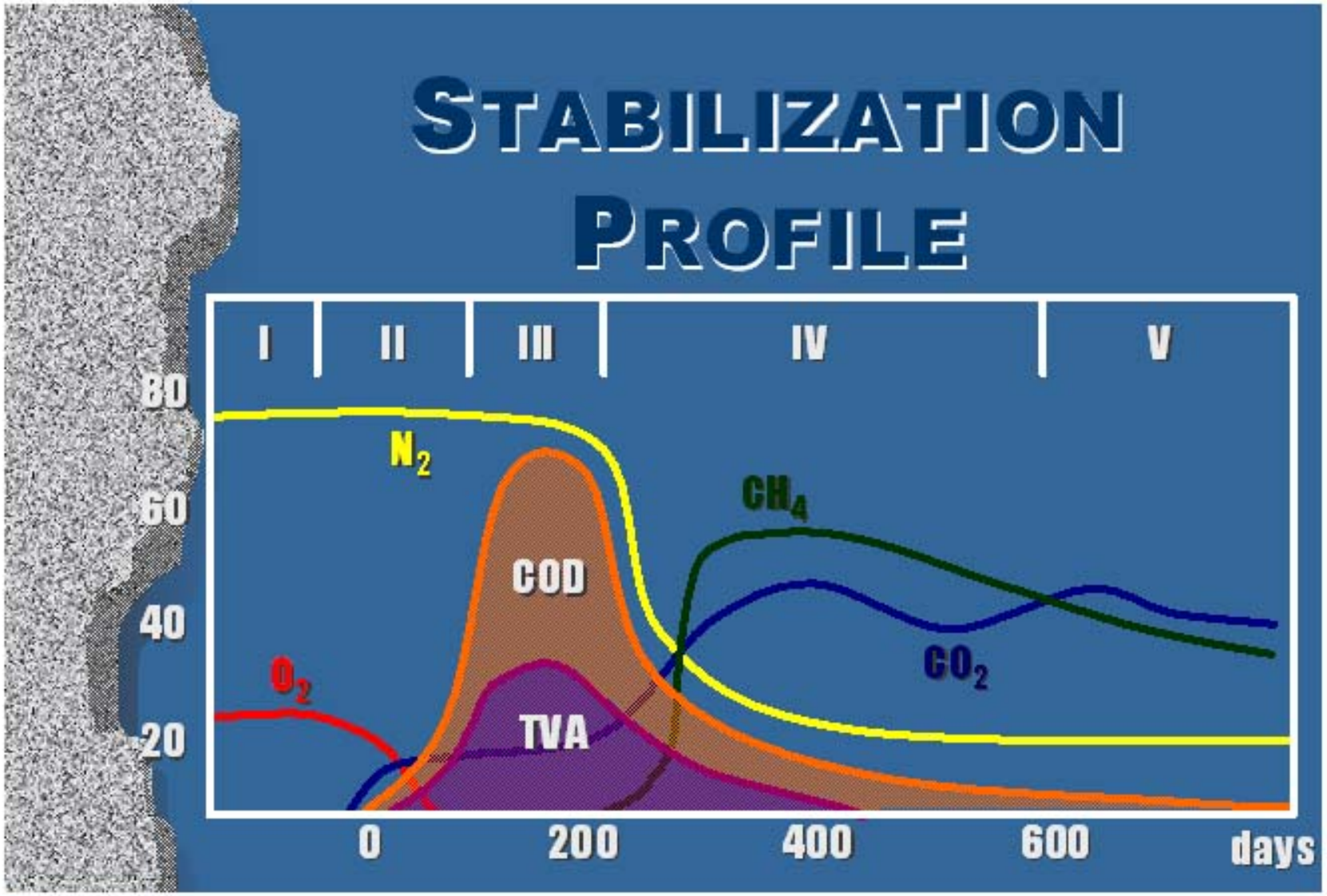
Leachate Trends in Bioreactors and Closed Landfills

John Baker-Director
New Technologies

Stabilization Profile



DATA ANALYSIS APPROACH

1. Waste Degradation Indicator Parameters:

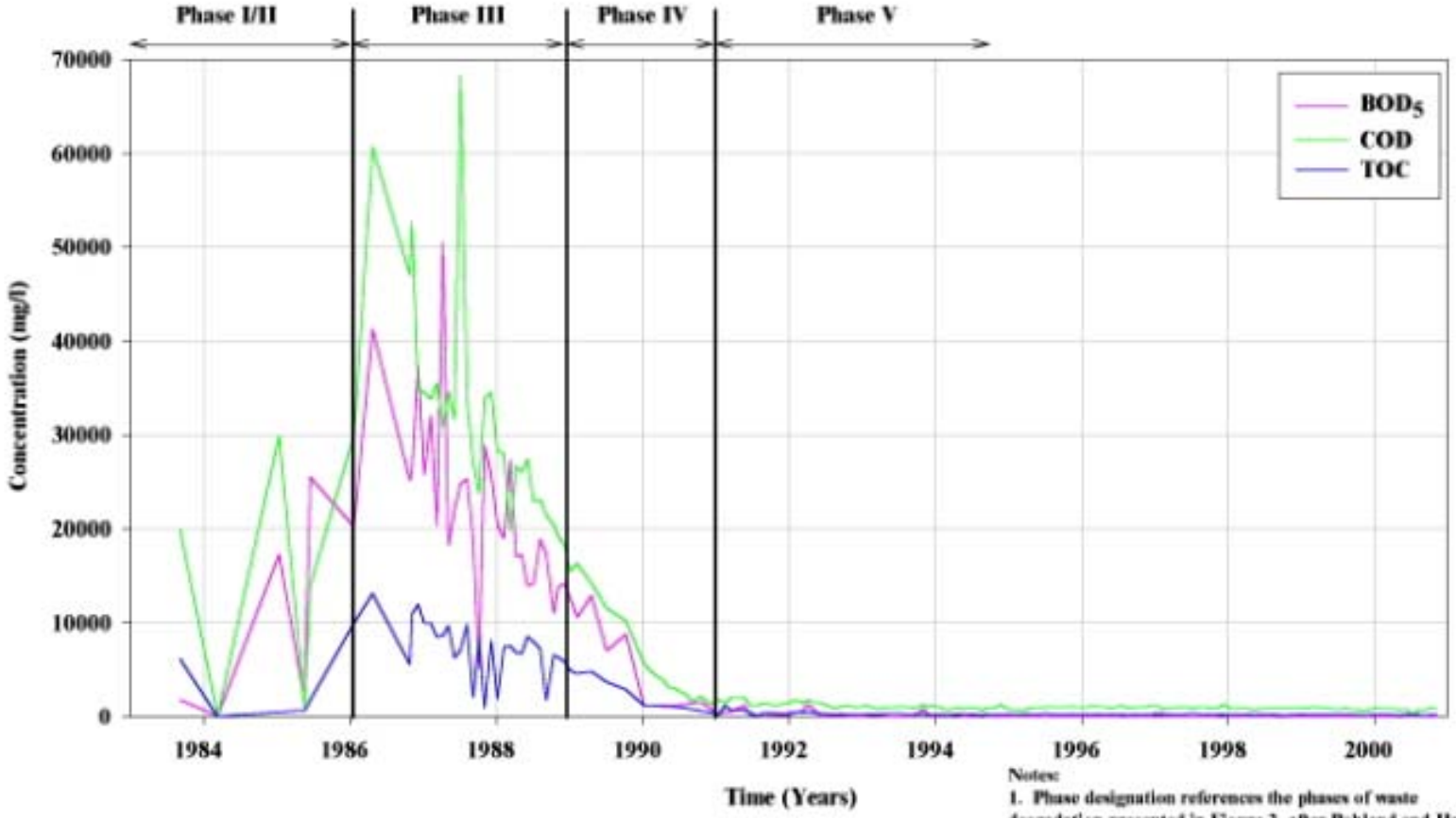
- **These parameters include BOD, COD, TOC, TVA, pH, and Total Alkalinity**
- **Parameters were evaluated by tracking concentration versus time and comparing to Pohland and Harper, 1986.**

Figure 3

LEACHATE QUALITY SUMMARY, BOD_5, COD, AND TOC

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware



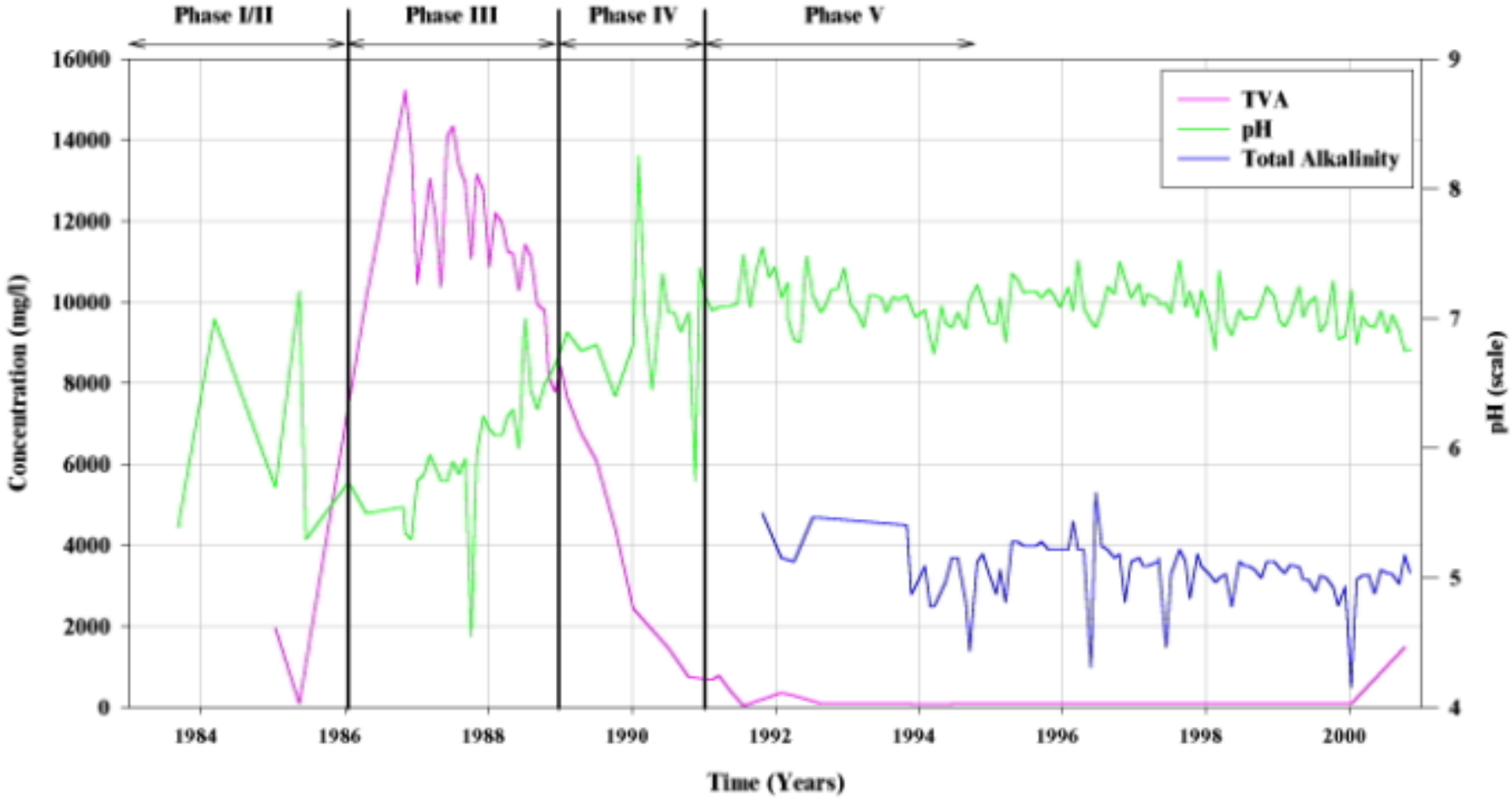
Notes:
1. Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.
2. BOD_5 concentrations that are greater than COD concentrations are assumed to be reported in error.

Figure 4

LEACHATE QUALITY SUMMARY, TVA, pH, AND TOTAL ALKALINITY

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware



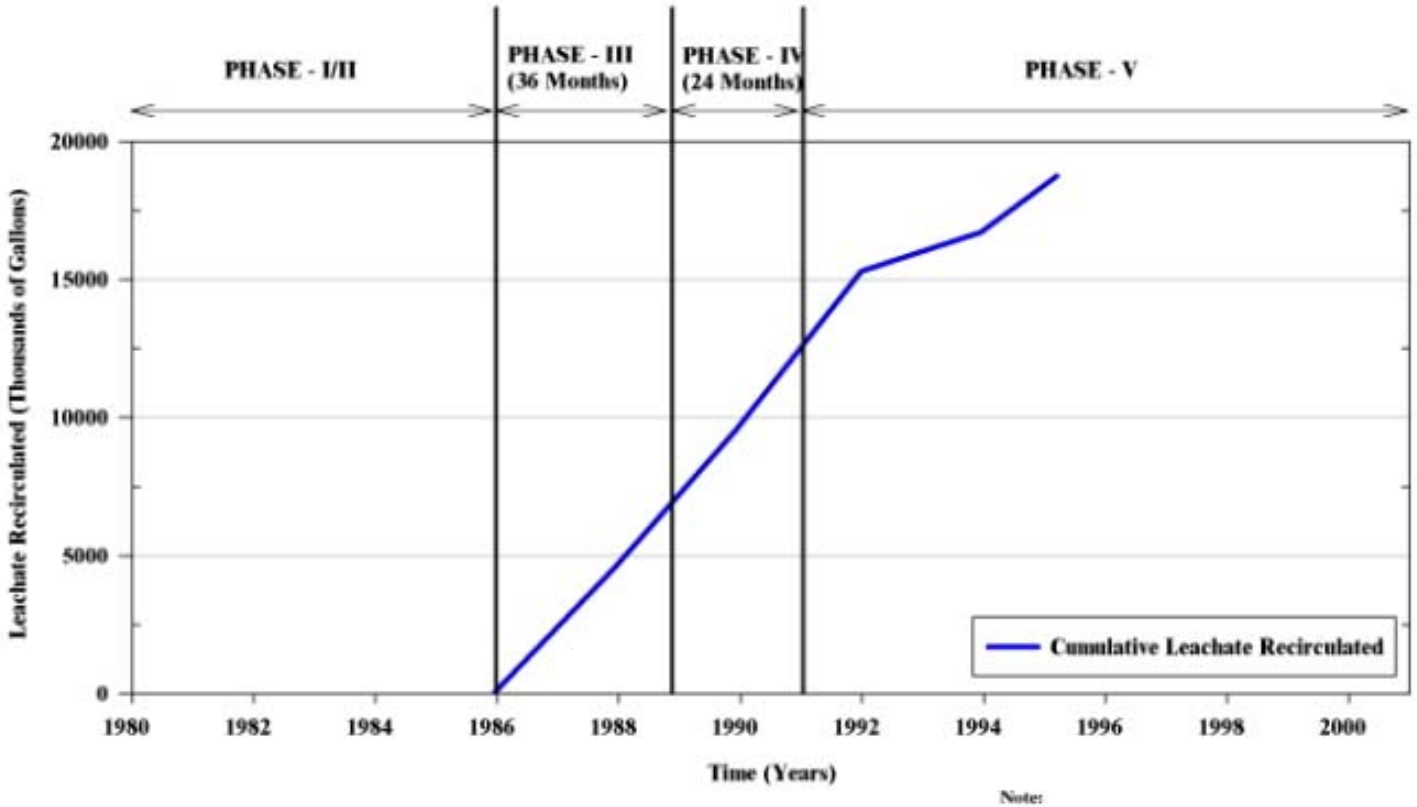
Note:
Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.

Figure 8

WASTE DEGRADATION PHASE SUMMARY, DISPOSAL CELL B

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware



Note:
Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.

DATA ANALYSIS APPROACH

2. Metals, VOCs and BTEX:

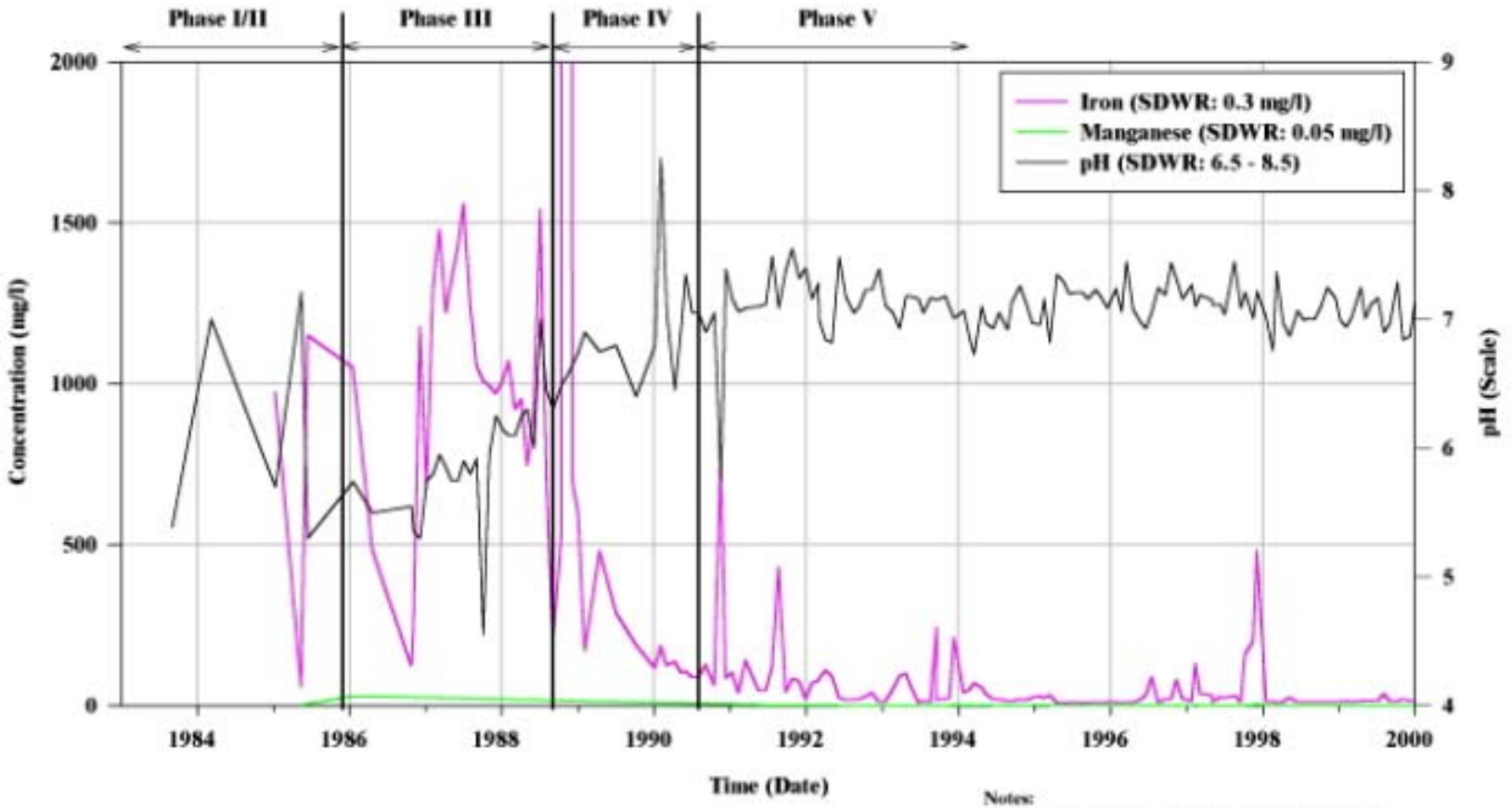
- **Parameters were evaluated by tracking concentration versus time**
- **Final concentrations of these parameters were compared to Drinking Water Standards, and findings of previous studies (Kilmer and Tustin, 1999)**

Figure 10

LEACHATE QUALITY SUMMARY, IRON, MANGANESE, AND pH

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware



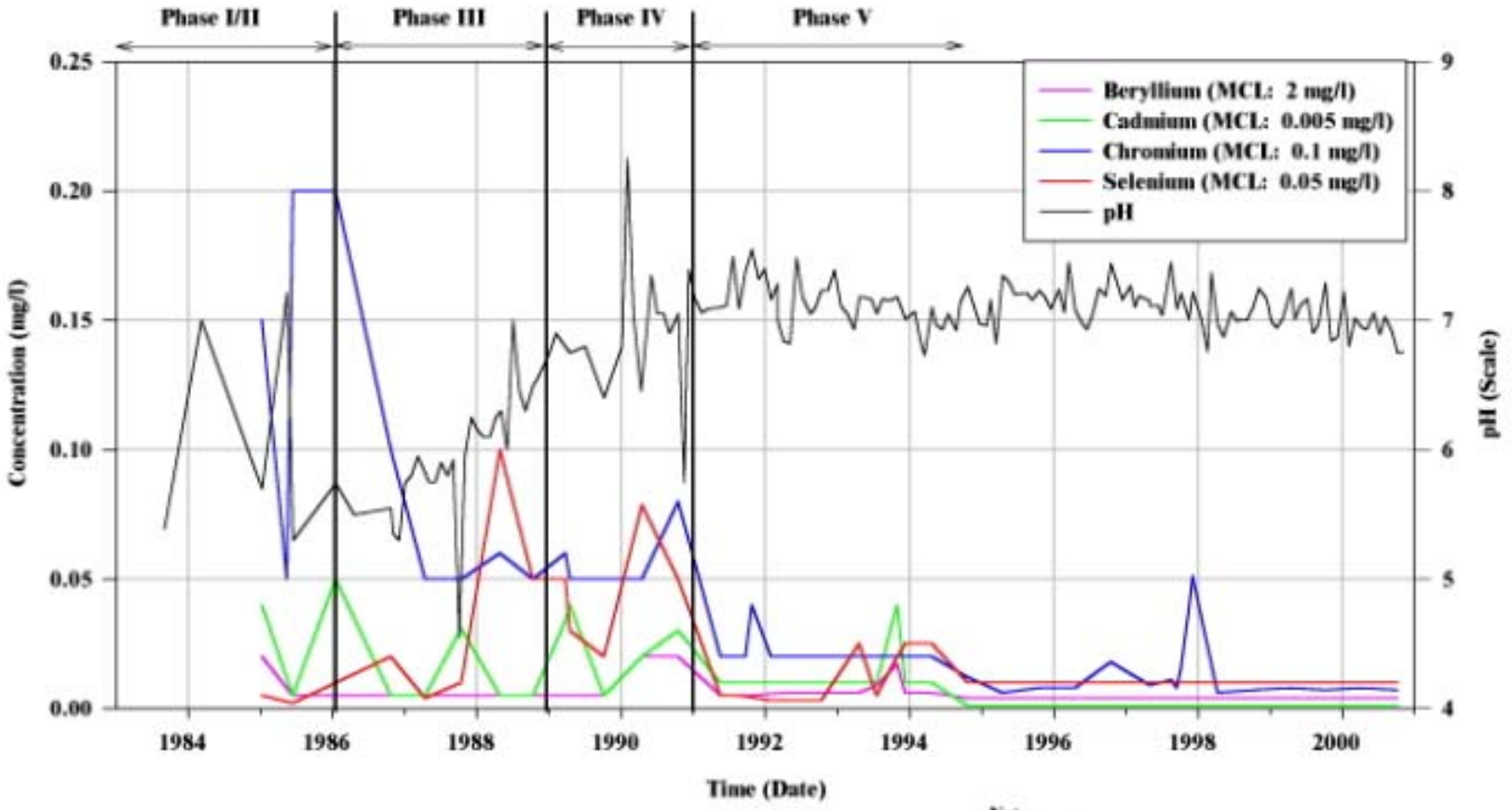
Notes:
1. Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.
2. SDWR: Secondary Drinking Water Regulation.

Figure 9

LEACHATE QUALITY SUMMARY, BERYLLIUM, CADMIUM CHROMIUM, SELENIUM, AND pH

Evaluation of Historical Data at Leachate Recirculating Landfills Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware

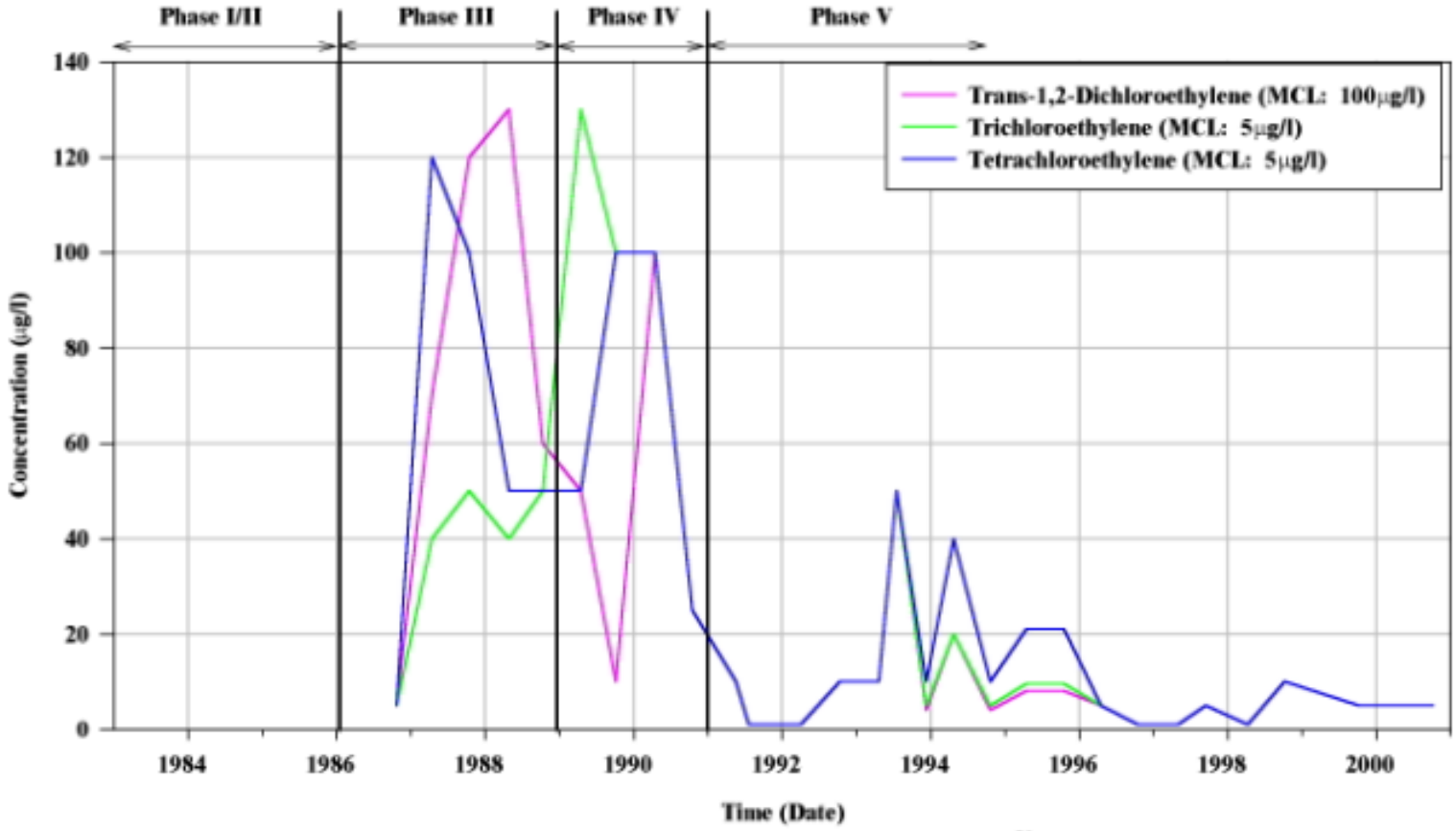


Note:
Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.

LEACHATE QUALITY SUMMARY, TRANS-1,2-DICHLOROETHYLENE, TRICHLOROETHYLENE, AND TETRACHLORETHYLENE

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware



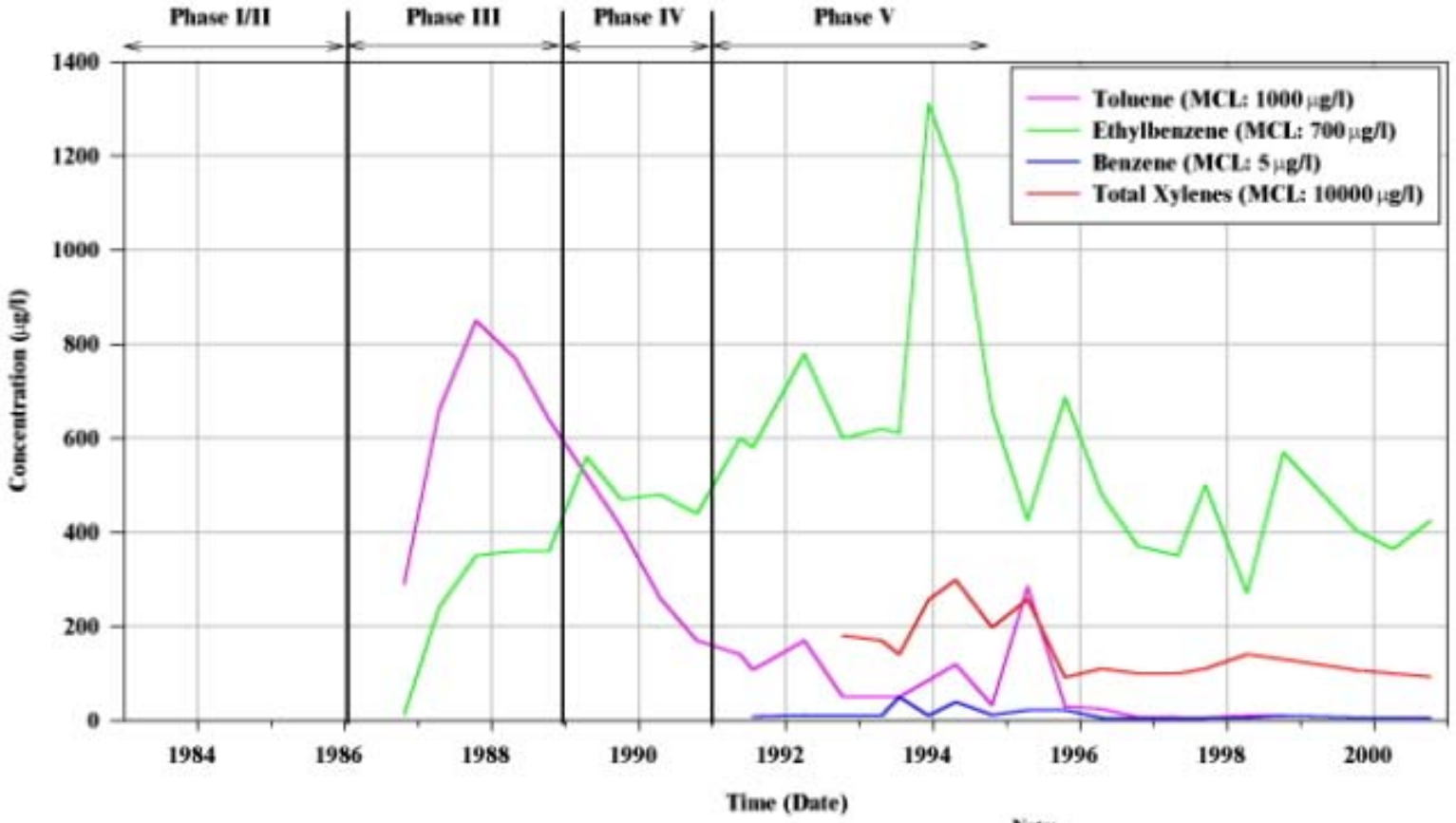
Note:
Phase designation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.

Figure 13

LEACHATE QUALITY SUMMARY, BTEX

Evaluation of Historical Data at Leachate Recirculating Landfills
Area A/B Disposal Cells, Central Solid Waste Management Center

Sandtown, Delaware

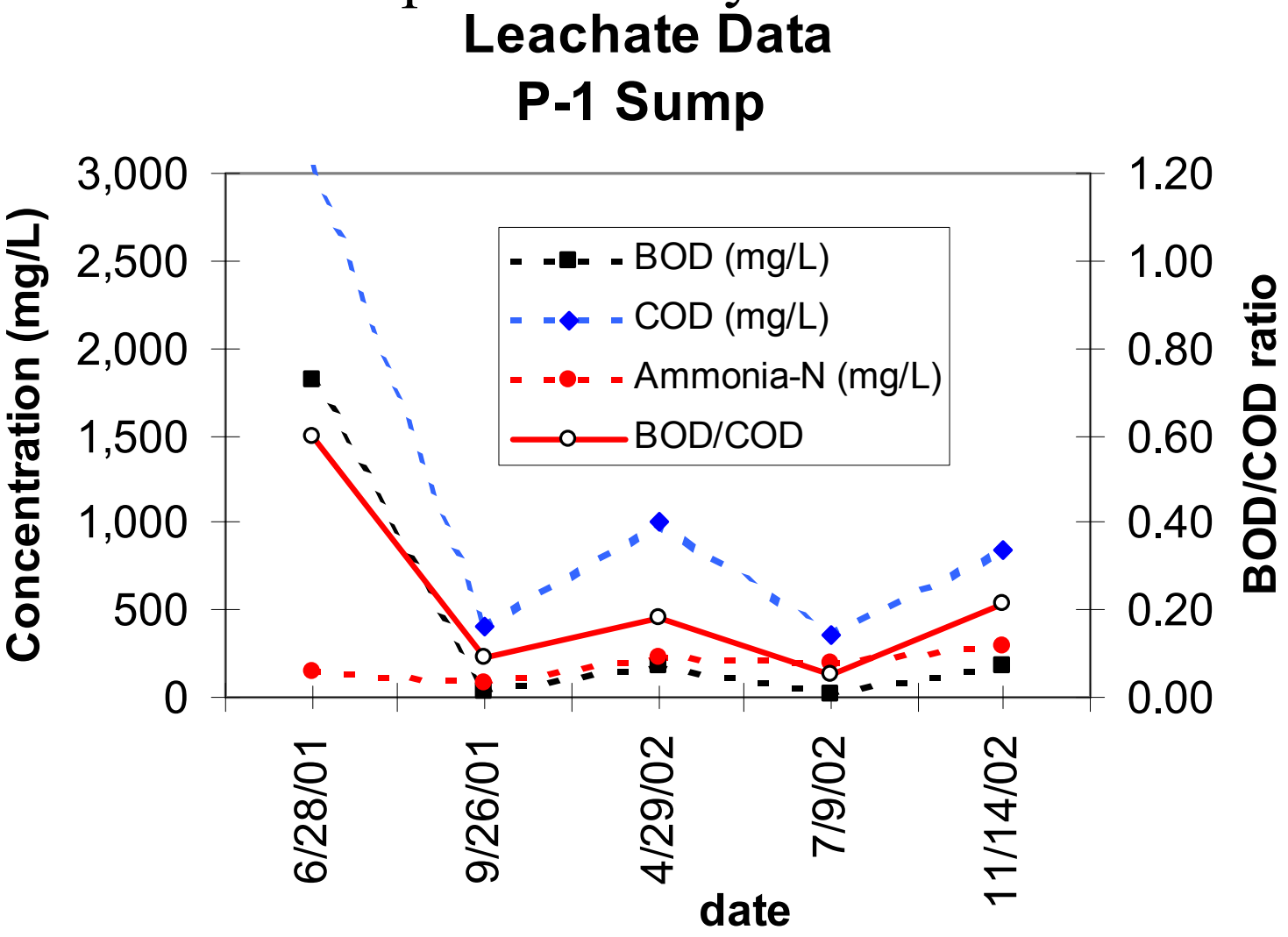


Note:
Phase esignation references the phases of waste degradation presented in Figure 2, after Pohland and Harper, 1986.

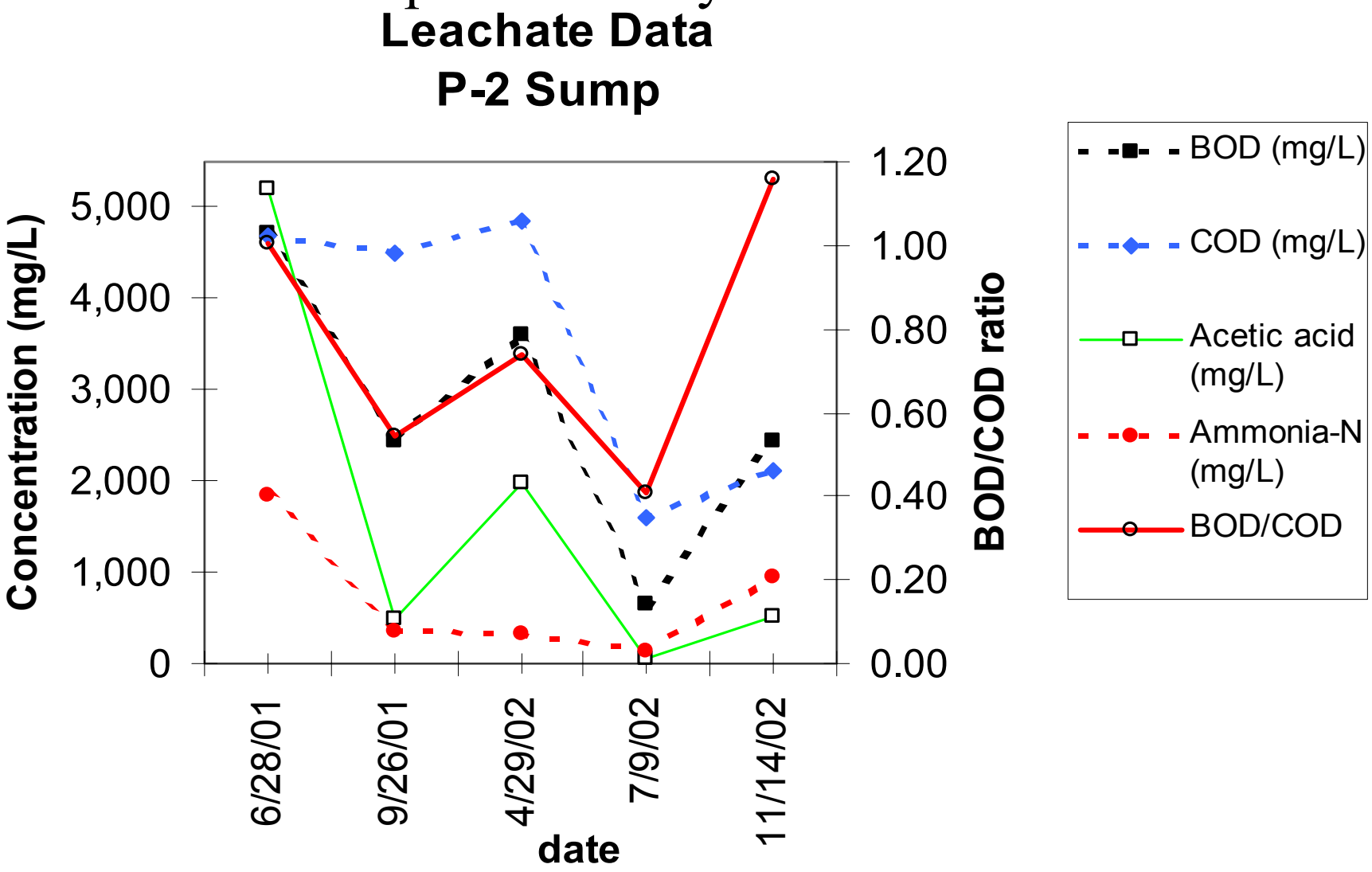
CONCLUSIONS

- The concentrations of waste degradation parameters in leachate followed the model suggested by Pohland and Harper, 1986.
- The data indicate that metals, VOCs and BTEX were not present at concentrations above their MCLs after a short period into Phase V.
- Based on WMI experience, this level of improvement in leachate quality is consistent with the improvements at other similarly operated leachate recirculating landfills.

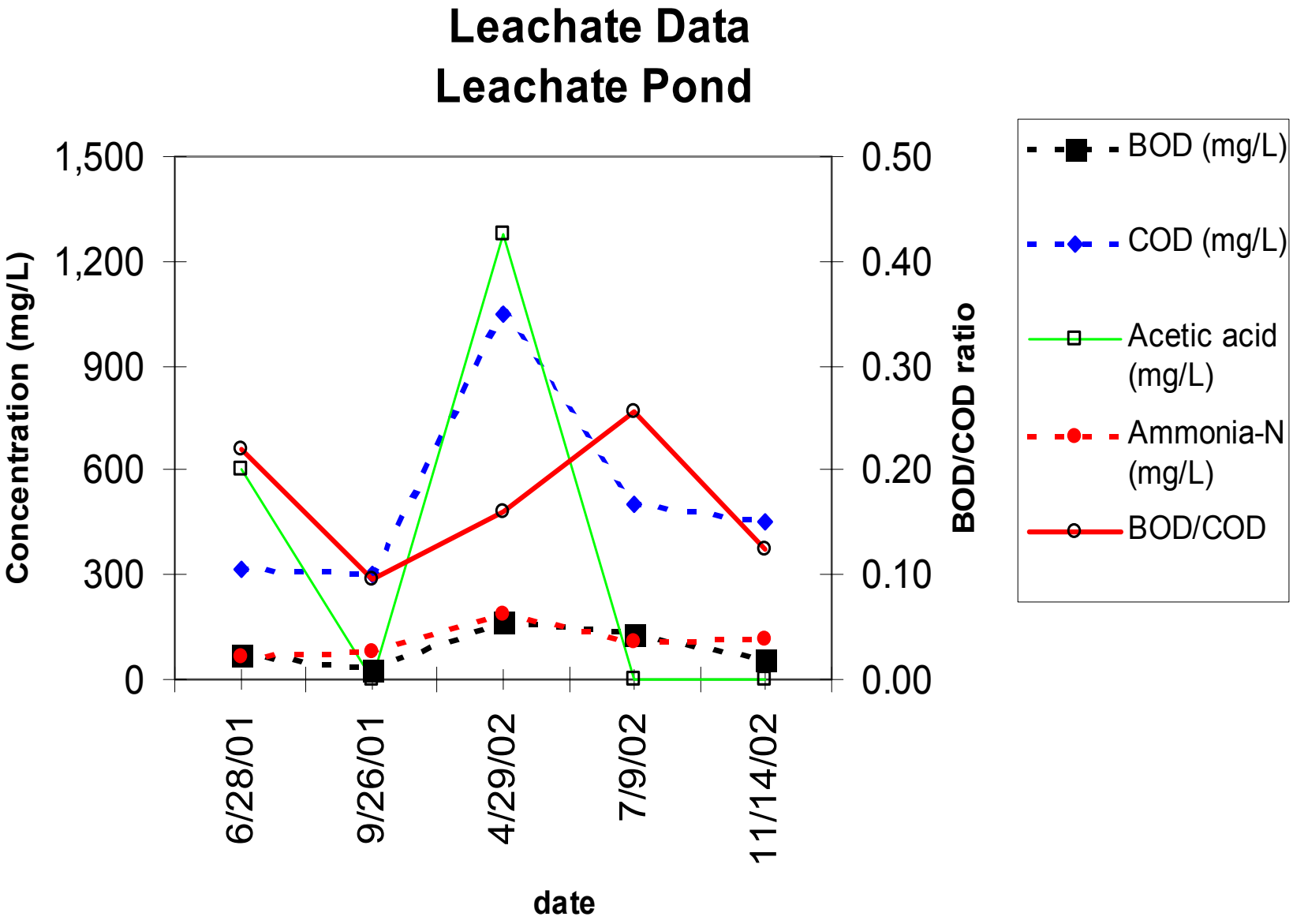
Central Disposal Facility Bioreactor Data



Central Disposal Facility Bioreactor Data



Central Disposal Facility Bioreactor Data



Central Disposal - VOCs

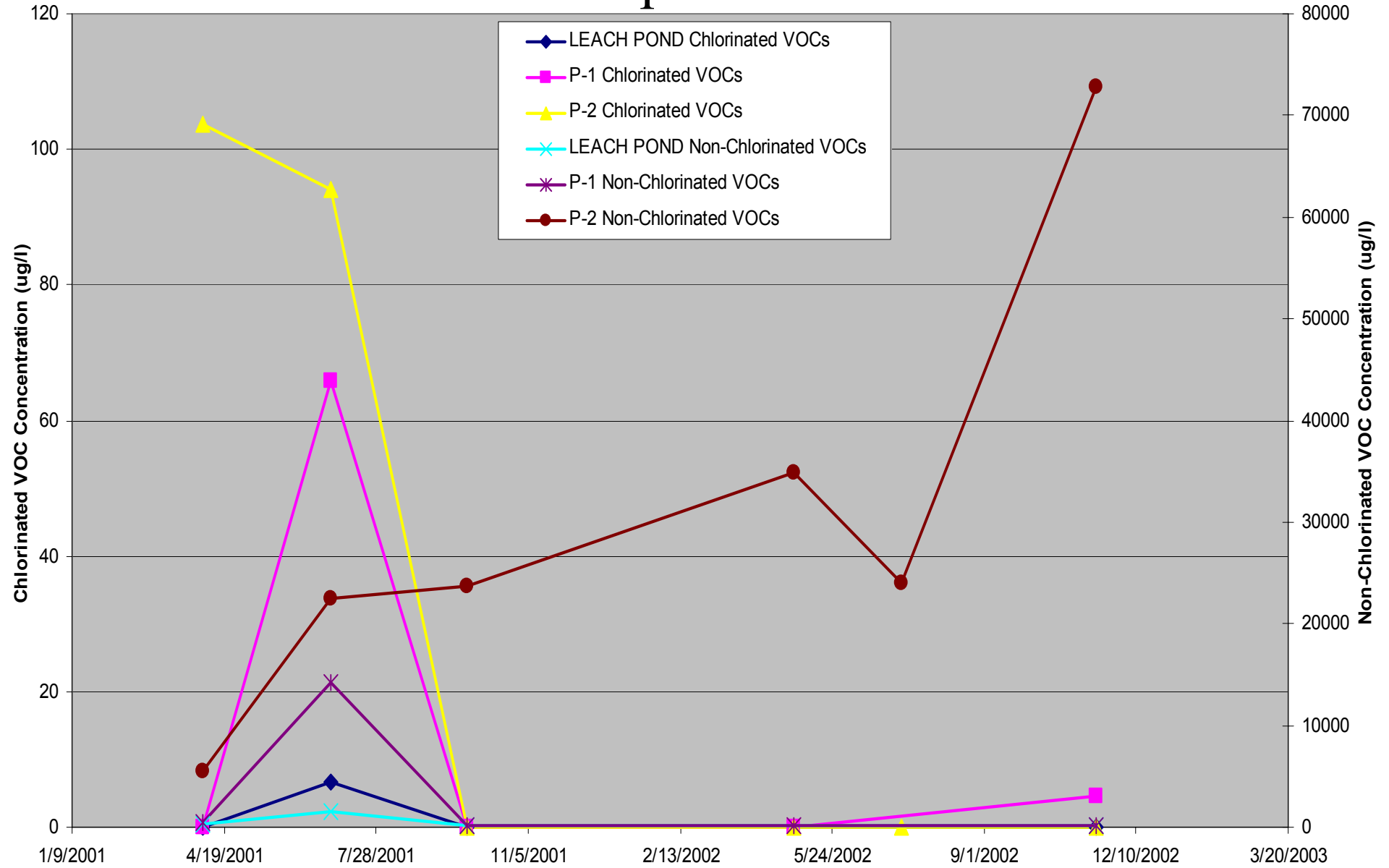


Figure 2: Comparison of COD Concentration

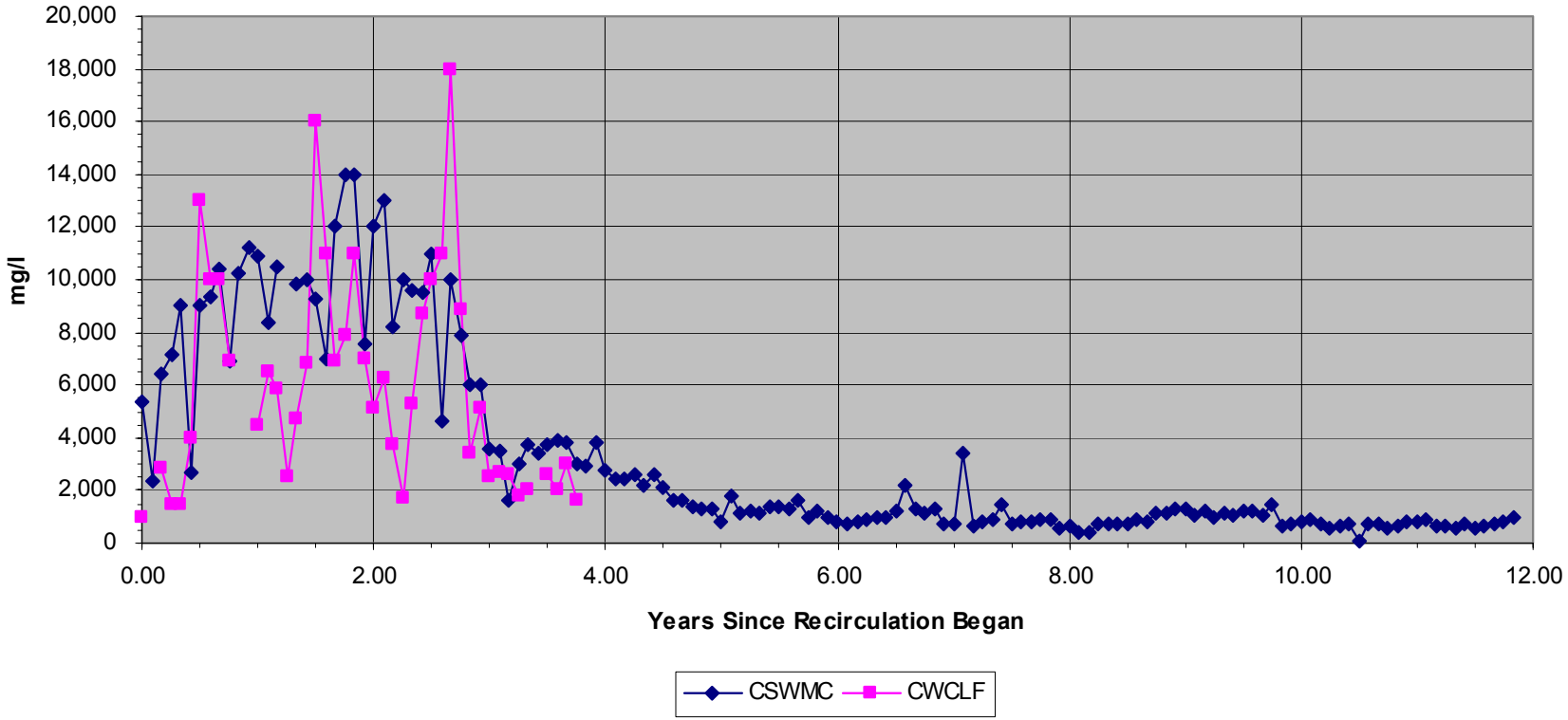
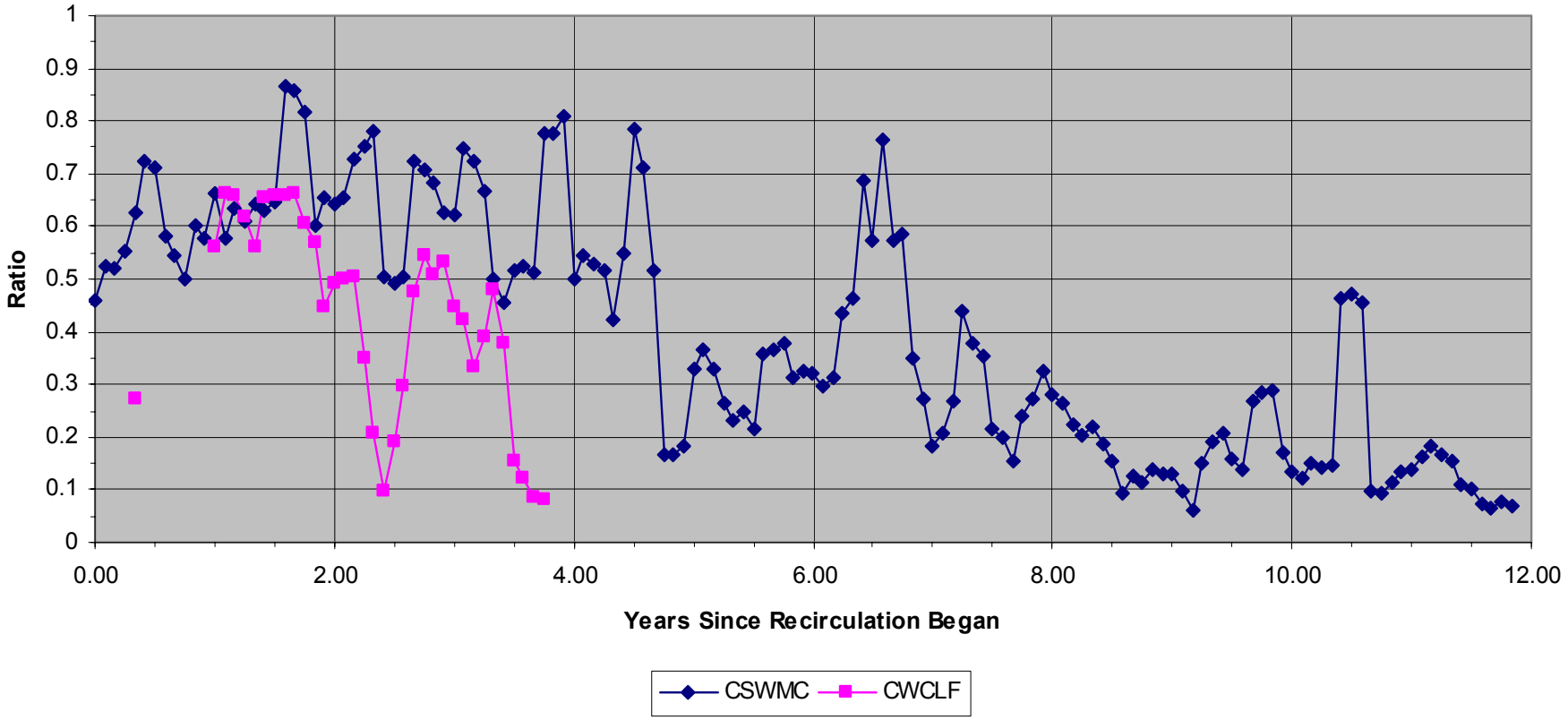
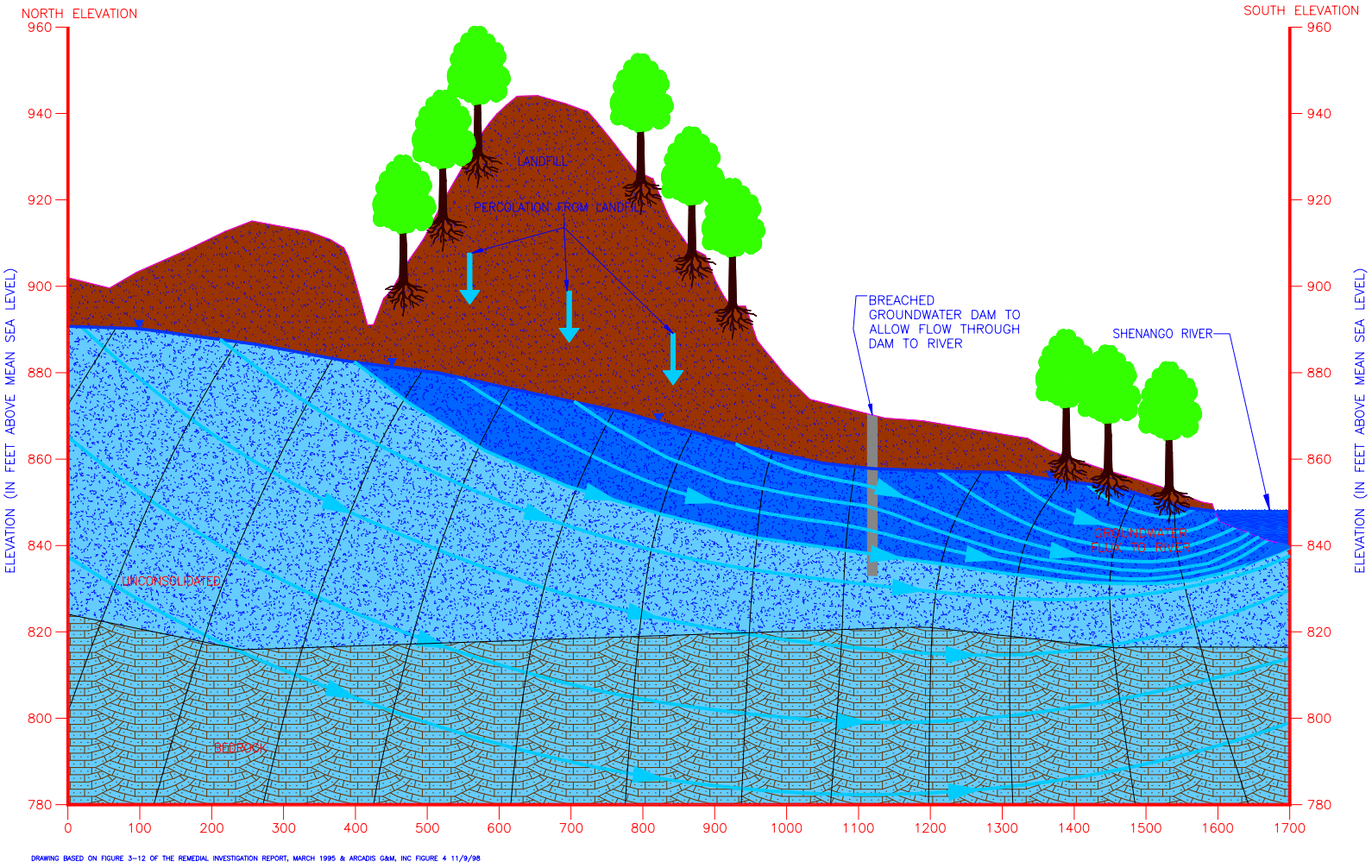
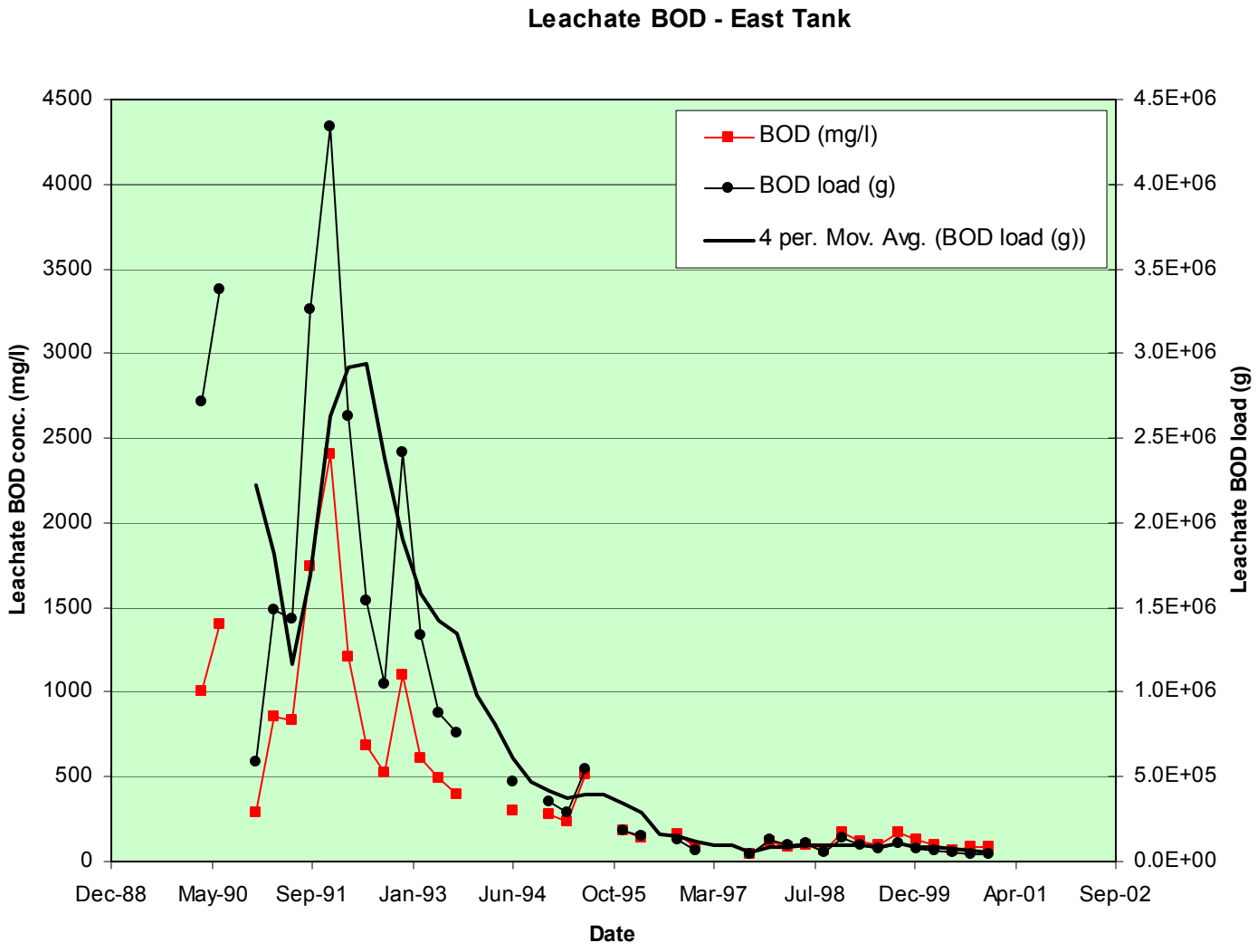


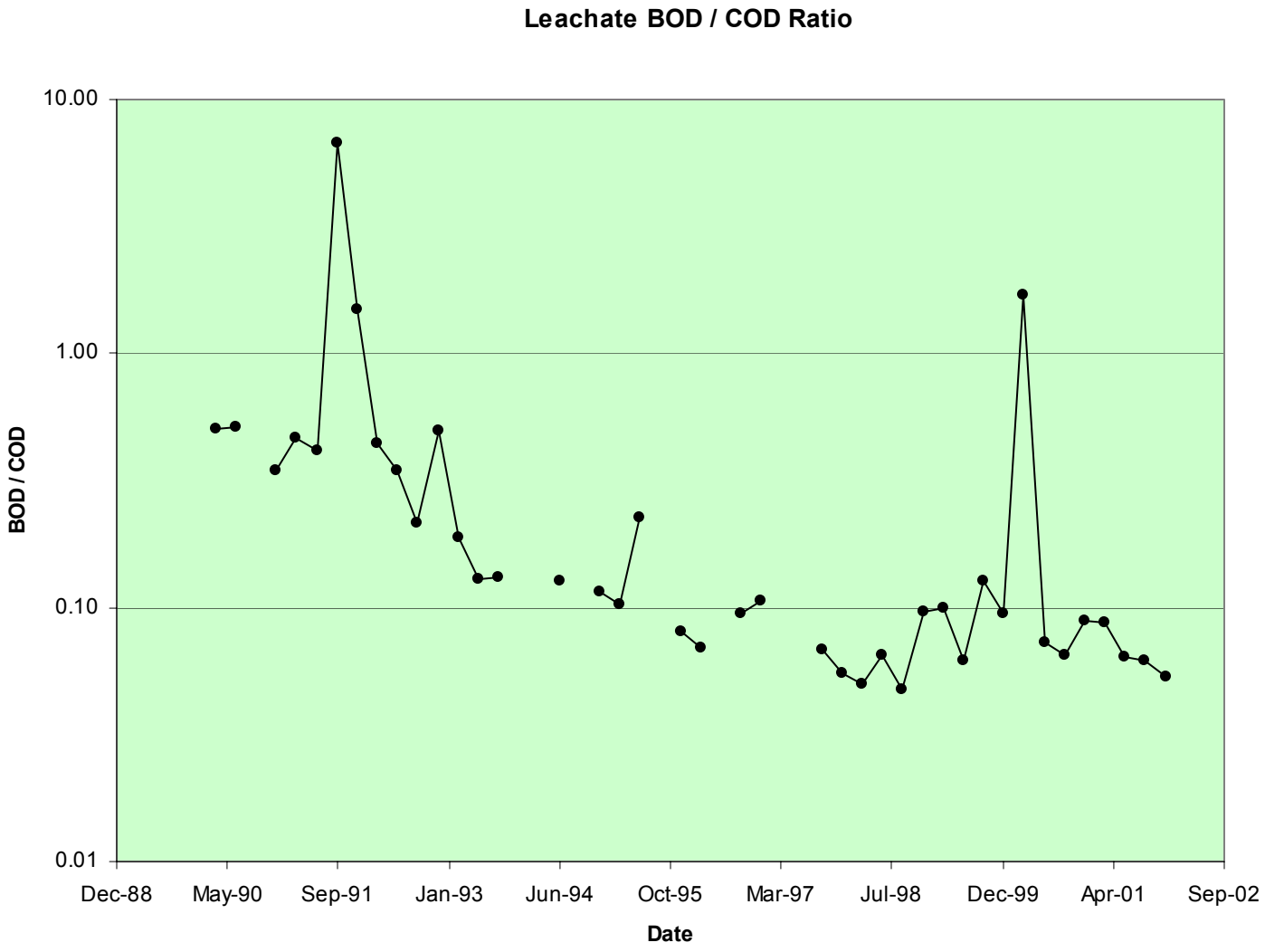
Figure 3: 3-Month Moving Average BOD/COD Ratio

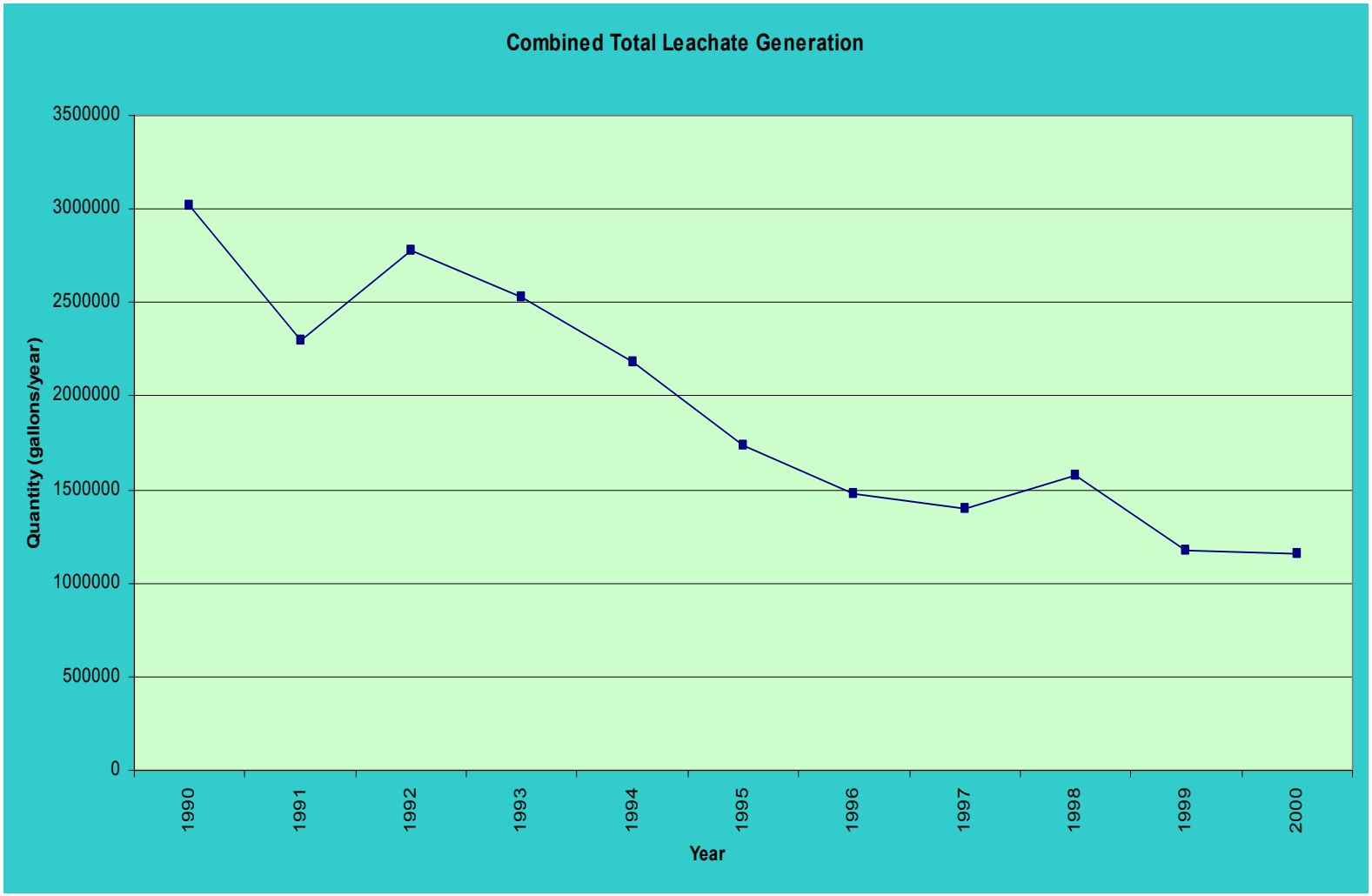




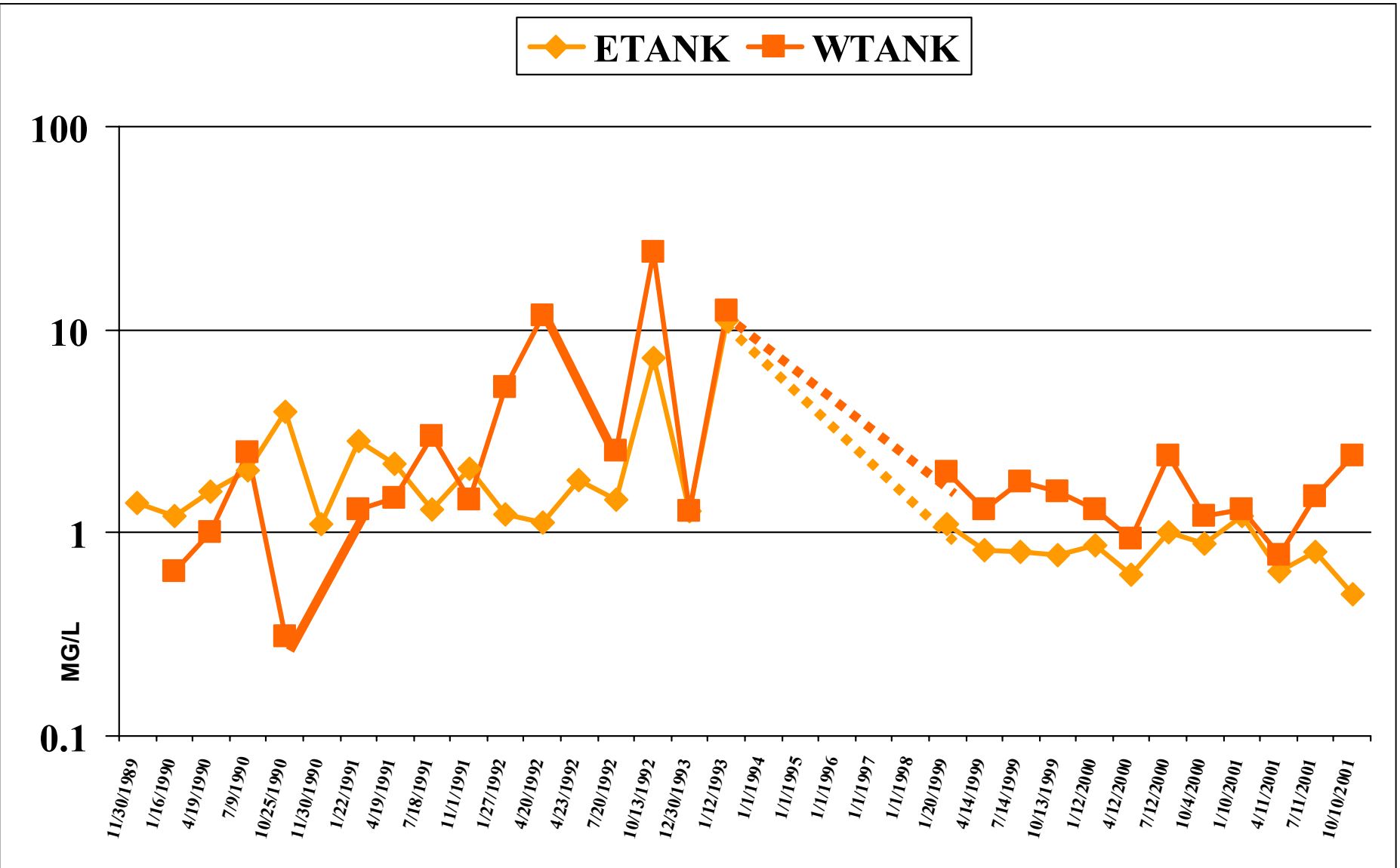
DRAWING BASED ON FIGURE 3-12 OF THE REMEDIAL INVESTIGATION REPORT, MARCH 1995 & ARCADIS G&M, INC FIGURE 4 11/9/98


Leachate BOD - East Tank
BOD (mg/l)
BOD load (g)
4 per. Mov. Avg. (BOD load (g))
Leachate BOD conc. (mg/l)
Leachate BOD load (g)
Date
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0.0E+00
5.0E+05
1.0E+06
1.5E+06
2.0E+06
2.5E+06
3.0E+06
3.5E+06
4.0E+06
4.5E+06
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02


Leachate BOD / COD Ratio
10.00
1.00
0.10
0.01
BOD / COD
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Date

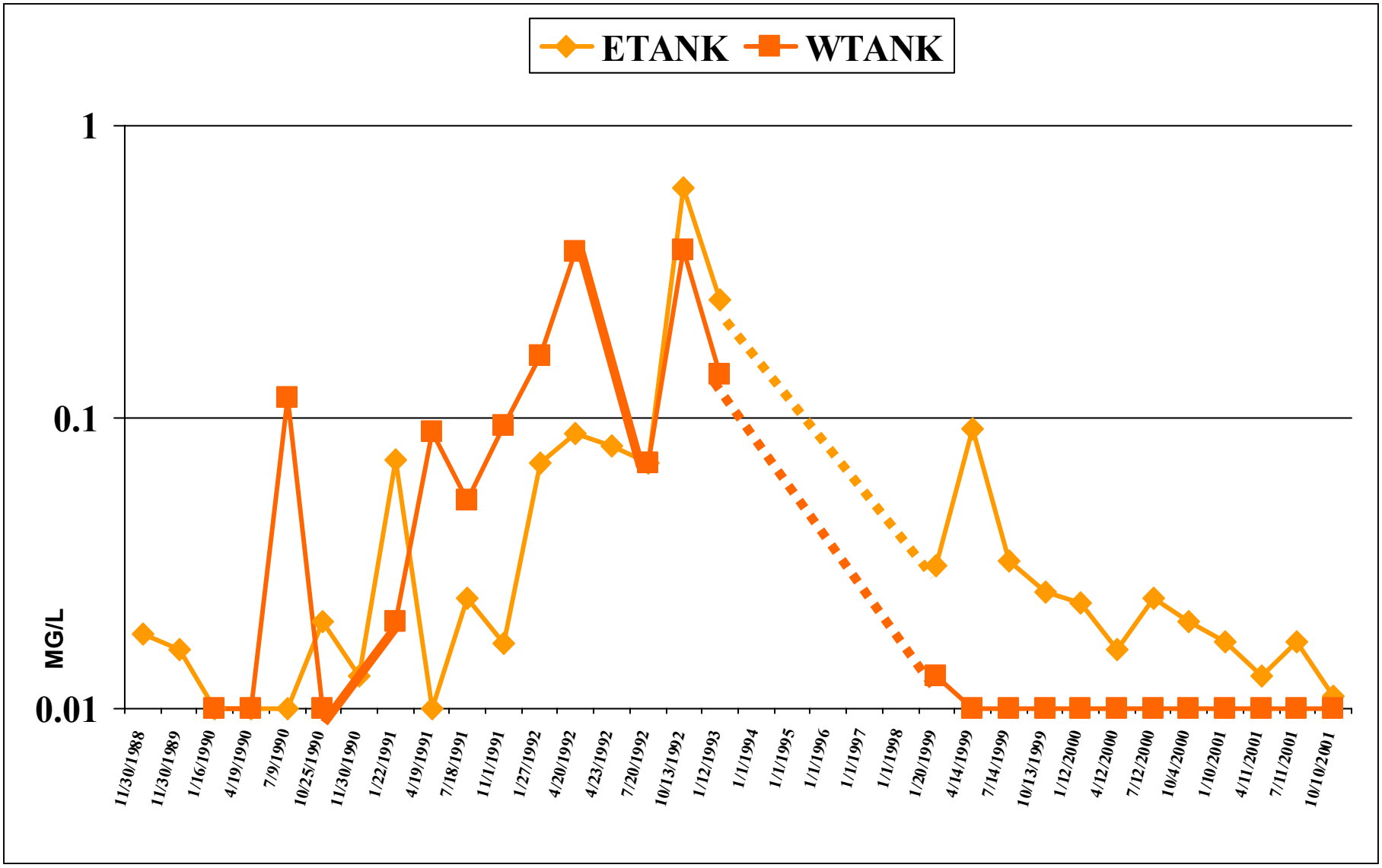

Combined Total Leachate Generation
Quantity (gallons/year)
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Year

BARIUM


ETANK
WTANK
100
10
1
0.1
MG/L
11/30/1989
1/16/1990
4/19/1990
7/9/1990
10/25/1990
11/30/1990
1/22/1991
4/19/1991
7/18/1991
11/1/1991
1/27/1992
4/20/1992
4/23/1992
7/20/1992
10/13/1992
12/30/1993
1/12/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/20/1999
4/14/1999
7/14/1999
10/13/1999
1/12/2000
4/12/2000
7/12/2000
10/4/2000
1/10/2001
4/11/2001
7/11/2001
10/10/2001

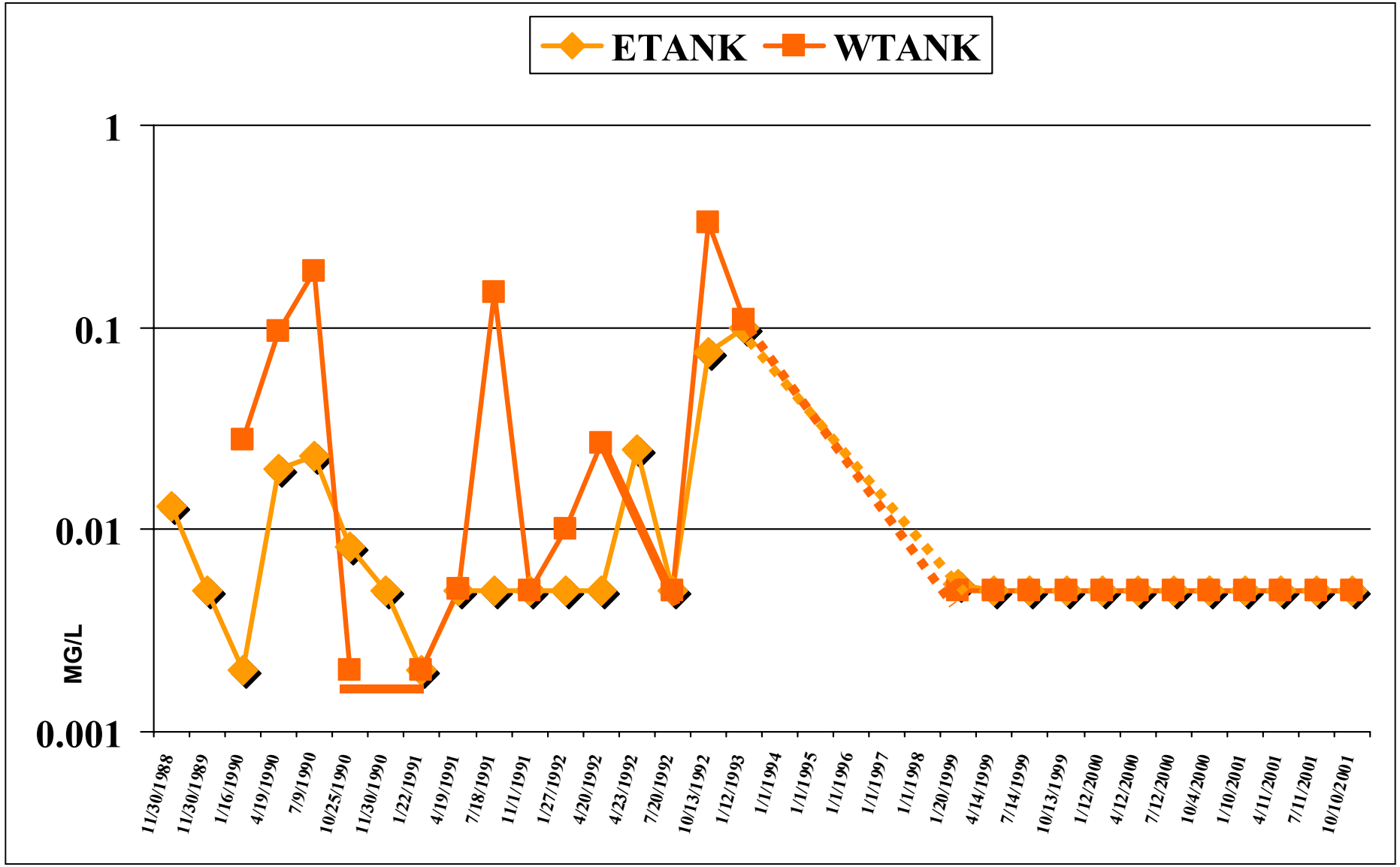
ARSENIC

WASTE MANAGEMENT



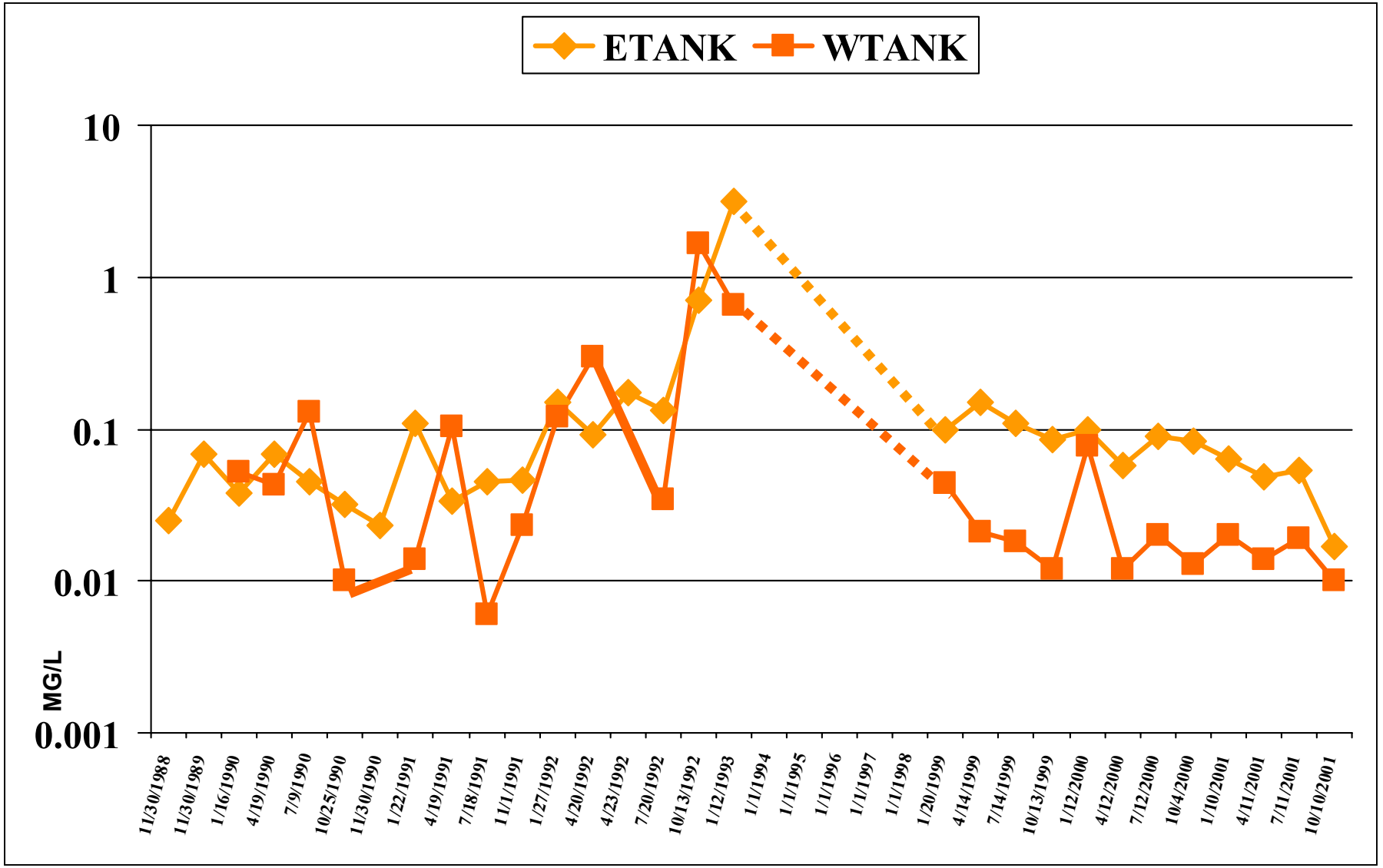
CADMIUM

WASTE MANAGEMENT



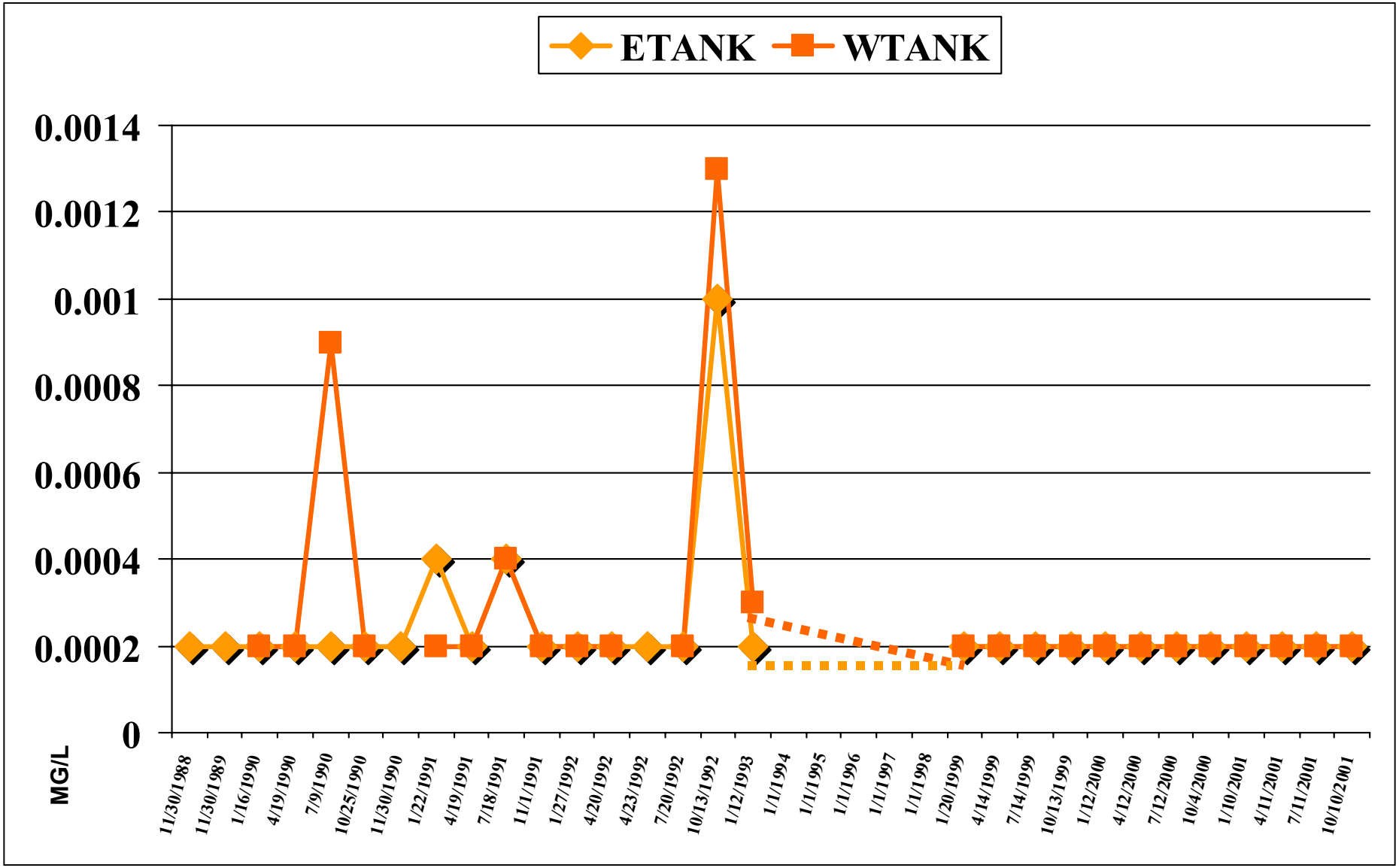
CHROMIUM

WASTE MANAGEMENT



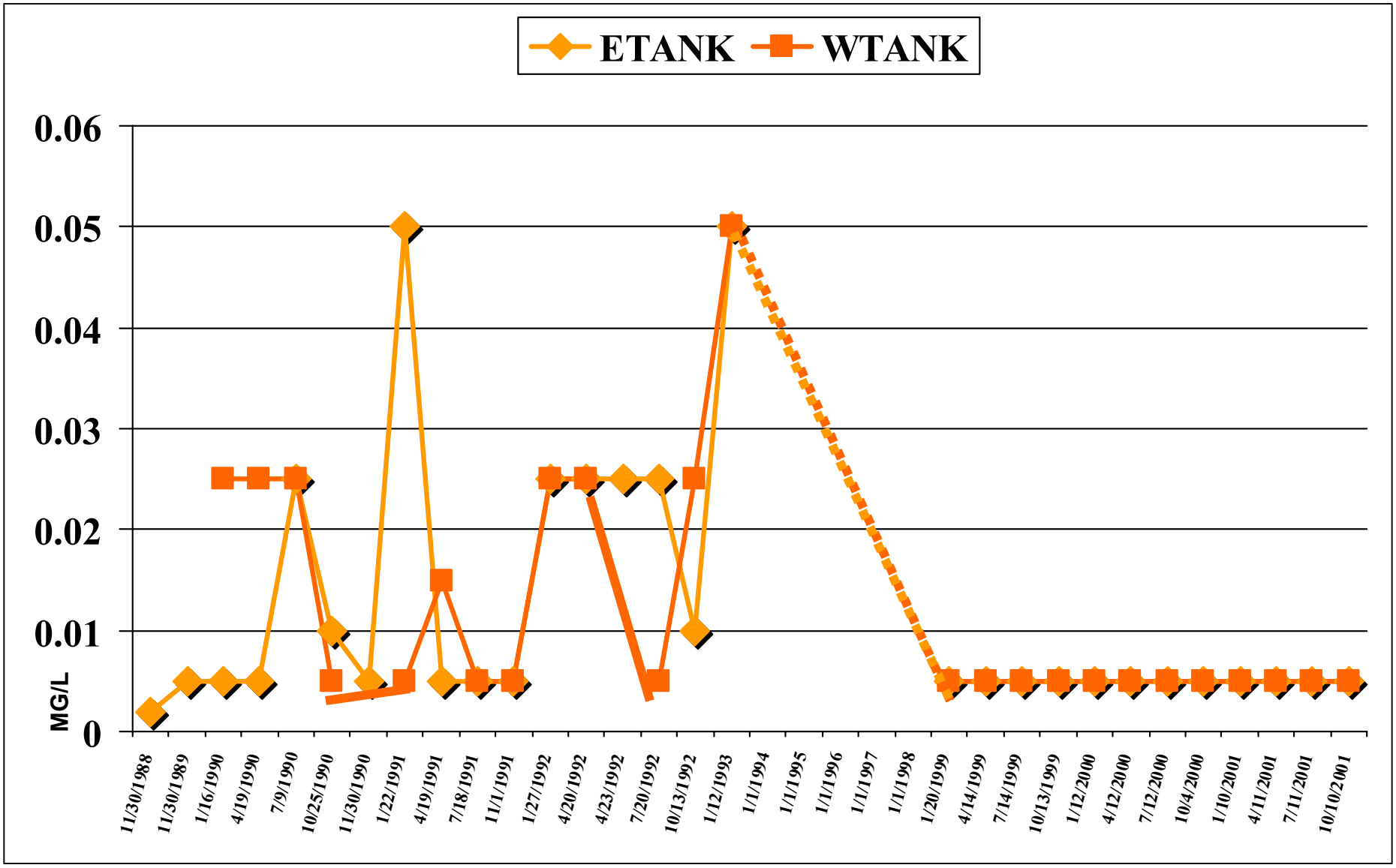
MERCURY

WASTE MANAGEMENT

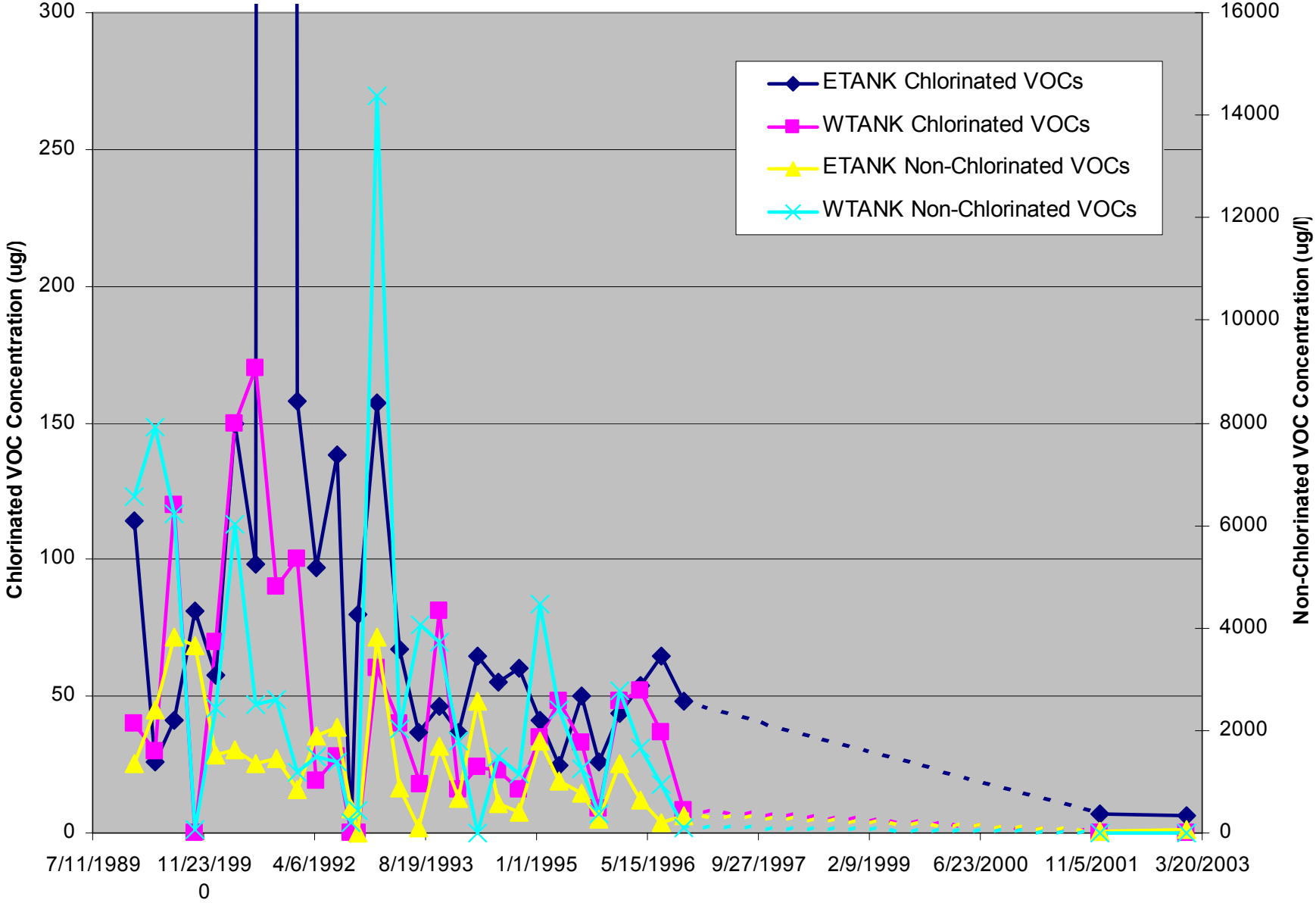


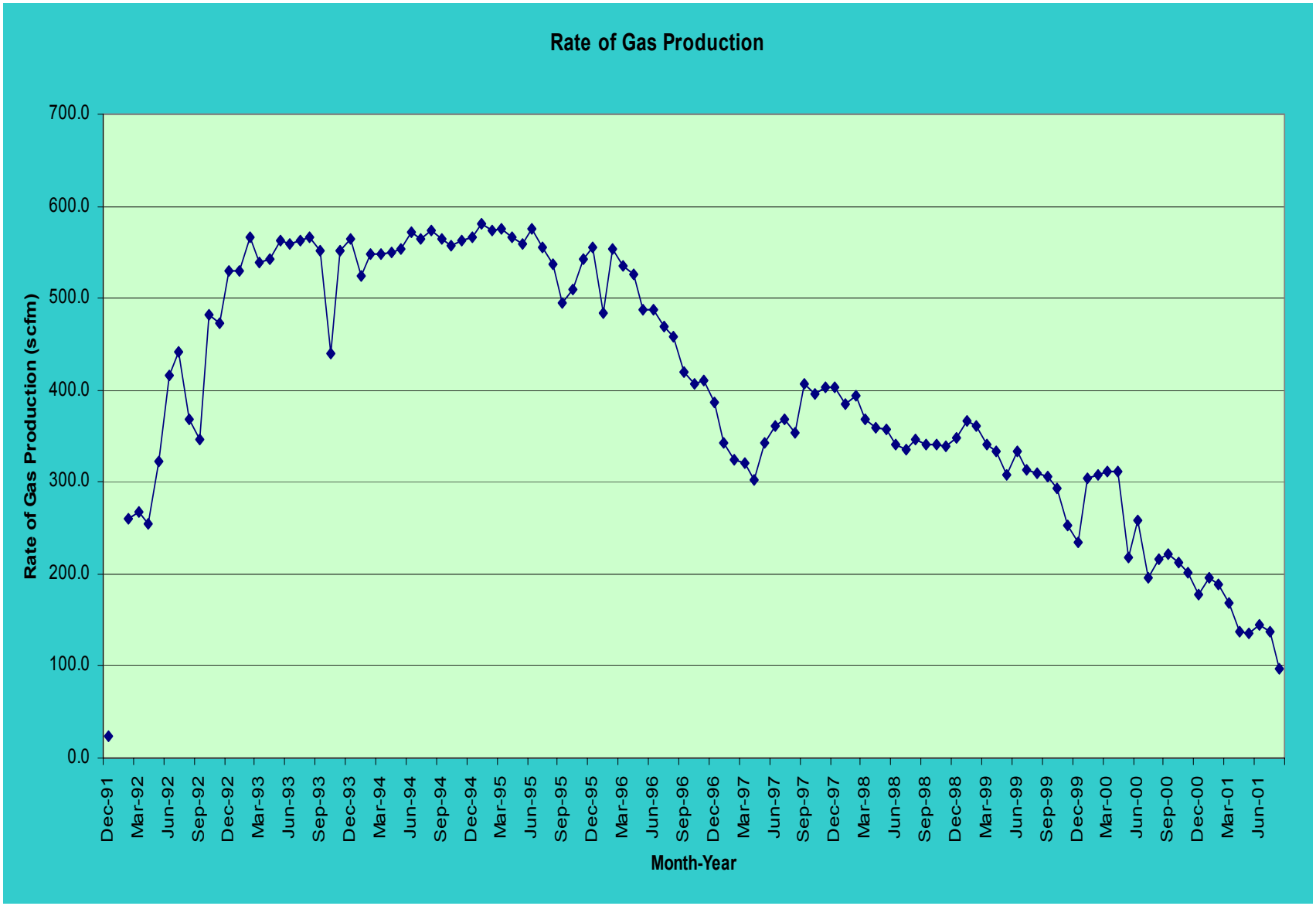
SELENIUM

WASTE MANAGEMENT



VOCs


ETANK Chlorinated VOCs
WTANK Chlorinated VOCs
ETANK Non-Chlorinated VOCs
WTANK Non-Chlorinated VOCs
Chlorinated VOC Concentration (ug/)
Non-Chlorinated VOC Concentration (ug/l)
300
250
200
150
100
50
0
16000
14000
12000
10000
8000
6000
4000
2000
0
7/11/1989
11/23/1990
4/6/1992
8/19/1993
1/1/1995
5/15/1996
9/27/1997
2/9/1999
6/23/2000
11/5/2001
3/20/2003


Rate of Gas Production
Rate of Gas Production (scfm)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Dec-91
Mar-92
Jun-92
Sep-92
Dec-92
Mar-93
Jun-93
Sep-93
Dec-93
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
Dec-95
Mar-96
Jun-96
Sep-96
Dec-96
Mar-97
Jun-97
Sep-97
Dec-97
Mar-98
Jun-98
Sep-98
Dec-98
Mar-99
Jun-99
Sep-99
Dec-99
Mar-00
Jun-00
Sep-00
Dec-00
Mar-01
Jun-01
Month-Year

Water Balance

- 2.3 pore volumes or 5.7 bed volumes moved through waste
- When BOD/COD <0.1, 0.2 pore volumes or 0.6 bed volumes were estimated
- Literature states that BOD/COD <0.1 occurs when 0.4 pore volumes are added

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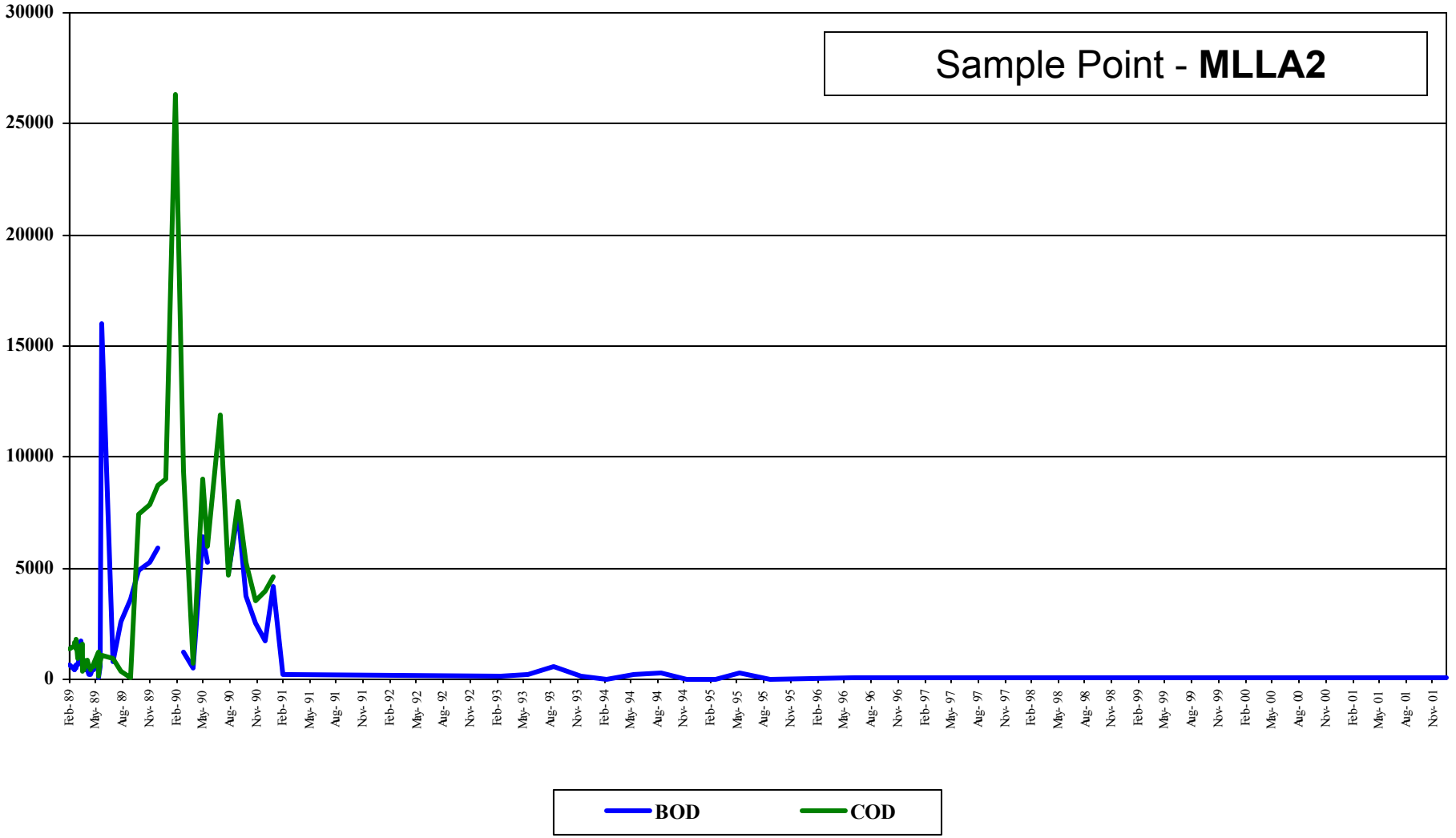
Leachate BOD/COD

WASTE MANAGEMENT

ALL BOD - COD Historical Data



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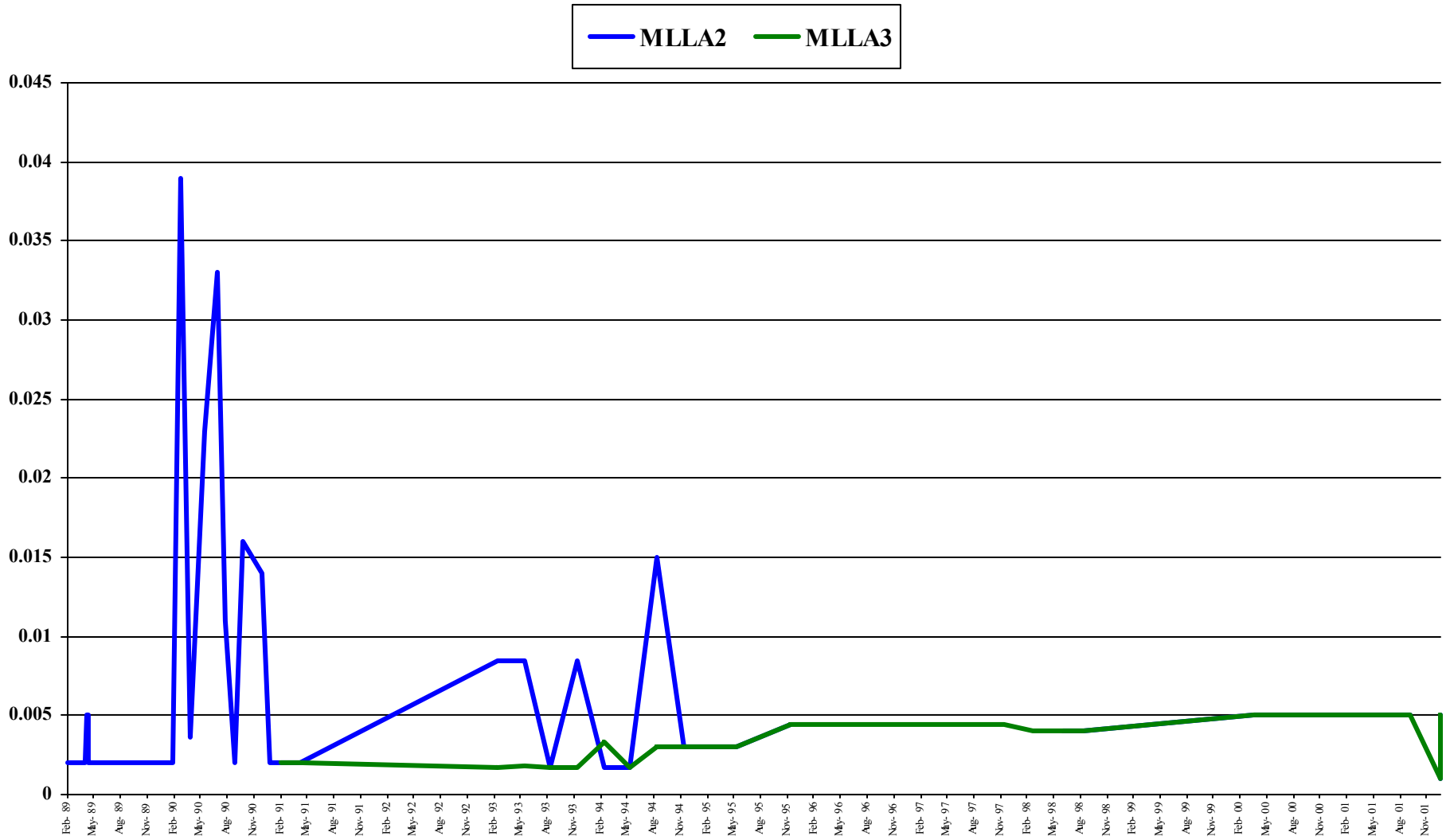
METALS

WASTE MANAGEMENT

Cadmium



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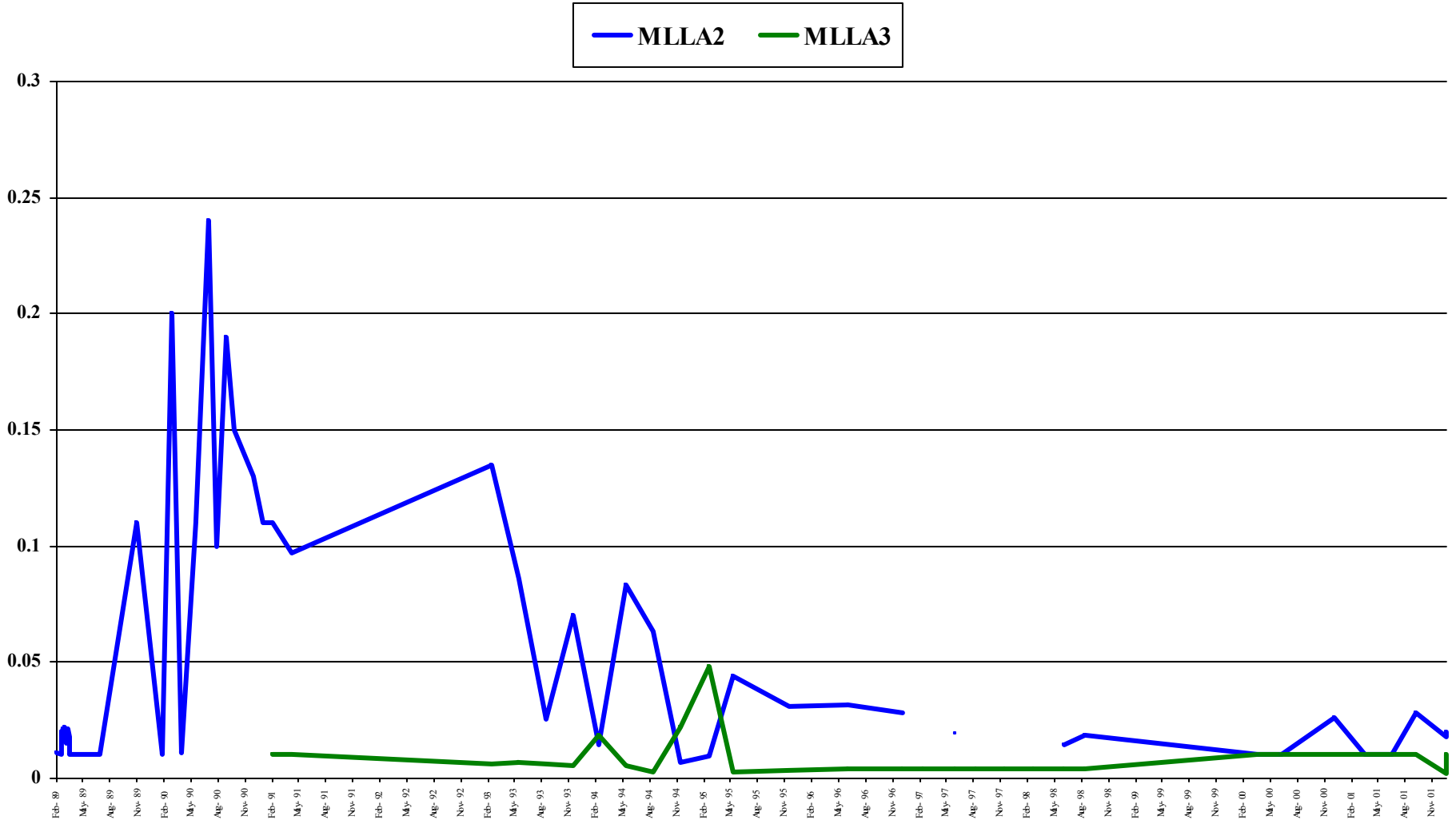
METALS

WASTE MANAGEMENT

Chromium



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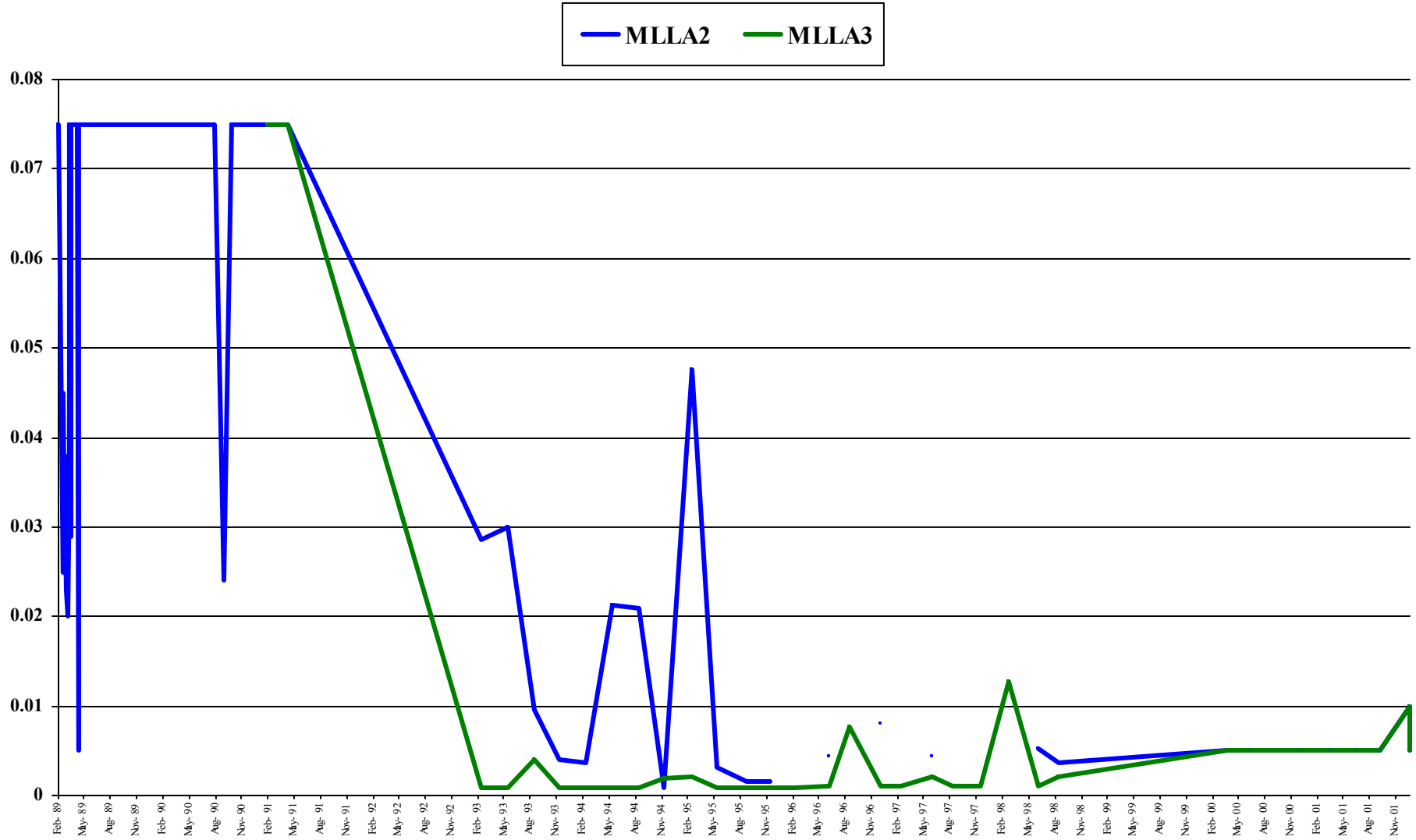
METALS

WASTE MANAGEMENT

Lead



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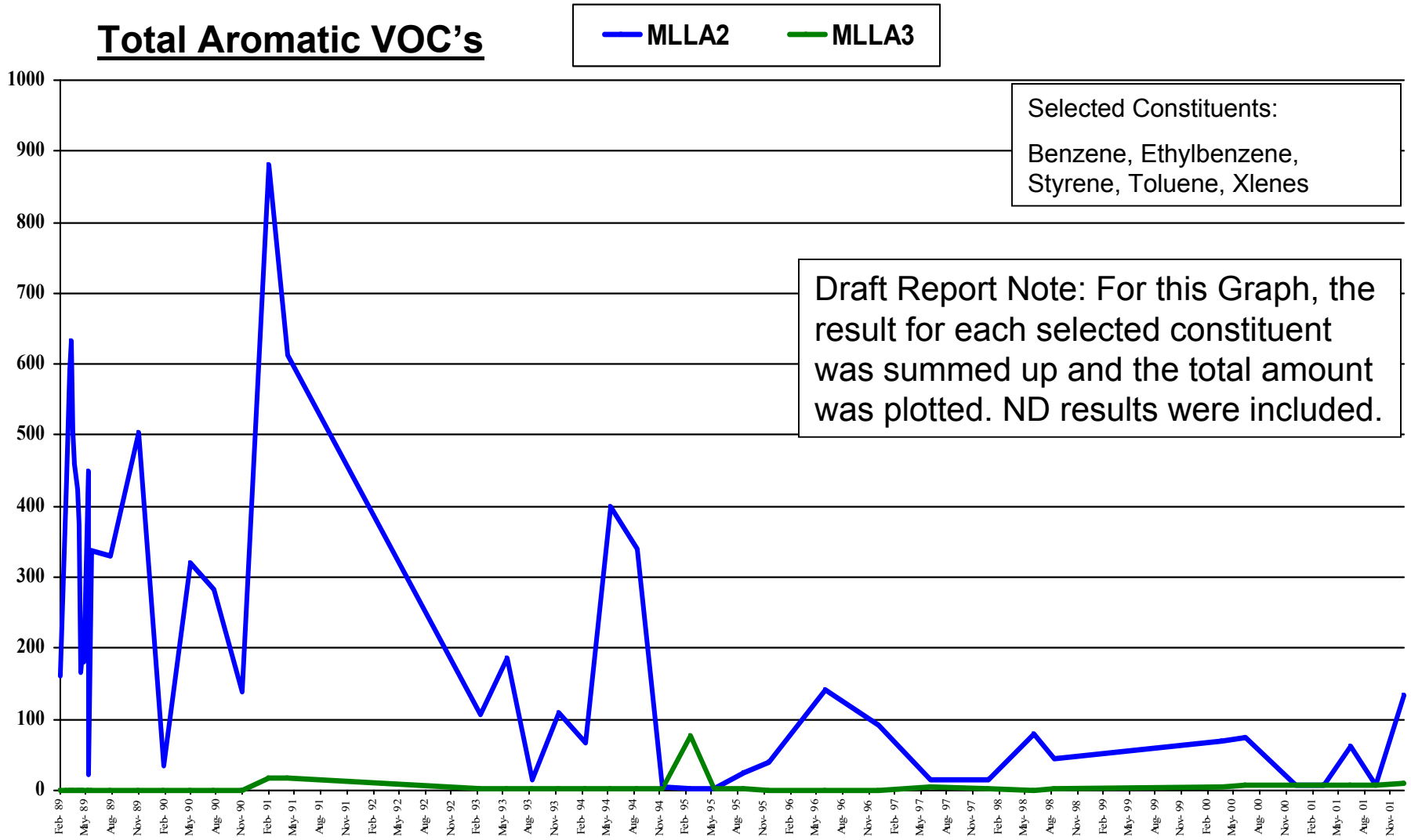
VOC's

WASTE MANAGEMENT

Total Aromatic VOC's



Selected Constituents:

Benzene, Ethylbenzene, Styrene, Toluene, Xlenes

Draft Report Note: For this Graph, the result for each selected constituent was summed up and the total amount was plotted. ND results were included.

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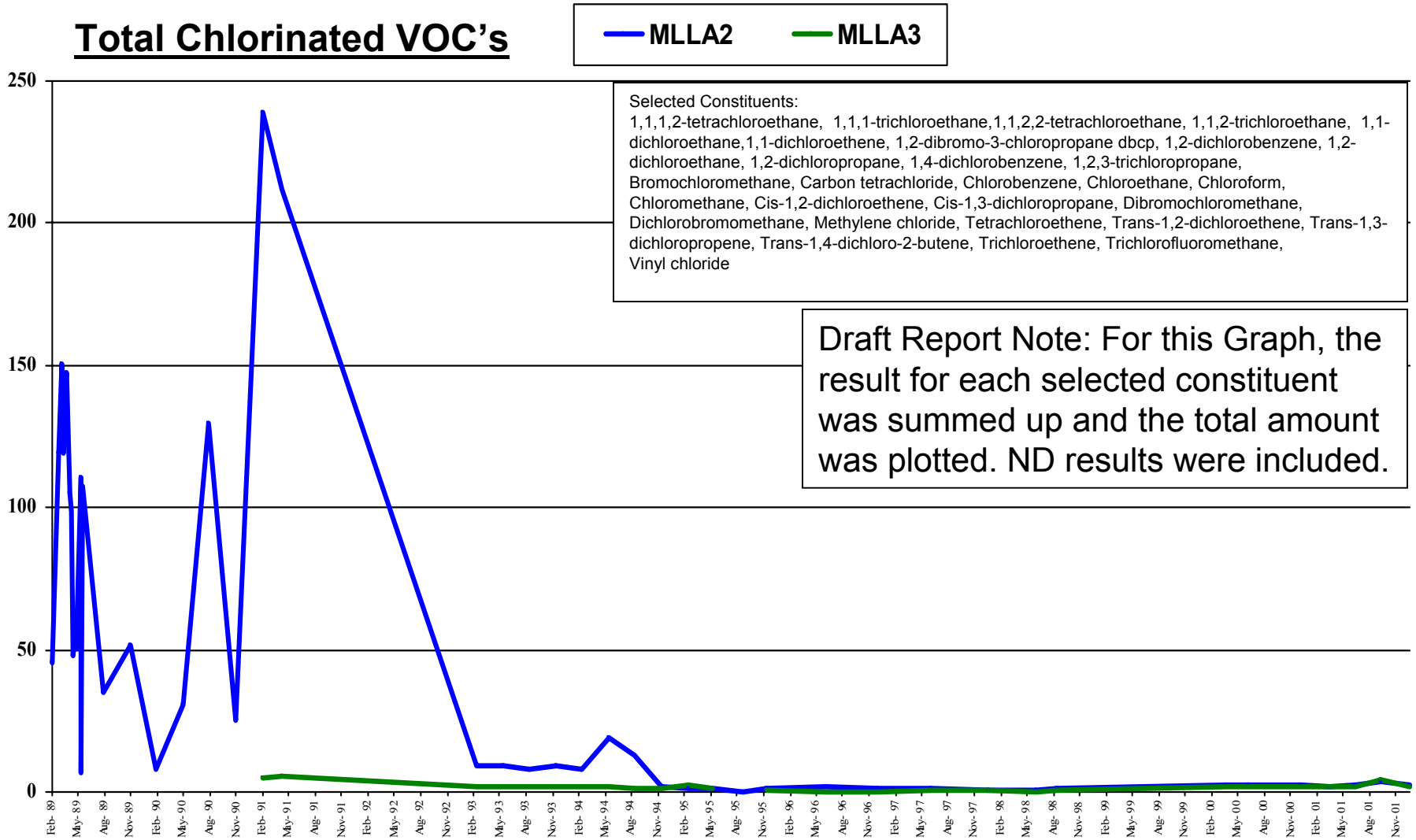
VOC's

WASTE MANAGEMENT

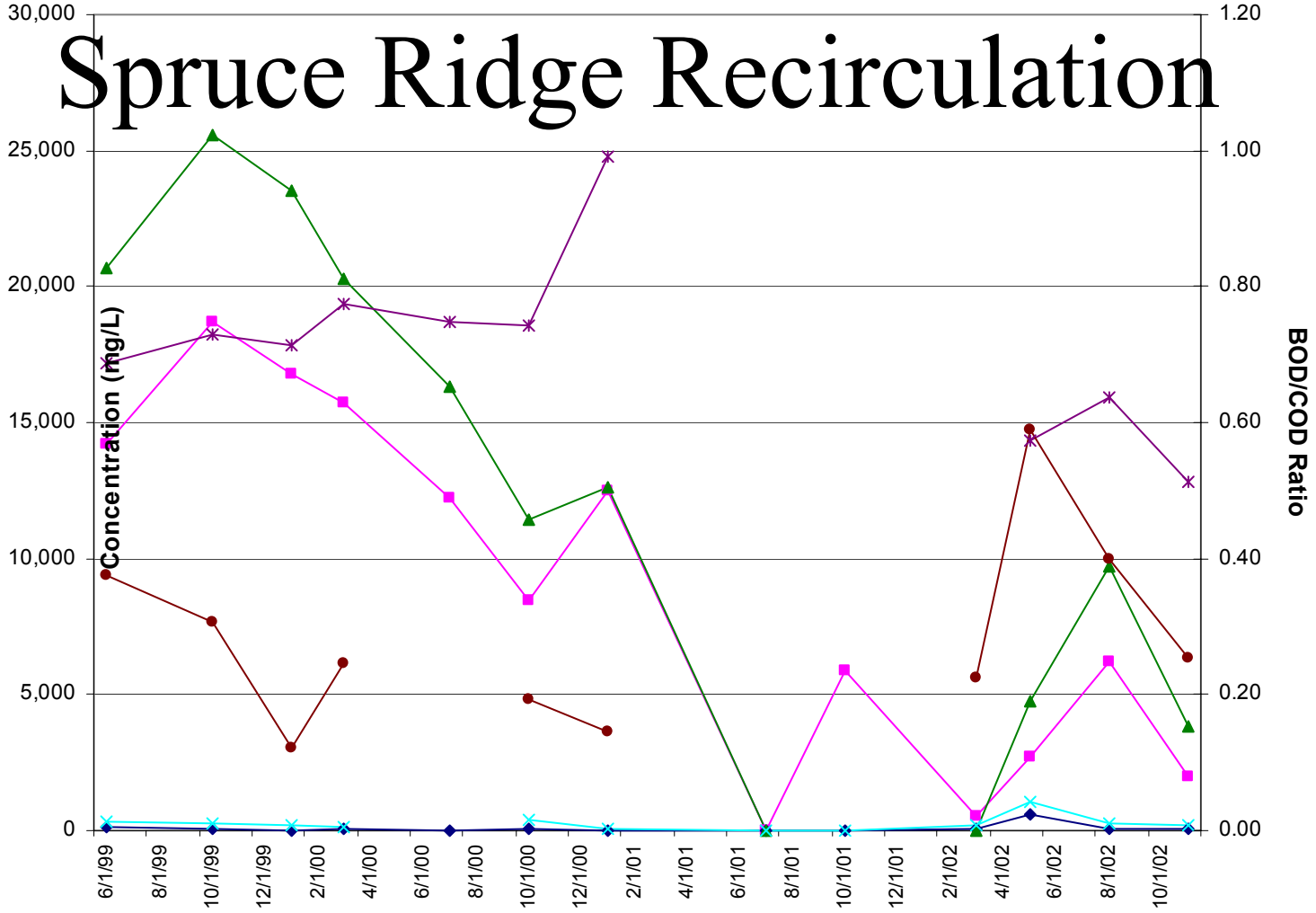
Total Chlorinated VOC's



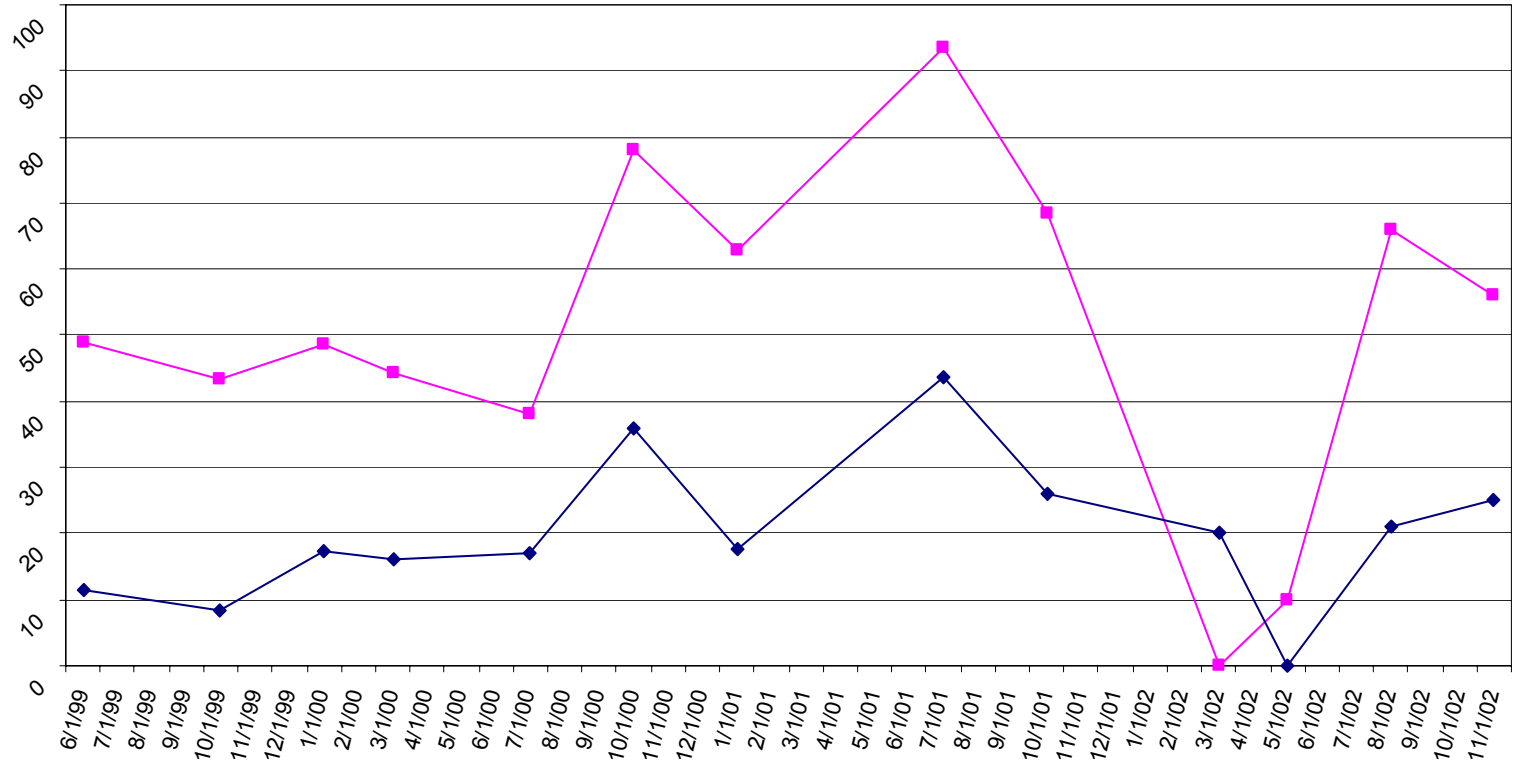
Selected Constituents:
1,1,1,2-tetrachloroethane, 1,1,1-trichloroethane,1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane,1,1-dichloroethene, 1,2-dibromo-3-chloropropane dbcp, 1,2-dichlorobenzene, 1,2-dichloroethane, 1,2-dichloropropane, 1,4-dichlorobenzene, 1,2,3-trichloropropane, Bromochloromethane, Carbon tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Cis-1,2-dichloroethene, Cis-1,3-dichloropropane, Dibromochloromethane, Dichlorobromomethane, Methylene chloride, Tetrachloroethene, Trans-1,2-dichloroethene, Trans-1,3-dichloropropene, Trans-1,4-dichloro-2-butene, Trichloroethene, Trichlorofluoromethane, Vinyl chloride

Draft Report Note: For this Graph, the result for each selected constituent was summed up and the total amount was plotted. ND results were included.

Spruce Ridge Recirculation



Arsenic


100
90
80
70
60
50
40
30
20
10
0
6/1/99
7/1/99
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
1/1/01
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3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
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12/1/01
1/1/02
2/1/02
3/1/02
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9/1/02
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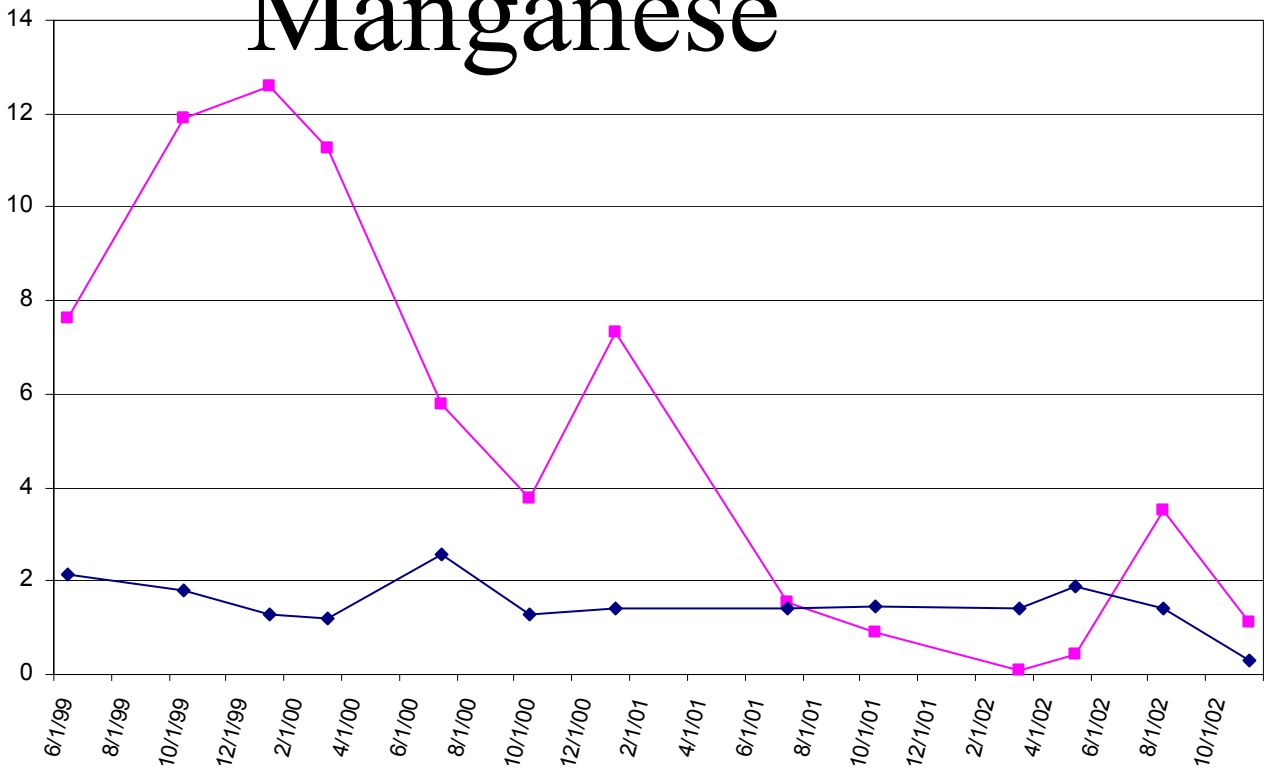
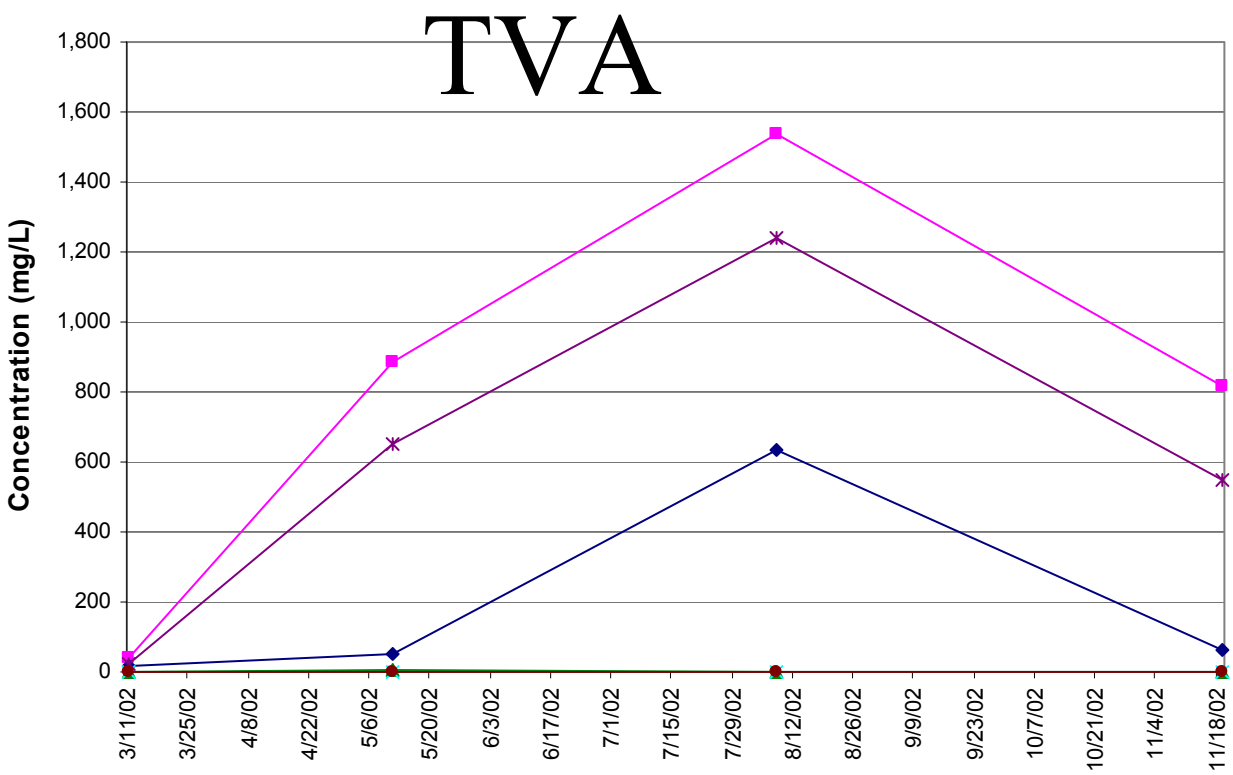
11/1/02

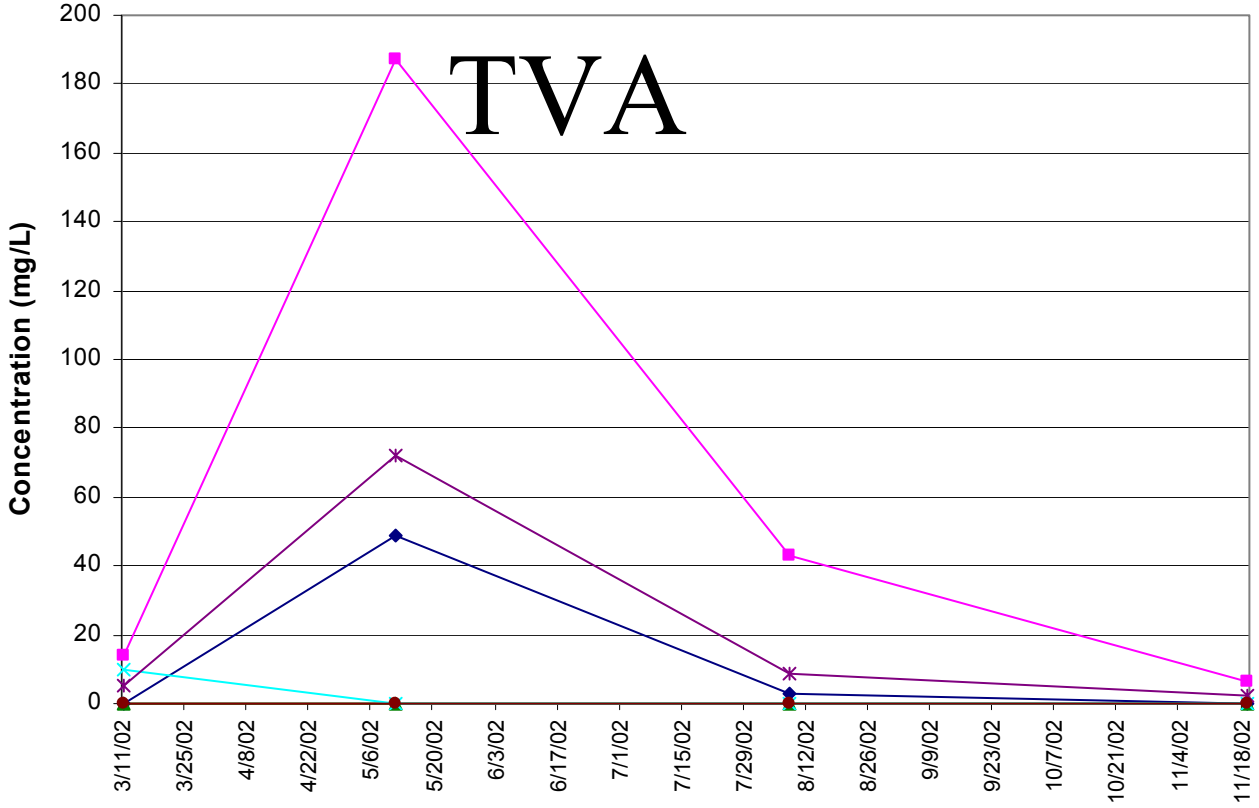
Manganese



	06/23/99	10/19/99	01/11/00	03/30/00	07/20/00	10/24/00	01/09/01	07/12/01	10/25/01	03/11/02	05/11/02	08/08/02	11/19/02
Manganese Conc. (mg/L) - Recirculation	7.6	11.9	12.6	11.28	5.764	3.78	7.3	1.53	0.904	0.097	0.41	3.5	1.1
Manganese Conc. (mg/L) - Control	2.13	1.78	1.28	1.199	2.559	1.27	1.42	1.42	1.45	1.4	1.9	1.4	0.3



	03/11/02	05/11/02	08/08/02	11/19/02
Acetic Acid Conc. (mg/L) - Recirculation	38	887	1,536	817
Butyric Acid Conc. - (mg/L) - Recirculation	17	52	632	63
Formic Acid Conc. (mg-L) - Recirculation	0	7	0	0
Lactic Acid Conc. (mg/L) - Recirculation	0	0	0	0
Propionic Acid (mg/l) - Recirculation	21	650	1,242	549
Pyruvic Acid (mg/l) - Recirculation	0	0	0	0



	03/11/02	05/11/02	08/08/02	11/19/02
Acetic Acid Conc. (mg/L) - Control	14	187	43	6.3
Butyric Acid Conc. - (mg/L) - Control	0	49	2.7	0
Formic Acid Conc. (mg-L) - Control	0	0	0	0
Lactic Acid Conc. (mg/L) - control	10	0	0	0
Propionic Acid (mg/1) - control	5	72	8.8	2.1
Pyruvic Acid (mg/1)-control	0	0	0	0