Kaufman's data shows that the pumping in the adjacent high-capacity water wells was already drawing in groundwater from the upper unconfined aquifer. In his report, he speculates that "the change (from an upward to a downward flow) is at least partly due to groundwater withdrawal via nearby high-capacity wells, . . municipal Well #7 and the Oscar Mayer Company wells." His water level readings in 1968 and 1969 show a constant westward flow direction for the majority of the landfill and the Burke plant sludge lagoons, #1 thru #7. The cause for this flow pattern was the cone of depression he measured along the west side of the landfill. These patterns are shown in Figure #3 in the Appendix.

Kaufman decided that the severe drop or trough in the groundwater table was part of the cone of depression from City Well #7 and Oscar Mayer wells. Kaufman reviewed the data and concluded "Reversal of the gradient so as to cause lateral flow out of the marsh is apparently a result of a combination of permeable drift, shallow depth to rock and nearby high capacity wells. Development of the pumping cone has proceeded eastward under the landfill, thereby inducing flow generally to the west and northwest. The remaining water in the landfill, primarily along the southern border and, to a lesser extent, along the eastern edge is not affected by the diversion and as a result is discharged locally to the ditch system and the marsh. Drainage of landfill leachate eastward toward the marsh is indicated only on the maps prepared from data collected in September and November, 1969, and may represent the exception. In any event, the percentage of area draining toward the marsh and the very slight gradient indicate small flow volumes compared to the total discharge from the landfill and the sewage disposal area.

Relative permeabilities of the glacial sediments also are related to the flow pattern in the landfill and sewage disposal areas. The cone or trough is most developed in the sandy morainal material below and adjacent to the northwestern quarter of the landfill. Drainage or diversion is easiest because of relatively high permeability compared to the more clayey materials present in the southern and southeastern parts of the landfill. Thus the cone has expanded along a path of least resistance until the clayey materials are reached. The marsh sediments have a low permeability and, in effect, constitute a boundary condition and an approximate limit on further eastward expansion of the cone."

It appears that the local clay and clayey silt deposits on the top of bedrock are a key to the groundwater flow patterns in the upper unconsolidated aquifer. A review of the bedrock and clay locations, shows that the most influential clay deposit is a roughly circular deposit varying in depth from 30' to 120' which lays on top of the upper weathered sandstone bedrock just south of the Burke Sewage Treatment Plant.

This clay deposit which has a very low permeability, blocks the cone of depression from the surrounding wells from reaching the groundwater in the upper sand aquifer located above it. This clay boundary along with the high recharge from the sludge lagoon area, creates the groundwater mound under the sludge lagoons. This mound is shown in Kaufman's data used to draw Figure #5.

CITY OF MADISON'S TRUAX DATA

The City's monitoring from 1970 to present confirms that the flow patterns mapped by Kaufman still remain the same. Figure #6 is an east-west cross section of the landfill showing geology and flow patterns. Figure #3 shows the cones of depression and groundwater contours.

The glacially deposited soils in the vicinity of Truax Landfill have been studied to determine their boundaries and soil types. Using the average porosities and permeabilities of these types of soil, it is anticipated that the actual horizontal flow velocities in the medium-sized silty sand aquifers will vary between 40' per year to 120' per year as the groundwater moved one-half mile towards the water supply wells.

Groundwater velocities of 80' per year match fairly well with the measured leachate contours at various monitoring wells down gradient of the landfill.

The Engineering Division has been monitoring five wells along the west side of the landfill. Representative water quality data showing the movement of the leachate plume is shown in the attached Table I.

TABLE 1

GROUNDWATER ANALYSIS

	Well No.	4/77	5/78	11/79	5/80	3/81	4/82	7/82	4/83	10/83	2/84	Well No.
Chloride (Mg/L)	101	-	-	-	-	63	68.5	80	80	92	80	101
	104	DRY	DRY	87	-	27	18	40	35	24	17	104
	121-A	3,900	Damaged Casing-Damaged Casing			5,130-	-	5,650	5,350	5,500	5,400	121-A
	200D	-	-	-	-	-	66	30	46	32	41	200D
	200S	-	-	-	-	-	0	1	225	24	62	200S
	152	-	-	-	52	137	-	Construction in Area		-	180	152
	OSC-5	49	42	-	-	42	-	-	-	-	48	OSC-5
Specific Conductance (MMHOS/CM)	101	-	-	-	-	1,610	1,490	1,580	2,210	2,200	2,100	101
	104	DRY	DRY	2,100	1,930	2,100	1,820	2,200	2,220	2,200	1,820	104
	121-A	16,800	Damaged Casing-Damaged Casing			15,000-		15,000	17,100	16,600	15,700	121-A
	200D	-	-	-	-	-	1,010	630	880	700	860	200D
	200S	-	-	-	-	-	320	380	2,200	560	960	200S
	152	-	-	-	600	1,960	-	Construction in Area		-	1,150	152
	OSC-5	825	810	-	-	870	-	-	-	-	820	OSC-5
Sodium (Mg/L)	101	-	-	-	-		96	84	100	90	84	101
	104	DRY	DRY	22	18	23.5	42	23	43	30	20	104
	121-A	1,470	Damaged Casing-Damaged Casing			1,570-		1,965	1,950	1,934	1,870	121-A
	200D	-	-	-	-	-	41	21	40	32	29	200-D
	200S	-	-	-	-	-	29	14	250	41	90	200-S
	152	-	-	-	27	31.5	-	Construction in Area		-	42	152
	OSC-5	18	18	-	-	19	-	-	-	-	22	OSC-5
Calcium (Mg/L)	101	-	-	-	-		124	112	153	142	199	101
	104	DRY	DRY	-	202	213	216	225	228	231	231	104
	121-A	630+	Damaged Casing-Damaged Casing			888-		900	948	840	788	121-A
	200-D	-	-	-	-	-	98	48	69	62	75	200-D
	200-S	-	-	-	-	-	38	40	142	57	80	200-S
	152	-	-	-	12	195	-	Construction in Area		-	15	152
	OSC-5	88	75	-	-	78	-	-	-	-	84	OSC-5
Magnesium (Mg/L)	101	-	-	-	-		87	90	132	136	50	101
	104	DRY	DRY	-	128	132	111	126	135	130	138	104
	121-A	138+	Damaged Casing-Damaged Casing			212-		222	240	240	54	121-A
	200-D	-	-	-	-	-	66	33	48	42	52	200-D
	200-S	-	-	-	-	-	11	16	29	46	21	200-S
	152	-	-	-	46	106	-	Construction in Area		-	99	152
	OSC-5	49	48	-	-	45	-	-	-	-	45	OSC-5

III. GROUNDWATER QUALITY

Truax Landfill Leachate

All groundwater data from 1968 to the present confirms the presence of two groundwater plumes. The Truax Landfill has created one plume and the Burke Sewage Treatment Plant has created another.

Due to the size of the treatment plant, its plume could be subdivided into the north irrigation field plume and the south irrigation field/ sludge lagoon plume.

Since the north irrigation field lacks sufficient monitoring wells and any operable wells have not been monitored since 1968, it is difficult to analyze what effect it has on the adjacent landfill plume.

It would be safe to assume that these two groundwater flows are mixed along their common boundaries. It appears however, that the leachate being detected west of the landfill is coming mainly from the landfill with minor contamination from the irrigation field.

Figure #3 and #6 show the estimated limits of the leachate plumes.

Truax Landfill was operated as an open-burning dump from the late 1940's until 1960. It is assumed that most of this waste was placed directly on the existing native soils at the low end of the landfill in the southeast corner bounded on both sides by drainage ditches. No liners of clay were placed under any of the waste and no leachate collection system exists at Truax. Almost all leachate percolates downward until it reaches the groundwater table.

Records show that when the City of Madison operated the site as an open-burning dump, almost all of the waste hauled to the site was combustible.

From 1961 until 1972, the site was operated as a sanitary landfill and it received almost all residential waste.

A groundwater contour was drawn on Figure #3 for a chloride ion concentration of 80 Mg/L and a specific conductance of 800 UMHOS based on monitored levels in the groundwater wells. This contour coincides with a groundwater plume which would have an average velocity of 80' per year which is a typical velocity for the soils encountered at Truax. The limits of the landfill leachate plume are shown on Figure #3. The groundwater monitoring shows that the landfill leachate is migrating off of the landfill site and has probably reached Oscar Mayer Well #5 and will reach the City Well #7 within 10-20 years.

BURKE TREATMENT PLANT LEACHATE

As mentioned previously, the leachate leaving the plant can be divided into two plumes. The one closest to the water supply wells is the one of greatest concern. This plume was fed by the south irrigation field and the sludge lagoons.

The plant was operated from 1914 to 1926 using a contact bed and trickling filters. It was closed down in 1936 and then used by the US Army from 1942 to 1945 for treating wastes from Truax Air Field.

The Oscar Mayer Company reactivated the plant in 1951 to treat meat packing wastes prior to discharging them to Madison Metropolitan's Treatment Plant. Sludge was lagooned on the site on a year round basis. The Burke Plant was last operated in 1976.

The monitoring well network along the west and south side of the treatment plant area is inadequate to detect the exact location of the treatment plant leachate plume.

But, based on the average groundwater velocities for the underlying sandy soils and the groundwater velocity detected under the landfill, the treatment plant leachate plume has had more than enough time to reach the Oscar Mayer supply wells.

The clay deposits directly below the treatment plant have slowed the leachate plume but have not stopped its migration towards the wells. It is expected that the leachate is being drawn around both sides of the roughly-circular clay deposit. Groundwater troughs exist on both sides of the clay barrier and the trough along the west side has monitoring wells which have detected a sewage leachate plume.

MONITORING WELL DATA

From Figure #3 it can be seen that the leachate plumes from the two sources are mixing along a variable boundary which passes near Wells #152, 101 and 200.

Well #101 is 35' deep and too shallow to pick up the landfill leachate plume, although it has detected the top of the sludge lagoon plume at various times.

Well #200 may have been contaminated by both plumes, but the evidence is not conclusive.

Well #152 it appears, is contaminated with landfill leachate only. The well water analyses are shown in Table #1 of the Appendix.

The relative strengths of the two plumes are shown in Table #2. The strengths of the various parameters at a point in the leachate plume 1,000 feet down gradient of the source were estimated from all monitoring well data on the site and from published data on similar treatment plants and landfills. (See Attached Table #2)

TABLE #2

ESTIMATED LEACHATE STRENGTHS 1000' DOWN GRADIENT

Parameter	Typical Landfill Leachate	Typical Sewage Treatment Plant Leachate
Chloride	120	200
Spec. Conductance	2,000	2,000
Sodium	40	100
Calcium	60	100
Magnesium	40	40
COD	80	150
Phosphorus - Total	.10	2.0
Potassium	5	20
BOD	8	40
Organic Nitrogen (Ammonia Indicator)	0.5	3.0

This data confirms the conclusion that separate leachate plumes are migrating towards the water supply wells.

The table shows that the sodium, potassium, ammonia, phosphate and BOD levels can be used to determine the source of the leachate.

Kaufman discussed using these same parameters to determine leachate plume sources in his study in 1970. He felt that the levels of sodium, potassium, nitrate plus nitrite, ammonia, phosphorus and chloride would all be high in ground water known to be polluted by sewage. His report also included an analysis of the sanitary wastes treated by Oscar Mayer Company which is shown in Table #3.

Of particular importance, are the exceedingly high concentrations of nitrogen and phosphorus and the high pH level. The most polluted ground water sampled for the 1970 study was under the sludge lagoons and had an ammonia level of 314 Mg/L and a total phosphorus level of 8.91 Mg/L.

(See Table #3 Attached)

TABLE #3

QUALITY OF SANITARY WASTES FROM THE OSCAR MAYER COMPANY[1]

Parameter		Sample Location			
	Pretreatment Plant Sludge	Burke Plant Sludge	Burke Plant Digester Sludge	Internatant From Lagoons	Secondary Effluent
pH	6.5	6.5	7.5	7.5	7.88
Specific Conductance	3100	2800	9100	7100	
Soluble Na mg/l	200	500	700	300	370
Soluble K mg/l	50	20	140[4]	60[5]	18
Soluble Mg mg/l	100	100	100[4]	90[5]	74
Soluble Ca mg/l	400	100	300[4]	130[5]	29
NO_3-N	30	50	50	1	
NH_3-N	192	96	840	5800	40[2]
Organic N	1600	1600	1000	900	15[2]
Total P	640	480	310	83	
Ortho P	11	20	17	21	
Cl	50	550	550[4]	325[5]	770
COD	116000	65900	22500	1700	
Total Soluble P	77	93	53	29	10
BOD	40000[3]	20000-30000[3]			138
Suspended Solids					90

1. All samples analyzed by W. Noel, City of Madison Health Department. Twenty secondary effluent samples collected from December 1966 to June 1967; mean values shown. Other wastes sampled and analyzed in May 1970; value shown based on one analysis of each waste category.
2. Concentration in effluent irrigated to North and South Fields.
3. D. Dencker, personal communication.
4. ± 50 mg/l accurace due to problems with dilution and color
5. ± 20 mg/l accuracy due to problems with dilution and color

Another comparison between landfill leachate and domestic waste waters was made by D.R. Brunner and R.A. Carnes and was used in a paper they authored which compared the relative strengths of leachates. Their data was used by the U.S.E.P.A. in one of the EPA solid waste manuals on groundwater monitoring. The Table is indicated below:

TABLE #4

CHARACTERISTICS OF LEACHATE AND DOMESTIC WASTE WATERS

Constituent	Old Leachate	Waste Water
Iron (Fe)	1.5	0.1
Magnesium (Mg)	81	30
Potassium (K)	---	---
Sodium (Na)	---	---
Phosphate (P)	4.96	10
Total N	7.51	40
BOD_5	---	200
COD	81	500

This table substantiates the preceeding tables and City water quality data gathered at Truax. The landfill plume should have a higher iron, magnesium, calcium and a pH around 6.0 and 7.0. The waste water plume should have a higher potassium, sodium, phosphate, nitrogen, BOD, COD and a pH around 7.0 to 8.0.

Wells #152 and #200 which are located on the boundary between the two leachate plumes, are beginning to detect groundwater with parameters that are approaching the levels expected for the landfill and waste water plant leachates.

The water analyses for Truax Wells #200 shallow on April 20, 1983, and for #152 on July 23, 1981 as follows:

PARAMETER	#200 (Mg/L)	#152 (Mg/L)
COD	183	251*
Organic Nitrogen	6.5	- -
Chlorides	225	168
Conductance (UMHOS/CM)	2200	2160
Potassium	25.4	2.5
Sodium	250	33.5
Calcium	142	166
Magnesium	29	109
pH	7.5	6.96
Iron	.13	4.37
Phosphorus (Ortho)	----	.12
BOD	39.6	6.7

*Data suspect: Normal Range = 25.0

A cross section, Figure #6, was drawn along the center line of the landfill leachate plume based on groundwater monitoring at Truax and data gathered at landfills located in similar soils with approximately the same groundwater velocities.

The monitoring well network at Truax is inadequate to draw firm conclusions on the exact location of the plume, but the data generated by Wells #104, 152, 200 and Oscar #5 was adequate to construct Figure #6.

It should be pointed out that Oscar Mayer Well #5 is already experiencing a slight drop in water quality.

It appears that either of the two leachate plumes could be the cause of the water degredation. The water analysis for Oscar Mayer Wells #2 and #5 and City Water Utility Wells #7 and #5 are shown in the Appendix.

Oscar Mayer Well #5 is 35 Mg/L higher in chlorides, 200 UMHOS/CM higher in conductance, and significantly higher in sodium, calcium, and magnesium than all of the surrounding high-capacity water supply wells.

IV. PROPOSED MONITORING PROGRAM

Leachate Parameters of Concern

Groundwater flow patterns based on the water table gradients and soil permeabilities are shown in Figure #3. It is assumed with reasonable certainty that the leachate plumes from the Truax Landfill and Burke Sewage Treatment Plant have already reached the bedrock aquifer at Oscar Mayer Well #5.

It is not certain which plume has migrated through the full depth of the upper sand aquifer and reached the lower sandstone aquifer in which the water supply wells are screened, but the Burke plume had a 20-30 year head start on the landfill leachate plume, and is more suspect. One or both plumes could be the cause of groundwater deterioration at Oscar's #5.

The groundwater flow patterns also show that the landfill plume is getting close to City Well #7. At this point, no contamination has been detected, but the leachate will invariably reach the well.

It is anticipated that the plume would reach #7 sometime within the next 20 years. The time it takes for the plume to reach #7 is dependent upon the well's pumping rate and how much the flow in the sandstone aquifer is channelized.

The leachate parameters that will be of concern as the wells become more contaminated are dependent upon the Federal Drinking Water Quality Standards. The parameters of concern cannot be selected at this time because of a lack of information from the existing groundwater monitoring network at Truax.

The City of Madison needs more information concerning the levels of heavy metals, organics and some other parameters which have been detected in the leachate but not reliably. The parameters already detected in the leachate which should be closely studied because of their potential for exceeding the drinking water standards are: nitrates, organic contaminants, manganese, cadmium, sodium and chlorides.

BURKE MONITORING PROGRAM

The City Engineering Division has no responsibility for the long-term care of the Burke Sewage Treatment Plant, but the City Health Department has been assigned the responsibility for protecting the environment which includes groundwater.

It is questionable whether the City Health Department should spend money studying the leachate plume from the Burke Treatment Plant since it is owned by someone else, it was operated for a considerable amount of time by Oscar Mayer Company and it is probable that the only well to be contaminated by the plume is Oscar Mayer Well #5.

The groundwater monitoring network around the Burke plant appears to be completely inadequate. Almost all of the 20 or so wells around the plant have screens which are set too shallow to detect any of the leachate. It would be very expensive to redrill all new deep wells that would be required to adequately monitor the Burke plant. The well construction alone could cost as much as $30,000. At this time, it appears the City of Madison should leave the treatment plant leachate plume alone and concentrate on getting the County to start a expanded monitoring program for the landfill. It is probable that the Department of Natural Resources will require the current owner of the Burke Treatment Plant property to start a monitoring program for that site.

TRUAX MONITORING PROGRAM

Since the Truax Landfill is now owned by the County and the monitoring program is to be expanded, the City should start negotiating with the County to accept the responsibility for the groundwater monitoring program.

As mentioned previously, there currently exists a lack of data for certain groundwater parameters which may be contaminating the groundwater. The levels of organic contaminants, which have not been monitored at all, and the levels of heavy metal which have been measured sporadically should be monitored on a regular basis.

Since leachate has been positively detected, the monitoring schedule should be set so that any significant change in the strength or rate of leachate movement is detected.

An effective monitoring program can be sustained if Wells #152, 200 deep, 132, 200 shallow, 121 deep, 121 shallow, 104, 101, City Water Well #7, and Oscar Mayer Well #5 are monitored for the following parameters:

Quarterly --

- 5-Day BOD
- COD
- Phosphorus
- Ammonia Nitrogen
- Nitrate
- pH
- Alkalinity
- Hardness
- Chlorides
- Specific conductance
- Soluble potassium
- Soluble sodium
- Soluble calcium
- Soluble Magnesium
- Sulfate
- Silver
- Barium
- Cadmium
- Chromium
- Cobalt
- Iron
- Lead
- Manganese
- Nickel
- Zinc

Semi-Annually --	Organic Contaminants (to be selected) Selenium Arsenic Mercury

Well #152 is a key well. It is the only well located towards the center of the leachate plume. Unfortunately, the well's screen is located only 5' below the groundwater surface. Should the data from the well become irregular or the groundwater table drop, the well should be replaced with a well nest. The new nest should have two wells with screens set approximately 65' and 85' deep.

If Well #152 remains functional, then no additional wells will probably be needed. Should the existing wells show that the levels of contaminants are increasing more quickly than anticipated and the drinking water standards are in danger of being exceeded, then a new well nest should be located down gradient of Well #152. Any new well should be located so that the attenuative ability of the soils can be estimated. If new wells are drilled, soil samples should be taken so that groundwater velocities can be determined from permeability tests.

BIBLIOGRAPHY

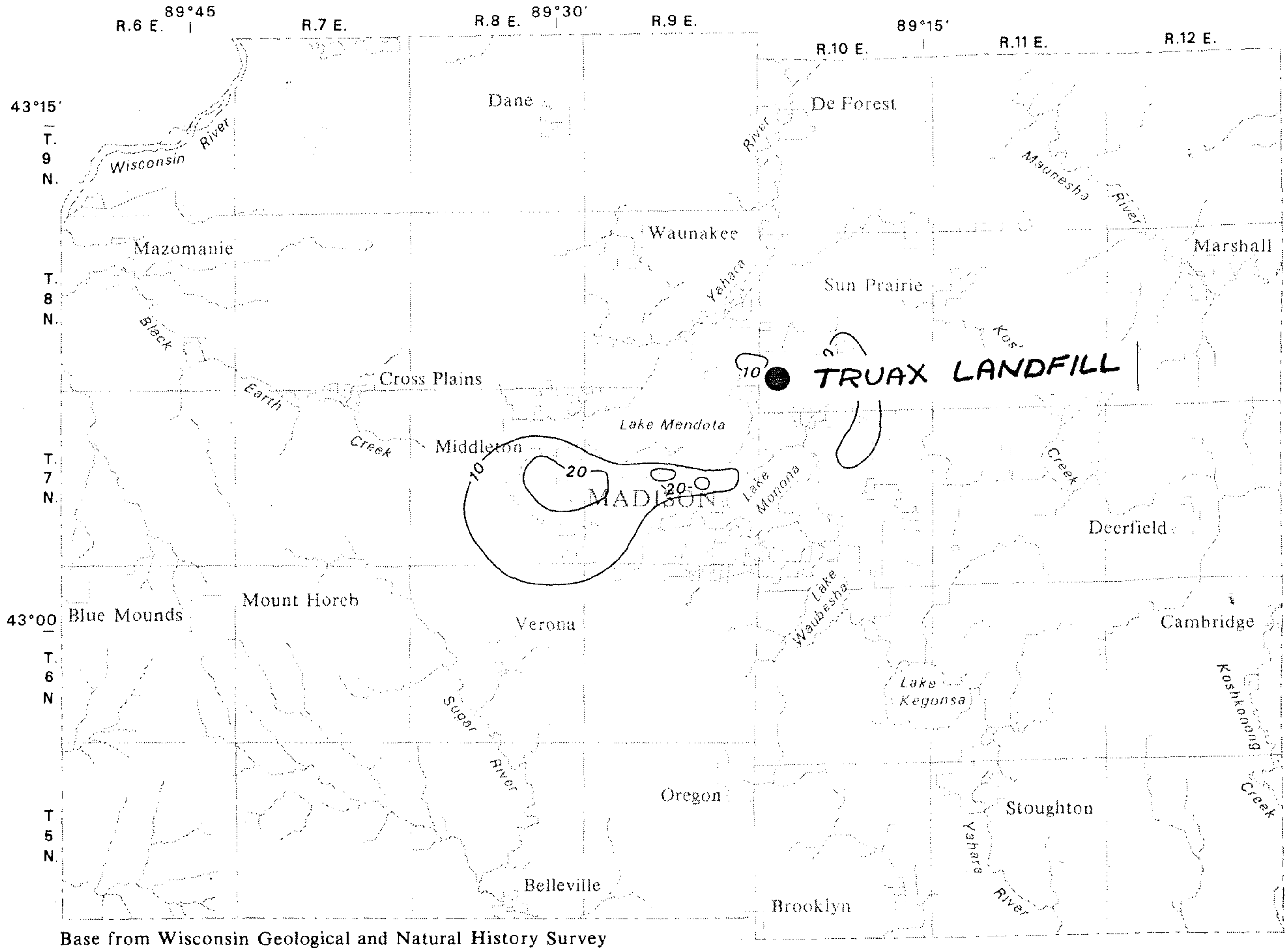
Dane County Regional Planning Commission. 1980. A Water Quality Plan for Star weather Creek. Madison, Wisconsin. 71 p.

Kaufman, R.F. 1970. Hydrogeology of solid waste disposal sites in Madison, Wisconsin. Ph.D. Thesis. Univ. Wisconsin, Madison

McCleod, R. S. 1975. A digital computer model for estimating hydrologic changes in the aquifer system in Dane County, Wisconsin. Wis. Geol. and Nat. History Survey Information Circular No. 30. Madison, WI 40 p.

McCleod, R. S. 1978. Water-level declines in the Madison area, Dane County, Wisconsin. USGS Open-File Report 78-936. Madison, WI 15 p.

U.S. Environmental Protection Agency. 1980. Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Sites. EPA: SW-611 Washington, DC 269 p.



Base from Wisconsin Geological and Natural History Survey

0 2 4 6 MILES

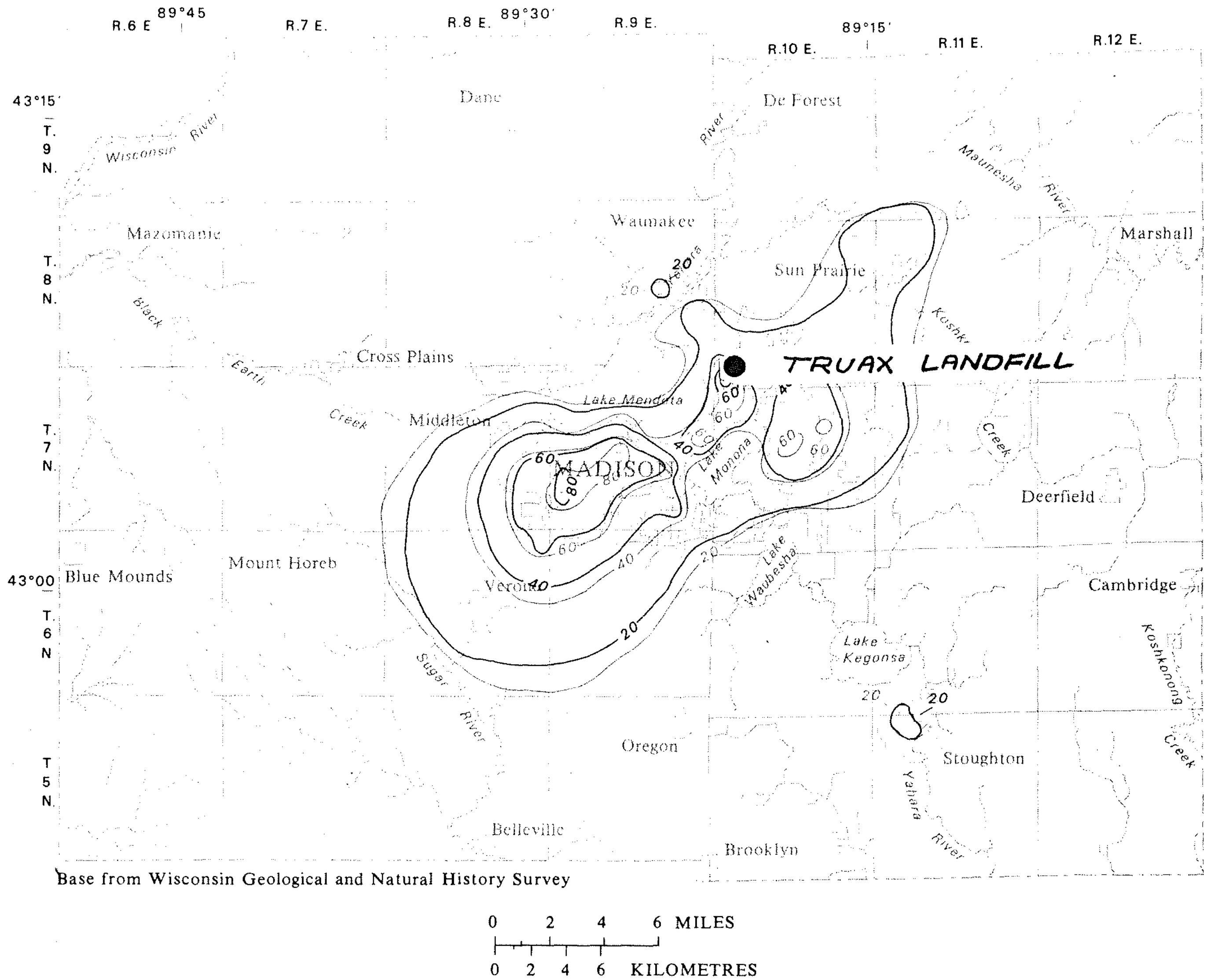
0 2 4 6 KILOMETRES

EXPLANATION

——— 10 ——— Line of approximate equal head decline

Interval 10 feet (3 metres)

Figure 1. Computed head declines in the upper aquifer by 1990.



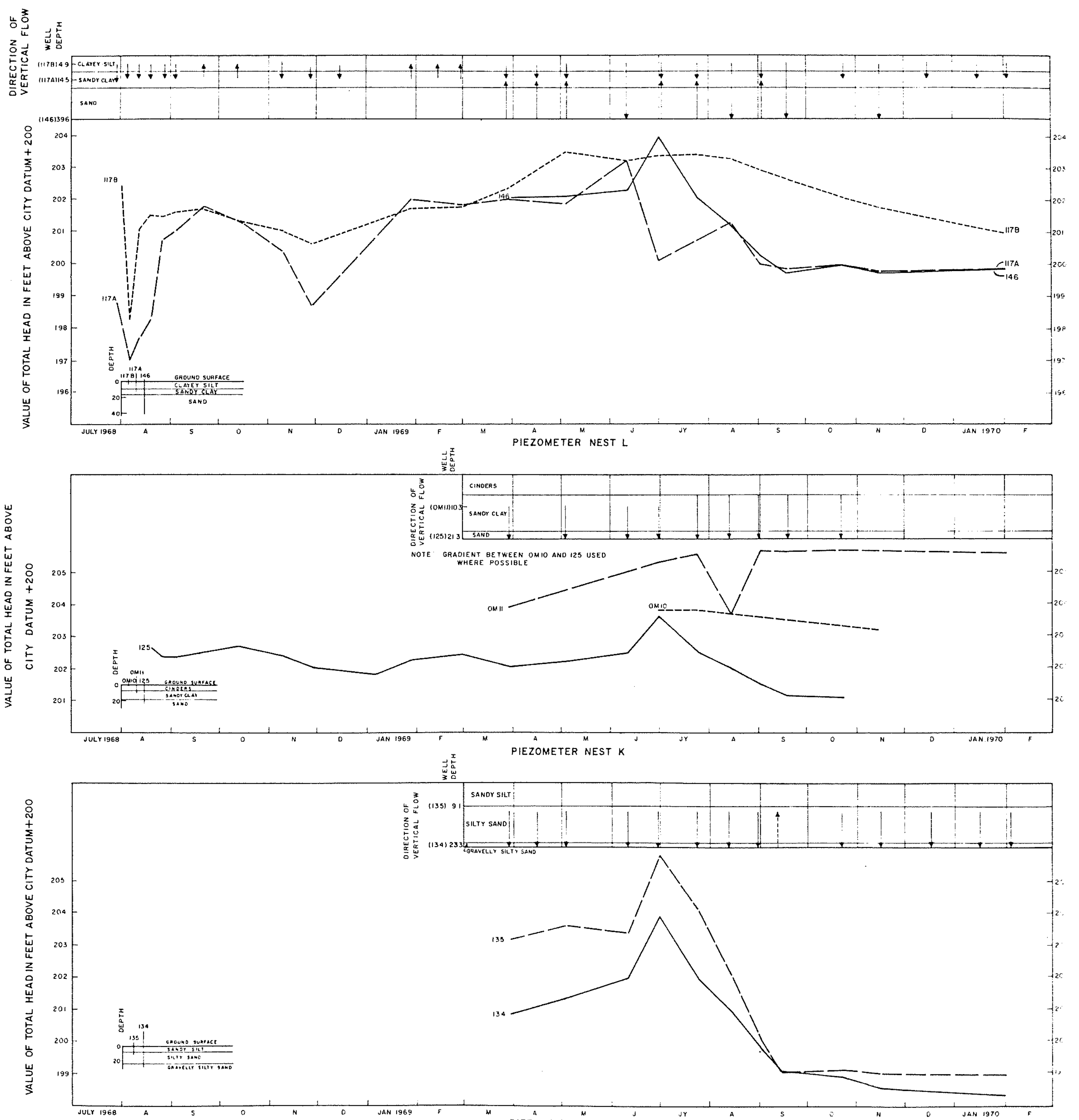
EXPLANATION

20 — Line of approximate equal head decline
McLeod, 1975

20 — Line of approximate equal head decline
This report

Interval 20 feet (6 metres)

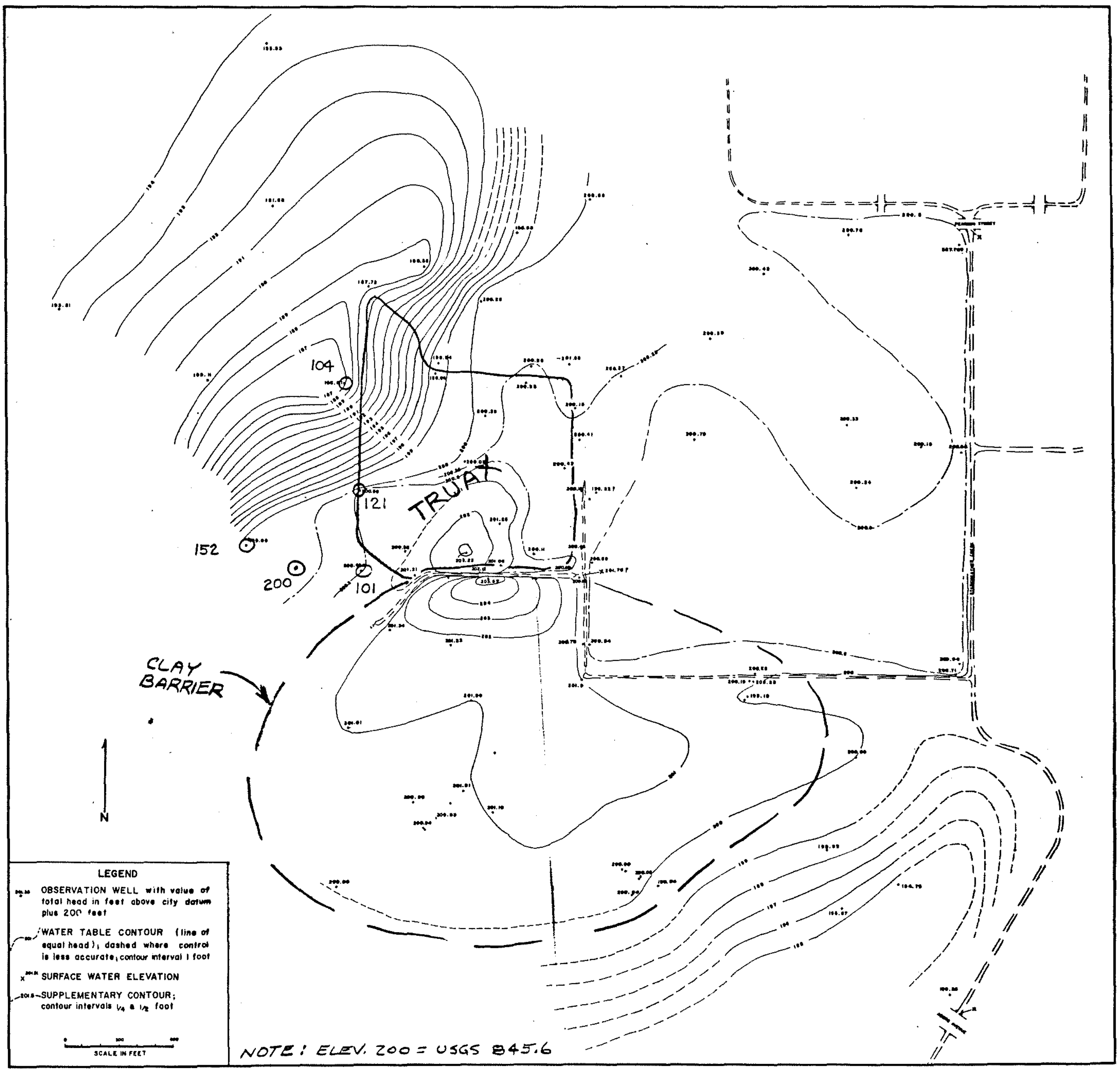
Figure 2 Comparison of computed head declines for the sandstone aquifer, 1990.



DISTRIBUTION OF TOTAL HEAD AND DIRECTION OF VERTICAL FLOW IN PIEZOMETER NESTS K, L, N IN THE TRUAX FIELD SANITARY LANDFILL AREA

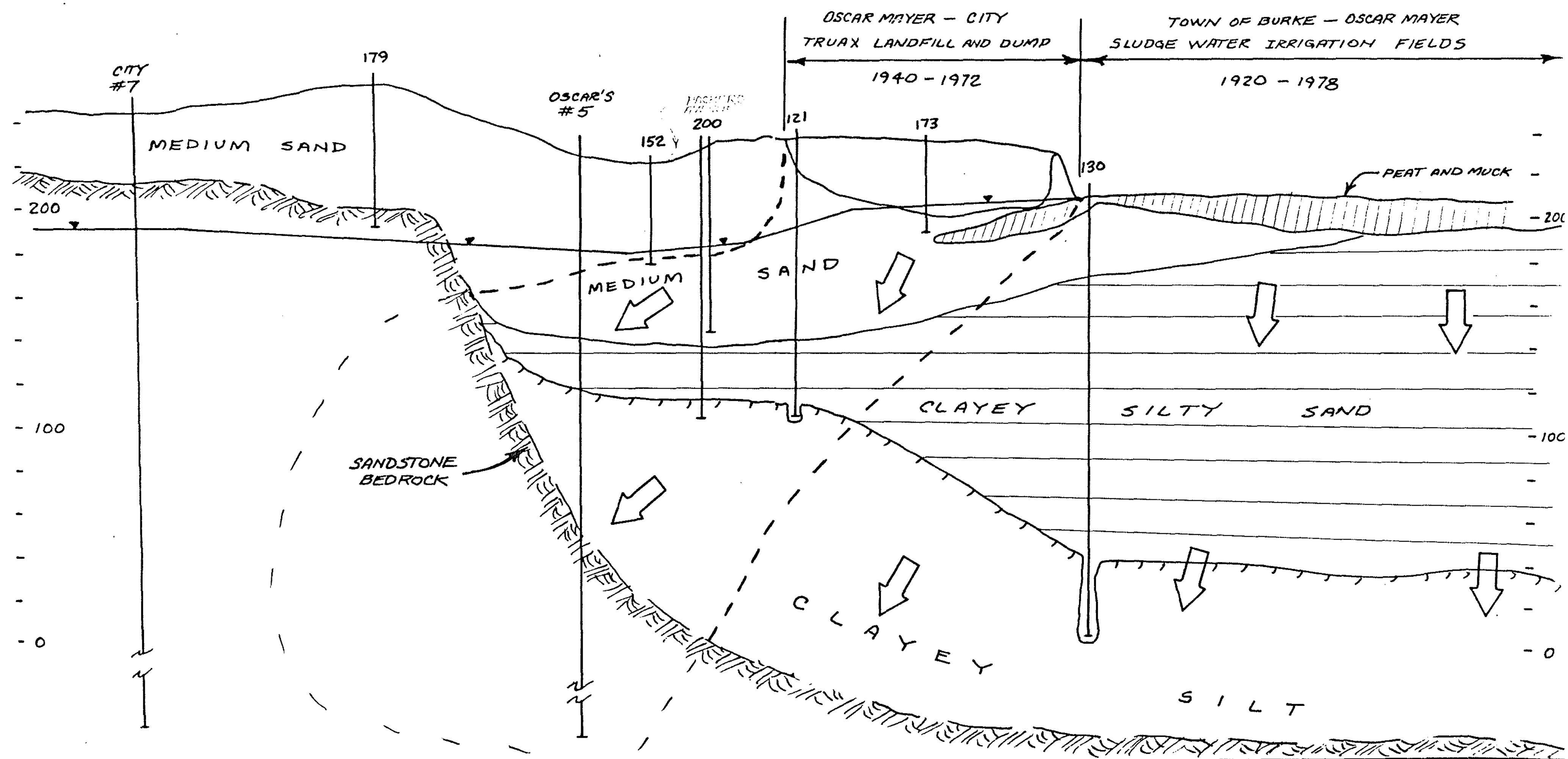
FIGURE 4

FIQURE 5



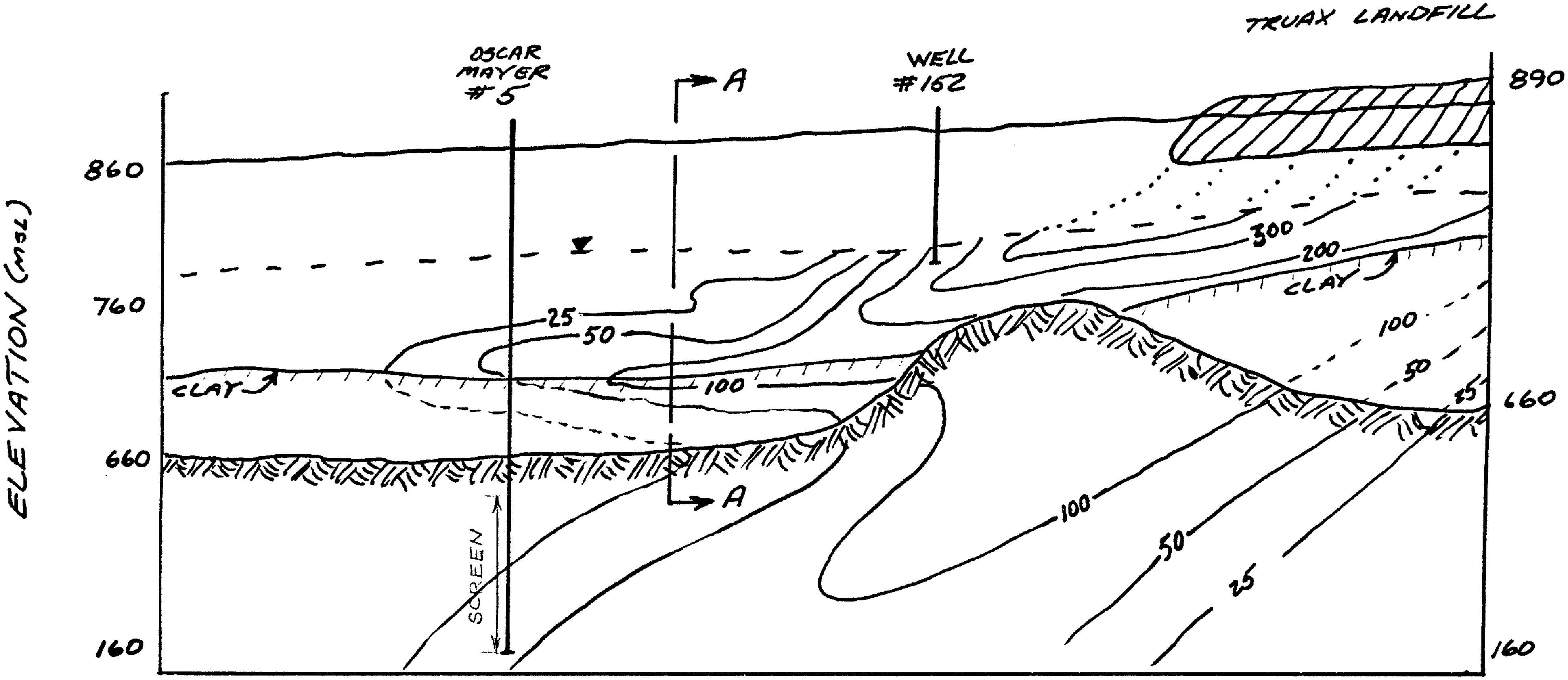
MAP OF THE TRUAX FIELD SANITARY LANDFILL AREA, SHOWING CONFIGURATION OF THE WATER TABLE, FEBRUARY 5, 1970

FIQURE 6

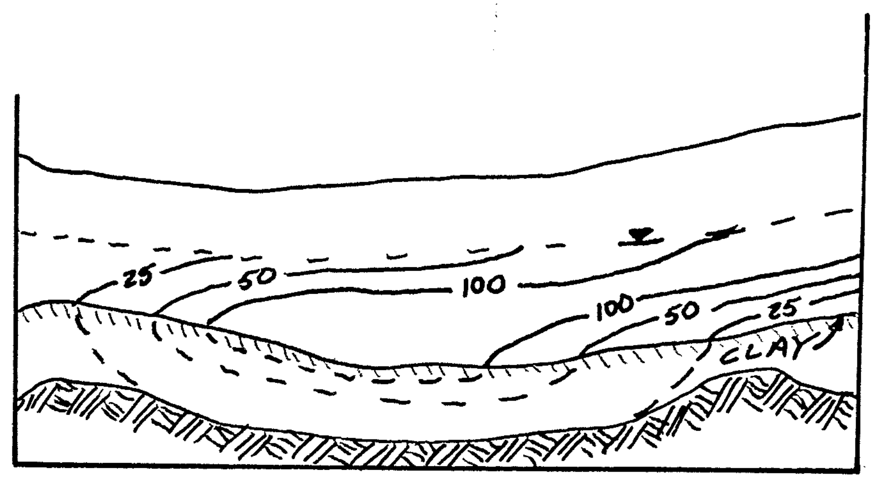


OSCAR MAYER – CITY
TRUAX LANDFILL AND DUMP
1940 – 1972
TOWN OF BURKE – OSCAR MAYER
SLUDGE WATER IRRIGATION FIELDS
1920 – 1978
CITY #7
179
OSCAR'S #5
152
200
121
173
130
MEDIUM SAND
PEAT AND MUCK
MEDIUM
SAND
SANDSTONE BEDROCK
CLAYEY
SILTY
SAND
CLAYEY
SILT
200
100
0
200
100
0

FIQURE 7



TYPICAL PROFILE - CHLORIDE ION
¢ LEACHATE PLUME



SECTION A-A

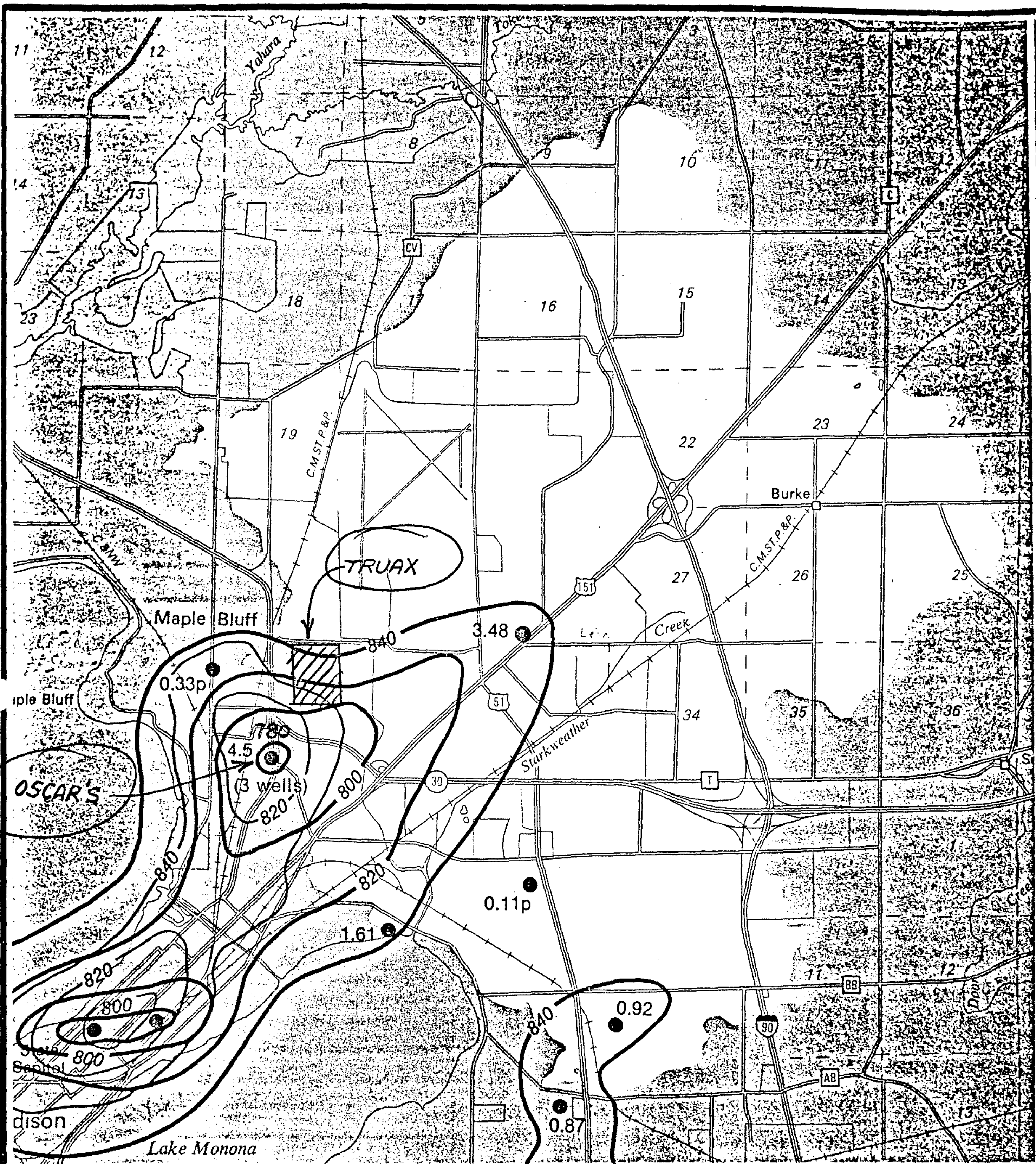


FIGURE 16

DEVELOPMENT OF THE GROUNDWATER CONE OF DEPRESSION: 1950-1975

May, 1980

1950 Groundwater Contour

1975 Groundwater Contour

840 20 Foot groundwater contour intervals.

● 1.5 Well Location and 1975 Average Daily Pumpage in MGD.
p = wells only pumped for a portion of the year.

0 ½ 1
Scale in Miles

Prepared by:
The Dane County Regional Planning

CALGON
SUBSIDIARY OF MERCK & CO., INC.

Calgon Analytical Laboratories

Water Analysis Report

APR 1977 C9067

Reported: 5/4 Reviewed by: [illegible]

PHYSICAL PROPERTIES		
pH at 25°C	7.6	
A reading	—	ml N/30 H_2SO_4
MO reading	20.3	ml N/30 H_2SO_4
B reading		ml N/30 H_2SO_4
Total Acidity		ml N/44 NaOH
Free Mineral Acidity		ml N/44 NaOH
Conductivity (un-neutralized)	825	µmhos/cm
Conductivity (neutralized)		µmhos/cm
Dissolved Solids @ 180°C	465	mg/l
Suspended Solids @ 105°C	<5	mg/l
Total Solids @ 180°C	475	mg/l
Specific Gravity		
Color		APHA units
Turbidity		J.T.U.
Sample Description (visual):	water white, clear	

CHEMICAL ANALYSIS	mg/l
Hydroxide (OH)	
Carbonate (CO_3)	
Bicarbonate (HCO_3)	412
Carbon Dioxide (CO_2)	
Ammonia (NH_3)	<0.05
Chloride (Cl)	49
Sulfate (SO_4)	60
Silica (SiO_2)	15
Nitrate (NO_3)	<5
Ortho Phosphate (PO_4)	<0.1
Polyphosphate (PO_4)-calc.	0.2
Organic Phosphonate (PO_4)-calc.	<0.1
Hardness as $CaCO_3$-dissolved	420
Calcium (Ca)-dissolved	88
Magnesium (Mg)-dissolved	49
Sodium (Na)	18
Potassium (K)	
Total Organic Carbon (TOC)	
Colloidal (Non-reactive) SiO_2 -	
Solvent (freon) Soluble	9.39/9.17
Surfactant-MBAS	

	mg/l
CS in Water	
CS in Glycol	
Na_4EDTA-Total	
Na_3NTA-Total	
Na_3NTA-Free	
Na_4EDTA/NTA-Total	
Na_4EDTA/NTA-Free	

METALS*	mg/l
Iron (Fe)	<0.05
Copper (Cu)	
Manganese (Mn)	<0.05
Aluminum (Al)	
Nickel (Ni)	
Zinc (Zn)	
Calcium (Ca)	
Magnesium (Mg)	
Hex Chromium as CrO_4-dissolved	
Total Chromium (CrO_4)	
Tri Chromium as CrO_4-calc	

TRACE ANALYSIS			mg/l
Trace Chloride			
Trace Silica			
Trace Iron			
Trace Copper			
Trace Nickel			
Trace Zinc			
Trace Calcium	(1)	(2)	(3)
Trace Magnesium	(1)	(2)	(3)
Trace Sodium	(1)	(2)	(3)

Plant Name: Oscar Mayer Co.
Address: Madison, Wisc.
Attention:
Type of Sample:
Sample Point: No. 5 Well
Date of Collection: 4-7-77 Time: 9:00 AM

PLANT RESULTS

PROCESS WATER ANALYSIS			
pH	NH_3	Fe	Trace Fe
A	Cl	Cu	Trace Cu
MO	SO_4	Mn	Trace Cl
B	SiO_2	Zn	Trace Na
Acidity	NO_3	Al	Trace SiO_2
Neutralized Conductivity	PO_4-ortho	Ni	Colloidal SiO_2
Un-neutralized Conductivity	PO_4-poly	CrO_4-Total	CS
Dissolved Solids	PO_4-Organic	CrO_4-Tri	Syndet
Susp. Solids	Hardness	CrO_4-Hex	Na_4EDTA-T
Total Solids	Ca		Na_3NTA-free
Color	Mg		
Turbidity	Na		TOC
CO_2			Solvent Sol.

DEPOSIT ANALYSIS	
Ident	
Chemical	#2
Spec only	

FOR CALGON USE ONLY		
Engineer: R. Jordan		Office Code: [illegible]
521-International	523-Oilfield	525-Cooling and Municipal
529-Special Accounts	531-Boiler Chemicals	532-Hall-Bradford
590-Wholesaler		Handling-

FORM NO. 5060M

FUEL OIL ANALYSIS	
Sodium (Na)	ppm
Sulfur (S)	%
Vanadium (V)	ppm
Ash	%
API Gravity	

*Unless stated otherwise, all metals are total (dissolved & particulate)

CALGO — SUBSIDIARY OF MERCK & CO., INC.

Calgon Analytical Laboratories

Water Analysis Report

Received: | Lab No: MAY 11 78 GS

Reported: 5/25 | Reviewed by: MS

Plant Name: Oscar - Mayer
Address: Madison, Wisc.
Attention: 53° F
Type of Sample: Grab
Sample Point: #5 well
Date of Collection: 5-5-78 Time: 1: PM
Treatment Product(s): None

PHYSICAL PROPERTIES		
pH at 25°C	7.7	
A reading	—	ml N/30 H_2SO_4/100 ml
MO reading	20.7	ml N/30 H_2SO_4/100 ml
B reading		ml N/30 H_2SO_4/100 ml
Total Acidity		as mg/l $CaCO_3$
Free Mineral Acidity		as mg/l $CaCO_3$
Conductivity (un-neutralized)	810	µmhos/cm
Conductivity (neutralized)		µmhos/cm
Dissolved Solids @ 180°C	500	mg/l
Suspended Solids @ 105°C	~~10~~ <5	mg/l
Total Solids @ 180°C	520	mg/l
Specific Gravity		
Color	<5	Platinum Cobalt Units
Turbidity	1.0	N.T.U.
Sample Description (visual):	water white. Clear	

CHEMICAL ANALYSIS	mg/l
Hydroxide (OH)	
Carbonate (CO_3)	
Bicarbonate (HCO_3)	
Carbon Dioxide (CO_2)	
Ammonia (NH_3)	0.05
Chloride (Cl)	42
Sulfate (SO_4)	55
Silica (SiO_2)	15
Nitrate (NO_3)	<5
Ortho Phosphate (PO_4)	<0.05
Polyphosphate (PO_4)-calc.	<0.05
Organic Phosphonate (PO_4)-calc.	<0.05
Fluoride (F)	<0.1
Hardness as $CaCO_3$-dissolved	CALC. 384
Calcium (Ca)-dissolved	75
Magnesium (Mg)-dissolved	48
Sodium (Na)	18
Potassium (K)	1.8
Total Organic Carbon (Non-Volatile)	
Colloidal (Non-reactive) SiO_2	
Oil/Grease	
Surfactant-MBAS	

	mg/l	
CS in Water		
CS in Glycol		
Na_4EDTA-Total		
Na_3NTA-Total		
Na_3NTA-Free		
Na_4EDTA/NTA-Total		as Na_3 NTA
Na_4EDTA/NTA-Free		as Na_3 NTA
Hydrazine		
Calsofix		

METALS*	mg/l
Iron (Fe)	≥ 0.20
Copper (Cu)	
Manganese (Mn)	≥ 0.05
Aluminum (Al)	
Nickel (Ni)	
Zinc (Zn)	
Calcium (Ca)	
Magnesium (Mg)	
Hex Chromium as CrO_4-dissolved	
Total Chromium (CrO_4)	
Tri Chromium as CrO_4-calc.	
Lead (Pb)	
Barium (Ba)	

TRACE ANALYSIS			mg/l
Ortho Phosphate (PO_4)			
Polyphosphate (PO_4)-calc.			
Organic Phosphonate (PO_4)-calc.			
Trace Chloride (Cl)			
Trace Silica (SiO_2)			
Trace Iron (Fe)			
Trace Copper (Cu)			
Trace Nickel (Ni)			
Trace Zinc (Zn)			
Trace Calcium (Ca)	(1)	(2)	(3)
Trace Magnesium (Mg)	(1)	(2)	(3)
Trace Sodium (Na)	(1)	(2)	(3)
Trace Aluminum (Al)			
Total Organic Carbon (TOC)			µg/l
Purgeable Organic Carbon (POC)			µg/l

*Unless stated otherwise, all metals are total (dissolved & particulate)

PLANT RESULTS			

WATER ANALYSIS

pH	NH_3	TOC	Fe-Total
A	Cl	Colloidal SiO_2	Cu-Total
MO	SO_4	Solvent Soluble	Mn-Total
B	SiO_2	Surfactant	Al-Total
Acidity	NO_3	CS-Water	Ni-Total
Un-neutralized Conductivity	PO_4-ortho	CS-Glycol	Zn-Total
Neutralized Conductivity	PO_4-poly	Na_4EDTA-T	Ca-Total
Dissolved Solids	PO_4-Organic	Na_3NTA-T	Mg-Total
Susp. Solids	Hardness-diss.	Na_3NTA-Free	Hex CrO_4
Total Solids	Ca-diss.	EDTA-NTA Total	Total CrO_4
Color	Mg-diss.	EDTA-NTA Free	Tri CrO_4
Turbidity	Na		
CO_2	K ~~F1~~	Flouride	

1512

TRACE ANALYSIS

PO_4 (<3 mg/l)	Fe (1-100 ppb)	Zn (5-100 ppb)	Na (1-500 ppb)
Cl (.1-5 mg/l)	Cu (1-70 ppb)	Ca (1-100 ppb)	Al (5-100 ppb)
SiO_2 (2-250 ppb)	Ni (1-150 ppb)	Mg (1-500 ppb)	TOC (25-5000 ppb)

Fuel Oil Analysis: #2 Oil ☐ #6 Oil ☐

Na	S	V	Ash	API Gravity

Wausau

Engineer: Gary Eiffler Office Code: 468

521-Intern'l	525-Cooling	529-Sp. Accts	532-Consult'ng
523-Oilfield	526-Polymer	531-Boiler Chem	590-Wholesaler

B

Date Results Needed: 5/21/78

Form 5060P

MADISON DEPARTMENT OF PUBLIC HEALTH LABORATORY REPORT

Laboratory Number: 3-534-4
Sample: OSCAR MAYER CO. WELL #5
Collected by: W. BENNETT
Date Collected 13 JUNE 1983
Weather:
Water Conditions:

Results: (Form)	(Unit if not PPM)		Soluble	Acid Soluble
Color	(Color Units)	(Type)		
Odor	(Threshold Odor No.)	(Type		
Turbidity	(Turbidity Units)			
Sample D.O.				
5 Day B.O.D.				
C.O.D.				
Total Phosphorus		(P)		
Soluble Phosphorus	(Total)	(P)		
Soluble Phosphorus	(Ortho)	(P)		
Total Solids				
Suspended Solids				
Dissolved Solids				515
Ammonia Nitrogen	(N)			
Organic Nitrogen	(N)			
Total Kjeldahl Nitrogen	(N)			
Nitrate Nitgrogen	(N)			
Nitrite Nitrogen	(N)			
Nitrite Nitrogen + Nitrate	(N)			
(Total Nitrogen)	(N)			
pH	(pH Units)			7.35
Alkalinity				330
Hardness				420
Chlorides	(Cl)			45.5
Specific Conductance	(u MHO/CM)			880
Sufactants	(ABS, LAS)			
Soluble Potassium	(K)			1.2
Soluble Sodium	(Na)			20
Soluble Calcium	(Ca)			86
Soluble Magnesium	(Mg)			44
Sulfate	(So_4)			
Sulfite	(H_2S)			
Sulfide	(So_3)			
Inorganic Mercury	(Hg)	(PPb)		
Organic Mercury	(Hg)	(PPb)		
Total Mercury	(hg)	(PPb)		
Silver	(ag)		.00	
Barium	(Ba)		.0	
Cadmium	(Cd)		.003	
Chromium	(Cr)		.00	
Cobalt	(Co)		.0	
Copper	(Cu)		.01	
Iron	(Fe)		.01	
Lead	(Pb)		.01	
Manganese	(Mn)		.05	
Nickel	(Ni)		.01	
Tin	(Sn)			
Zinc	(Zn)		.04	
Total Heavy Metals			.1	
Arsenic	(As)			
Selenium	(Se)			

MPH-L 1-8

MADISON DIVISION OF PUBLIC HEALTH LABORATORY

Laboratory Number: 1-30-15
Sample: O.M. WELL #3 ABERG

Collected by: B. SALEY
Date Collected 12 MAR 81
Time Collected: AM
Air Temperature:
Weather:
Water Temperature:
Water Conditions:

Results: (Form)	(Unit if not PPM)			
Color	(Color Units)	(Type)		
Odor	(Threshold Odor No.)	(Type)		
Turbidity	(Turbidity Units)			
Sample D.O.				
5 Day B.O.D.				
C.O.D.				
Total Phosphorus		(P)	.00	
Soluble Phosphorus (Total)		(P)		
Soluble Phosphorus (Ortho)		(P)	.00	
Total Solids				
Suspended Solids				
Ammonia Nitrogen	(N)			
Organic Nitrogen	(N)			
Nitrate Nitrogen	(N)		1.1	
Nitrite Nitrogen	(N)			
Nitrite Nitrogen + Nitrate	(N)			
(Total Nitrogen)	(N)			
pH	(pH Units)			
Alkalinity				
Hardness			395	
Chlorides	(Cl)		42.2	
Specific Conductance	(u MHO/CM)		870	
Sufactants	(ABS,LAS)			
Soluble Potassium	(K)		1.4	
Soluble Sodium	(Na)		19	
Soluble Calcium	(Ca)		78	
Soluble Magnesium	(Mg)		45	
Sulfate	(SO_4)			
Sulfite	(H_2S)			
Sulfide	(SO_3)			
Inorganic Mercury	(Hg)	(PPb)		
Organic Mercury	(Hg)	(PPb)		
Total Mercury	(hg)	(PPb)		Acid Soluble
Silver	(ag)		.00	.00
Barium	(Ba)		.05	.05
Cadmium	(Cd)		.002	.001
Chromium	(Cr)		.00	.01
Cobalt	(Co)		.0	.0
Copper	(Cu)		.01	.01
Iron	(Fe)		.09	.16
Lead	(Pb)		.01	.02
Manganese	(Mn)		.05	.04
Nickel	(Ni)		.01	.00
Tin	(Sn)			
Zinc	(Zn)		.01	.01
Total Heavy Metals			.2	.3
Arsenic	(As)			
Selenium	(Se)			

UNIT WELL #7

	DEC. '44	FEB. '61	JUN. '66	MAR. '71	JUL. '73	Grand H2O Quality thru 19.. MAR. '67	Summary 1975 City Health Dept.	Summary 1976 City Health Dept.	SUMMARY 1977 CITY HEALTH DEPT.	SUMMARY 1978 HEALTH DEPT.	SUMMARY 1979 HEALTH DEPT.	SUMMARY 1980 (ONE ONLY 1 SAMPLE) HEALTH LAB.	SUMMARY 1981 1 sample HEALTH	SUMMARY 1982 1 sample HEALTH LAB.	SUMMARY 198? HEALTH
Alkalinity	326	318	318	328	328							317	330	340	327
Hardness	350	335	351	344	356	347	345	346	338	340	323	322	375	372	382
Total Solids	344	328	574	362	406	Dis. 344						390		409	397
Turbidity															.7
Specific Conductance							675	718	671	640	655	675	700	560	655
Temperature															
DISOLVED SOLIDS						344									
pH	7.2	7.3	7.5/7.2	7.6	7.9	7.6	7.15	7.2	7.36	7.2		7.28	7.39	7.34	7.46
Calcium	70	70	73	62	70	73		69	64	68	62	72	70	75	78
Chlorides	9.0	0.0	2	2	2	5.2	3.5	2.1	2.5	3.9	3.8	4.2		3.5	3.5
Fluorides	<.1	0.0	0.2	.20	<.1	1.3									
Magnesium	42	35.5	41	46	44	40		39	39	38	38	38	41	41	43
Nitrogen - Total															
Ammonia - N											.04	.04		.00	.10
Organic - N											.04				
Nitrate - N		0.0	<.5	.16		.1			.75	.50	.25	.75	0.25	0.1	.35
Nitrite - N		0.0	.003												
Nitrate + Nitrite - N					<.5										
TOT. DIS. ORG. CARBON															
Phosphate - Total									.02	.00	.01				
Soluble PO_4 - (Total)															
Soluble PO_4 - (Ortho.)									.00	.00	.01	.01			
Potassium						1.0	1.5	1.3	1.3	1.4	1.2	1.3	1.4		1.4
Sodium			3	4	4.1	4.4	4.3	3.8	3.9	4.1	3.6	3.9	3.9	4.4	4.0
SELENIUM									.001			.00	.000	.002	.000
Sulfate	11.4	14.5	22	24	29	23		34	44	46		41	12		
Hydrogen Sulfide			0												
Mercury - Inorganic															
Mercury - Organic															
Mercury - Total												.0001			.0025
ARSENIC									.00			.00	.00		.00
Cadmium								.00	.000	.000	.004	.005	.003	.000	.002
Chromium								.00	.00	.00	.00	.00	.00	.00	.00
Cobalt								.0	.0	.0	.0	.0	.0		.0
Copper								.11	.02	.00	.00	.01	.00	.00	.00
Iron	.4	.10	.65	<.04	<.04			.49	.20	.11	.00	.00	.08	.27	.02
SILVER								.00	.00	.00	.00	.00	.00	.00	.00
Lead								.01	.00	.00	.01	.01	.00	.01	
Manganese	0	0.0	<.04	<.04	<.04			.02	.01	.01	.02	.03	.02	.03	
Nickel									.00	.00	.01	.00	.00		
Tin									.01	.0	.0	.0			
Zinc									.01	.01	.02	.00	.00	.03	.14
Total Heavy Metals								.7	.3	.2	.2	.1	.1	.3	.3
BARIUM								.0	.08	.03	.08	.0	.0	.0	.08
Silica											16				6.5
Dissolved Oxygen												1.87			
Free CO_2												42			
Carbonate		0.0				0									
Bicarbonate		318				399									
Na : Cl	–	–	2.34	3.11	3.17	1.30	–	3.0	2.91	2.30	1.58	1.43	–	1.49	1.76
Ca : Mg	1.01	1.20	1.08	0.82	0.92	1.11	–	1.08	1.00	1.15	1.00	1.15	1.07	1.11	1.10

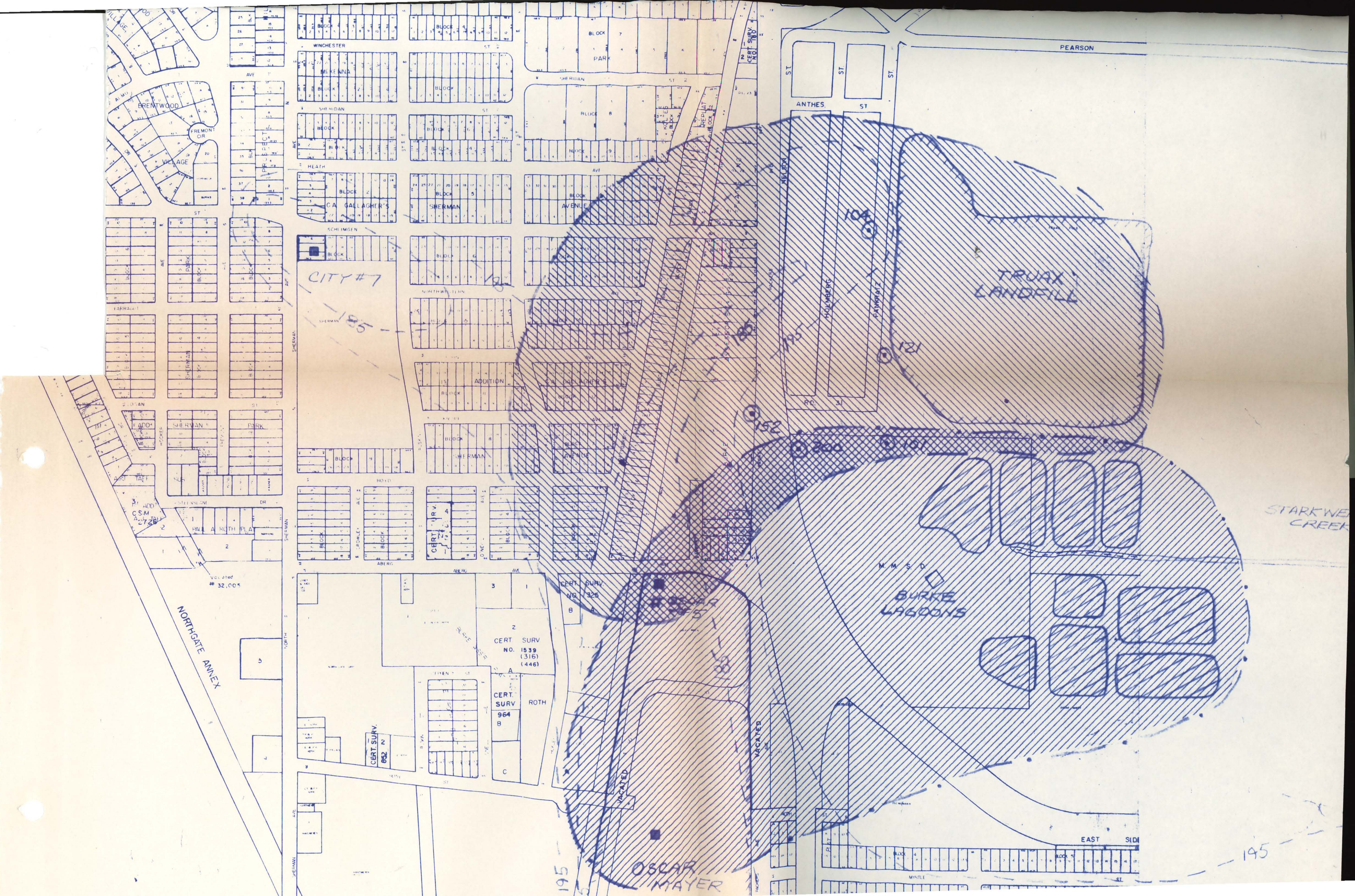
UNIT WELL #15

Radiological test 9/11/74

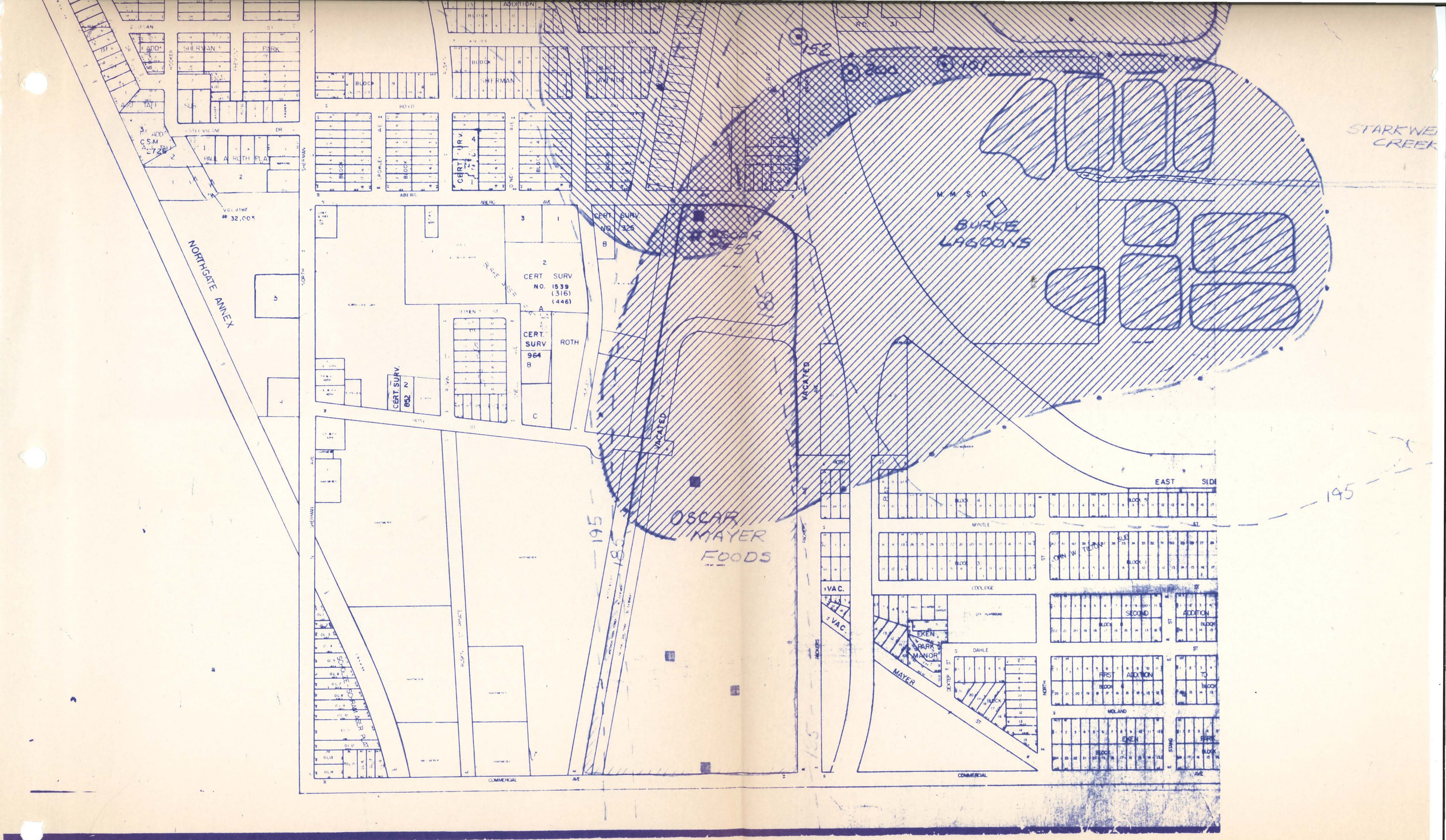
	Oct. '64 Test Well-24 hrs.	May '65	Oct. '65 Final Test Pumping	Jun. '66	Aug. '67	Mar. '71	Feb. '73	3-11-75 City Health Dept.	Summary 1975 City Health Dept.	Summary 1976 City Health Dept.	Summary 1977 City Health Dept.	Summary 1978 City Health Dept.	Summary 1979 City Health Dept.	Summary 1980 Health Lab	Summary 1981 Health Lab
kalinity	317	268		266	282	308	300						297	297	302
rdness	368	282	296	306	310	312	324	328	322	319	315	330	313	338	339
tal Solids	432		314	472	342		364								358
rbidity													.05		
ecific Conductance								580	617	699	633	566	615	637	618
mperature															
	7	7.7	7.5	7.8	7.5	7.6	8.2	7.25	7.1	7.15	7.34	7.22	7.4	7.3	7.27
lcium	80		63.8	67	65	60.5	67		64	66	63	68	63	72	66
lorides	9		2	2.7	2	4	3	3.5	4.2	4.4	5.1	8.0	7.6	8.07	8.25
uorides	.1		.2	.1	.3	.15	.1								
gnesium	40.8		36	33.2	36.9	39	38		36	35	34	35	34	34	36
trogen - Total															
monia - N													.01	.00	
ganic - N													.00		
trate - N	1.76		.55	.926	.086	.406		1.55	1.19	2.18	3.0	2.14	2.11	2.68	1.8
trite - N	.011		—	.851	.912										
trate + Nitrite - N							2.05								
T. DIS. ORG. CARBON															
osphate - Total											.02	.02	.01		
luble PO_4 - (Total)															
luble PO_4 - (Ortho.)											.01	.01	.00	.03	.00
tas um									1.2	1.1	1.1	1.2	1.2	1.1	1.2
dium				2.8	3	4	3.9		3.7	3.5	3.9	3.9	3.9	4.2	4.4
SELENIUM										.001	.000	.00		.00	.000
lfate	16		4	7	7	14	11		16	17.5	19	22			19.3
drogen Sulfide															
rcury - Inorganic											.000				
rcury - Organic															
rcury - Total												.000		.0000	.000
ARSENIC										.00	.00	.00		.00	
dmium									.00	.00	.001	.001	.003	.001	.000
romium									.00	.00	.00	.00	.00	.00	.00
balt									.0	.0	.0	.0	.0	.0	.0
pper									.00	.01	.02	.00	.00	.01	.01
on	.18	.04	.06	.40	<.04	'	<.04		.02	.03	.05	.03	.02	.01	.00
SILVER										.00	.00	.00	.00	.00	.00
ad									.02	.01	.00	.01	.00	.01	.00
nganese	<.05	<.05	<.05	.04	<.04		<.04		.01	.00	.01	.00	.00	.01	.00
ckel									.01	.01	.00	.00	.00	.01	.00
n									.0	.0	.00	.0	.0	.0	
nc									.01	.03	.01	.01	.03	.03	.00
tal Heavy Metals									.0	.1		.1	.1	.1	.0
BARIUM										.0	.06	.04	.01	.0	.02
lica															13
ssolved Oxygen	0.0													4.77	
ee CO_2														32	
rbo e															
carbonate															
Na:Cl		-	-	1.60	2.32	1.54	2.02	-	1.38	1.16	1.22	.87	.79	0.81	0.78
Ca:Mg	1.19	-	1.08	1.23	1.07	0.94	1.08	-	1.09	1.16	1.13	1.19	1.11	1.3	1.10

UNIT WELL #15

	SUMMARY 1982 HEALTH LAB	SUMMARY 1983 HEALTH LAB
Alkalinity	307	310
Hardness	335	341
Total Solids	363	365
Turbidity	.3	.1
Specific Conductance	613	612
Temperature		
pH	7.38	7.52
Calcium	67	71
Chlorides	9.5	9.9
Fluorides		
Magnesium	36	38
Nitrogen - Total		
Ammonia - N	.04	.01
Organic - N		
Nitrate - N	1.9	1.8
Nitrite - N		
Nitrate + Nitrite - N		
Phosphate - Total		
Soluble PO_4 - (Total)		
Soluble PO_4 - (Ortho.)		
Potassium	1.3	1.4
Sodium	5.0	5.2
SELENIUM	.000	.000
Sulfate		21.8
Hydrogen Sulfide		
Mercury - Inorganic		
Mercury - Organic		
Mercury - Total	.000	.0005
ARSENIC	.00	.00
Cadmium	.001	.000
Chromium	.00	.00
Cobalt	.0	.0
Copper	.00	.00
Iron	.02	.02
SILVER	.00	.01
Lead	.00	.00
Manganese	.00	.00
Nickel	.02	.00
Tin		
Zinc	.03	.01
Total Heavy Metals	.1	.0
BARIUM	.02	.02
Silica	6	6
Dissolved Oxygen		
Free CO_2		
Carbonate		
Bicarbonate		
Na:Cl	0.82	0.81
Ca:Mg	1.12	1.14



PEARSON
ANTHES ST
CITY #7
TRUAX LANDFILL
104
121
152
200
101
185
195
M.M.S.D.
BURKE LAGOONS
STARKWEATHER CREEK
OSCAR MAYER
NORTHGATE ANNEX
BRENTWOOD VILLAGE
FREMONT CIR
C.A. GALLAGHER'S
SHERMAN AVENUE
PAUL A ROTH PLAT
CERT. SURV. NO. 1539 (316) (446)
CERT. SURV. 964
CERT. SURV. 852
CERT. SURV. NO. 325
ROTH
VACATED
EAST SIDE
WINCHESTER
SHERIDAN
HEATH
SCHLIMGEN
NORTHWESTERN
FARRAGUT
ABERG AVE
HOLMBERG
FAIRWAY
NELSON
MYRTLE ST



LEACHATE PLUMES
GROUNDWATER TROUGH

FIQURE 3