Case 8224

OCD

Exhibits

13 thru 17

April 3, 1985

San Juan Basin Produced Water Hearing

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BEFORE THE
OIL CONSERVATION DIVISION
[illegible]

Case No. 8224 Exhibit No. 13
Submitted by OCD
Hearing Date 4-3-85

EID Sampling-Community Water supplies Spring 1984

VOLATILE ORGANIC SAMPLING RESULTS

Bernalillo County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Albuquerque	342,000	ND	ND	ND	ND	ND
"	"	1 mg/l	2 mg/l	3 mg/l	ND	ND
"	"	ND	ND	ND	ND	ND
"	"	2 mg/l	ND	ND	ND	ND
Kirtland Air Force	16,110	5 mg/l	ND	ND	ND	ND
New Mexico Utilities	6,400	ND	ND	ND	ND	ND
Sandia Peak Utility	2,200	ND	ND	ND	ND	ND
University of N. M.	24,800	4 mg/l	1 mg/l	1 mg/l	4 mg/l	ND

Catron County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_2$	OTHER VOC
Reserve	750	ND	ND	ND	ND	ND

Chaves County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBR_2Cl$	$CHBr_3$	OTHER VOC
Berrendo Coop	3,680	ND	ND	ND	ND	ND
Dexter	1,200	ND	ND	ND	ND	ND
Hagerman	1,075	ND	ND	ND	ND	ND
Roswell	39,000	ND	ND	.ND	ND	ND
Roswell	39,000	ND	ND	ND	ND	ND

Cibola County

Water System	Pop.	$CHCl_3$	$CHCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Bluewater Village	1,015	ND	ND	ND	ND	ND
Grants	10,300	ND	ND	ND	ND	ND
Milan	3,870	ND	ND	ND	ND	ND
San Rafael	1,100	ND	ND	ND	ND	ND

Colfax County

Water System	Pop.	$CHCl_3$	$CHCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
*Raton	9,600	18 mg/l	ND	ND	ND	ND
*Springer	1,800	16 mg/l	16 mg/l	9 mg/l	ND	ND

(List obtained from EID Water Supply Section)
(Values reported as microgram/liter)

DW Boyer

Curry County

Water System	Pop.	$CHCl_3$	$CHCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Cannon Air Force	8,000	ND	ND	1 mg/l	ND	ND
Southwestern Public	37,000	ND	ND	ND	ND	ND
Southwestern Public	"	ND	ND	ND	ND	ND
Texico	1,000	ND	ND	ND	ND	ND

DeBaca County

Water System	Pop.	$CHCl_3$	$CHCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Fort Sumner	1,400	ND	ND	ND	ND	ND

Dona Ana County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Anthony	3,300	ND	ND	ND	ND	ND
Chaparral	2,840	ND	ND	ND	ND	ND
Dona Ana	4,500	ND	ND	ND	ND	ND
Garfield	1,050	ND	ND	ND	ND	ND
Hatch	2,000	ND	ND	ND	ND	ND
Las Cruces	50,000	4 mg/l	4 mg/l	6 mg/l	7 mg/l	ND
Las Cruces	"	2 mg/l	1 mg/l	3 mg/l	3 mg/l	ND
Mesilla	2,080	3 mg/l	3 mg/l	3 mg/l	ND	ND
Mesquite	1,020	ND	ND	ND	ND	ND
N.M. State University	12,000	1 mg/l	ND	ND	ND	ND
Sunland Park	4,500	ND	ND	ND	ND	ND
White Sands Missile	4,500	ND	ND	ND	ND	ND

Eddy County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Artesia Municipal	1,200	ND	ND	ND	ND	ND
Artesia Rural Coop	12,000	ND	ND	ND	ND	ND
Carlsbad Municipal	32,000	ND	ND	ND	ND	ND
Loving	1,700	1 mg/l	ND	ND	ND	ND
Otis	3,390	ND	ND	ND	ND	ND

Grant County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2CL$	$CHBr_3$	OTHER VOC
Bayard	4,000	ND	ND	ND	ND	ND
Central	1,970	ND	ND	ND	ND	ND
Hurley	1,590	ND	ND	ND	ND	ND
Silver City	14,000	ND	ND	ND	ND	ND

Guadalupe County

Water System	Pop	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Santa Rosa	2,485	NO	RESULTS	YET		

Harding County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Roy	451	ND	ND	ND	ND	ND

Hidalgo County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Lordsburg	3,900	ND	ND	ND	ND	ND

Lea County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Eunice	3,000	ND	ND	ND	ND	ND
Hobbs Municipal	35,960	ND	ND	ND	13 mg/l	ND
Hobbs Municipal	"	ND	ND	ND	1 mg/l	ND
Jal	2,675	ND	ND	ND	ND	ND
Lovington Municipal	11,000	ND	ND	ND	ND	ND
Tatum	1,000	ND	ND	ND	1 mg/l	ND

Lincoln County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Alto Village	1,000	ND	ND	ND	ND	ND
*Capitan	1,200	18 mg/l	5 mg/l	ND	ND	ND
*Carrizozo	1,925	ND	ND	ND	ND	ND
Ruidoso Downs	3,000	ND	ND	ND	ND	ND
*Ruidoso	4,500	31 mg/l	10 mg/l	3 mg/l	ND	ND

Los Alamos County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Los Alamos	17,000	ND	ND	ND	1 mg/l	ND

Luna County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Deming	9,000	NO	RESULTS	YET		

McKinley County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Gallup	18,000	ND	1 mg/l	1 mg/l	1 mg/l	ND
Thoreau	1,000	ND	ND	ND	ND	ND

Mora County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Mora MDWCA	1,000	33 mg/l	2 mg/l	ND	ND	ND

Otero County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHCl_3$	OTHER VOC
Alamogordo	25,000	38 mg/l	14 mg/l	8 mg/l	ND	ND
Holloman A.F.	15,000	1 mg/l	1 mg/l	3 mg/l	ND	ND
La Luz	1,500	ND	ND	1 mg/l	ND	ND
*Tularosa	2,850	12 mg/l	14 mg/l	15 mg/l	ND	ND

Quay County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHCl_3$	OTHER VOC
Logan	1,000	NO RESULTS YET				
Tucumcari	7,800	NO RESULTS YET				

Rio Arriba County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHCl_3$	OTHER VOC
Chama MDWCA	1,200	63 mg/l	3 mg/l	1 mg/l	ND	ND
Espanola	8,000	ND	ND	ND	ND	ND

Roosevelt County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHCl_3$	OTHER VOC
Portales	10,200	ND	ND	ND	ND	ND
Roosevelt Co Coop	1,940	ND	ND	ND	ND	ND

Sandoval County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Albuquerque Util	15,000	ND	ND	ND	ND	ND
Cuba	2,000	ND	ND	ND	ND	ND

San Juan County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
City of Aztec	6,000	36 mg/l	22 mg/l	ND	ND	ND
*Bloomfield	5,000	78 mg/l	6 mg/l	ND	ND	ND
*Farmington	40,000	37 mg/l	1 mg/l	ND	ND	ND
#Farmington	"	13 mg/l	3 mg/l	ND	ND	#
Flora Vista	1,500	9 mg/l	.5 mg/l	ND	ND	ND
Lee Acres Water	22,540	75 mg/l	5 mg/l	ND	ND	ND
*Lower Valley	5,200	44 mg/l	6 mg/l	ND	ND	ND
West Hammond	1,160	72 mg/l	5 mg/l	ND	ND	ND

SAN MIGUEL COUNTY

Water System	Pop.	$CHCl_3$	$CHBr_2Cl$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Las Vegas	15,000	44 mg/l	5 mg/l	ND	ND	ND
Pecos	1,000	ND	ND	ND	ND	ND

Santa Fe County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Country Club MHP	1,000	ND	ND	ND	ND	ND
**Santa Fe Domestic	50,000	43 mg/l	1 mg/l	ND	ND	ND
Santa Fe Domestic	"	ND	ND	ND	ND	ND
State Penitentiary	1,130	ND	ND	ND	ND	ND

Sierra County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Truth or Consequences	7,000	ND	ND	ND	ND	ND

Socorro County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Magdalena	1,020	ND	ND	ND	ND	ND
##Socorro	7,500	ND	ND	ND	ND	##

Taos County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Questa	1,720	ND	ND	ND	ND	ND
Red River	3,400	ND	ND	ND	ND	ND
Taos	3,200	ND	ND	ND	ND	ND

Torrance County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Mountainair	1,150	ND	ND	ND	ND	ND

Union County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Clayton	3,200	ND	ND	ND	ND	ND

Valencia County

Water System	Pop.	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	OTHER VOC
Belen	10,000	ND	ND	ND	ND	ND
Los Lunas	4,000	ND	ND	ND	ND	ND
Rio Grande Utility	2,360	ND	ND	ND	ND	ND

ND = Not Detected

* = Surface Water Sources

** = Combination of Surface and Ground Water

= 2 mg/l of M-xylene; Also, ethyl benzene, p-xylene & o-xylene detected less than 1 mg/l. Area is served by Farmington's new Surface Water Plant.

= 6 mg/l of Di-chlorobenzene. The sample was taken in a rest room with a strong deodorant smell and we suspect contamintion of the sampling.

RESAMPLING AT SITES WITH POSITIVE VOC RESULTS OTHER THAN THMs

Should be μg/l instead of mg/l.

1. Farmington Water Plant (New Plant)

Resample #1 - Treatment Plant - Treated Water
2 mg/l - metaxylene
26 mg/l - $CHCl_3$
13 mg/l - $CHBrCl_2$
Also, detected para xylene and ortho xylene at <1 mg/l.

Resample #2 - Treatment Plant - Raw Water in Primary Clorifier
No purgeables detected.

Resample #3 - San Juan College, Student Services Bldg.
2 mg/l - Toluene
2 mg/l - Meta xylene
1 mg/l - Ortho Xylene
83 mg/l - $CHCl_3$
9 mg/l - $CHBrCl_3$

Also, detected ethyl benzene and para xylene at <1 mg/l.

Resample #4 - 7211 East Main
2 mg/l - Meta Xylene
33 mg/l - $CHCl_3$
13 mg/l - $CHBrCl_2$
3 mg/l - $CHBr_2Cl$
Also, detected ethyl benzene, para xylene at <1 mg/l.

Note: Only areas served by Farmington's new Surface Water Plant were resampled since the area served by the old Surface Water Plant only had THMs when it was first sampled.

2. Socorro Water

Resample #1 - No purgeables detected.

Note: The original sample had 6 mg/l of para-dichlorobenzene. This sample was collected in a bathroom with a strong deodorant smell and we have had trouble in the past with this same chemical under similar circumstances. We strongly suspect result was due to sampling technique error (i.e. wrong location).

CHEMICAL QUALITY OF
NEW MEXICO
COMMUNITY WATER SUPPLIES
-1980-

A Compilation of Chemical and Physical Data

Environmental Improvement Division
Thomas E. Baca, Director

Water Supply Section

Francisco N. Garcia
Program Manager

Steven T. Pierce
Environmental Scientist

24 - SAN JUAN

System Name	Aztec	Berean Mission	Blanco 1	Blanco 2	Blanco 3
Well Name	Animas River After Treatment	Composite of wells	Infiltration Gallery	Spring #1	Proposed New Well
Code Number	098-24	668-24	315-24	315-24	315-24
Latitude	36-49-30	36-24-31	36-42-20	36-42-48	36-45-20
Longitude	107-59-30	107-51-30	108-03-35	107-53-00	107-46-36
ARSENIC	<0.004 (3)	<0.005	<0.005	0.003	0.004
BARIUM	0.20 (3)	0.2	<0.10	0.10	0.13
CADMIUM	<0.001 (3)	<0.001	<0.005	<0.001	<0.001
CHROMIUM	<0.005 (3)	<0.005	<0.005	0.008	<0.005
FLUORIDE	0.44 (3)	0.58 (2)	0.47	0.23	0.35
LEAD	<0.008 (7)	<0.005	<0.005	<0.005	<0.005
MERCURY	<0.0009(3)	<0.0005	0.0011	0.0005	<0.0005
NITRATE	0.11 (2)	0.03 (2)	0.56	0.03	0.03
SILVER	<0.001 (3)	0.013	<0.005	0.002	0.003
SELENIUM	<0.007 (7)	0.004	<0.005	0.002	<0.001
GROSS ALPHA	0 ± 2.5 (4)	-0.7 ± 0.4			
GROSS BETA	2.3 ± 3 (4)	0.4 ± 0.8			
RADIUM-226					
RADIUM-228					
ALKALINITY	150	289 (2)	206	121	215
BICARBONATE	183.1	282.1 (2)	251.8	149.6	262.3
CALCIUM	84.2	2.6 (2)	65.9	50.2	74.4
CARBONATE	0.0	52.8 (2)	0.0	0.0	0.0
CHLORIDE	44.2	6.9 (2)	4.2	4.2	4.1
COLOR	0	0 (2)	0	0	10.0
CONDUCTANCE	757	1,020 (2)	557	398	604
FOAMING AGENTS	<0.05	<0.05 (2)	<0.05	<0.05	<0.05
HARDNESS	287	14 (2)	217	142	215
IRON	<0.25	<0.25 (2)	<0.25	<0.25	0.46
MAGNESIUM	28.2	1.8 (2)	12.8	4.0	7.1
MANGANESE	<0.05	<0.05 (2)	<0.05	<0.05	0.23
ODOR	chlorine	none (2)	none	none	none
pH	8.02	9.23 (2)	7.89	7.97	7.73
POTASSIUM	5.46	0.39 (2)	1.56	1.17	2.34
SODIUM	41.4	223.1 (2)	57.5	23.0	39.1
SULFATE	164.1	181.5 (2)	119.9	68.5	95.8
TOTAL FILT. RES.	645	579 (2)	274	266	336
TURBIDITY	2.2	0.4 (2)	0.2	0.5	3.7

24 - SAN JUAN

System Name	Bloomfield 1	Brethren in Christ Mission	EPNG (Angel Peak)	EPNG (Ballard)	EPNG (Blanco)
Well Name	San Juan River after Treatment	Well #1	Well #1	Composite of wells	San Juan River after Treatment
Code Number	101-24	670-24	671-24	672-24	673-24
Latitude	36-43-15	36-20-00			
Longitude	107-58-40	108-49-30			
ARSENIC	<0.003 (2)	<0.005	<0.005	0.011	0.011
BARIUM	0.20 (2)	0.10	<0.10	<0.10	0.11
CADMIUM	<0.001 (2)	<0.001	<0.001	<0.001	<0.001
CHROMIUM	<0.005 (2)	<0.005	0.015	<0.005	<0.005
FLUORIDE	0.24 (3)	0.45	1.10	1.03	0.23
LEAD	<0.005 (2)	<0.005	<0.005	<0.005	0.004
MERCURY	<0.0011 (5)	0.0006	<0.0005	<0.0005	0.002
NITRATE	0.06 (2)	0.17	0.12	0.04	0.02
SILVER	<0.001 (2)	0.006	<0.005	0.001	<0.005
SELENIUM	<0.001 (2)	<0.0025	<0.005	0.012	0.007
GROSS ALPHA	0 ± 2.5 (4)	0.8 ± 0.5		-	
GROSS BETA	1.3 ± 2.5 (4)	1.4 ± 0.8			
RADIUM-226					
RADIUM-228					
ALKALINITY	86 (2)	294	DATA	DATA	DATA
BICARBONATE	105.3 (2)	286.0			
CALCIUM	35.0 (2)	1.0			
CARBONATE	0.0 (2)	37.3	NOT	NOT	NOT
CHLORIDE	4.0 (2)	4.2			
COLOR	12.5 (2)	0.0			
CONDUCTANCE	294 (2)	780	AVAILABLE	AVAILABLE	AVAILABLE
FOAMING AGENTS	< 0.05 (2)	< 0.05			
HARDNESS	110 (2)	3			
IRON	< 0.46 (2)	< 0.25			
MAGNESIUM	5.4 (2)	0.0			
MANGANESE	< 0.05 (2)	< 0.05			
ODOR	none (2)	none			
pH	8.08 (2)	9.09			
POTASSIUM	2.15 (2)	0.00			
SODIUM	19.6 (2)	177.1			
SULFATE	59.8 (2)	98.4			
TOTAL FILT. RES.	191 (2)	478			
TURBIDITY	10.0 (2)	0.2			

24 - SAN JUAN

SYSTEM NAME	EPNG (Chaco)	EPNG (Kutz)	EPNG (San Juan River)	ERNIE'S Trailer Park	FARMINGTON
Well Name	Composite of wells and San Juan River	San Juan River after treatment	San Juan & Animas Rivers	Well #1	San Juan & Animas Rivers
Code Number	674-24	675-24	676-24	642-24	102-24
Latitude	36-43-15				36-44-00
Longitude	107-58-40				108-12-15
ARSENIC	0.011	0.006	<0.005	<0.005	<0.005 (5)
BARIUM	<0.10	<0.10	<0.10	<0.10	<0.11 (5)
CADMIUM	<0.001	<0.001	<0.001	<0.001	<0.001 (5)
CHROMIUM	<0.005	<0.005	<0.005	<0.005	<0.005 (5)
FLUORIDE	0.80	0.22 (2)	0.39	0.57	0.59 (5)
LEAD	<0.005	0.004	0.004	<0.005	<0.005 (5)
MERCURY	0.0021	0.0011	0.0009	0.0017	<0.0006 (5)
NITRATE	0.08	0.08 (3)	0.02	1.30	0.11 (5)
SILVER	0.001	<0.005	<0.005	<0.001	<0.001 (5)
SELENIUM	0.014	0.003	0.002	0.001	<0.004 (5)
GROSS ALPHA	0 ± 2.5			3.3 ± 0.9	0 ± 2.5 (3)
GROSS BETA				8.9 ± 1.3	4.3 ± 3.7 (3)
RADIUM-226					
RADIUM-228					
ALKALINITY	155	145	DATA	277	102 (3)
BICARBONATE	188.7	182.3		338.4	124.4 (3)
CALCIUM	24.5	84.4		163.6	46.8 (3)
CARBONATE	0.0	0.0	NOT	0.0	0.0 (3)
CHLORIDE	11.6	16.5		41.5	18.7 (3)
COLOR		0		0	1.7 (3)
CONDUCTANCE	820	948	AVAILABLE	1,175	509 (3)
FOAMING AGENTS		<0.05		<0.05	<0.05 (3)
HARDNESS	80	269		496	140 (3)
IRON	<0.25	0.35		<0.25	<8.50 (3)
MAGNESIUM	4.5	14.2		21.4	5.7 (3)
MANGANESE		<0.05		<0.05	<6.03 (3)
ODOR		none		none	none (3)
pH	7.90	8.01		7.65	8.03 (3)
POTASSIUM	1.00	2.34		5.85	2.21 (3)
SODIUM	155.0	101.2		55.2	42.9 (3)
SULFATE	268.3	294.3		276.7	114.0 (3)
TOTAL FILT. RES.	488	825		789	305 (3)
TURBIDITY	1.2	5.5		0.3	0.5 (2)

System Name	Fergie's Trailer Park	Flora Vista WUA	Harmony Trailer Parks #1 & #2	Harmony Trailer Park #3	Lee Acres WUA
Well Name	Well #1	Distribution, only	Well #1	Spring #1	Distribution, only
Code Number	678-24	100-24	681-24	682-24	302-24
Latitude	36-45-00		36-43-00	36-42-50	
Longitude	108-40-00		108-10-40	108-10-30	
ARSENIC	<0.005		<0.005	<0.005	
BARIUM	<0.10	SEE	0.2	0.2	SEE
CADMIUM	<0.001		<0.001	<0.001	
CHROMIUM	<0.005		<0.005	<0.005	
FLUORIDE	0.35		0.53	0.57	
LEAD	<0.005	AZTEC	<0.005	<0.005	BLOOM FIELD
MERCURY	<0.0005		<0.0005	<0.0005	
NITRATE	0.13		3.66 (7)	1.98	
SILVER	<0.005		0.001	0.001	
SELENIUM	<0.005	SYSTEM	0.002	<0.0025	SYSTEM
GROSS ALPHA	1.3 ± 0.5		4.0 ± 0.6	3.3 ± 0.9	
GROSS BETA	2.4 ± 0.7		7.4 ± 0.7	5.7 ± 1.2	
RADIUM-226					
RADIUM-228					
ALKALINITY	189		223	227	
BICARBONATE	230.8		274.2	279.7	
CALCIUM	126.2		139.6	133.6	
CARBONATE	0.0		0.0	0.0	
CHLORIDE	28.7		28.4	25.4	
COLOR	0		0	0	
CONDUCTANCE	930		956	930	
FOAMING AGENTS	<0.05		<0.05	<0.05	
HARDNESS	394		428	410	
IRON	<0.25		<0.25	<0.25	
MAGNESIUM	19.0		19.3	18.7	
MANGANESE	<0.05		<0.05	<0.05	
ODOR	none		none	none	
pH	7.71		7.58	7.56	
POTASSIUM	1.56		3.51	3.90	
SODIUM	50.6		41.4	39.1	
SULFATE	271.4		210.1	222.0	
TOTAL FILT. RES.	610		624	601	
TURBIDITY	0.1		0.3	0.1	

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System Name	Lower Valley WUA	Navajo Mission Inc.	San Juan River Estates	Southside WUA	West Hammond MDWCA
Well Name	Distribution, only	Well #1	Well #1 & Infiltration Gallery	Distribution, only	Distribution, only
Code Number	103-24	509-24	367-24	099-24	669-24
Latitude Longitude		36-43-55 108-14-05	36-49-00 107-43-00		
ARSENIC		<0.005	<0.007 (2)		
BARIUM	SEE	<0.10	<0.06 (2)	SEE	SEE
CADMIUM		<0.001	<0.006 (2)		
CHROMIUM		<0.005	<0.008 (2)		
FLUORIDE		0.73	0.18 (2)		
LEAD	FARMINGTON	<0.005	<0.008 (2)	AZTEC	BLOOMFIELD
MERCURY		0.0013	<0.0009(2)		
NITRATE		0.42	0.07 (2)		
SILVER		<0.005	<0.014 (2)		
SELENIUM	SYSTEM	<0.005	<0.005	SYSTEM	SYSTEM
GROSS ALPHA		1.6 ± 0.7			
GROSS BETA		3.6 ± 1.1			
RADIUM-226					
RADIUM-228					
ALKALINITY		218	90 (2)		
BICARBONATE		266.3	109.7 (2)		
CALCIUM		154.6	34.4 (2)		
CARBONATE		0.0	0.0 (2)		
CHLORIDE		31.9	9.1 (2)		
COLOR		0	0 (2)		
CONDUCTANCE		1,134	299 (2)		
FOAMING AGENTS			<0.05		
HARDNESS		443	112 (2)		
IRON			<0.15 (2)		
MAGNESIUM		13.7	6.5 (2)		
MANGANESE			<0.05 (2)		
ODOR		0	none (2)		
pH		7.89	7.85 (2)		
POTASSIUM		2.73	1.76 (2)		
SODIUM		59.8	15.0 (2)		
SULFATE		269.2	43.5 (2)		
TOTAL FILT. RES.			179 (2)		
TURBIDITY			1.9 (2)		

From: Hydrogeology of The Aztec Quadrangle,
San Juan County, New Mexico
NMBM&MR Hydrologic Sheet #1, 1979

TABLE 1—RECORDS OF WELLS IN THE AZTEC QUADRANGLE; See fig. 9 for locations. EPNG = El Paso Natural Gas Corp.; Qal = alluvium, Tsj = San Jose Formation, Tn = Nacimiento Formation; D = domestic, S = stock, I = industrial, P & A = plugged and abandoned; SC = specific conductance; * indicates *chemical analysis given in table 3; — means information not available.*

owner or well name	field no.	location no.	approx. elev. (ft)	total depth (ft)	water depth (ft)/date	principal aquifer	total aquifer thickness (ft)	well type	year constructed	use	pump type	chemical analysis?	remarks
Cox Canyon	A1	32.11.23.100	6,400	–	53/9-75	Qal	–	drld	–	S	W	–	P&A
B. Heizer	A2	32.10.15.100	5,945	35	–	Qal	35	dug	–	D,S	E	*	water softener used
W. Head	A3	32.10.15.200	5,920	30	15/9-74	Qal	30	dug	–	D	E	–	24-inch steel casing
F. Clark	A4	32.10.21.400	5,920	104	24/9-74	Qal	–	drld	1962	D,S	E	*	3 sands: 45, 60, 97
H. Knowlton	A5	32.10.28.400	5,925	35	16/9-74	Qal	35?	drld	1967	D,S	E	–	S.C. = 1000 μmhos
A. Flaherty	A6	32.10.32.400	5,820	30	–	Qal	30?	dug	–	D	–	*	not potable
C. Lanier	A7	32.10.33.200	5,870	55	45-55/?	Qal	55?	dug	1950?	D,S	–	*	
C. Saller	A8	32.10.33.400	5,920	64	36/9-74	Qal	64?	dug	–	D	E	–	S.C. = 1025 μmhos
M. Bishop	A9	31.11.24.400	5,745	40	8/9-74	Qal	40?	dug	–	D,S	E	*	water softener used
F. Randalmon	A10	31.11.26.100	5,680	57	–	Qal	57?	drld	–	–	–	*	
A. Hill	A11	31.11.26.400	5,720	39	23/8-75	Qal	39?	drld	1961	D,S	E	*	set in coarse gravel
L. Long	A12	31.11.26.400	5,770	70	–	Qal	70?	drld	–	I	E	–	S.C. = 1120 μmhos
G. Foster	A13	31.11.34.300	5,670	60	7/8-75	Qal	60?	drld	–	D	E	*	
L. Likes	A14	30.11.34.400	5,680	47	20/?	Qal	47?	drld	1974	D	E	*	
A. Karlan	A15	31.10.4.200	5,760	–	14/9-74	Qal	–	dug	–	D	E	–	S.C. = 780 μmhos
unknown	A16	31.10.5.200	5,834	–	–	Qal	–	dug	–	D,S	E	–	S.C. = 1100 μmhos
Pan Am Petrol.	A17	31.10.5.000	5,810	27?	–	Qal	–	–	–	I?	–	*	
J. Hollar	A18	31.10.6.400	5,795	30	–	Qal	–	drld	1950	D	E	*	strong odor, staining
C. Smith	A19	31.10.8.100	5,790	–	5/9-74	Qal	–	dug	1952	D	E	–	S.C. = 760 μmhos
E. Flaherty	A20	31.10.18.100	5,780	30	16/9-74	Qal	30?	drld	1950	D,S	E	*	taps shallow spring
J. Boston	A21	30.11.4.400	5,640	50	35/9-74	Qal	35?	drld	–	D,S	E	–	S.C. = 890 μmhos
C. Van Dusen	A22	30.11.9.000	–	–	–	Qal	–	–	–	–	–	*	
A. Moore	A23	30.11.10.000	–	32	–	Qal	–	agrd	1958	–	E	–	
R. Chavez	A24	29.9.3.200	5,612	16	6/10-74	Qal	–	dug	1960	D,S	E	–	S.C. = 460 μmhos
M. Jacquez	A25	29.9.4.100	5,615	54	36/10-74	Qal	–	drld	1958	D	E	–	S.C. = 820 μmhos
C. Gurule	A26	29.9.4.100	5,610	45	–	Qal	45?	drld	–	D	E	*	
R. Gutierrez	A27	29.9.4.400	5,575	20	9/10-74	Qal	–	dug	1911	D	N	–	S.C. = 595 μmhos
EPNG, Barnes #2	S2	32.11.23.300	6,200	585	–	Tsj	126?	drld	1953	I	–	–	P&A
EPNG, Schwertfeger #4	S11b	31.9.10.300	6,520	462	–	Tsj	100	drld	1952	I	–	–	P&A
EPNG, Riddle #1D	S12	31.9.17.300	6,490	550	–	Tsj	40	drld	1953	I	–	–	yielded 6 gpm; P&A
EPNG, Barret #1	S13	31.9.19.000	6,560	517	–	Tsj	55	drld	1952	I	–	–	yielded 20 gpm; P&A
EPNG, Barret #2	S14	31.9.20.200	6,260	202	–	Tsj	30	drld	–	I	–	–	yielded 20 gpm; P&A
Little Pump	S15	31.9.28.100	6,180	100+	51/2-76	Qal-Tsj	–	drld	–	S	–	*	not used
EPNG, Schwertfeger #1	S16	31.9.27.300	6,080	120	–	Tsj	25	drld	–	I	–	–	yielded 40 gpm
EPNG, Schwertfeger #2	S17	31.9.27.400	6,080	118	–	Tsj	34	drld	1952	I	–	–	yielded 20 gpm
EPNG, Turner #1	S20	30.10.13.000	6,480	425	345/?	Tsj	–	drld	–	I	–	–	
EPNG, Florance #1	S22	30.10.24.200	6,280	293	–	Tsj	–	drld	1953	I	–	–	yielded 20 gpm
EPNG, Barnes #1	N1	32.11.24.200	6,200	105	–	Tn	35	drld	1953	I	–	–	
EPNG, Horton #1	N2	32.11.29.300	6,400	588	–	Tn	55	drld	1953	I	–	–	outside Aztec quad.
EPNG, Neal #6	N3	32.11.33.200	6,150	321	–	Tn	48	drld	1953	I	–	–	
N.M. Port of Entry	N4	32.10.16.400	5,680	750	51/3-75	Tn	–	drld	–	D	–	*	
M. Randalmon	N5	31.11.24.300	5,700	173	7/9-74	Tn	–	drld	–	–	–	–	not potable
R. Pettijohn	N6	31.11.34.300	5,720	95	69/9-74	Tn	–	drld	1960	D	E	–	S.C. = 2240 μmhos
G. Saline	N7	31.11.35.300	5,720	–	8/9-74	Tn	–	drld	1952	D	E	–	S.C. = 1575 μmhos
EPNG, Lucerne #1	N8	31.10.10.200	6,120	455	–	Tn	67	drld	1955	I	–	–	yielded 25 gpm
EPNG, Kelly	N10	31.10.14.300	6,250	555	–	Tn	28	drld	1954	I	–	–	P&A
EPNG, Riddle #20	N11	31.9.20.300	6,520	510	–	Tn	150?	drld	1953	I	–	–	yielded 50 gpm
K. McCament	N13	30.11.19.100	5,575	143	24/9-74	Tn	–	drld	1968	S	E	–	S.C. = 1240 μmhos
Atlantic, State #1	N14	30.10.2.100	6,360	520	–	Tn	55	drld	1954	I	–	*	yielded 30 gpm
B. Redding	N15	30.10.3.400	6,400	320	50/?	Tn	–	drld	1975	D	E	*	
Hartman	N16	30.10.20.300	6,190	–	91/?	Tn	–	drld	–	S	W	–	
EPNG, Riddle #1	N17	30.10.23.200	6,280	311	–	Tn	20	drld	1952	I	–	–	yielded 20 gpm
EPNG, Knickerbocker #1	N18	30.10.23.400	6,219	886	–	Tn	–	drld	1972	I	E	*	
Slane Canyon	N19	30.10.27.100	6,180	–	53/9-75	Tn	–	drld	–	S	W	–	
EPNG, Quigley #1	N20	30.9.6.300	6,320	396	–	Tn	37	drld	1953	I	–	–	yielded 16 gpm
EPNG, Wood River #1	N21	30.9.8.200	6,200	258	–	Tn	123	drld	–	I	–	–	yielded 25 gpm
R. Valencia	N22	30.9.35.300	5,620	30	2+/10-74	Tn	–	drld	–	D,S	E	–	S.C. = 4500 μmhos
C. Pacheco	N23	29.9.5.300	5,600	30	13/10-74	Tn	–	drld	1960		N	–	not used
F. Montoya	N24	29.9.6.400	5,630	48	22/10-74	Tn	–	drld	1962	D	E	–	S.C. = 1750 μmhos

Hydrogeology (Con'T)

[illegible]
the Ojo Alamo Sandstone is only about 1,000 ft (300 m) deep, this source could be tapped if only fair quality water were required.

Stone, W. J., 1976, Index to [illegible] resource data: New Mexico Bureau of Mines and Mineral Resources, Ann. Rept. for July 1, 1975, to June 30, 1976, p. 38-43

TABLE 3—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE AZTEC QUADRANGLE. Well field numbers correspond to those in table 1; see fig. 9 for locations. Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, HCO_3 = bicarbonate, SO_4 = sulfate, Cl = chlorine. Concentrations of constituents given as equivalents per million; TDS = total dissolved solids, ppm = parts per million; μmhos = micromhos.

owner or well name	field no.	date	HCO_3	Cl	SO_4	Na	K	Mg	Ca	TDS (ppm)	specific conductance (μmhos)
B. Heizer	A2	8/75	2.25	0.48	2.54	1.61	0.00	1.85	2.01	308	550
N.M. Port of Entry	N4	3/75	0.41	115.66	0.44	95.70	0.17	0.72	19.46	6,754	12,700
F. Clark	A4	9/75	3.75	2.56	4.58	9.35	0.04	0.58	1.39	687	1,120
A. Flaherty	A6	8/75	4.25	1.11	25.44	15.77	0.07	3.17	12.21	1,923	2,600
C. Lanier	A7	9/75	3.00	0.85	4.89	2.18	0.19	2.78	4.02	528	943
M. Bishop	A9	8/75	2.59	0.72	3.04	1.57	0.04	1.97	3.00	694	650
F. Randalmon	A10	8/59	4.61	0.73	3.04	1.52		0.56	5.09	484	777
A. Hill	A11	8/75	2.25	0.64	9.26	3.09	0.02	2.47	5.99	759	950
G. Foster	A13	8/75	2.75	0.31	2.39	1.07	0.11	0.82	3.73	317	610
L. Likes	A14	8/75	2.51	0.68	12.70	4.22	0.03	1.40	9.73	1,021	1,320
Pan Am Petroleum	A17	4/59	6.00	1.61	7.77	5.83	–	2.23	7.34	1,104	–
J. Hollar	A18	9/75	4.51	0.71	3.44	4.57	0.05	1.73	2.62	508	820
F. Flaherty	A20	9/75	4.25	0.41	5.20	2.14	0.49	1.87	5.39	576	780
C. Van Dusen	A22	7/54	4.95	1.07	61.22	26.27		–	–	–	4,320
C. Curulo	A26	2/76	1.50	0.28	5.33	3.61	0.09	0.52	3.27	512	840
Little Pump	S15	2/76	5.24	0.68	4.64	5.22	0.28	2.14	2.84	643	1,205
Atlantic State #1	N14	11/75	1.75	0.34	11.26	2.00	0.07	1.86	9.46	1,004	1,523
EPNG, Knickerbocker #1	N18	3/72	0.20	0.60	75.00	65.00	–	1.10	8.80	5,204	–
EPNG, Knickerbocker #1	N18	10/74	2.00	1.00	54.00	46.00	–	1.00	10.00	1,921	–

TABLE 4—CHEMICAL ANALYSES OF WATER FROM SPRINGS IN THE AZTEC QUADRANGLE. Spring field numbers correspond to those in table 2; see fig. 9 for locations. Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, HCO_3 = bicarbonate, SO_4 = sulfate, Cl = chlorine. Concentrations of constituents given as equivalents per million; TDS = total dissolved solids, ppm = parts per million; μmhos = micromhos.

spring name	field no.	date	HCO_3	Cl	SO_4	Na	K	Mg	Ca	TDS (ppm)	specific conductance (μmhos)
Cave	S1	6/75	2.51	0.40	16.64	4.44	0.21	1.73	14.20	1,305	1,650
Cattail	S3	6/75	3.75	0.40	5.04	6.05	0.22	1.40	1.60	567	820
High Hopes	S4	8/75	2.00	0.17	1.46	0.42	0.05	0.62	2.60	208	350
Arch Rock	S7	6/75	2.25	0.17	1.97	1.34	0.00	0.86	2.26	256	390
Hart #1	S8	6/75	1.25	0.07	1.25	0.77	0.00	1.44	1.31	150	295
Hart #2	S9	6/75	3.25	0.65	3.89	1.50	0.05	1.32	4.61	454	700
Last Chance	S10	6/75	1.25	0.11	0.59	0.68	0.00	0.18	1.09	110	183
Hidden	S11a	6/75	2.75	0.60	19.73	6.96	0.08	3.17	13.61	1,528	1,800
Cottonwood	S18	6/75	2.25	0.17	1.87	1.04	0.03	0.99	2.30	249	450
Mud	S19	9/75	2.00	0.12	8.95	1.70	0.09	1.89	7.37	709	1,000
Garrison	N9	6/75	1.25	0.07	0.99	0.45	0.01	0.34	1.61	136	
Thurston	N12	6/75	2.75	0.53	41.60	22.29	0.11	2.47	21.50	3,081	2,900

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TABLE 8. Produced Water Chemical Concentrations from Dakota Formation Gas and Oil Well Locations. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Consolidated O&G	Tenneco	Tenneco	Southland Royalty
SAMPLING STATION	Separator at Langendorf 1E	Separator at San Juan Gravel A-1E	Pit at Gravel A-1E	Pit at Flora Vista 1
LOCATION	31N-13W-34P	29N-13W-21H	29N-13W-21H	30N-12W-22F
POOL	Basin-Dakota	Basin-Dakota	Basin-Dakota	Basin-Dakota
DATE	4/5/84	4/6/84	4/6/84	4/6/84
CALCIUM	360	670	570	190
MAGNESIUM	72	150	120	71
SODIUM				
POTASSIUM				
BICARBONATE				
CARBONATE				
SULFATE (600)	4,431			
CHLORIDE (250)	11,323			
FLUORIDE (1.6)				
TDS (1000)	15,294			
pH (Units)				
COD				
TOC				
ALUMINUM (5.0)	0.12	0.16	1.6	0.85
ARSENIC (0.1)	0.068	0.033	0.27	0.057
BARIUM (1.0)	L0.10	1.7	1.5	0.24
BERYLLIUM	L0.10	L0.10	L0.10	L0.10
BORON (0.75)	6.2	4.1	3.3	4.6
CADMINUM (0.01)	L0.10	0.12	0.14	L0.10
CHROMIUM (0.05)	0.16	0.46	0.36	0.26
COBALT (0.05)	L0.10	L0.10	L0.10	L0.10
COPPER (1.0)	L0.10	L0.10	0.20	0.22
IRON (1.0)	19	14	5.6	2.6
LEAD (0.05)	0.22	0.33	0.35	0.34
MANGANESE (0.2)	0.32	0.82	0.72	0.58
MERCURY (0.002)	L0.0005	L0.0005	L0.0005	L0.0005
MOLYBDENUM (1.0)	L0.10	0.14	0.19	0.16
NICKEL (0.2)	L0.10	0.17	0.11	L0.10

TABLE 8 continued.

SELENIUM (0.05)	0.31	0.139	0.072	0.24
SILICON	28	26	25	38
SILVER (0.05)	L0.10	L0.10	L0.10	L0.10
STRONTIUM	18	82	52	17
TIN	0.24	0.33	0.30	0.28
VANADIUM	0.10	0.18	0.12	L0.10
YTTRIUM	L0.10	L0.10	L0.10	L0.10
ZINC (10.0)	L0.10	L0.10	0.16	0.13
BENZENE (0.01)	14.4	8.86	4.5	3.2
TOLUENE (15.0)	12.2	10.2	0.76	0.73
ETHYLBENZENE	0.28	0.77	0.068	0.08
p-XYLENE	1.3	0.74	0.06	0.13
m-XYLENE	4.6	2.1	0.7	3.3
o-XYLENE	1.6	0.23	0.23	0.43
COLLECTOR	OCD	OCD	OCD	OCD
ANALYST	SLD	SLD	SLD	SLD
COMMENTS	1 section E of Vul. area, rptd '83 wtr 4675 bbls	In vul area, rptd '83 wtr 0 bbls	In vul area, sample from below oil layer	In vul area, wtr 1 ft. in pit, rptd '83 wtr 948 bbls

TABLE 8. continued. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Pioneer	Tenneco	Tenneco	Amoco
SAMPLING STATION	Condensate at Ellsworth 1	Separator at Cornell A-1E	Separator at Valdez A-1E	Separator at Gallegos Canyon Unit Com 94E
LOCATION	30N-12W-29N	29N-12W-10N	29N-11W-24G	29N-13W-23A
POOL	Basin-Dakota	Basin-Dakota	Basin-Dakota	Basin-Dakota
DATE	4/6/84	9/6/84	9/6/84	9/7/84
CALCIUM		44.0/49	24/25	760.0/690
MAGNESIUM		11.3/5.8	7.3/3.7	170.8/120
SODIUM		759	426	11,270
POTASSIUM		26.9	5.07	335
BICARBONATE		291.8	59.1	502.8
CARBONATE		0.0	0.0	0.0
SULFATE (600)		23.6	160.5	None Detected
CHLORIDE (250)		1205	641.4	21,969
FLUORIDE (1.6)		0.25	0.06	0.44
TDS (1000)		2200	1238	34,650
pH (Units)		8.0	7.7	7.3
COD				
TOC		153		229
ALUMINUM (5.0)		L0.10	L0.1	0.31
ARSENIC (0.1)		L0.005	L0.005	0.012
BARIUM (1.0)		0.65	L0.1	0.33
BERYLLIUM		L0.10	L0.1	L0.10
BORON (0.75)		0.50	0.2	0.20
CADMINUM (0.01)		L0.10	L0.1	L0.10
CHROMIUM (0.05)		L0.10	L0.1	L0.10
COBALT (0.05)		L0.10	L0.1	L0.10
COPPER (1.0)		0.15	L0.1	0.11
IRON (1.0)		49.	70	150
LEAD (0.05)		L0.10	L0.1	0.17
MANGANESE (0.2)		0.36	0.55	2.1
MERCURY (0.002)				
MOLYBDENUM (1.0)		L0.10	L0.1	L0.10
NICKEL (0.2)		L0.10	L0.1	L0.10

TABLE 8 continued.

SELENIUM (0.05)		L0.005	0.006	0.029
SILICON		10	3.1	18
SILVER (0.05)		L0.10	L0.1	L0.10
STRONTIUM		2.3	1.2	140
TIN		L0.10	L0.1	0.14
VANADIUM		L0.10	L0.1	L0.10
YTTRIUM		L0.10	L0.1	L0.10
ZINC (10.0)		L0.10	L0.1	0.15
BENZENE (0.01)	12,400		21.9	21.8
TOLUENE (15.0)	80,400		42.6	14.2
ETHYLBENZENE	1,910		0.96	L1
p-XYLENE	3,530		2.4	L1
m-XYLENE	61,600		9.7	2.2
o-XYLENE	7,760		2.0	1
COLLECTOR	OCD	OCD	OCD	OCD
ANALYST	SLD	SLD	SLD	SLD
COMMENTS	In vul area, rptd '83 wtr 69 bbls, sample is condensate from separator drip pipe	No organics sampled, 2 sections N. of vul. area, rptd '83 wtr, 0 bbls.	Dual completion well, in vul. area, rptd '83 wtr 0 bbls.	In vul area, rptd '83 wtr. 280 bbls, has fiber-glass tank

TABLE 8. continued. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Union Texas	Union Texas	Union Texas	Duncan
SAMPLING STATION	Separator at Zachry 16	Pit at Zachry 16	Separator at Albright 7E	Battery Pit at Hogback 6
LOCATION	29N-10W-33H	29N-10W-33H	29N-10W-22P	29N-16W-6L
POOL	Basin-Dakota	Basin-Dakota	Basin-Dakota	Slick Rock Dakota (Oil)
DATE	1/11/85	1/11/85	1/11/85	1/11/85
CALCIUM	8.6/13.	473/320	82.4/65.	33.0/45.
MAGNESIUM	1.7/0.93	24.3/7.6	10.9/8.7	L0.1/10.
SODIUM	633	757	1785	610
POTASSIUM	4.29	5.46	112	7.80
BICARBONATE		629.8		
CARBONATE		0		
SULFATE (600)	94.6	1548	2510.4	405
CHLORIDE (250)	436.4	444	326	141.8
FLUORIDE (1.6)	0.57	0.60	0.39	1.02
TDS (1000)	1536.0	3336	4934	1720
pH (Units)	8.08	7.73	7.69	7.83
COD				
TOC				
ALUMINUM (5.0)	0.20	7.8	L0.10	3.0
ARSENIC (0.1)	0.050	0.017	0.019	0.017
BARIUM (1.0)	0.13	0.37	0.22	0.11
BERYLLIUM	L0.10	L0.10	L0.10	L0.10
BORON (0.75)	0.56	0.54	0.83	0.15
CADMINUM (0.01)	L0.10	L0.10	L0.10	L0.10
CHROMIUM (0.05)	0.19	L0.10	L0.10	L0.10
COBALT (0.05)	L0.10	L0.10	L0.10	L0.10
COPPER (1.0)	0.27	L0.10	L0.10	L0.10
IRON (1.0)	190	14	13.	8.1
LEAD (0.05)	0.32	L0.10	L0.10	L0.10
MANGANESE (0.2)	2.8	1.9	0.12	0.42
MERCURY (0.002)				
MOLYBDENUM (1.0)	L0.10	L0.10	L0.10	L0.10
NICKEL (0.2)	0.12	L0.10	L0.10	L0.10
SELENIUM (0.05)	0.008	0.008	0.020	0.010
SILICON	0.58	1.8	1.5	0.81
SILVER (0.05)	L0.10	L0.10	L0.10	L0.10

TABLE 8. continued.

STRONTIUM	0.43	11	3.3	0.50
TIN	7.63	L0.10	L0.10	L0.10
VANADIUM	L0.10	L0.10	L0.10	L0.10
YTTRIUM	L0.10	L0.10	L0.10	L0.10
ZINC (10.0)	1.1	L0.10	L0.10	0.26
BENZENE (0.01)	64.6	2.18	29.7/18.4	ND
TOLUENE (15.0)	53.4	5.34	55.8/22.8	ND
ETHYLBENZENE	1.95	ND	0.80/0.27	ND
p-XYLENE	4.59	0.52	1.93/0.49	ND
m-XYLENE	16.25	2.10	5.96/1.34	0.015
o-XYLENE	4.26	0.50	0.80/0.52	ND
COLLECTOR	OCD	OCD	OCD	OCD
ANALYST	SLD	SLD	SLD	SLD
COMMENTS	1 Section S. of vul area, rptd '83 water 0 bbls, Tin values as reported by SLD	Line btwn pit & separator frozen,4" snow 0n 1/9/85	In vul area little wtr in pit, rptd '83 wtr 73 bbls, dual completion well, 2 organic samples taken.	Unsaturated hydrocarbons detected, pit in vul area, battery serves 9 wells, pit out of service for 3 months, wtr goes to inject well, some water in pit may be snow melt.

TABLE 9. Produced Water Chemical Concentrations from Mesaverde Formation Gas Well Locations. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Tenneco	Tenneco	Southern Union Exploration	
SAMPLING STATION	Separator at Florence 2	Separator at Florence 37A	Separator at Largo Fed 1A	Pit at Largo Federal 1A
LOCATION	30N-9W-20A	30N-8W-6J	29N-9W-34C	29N-9W-34C
POOL	Blanco Mesaverde	Blanco Mesaverde	Blanco Mesaverde	Blanco Mesaverde
DATE	9/6/84	9/6/84	1/11/85	1/11/85
CALCIUM	8.0/11.	1.6/1.3		293/250
MAGNESIUM	4.9/0.40	0.7/0.34		9.7/6.4
SODIUM	166.	0.0		94.3
POTASSIUM	9.75	0.00		1.95
BICARBONATE	212.0	17.3		-
CARBONATE	0.0	0.7		-
SULFATE (600)	12.6	6.3		680
CHLORIDE (250)	165.7	3.0		73.3
FLUORIDE (1.6)	0.14	0.04		0.20
TDS (1000)	488.	50.		1420
pH (Units)	8.03	7.16		6.96
COD				
TOC				
ALUMINUM (5.0)	L0.10	L0.10		2.1
ARSENIC (0.1)	L0.005	L0.005		0.055
BARIUM (1.0)	0.35	L0.10		L0.10
BERYLLIUM	L0.10	L0.10		L0.10
BORON (0.75)	L0.10	L0.10		L0.10
CADMINUM (0.01)	L0.10	L0.10		L0.10
CHROMIUM (0.05)	L0.10	L0.10		L0.10
COBALT (0.05)	L0.10	L0.10		L0.10
COPPER (1.0)	0.53	0.37		L0.10
IRON (1.0)	26.	45		5.6
LEAD (0.05)	L0.10	L0.10		L0.10
MANGANESE (0.2)	0.20	0.42		1.4
MERCURY (0.002)				
MOLYBDENUM (1.0)	L0.10	L0.10		L0.10
NICKEL (0.2)	L0.10	L0.10		L0.10

TABLE 9. continued

SELENIUM (0.05)	L0.005	0.006		L0.005
SILICON	2.9	0.66		0.79
SILVER (0.05)	L0.10	L0.10		L0.10
STRONTIUM	0.51	L0.0		2.2
TIN	L0.10	L0.10		L0.10
VANADIUM	L0.10	L0.10		L0.10
YTTRIUM	L0.10	L0.10		L0.10
ZINC (10.0)	L0.10	L0.10		L0.10
BENZENE (0.01)	29.5	15.8	65.0	4.40
TOLUENE (15.0)	26.3	20.6	2.43	3.15
ETHYLBENZENE	0.55	0.67	0.03	ND
p-XYLENE	0.93	1.6	0.04	0.25
m-XYLENE	3.2	7.6	0.14	1.60
o-XYLENE	1.1	2.0	0.04	0.35
COLLECTOR	OCD	OCD	OCD	OCD
ANALYST	SLD	SLD	SLD	SLD
COMMENTS	2 Sec N. of vul. area, rptd '83 wtr 0 bbls.	2 Sec. N. of vul. area, rptd '83 wtr 0 bbls.	1 Sec. S. of vul. area, rptd '83 wtr 0 bbls, not enough water in separator for inorganics, other unsaturated hydrocarbons detected in organic analysis.	Pit had water and paraffin, 4" snow on 1/9/85, other unsat. hydrocarbons detected.

TABLE 9. continued. (All concentrations given in mg/e. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Union Texas Petroleum
SAMPLING STATION	Separator at Albright 7E
LOCATION	29N-10W-22P
POOL	Blanco Mesaverde
DATE	1/11/85
CALCIUM	98.7/72
MAGNESIUM	20.8/14.
SODIUM	3809
POTASSIUM	95.9
BICARBONATE	
CARBONATE	
SULFATE (600)	L0.5
CHLORIDE (250)	5721.2
FLUORIDE (1.6)	0.57
TDS (1000)	10,094
pH (Units)	7.59
COD	
TOC	
ALUMINUM (5.0)	0.11
ARSENIC (0.1)	0.034
BARIUM (1.0)	21.
BERYLLIUM	L0.10
BORON (0.75)	0.30
CADMINUM (0.01)	L0.10
CHROMIUM (0.05)	L0.10
COBALT (0.05)	L0.10
COPPER (1.0)	0.64
IRON (1.0)	29
LEAD (0.05)	0.93
MANGANESE (0.2)	0.21
MERCURY (0.002)	
MOLYBDENUM (1.0)	L0.10
NICKEL (0.2)	L0.10
SELENIUM (0.05)	0.037
SILICON	4.2

SILVER (0.05)	L0.10
STRONTIUM	13
TIN	0.15
VANADIUM	L0.10
YTTRIUM	L0.10
ZINC (10.0)	0.39
BENZENE (0.01)	13.2
TOLUENE (15.0)	20.3
ETHYLBENZENE	0.5
p-XYLENE	1.2
m-XYLENE	4.2
o-XYLENE	1.5

COLLECTOR	OCD
ANALYST	SLD
COMMENTS	Dual completion well, in vul. area, rptd '83 wtr. 73 bbls., other unsat. hydrocarbons detected.

TABLE 10. Produced Water Chemical Concentrations from Gallup Formation Oil Well Locations. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	Greenwood Resources	Greenwood Resources	Slayton Oil Company	Union Texas Petroleum
SAMPLING STATION	Storage tank at Kirtland #3	Buried Steel tank at Kirtland #11	Recycled wtr at NW Cha Cha Unit Waterflood	Pit at Zachry 30
LOCATION	29N-14W-18B	29N-14W-18C	29N-14W-21	19N-10W33A
POOL	Cha Cha Gallup (Oil)	Cha Cha Gallup (Oil)	Cha Cha Gallup (Oil)	Armenta Gallup (Oil)
DATE	1/11/85	1/11/85	1/11/85	1/11/85
CALCIUM	32.6/24.	172/130	18.8/18.	180/170.
MAGNESIUM	L0.1/4.1	47.4/28	L0.1/2.8	34.0/36.
SODIUM	2841	5785	2065	1155
POTASSIUM	16.8	74.1	13.7	149
BICARBONATE	1177.5	86.4	934	221.1
CARBONATE	287.0	0	127.6	0
SULFATE (600)	10.7	L0.5	44.6	308
CHLORIDE (250)	2409	2990	3161	1800
FLUORIDE (1.6)	2.27	0.51	3.31	0.55
TDS (1000)	7146	15,960	5214	4046
pH (Units)	8.37	7.9	8.43	7.2
COD				
TOC				
ALUMINUM (5.0)	L0.10	L0.10	L0.10	L0.10
ARSENIC (0.1)	0.025	0.041	0.020	0.014
BARIUM (1.0)	5.3	16	1.1	0.33
BERYLLIUM	L0.10	L0.10	L0.10	L0.10
BORON (0.75)	3.3	1.4	2.4	2.6
CADMINUM (0.01)	L0.10	L0.10	L0.10	L0.10
CHROMIUM (0.05)	L0.10	L0.10	L0.10	L0.10
COBALT (0.05)	L0.10	L0.10	L0.10	L0.10
COPPER (1.0)	L0.10	L0.10	L0.10	L0.10
IRON (1.0)	10.	40	0.55	1.7
LEAD (0.05)	L0.10	L0.10	L0.10	L0.10
MANGANESE (0.2)	0.11	0.59	0.08	0.95

TABLE 10. continued

MERCURY (0.002)				
MOLYBDENUM (1.0)	L0.10	L0.10	L0.10	L0.10
NICKEL (0.2)	L0.10	L0.10	L0.10	L0.10
SELENIUM (0.05)	0.030	0.049	0.021	0.015
SILICON	2.0	2.3	0.94	1.1
SILVER (0.05)	L0.10	L0.10	L0.10	L0.10
STRONTIUM	5.2	35	2.8	7.9
TIN	L0.10	0.12	L0.10	L0.10
VANADIUM	L0.10	L0.10	L0.10	L0.10
YTTRIUM	L0.10	L0.10	L0.10	L0.10
ZINC (10.0)	L0.10	L0.10	L0.10	L0.10
BENZENE (0.01)	5.75	2.90	7.30	0.58
TOLUENE (15.0)	2.90	0.93	2.80	0.74
ETHYLBENZENE	0.1	None Detected	0.22	0.16
p-XYLENE	0.09	0.09	0.16	0.15
m-XYLENE	0.41	0.45	0.66	0.48
o-XYLENE	0.27	0.26	0.29	0.24
COLLECTOR	OCD	OCD	OCD	OCD
ANALYST	SLD	SLD	SLD	SLD
COMMENTS	In vul area, rptd '83 wtr 5133 bbls, other unsat. hydrocarbons detected in organic no wtr. in Co. formerly Caribou Four Corners	In vul area, rptd '83 wtr 177 bbls, other unsat. hydrocarbons detected	Other unsat. hydrocarbons detected in organic analysis	1 Sec. S. of vul. area, rptd '83 wtr 0 bbls., 4" snow 1/9/85, other unsat. hydrocarbons detected; no wtr. in separator, pit also receives wtr from tank drain.

TABLE 11. Produced Water Chemical Concentrations from Chacra Formation Gas Well Locations. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	TENNECO	UNION TEXAS PETROLEUM
SAMPLING STATION	Separator at Valdez A-1E	Separator at Zachry 22
LOCATION	29N-11W-24G	29N-10W-33B
POOL	Otero Chacra	Otero Chacra
DATE	9/6/84	1/11/85
CALCIUM	196./180.	22.2
MAGNESIUM	50.3/48.	1.82
SODIUM	8901.	1102
POTASSIUM	83.9	8.58
BICARBONATE	766.4	
CARBONATE	0.0	
SULFATE (600)	ND	2.3
CHLORIDE (250)	16,632	1773.3
FLUORIDE (1.6)	0.72	0.15
TDS (1000)	24,615	
pH (Units)	7.76	
COD		
TOC		
ALUMINUM (5.0)	L0.1	
ARSENIC (0.1)	0.13	
BARIUM (1.0)	18.	
BERYLLIUM	L0.1	
BORON (0.75)	1.1	
CADMINUM (0.01)	L0.1	
CHROMIUM (0.05)	L0.1	
COBALT (0.05)	L0.1	
COPPER (1.0)	0.14	
IRON (1.0)	16	
LEAD (0.05)	L0.1	
MANGANESE (0.2)	0.14	
MERCURY (0.002)		
MOLYBDENUM (1.0)	L0.1	
NICKEL (0.2)	L0.1	
SELENIUM (0.05)	0.038	

TABLE 11. continued

SILICON	7.5	
SILVER (0.05)	L0.1	
STRONTIUM	22.	
TIN	L0.1	
VANADIUM	L0.1	
YTTRIUM	L0.1	
ZINC (10.0)	0.23	
BENZENE (0.01)	5.4	
TOLUENE (15.0)	7.4	
ETHYLBENZENE	0.49	
p-XYLENE	0.65	
m-XYLENE	2.4	
o-XYLENE	0.99	
COLLECTOR	OCD	OCD
ANALYST	SLD	SLD
COMMENTS	Dual Completion well, in vul. area, rptd '83 wtr. 0 bbls.	1 Sec. S of vul. area, rptd '83 wtr. 0 bbls., organic sample frozen and broken, separator produced about 3 qts. distillate, little wtr. to get sufficient sample.

TABLE 12. Produced Water Chemical Concentrations from Two Miscellaneous Sites. (All concentrations given in mg/l. NM ground water standards given in left margin. Blank spaces indicate constituent not analyzed or not reported. L = Less than. Heavy metal samples acidified, not filtered.)

LESSEE	A. L. BYRD	EL PASO NATURAL GAS
SAMPLING STATION	Pit at Hare 1	Pit at Pipeline drip
LOCATION	29N-11W-14O	32N-13W-35J
POOL	Bloomfield Farmington (Oil)	Unknown
DATE	1/11/85	1/10/85
CALCIUM	369/320.	/24
MAGNESIUM	15.8/17.	/5.0
SODIUM	4432	649
POTASSIUM	10.1	6.24
BICARBONATE		
CARBONATE		
SULFATE (600)	L0.5	579
CHLORIDE (250)	7540.6	596.2
FLUORIDE (1.6)	1.47	0.21
TDS (1000)	13,092	1916
pH (Units)	7.6	7.4
COD		
TOC		
ALUMINUM (5.0)	L0.10	7.5
ARSENIC (0.1)	0.104	0.010
BARIUM (1.0)	4.0	0.10
BERYLLIUM	L0.10	L0.10
BORON (0.75)	0.42	0.20
CADMINUM (0.01)	L0.10	L0.10
CHROMIUM (0.05)	L0.10	L0.10
COBALT (0.05)	L0.10	L0.10
COPPER (1.0)	L0.10	L0.10
IRON (1.0)	3.2	31.
LEAD (0.05)	L0.10	L0.10
MANGANESE (0.2)	0.59	0.51
MERCURY (0.002)		
MOLYBDENUM (1.0)	L0.10	L0.10
NICKEL (0.2)	L0.10	L0.10

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

Case No. 8224 Exhibit No. 15
Submitted by OCD
Hearing Date 4-3-85

Notes of Oscar Simpson
April 5-6, 1984 Sampling DGK 3/15/85

Sample 1-A, 1AB, 1-ABC (See Pictures)
location - 1110' FSL & 875 FEL SEC. 34 T31N R13W
DATE & TIME - 4-5-84 11:00AM SJ County
Collected By - OAS & MP
Well Name - Langendorf
Company - Consolidated Oil & Gas Co.
Comments collected samples of produced water from discharge pipe of 3 phase seperator that was discharging into lined pit (Seperator closest to lined pit)
Formation Dakota & Mesa Verde
- there are two wells & 2 seperators
- Need to determine which is what
- Near La Plata River Valley

Sample #1-A Langendorf (4) 40 mL glass viles with teflon caps - no preservatives test for organics

Sample #1-AB 1qt cube container
NF - NA
& placed on ice

Sample #1-ABC 1qt cube container
NF-A-10 ML HNO_3
& Placed on ice
test for metals

Sample #2 - Longendorf (glychol Dehydrator,
2-40 mL glass Viles (w) Teflon Caps

location: South 3 phase seperator from discharge
pipe - see pictures

SJ Co. Sec 34 T31N R13W at lined pit

Date + Time 4-5-84 11:00AM

Collected By DAS + MP

Well Name Longendorf

Company Consolidated Oil + Gas Co.

Comments - sample of south glychol dehydrator
discharge pipe - steam + liquid
comming off smell of hydrocarbon
see pictures

form Dakota or Mesa Verde

Sample #3 PiPE 2-40 ML glass viles with Teflon

location - Sec. 21 T29N R13W
800' FEL + 1540 FNL
(Name) San Juan gravel A-1E
San Juan Co. NM
Form Dakota /PC

Date + time 4-6-84 7:00AM

Company Tenneco oil Company

Remarks . sample of prod water at discharge of 3 phase seperator before going into unlined pit (see pictures)
- Note pit has a 2" thick oil + Parafin surface on pit

By OAS - sample in area of shallow ground water 3' to water
- area had surface water 30 yds to the NE next to River + a gravel Co.

Sample #3-A same as above
1 qt cube container
NF-A-10 mL HNO3
test for metals

Sample #4 PiT same loc of pit water 2-40 ML ViLES
Water from pit below oil layer

Sample #4-B PiT Same loc of pit water 1 qt cu cont
NF-A-10 ML HNO3

Sample #5 Pioneer Prod. NO. 1

location (N) W½ Sec 29 T30N R12W
well Ellsworth Unit NO 1
Pioneer Production Corp.
SJ Co. NM 320 AC Fe lease
300' FSL 2140 FWL

Date & Time (Fri) 4-6-84 12:25PM

By DAS

remarks of just off S of 200' yds of hwy
bet Farmington & Aztec in
& around houses from discharge
pipe of seperator - dripping
pure hydrocarbon see pict on grd.
& next to arroyo & houses

— 2-40 mL glass vials w Teflon caps
no pres.

PS

Sample #6 Southland of Southland Royalty Co-Joe

Location Sec 22 T30N R12N SJ Co NM

2500 FNL 1700 FWL

Florvita Well No 1

Date & time 4-6-84 (Fri) 1:00 PM

By OAS

Remarks Sample of pit water that received discharges from 3 phase separator & tank battery in River Valley of Animas See Pictures
- Water 1' deep in pit & black with hydrocarbon screen

1-qt cuba container of pit water for metals
NF-A 10 mL HNO_3

Field notes for
D. Boyer, NMOCD,
Farmington - San Juan
Basin Trip Sept 5-7, 1984
DG Boyer

Tenneco Florence #2 (Mesa Verde)
84-09-06-1205
Produced water sample
taken (8409061205 send
results to Marty) from separator
4 pits - besides normal
3, had "blowdown pit"
where water & oil "down"
by natural line
pressure into pit, several
bbs blown every week
or so to unlined pit.
Since is at Atms. pressure
can't go into low pressure
line.

~900
Tenneco has [illegible] wells
in SJB; 500 Dakota,
400 in other wells in
other formations)

25,000 bbl/day produced
water at Hospah; no
pits, is injected

Tenneco Florence #2 (Mesa Verde)
84-09-06-1205
Produced water sample
taken (8409061205)(send
results to Marty) from separator
4 pits - besides normal
3, had "blowdown pit"
where water took "down"
by natural line
pressure into pit, several
bbl blown every week
or so to unlined pit.
Since is at Atms. pressure
can't go into low pressure
line.

Florence 37A - Mesa Verde

(1) 300 ft cathodic protection
well - Flows
*~5 gpm. Gas Fumes seen at end
of pipe prior to stock
tank. Flow due to
either (a) natural shallow
gas in formation or
from fractures
(natural or man made?)
(b) or leaky casing from
nearby wells.
8409061426

(2) sample from separator
prior to discharge to pit,
Mesa Verde produced water
8409061440

* measured (w) 2 1/2 gallon bucket

Valdez A-1-E

(1) Dakota Produced Water,
prior to Pit 8409061605

(2) Chacra Produced Water,
prior to Pit
8409061615
(Dual completion)

Cornell A-1-E
Dakota Produced water
prior to Pit
8409061650

Amoco
Gallegos Canyon Unit
Com NO 94E
NENE Sec 23, 29N 13W

Produced Dakota water
840907 1330
Sample from Separator
(includes some drip, used
paper towel & can to separate
prior to bottling) water in
Fiberglass tank

Fieldnotes for
D. Boyer, OCD,
Farmington-San Juan
Basin Trip Jan 10-11, 1985.

DKBoyer

EPNG Pipeline Drip
NE La Plata
T32N, R13W, Sec 35.413
(400' NE Greenhorn Cemetery)
Sample taken 8501101420

Small amount of water in bottom. May include much or some snow melt
Pit ≈10'×6'; 2½' deep.

Snow about 1" deep on N-facing slope, absent elsewhere (original snow depth ≈ 4")

Pit sides and tumbleweeds blown in discolored (gray black)

Leave Santa Fe 7AM 1/10/85
Return Santa Fe 10PM 1/11/85
OF-6981, Chev. Malibu
1/9 - Snow in SF, 1/10 snow on highway near Cuba

1/11/85

Union Texas Petrol
Zachry #30 A

960 FNL, 570 FEL
(NE, NE) Sec 33 T29N R10W
Lease SF 080724-A.
Gallup Formation
(Oil Well)
850111 0845 Pit

~~850111 0850~~ Separator
(unable to obtain; no H_2O)
Pit receives water
From separator
& tank drain

UT Petroleum
Picture Cliffs Drip
From Gathering line
(Pit Dry, Drip Dry

(990N 990E) Sec 33.22
Zachry #8 29-10
Lease SF 080724

U-T Petroleum
Chacra
850111 0910
Zachry #22

(950 FNL, 1520 E) Sec 33.21 (NW of NE)
Obtained organic sample *
from drip, unable to obtain
enough Produced water for Ca/An, HI
(Produced about 3 quarts
distillate, little H_2O)
~~1510 N, 1030 E, Sec 33~~
(One sample only NF, NA)

* Organic sample frozen and
broken 1/12/85 AWB

Zachry #16

1510 N, 1030' E, Sec 33.24
Dakota Well.

(850111092 5
(sample from Pit)

(850111093 3
(sample from separator)

Line between well
and separator frozen

Pictured Cliffs Formation
wells generally dry
of water, - when dumps
were mainly "drip"
(distillate) + several
gallons.

U.T. Petroleum
Compressor station
4' x 4' unlined
Tank drain pit had
3-4" of oil.

South Union Exp.
Largo Federal 1A

T29N 9W Sec 34, 21
1190N [illegible] 1595W
Mesa Verde
(850111 1110 Pit)
Pit had water & Paraffin
(8501 11117 Separator)

Unable to get sample from
separator except for
organics - Not enough
water, mainly drip.

Union-Texas
Albright 7E
Mesa Verde / Dakota
Dual Completion
790S 790E Sec 22 29N 10W
Little water in Pit, Samples from:
(Mesa Verde 850111155) Separator

(Dakota 850111207) Separator
Sect 22, 44

Oil well – Mitchell Const Co.
Hare #1, Bloomfield
S.E., S.E. Section 14, 29N, 11W
8x10x2' ~~[illegible]~~ unlined pit
Full of oil & water
Farmington Sand Oil Well
8501111225

1.3 miles E of Highway 44
on Hwy 17 &
KOA Campground
(See Notes of Shuey at end of this section

Kirtland #3
Greenwood Resources
(Gallup well)
8501111355
Sample from produced
H_2O storage tank
Each day well makes 18 bbl oil
15 bbl H_2O
50 mcf gas
Elev. 5193 (Sec 18, 21B2
730 FNL 2250 FEL
Sec 18, T29N, 14W

Kirtland #11
Greenwood Res. Co.
8501111415

Sample from ~~[illegible]~~ Pit
(steel tank buried)
after separator

E1/2, NW 1/4 Sec 18, T29N R14W
1310 FNL 1740 FWL
Elev. 5,141 ft. (Sec 18, 1411)

Road Entrance
(Location 1.6 miles E of St. Michael ch)
Slayton Oil Co. Waterflood
(Gallup)
NW Cha Cha Unit
29N 14W Sec 21, 231
~1000 BBLS
(can work up to 1500 bbls)
8501111500
Inj water from alluvium
at River
10 injection wells
over several miles of

T29N, R14W
(Kirtland Quad)

Walter Duncan
Hogback #6, 5:20pm
Pit at Tank battery
~150' E of North Hogback #6

1900 FSL 620 FWL
Sec 6 T29N R16W
8501111600

Battery has about 9 wells producing about 7 barrels produced water which goes to an injection well. Up to 3 months ago (when separator fixed) pit received lots of water. Pit is ~25 × 8 × 5' (unknown how long condition exists, water in pit may be snow melt.)

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
Case No. 8224 Exhibit No. 16
Submitted by OCD
Hearing Date 4-3-85

ORGANIC COMPOUNDS AND GROUND-WATER POLLUTION

There are more than one million organic compounds; this article will help you understand their origins and their significance in ground water.

by Wayne A. Pettyjohn and Arthur W. Hounslow

Introduction

Pollution of ground water by organic compounds is widespread but only recently have the public and regulatory agencies awakened to this hazard. In the greatest number of cases the pollution has been the result of thoughtless or careless activities, often based on a foundation of ignorance. Who would have thought, for example, that the widespread use of septic tank cleaners on Long Island would lead to unusually high levels of trichloroethylene, a chlorinated hydrocarbon, in the ground water. Nematodes in the agricultural fields of California are a serious problem, but neither the agriculturalists nor the manufacturers suspected that the nematocide DBCP (dibromochloropropane) would infiltrate to such an extent that it would become a significant ground-water pollutant.

Water supplies contaminated by organic compounds may be characterized by unusual taste, odor or even color, but in cases such as these, the consumer is at least forewarned. Much more insidious are those supplies that contain small concentrations that are not easily detected or even looked for during routine chemical analysis. The long-term health effects brought about by consumption of low levels of organic contaminants over a long time period are simply unknown, or based on speculation and educated guesses.

Organic chemical pollution is characterized by great complexity, not only because of the substantial number of compounds but because organic molecules can be very small to unusually large, and these substances may react or interact to form entirely new and sometimes unexpected products. It has been reported that chlorine, phenolic compounds and acetic acid wastes discharged to a disposal pond reacted to form the herbicide 2, 4-D, which not only contaminated the ground water but also led to crop damage when the water was used for irrigation (Middleton and Walton 1961).

Most hydrogeologists have at least some knowledge of ground-water pollution by gasoline or other petroleum products, ABS, LAS and pesticides. More recently such terms as PCB, PBB, carbamates, kepone and C-56, as well as a group of almost unpronounceable chemicals, such as di-n-butyl phthalate, 3-methylcyclohexanol, tetrachloroethane, trichloroethylene and dichloromethane, have begun to make their appearance in the literature.

Hydrogeologists, among others, need to have some understanding of these compounds. Some compounds, for example, have great mobility in the subsurface environment and migrate quickly through confining layers or the unsaturated zone. Others are almost immediately sorbed and still others are quickly degraded by microbiological activity. Some compounds are soluble in water, others are not; some are more dense and others are less dense than water. These factors have an influence on the design of detection and monitoring systems.

Chemistry of Organic Compounds

Organic chemistry deals with the study of compounds that contain carbon. Originally it was assumed that organic compounds could only be obtained from plant or animal sources but in reality, many can be synthesized from inorganic matter. Today, in fact, most organic compounds are synthesized, sometimes from inorganic material, but most commonly from other organic compounds, such as petroleum or coal.

The apparent complexity of organic chemistry diminishes when one understands three basic differences that exist between organic and inorganic chemistry.

- Organic compounds are molecules in the true sense of the word. The bonding is predominantly covalent. They do not form extended three-dimensional lattice structures as does, for example, sodium chloride.
- When dissolved in water, organic compounds usually do not dissociate into ions as do many inorganic compounds. If dissociation does occur it is usually very limited. Thus, a molecule of methane (CH_4) when dissolved in water will remain as a molecule of methane. Halite, on the other hand, when dissolved in water will no longer be halite, but will consist of an aqueous solution of sodium and chloride ions.
- The third and most significant difference is that organic chemistry is primarily a study of a number of characteristic or functional groups, each of which possesses certain well-defined properties. These groups are usually simple combinations of two or more of the following atoms: C, H, O, S, N, P. Examples are: -OH alcohol or phenol groups, -COOH acid, $-NH_2$ amine groups.

The presence of such fundamental groups in a molecule confers upon that molecule the properties characteristic of its group. Once these properties have been determined by studying a few relatively simple molecules containing them, this knowledge can be applied to predict with considerable accuracy how a more complex molecule, containing the same groups, would react.

Carbon atoms can bond to form chains (straight or branched) or rings (cyclic compounds) or mixtures of the two. Moreover, these molecules may contain thousands of atoms.

Hydrocarbons such as petroleum distillates like kerosene, gasoline, paraffin, and naphtha, contain only carbon and hydrogen. Hydrogen atoms can be replaced by other atoms or groups of atoms to form derivatives. Many insecticides, for example, are chlorinated hydrocarbons that are formed by replacing hydrogen atoms with chlorine atoms. Most hydrocarbon compounds are obtained from natural sources. Carbolic acid (phenol), creosote, coal tar and coal gas (methane) are derived by destructive distillation of coal. Similarly, wood yields wood alcohol (methanol), acetone, acetic acid and charcoal. Fractional distillation of coal tar produces benzene, toluene, naphthalene and anthracene.

The natural complex organic molecules synthesized by living organisms are primarily fats, carbohydrates and proteins. The chemical treatment of many carbohydrates will yield starch and sugars. The sugars may be changed by fermentation to ethanol (ethyl alcohol) and acetic acid.

A few of the more common and most important organic compounds include methane (natural gas, marsh gas, fire damp); acetylene; benzene, which is used in the manufacture of dyes; the solvent chloroform (trichlormethane); and methanol. The latter is a very poisonous compound that is easily oxidized to formaldehyde, reacts with acids to form esters, and is used as a solvent, a fuel, as antifreeze and in the manufacture of varnishes and shellacs. Ethanol is used as a solvent, in beverages, in organic synthesis, as a fuel, in the preparation of ether and chloroform, as antifreeze, and in medicines. Glycerol, a trihydroxy alcohol obtained from fats, is used in the preparation of pharmaceuticals, nitroglycerine and dynamite, as well as antifreeze mixtures. The solvent acetone is used in the preparation of chloroform, lacquers and explosives, while acetic acid is used in making vinegar, white lead (lead acetate), esters and dyes. Ethyl ether is a solvent and anesthetic.

Other important compounds include a variety of fats and oils used for food and the manufacture of soap. For example, sucrose is used as a food, a food preservative and in making glucose. Cellulose, a natural fiber, is used for making paper and rayon, while nylon, a synthetic material, is utilized for clothing, cord for tires, toothbrushes, etc. Many other synthetic fibers (Dacron, Orlon and Teflon), have important commercial uses.

Plastics are substances that can be molded into any desired shape and include a multitude of different synthetic compounds employed in the manufacture of a great number of common items. Vitamins, antibiotics (such as aureomycin), the sulfa drugs, anesthetics, antiseptics and germicides are also common organic compounds.

It is abundantly clear that organic compounds are a necessary part of every day living. Also evident is the fact that a large percentage eventually become waste or by their use, end up some place in the environment. Thus, organic compounds, either naturally occurring or man-made, are truly ubiquitous. It is not surprising that the man-made compounds, in particular, are being detected with increasing frequency in both surface and ground water.

Analysis of Organic Compounds

The concentration of organic compounds in water is determined and reported in a variety of ways; these represent a considerable range in purpose and accuracy. Techniques used for scanning samples and obtaining a general range in concentration include COD, BOD, TOC, DOC, SOC and MBAS. Specific molecules or groups, particularly those that appear in the parts per billion (ppb) range, are examined by GC, MS and a variety of other sophisticated methods.

Chemical oxygen demand (COD) is commonly used to determine the amount of organic pollution in municipal and industrial waste and is based on the assumption that all organic compounds can be oxidized to carbon dioxide and water. Results are reported as milligrams of oxygen per liter. The test cannot distinguish between biologically oxidizable and biologically inert organic matter, but on the other hand, the method requires little time.

The amount of oxygen required by bacteria to oxidize organic material to carbon dioxide under aerobic conditions is the biochemical oxygen demand (BOD). BOD values are generally less than COD. The BOD test is used to evaluate domestic and municipal wastes. Its major disadvantage is that it requires a minimum of five days to complete.

Concentrations of total organic carbon (TOC) are generally less than the actual amount of organic matter present in a water sample (Standard Methods, p. 532), but it is a more direct expression of the amount than either BOD or COD. The test can be carried out in a few minutes. TOC consists of dissolved organic carbon (DOC) and suspended organic carbon (SOC). DOC reflects the concentration of organic matter in a water sample that passes through a 0.45-micrometer silver membrane filter (Malcolm and Leenheer 1973) and it may indicate the existence of organic compounds that are soluble in water.

Pollution of ground water by synthetic detergents, in particular the surfactant alkyl benzene sulfonate (ABS), led to frothing and the covering of many water courses with a thick layer of foam. In the mid-1960s, the detergent industry completed its switch from the non-biodegradable branched chain alkyl group to the more biodegradable linear alkalate sulfonate (LAS), which consists of a straight-chain alkyl group. Of course, detergents still find their way into ground-water supplies and the chemical test for their presence is reported as MBAS (methylene-blue-active substances).

If the concentrations of organic compounds in water are exceedingly low, the water to be sampled is pumped through a column filled with activated carbon, which concentrates the organic matter. The organic matter is then desorbed from the packed column with chloroform. Chloroform desorbs neutral and basic organic compounds, which are largely nonpolar, such as heptanes, xylenes, toluene and other derivatives of benzene. Results are reported as carbon chloroform extract (CCE).

Similarly the carbon columns can be flushed with alcohol (ethanol) to release acids or polar substances, such as the chlorophenols, nitrophenols and cresote. This is reported as the carbon alcohol extract (CAE).

These methods can be used for determining the general organic concentration in a water sample and with special additional laboratory procedures, the extract can be analyzed to determine specific organic compounds or classes of compounds. On the other hand, some organic compounds may not be sorbed on the column or extracted by the solvent used, thus leading to negative errors.

In addition to traditional carbon-filled columns, investigators now employ columns packed with a macroreticular resin, such as trade-named XAD-2, or a polyamide resin, such as trade-named Polyamide Woelm (PAW). These resins have a high capacity for sorption of certain organic compounds that occur in extremely dilute concentrations in water and, therefore, offer certain advantages over activated carbon. Other workers are attempting to develop satisfactory analytical methods for determining the presence and concentration of chlorinated organic compounds exclusively. They will be reported as TOCl (total organic chlorine).

The tests thus far described are broad, screening tests generally presupposing the presence of parts per million (ppm) quantities of organics. These minute concentrations have little meaning to most people; by way of example keep in mind the fact that 1 ppm represents 1 drop in 10 gallons, or 1 ounce of vermouth in an 8,000 gallon tank car of gin. On the other hand, 1 part per billion (ppb) represents a half teaspoon in a 600,000 gallon water tower. If this water tank was full of a pollutant and it was emptied into Lake Ontario (volume = 1,720 km^3) the resulting mixture in the lake would contain about 1.3 ppb of this pollutant.

There are basically two approaches for the instrumental analysis of small quantities of organics. One technique uses the absorption of various wavelengths of electromagnetic radiation from x-rays to radiowaves. These methods have been available for several decades but are becoming more precise and sophisticated with the continuing revolution in microelectronics. The analyses do, however, rely on skillful experienced operators for interpretation of results. Examples include X-ray diffraction, ultraviolet, visible and infrared absorption spectroscopy, Raman spectroscopy, electron spin resonance (esr) and nuclear magnetic resonance (nmr).

The second, more recent technique, which is more amenable to computerized multi-sample processing, is gas chromatography followed by mass spectrometry (GC/MS). The gas chromatographic system separates groups of compounds, which are then detected by mass spectroscopy. In the latter device, the molecule is ionized by a beam of high-energy electrons. This results in a series of charged fragments of various sizes that are separated by a magnetic field according to charge-to-mass ratios. The number of particles of each mass is recorded. The GC/MS technique is ideal for highly volatile organics, which are separated and concentrated by an inert gas purge of the water sample. In other cases the organics are concentrated by solvent extraction or sorption/desorption before running the analysis.

Unfortunately many of the organic compounds in most water are non-volatile and non-extractable, and thus not amenable to the GC/MS techniques. In cases such as these, each sample must be analyzed on an individual basis using one or more of the classical techniques discussed earlier.

One aspect of organic analysis that is frequently overlooked is the proper collection and preservation of the water samples. Because the concentration of many organic contaminants is so small, the opportunities for sample contamination are legion. Examples of improper collection and storage include the use of rubber or cheap plastic hoses for sample collection and the use of organic additives in drilling fluids. More subtle is the possibility of sorption of the organics from the water by the containers in which they are stored, or their removal from the solution by microbial degradation (Pettyjohn and others 1981). Thus many of the existing analyses of trace organics are questionable at best.

Toxicity

The investigator may be in a position of having spent $200 to $2,000 or more for an organic analysis of a water sample. The burning question then becomes: "Is the water safe to drink?" This is possibly the most difficult question to answer in any water-quality investigation. Even the question itself is ambiguous because one needs to define how much and over what period.

Our usual interpretation of toxicity is one of immediate poisoning or acute toxicity. It answers the question how much one can consume before dying. An example is the ingestion of one fifth of gin, vodka, scotch, etc., over a period of an hour or so. If the amount of alcohol in the blood exceeds 0.4-0.5 percent, a coma and frequently death results.

More important in water-quality studies is the concept of chronic toxicity, which is the long-term effect of ingesting a particular contaminant. This may be stated as "What harmful effects will result from drinking this contaminated water each day for a life-time?" Will the end result be cancer, or could genetic mutations be induced or could a fetus suffer damage, or could one's life span be shortened by other problems? These are but a few of the questions that must be answered. Present methods of obtaining these data, however, are primitive in the extreme. At best we can extrapolate over n-mouse generations and at worst make a guess. Even then we cannot take into account interactions between various pollutants; thus the presence of compound A may make compound B an order of magnitude more (or less) toxic than if it were consumed alone. We are all aware of the time it took to determine that long-term cigarette smoking leads to an increased risk of cancer, but then again, so does overexposure of the skin to sunlight. There are many additives in our foods. Can the effect of these be separated from the effect of other organics in our water supplies. Epidemology is a statistical study of populations beset with difficulties, such as population movement, lack of matching controls, unreliable dose data, and the 20- to 30-year latency of many diseases.

In the water-quality criteria for the protection of human health, the Environmental Protection Agency (45 FR 79318, November 28, 1980) uses three criteria to set limits based on carcinogenic, toxic or organoleptic (taste and odor) properties. The carcenogenic criteria are based on the average ingestion of two liters/day of water and the results expressed as an increase of cancer over a lifetime for a specific population. They use one additional case of cancer in a population of 100,000, 1,000,000 and 10,000,000. Some of these criteria are presented in Table 1.

Another aspect of risk determination that must be assessed is the concept of threshold, that is, is there a safe level? One must also keep in mind that zero risk is probably not attainable.

A good example of risk-benefit considerations is the use of chlorine for killing microorganisms in water. The number of deaths resulting from water-borne diseases, such as cholera and typhoid fever, was staggering prior to the widespread practice of chlorinating public water supplies. Recently it has been found that chlorine reacts with some organic compounds in the water to form chloroform, a potential carcinogen. Do we therefore immediately stop the chlorination of water? The choice is a high probability of illness from a water-borne disease, or a much lower probability of dying of cancer in the future.

Table 1
Water-Quality Criteria for the More Common Toxic Pollutants in Water

Toxic Pollutants in Water

Name	PDWS (1, 5)	T-O (2, 5)	Toxic (3, 5)	Cancer (4, 5)
Hydrocarbons with or without O and/or N functional groups				
Non-Aromatic Chains				
Acrolein -			320 μg/L	
Acrylonitrile				0.058 μg/L
N-Nitroso Dimethylamine				1.4 ng/L
N-Nitroso Diethylamine				0.8 ng/L
N-Nitroso Di-N-Butylamine				6.4 ng/L
N-Nitroso Diphenylamine				4900 ng/L
N-Nitrosopyroline				16.0 ng/L
Single Ring Aromatics				
Benzene				0.66 μg/L
Toluene			14.3 mg/L	
Ethyl Benzene			1.4 mg/L	
Phenol		0.3 mg/L	3.5 mg/L	
2,4-Dimethylphenol		400 μg/L		
2,4-Dinitrophenol			70 μg/L	
2,4—Dinitro-O-Cresol			13.4 μg/L	
Nitrobenzene		30 μg/L	19.8 mg/L	
2,4-Dinitrotoluene				0.11 μg/L
Dimethyl Phthalate			313 mg/L	
Diethyl Phthalate			350 mg/L	
Dibutyl Phthalate			34 mg/L	
Di-2-Ethyl Hexyl Phthalate			15 mg/L	
Polycyclic Aromatics				
Acenaphthene		20 μg/L		
Fluoranthene			42 μg/L	
Benzidine				0.12 ng/L
1,2-Diphenyl Hydrazine				42 ng/L
Organohalogen Compounds				
Non-Aromatics				
Methane Derivatives				
Halomethanes	100 μg/L			0.19 μg/L
Chloroform				0.19 μg/L
Carbon Tetrachloride				0.4 μg/L
Ethane Derivatives				
Chloroethene (Vinyl Chloride)				2.0 μg/L
1,2-Dichloroethane				0.94 μg/L
Dichloroethylene				0.33 μg/L
1,1,1-Trichloroethane			18.4 mg/L	
1,1,2-Trichloroethane				0.6 μg/L
Trichloroethylene				0.8 μg/L
1,1,2,2-Tetrachloroethane				0.17 μg/L
Tetrachlorethylene				1.8 μg/L
Hexachloroethane				1.9 μg/L
Propane Derivatives				
Dichloropropane/Dichloropropene			87 μg/L	
Butane Derivatives				
Hexachlorobutadiene				0.45 μg/L

Pentane Derivatives				
Hexachlorocyclopentadiene		1.0 μg/L	206 μg/L	
Hexane Derivatives				
Hexachlorocyclohexane				
Alpha HCH				9.2 ng/L
Beta HCH				16.3 ng/L
Gamma HCH (Lindane)	4 μg/L			18.6 ng/L
Technical HCH				12.3 ng/L
Complex Cyclic Compounds				
Aldrin				0.074 ng/L
Dieldrin				0.71 ng/L
Chlordane				0.46 ng/L
Heptachlor				0.28 ng/L
Isophorone			5.2 mg/L	
Endosulfan			74 μg/L	
Endrin	1 μg/L			
Toxaphene	5 μg/L			0.71 ng/L
Ether Derivatives				
Bis-(Chloromethyl)-Ether				0.0038 ng/L
Bis-(2-Chloroethyl)-Ether				0.03 μg/L
Bis-(2-Chloroisopropyl)-Ether			34.7 μg/L	
Single Ring Aromatics				
Monochlorobenzene		20 μg/L	488 μg/L	
Dichlorobenzenes			400 μg/L	
1,2,4,5-Tetrachlorobenzene			38 μg/L	
Pentachlorobenzene			74 μg/L	
Hexachlorobenzene				0.72 ng/L
Monochlorophenols		0.1 μg/L		
2,4-Dichlorophenol		0.3 μg/L	3.09 mg/L	
2,3-Dichlorophenol		0.04 μg/L		
2,5-Dichlorophenol		0.5 μg/L		
2,6-Dichlorophenol		0.2 μg/L		
3,4-Dichlorophenol		0.3 μg/L		
2,4,5-Trichlorophenol		1.0 μg/L	2.6 mg/L	
2,4,6-Trichlorophenol		2.6 μg/L		1.2 μg/L
2-Methyl 4-Chlorophenol		1800 μg/L		
3-Methyl 4-Chlorophenol		3000 μg/L		
3-Methyl 6-Chlorophenol		20 μg/L		
Pentachlorophenol		30 μgm/L	1.01 mg/L	
2,4-D	100 μg/L			
2,4,5-T	10 μg/L			
Polycyclic Aromatics				
3,3'-Dichlorobenzidine				0.013 μg/L
Polychlorinated Biphenyls				0.79 ng/L
DDT and Metabolites				0.24 ng/L
Methoxychlor	0.1 mg/L			

Notes:

1. EPA National Interim Drinking Water Regulations. 40 CFR 141, July 1, 1981.
2. *Organoleptic concentration; taste and odor.
3. *Toxic concentration.
4. *Increase in cancer risk over lifetime of one in one million.
   This does not represent a judgment on an "acceptable" risk level.

*Source: Modified after 45 FR 79318, November 28, 1980.

5. mg/L = milligrams/liter
   μg/L = micrograms/liter
   ng/L = nanograms/liter

Mobility

The detection of an organic compound in a ground-water sample should not be the end of an investigation. Rather, one needs to determine the contaminant's mobility and persistence. Is it lost by volatilization, is it sorbed on solid particles of soils or sediment, or is it degraded either by microorganisms or abiotically? Further, are the degradation products more or less troublesome than the original pollutant, and what is their mobility?

Owing to the complexity of the various physical, chemical and biological controls that influence the migration and degradation of organic compounds, no hard and fast rules regarding their occurrence in the subsurface can be readily established. Physical and chemical characteristics of these compounds may act in opposing manners so that the expected or predicted simply does not occur. Some organic compounds act as wetting agents and move quickly through earth materials of low permeability at rates that may exceed that of water. The difference in velocity of selected organic compounds originating at a particular site results in what is known as the chromatographic effect. For example, if a mixture of compounds is introduced into the subsurface, the different rates of migration of individual components will result in a halo effect characterized by diffuse zones that are typified by different compounds or groups.

Chromatographic movement is largely a function of the physical characteristics of the soil matrix as opposed to its chemical and biological properties. A predicted chromatographic movement is made more difficult, however, because of the interactions between the organic compounds and chemical-biological processes in the soil matrix.

Several mechanisms influence or control the migration and fate of organic compounds in the subsurface. These include, among others, sorption, volatility, dilution, biologic activity and chemical reaction.

Sorption

Most recent investigations have concentrated on defining sorption phenomena. Adsorption from an aqueous solution is the result of two processes (Weber 1972):

A. The solute has a low affinity for water, or

B. It has a high affinity for the solid.

In the former case the solute is hydrophobic and has a low solubility in water. In the second case the attraction of the solute to the adsorbant may result from charged surface sites, physical adsorption or actual bond formation. The subsurface solids primarily responsible for adsorption are solid organic matter, clay minerals and amorphous hydroxides.

Experimental determinations of adsorption result in a graph known as an adsorption isotherm. This is a plot of the amount of material adsorbed per gram of adsorbant versus the concentration of the adsorbate in solution. The results may be a straight line or an exponential curve.

In the case of hydrophobic organic compounds (with low water solubility), the predominant sorbent in soil and sediment is solid organic matter. It has been further established that the distribution of these hydrophobic organics between water and solid organic matter can be approximated by their distribution between water and the organic solvent octanol. This distribution coefficient also correlates reasonably well with their solubility in water. The sorption phenomenon, in several cases, serves as a major control on the migration of organic compounds. For example, the pesticide DDT is quickly sorbed by the soil and thus does not move freely in the ground. In a sandy soil with low organic matter content, chlorobenzene is sorbed to some extent, dichlorobenzene is retarded about twice as much and trichlorobenzene is sorbed even more. The low molecular weight chlorinated hydrocarbons, such as chloroform and trichloroethylene, are not sorbed appreciably by soil that does not contain appreciable concentrations of organic matter. On the other hand, highly water-soluble substances, such as acetone and methanol, are hardly retarded at all, but fortunately they are readily biodegraded.

Volatility

Many compounds, such as the halomethanes, are volatile, but the volatile loss is not too important once the substance is in the soil and the loss is insignificant after it mixes with ground water. Thus volatility is not an important attenuation mechanism when the compounds lie deeper than a foot or more below the soil surface.

Dilution

Any compound that reaches the water table has an opportunity to be attenuated by dilution, and many individuals look upon this aspect as a major control. Dilution, however well it may work in a stream, is not a process that can be depended upon to solve ground-water pollution problems. Due to the generally low ground-water velocity and laminar flow, mixing and thus dilution of a contaminant in the subsurface is the exception rather than the rule. Contaminants tend to maintain much of their integrity as they move from points of recharge to zones of discharge.,

Biodegradation

Synthetic organic compounds are not easily broken down by microbial action. The most degradable substances include those biologically produced, such as sugars and amino acids. Linear non-branched compounds are more easily biodegraded than are branched forms and rings. The side chains of the latter are generally attacked first.

During biodegradation, certain anaerobic bacteria commonly produce short-chain organic acids, while other forms further break down these byproducts to methane, carbon dioxide and inorganic substances. Aerobic bacteria decompose organic compounds into carbon dioxide and mineral matter, such as sulfate, nitrate and other inorganic compounds.

In some situations, organic compounds may not be readily biodegraded in ground water because of the absence of microbial population or because of overloading with contaminants. It is suspected, however, that both large and varied microbial populations are ubiquitous and require only sufficient amounts of nutrients to flourish, but this concept has not been adequately proven.

Abiotic Degradation

Many compounds can be transformed chemically in a reducing anaerobic environment, which occurs at some depth below the water table. DDT occurs in a highly oxidized state and is quickly reduced in ground water but new compounds are produced.

Hydrocarbons occur in a highly reduced state and, therefore, break down very slowly in an anaerobic environment, such as ground water. However, in an aerobic system, such as the soil, hydrocarbons degrade rapidly. This is the reason controlled disposal of used oils on the land surface is now being practiced on a limited scale.

Most of the halogenated organic compounds are more dense than water and thus will sink to the bottom of an aquifer or at least to a deeper unit of lower permeability. Examples include trichloroethylene and chloroform.

Sources of Organic Compounds in Ground Water

Organic compounds in ground water are either naturally occurring or result from man's activities. The latter, of course, are more widely publicized and the literature and news media make constant reference to examples. Sources are abundant and widespread, ranging from leaking gasoline storage tanks, industrial lagoons, spillage during transportation and septic tanks, to the use of agricultural chemicals, to mention only a few. The quantity in ground water and the concentration, particularly of solvents, in some instances is astonishing. An abbreviated list of the more toxic organic compounds that have contaminated ground water is shown in Table 1.

On the other hand, naturally occurring organic compounds are not widely discussed despite the fact that concentrations might amount to several parts per million. In central and western North Dakota, for example, many domestic and rural wells obtain their supplies from lignite seams. This water may range from colorless to black. There is no noticeable taste. Even high-yield municipal wells in this area, which generally tap outwash deposits, commonly produce brown water that is due to the presence of lignite.

One should expect ground water in a great many places to contain at least trace amounts of naturally occurring organic compounds. A major fraction of these compounds will be fulvic acid. It is suspected that these substances pose little problem themselves but they might well lead to or increase the mobility of heavy metals (Hounslow 1981) and possibly some organic contaminants. This could be a fruitful area of research.

Conclusions

There is much to learn about organic compounds in ground water, how they react and what we can do about them. There is no doubt that investigations by individuals trained in organic chemistry are urgently needed. Anyone who examines the literature soon realizes that lists, regulations and procedures are strongly influenced by bureaucrats and workers with little or no knowledge of chemistry.

Hydrogeologists need to critically examine chemical analyses and use care in the collection and storage of samples, as well as in the selection of commercial laboratories. Investigators also need to consider the chromatographic effect of organic compounds in ground water and the effect of well design, materials and sampling.

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Biographical Sketches

Arthur W. Hounslow is currently professor of geology, Oklahoma State University. He obtained his B.Sc. degree from the University of Melbourne (Australia) and M.Sc. and Ph.D. degrees from Carleton University (Canada). Dr. Hounslow has taught at Idaho State University and was employed as senior project mineralogist at Colorado School of Mines Research Institute and as a geochemist with the Ground-Water Research Branch of the U.S. Environmental Protection Agency. His current research interests include ground-water geochemistry, specifically rock-water interaction and organic and inorganic characterization of subsurface materials.

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BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
Case No. 8724 Exhibit No. 17
Submitted by OCD
Hearing Date 4-3-85