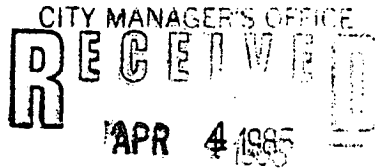




# CITY OF SACRAMENTO

3

DEPARTMENT OF PUBLIC WORKS  
915 I STREET SACRAMENTO, CALIFORNIA 95814  
CITY HALL ROOM 207 TELEPHONE (916) 449-5281



M. H. JOHNSON  
Director

May 9, 1985

Transportation & Community  
Development Committee  
Sacramento, California

Honorable Members in Session:

SUBJECT: Water Quality Issues Associated with Existing (old)  
Landfill - Supplemental Report

SUMMARY:

This report supplements the water quality report of March 26, 1985 (see attached) by supplying results of tests performed on monitoring wells located at the 28th Street landfill.

BACKGROUND:

The Regional Water Quality Control Board collected samples for volatile organic chemical analyses from groundwater samples at the 28th Street landfill site on January 31 and February 25, 1985. The City's American River Plant Laboratory split samples with the Regional Board on the February 25th sample run. The samples were collected from City monitoring wells 1, 3, and 4. (See attachment A for monitoring well locations). The Regional Board sampled the American River in the area of the landfill on January 25, 1985. The American River Plant Laboratory sampled the River on March 12, 1985.

All samples were tested for volatile organic compounds. The Regional Board's laboratory performed tests according to EPA methods 601, 624, and 625. The City performed tests according to method 601. These methods check for a great many organic compounds.

The results of the tests detected the following levels of specific organic compounds in parts per billion (ppb). Results are compared with the California recommended action levels for drinking water. Attachment B consists of a complete list of California Department of Health Service action levels for organic compounds.

May 9, 1985

January 31, 1985  
Monitoring Well #1

		<u>ACTION LEVEL</u>
1,2-trans-dichloroethylene . . . . .	6	none
vinyl chloride . . . . .	8	2

Monitoring Well #3

benzene . . . . .	2	0.7
1,1-dichloroethane . . . . .	.21	none
1,2-trans-dichloroethylene . . . . .	.30	none
ethylbenzene . . . . .	4	none
methylene chloride . . . . .	1	40
tetrachloroethylene . . . . .	1	4
trichloroethylene . . . . .	2	5
vinyl chloride . . . . .	9	2
ethanedioicacid . . . . .	3	none
1,1-dibromo-2-chloro-2-fluoro- cyclopropane. . . . .	.11	none
dichlorofluoromethane . . . . .	5	none
1,1'-oxybis-ethane . . . . .	6	none
dimethoxymethane . . . . .	1	none
2-propanol . . . . .	3	none
1,3-dichlorobenzene . . . . .	.14	none

January 31, 1985  
Monitoring Well #4

		<u>ACTION LEVEL</u>
ethylbenzene . . . . .	1	none
toluene . . . . .	5	100
ethanedioicacid . . . . .	220	none
tetrahydrofuran . . . . .	206	none
2,3,4-trimethyl(2-alpha, 3-alpha, 4-beta) oxetane . . . . .	1	none
cyclohexanone. . . . .	3	none
tricyclo(3.3.1.1 <sup>3</sup> .7)decane . . . . .	1	none
1,1,3-trimethyl-cyclohexane. . . . .	1	none
4-methyl-1-(1-methylethyl)- bicyclo(3.1.0)hex-2-ene . . . . .	2	none
1,2-dimethyl-benzene . . . . .	2	none
2,4-diethyl-1-methyl-cyclohexane . . . . .	2	none
1,4-dichloro-benzene . . . . .	2	none

February 25, 1985  
Regional Board

Monitoring Well #1

	<u>City</u>	<u>ACTION LEVEL</u>
1,2-trans-dichloroethylene . . . . .	6	none
vinyl chloride . . . . .	6	2

Monitoring Well #3

1,1-dichloroethane . . . . .	0	none
1,2-trans-dichloroethylene . . . . .	3	none
dichlorodifluoromethane . . . . .	not tested	none
dichlorofluoromethane . . . . .	not tested	none
1,1'-oxybis-ethane . . . . .	not tested	none
vinyl chloride . . . . .	26	2

Monitoring Well #4

tetrahydrofuran . . . . .	not tested	none
1,1,3-trimethyl-cyclohexane . . . . .	not tested	none
3-ethyl-2,5-dimethyl-cyclohexane . . . . .	not tested	none
3-ethyl-2,5-dimethyl-1,3-hexadiene . . . . .	not tested	none
1,2,3-trimethyl-cyclohexane . . . . .	not tested	none

The results show that the recommended action level of the State Department of Health Services was exceeded in well #1 for vinyl chloride. Well #3 exceeded drinking water action levels for benzene and vinyl chloride. Well #4 did not exceed any drinking water standards for volatile organic compounds. None of the monitoring wells is currently use for drinking water sources

River Testing

The Regional Board performed extensive sampling of the American River in the vicinity of the landfill on January 25, 1985. Trichloroethelyne was present in all samples and was attributed to the well documented seep into the River near Aerojet. The only other organic chemical found was 5 ppb of 1,1,2-trichloroethane in one sample. This chemical has not been found in any of the monitoring wells at the landfill. There is no action level for this compound.

May 9, 1985


The City sampled the River above and below the landfill site on March 12, 1985. Again, trichloroethylene attributed to the Aerojet problem was found in both samples. No other organic compounds were detected. The water quality surveys performed on the American River clearly indicate that the 28th Street landfill has had no deleterious effect on the River.

ANALYSIS

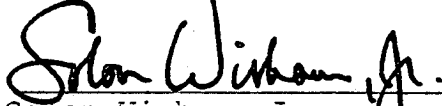
Vinyl chloride and benzene have been detected in monitoring wells at the landfill in concentrations higher than the recommended action levels for drinking water. Whenever there is deterioration of groundwater quality, it is cause for concern, but the levels found in groundwater at the landfill site are nowhere near the levels found in toxic dumpsites throughout our area. There are no known wells near the site currently being used for drinking water. An irrigation well near the site was tested February 25, 1985. No volatile organic compounds were found in this well.

The existing monitoring wells have deteriorated to the point that it is difficult to obtain representative samples. New wells will be drilled in the very near future. The Regional Board has indicated that they will wait for these wells to be placed in service before further samples are taken for volatile organic analyses. City staff is working closely with the Regional Board and will be performing further testing when the new monitoring wells are placed in service.

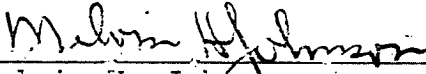
Respectfully submitted,

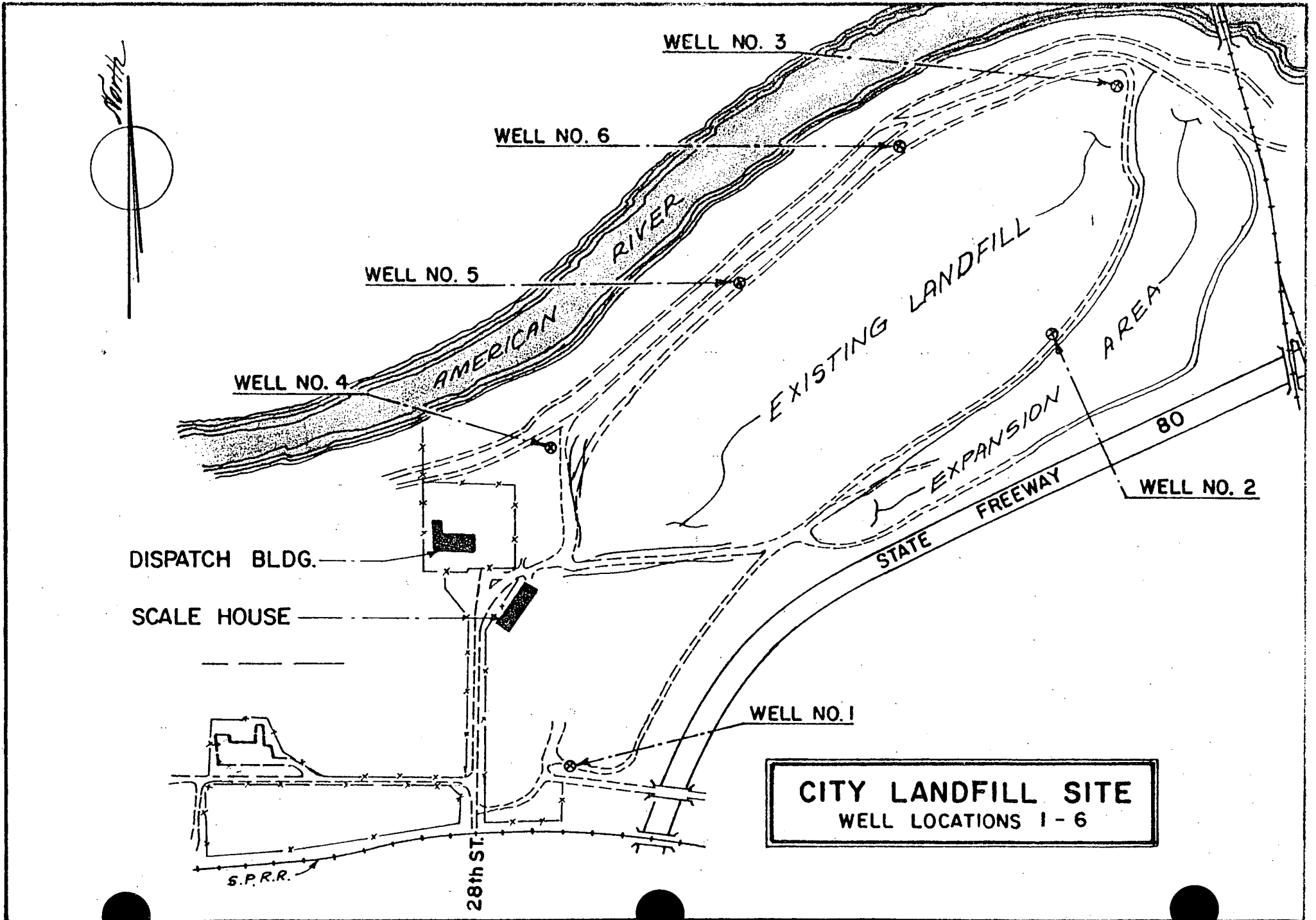
  
Lee J. Harry  
Assistant Superintendent  
Water Production Facilities

APPROVED FOR COMMITTEE  
INFORMATION:

  
Solon Wisham, Jr.  
Assistant City Manager

APPROVED:

  
Melvin H. Johnson  
Director of Public Works



**CITY LANDFILL SITE**  
WELL LOCATIONS 1 - 6

## State Department of Health Services

## Action Levels Recommended

by the Department of Health Services

Chemical	Action Level parts per billion (ppb)
<u>Pesticides</u>	
<u>Chlorinated Hydrocarbon</u>	
Aldrin	Limit of Quantification(0.05)
a-Benzene Hexachloride (a-BHC)	0.70
b-Benzene Hexachloride (b-BHC)	0.30
Chlordane	0.055
Dieldrin	Limit of Quantification (0.05)
Heptachlor	0.02
Heptachlor Epoxide	0.10
Pentachlorophenol	30.00
<u>Organophosphate</u>	
Dimethoate	140.00
Diazinon	14.00
Ethion	35.00
Mslathion	160.00
Methyl Parathion	30.00
Parathion	30.00
Trithion	7.00
<u>Carbamate</u>	
Aldicarb	10.00
Baygon	90.00
<u>Phthalamide</u>	
Captan	350.00
<u>Amides</u>	
Diphenamide	40.00
<u>Fumigants</u>	
Dibromochloropropane	1.00
1,2-Dichloropropane	10.00
Ethylene Dibromide	Limit of Quantification (0.05)

SEB Rev.082484

Miscellaneous  
Terrachlor  
(Pentacloronitrobenzene) 0.90

<u>Herbicides</u>	
CIPC (isopropyl N (3-chlorophenyl) carbamate)	350.0
Bolero (thiobencarb)	10.0 (Tentative) 1.0*
Ordram (Molinate)	20.0
Glyphosate	500.0
<u>Purgeable Halocarbons</u>	
Carbon Tetrachloride	5.00
1,2-Dichloroethane	1.00
1,1-Dichloroethylene	Limit of Quantification (0.10-0.4)
Methylene Chloride	40.00
Tetrachloroethylene	4.00
1,1,1-Trichloroethane	200.00
Trichloroethylene	5.00
Vinyl Chloride	2.00

<u>Purgeable Aromatics</u>	
Benzene	0.70
1,2-Dichlorobenzene	130.00 (10)*
1,3-Dichlorobenzene	130.00 (20)*
1,4-Dichlorobenzene	130.00 (0.3)*
(Action Level for dichlorobenzene is either for a single isomer or for the sum of the 3 isomers)	
Toluene	100.00
Ortho-Xylene	620.00
Para-Xylene	620.00
Meta-Xylene	620.00
(Action Level for Xylene is either for a single isomer or the sum of the 3 isomers)	

<u>Phenols</u>	
2,4-dimethylphenol	400.00*
Phenol	1.00* (For Chlorinated Systems)

<u>Aldehydes</u>	
Formaldehyde	30.00

\*Taste &amp; Odor Threshold



# CITY OF SACRAMENTO

## DEPARTMENT OF PUBLIC WORKS

DIVISION OF WATER AND  
SEWERS

LARRY L. COMARSH  
Division Manager

March 28, 1985

Transportation and Community Development Committee  
Sacramento, California

Honorable Members in Session

SUBJECT: Water Quality Issues Associated with Existing (old) Landfill

### SUMMARY

This report responds to a request for information on whether the City's existing 28th Street Sanitary Landfill has adversely affected the quality of the ground-water beneath the site. Information is also presented concerning the potential for adverse impacts on the American River and the City's drinking water supplies.

### BACKGROUND

Concern has been expressed that leachate from the site of the City's sanitary landfill has contaminated the groundwater and poses a threat to the American River and the City's water supply. A suggestion has been made by a health consultant representing concerned citizens that increased monitoring be implemented to more adequately address this problem. It was suggested that more information was needed in order to track any movement of contamination plumes in the ground-water and properly assess whether the river water or sediment was being affected.

In 1975, the California Regional Water Quality Board Central Valley Region issued Order No. 75-155 specifying waste discharge requirements for the City's 28th Street Sanitary Landfill. Background information was supplied to the Regional Board through a report performed for the City by the Spink Corporation in 1973.

The Spink Report noted that the groundwater in the vicinity of the landfill slopes to the south, away from the American River. The report also stated that during the spring there is a ridge in the groundwater table a short distance south and roughly parallel to the river. It was believed that this phenomenon resulted from the fact that when the river flows were high in the winter, the river lost water to the groundwater; but as the river dropped in the spring, the groundwater flowed toward the river. In addition to supplying information on

water elevation, water quality in the groundwater beneath the site was also addressed. As can be seen by the information supplied in attachment A, the water quality beneath the site was poor. The water did not meet drinking water standards for iron, manganese, or bacteria indicative of sanitary quality. It is unknown if the poor quality of the groundwater beneath the site was caused by previous leachate through material at the site or whether there was naturally poor water quality. There is a history of high iron and manganese deposits in groundwater in this area. In fact, the City had to construct an iron and manganese removal plant in order to use the groundwater at the site of our Riverside groundwater extraction system. The waste discharge requirements established by the Regional Board stipulated that monitoring wells be placed at the site to determine the elevation of groundwater and to allow sampling for water quality. The location of these wells was established under the direction of the Regional Board. Sampling requirements stipulated that quarterly determinations be made for elevation, electrical conductance, hardness, pH, chlorides, iron, and chemical oxygen demand. Four well locations were selected and the monitoring program began.

The City of Sacramento has complied with all requirements of the Regional Board and submitted quarterly reports from 1975 until the present.

City water quality staff have long been concerned about the proximity of the landfill to the American River. Although the monitoring requirements would be adequate to show a general trend in water quality deterioration, additional tests were performed to see if there were toxic chemicals present. In October, 1975, trace metal analyses were performed on the four monitoring wells. All wells were found to be free of arsenic, fluoride, boron, cadmium, chromium, lead, and mercury. In addition, some river monitoring was performed. As shown by attachment B, water quality surveys were conducted on three occasions in 1976. Each of these surveys indicated that the groundwater in the vicinity of the sanitary landfill had absolutely no effect on water quality in the river. These findings supported the original geohydrological information which suggested there was a ridge which prevents the movement of the groundwater at the site into the river.

Reassured that the sanitary landfill had no effect on the river, subsequent analyses were limited to those necessary to satisfy the monitoring requirements of the Regional Board.

An environmental impact report (EIR) was performed in 1983 when the City sought permission from regulatory agencies to expand the existing landfill. The EIR addressed increased concern about protecting groundwater quality. An impermeable clay liner will be used at the new site to prevent leachate from entering the groundwater, and a dewatering system used to protect the clay liner from uplift. Quite simply put, the increased knowledge regarding groundwater contamination has prompted regulatory agencies to require stringent mitigation measures. The expanded site will be far superior to the old site in protecting groundwater quality.



The Regional Board as the regulatory agency with the responsibility for protecting groundwater quality reviewed the EIR and established new waste discharge requirements to include both the old and expanded landfill sites. Their order No. 84-094 establishes water quality limits which shall not be exceeded in the groundwater beneath the site. These limits are set for the general parameters pH, specific conductance, chloride, iron, hardness, and chemical oxygen demand. The new requirements also establish new monitoring wells be placed. The location of these wells will allow the tracking of movement of any plume of contamination beneath the site. In establishing the new discharge requirements, the Regional Board thoroughly reviewed existing water quality data supplied in the EIR and the City's quarterly monitoring reports. The health consultant representing concerned citizens has presented graphical information showing that average values for electrical conductance and iron have increased over the past few years (SEE ATTACHMENT C). Staff has further investigated and plotted running averages of all parameters monitored. As seen by the graphs shown in attachment D, some water quality parameters have indeed recently increased in some of the wells.

City staff is currently working closely with the Regional Board to determine additional information necessary to reach a conclusion on the groundwater below the landfill. The following action is being taken. (1) Existing monitoring wells are being replaced with new larger diameter wells which can more thoroughly be purged prior to sample collection. This will assure a sample representative of actual conditions in the groundwater. (2) The American River will be sampled both above and below the landfill each month to determine if any material from the water at the landfill is entering the River. The first monitoring of the River has been completed and shows no difference in the River downstream from the landfill site. (3) the six monitoring wells currently at the landfill site will be monitored on a biweekly basis for a period of two months to resolve questions of fluctuating water quality. (4) the groundwater will be tested for the complete list of priority pollutants established by the EPA. (5) Sediment samples were obtained from the river bottom above and below the landfill. The results of preliminary testing showed no significant difference in measured constituents in the sediment above and below the landfill. (6) Testing has been done on existing monitoring wells for detection of selected organic pollutants. Preliminary results have shown very small amounts of some compounds. These are considered preliminary in nature because of problems in obtaining representative samples. Further testing is necessary to resolve problems such as deterioration and silting in existing monitoring wells. New wells will be drilled and developed and extensive testing will be performed. The results of these tests will properly represent the water quality in the monitoring wells.

#### ANALYSIS

Staff shares concern with interested citizens about the proximity of the 28th street landfill to the American River. The requirements for the existing site relied on control of ponded water to keep leachate from contaminating the groundwater. Current technology requires the addition of an impervious shield to prevent leachate from entering the groundwater. The new site will be far better protected than the old. Although staff also shares concern with the citizens and their health consultant regarding the presence of toxic constituents in the sources of the City's drinking water, there is currently no evidence to indicate that the landfill is responsible for degradation of any drinking supply.

Staff has monitored the river and found no difference in water quality downstream from the landfill. The intake for the City's Sacramento River Water Treatment Plant is located just below the confluence of the American River and contains a great deal of American River water. This source is extensively tested for inorganic, organic, and radiological pollutants. The water quality staff has been extremely successful in identifying sources of degradation to our drinking water supplies. We have discovered problems with rice herbicides and industrial seepage coming from the vicinity of Aerojet and are committed to solving these problems. We have not found degradation of current water sources caused by the presence of the 28th Street landfill. Staff has worked closely with and satisfied all requirements of the Regional Water Quality Control Board. Because the type of material disposed of at the site does not consist of toxic wastes, the risk of contaminating the groundwater beneath the site with industrial pollutants has been considered small. This is the reason that extensive testing for priority pollutants has not been required in the past. These tests will be performed in the future as part of the monitoring program. Information gained through these analyses will be used to determine whether any corrective action needs to be taken.

Staff would summarize the following points. (1) The current landfill has almost completed its useful life. (2) The expansion site will include extensive measures to protect the groundwater quality. (3) There is absolutely no evidence of any adverse effect on the American River because of past waste disposal practices at the landfill. (4) Initial monitoring indicated in 1975 that the groundwater beneath the site contained iron and manganese in concentrations exceeding drinking water standards, but these compounds are not considered toxic and are regulated in California solely as consumer acceptance standards. (5) Routine monitoring has indicated an increase in these indicator parameters in the groundwater at the existing site. This information has prompted increased monitoring requirements which will be used to fill the data gaps currently existing. (6) Cessation of activities at the site would have no impact on water quality because the expansion site will be adequately protected so leachate will not enter the groundwater. The material has already been placed at the existing site so cessation of activities will not influence the future control of leachate. (7) A closure plan will be required when all activities at the existing site cease. This closure plan will require monitoring to insure that any water supply is not affected by the site. In the event that a water supply is adversely affected, mitigation measures would be required. In the event toxic chemicals are detected in the groundwater beneath the site, mitigation measures would also be required. (8) The landfill has not been a site for disposal of toxic wastes.

There is currently no evidence that the site of the City's landfill is having an adverse effect on any water supply. The water beneath the site has shown an increase in indicator parameters over the past few years, but is not used as a source of drinking water and has been considered unacceptable for this purpose since monitoring began. These indicator parameters are not considered toxic substances but express the general mineral content of the water, and are regulated as secondary or consumer acceptance standards in California.

March 28, 1985

As recommended by a health consultant for concerned citizens, additional testing is planned to determine if the groundwater beneath the site contains any toxic substances. Staff will continue to keep a close watch on the potential for adverse effects on our drinking water sources caused by the 28th Street sanitary landfill. Council will be informed of any new developments as they occur.

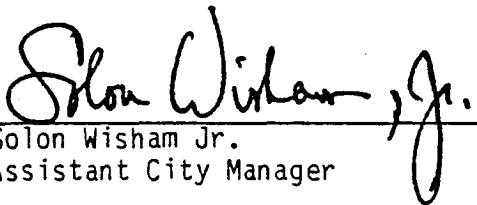
Respectfully submitted,



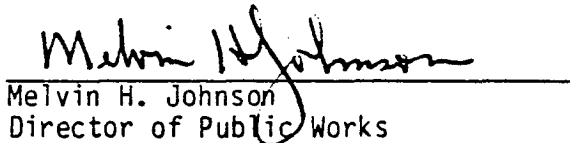
Lee J. Harry  
Assistant Superintendent  
Water Production Facilities

APPROVED:

APPROVED FOR COMMITTEE INFORMATION:



Solon Wisham Jr.  
Assistant City Manager



Melvin H. Johnson  
Director of Public Works

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attachments

TABLE 2

## ON-SITE GROUNDWATER QUALITY DATA

ATTACHMENT A

Well	Date	Coliform Index (MPN/100 ml)	Fecal Coliforms	Total Hardness (ppm as Ca CO <sub>3</sub> )	Alkalinity (ppm)	Iron (ppm)	Manganese (ppm)	Chlorides (ppm)	Nitrates (ppm)	pH	Spec. Conduct.	C. O. D.
not specified	3-12-72	16										
not specified	4-18-72	15										
Clayton Mize	5-03-72	16	2.2	107	117	4.2	1.0	6.0	.01	6.8	175	
not specified	5-05-72	23										
private well	5-05-72	16										
not specified	5-16-72	2.2										
not specified	6-01-72	9.1										
#1	6-01-72	9.2										
#1	6-08-72	5										
not specified	6-15-72	5.1										
#1	6-22-72	2		300	328			18	.01	7.0	480	56
#1	6-29-72	2										
#1	7-06-72	2										
#1	7-13-72	2										
#1	7-20-72	5.1		280	308	2.43	.06	14	.01	6.7	432	50
#2	7-20-72	16										
#3	7-20-72	16										
#4	7-20-72	2.2		136	154	9.6	.60	8	.03	6.8	254	230
#1	7-27-72	2.2										
#2	7-27-72	9		370	66	2.38	.77	9	.01	6.5	648	100
#3	7-27-72	240		60	48	7.3	1.7	9	.01	6.6	157	138
#4	7-27-72	2.2										
#1	8-29-72	2.2										
#2	8-29-72	5.1										
#3	8-29-72	16										

Well	Date	Coliform Index (MPN/100 ml)	Fecal Coliform	Total Hardness (ppm as Ca C)	Alkalinity (ppm)	Iron (ppm)	Manganese (ppm)	Chlorides (ppm)	Nitrates (ppm)	pH	Spec. Conduct.	C. O. D.
#4	8-29-72	2.2										
#1	9-28-72	2.2										
#2	9-28-72	7										
#3	9-28-72	93										
#4	9-28-72	3										
#5	9-28-72	9.2										
#1	10-26-72	2.2										
#2	10-26-72	2.2										
#3	10-26-72	2.2										
#4	10-26-72	2.2										
#5	10-26-72	16										
#1	11-30-72	240										
#2	11-30-72	8.6										
#3	11-30-72	64										
#4	11-30-72	2.1										
#5	11-30-72	2.1										
#1	2-20-73	49	-									
#2	2-20-73	105	9									
#3	2-20-73	30	-									
#4	2-20-73	3	-									
#5	2-20-73	88	-									
#1	3-28-73	4	3	228	264	12	0.1	11	0.5	7.2	462	
#2	3-28-73	4	3	380	30	2.3	0.8	35	42	7.0	687	
#3	3-28-73	43	3	310	124	0.75	0.10	6	39	7.3	537	
#4	3-28-73	240	43	100	93	2.2	0.10	10	0.7	6.4	237	
#5	3-28-73	240	9	126	41	2.0	0.5	9	0.5	6.4	137	

American River  
Water Quality Survey

April 20, 1976

<u>Sample Location</u>	<u>Temperature °C</u>	<u>EC µmhos/cm</u>	<u>Iron</u>	<u>Chlorides</u>
1 West	15.5	62	0.03	4.0
Mid	15.5	62	0.03	4.0
East	16.0	62	0.03	3.8
2 North	17.0	68	0.03	4.2
Mid	16.5	68	0.03	4.4
South	16.5	68	0.03	4.4
3 North	17.0	69	0.03	4.6
Mid	17.0	69	0.03	4.5
South	17.0	68	0.03	4.7
4 North	17.5	70	0.05	4.6
Mid	17.5	71	0.03	4.8
South	17.0	71	0.03	5.0
5 North	17.5	68	0.04	4.5
Mid	17.5	69	0.04	4.6
South	17.5	69	0.03	4.5
6 Mid	17.5	69	----	----

Note: All results are expressed in mg/l except where noted.

AMERICAN RIVER  
WATER QUALITY SURVEY

April 28, 1976

<u>Sample Location</u>	<u>EC umhos/cm</u>	<u>Iron</u>	<u>Chlorides</u>
1 West	65	0.21	3.7
Mid		0.14	
East		0.06	
2 North	70	0.07	4.0
Mid		0.12	
South		0.10	
3 North	72	0.10	4.6
Mid		0.07	
South		0.09	
4 North	74	0.08	4.6
Mid		0.07	
South		0.09	
5 North	69	0.09	4.3
Mid		0.09	
South		0.09	

Note: All results are expressed in mg/l except where noted.

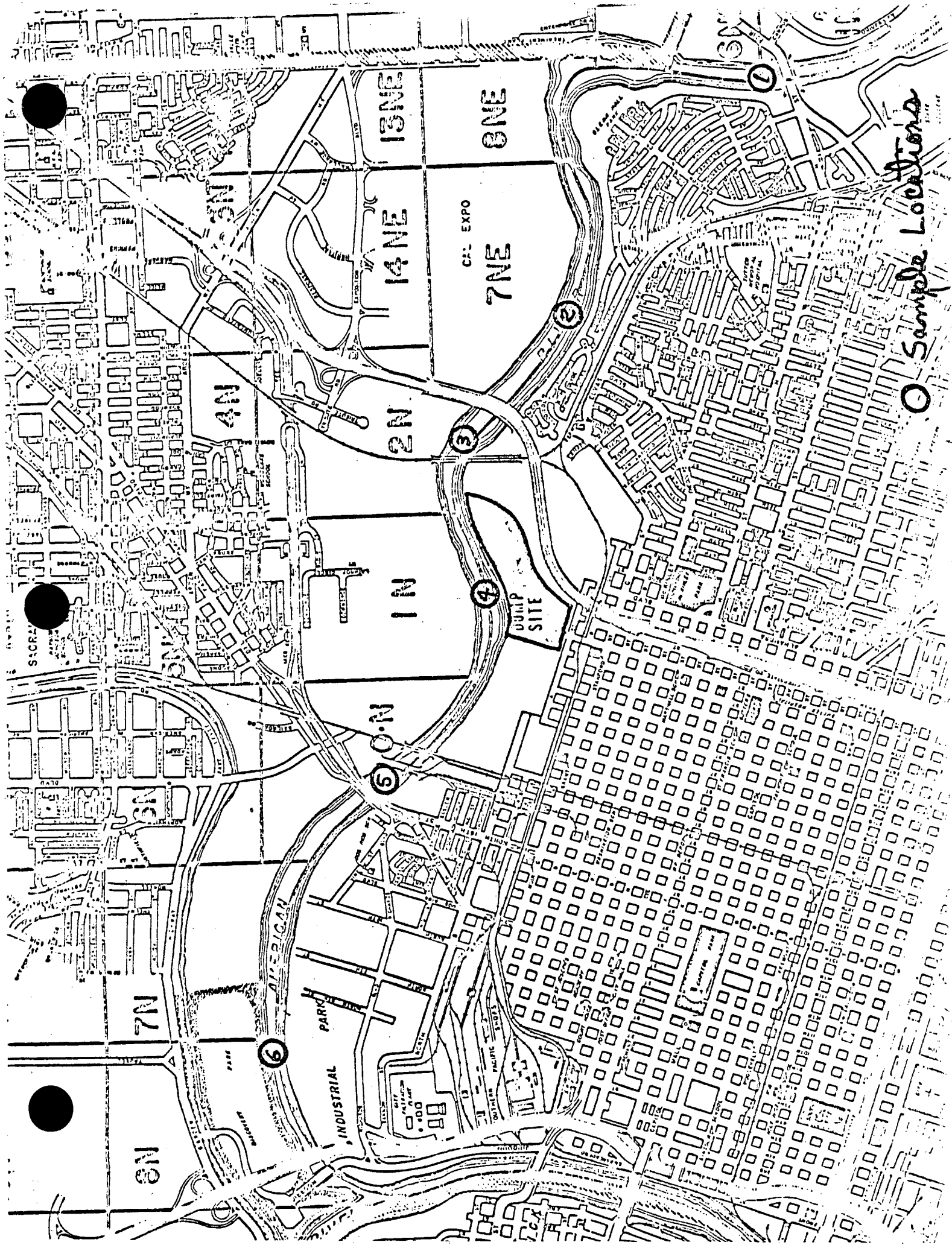
AMERICAN RIVER  
WATER QUALITY SURVEY

June 17, 1976

<u>Sample Location</u>	<u>EC</u> <u>micromhos/cm</u>	<u>Iron</u>
1. West		0.03
Mid	80	0.04
East		0.03
2. North		0.04
Mid	80	0.05
South		0.04
3. North		0.04
Mid	80	0.04
South		0.04
4. North		0.04
Mid	80	0.04
South		0.04
5. North		0.06
Mid	79	0.06
South		0.06

Note: All results are expressed in mg/l except EC (micromhos/cm).





Sample Locations

8N

7N

5N

4N

4N

3N

6·N

1N

2N

14NE

13NE

7NE

8NE

CAL. EXPO

PUMP SITE

INDUSTRIAL PARK

OCEAN

6

4

3

2

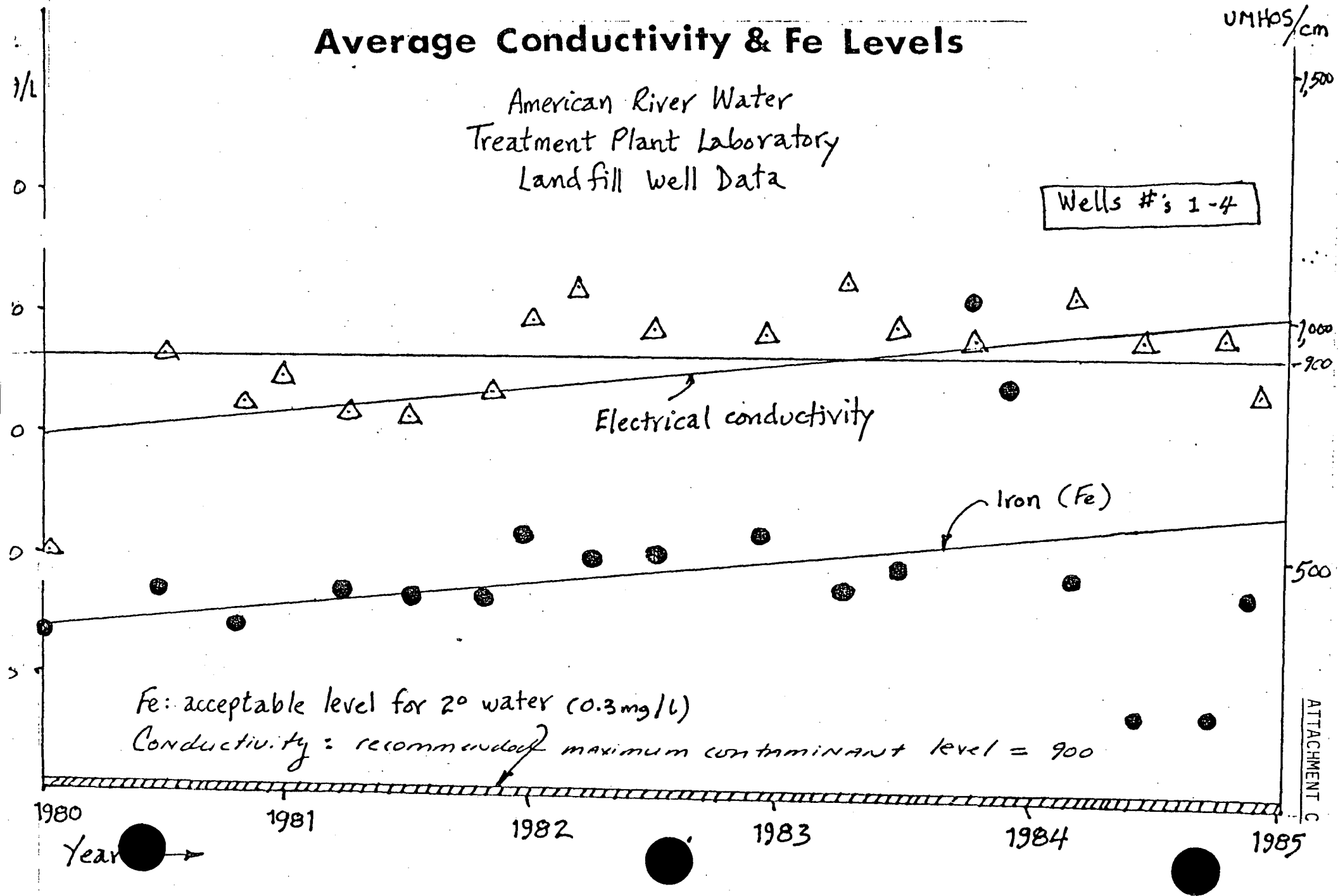
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# Average Conductivity & Fe Levels

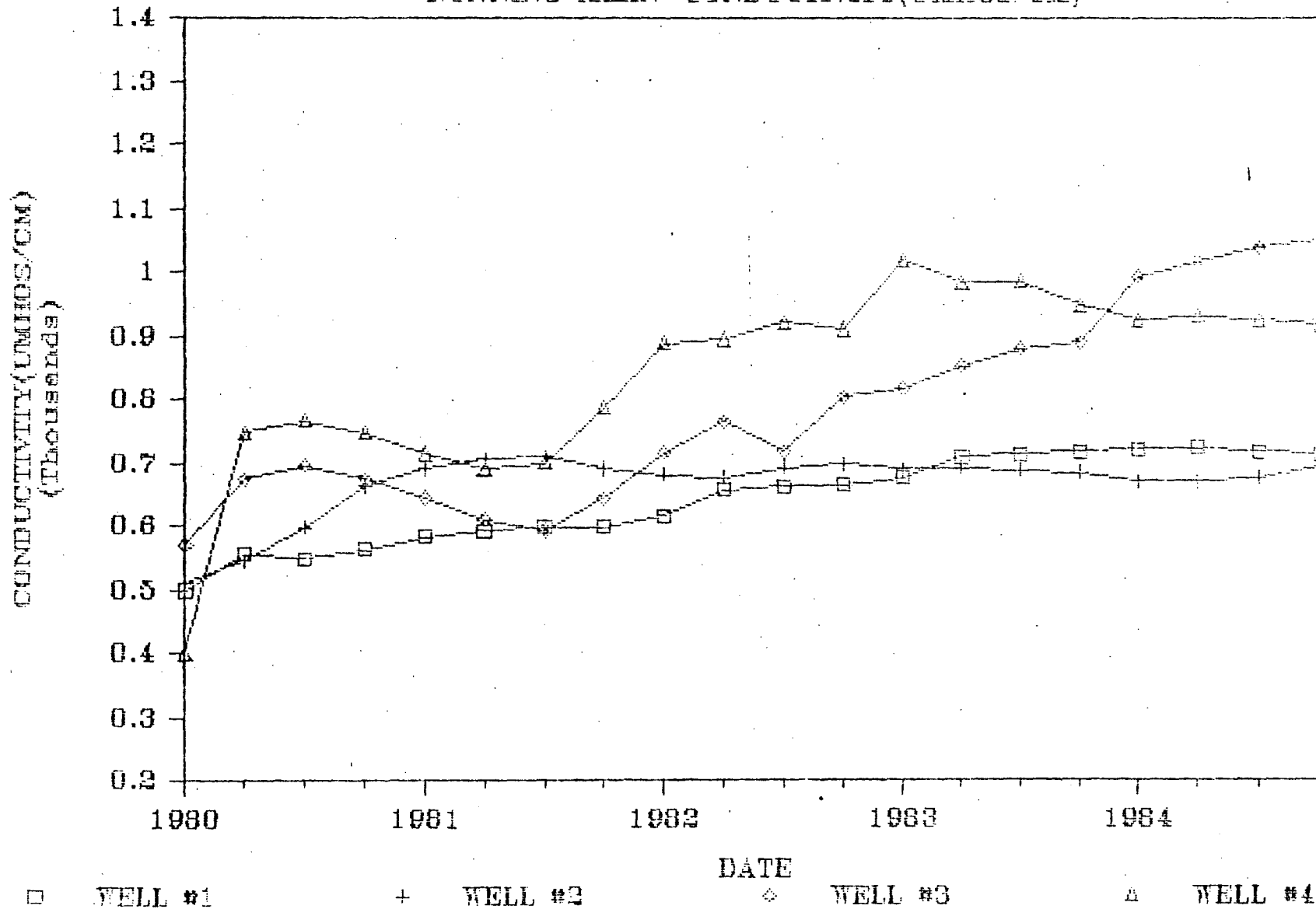
American River Water  
Treatment Plant Laboratory  
Landfill Well Data

Wells #'s 1-4



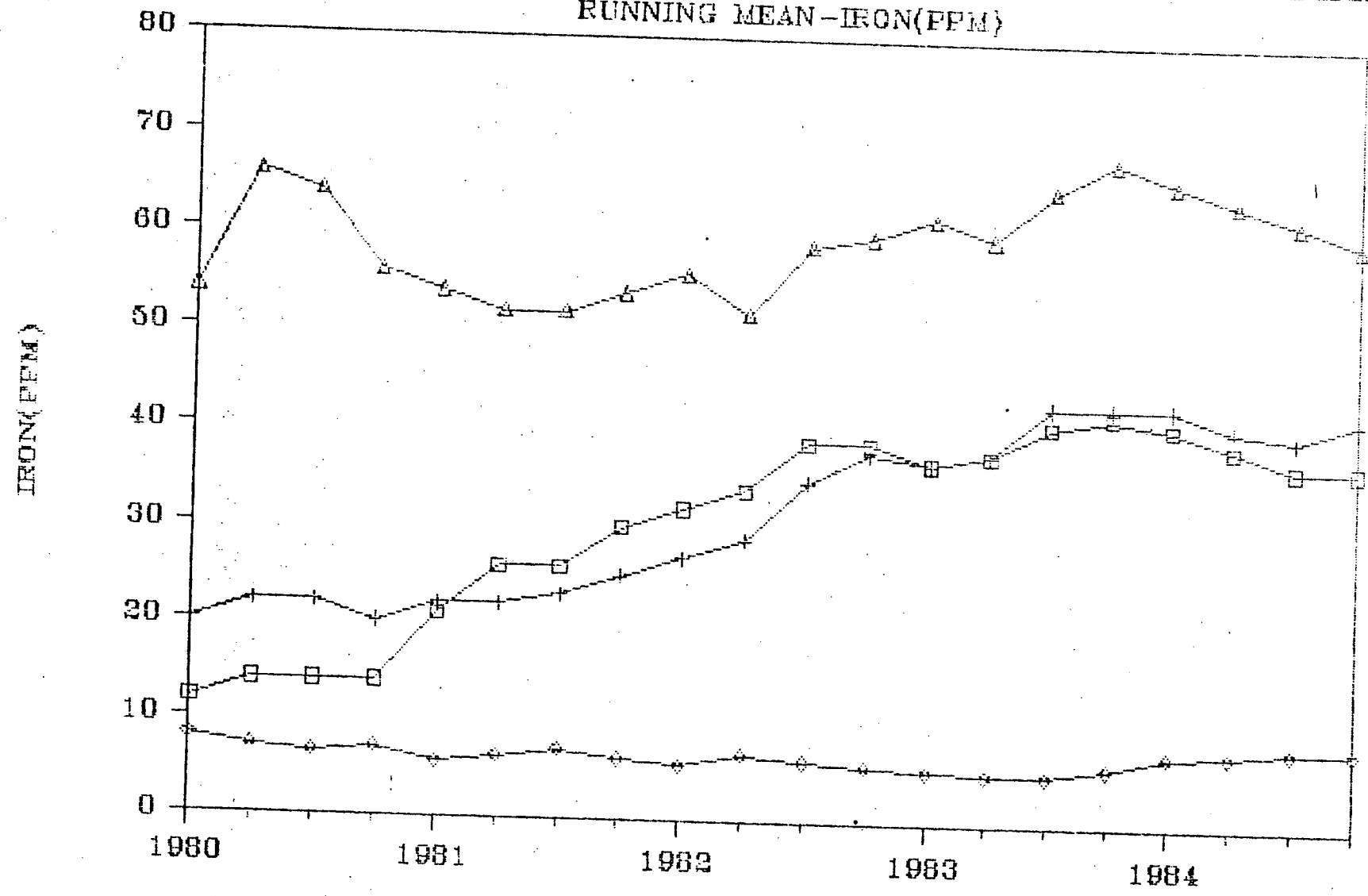
## CITY OF SACRAMENTO--LANDFILL WELLS

RUNNING MEAN-CONDUCTIVITY(UMHOS/CM)



# CITY OF SACRAMENTO--LANDFILL WELLS

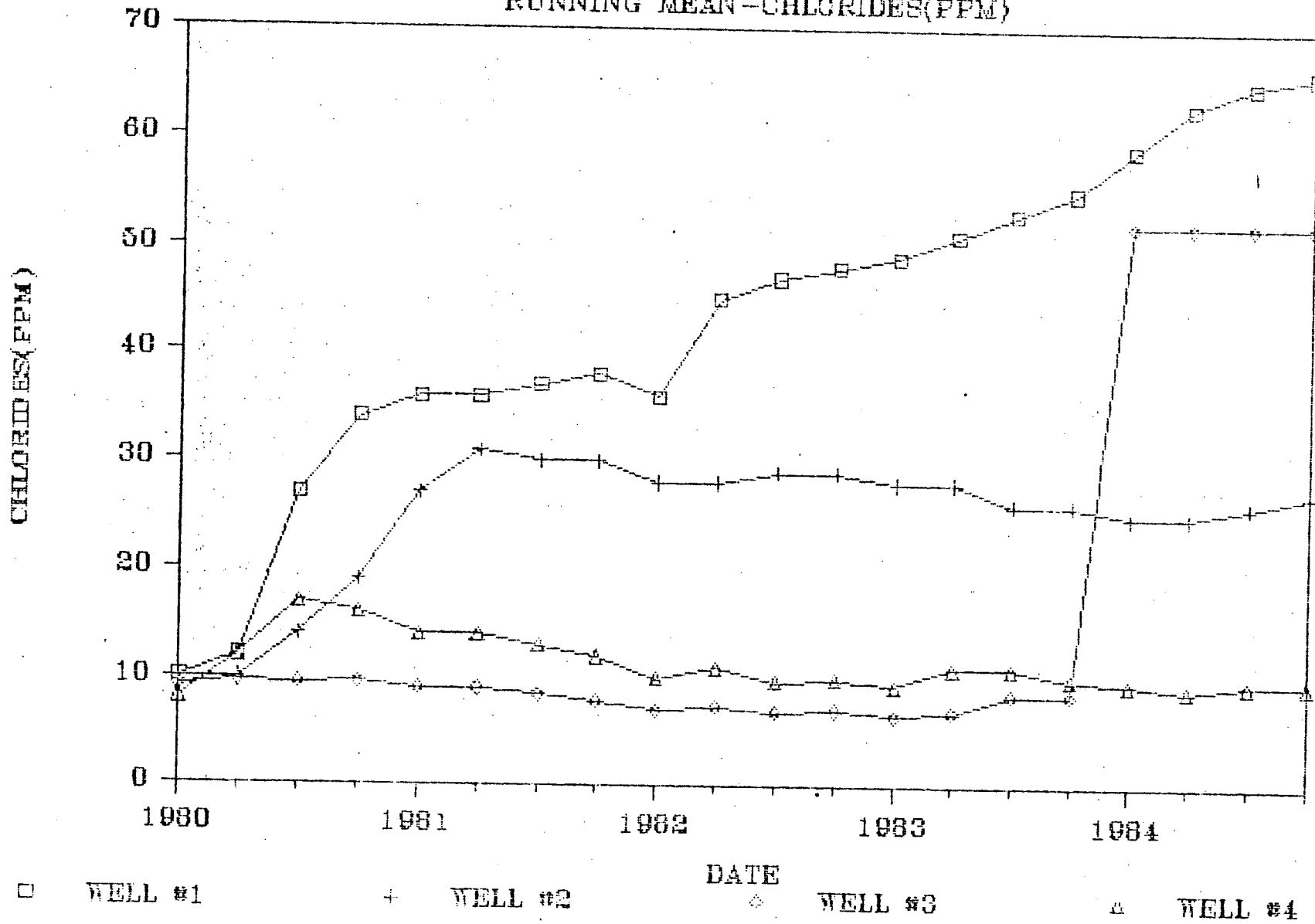
RUNNING MEAN-IRON (PPM)



WELL #1     
  WELL #2     
 DATE     
  WELL #3     
  WELL #4

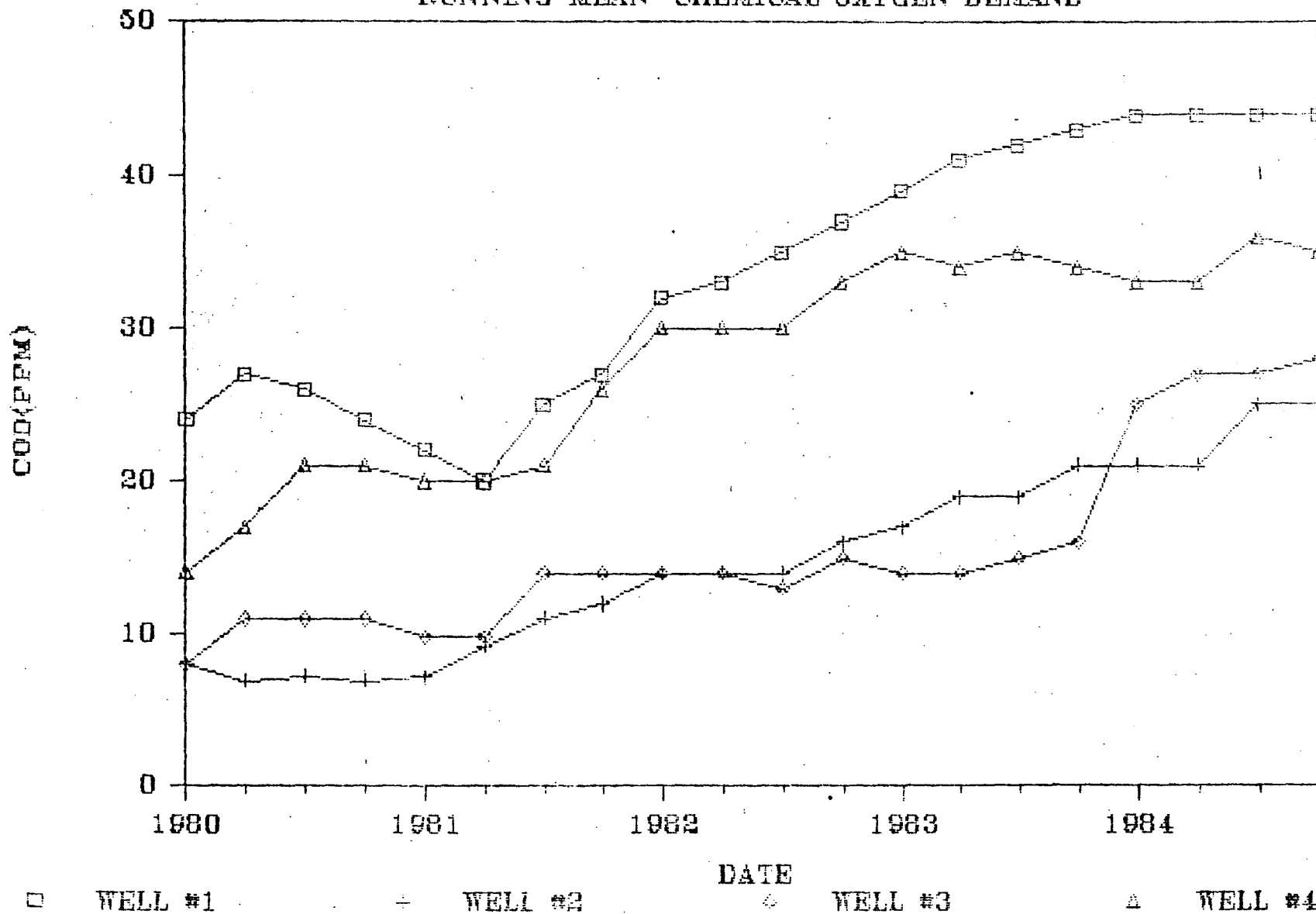
# CITY OF SACRAMENTO--LANDFILL WELLS

## RUNNING MEAN--CHLORIDES (PPM)



# CITY OF SACRAMENTO -- LANDFILL WELLS

RUNNING MEAN-CHEMICAL OXYGEN DEMAND



# CITY OF SACRAMENTO--LANDFILL WELLS

RUNNING MEAN-HARDNESS(PFM)

