Fac/Perm/Co ID #	Date	Doc ID#
bc	11, 03, 98	DIN

50-02

1325 Dills Cove Rd.
Sylva, NC 28779

MOUNTAIN GEOLOGY, INC.

Phone & Fax
(828) 586-3955

10/30/98

NOV 1998
Received
Solid Waste
Section

Dave Fowler
Director of Services
Jackson County
401 Grindstaff Cove Rd
Sylva, NC 28779

RE: Statistical Analysis
Landfill Monitoring Wells

Attached is a report from G.N. Richardson & Associates regarding their statistical evaluation and analysis of ground water data from the landfill monitoring wells..

Monitor well # 2 is a background well and # 3 doesn't have statistically significant levels. Wells # 1, # 4, & # 5 have statistically significant concentrations of organic compounds, some of which are greater than groundwater standards. These are tabulated.

This information should be transmitted to:

Mark Poindexter
Solid Waste Section
P. O. Box 277687
Raleigh, NC 27611-7687

If you need further information, please contact me.

Michael H. Owens

MICHAEL H. OWENS

Statistically significant organic compounds

Well #	compound	max level (ug/l)	2L(ug/l)
1	1,1-dicloroethane	41.7	700.0
	* methylene chloride	84.0	5.0
	trichlorofluoromethane	15.9	2,100.0
	xylene	31.7	530.0
4	cis-1,2-dichloroethene	33.5	70.0
	* tetrachloroethene	9.9	0.7
5	* benzene	11.0	1.0
	1,4 - dichlorobenzene	11.3	75.0
	1,1-dichloroethene	12.0	700.0
	* cis-1,2-dichloroethene	75.3	70.0
	* tetrachloroethene	10.0	0.7
	* trichloroethene	11.0	2.8

* = greater than 2L groundwater standards

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

October 19, 1998

Mr. Mike Owens
Mountain Geology
1325 Dills Cove Road
Sylva, NC 28779

RE: Ground Water Statistical Analysis
Jackson County Landfill

Dear Mr. Owens:

G. N. Richardson and Associates, Inc. (GNRA) has completed a statistical evaluation and analysis of the ground water data from the above referenced site. This report summarizes the statistical methods and results of this analysis. Also included are summary tables, statistical outputs, and time-concentration graphs for your review.

Methods

The ground water data from 12/16/93 through 4/27/98 was entered into a statistical database for the site. This data was reviewed for data entry errors, and then filtered for detected constituents and imported into a statistical analysis package.

The statistical methodology followed the guidance set forth in the EPA Statistical Analysis of Ground Water Data at RCRA Facilities - Interim Final Guidance (1989) and the Addendum to Interim Final Guidance (1992). The methods also conform with current North Carolina regulations. General methods followed the attached flow chart (Appendix A).

The statistical properties (distribution, variance, percent non-detects, and basic statistics) of the data were examined to determine the most appropriate method of analysis. Time concentration graphs were reviewed for trends and changes, as well as possible outlier data. Following this review, each constituent was statistically analyzed using the methods listed on Table 1.

Due to the lack of normality in all of the data sets, non-parametric analysis methods were used. Constituents with less than 50% non-detects were analyzed using the Kruskal-Wallis non-parametric test. It is recommended that constituents with between 50% and 90% non-detects be analyzed using non-parametric prediction limits. However, the false positive rate for this test was 26.7%. Therefore, Kruskal-Wallis was used for this analysis as well. Kruskal-Wallis tests have been proven reliable for data sets with up to 90% non-detects. Constituents with over 90% non-detects and detected levels within the last four events were analyzed using Poisson prediction limits. Constituents with over 90% non-detects and detected levels in early sampling events only were not analyzed because prediction limits only use recent events to compare with background data.

The Kruskal-Wallis test ranks the data in order of increasing concentrations and then compares each compliance well to the background data set. The ranking of data eliminates any bias due to the lack of normal (bell shaped) distribution in the data.

Poisson prediction limits, recommended by the EPA for data with over 90% non-detects, compare each compliance well with a limit determined by the background data set. This method is questionable for two reasons. First, it was developed for use on complete VOC data scans, not individual parameters. Also, it was originally created to compare one data set with another, not multiple sets (compliance wells). For these reasons, we recommend a qualitative review of data for constituents with greater than 90% non-detected values.

Results

The results of the statistical analysis are summarized in Table 1. Statistical outputs (Appendix B) and time-concentration graphs (Appendix C) of constituents with statistically significant differences from background levels are included for your review.

Only one inorganic constituent, barium, showed statistically significant differences between compliance wells (MW-4 and MW-5) and the background well. All wells, including the background well, had detected results for barium. This result is most likely due to spatial variability in ground water chemistry. Barium is commonly found in ground water analyses as a naturally occurring metal.

Seven organic parameters, presented in Table 1, were found to be statistically significant using the Kruskal-Wallis test. Two additional parameters (trichloroflouromethane and xylenes) showed significant results using the Poisson limits. The results show statistically significant results for organic parameters in three wells: MW-1 (4 parameters), MW-4 (2 parameters), and MW-5 (6 parameters). MW-3 does not have significantly higher levels than background for any organic constituent.

A review of the time vs. concentration graphs for the constituents with significant results reveals a few trends. Organic concentrations in MW-5 are stable or decreasing slightly except for cis-1,2-dichloroethene. Monitoring well MW-1 shows increasing levels of methylene chloride and dichloroethane since the second sampling event in 1996. Monitoring well MW-4 seems to be slightly increasing in cis-1,2-dichloroethene while decreasing in tetrachloroethene. Overall, ground water quality at the Jackson County Landfill is relatively stable.

If you have any questions, or require further information, please do not hesitate to contact us at (919) 828-0577.

Sincerely,
G. N. Richardson and Associates

Philip May
Staff Scientist

Joan A. Finkbeiner, P.G.
Principal, Hydrogeologist

attachments

Table 1
Jackson County Landfill

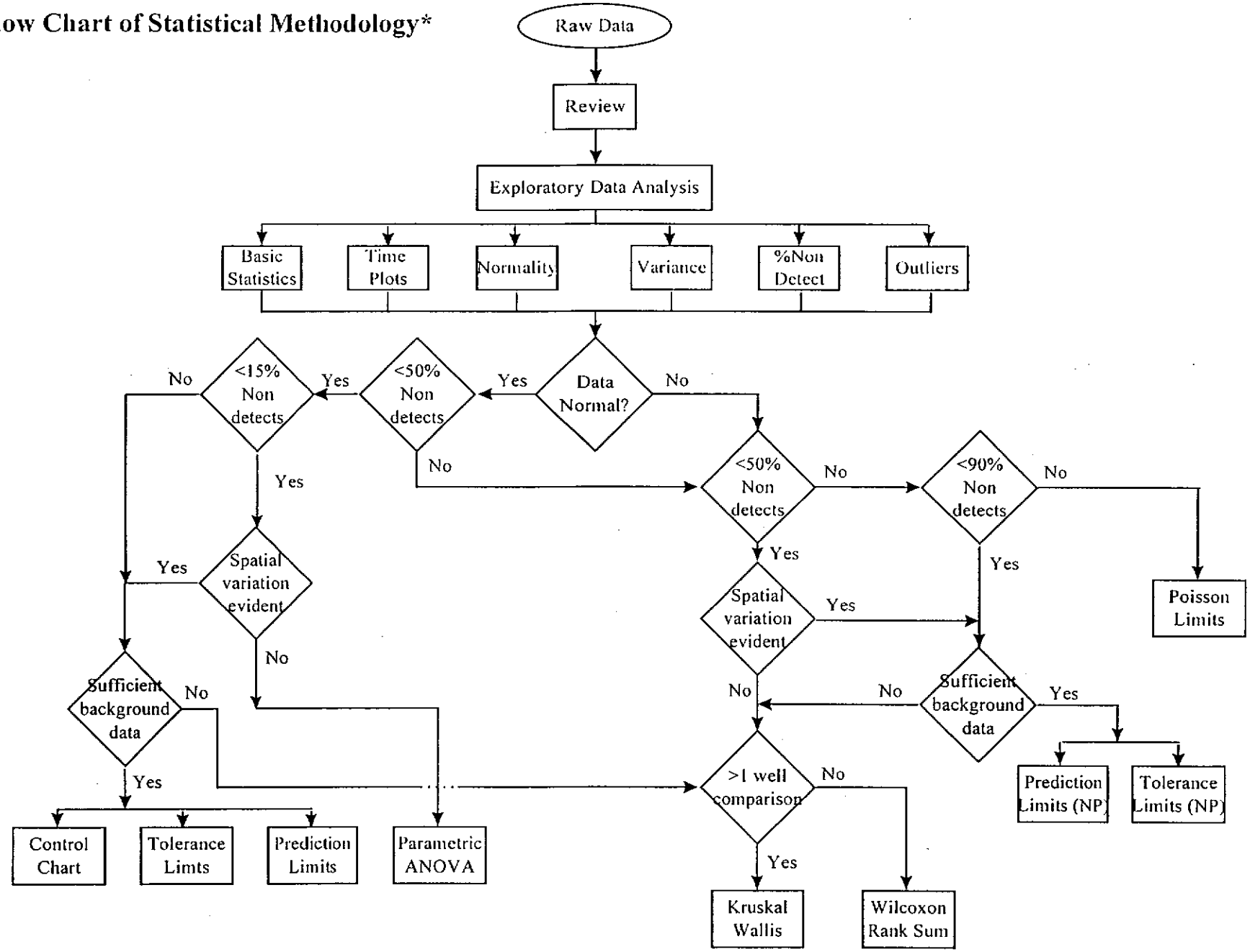
Statistical Summary

Inorganic parameters	Percent Non-detect	Detected 4/27/98	Statistical Method	Significant results? MW-1	MW-3	MW-4	MW-5
Antimony	96.4	No	NT				
Arsenic	94.5	No	NT				
Barium	34.5	Yes	KW			Yes	Yes
Cadmium	89.1	Yes	KW				
Cobalt	74.5	Yes	KW				
Copper	98.2	No	PO				
Lead	69.1	Yes	KW				
Nickel	98.2	No	PO				
Selenium	96.4	No	NT				
Vanadium	98.2	No	NT				
Zinc	52.7	Yes	KW				
Organic parameters	**Non-detect**		**Method**	**MW-1**	**MW-3**	**MW-4**	**MW-5**
Benzene	69.1	Yes	KW				Yes
Chlorobenzene	83.6	Yes	KW				
Chloroethane	90.1	Yes	KW				
1,4-Dichlorobenzene	76.4	Yes	KW				Yes
1,1-Dichloroethane	52.7	Yes	KW	Yes			Yes
1,2-Dichloroethane	98.2	Yes	PO				
cis-1,2-Dichloroethene	56.4	Yes	KW			Yes	Yes
1,2-Dichloropropane	96.4	Yes	PO				
Ethyl benzene	96.4	No	NT				
Methyl chloride	98.2	Yes	PO				
Methylene chloride	76.4	Yes	KW	Yes			
Tetrachloroethene	65.5	Yes	KW			Yes	Yes
Toluene	89.1	Yes	KW				
1,1,1-Trichloroethane	92.7	Yes	PO				
Trichloroethene	76.4	Yes	KW				Yes
Trichloroflouromethane	96.4	Yes	PO	Yes			
Vinyl chloride	85.5	Yes	KW				
Xylene	90.9	Yes	PO	Yes			

KW	Kruskal-Wallis non-parametric test
NT	Not tested
PO	Poisson prediction limit

APPENDIX A

Flow Chart of Statistical Methodology*



*Based on EPA Statistical Analysis of Ground-Water Data ar RCRA Facilities - Interim Final Guidance (1989) and Addendum to Interim Final Guidance (1992)

APPENDIX B

Kruskal-Wallis Non-Parametric Test
Parameter: Barium, total

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<500	10
	01/31/1994	ND<500	10
	02/24/1994	ND<500	10
	03/18/1994	ND<500	10
	10/27/1994	ND<500	10
	04/28/1995	ND<500	10
	03/05/1996	16	20
	10/07/1996	23	21
	05/07/1997	24	22
	11/10/1997	29	23
	04/27/1998	29	24

Rank Sum = 170
Rank Mean = 15.4545

Background Rank Sum = 170
Background Rank Mean = 15.4545

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<500	10
	01/31/1994	ND<500	10
	02/24/1994	ND<500	10
	03/18/1994	ND<500	10
	10/27/1994	ND<500	10
	04/28/1995	ND<500	10
	03/05/1996	57	28
	10/07/1996	63	30
	05/07/1997	59	29
	11/10/1997	83	34
	04/27/1998	65	31

Rank Sum = 212
Rank Mean = 19.2727

MW-4	12/16/1993	340	49
	01/31/1994	430	52
	02/24/1994	290	46
	03/18/1994	180	43
	10/27/1994	ND<500	10
	04/28/1995	468	54
	03/05/1996	442	53
	10/07/1996	374	51
	05/07/1997	326	48
	11/10/1997	930	55
	04/27/1998	320	47

Rank Sum = 508
Rank Mean = 46.1818

MW-5	12/16/1993	180	44
	01/31/1994	160	42
	02/24/1994	110	35
	03/18/1994	130	38

	05/07/1997	121	37
	11/10/1997	150	41
	04/27/1998	120	36

Rank Sum = 407
Rank Mean = 37

MW-1	12/16/1993	340	50
	01/31/1994	ND<500	10
	02/24/1994	ND<500	10
	03/18/1994	ND<500	10
	10/27/1994	ND<500	10
	04/28/1995	ND<500	10
	03/05/1996	42	25
	10/07/1996	54	27
	05/07/1997	51	26
	11/10/1997	71	33
	04/27/1998	66	32

Rank Sum = 243
Rank Mean = 22.0909

Calculation Results:

Kruskal-Wallis H Statistic = 29.145
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 30.395
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
29.145 > 9.48773 indicating possible contamination at 5% significance level
30.395 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 15.4545

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	19.2727	3.81818	15.4191
MW-4	46.1818	30.7273	15.4191
MW-5	37	21.5455	15.4191
MW-1	22.0909	6.63636	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 15.4545

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	19.2727	3.81818	15.4191
MW-4	46.1818	30.7273	15.4191
MW-5	37	21.5455	15.4191
MW-1	22.0909	6.63636	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: Benzene

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	19.5
	01/31/1994	ND<5	19.5
	02/24/1994	ND<5	19.5
	03/18/1994	ND<5	19.5
	10/27/1994	ND<5	19.5
	04/28/1995	ND<5	19.5
	03/05/1996	ND<5	19.5
	10/07/1996	ND<5	19.5
	05/07/1997	ND<5	19.5
	11/10/1997	ND<5	19.5
	04/27/1998	ND<5	19.5

Rank Sum = 214.5
Rank Mean = 19.5

Background Rank Sum = 214.5
Background Rank Mean = 19.5

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	19.5
	01/31/1994	ND<5	19.5
	02/24/1994	ND<5	19.5
	03/18/1994	ND<5	19.5
	10/27/1994	ND<5	19.5
	04/28/1995	ND<5	19.5
	03/05/1996	ND<5	19.5
	10/07/1996	3.87	43
	05/07/1997	ND<5	19.5
	11/10/1997	ND<5	19.5
	04/27/1998	1.87	39

Rank Sum = 257.5
Rank Mean = 23.4091

MW-4	12/16/1993	ND<5	19.5
	01/31/1994	ND<5	19.5
	02/24/1994	ND<5	19.5
	03/18/1994	ND<5	19.5
	10/27/1994	ND<5	19.5
	04/28/1995	ND<5	19.5
	03/05/1996	ND<5	19.5
	10/07/1996	3.42	41
	05/07/1997	ND<5	19.5
	11/10/1997	ND<5	19.5
	04/27/1998	2	40

Rank Sum = 256.5
Rank Mean = 23.3182

MW-5	12/16/1993	9.9	52
	01/31/1994	10	53
	02/24/1994	10	54
	03/18/1994	11	55

	05/07/1997	7.36	49
	11/10/1997	7.76	50
	04/27/1998	4.83	44

Rank Sum = 522.5
Rank Mean = 47.5

MW-1	12/16/1993	ND<5	19.5
	01/31/1994	ND<5	19.5
	02/24/1994	ND<5	19.5
	03/18/1994	ND<5	19.5
	10/27/1994	ND<5	19.5
	04/28/1995	ND<5	19.5
	03/05/1996	ND<5	19.5
	10/07/1996	3.65	42
	05/07/1997	5	45
	11/10/1997	5	46
	04/27/1998	ND<5	19.5

Rank Sum = 289
Rank Mean = 26.2727

Calculation Results:

Kruskal-Wallis H Statistic = 21.3634
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 31.8709
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
21.3634 > 9.48773 indicating possible contamination at 5% significance level
31.8709 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 19.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	23.4091	3.90909	15.4191
MW-4	23.3182	3.81818	15.4191
MW-5	47.5	28	15.4191
MW-1	26.2727	6.77273	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 19.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	23.4091	3.90909	15.4191
MW-4	23.3182	3.81818	15.4191
MW-5	47.5	28	15.4191
MW-1	26.2727	6.77273	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: 1,4-Dichlorobenzene

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	ND<5	21.5
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	ND<5	21.5

Rank Sum = 236.5
Rank Mean = 21.5

Background Rank Sum = 236.5
Background Rank Mean = 21.5

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	6.41	50
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	ND<5	21.5
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	2.19	43

Rank Sum = 286.5
Rank Mean = 26.0455

MW-4	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	5.23	47
	05/07/1997	ND<5	21.5
	11/10/1997	5.92	49
	04/27/1998	3.92	44

Rank Sum = 312
Rank Mean = 28.3636

MW-5	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	5.1	46
	03/18/1994	5.3	48

	05/07/1997	ND<5	21.5
	11/10/1997	11.3	54
	04/27/1998	11.1	53

Rank Sum = 445
Rank Mean = 40.4545

MW-1	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	ND<5	21.5
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	3.97	45

Rank Sum = 260
Rank Mean = 23.6364

Calculation Results:

Kruskal-Wallis H Statistic = 9.44398
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 17.0224
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
9.44398 < 9.48773 indicating no contamination at 5% significance level
17.0224 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	26.0455	4.54545	15.4191
MW-4	28.3636	6.86364	15.4191
MW-5	40.4545	18.9545	15.4191
MW-1	23.6364	2.13636	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	26.0455	4.54545	15.4191
MW-4	28.3636	6.86364	15.4191
MW-5	40.4545	18.9545	15.4191
MW-1	23.6364	2.13636	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: 1,1-Dichloroethane

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	15
	01/31/1994	ND<5	15
	02/24/1994	ND<5	15
	03/18/1994	ND<5	15
	10/27/1994	ND<5	15
	04/28/1995	ND<5	15
	03/05/1996	2.4	30
	10/07/1996	ND<5	15
	05/07/1997	ND<5	15
	11/10/1997	ND<5	15
	04/27/1998	3.07	33

Rank Sum = 198
Rank Mean = 18

Background Rank Sum = 198
Background Rank Mean = 18

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	15
	01/31/1994	ND<5	15
	02/24/1994	ND<5	15
	03/18/1994	ND<5	15
	10/27/1994	12.5	51
	04/28/1995	ND<5	15
	03/05/1996	ND<5	15
	10/07/1996	5.88	41
	05/07/1997	ND<5	15
	11/10/1997	5.32	39
	04/27/1998	2.52	31

Rank Sum = 267
Rank Mean = 24.2727

MW-4	12/16/1993	ND<5	15
	01/31/1994	ND<5	15
	02/24/1994	ND<5	15
	03/18/1994	ND<5	15
	10/27/1994	ND<5	15
	04/28/1995	ND<5	15
	03/05/1996	4.3	36
	10/07/1996	4.04	35
	05/07/1997	ND<5	15
	11/10/1997	5.83	40
	04/27/1998	2.79	32

Rank Sum = 248
Rank Mean = 22.5455

MW-5	12/16/1993	11	48
	01/31/1994	10	47
	02/24/1994	11	49
	03/18/1994	12	50

	05/07/1997	5.06	38
	11/10/1997	5	37
	04/27/1998	3.19	34

Rank Sum = 447
Rank Mean = 40.6364

MW-1	12/16/1993	ND<5	15
	01/31/1994	ND<5	15
	02/24/1994	ND<5	15
	03/18/1994	7	45
	10/27/1994	ND<5	15
	04/28/1995	ND<5	15
	03/05/1996	7.9	46
	10/07/1996	21.7	52
	05/07/1997	25.4	53
	11/10/1997	41.7	55
	04/27/1998	32.1	54

Rank Sum = 380
Rank Mean = 34.5455

Calculation Results:

Kruskal-Wallis H Statistic = 14.8357
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 17.3814
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
14.8357 > 9.48773 indicating possible contamination at 5% significance level
17.3814 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 18

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	24.2727	6.27273	15.4191
MW-4	22.5455	4.54545	15.4191
MW-5	40.6364	22.6364	15.4191
MW-1	34.5455	16.5455	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 18

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	24.2727	6.27273	15.4191
MW-4	22.5455	4.54545	15.4191
MW-5	40.6364	22.6364	15.4191
MW-1	34.5455	16.5455	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: cis-1,2-Dichloroethene (-ethylene)

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	16
	01/31/1994	ND<5	16
	02/24/1994	ND<5	16
	03/18/1994	ND<5	16
	10/27/1994	ND<5	16
	04/28/1995	ND<5	16
	03/05/1996	ND<5	16
	10/07/1996	ND<5	16
	05/07/1997	ND<5	16
	11/10/1997	ND<5	16
	04/27/1998	ND<5	16

Rank Sum = 176
Rank Mean = 16

Background Rank Sum = 176
Background Rank Mean = 16

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	16
	01/31/1994	ND<5	16
	02/24/1994	ND<5	16
	03/18/1994	ND<5	16
	10/27/1994	ND<5	16
	04/28/1995	ND<5	16
	03/05/1996	ND<5	16
	10/07/1996	2.5	33
	05/07/1997	ND<5	16
	11/10/1997	ND<5	16
	04/27/1998	2.25	32

Rank Sum = 209
Rank Mean = 19

MW-4	12/16/1993	14	41
	01/31/1994	11	39
	02/24/1994	8.9	37
	03/18/1994	9.5	38
	10/27/1994	ND<5	16
	04/28/1995	14	42
	03/05/1996	12.3	40
	10/07/1996	21	45
	05/07/1997	17.4	43
	11/10/1997	33.5	50
	04/27/1998	18.2	44

Rank Sum = 435
Rank Mean = 39.5455

MW-5	12/16/1993	24	46
	01/31/1994	24	47
	02/24/1994	26	48
	03/18/1994	33	49

	05/07/1997	75.3	55
	11/10/1997	72.6	54
	04/27/1998	55.7	52

Rank Sum = 487
Rank Mean = 44.2727

MW-1	12/16/1993	ND<5	16
	01/31/1994	ND<5	16
	02/24/1994	ND<5	16
	03/18/1994	ND<5	16
	10/27/1994	ND<5	16
	04/28/1995	ND<5	16
	03/05/1996	ND<5	16
	10/07/1996	2.87	34
	05/07/1997	5.27	36
	11/10/1997	ND<5	16
	04/27/1998	4.49	35

Rank Sum = 233
Rank Mean = 21.1818

Calculation Results:

Kruskal-Wallis H Statistic = 28.6966
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 34.9503
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
28.6966 > 9.48773 indicating possible contamination at 5% significance level
34.9503 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 16

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	19	3	15.4191
MW-4	39.5455	23.5455	15.4191
MW-5	44.2727	28.2727	15.4191
MW-1	21.1818	5.18182	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 16

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	19	3	15.4191
MW-4	39.5455	23.5455	15.4191
MW-5	44.2727	28.2727	15.4191
MW-1	21.1818	5.18182	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: Methylene Chloride

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<10	21.5
	01/31/1994	ND<10	21.5
	02/24/1994	ND<10	21.5
	03/18/1994	ND<10	21.5
	10/27/1994	ND<10	21.5
	04/28/1995	ND<10	21.5
	03/05/1996	ND<10	21.5
	10/07/1996	ND<10	21.5
	05/07/1997	ND<10	21.5
	11/10/1997	ND<10	21.5
	04/27/1998	ND<10	21.5

Rank Sum = 236.5
Rank Mean = 21.5

Background Rank Sum = 236.5
Background Rank Mean = 21.5

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<10	21.5
	01/31/1994	ND<10	21.5
	02/24/1994	ND<10	21.5
	03/18/1994	ND<10	21.5
	10/27/1994	ND<10	21.5
	04/28/1995	ND<10	21.5
	03/05/1996	ND<10	21.5
	10/07/1996	ND<10	21.5
	05/07/1997	ND<10	21.5
	11/10/1997	ND<10	21.5
	04/27/1998	ND<10	21.5

Rank Sum = 236.5
Rank Mean = 21.5

MW-4	12/16/1993	9.2	45
	01/31/1994	6.8	44
	02/24/1994	ND<10	21.5
	03/18/1994	ND<10	21.5
	10/27/1994	ND<10	21.5
	04/28/1995	ND<10	21.5
	03/05/1996	ND<10	21.5
	10/07/1996	ND<10	21.5
	05/07/1997	ND<10	21.5
	11/10/1997	ND<10	21.5
	04/27/1998	ND<10	21.5

Rank Sum = 282.5
Rank Mean = 25.6818

MW-5	12/16/1993	21	52
	01/31/1994	15	49
	02/24/1994	15	50
	03/18/1994	13	47

	05/07/1997	ND<10	21.5
	11/10/1997	ND<10	21.5
	04/27/1998	ND<10	21.5

Rank Sum = 348.5
Rank Mean = 31.6818

MW-1	12/16/1993	6.3	43
	01/31/1994	11	46
	02/24/1994	18	51
	03/18/1994	24	53
	10/27/1994	ND<10	21.5
	04/28/1995	14	48
	03/05/1996	ND<10	21.5
	10/07/1996	ND<10	21.5
	05/07/1997	84	55
	11/10/1997	ND<10	21.5
	04/27/1998	83.5	54

Rank Sum = 436
Rank Mean = 39.6364

Calculation Results:

Kruskal-Wallis H Statistic = 10.2358
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 18.4496
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
10.2358 > 9.48773 indicating possible contamination at 5% significance level
18.4496 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	21.5	0	15.4191
MW-4	25.6818	4.18182	15.4191
MW-5	31.6818	10.1818	15.4191
MW-1	39.6364	18.1364	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	21.5	0	15.4191
MW-4	25.6818	4.18182	15.4191
MW-5	31.6818	10.1818	15.4191
MW-1	39.6364	18.1364	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: Tetrachloroethene (-ethylene)

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	18.5
	01/31/1994	ND<5	18.5
	02/24/1994	ND<5	18.5
	03/18/1994	ND<5	18.5
	10/27/1994	ND<5	18.5
	04/28/1995	ND<5	18.5
	03/05/1996	ND<5	18.5
	10/07/1996	ND<5	18.5
	05/07/1997	ND<5	18.5
	11/10/1997	ND<5	18.5
	04/27/1998	ND<5	18.5

Rank Sum = 203.5
Rank Mean = 18.5

Background Rank Sum = 203.5
Background Rank Mean = 18.5

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	18.5
	01/31/1994	ND<5	18.5
	02/24/1994	ND<5	18.5
	03/18/1994	ND<5	18.5
	10/27/1994	5.83	43
	04/28/1995	ND<5	18.5
	03/05/1996	ND<5	18.5
	10/07/1996	ND<5	18.5
	05/07/1997	ND<5	18.5
	11/10/1997	ND<5	18.5
	04/27/1998	ND<5	18.5

Rank Sum = 228
Rank Mean = 20.7273

MW-4	12/16/1993	9.9	52
	01/31/1994	8.1	46
	02/24/1994	8.1	47
	03/18/1994	8.7	48
	10/27/1994	ND<5	18.5
	04/28/1995	9.3	49
	03/05/1996	6	44
	10/07/1996	4.38	39
	05/07/1997	5.03	41
	11/10/1997	7.15	45
	04/27/1998	4.38	40

Rank Sum = 469.5
Rank Mean = 42.6818

MW-5	12/16/1993	9.7	51
	01/31/1994	10	53
	02/24/1994	10	54
	03/18/1994	10	55

	05/07/1997	ND<5	18.5
	11/10/1997	ND<5	18.5
	04/27/1998	1.51	37

Rank Sum = 416
Rank Mean = 37.8182

MW-1	12/16/1993	ND<5	18.5
	01/31/1994	ND<5	18.5
	02/24/1994	ND<5	18.5
	03/18/1994	ND<5	18.5
	10/27/1994	ND<5	18.5
	04/28/1995	ND<5	18.5
	03/05/1996	ND<5	18.5
	10/07/1996	2.85	38
	05/07/1997	ND<5	18.5
	11/10/1997	ND<5	18.5
	04/27/1998	ND<5	18.5

Rank Sum = 223
Rank Mean = 20.2727

Calculation Results:

Kruskal-Wallis H Statistic = 22.0631
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 30.6561
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
22.0631 > 9.48773 indicating possible contamination at 5% significance level
30.6561 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 18.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	20.7273	2.22727	15.4191
MW-4	42.6818	24.1818	15.4191
MW-5	37.8182	19.3182	15.4191
MW-1	20.2727	1.77273	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 18.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	20.7273	2.22727	15.4191
MW-4	42.6818	24.1818	15.4191
MW-5	37.8182	19.3182	15.4191
MW-1	20.2727	1.77273	15.4191

Kruskal-Wallis Non-Parametric Test
Parameter: Trichloroethene (-ethylene)

Kruskal Wallis Ranks

Background Wells

Well ID	Date	Result	Rank
MW-2	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	ND<5	21.5
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	ND<5	21.5

Rank Sum = 236.5
Rank Mean = 21.5

Background Rank Sum = 236.5
Background Rank Mean = 21.5

Compliance Wells

Well ID	Date	Result	Rank
MW-3	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	ND<5	21.5
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	ND<5	21.5

Rank Sum = 236.5
Rank Mean = 21.5

MW-4	12/16/1993	5.8	49
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	5.7	48
	03/05/1996	5.4	47
	10/07/1996	4.53	46
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	2.39	45

Rank Sum = 364
Rank Mean = 33.0909

MW-5	12/16/1993	ND<5	21.5
	01/31/1994	11	53
	02/24/1994	11	54
	03/18/1994	11	55

	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	0.99	43

Rank Sum = 444
Rank Mean = 40.3636

MW-1	12/16/1993	ND<5	21.5
	01/31/1994	ND<5	21.5
	02/24/1994	ND<5	21.5
	03/18/1994	ND<5	21.5
	10/27/1994	ND<5	21.5
	04/28/1995	ND<5	21.5
	03/05/1996	ND<5	21.5
	10/07/1996	2.16	44
	05/07/1997	ND<5	21.5
	11/10/1997	ND<5	21.5
	04/27/1998	ND<5	21.5

Rank Sum = 259
Rank Mean = 23.5455

Calculation Results:

Kruskal-Wallis H Statistic = 12.1337
Kruskal-Wallis H Statistic (adjusted for tied non-detects) = 21.8705
95% Confidence comparison value is 9.48773 at 4 degrees of freedom
12.1337 > 9.48773 indicating possible contamination at 5% significance level
21.8705 > 9.48773 indicating possible contamination at 5% significance level when adjusted for ties

---

Individual Well Comparisons at 1.25% Significance Level per Comparison

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	21.5	0	15.4191
MW-4	33.0909	11.5909	15.4191
MW-5	40.3636	18.8636	15.4191
MW-1	23.5455	2.04545	15.4191

Individual Well Comparisons at Groupwise 5% Significance Level (1.25% Significance Level per comparison)

1.25% Z score is 2.25713
Mean background rank is 21.5

Well	Mean Rank	Dif from Bkg	Critical Value
MW-3	21.5	0	15.4191
MW-4	33.0909	11.5909	15.4191
MW-5	40.3636	18.8636	15.4191
MW-1	23.5455	2.04545	15.4191

Poisson Prediction Limit

Parameter: Trichlorofluoromethane

Recent Dates = 4
Poisson Count of 11 background Samples = 27.5
99% t-test = 2.76377
95% t-test = 1.81246

Well: MW-3

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

Well: MW-4

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

Well: MW-5

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

Well: MW-1

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	23	TRUE	TRUE

Poisson Prediction Limit

Parameter: Xylene

Recent Dates = 4
Poisson Count of 11 background Samples = 27.5
99% t-test = 2.76377
95% t-test = 1.81246

Well: MW-3

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

Well: MW-4

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

Well: MW-5

Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

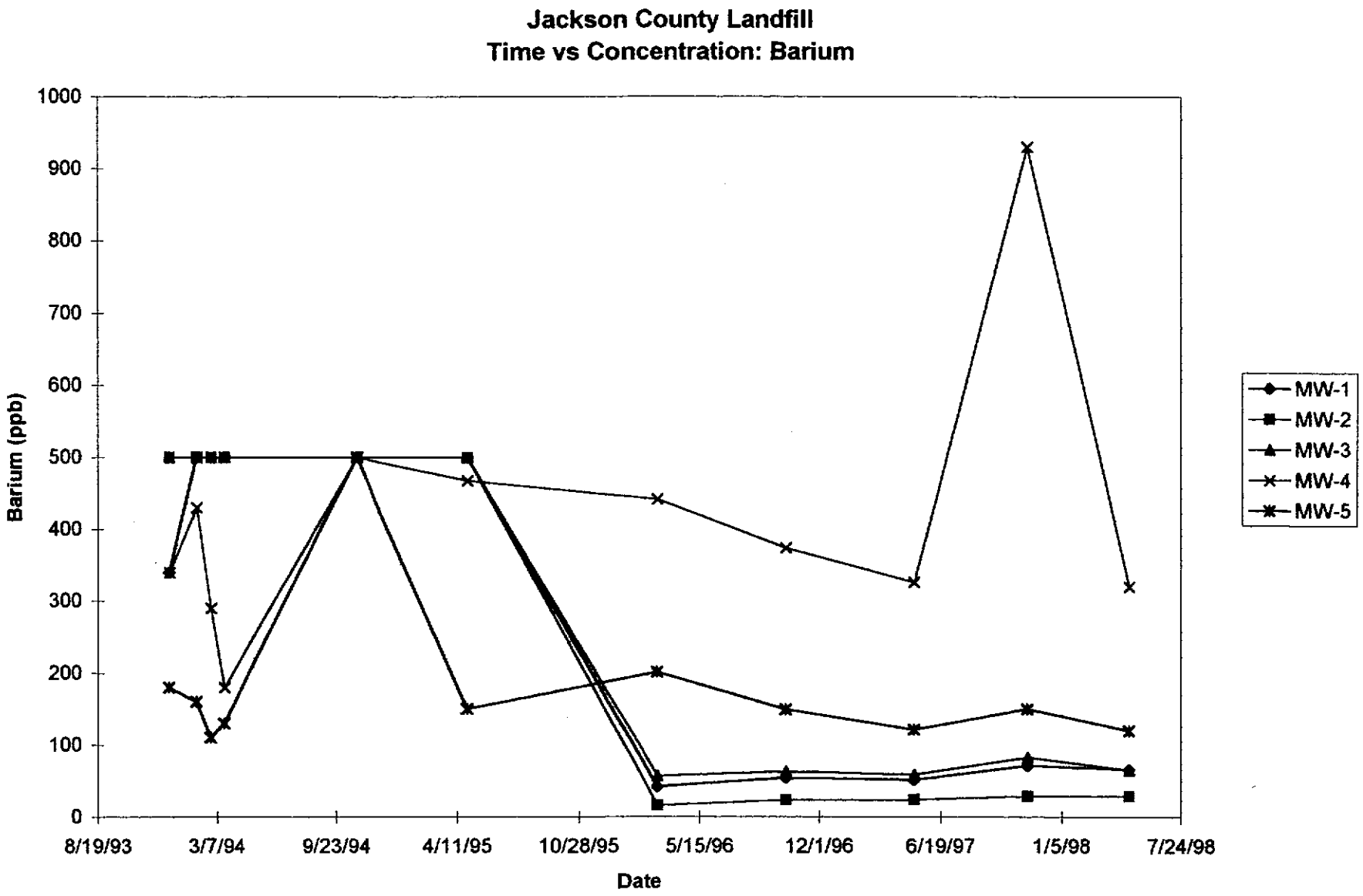
Samples	Sum	95 %tile	99 %tile
4	10	FALSE	FALSE

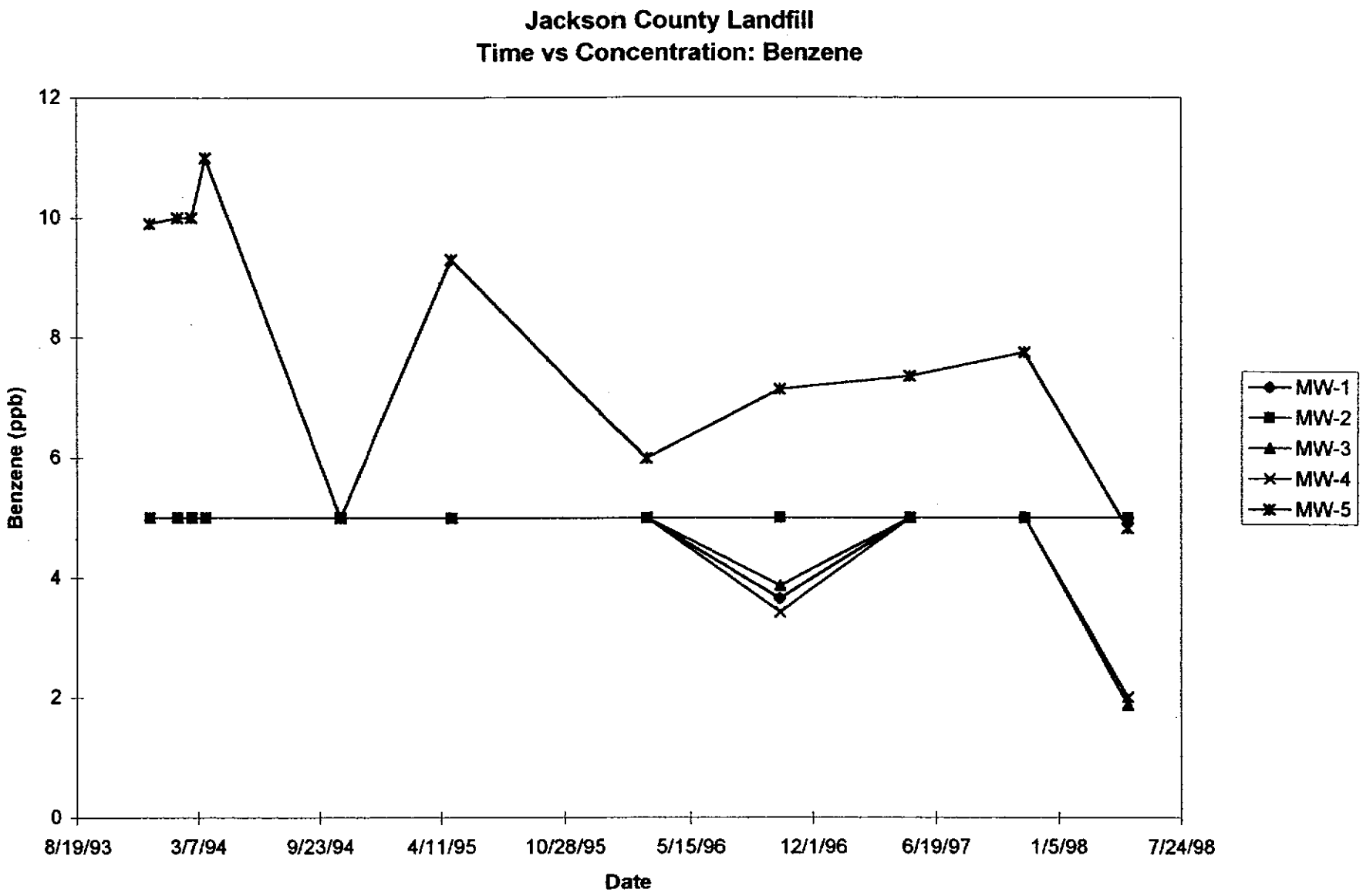
Well: MW-1

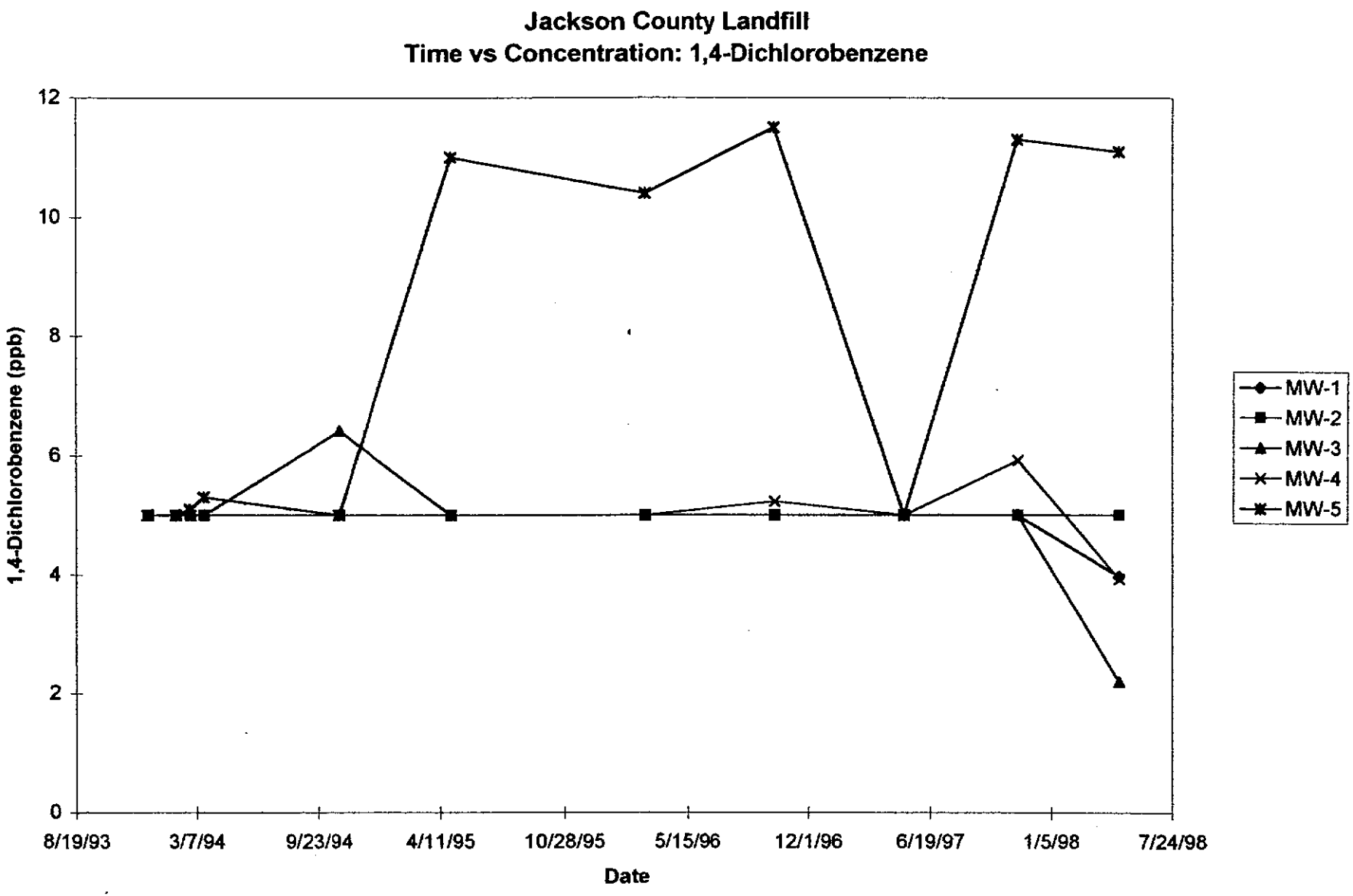
Number of comparisons = 4
Future Samples (k) = 4
c = 0.363636
99% Prediction Limit (Tk) = 21.6888
95% Prediction Limit (Tk) = 17.3168

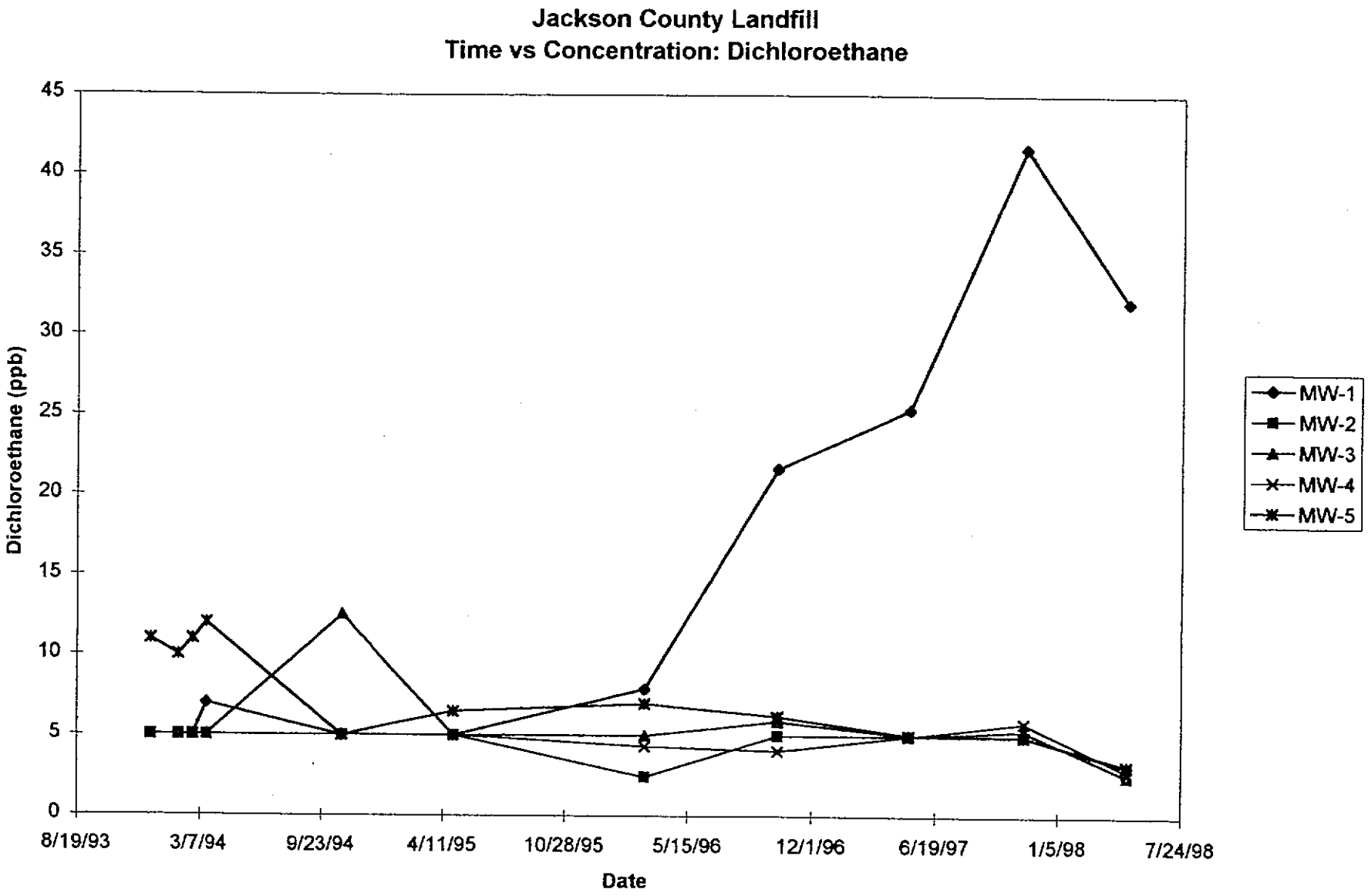
Samples	Sum	95 %tile	99 %tile
4	101.89	TRUE	TRUE

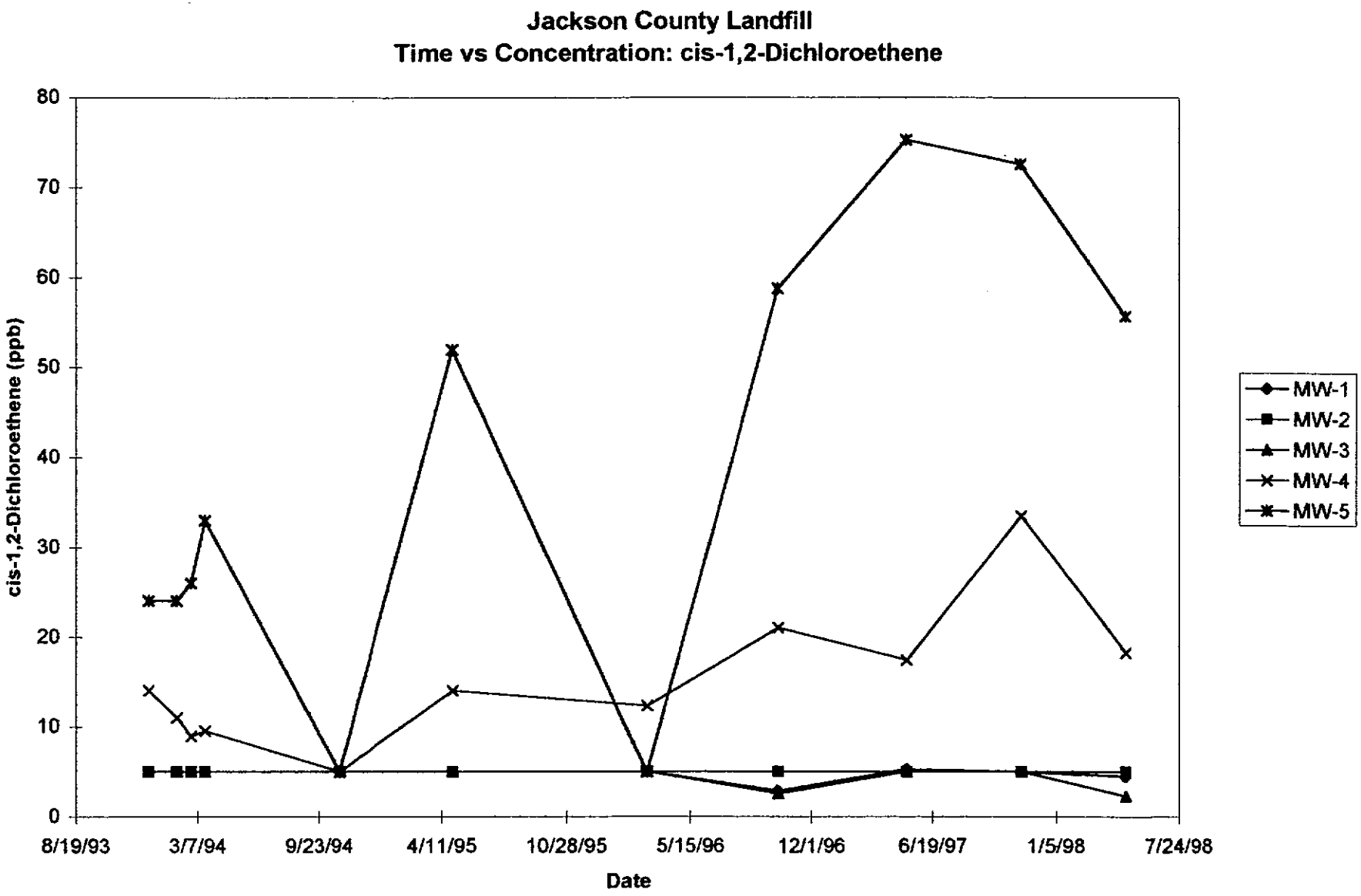
APPENDIX C

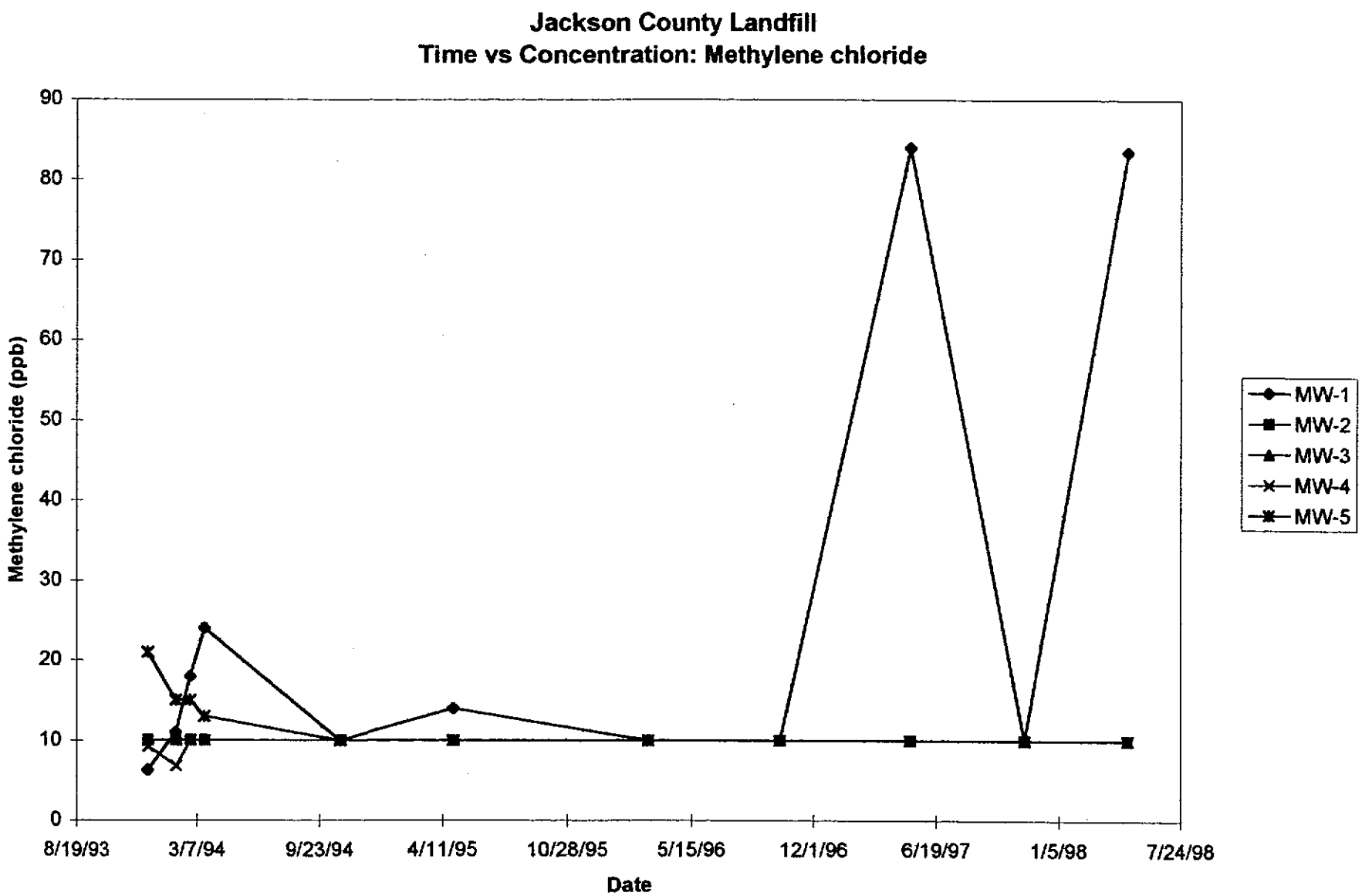

Jackson County Landfill
Time vs Concentration: Barium
Barium (ppb)
1000
900
800
700
600
500
400
300
200
100
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5

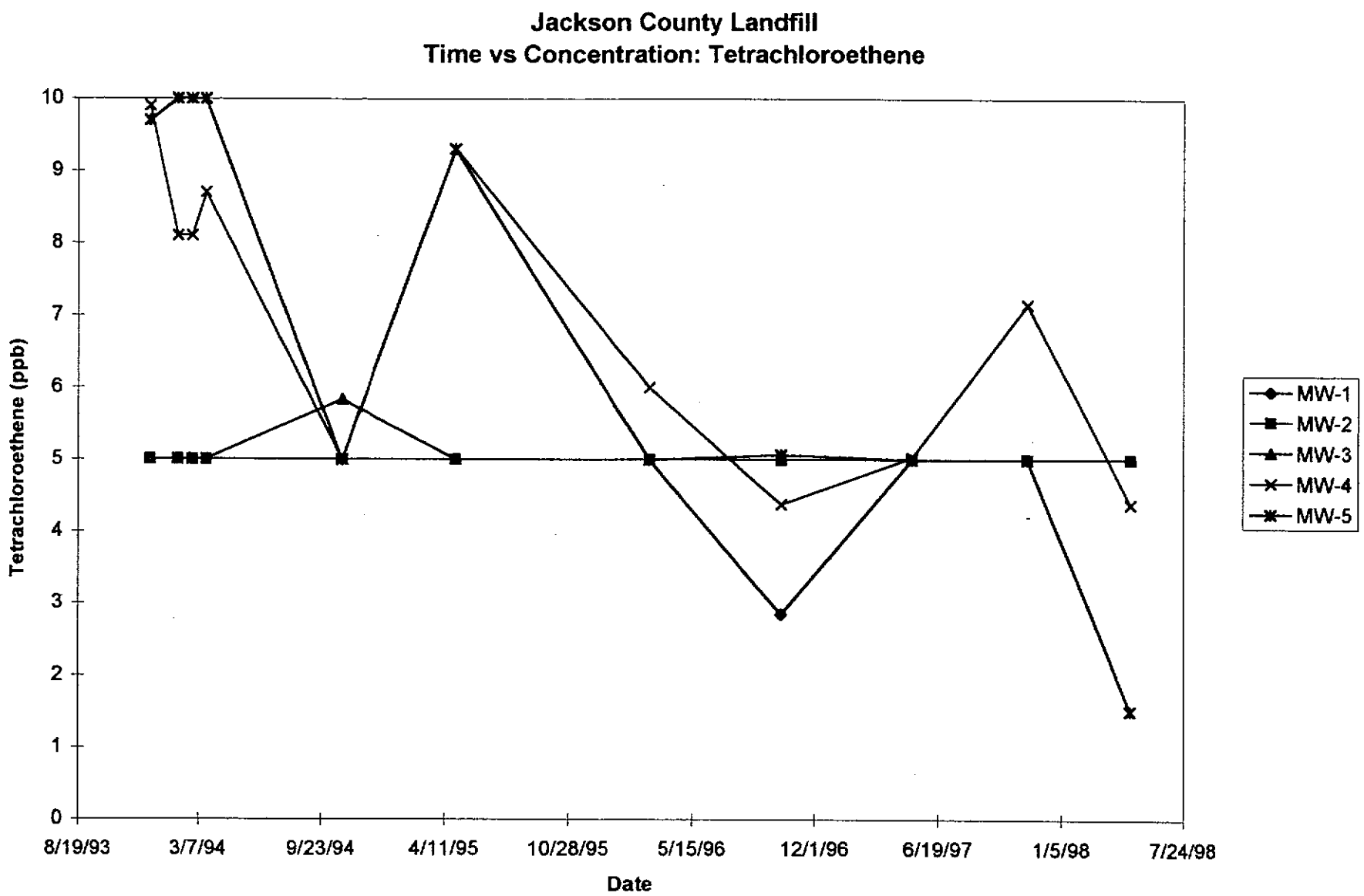

Jackson County Landfill
Time vs Concentration: Benzene
Benzene (ppb)
12
10
8
6
4
2
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5

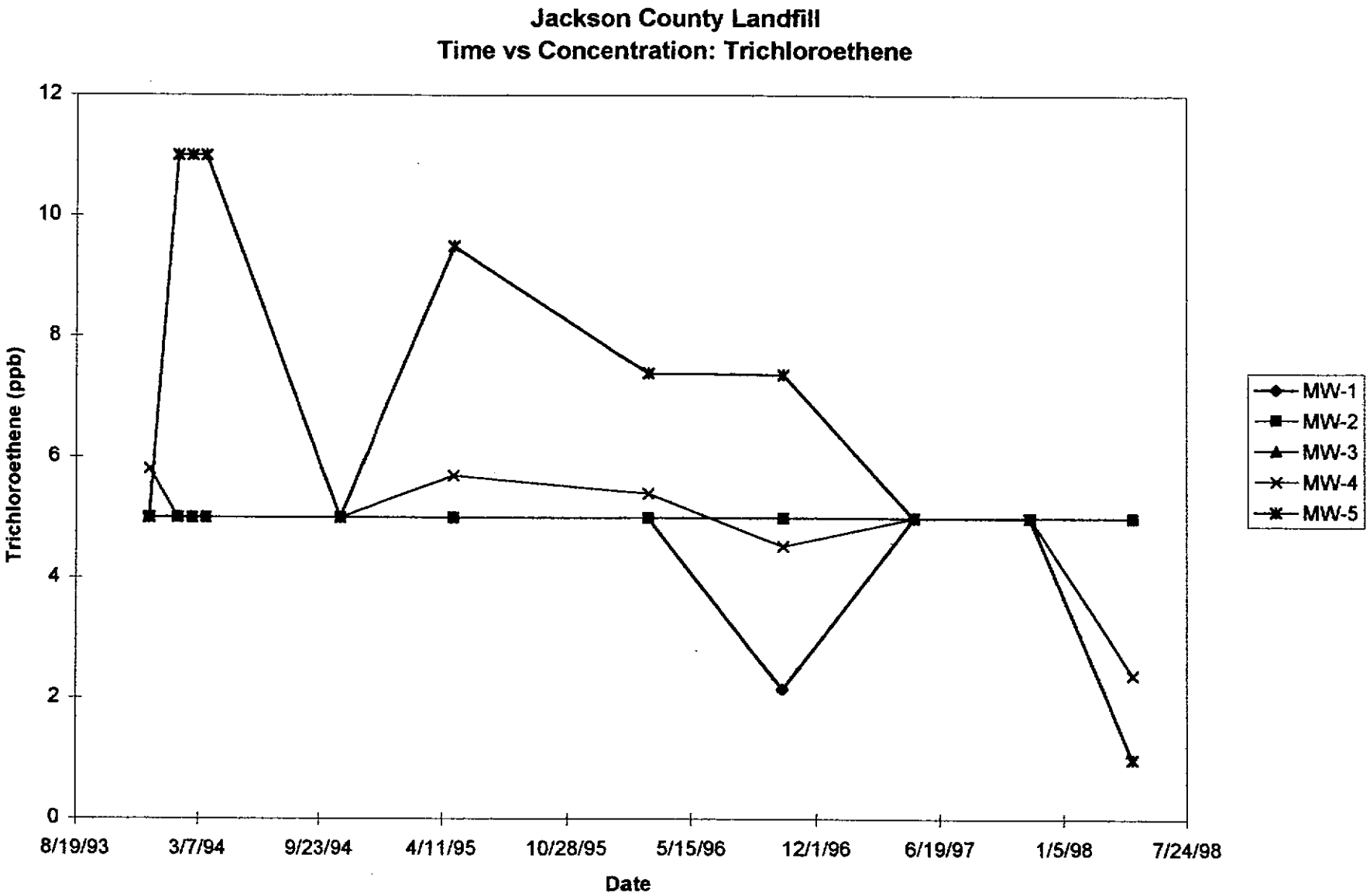

Jackson County Landfill
Time vs Concentration: 1,4-Dichlorobenzene
1,4-Dichlorobenzene (ppb)
0
2
4
6
8
10
12
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5


Jackson County Landfill
Time vs Concentration: Dichloroethane
Dichloroethane (ppb)
45
40
35
30
25
20
15
10
5
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5


Jackson County Landfill
Time vs Concentration: cis-1,2-Dichloroethene
cis-1,2-Dichloroethene (ppb)
80
70
60
50
40
30
20
10
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5


Jackson County Landfill
Time vs Concentration: Methylene chloride
Methylene chloride (ppb)
90
80
70
60
50
40
30
20
10
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5


Jackson County Landfill
Time vs Concentration: Tetrachloroethene
Tetrachloroethene (ppb)
10
9
8
7
6
5
4
3
2
1
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5


Jackson County Landfill
Time vs Concentration: Trichloroethene
Trichloroethene (ppb)
12
10
8
6
4
2
0
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
1/5/98
7/24/98
Date
MW-1
MW-2
MW-3
MW-4
MW-5