HRC stimulation of Cr-bioreduction at Hanford:
Field Geochemistry During Biostimulation

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PNNL

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Pacific Northwest National Laboratory
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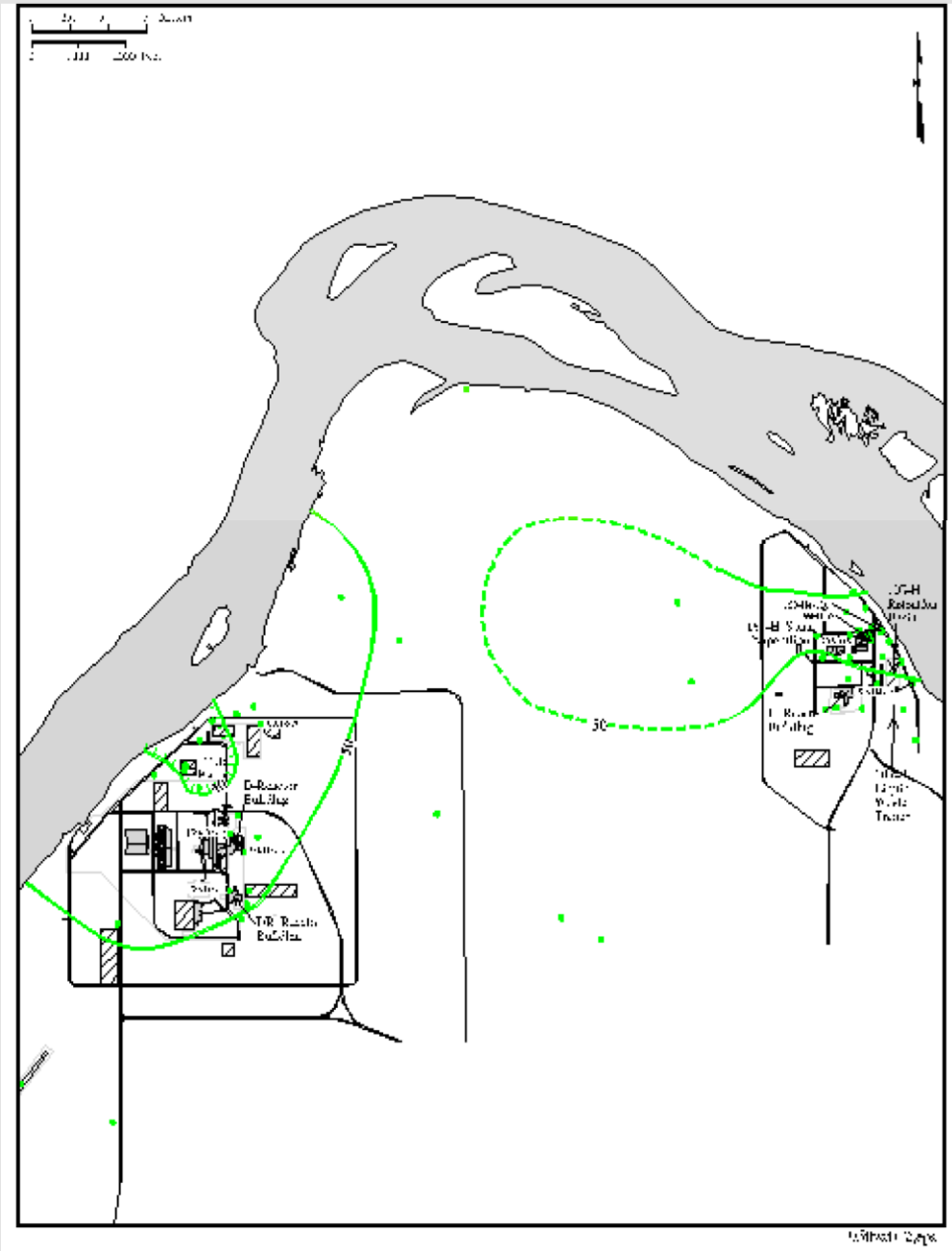
Outline of presentation

- Introduction and summary of earlier field results
- Field sampling setup
- Field data results
- Future Sediment sampling, well installation and planning for the next biostimulation experiment

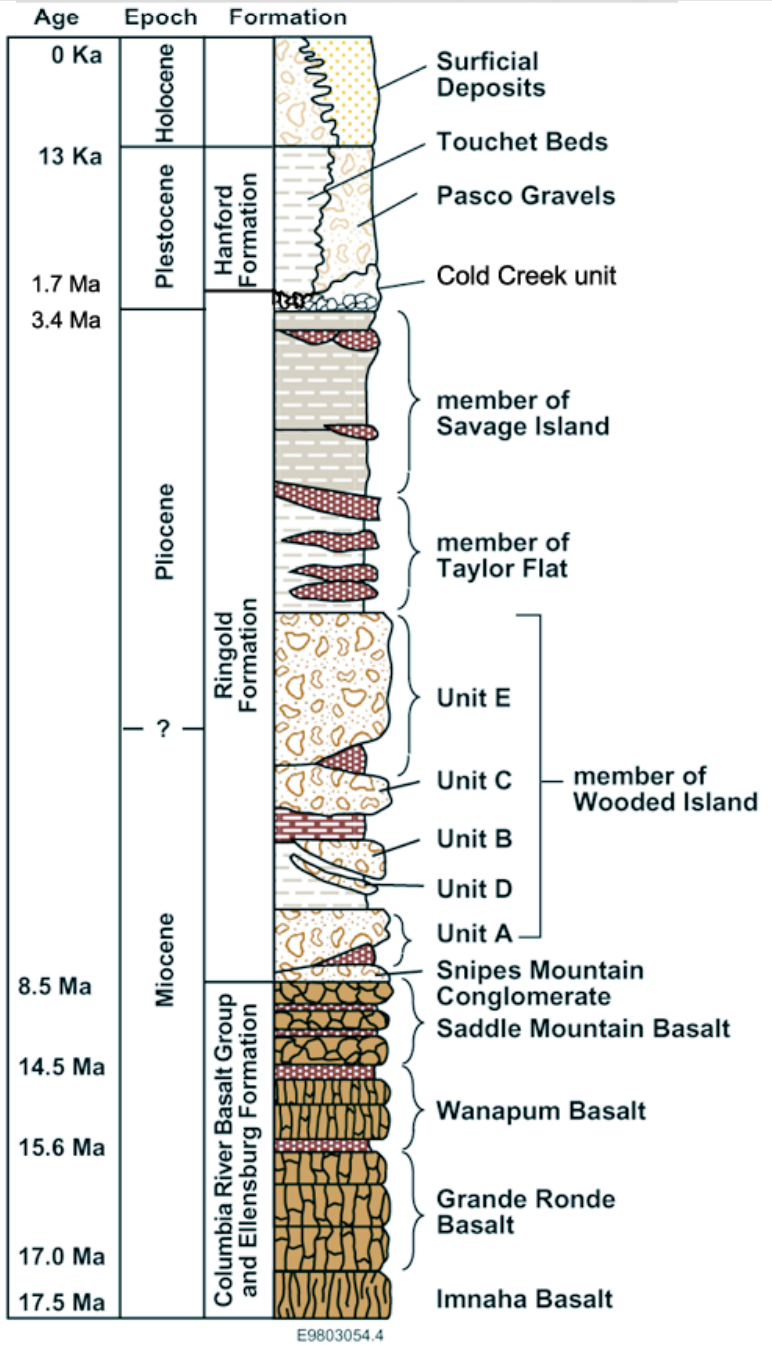
Introduciton and Summary of Earlier Field Results

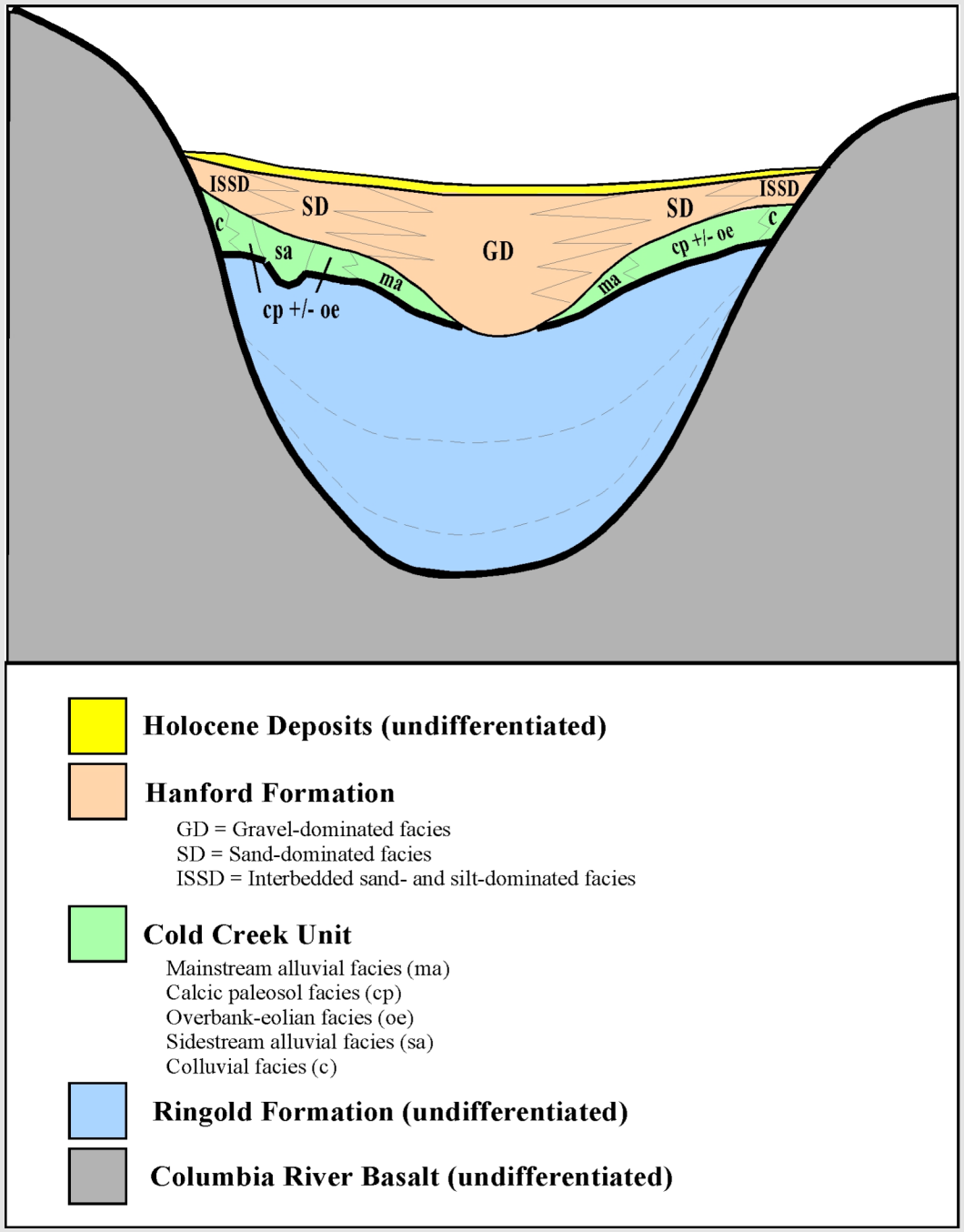
- Geohydrology and contaminant (Cr) source
- Overall experimental concept
- Well drilling and completion
- Tracer tests
  - Natural gradient
  - Forced gradient

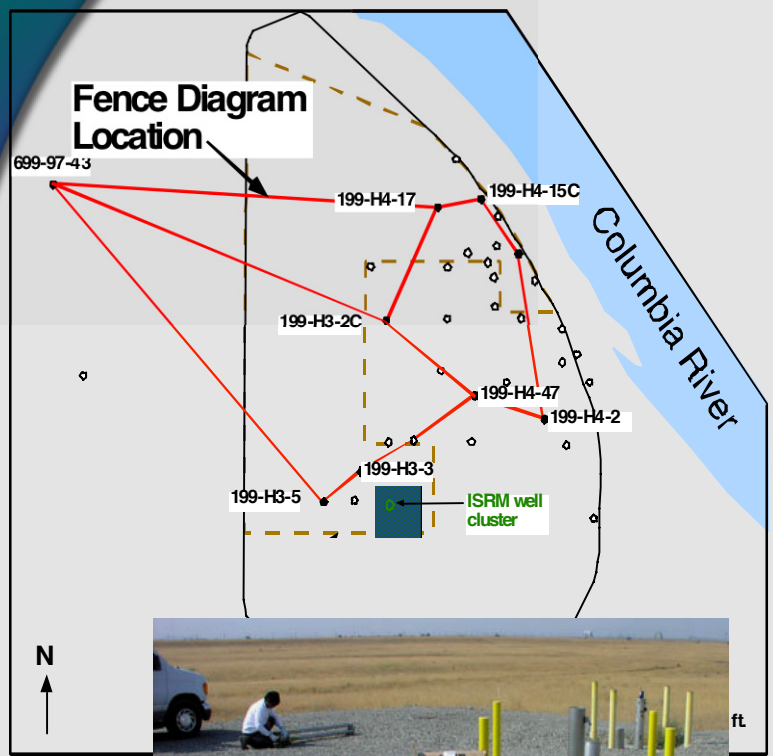
Chromate plumes at the Hanford Site

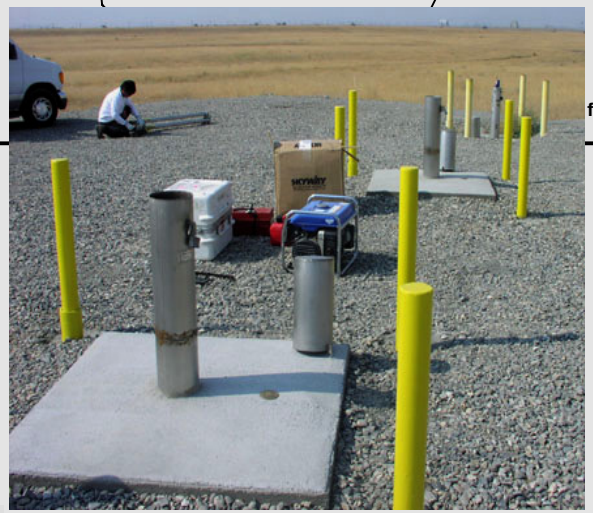


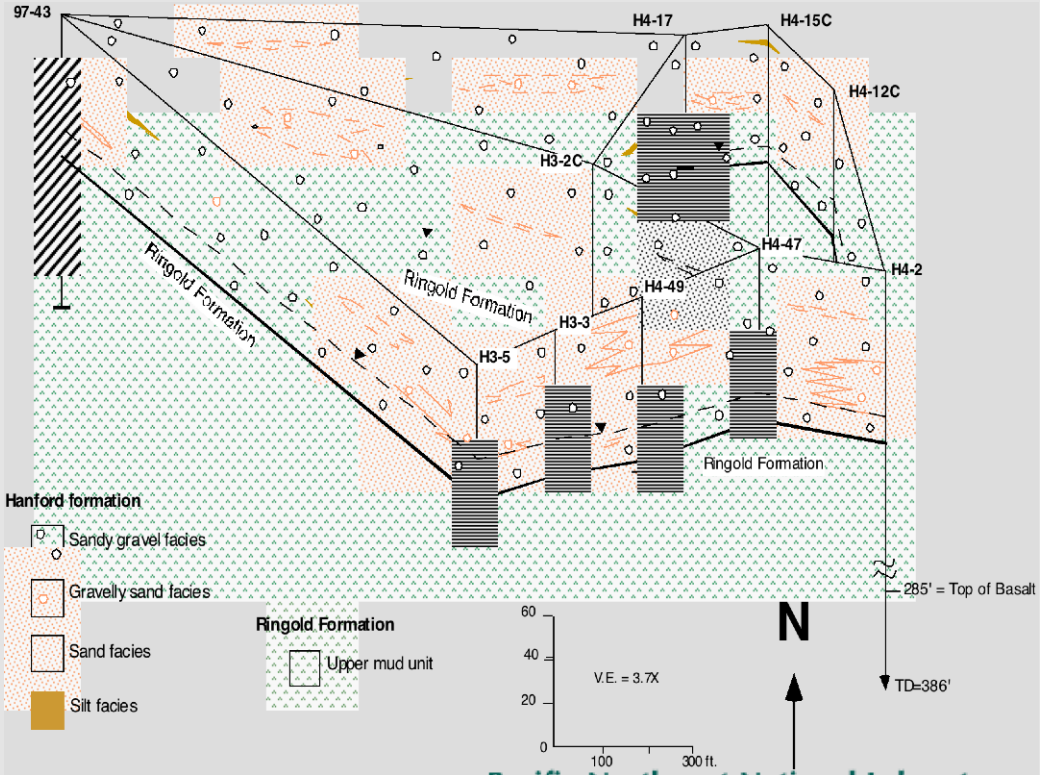
General Stratigraphy



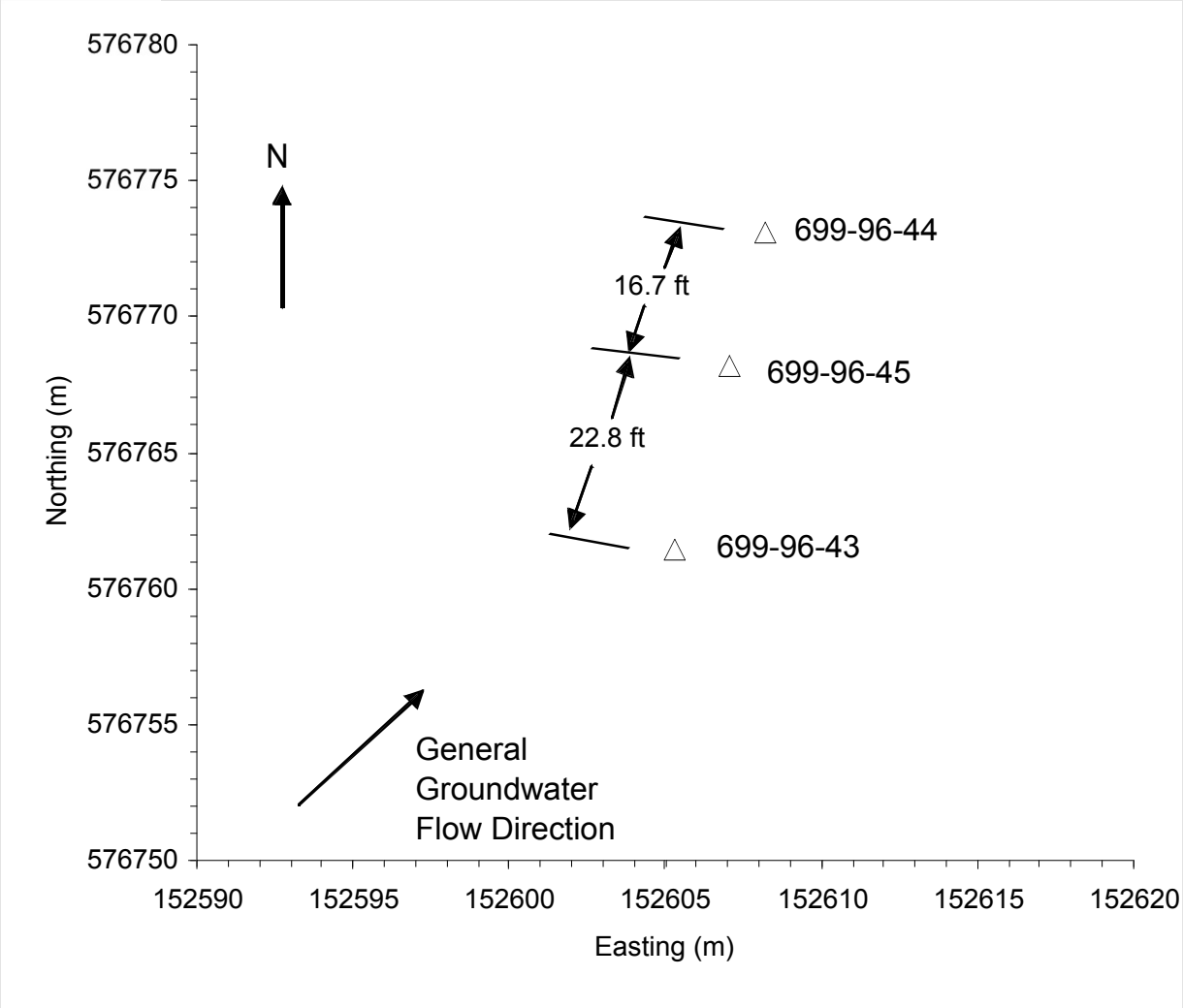



Fence Diagram Location
699-97-43
199-H4-17
199-H4-15C
199-H3-2C
199-H4-47
199-H4-2
199-H3-3
199-H3-5
ISRM well cluster
Columbia River
N
ft




97-43
H4-17
H4-15C
H4-12C
H3-2C
H4-47
H4-2
H4-49
H3-3
H3-5
Ringold Formation
Ringold Formation
Ringold Formation
Hanford formation
Sandy gravel facies
Gravelly sand facies
Sand facies
Silt facies
Ringold Formation
Upper mud unit
60
40
20
0
100
300 ft.
V.E. = 3.7X
N
285' = Top of Basalt
TD=386'

Layout of Wells at Cr Bioreduction Site



Lithology and completion Diagram for 699-96-44

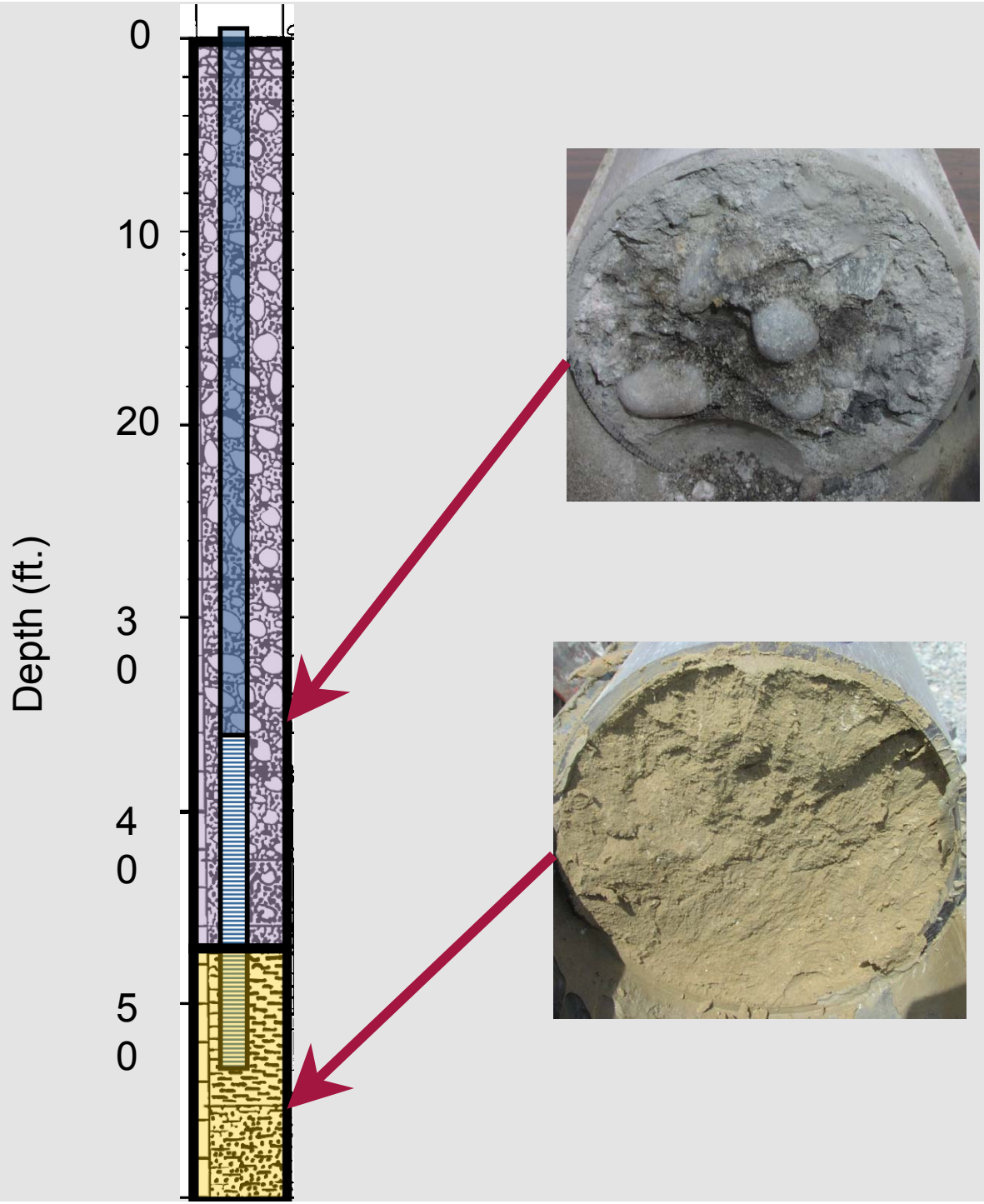
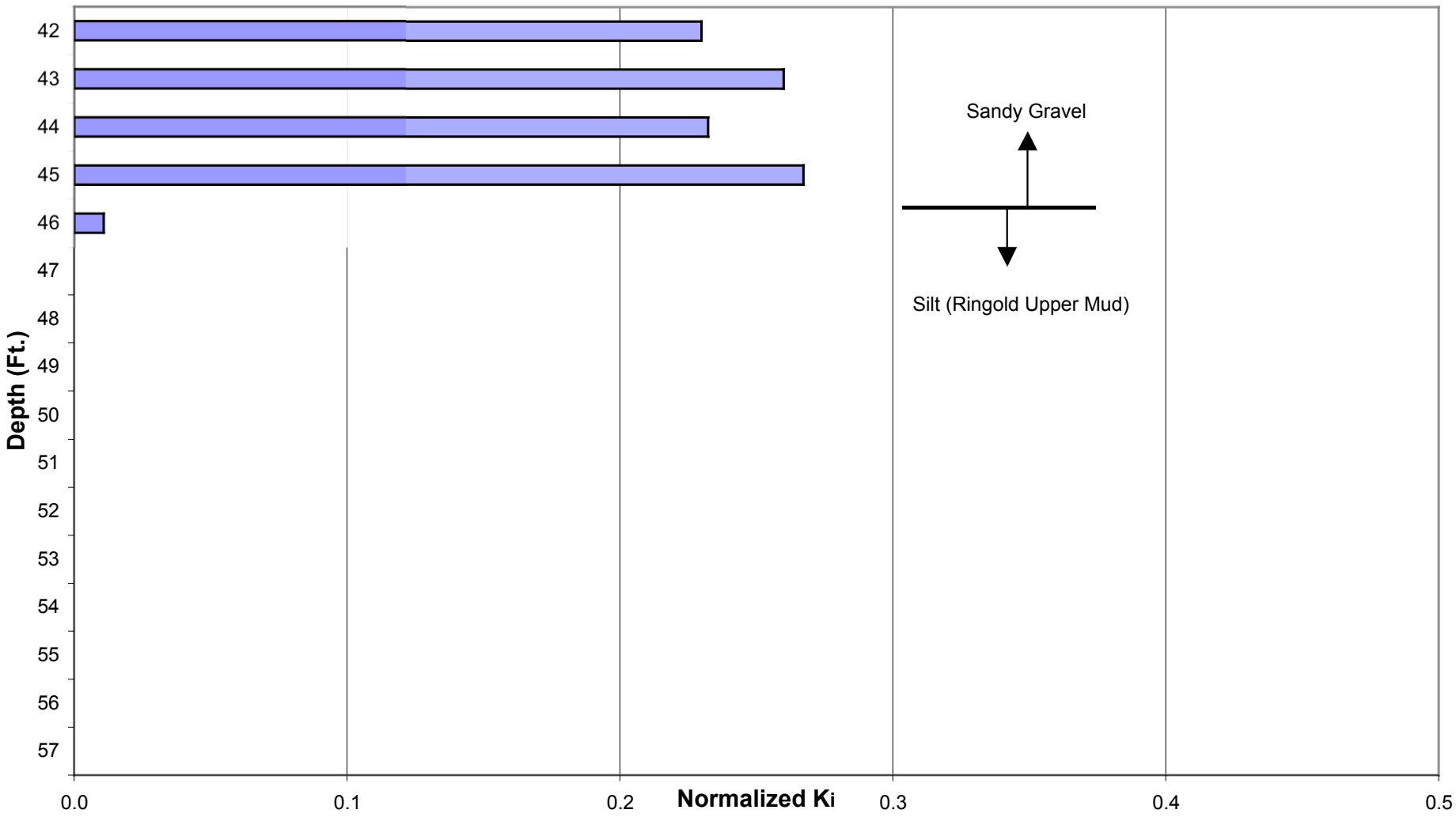
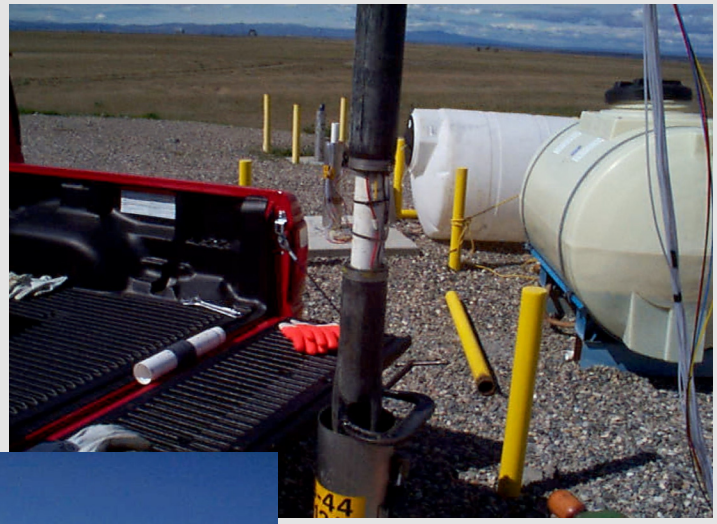


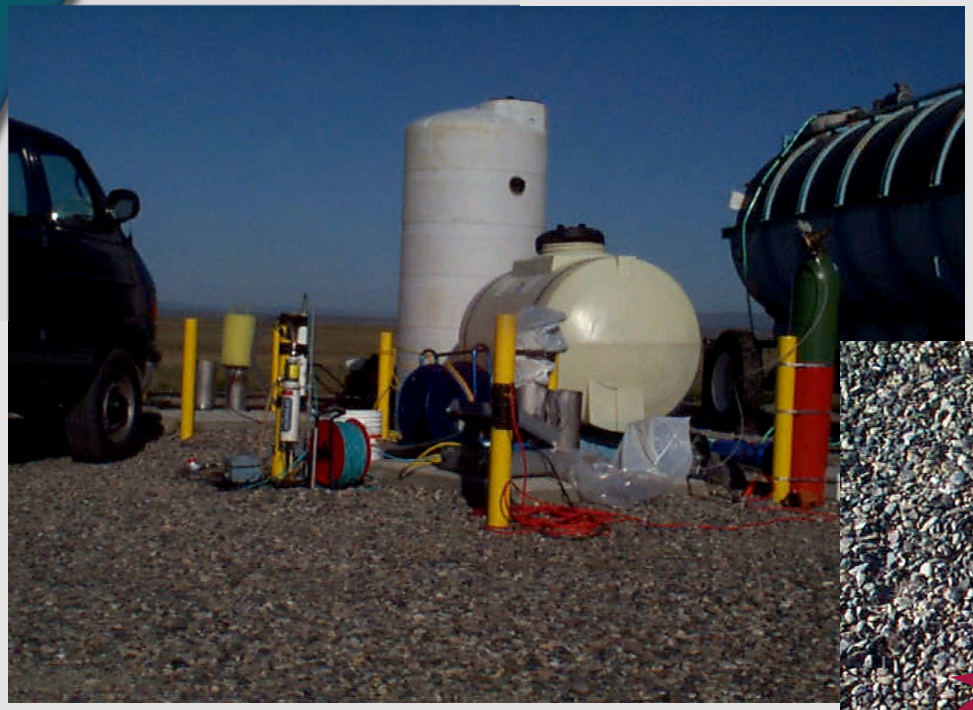
Figure 7: Profile of Hydraulic Conductivity of Well 44



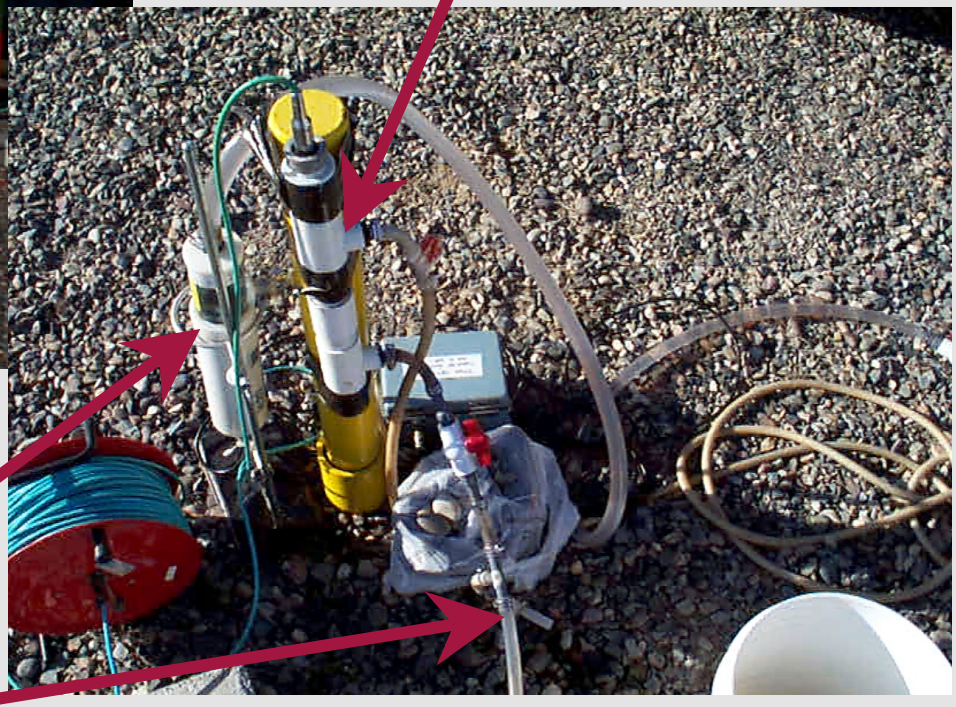
Modifications prior to forced gradient tracer test



Hourly data collection during tracer test

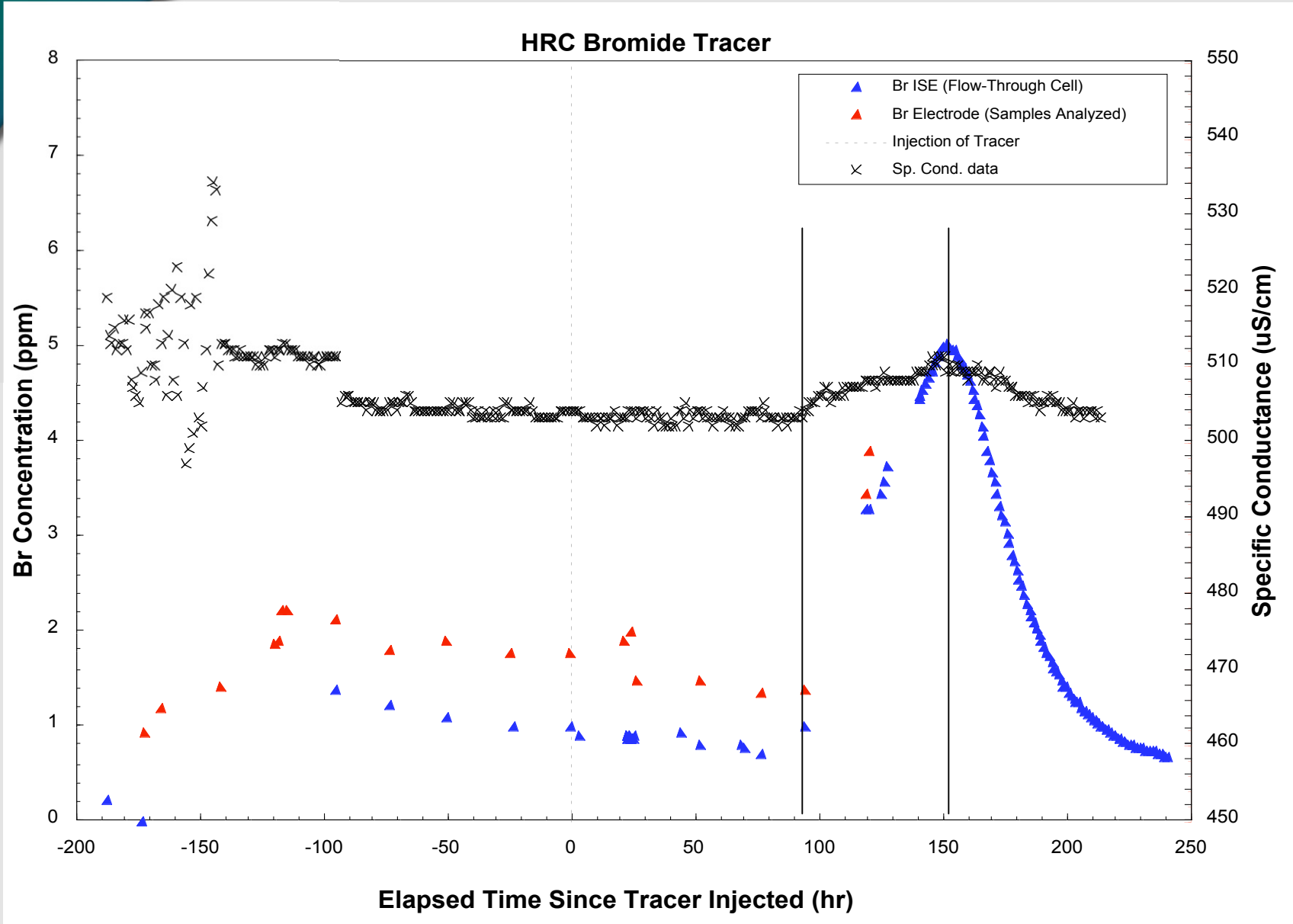


Flow cell with Br sensor



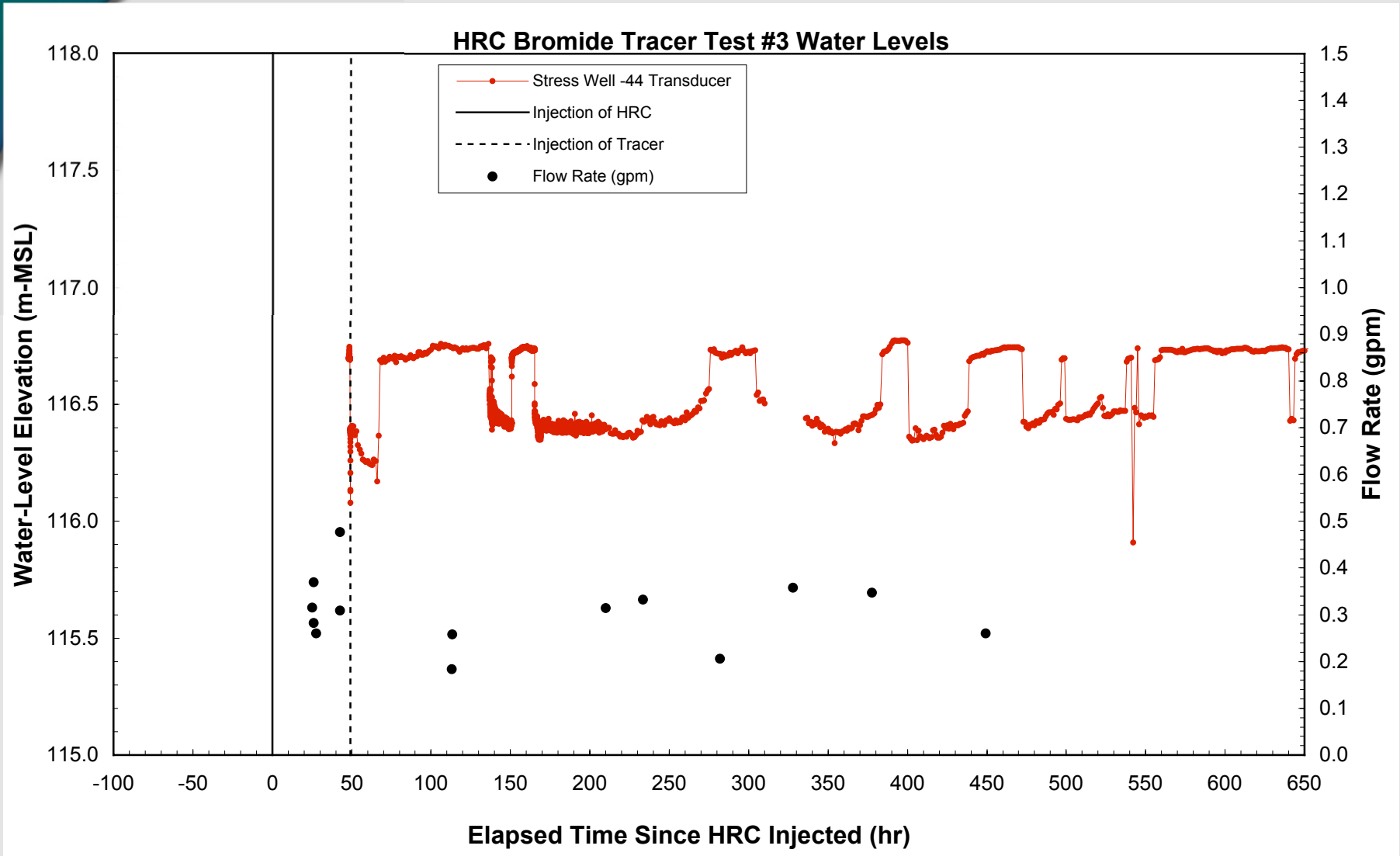
Flow cell with multiparameter probe
(pH, ORP, conductivity, T, DO)

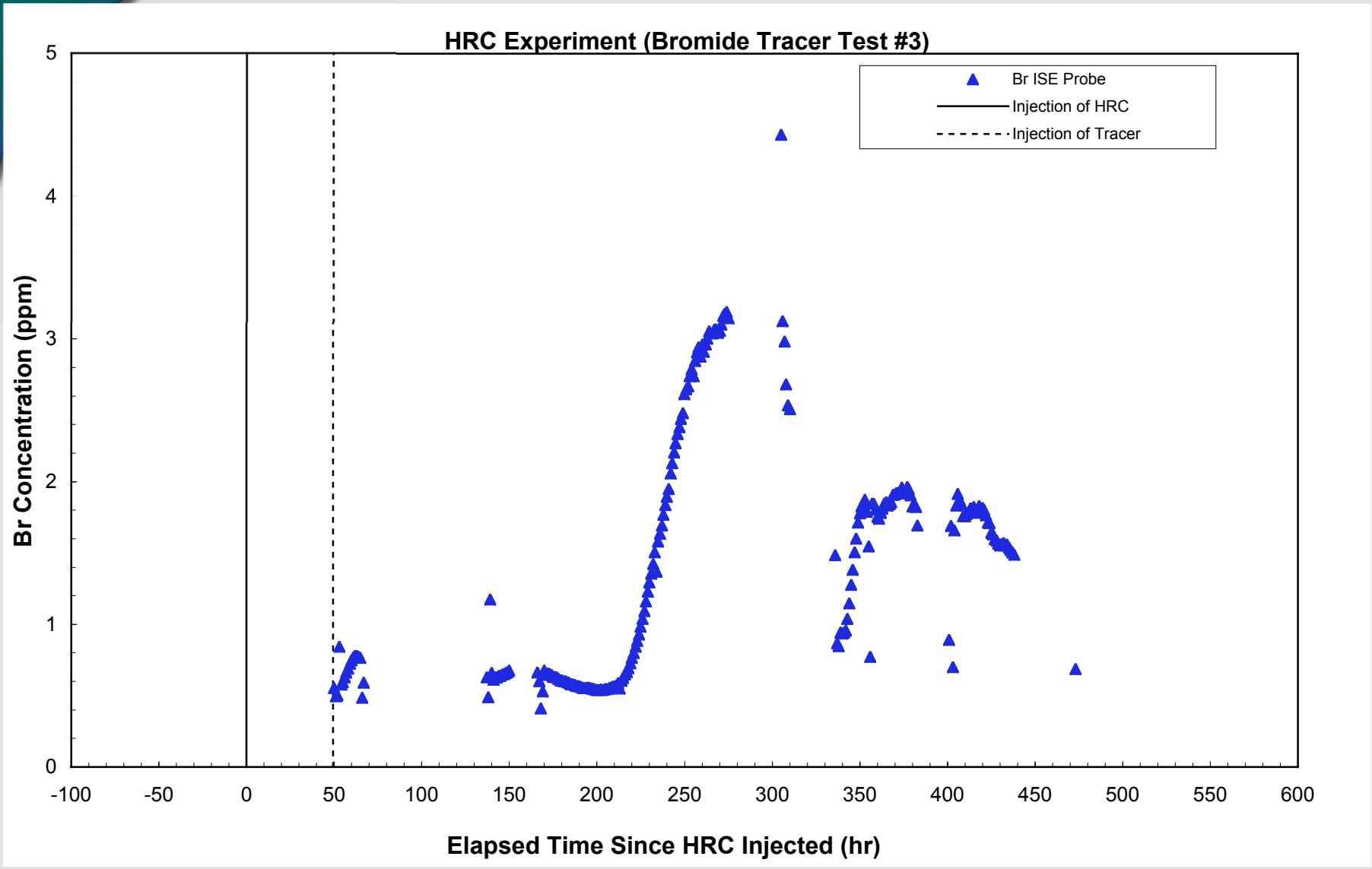
Sampling port

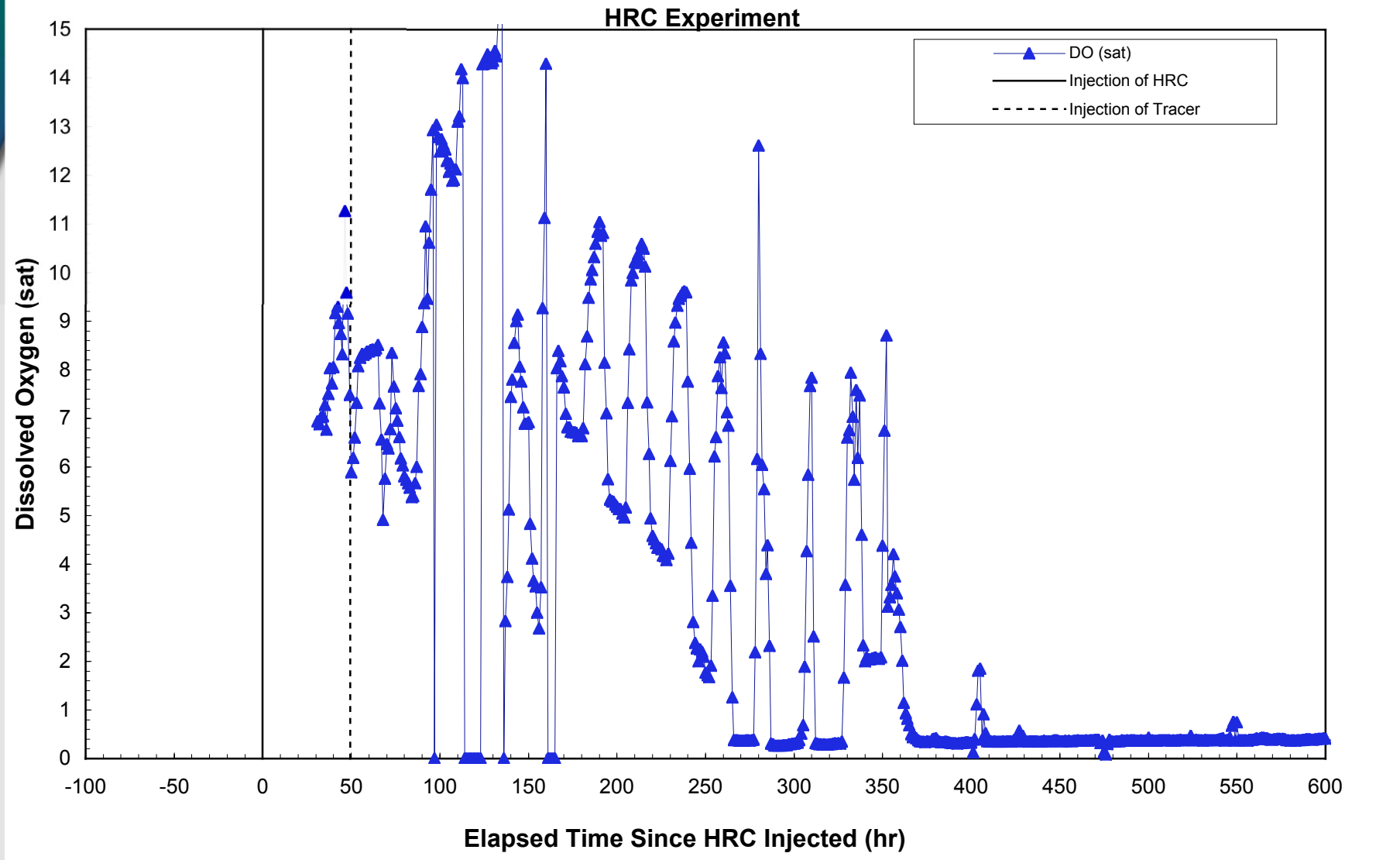

HRC Bromide Tracer
Br ISE (Flow-Through Cell)
Br Electrode (Samples Analyzed)
Injection of Tracer
Sp. Cond. data
Br Concentration (ppm)
Specific Conductance (uS/cm)
Elapsed Time Since Tracer Injected (hr)
0
1
2
3
4
5
6
7
8
450
460
470
480
490
500
510
520
530
540
550
-200
-150
-100
-50
0
50
100
150
200
250

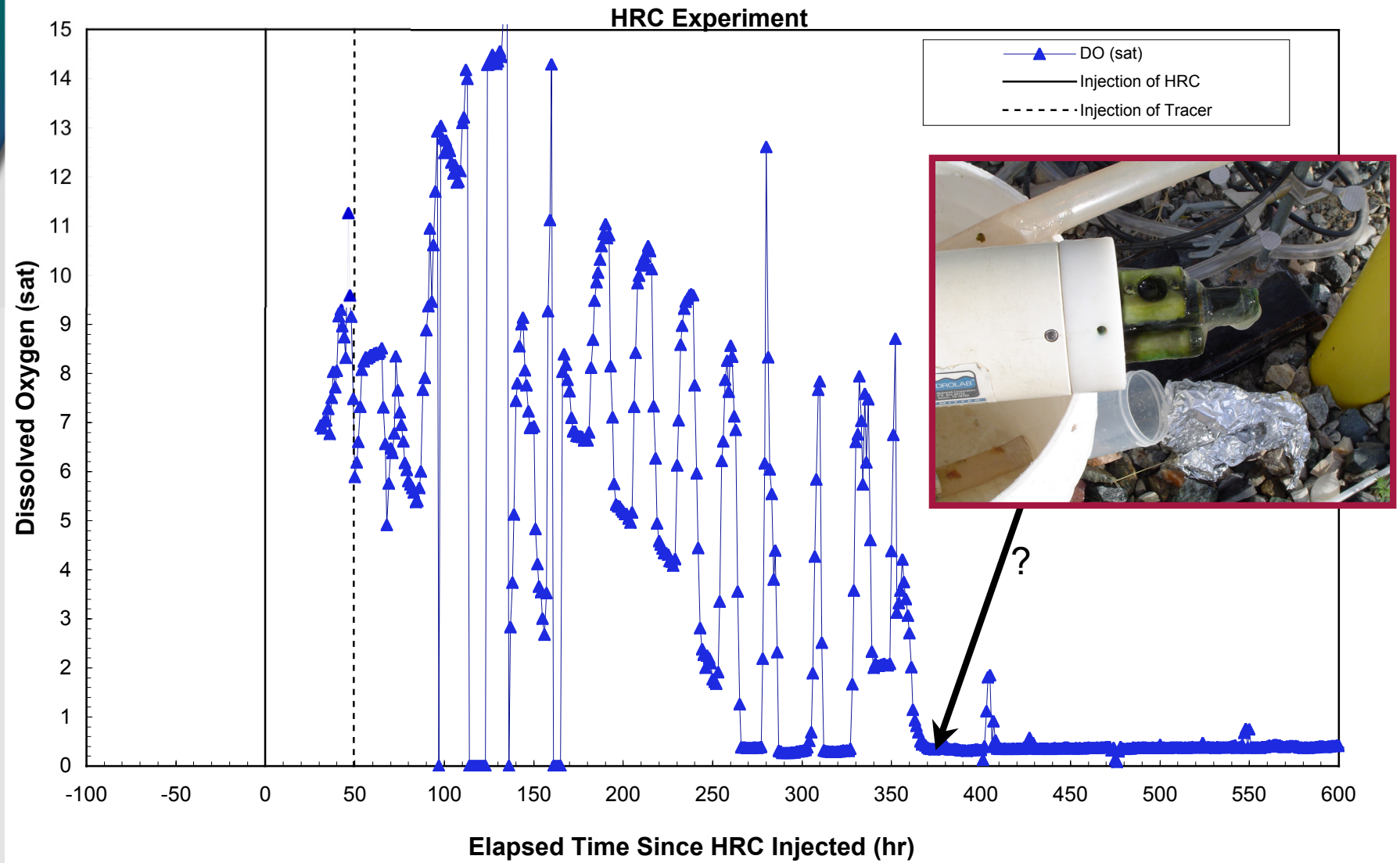
Original Plan for Biostimulation Experiment

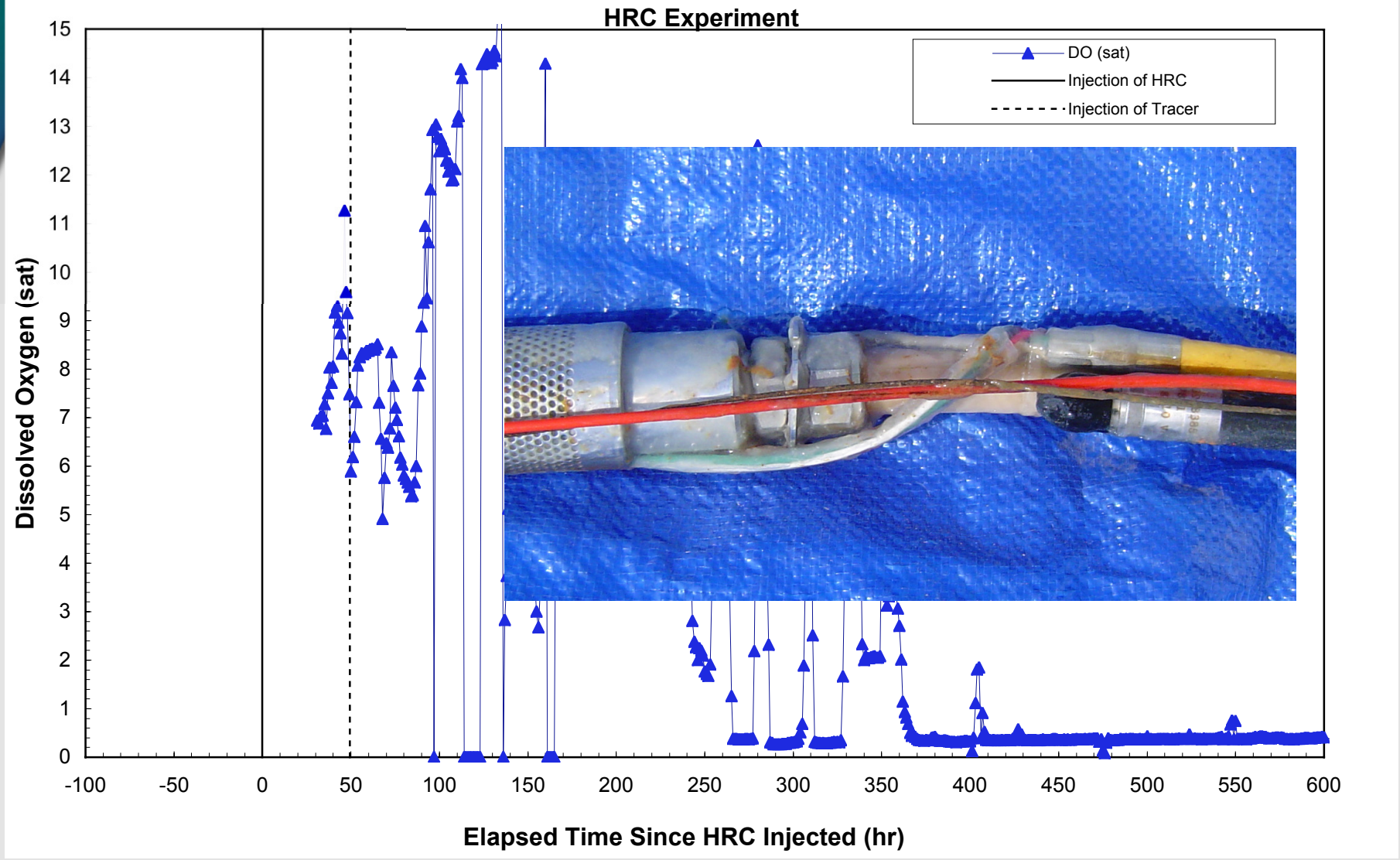
- Re-establish forced gradient (constant drawn-down pumping regime)
- Inject Br just prior to HRC
- Inject HRC
- Inject Br into well bore only
- Continue pumping for 2 weeks, monitoring all parameters
- Sample weekly to monthly re-establishing forced gradient each time

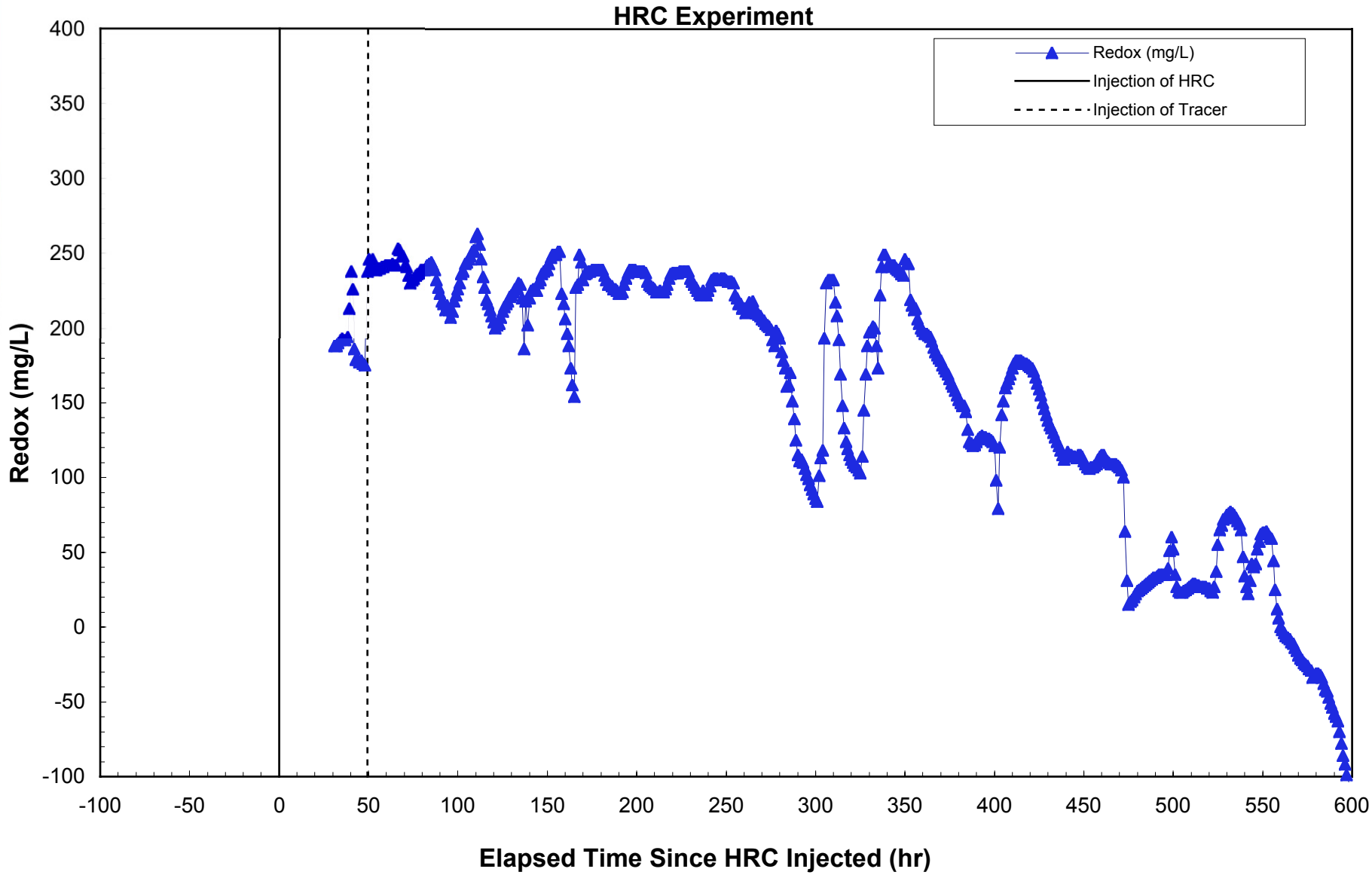

HRC Bromide Tracer Test #3 Water Levels
Stress Well -44 Transducer
Injection of HRC
Injection of Tracer
Flow Rate (gpm)
Water-Level Elevation (m-MSL)
Flow Rate (gpm)
Elapsed Time Since HRC Injected (hr)
118.0
117.5
117.0
116.5
116.0
115.5
115.0
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650

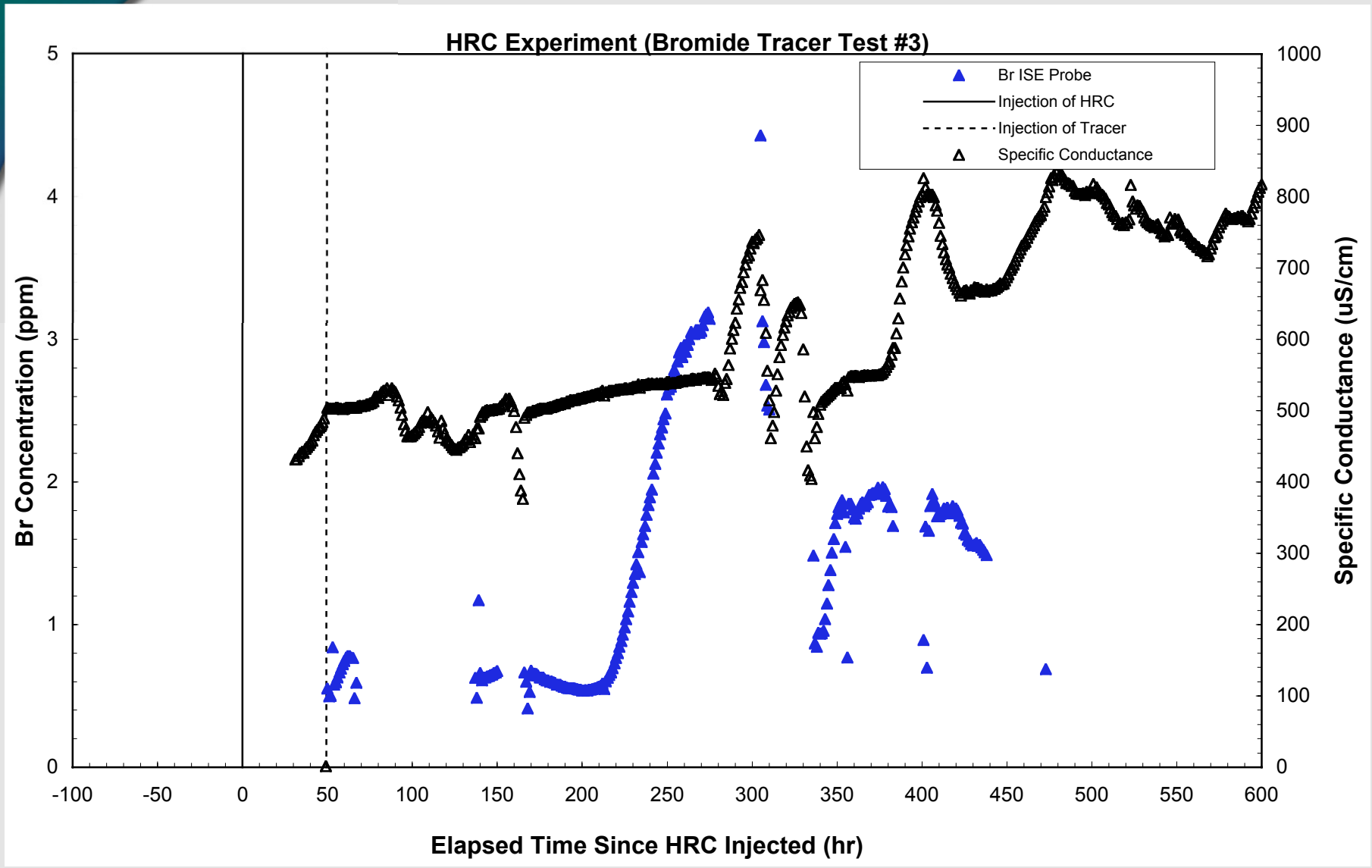

HRC Experiment (Bromide Tracer Test #3)
Br ISE Probe
Injection of HRC
Injection of Tracer
Br Concentration (ppm)
Elapsed Time Since HRC Injected (hr)
0
1
2
3
4
5
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600

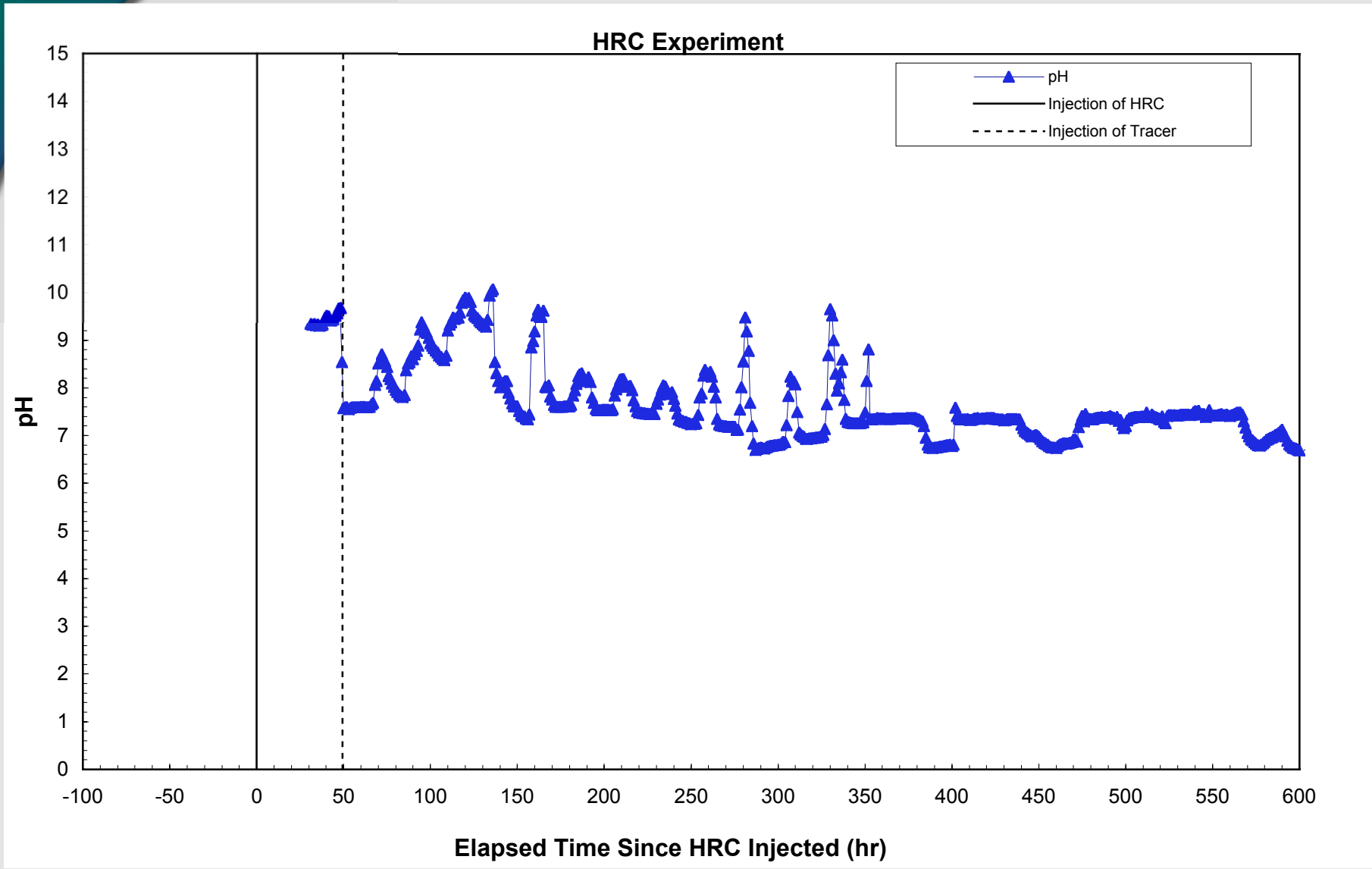

HRC Experiment
DO (sat)
Injection of HRC
Injection of Tracer
Dissolved Oxygen (sat)
Elapsed Time Since HRC Injected (hr)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600

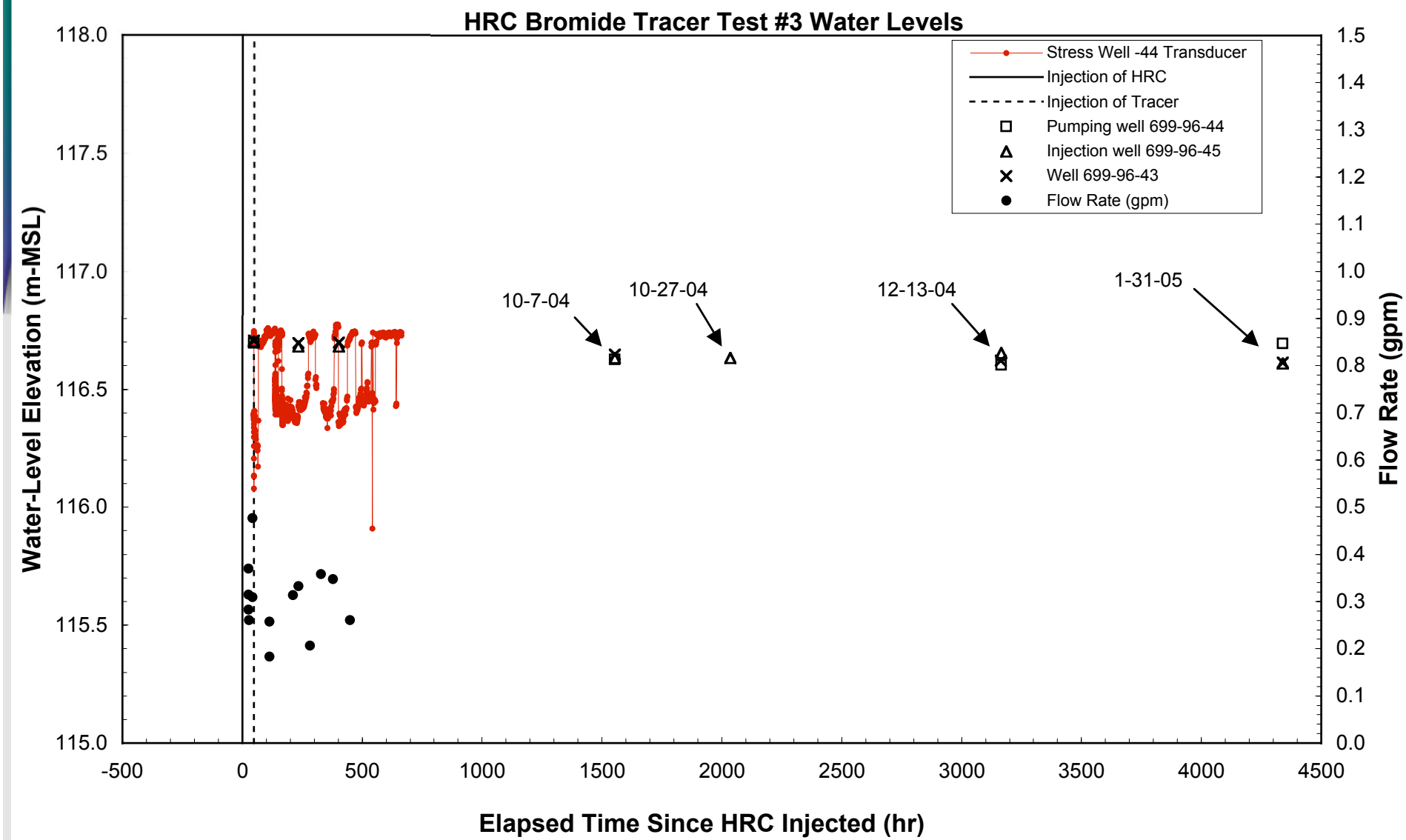

HRC Experiment
DO (sat)
Injection of HRC
Injection of Tracer
Dissolved Oxygen (sat)
Elapsed Time Since HRC Injected (hr)
?
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600

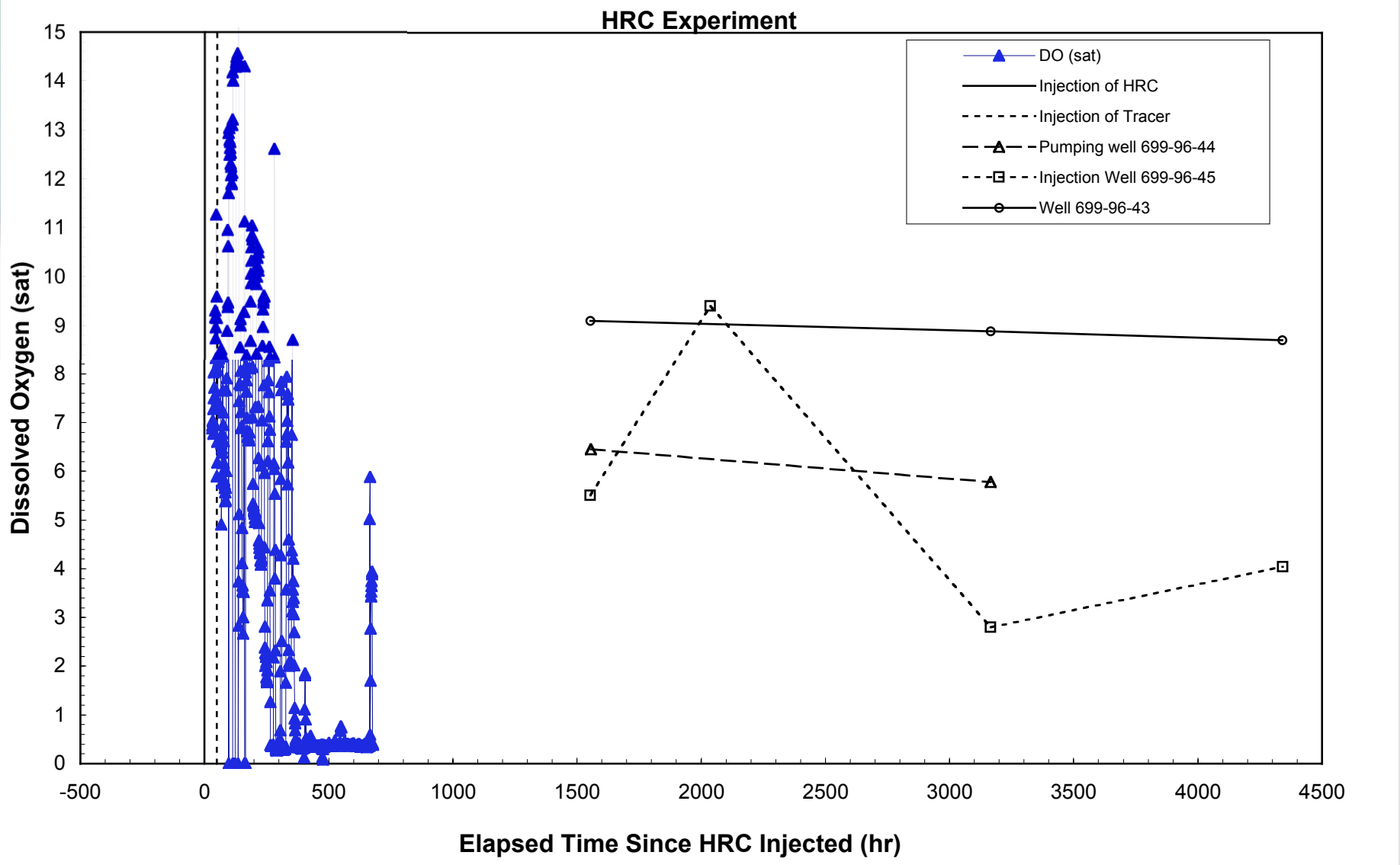

HRC Experiment
DO (sat)
Injection of HRC
Injection of Tracer
Dissolved Oxygen (sat)
Elapsed Time Since HRC Injected (hr)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600

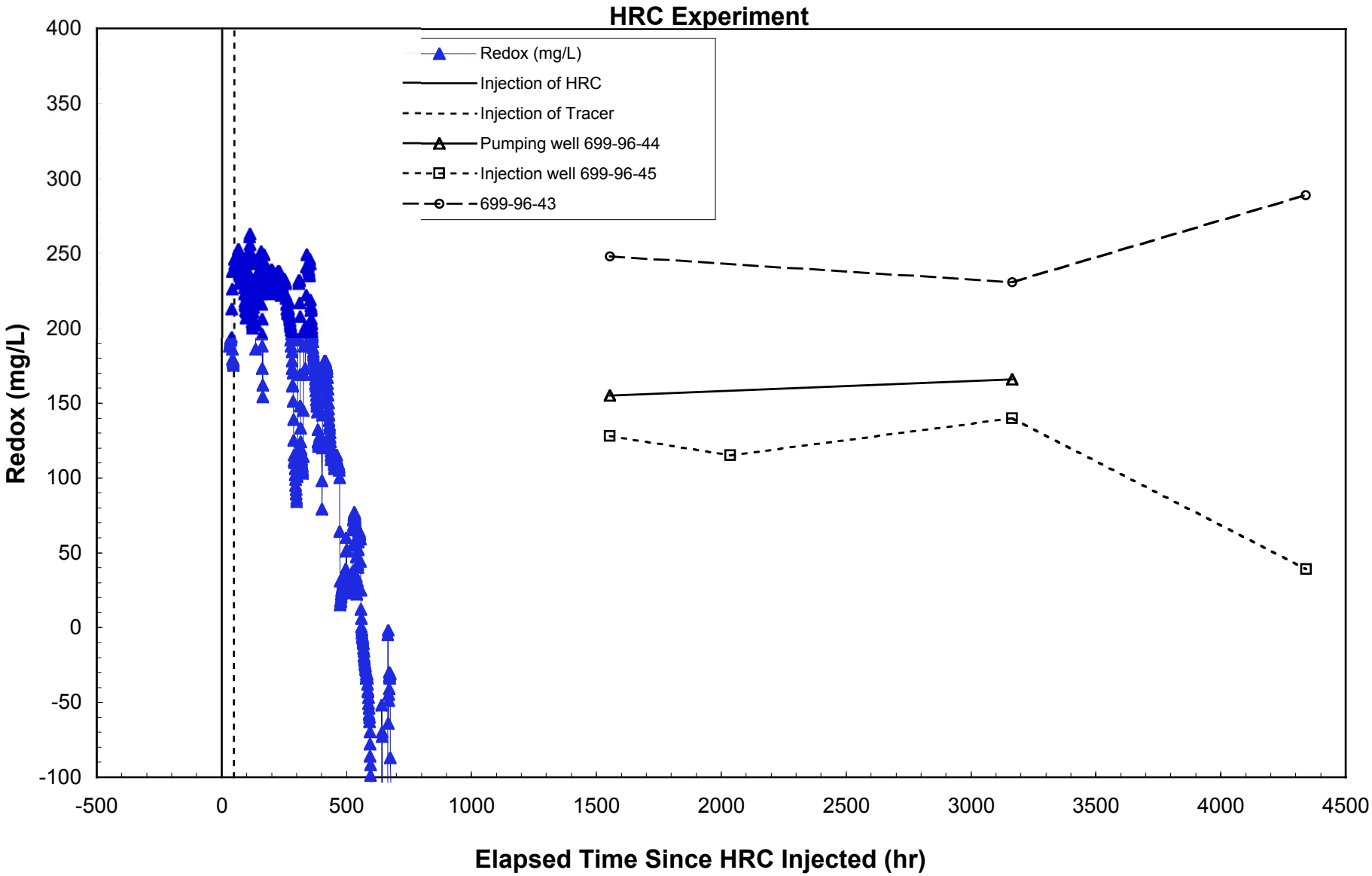

HRC Experiment
Redox (mg/L)
Injection of HRC
Injection of Tracer
Redox (mg/L)
400
350
300
250
200
150
100
50
0
-50
-100
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
Elapsed Time Since HRC Injected (hr)

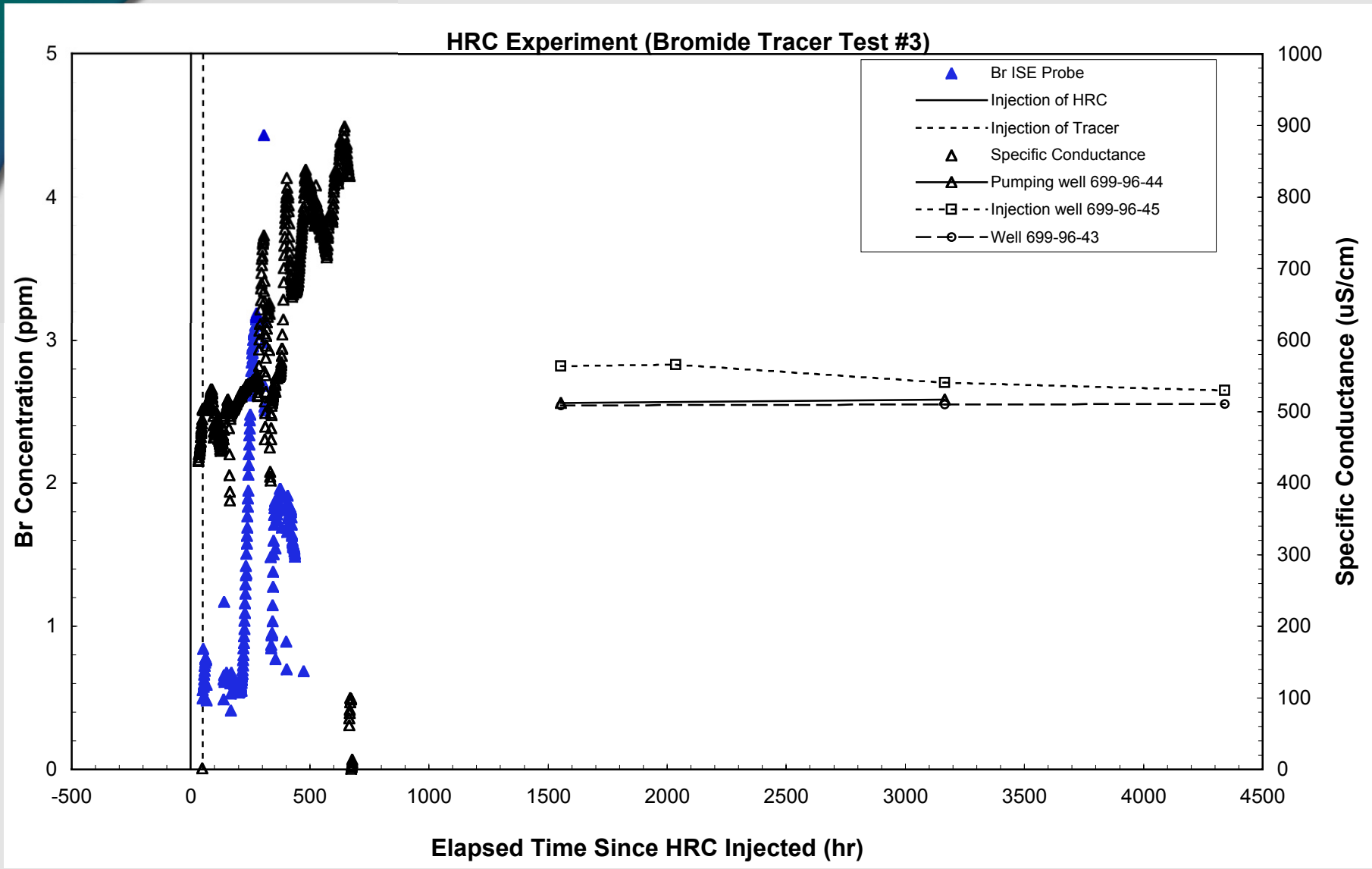

HRC Experiment (Bromide Tracer Test #3)
Br ISE Probe
Injection of HRC
Injection of Tracer
Specific Conductance
Br Concentration (ppm)
Specific Conductance (uS/cm)
Elapsed Time Since HRC Injected (hr)
0
1
2
3
4
5
0
100
200
300
400
500
600
700
800
900
1000
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600

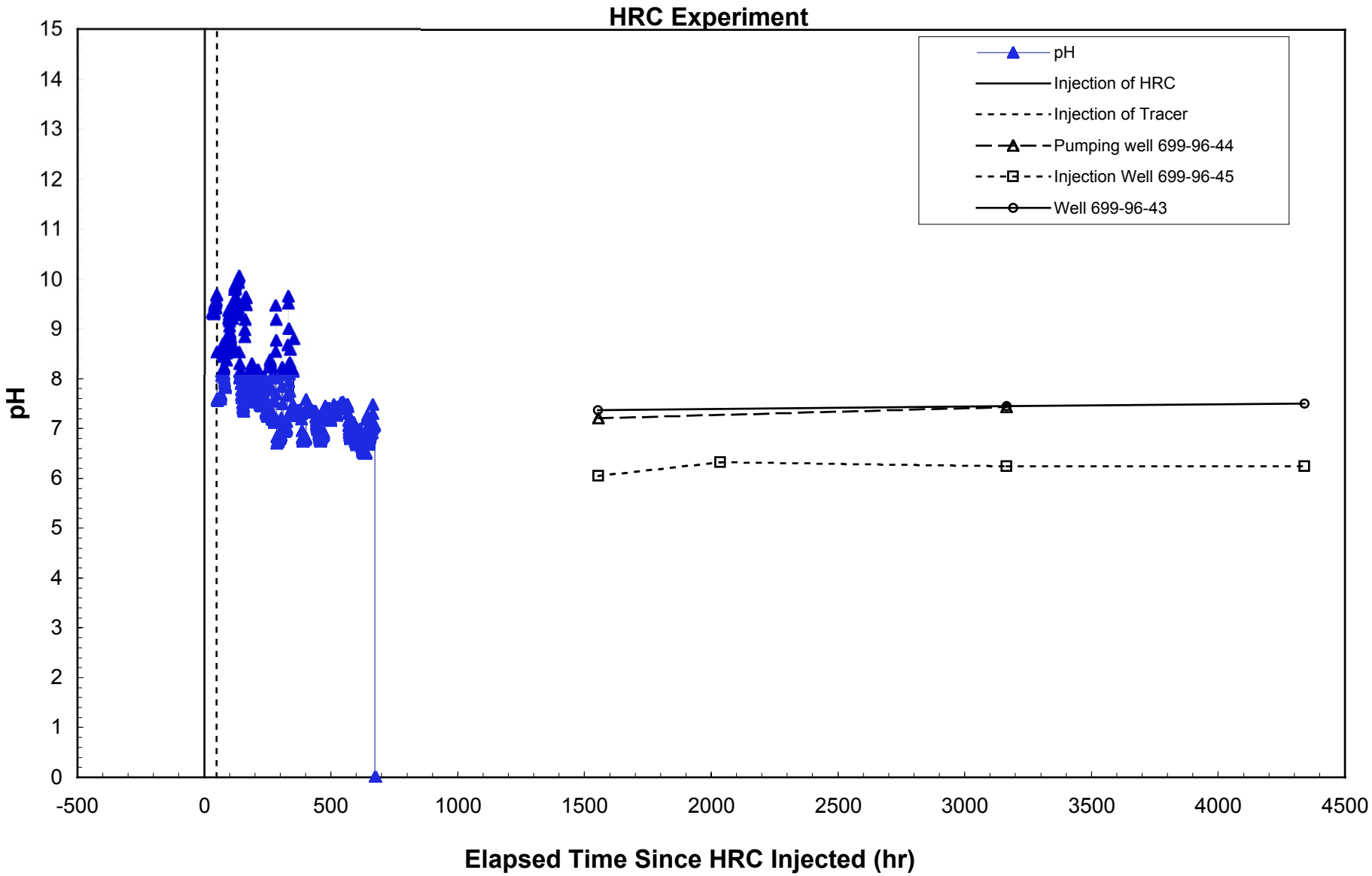

HRC Experiment
pH
Injection of HRC
Injection of Tracer
pH
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
Elapsed Time Since HRC Injected (hr)


HRC Bromide Tracer Test #3 Water Levels
Stress Well -44 Transducer
Injection of HRC
Injection of Tracer
Pumping well 699-96-44
Injection well 699-96-45
Well 699-96-43
Flow Rate (gpm)
10-7-04
10-27-04
12-13-04
1-31-05
Water-Level Elevation (m-MSL)
Flow Rate (gpm)
Elapsed Time Since HRC Injected (hr)
118.0
117.5
117.0
116.5
116.0
115.5
115.0
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500


HRC Experiment
Dissolved Oxygen (sat)
Elapsed Time Since HRC Injected (hr)
DO (sat)
Injection of HRC
Injection of Tracer
Pumping well 699-96-44
Injection Well 699-96-45
Well 699-96-43
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500


HRC Experiment
Redox (mg/L)
Injection of HRC
Injection of Tracer
Pumping well 699-96-44
Injection well 699-96-45
699-96-43
Redox (mg/L)
400
350
300
250
200
150
100
50
0
-50
-100
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Elapsed Time Since HRC Injected (hr)


HRC Experiment (Bromide Tracer Test #3)
Br ISE Probe
Injection of HRC
Injection of Tracer
Specific Conductance
Pumping well 699-96-44
Injection well 699-96-45
Well 699-96-43
Br Concentration (ppm)
Specific Conductance (uS/cm)
Elapsed Time Since HRC Injected (hr)
0
1
2
3
4
5
0
100
200
300
400
500
600
700
800
900
1000
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500


HRC Experiment
pH
Injection of HRC
Injection of Tracer
Pumping well 699-96-44
Injection Well 699-96-45
Well 699-96-43
pH
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Elapsed Time Since HRC Injected (hr)

Summary

- Successfully tracked Br, DO, Redox, Conductivity during the experiment
- Parameters behaved as expected
- Evidence for breakthrough of HRC on 18 August 2004 (15 days after HRC injection)
- Biofilm growth on sensors likely impacted late-time DO data
- Subsequent data (discrete sampling points) show system recovery