Field Application of In-Well Aeration aka Density Driven Convection for VOC/PCE Remediation

By

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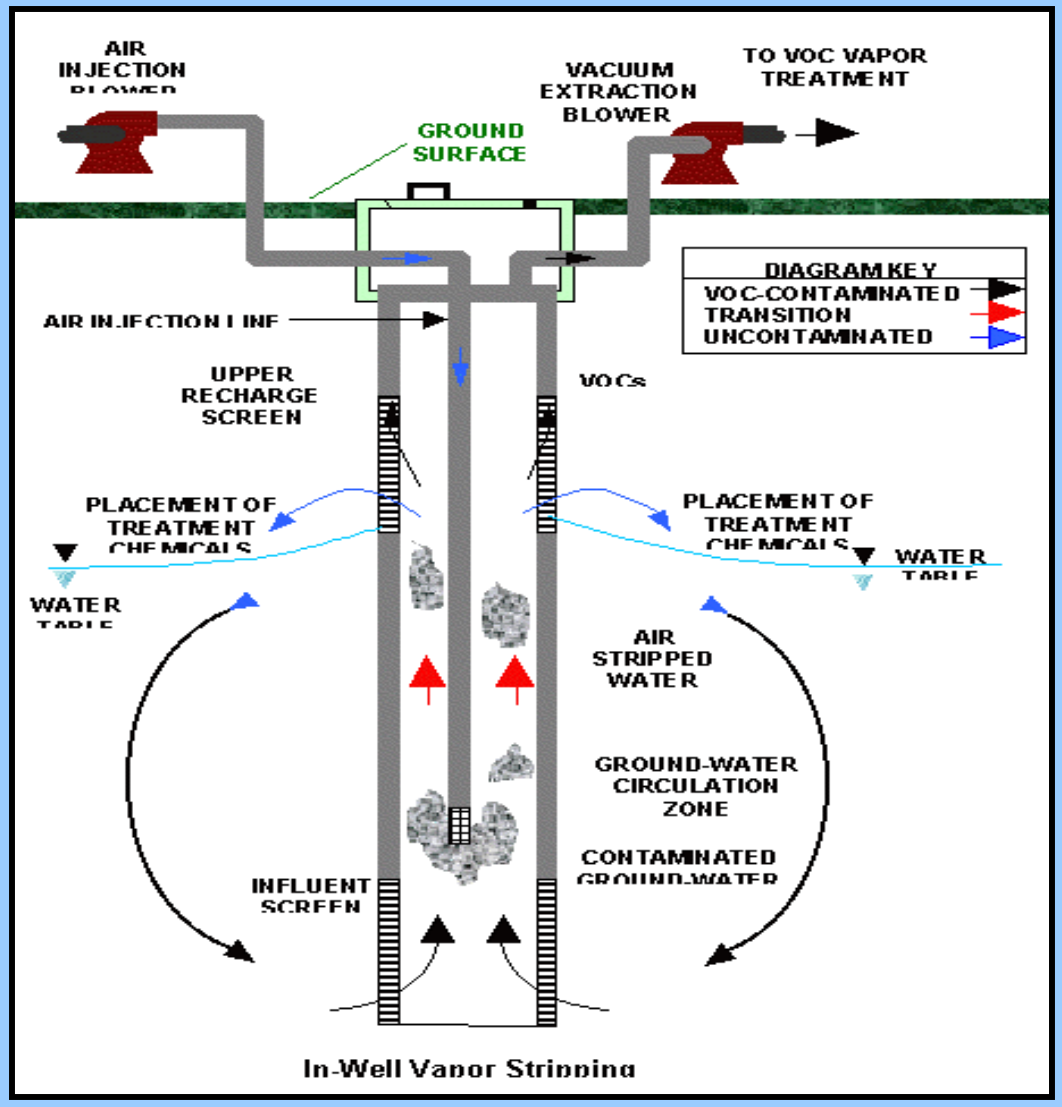
In-Well Aeration aka Density Driven Convection for VOC/PCE Remediation

- Introduction
- System Description
- Design Considerations
- Site Application
- Conclusions & Recommendations

DENSITY DRIVEN CONVECTION



In-Well Vapor Stripping

DESIGN CONSIDERATIONS

- **Optimize System Processes**
  - **Mass Transfer Efficiency**
  - **Circulation Area**
  - **Geochemical Environment**

DESIGN CONSIDERATIONS

Mass Transfer Efficiency

- Henry's Law Constant
- Temperature
- Air flow-rate (air/water ratio)
- Residence time (contact length)
- Bubble size (0.25-0.5 inch)

DESIGN CONSIDERATIONS

Circulation Area

- Anisotropic ratio is
  - -Horizontal hydraulic conductivity
  - -Vertical hydraulic conductivity
- Type of substrate
- Plume thickness
- Pumping rate

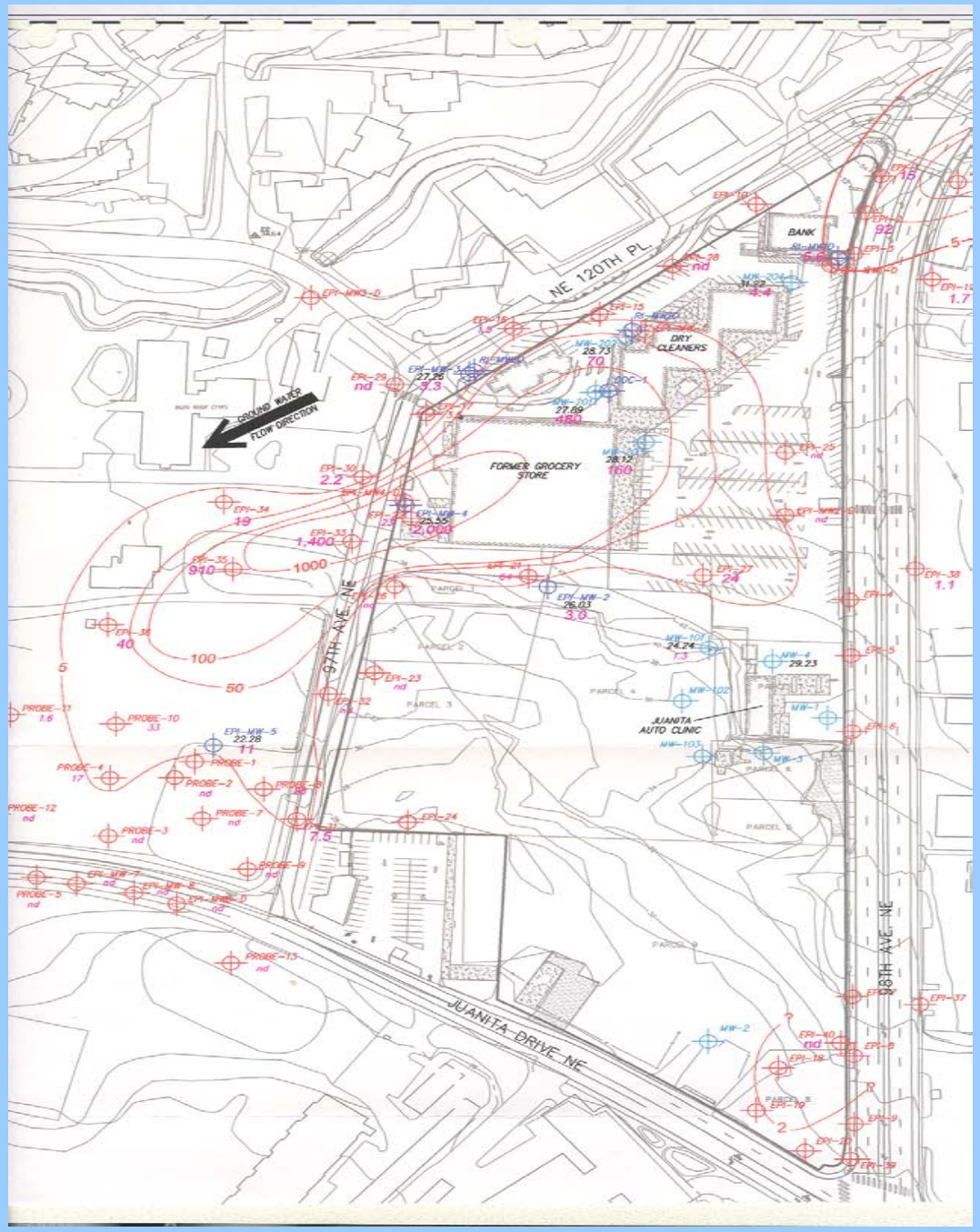
DESIGN CONSIDERATIONS

Geochemistry Environment

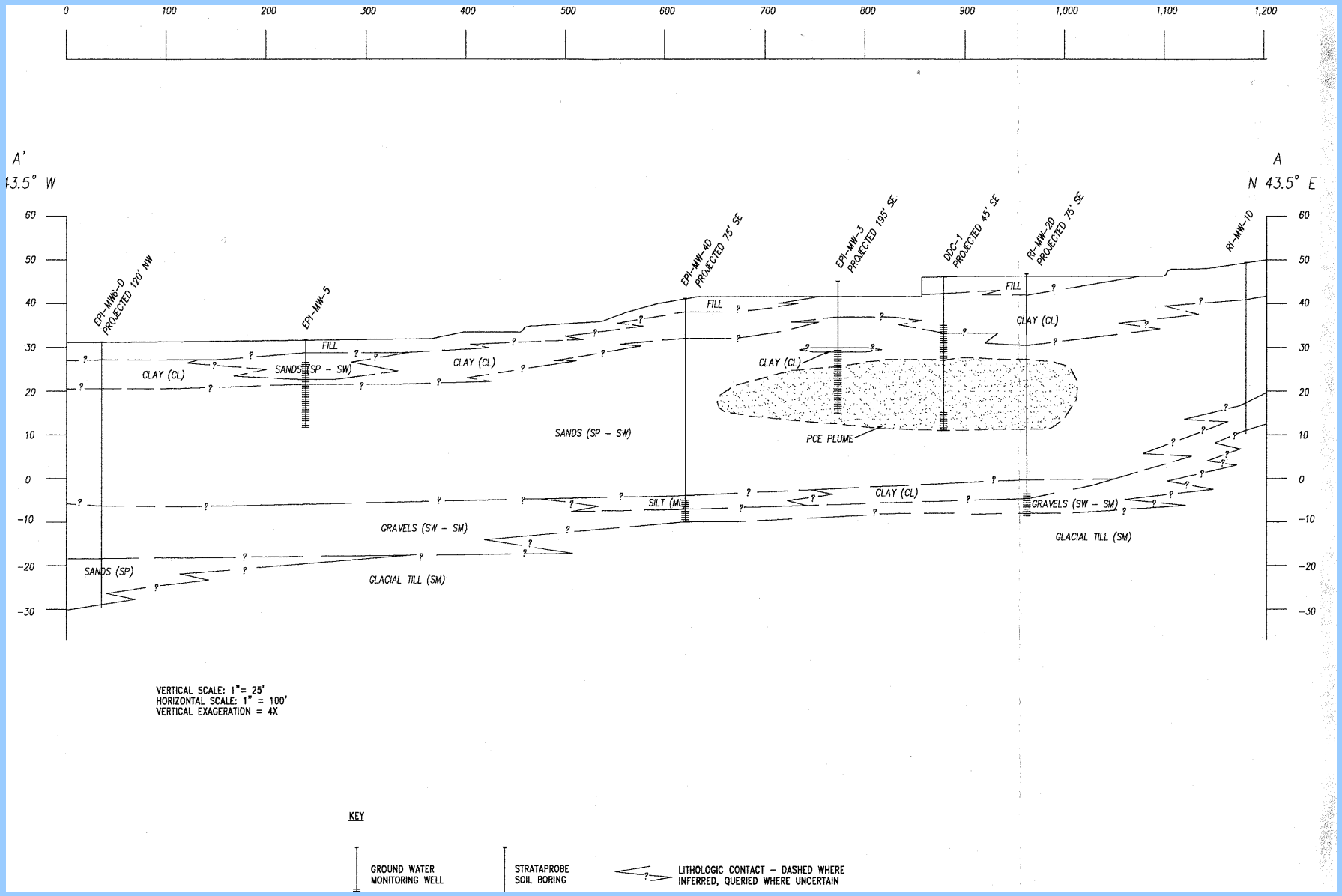
- Groundwater system characteristics
- High Fe -> precipitation
- Calcite system

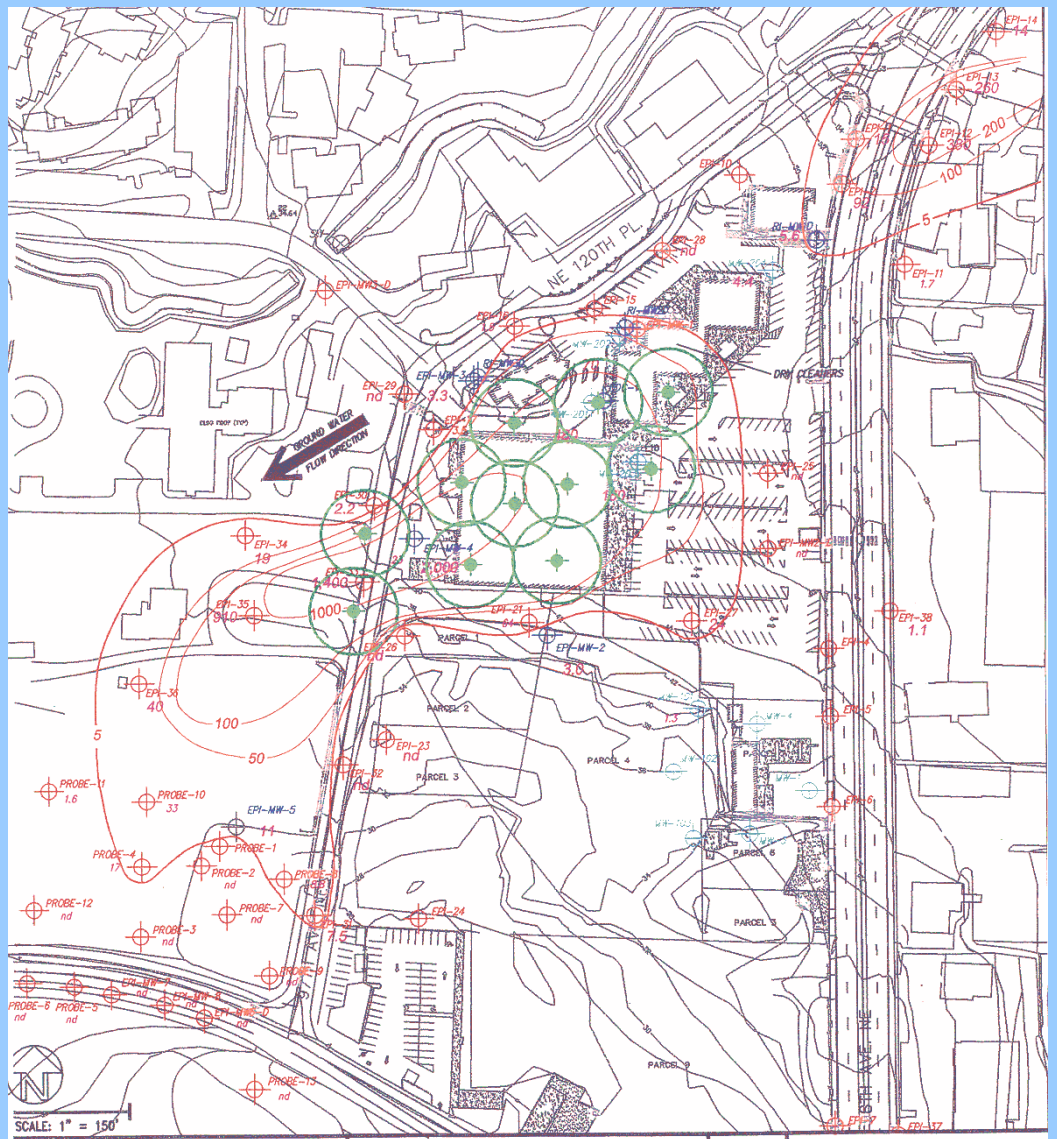
  -if DDC increases pH

  -modify using CO_2


NE 120TH PL
BANK
DRY CLEANERS
FORMER GROCERY STORE
GROUND WATER FLOW DIRECTION
97TH AVE NE
98TH AVE NE
JUANITA AUTO CLINIC
JUANITA DRIVE NE
PARCEL 1
PARCEL 2
PARCEL 3
PARCEL 4
PARCEL 5
PARCEL 6
PARCEL 7
PARCEL 8
PARCEL 9
PARCEL 10
EPI-MW-1 27.25 5.3
EPI-MW-2 26.03 3.0
EPI-MW-4 23.55 12,000
EPI-MW-5 22.28 11
MW-201 28.73 70
MW-202 27.89 480
MW-203 28.12 160
MW-204 31.22 4.4
MW-4 29.23
MW-101 24.24 1.3
EPI-30 2.2
EPI-34 19
EPI-33 1,400
EPI-35 910
EPI-36 40
EPI-31 64
EPI-27 24
EPI-38 1.1
EPI-23 nd
EPI-32 nd
EPI-24 7.5
EPI-29 nd
EPI-28 nd
EPI-25 nd
EPI-40 nd
EPI-37 2
PROBE-11 1.6
PROBE-10 33
PROBE-4 17
PROBE-1
PROBE-2 nd
PROBE-7 nd
PROBE-3 nd
PROBE-12 nd
PROBE-9 nd
PROBE-5 nd
PROBE-13 nd
1000
100
50
5

SW-NE CROSS SECTION





EPI-MW-5 EPI GROUND WATER MONITORING WELL

TERRA GROUND WATER MONITORING WELL

EPI-20 EPI STRATAPROBE GROUND WATER SAMPLING LOCATION

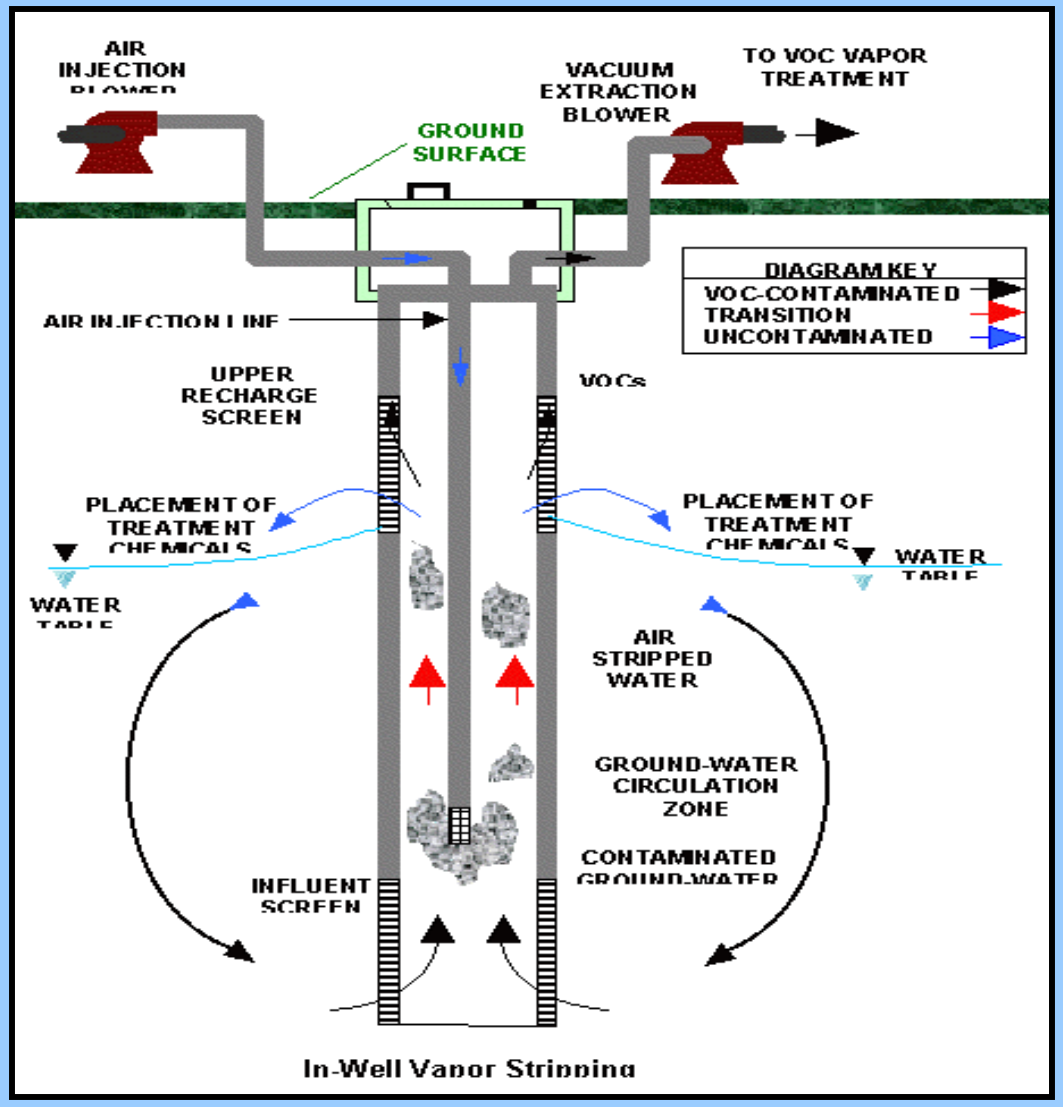
5 PCE CONCENTRATION CONTOUR

PROPOSED DDC WELL

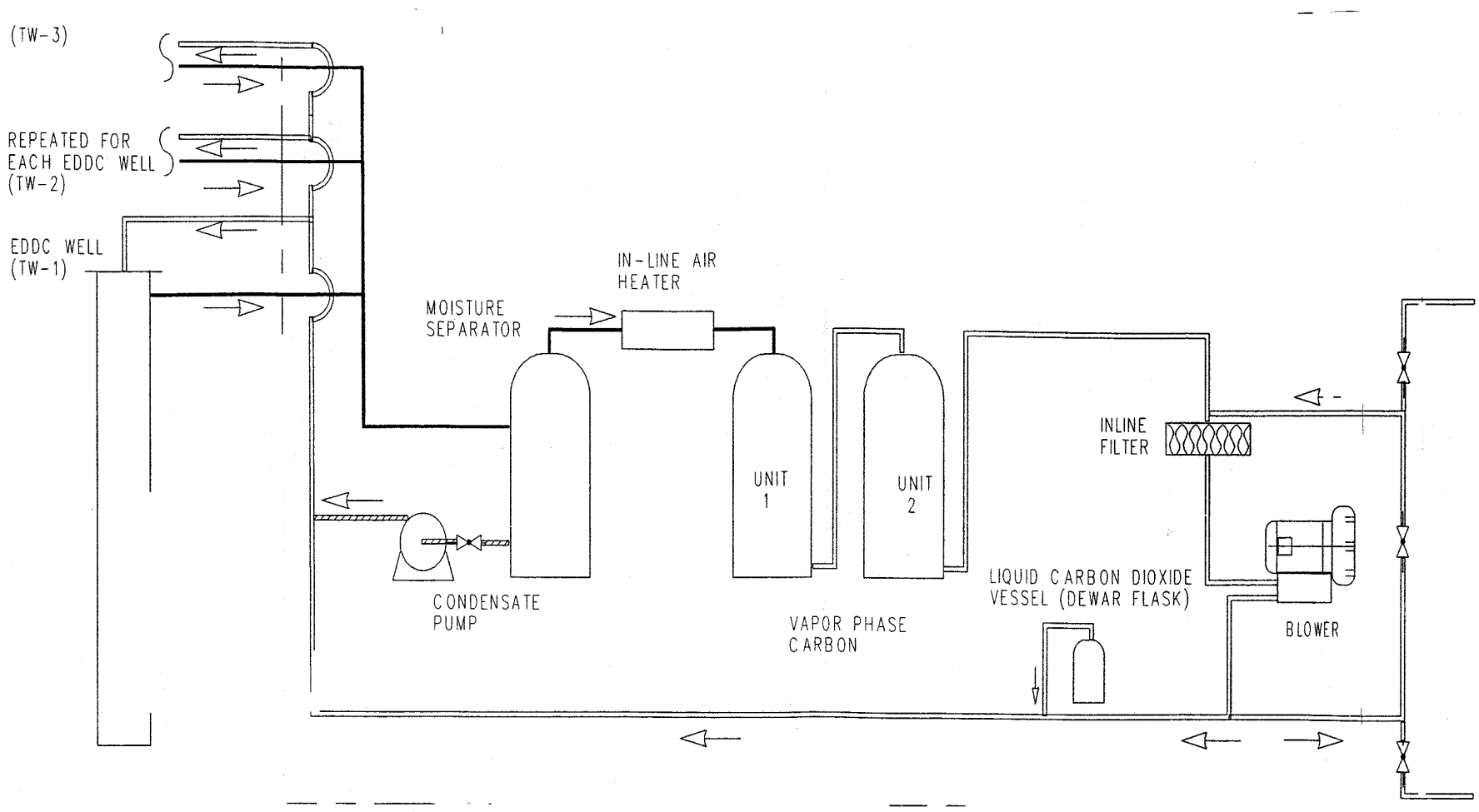
PROPOSED CONCEPTUAL PLAN FOR DDC WELLS PLACEMENT

PROJECT			
PREPARED FOR	JUANITA VILLAGE, LLC		
LOCATION	JUANITA VILLAGE KIRKLAND, WASHINGTON		
SHEET 1 of 1	DRAWN BY EMK	REVIEWED BY JRK	DATE 04/21/00

DENSITY DRIVEN CONVECTION



DDC SYSTEM LAYOUT



SYSTEM FLUXES

WELLHEAD PIPING CONFIGURATION

PIPING CONFIGURATION at TREATMENT UNIT

DDC EQUIPMENT UNIT

DDC at JUANITA VILLAGE SITE

Juanita Village Site Groundwater Monitoring Results Perchloroethene, ug/L (ppb)

Up-gradient - to - down-gradient - - - -
northeast - to - southwest groundwater flow - - - -

Monitoring Wells	MW-1	MW-2	MW-3	MW-4	TW-7	MW-7	TW-1
RI/Pre Treatment Results	66	450	350	1900	11	2000	160
Recent - Jan 03	2.4	13	84	93	21	76	8
Percent improvement	**96%**	**97%**	**76%**	**95%**	**nc**	**96%**	**95%**

Juanita Village Site Groundwater Monitoring Results - Perchloroethene, ug/L (ppb)

Up-gradient - to - down-gradient - - - - northeast - to - southwest groundwater flow - - - -

Monitoring Date/Well	MW-1	MW-2	MW-3	MW-4	TW-7	MW-7	TW-1
May-98	66	450	350	1900	na	na	na
Jun-98	45	na	na	2600	na	na	na
Sep-98	7.7	67	200	280	na	290	na
Aug-99	4.4	70	160	480	na	2000	na
Jan-01	3.8	18	130	120	na	490	na
Apr-01	17	11	96	86	9.8	130	160
July-01	nd<2.0	8.2	77	60	11	98	12
Oct-01	6.8	8.7	110	75	20	9.4	nd<2.0
Dec-01	6.2	7.1	81	48	8.5	3.8	11
Mar-02	11	8.3	88	61	42	94	4.7
Jul-02	13	11	120	63	33	110	24
Oct-02	7.9	40	90	93	na	77	4.3
Jan-03	2.4	13	84	na	21	76	8

RI/Pre Treatment Results	66	450	350	1900	11	2000	160
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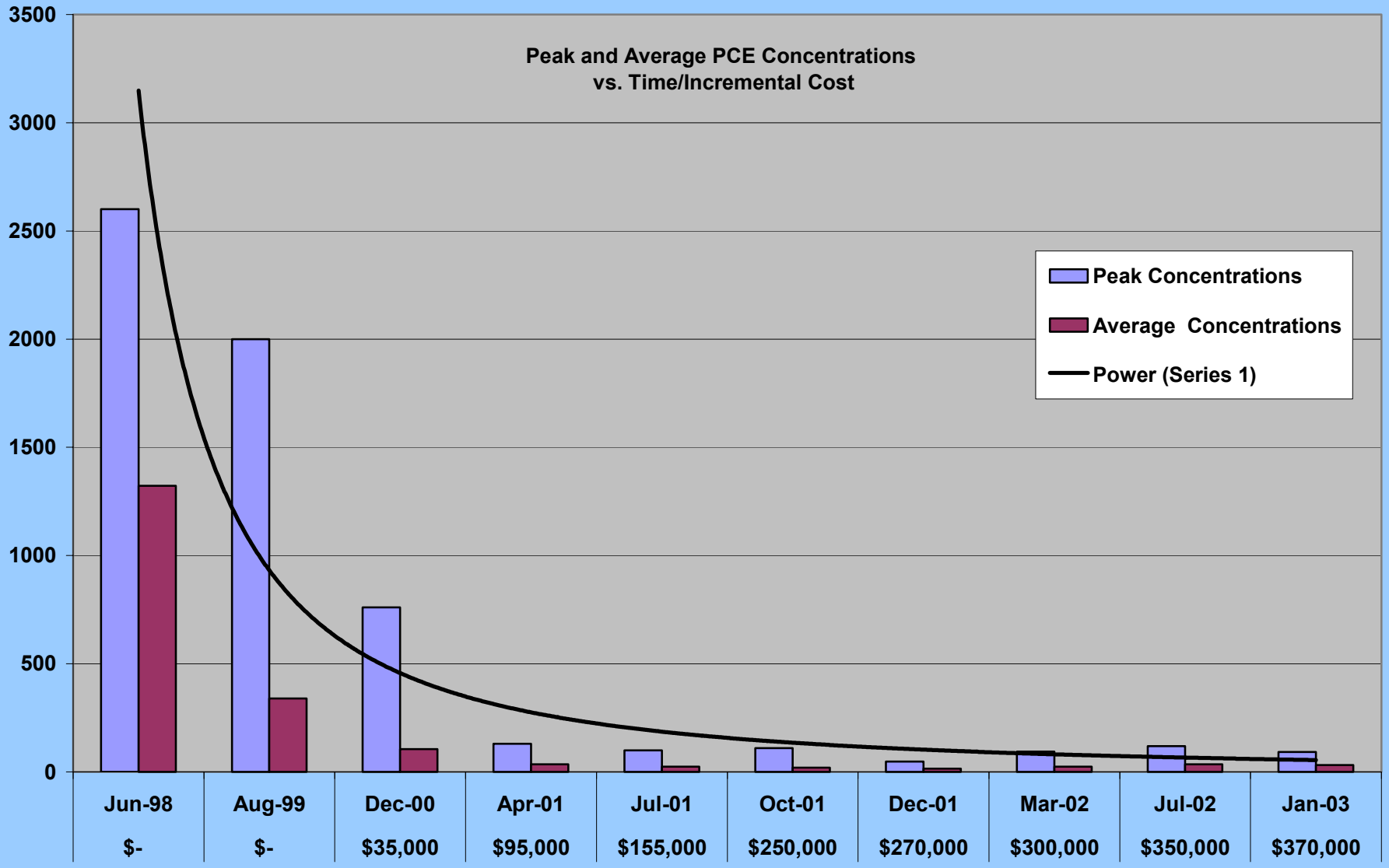
Percent improvement	**96%**	**97%**	**76%**	**95%**	**nc**	**96%**	**95%**


Peak and Average PCE Concentrations
vs. Time/Incremental Cost
3500
3000
2500
2000
1500
1000
500
0
Peak Concentrations
Average Concentrations
Power (Series 1)
Jun-98
$-
Aug-99
$-
Dec-00
$35,000
Apr-01
$95,000
Jul-01
$155,000
Oct-01
$250,000
Dec-01
$270,000
Mar-02
$300,000
Jul-02
$350,000
Jan-03
$370,000

DDC RESULTS at JV

Total Pounds of PCE Removed

- On-property DDC system…..….19.5 #
- On-property SVE system…..…197.0 #
- Off-property DDC well……0.7 #
- Off-property SVE well……..… 13.6 #

Total pounds of PCE	230.8 pounds
Remediation costs	$370,000

OTHER APPLICATIONS

Other DDC Remediation Site Results:

- 1,1,1-TCA at Pasco Landfill, WA
- 1,1-DCE at Pasco Landfill, WA
- TCE at former EMF site, Seattle, WA
- TCE at Coeur d'Alene, ID

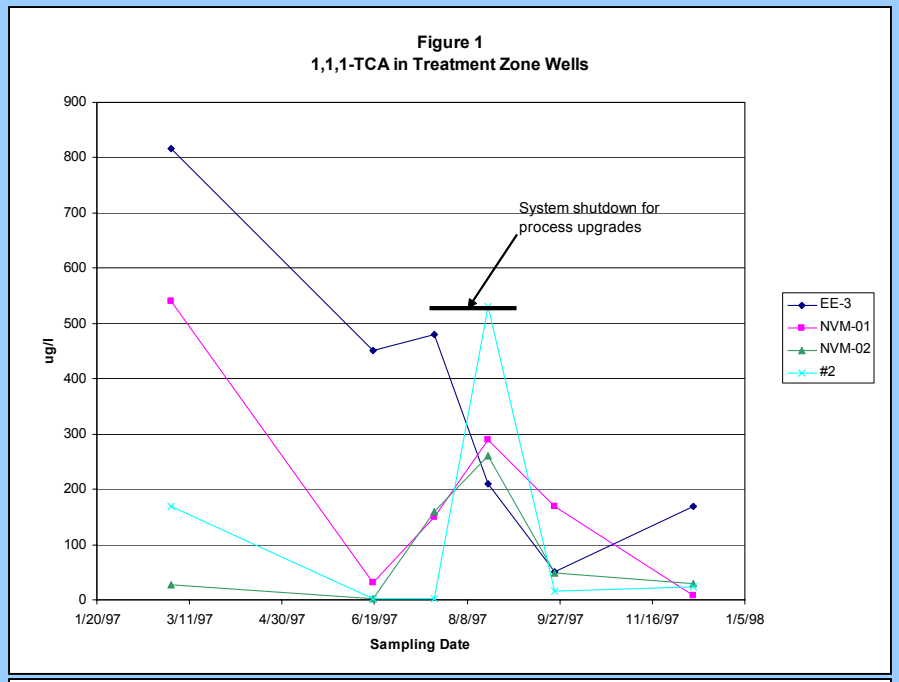


Figure 1
1,1,1-TCA in Treatment Zone Wells
900
800
700
600
500
400
300
200
100
0
ug/l
System shutdown for
process upgrades
EE-3
NVM-01
NVM-02
#2
1/20/97
3/11/97
4/30/97
6/19/97
8/8/97
9/27/97
11/16/97
1/5/98
Sampling Date

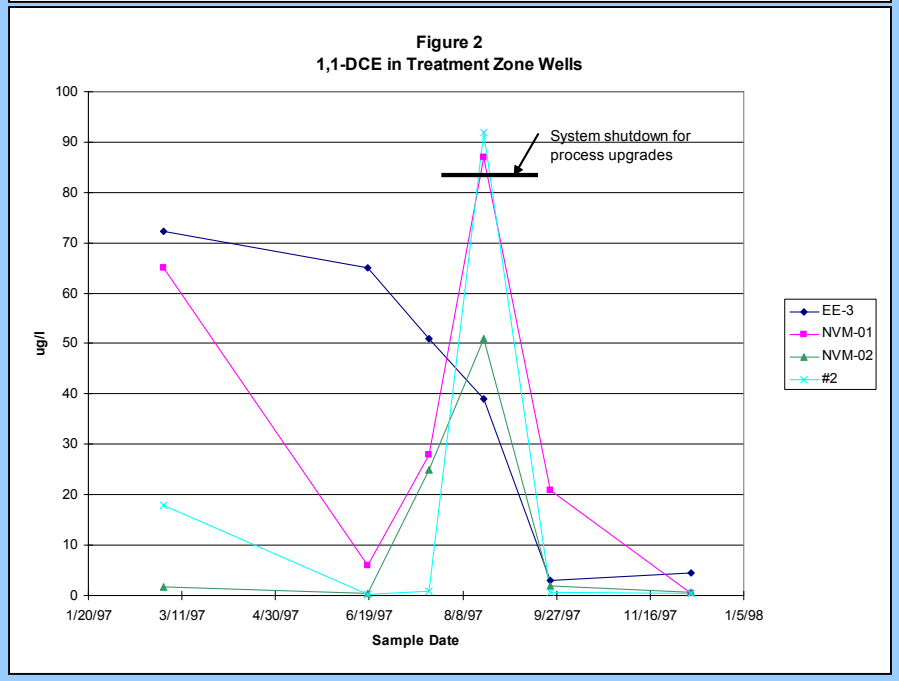
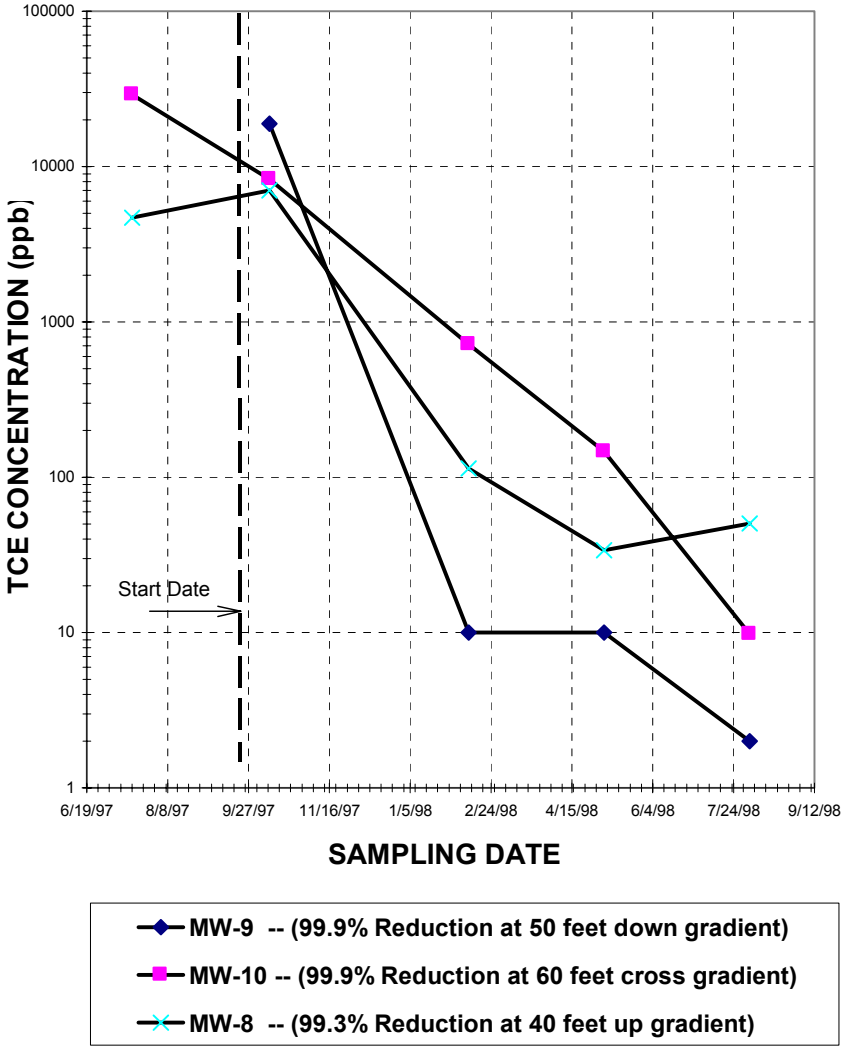
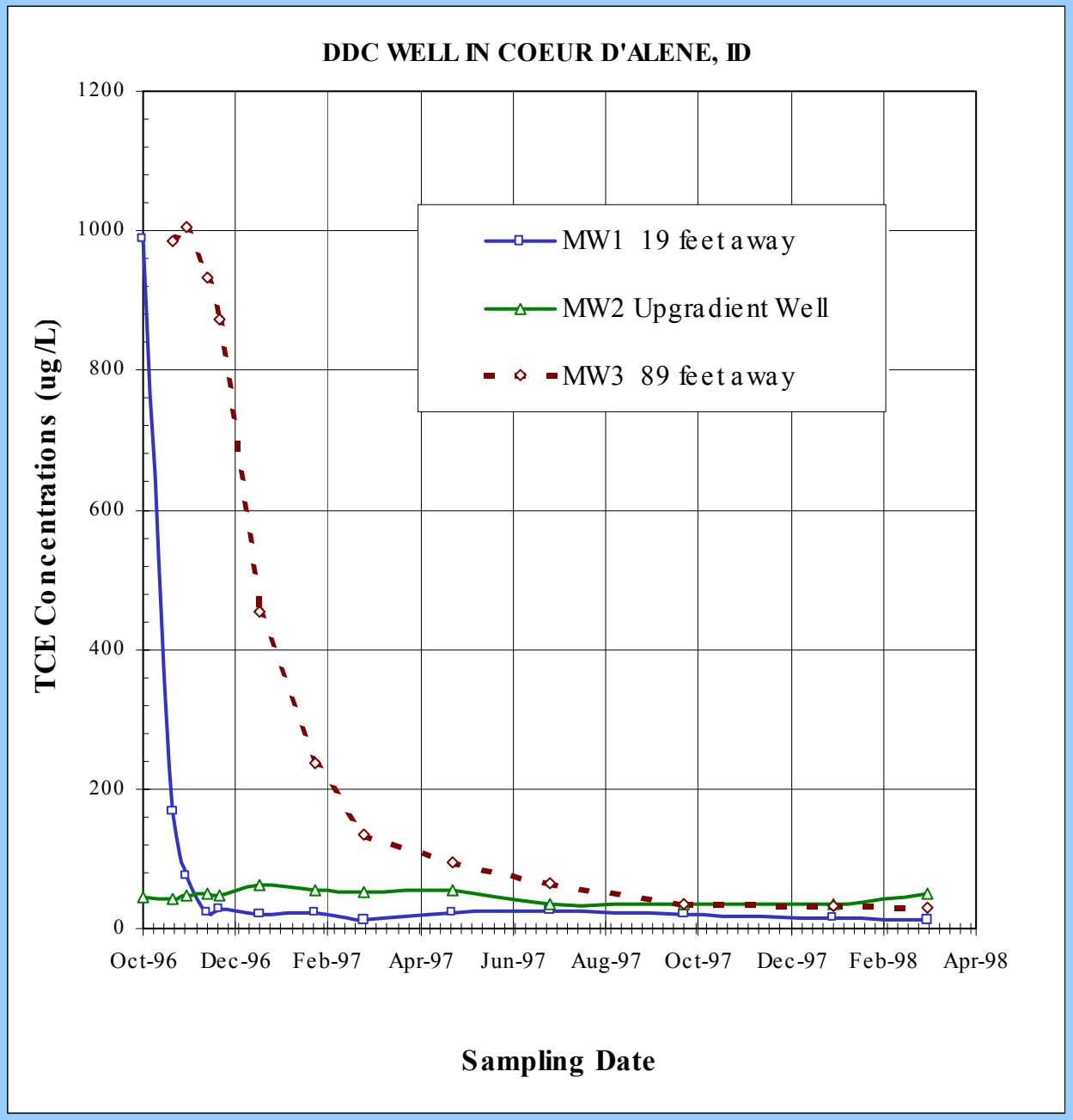


Figure 2
1,1-DCE in Treatment Zone Wells
100
90
80
70
60
50
40
30
20
10
0
ug/l
System shutdown for
process upgrades
EE-3
NVM-01
NVM-02
#2
1/20/97
3/11/97
4/30/97
6/19/97
8/8/97
9/27/97
11/16/97
1/5/98
Sample Date

Observed TCE Concentration Reductions in Performance Monitoring Wells, Former EMF Site

(note logarithmic scale on y -axis)




DDC WELL IN COEUR D'ALENE, ID
TCE Concentrations (ug/L)
1200
1000
800
600
400
200
0
MW1 19 feet away
MW2 Upgradient Well
MW3 89 feet away
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Sampling Date

CONCLUSIONS

Density Driven Convection Remediation

- DDC is effective treatment for VOC
- VOC reduction 95-99%
- DDC estimated effective at 50-80 ft radius
- 6-18 months
- Remediation costs $200,000-$1m

NEW ADAPTATIONS

New Adaptations of DDC:

- **DDC/co-metabolism**
- **DDC/advanced oxidation**
- **DDC/reactive media in infiltration**
- **DDC/bioslurping**

RECOMMENDATIONS

Density Driven Convection Remediation:

- DDC is effective for VOC & some Semi-VOC
- New DDC adaptations are effective

- DDC <u>not</u> effective with metals, pesticides, inorganics
- DDC <u>not</u> effective in low permeable substrate

Special thanks to…

- Juanita Village LLC
- John Kane of

  Kane Environmental, Inc.
- Tom McKeon of

  Project Performance Corporation