Biological Treatment of Perchlorate at Low Concentrations in Water

Baldwin Park Operable Unit San Gabriel Basin

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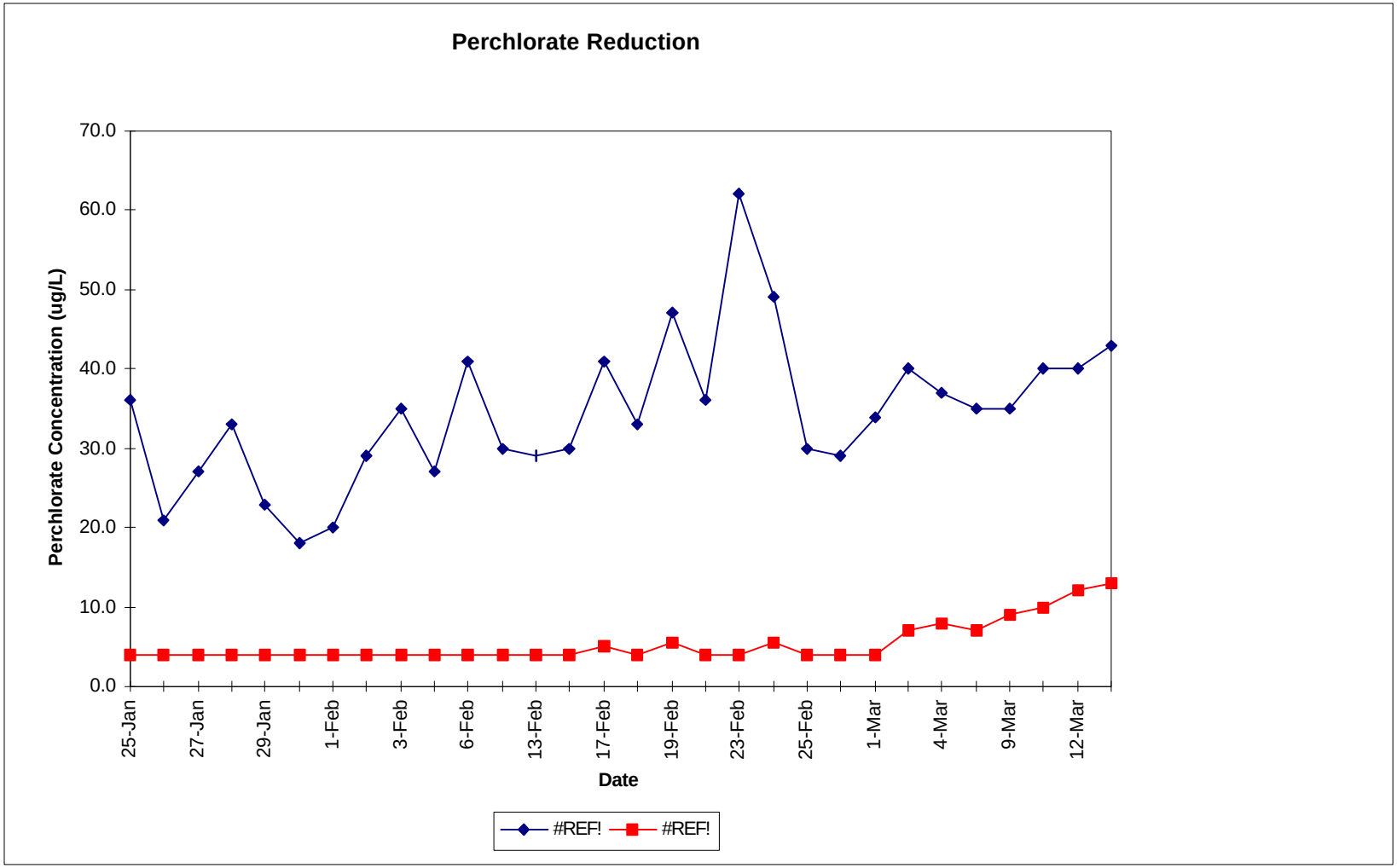
Harding Lawson Associates

Treatability Study Objectives

- Treat water containing 50 to 100 ug/L perchlorate
- Treat water containing 4 to 6 mg/L nitrate
- Produce effluent with perchlorate of 18 ug/L or lower
- Test alternate source of microorganisms
- Assess potability of effluent

Treatment Technology

- Attached-growth fluidized bed bioreactor
- Granular activated carbon
- Recycle capacity
- Carbon separation
- Feed system for nutrients (N and P)
- Feed system for organic substrate (ethanol)


Perchlorate Reduction
Perchlorate Concentration (ug/L)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
25-Jan
27-Jan
29-Jan
1-Feb
3-Feb
6-Feb
13-Feb
17-Feb
19-Feb
23-Feb
25-Feb
1-Mar
4-Mar
9-Mar
12-Mar
Date
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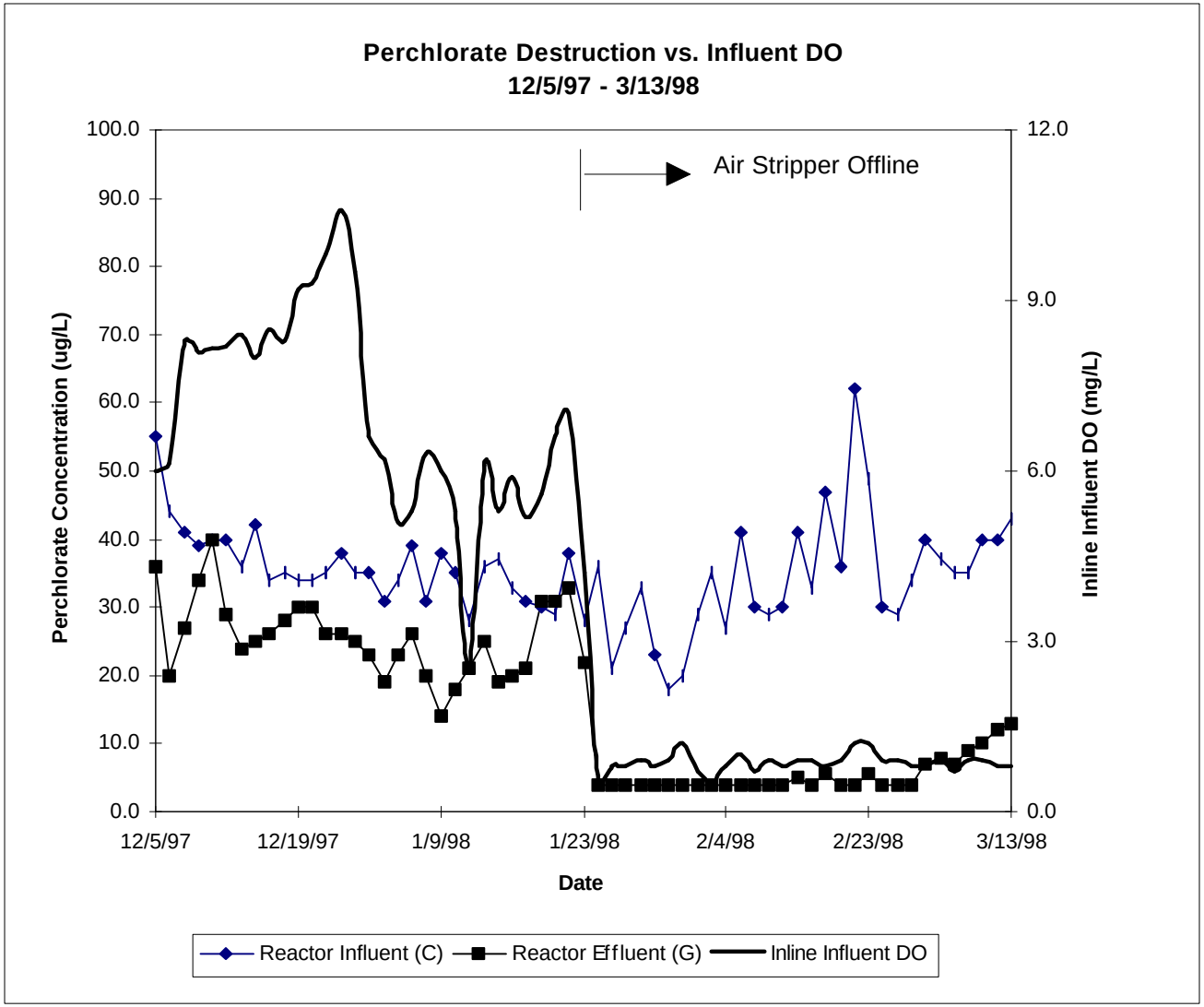
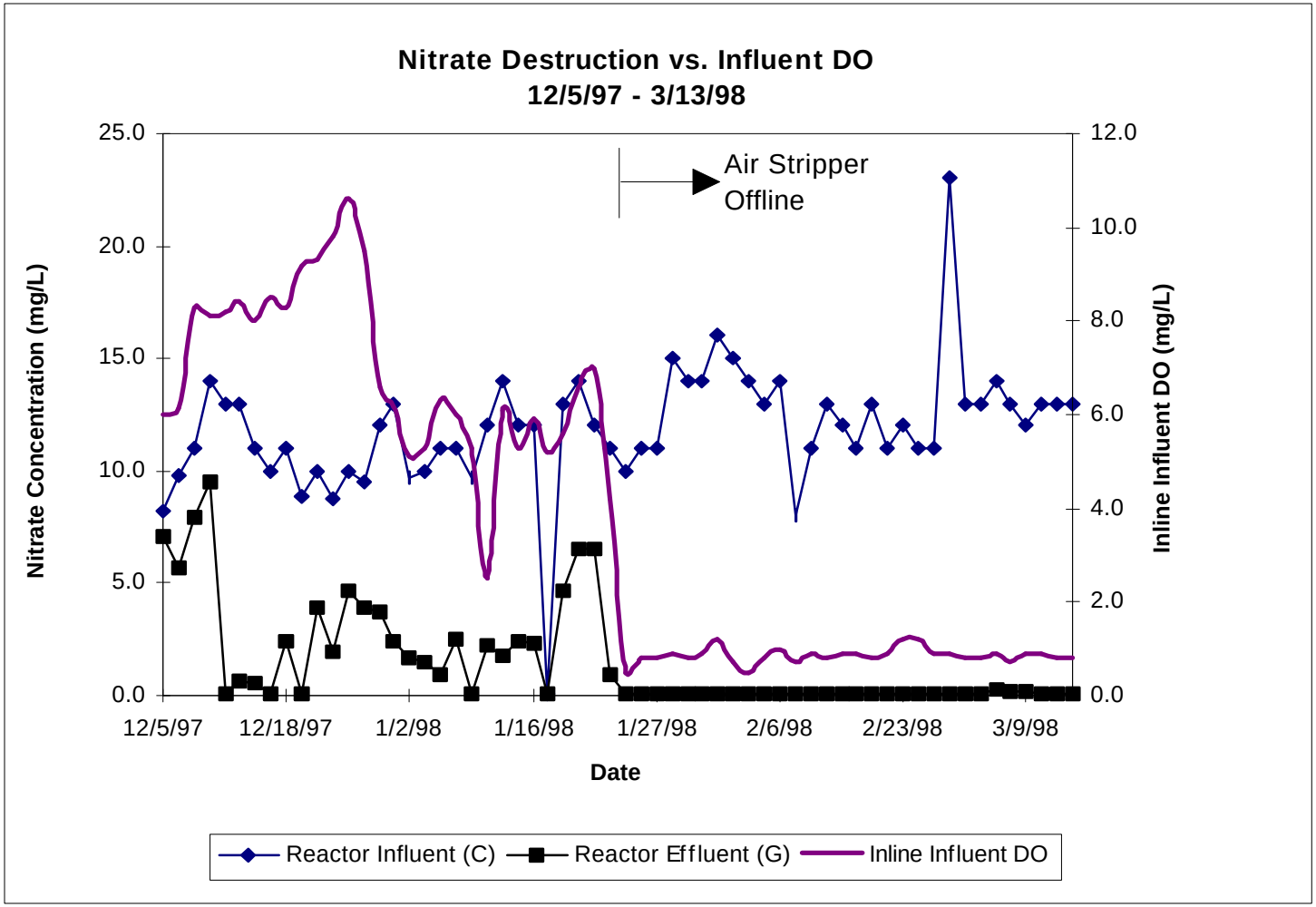
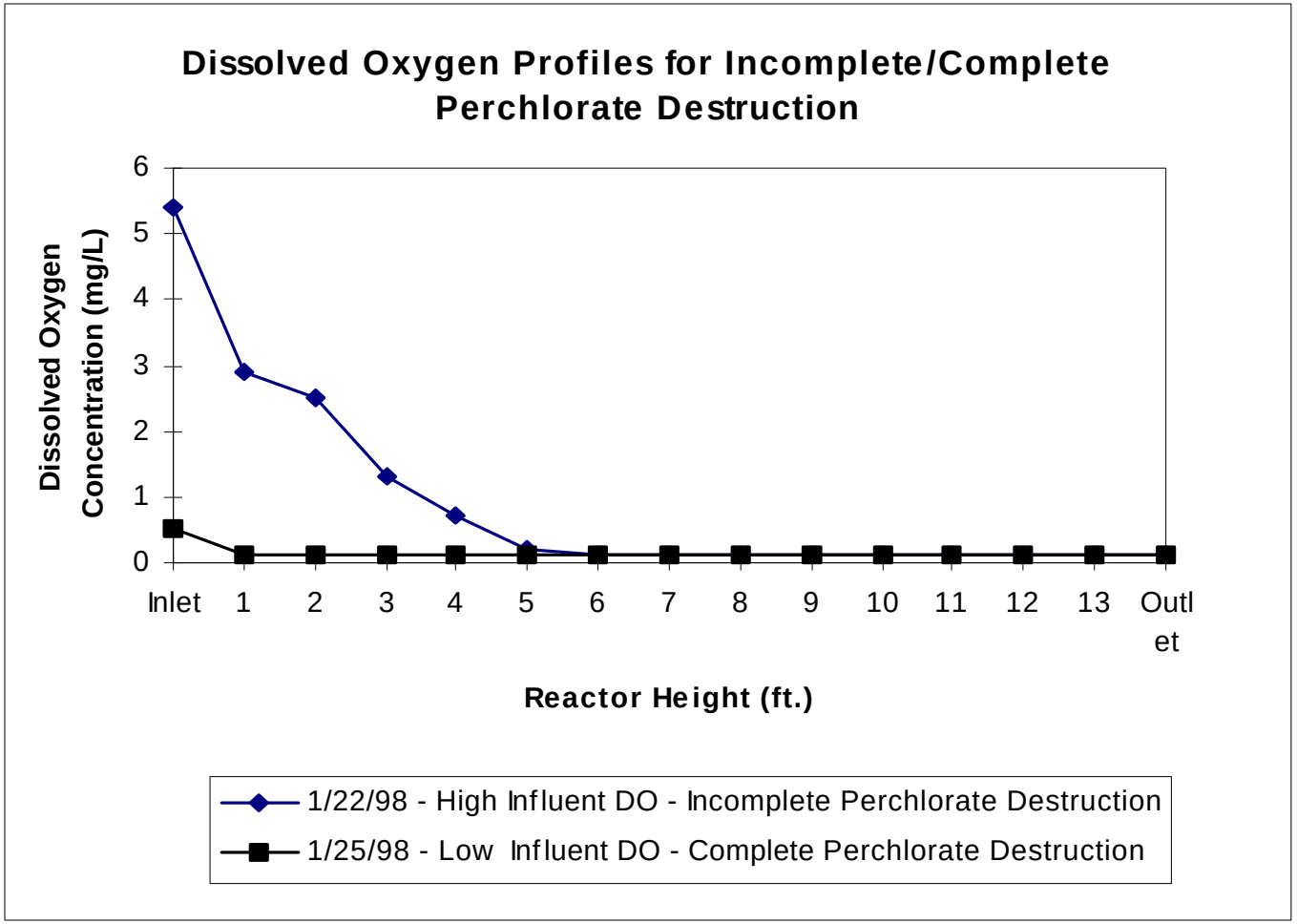
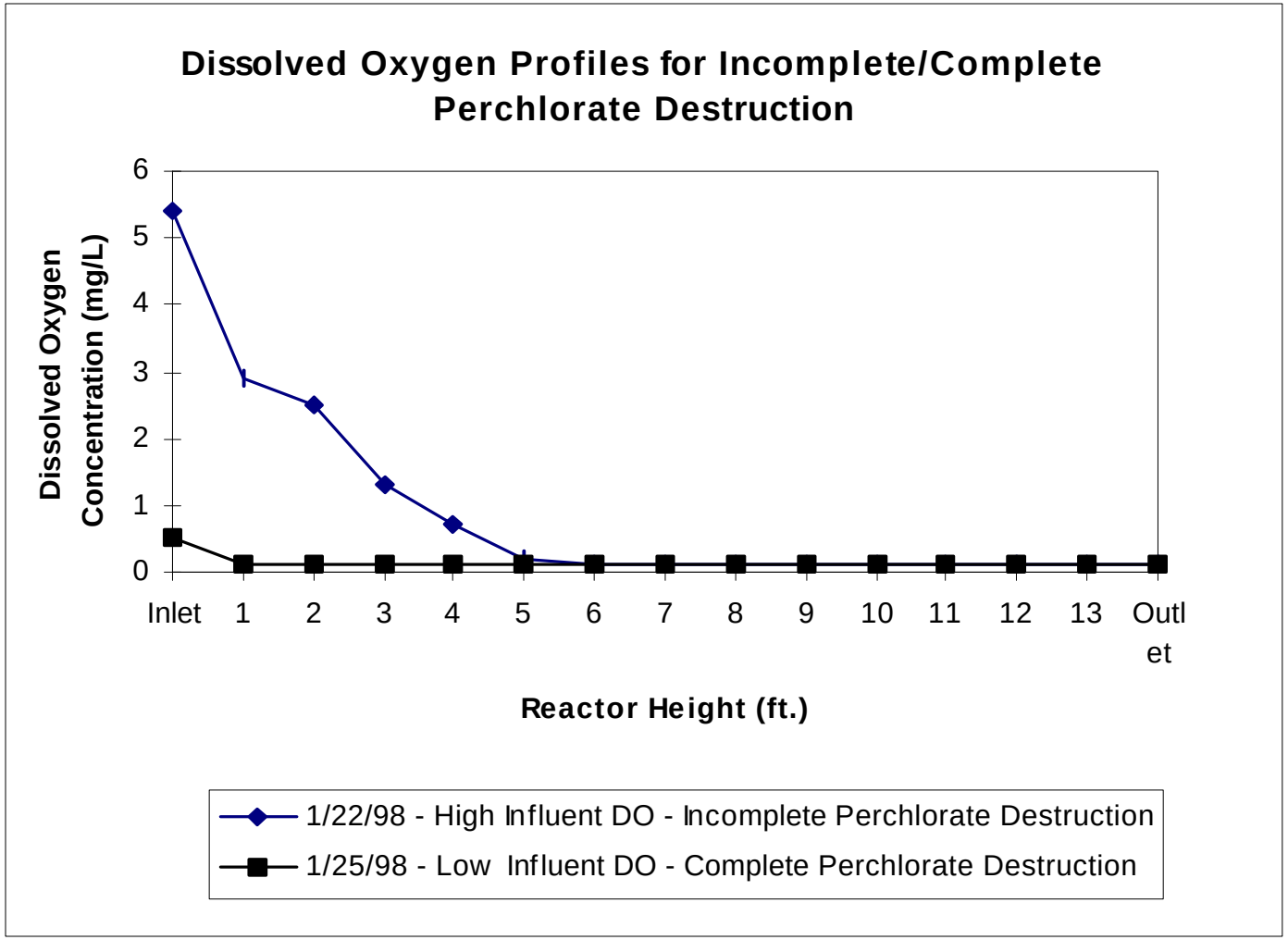
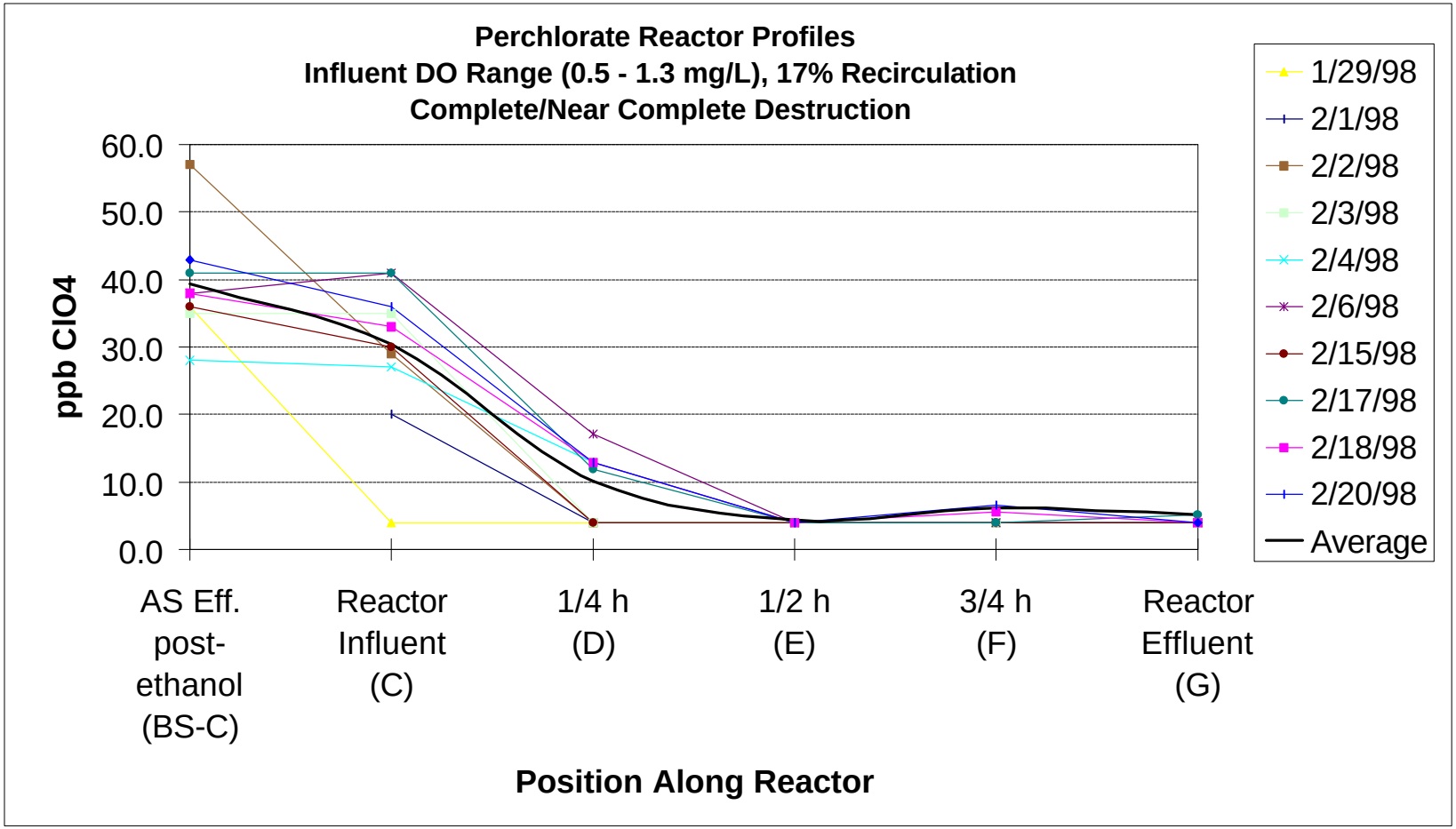
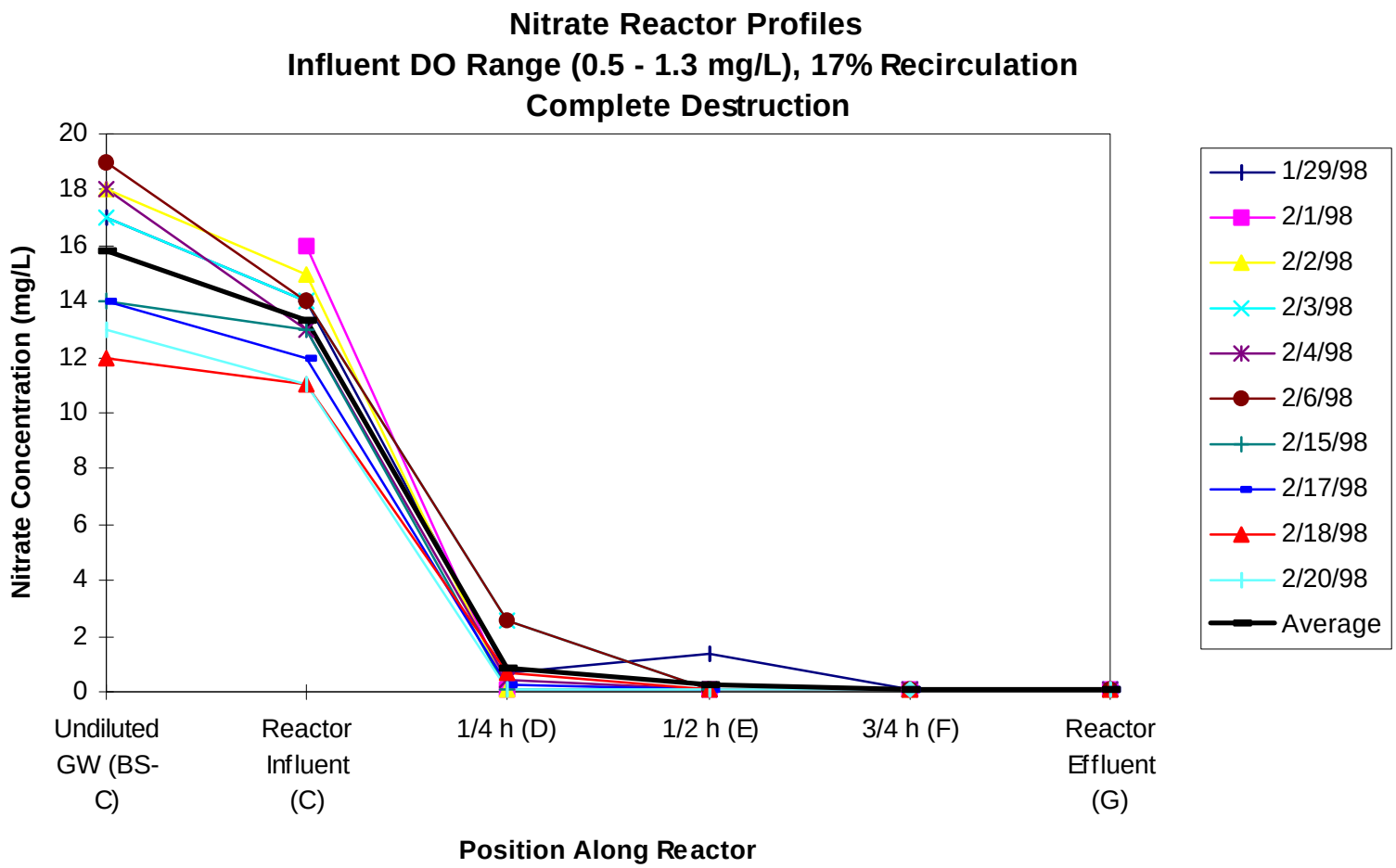

Perchlorate Destruction vs. Influent DO
12/5/97 - 3/13/98
Air Stripper Offline
Perchlorate Concentration (ug/L)
Inline Influent DO (mg/L)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
12.0
9.0
6.0
3.0
0.0
12/5/97
12/19/97
1/9/98
1/23/98
2/4/98
2/23/98
3/13/98
Date
Reactor Influent (C)
Reactor Effluent (G)
Inline Influent DO

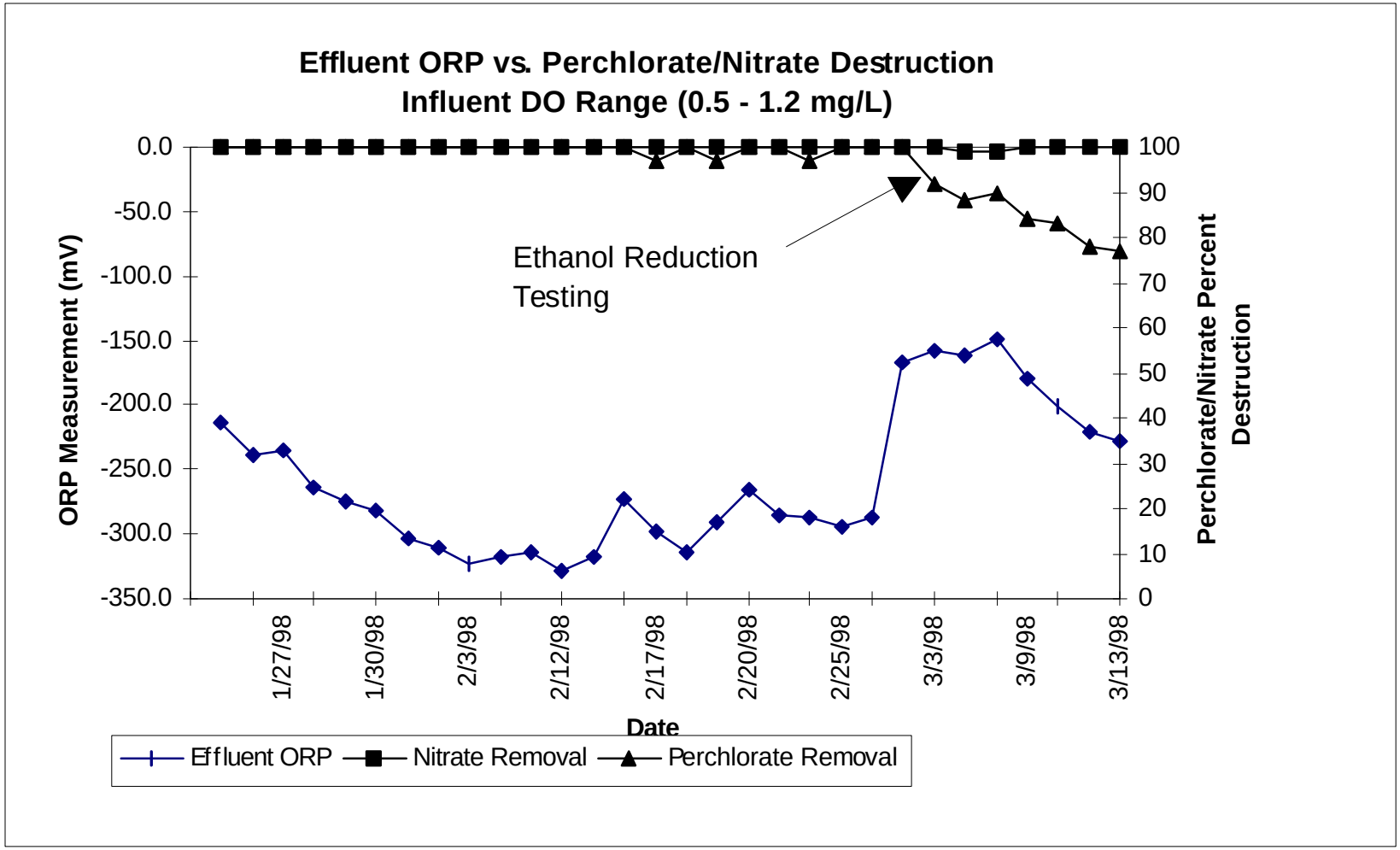

Nitrate Destruction vs. Influent DO
12/5/97 - 3/13/98
Air Stripper
Offline
Nitrate Concentration (mg/L)
Inline Influent DO (mg/L)
25.0
20.0
15.0
10.0
5.0
0.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
12/5/97
12/18/97
1/2/98
1/16/98
1/27/98
2/6/98
2/23/98
3/9/98
Date
Reactor Influent (C)
Reactor Effluent (G)
Inline Influent DO

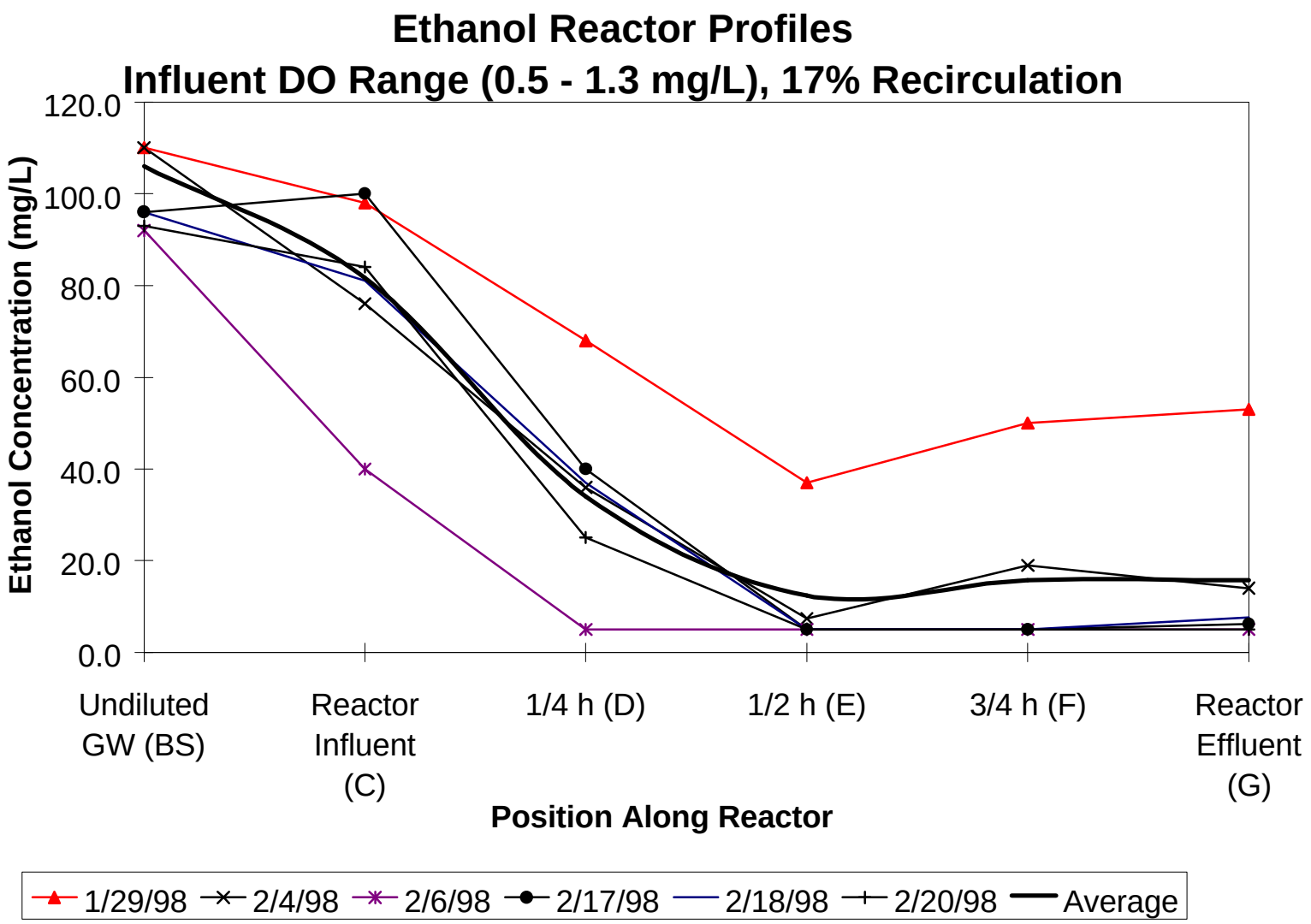

Dissolved Oxygen Profiles for Incomplete/Complete Perchlorate Destruction
Dissolved Oxygen Concentration (mg/L)
6
5
4
3
2
1
0
Inlet
1
2
3
4
5
6
7
8
9
10
11
12
13
Outlet
Reactor Height (ft.)
1/22/98 - High Influent DO - Incomplete Perchlorate Destruction
1/25/98 - Low Influent DO - Complete Perchlorate Destruction

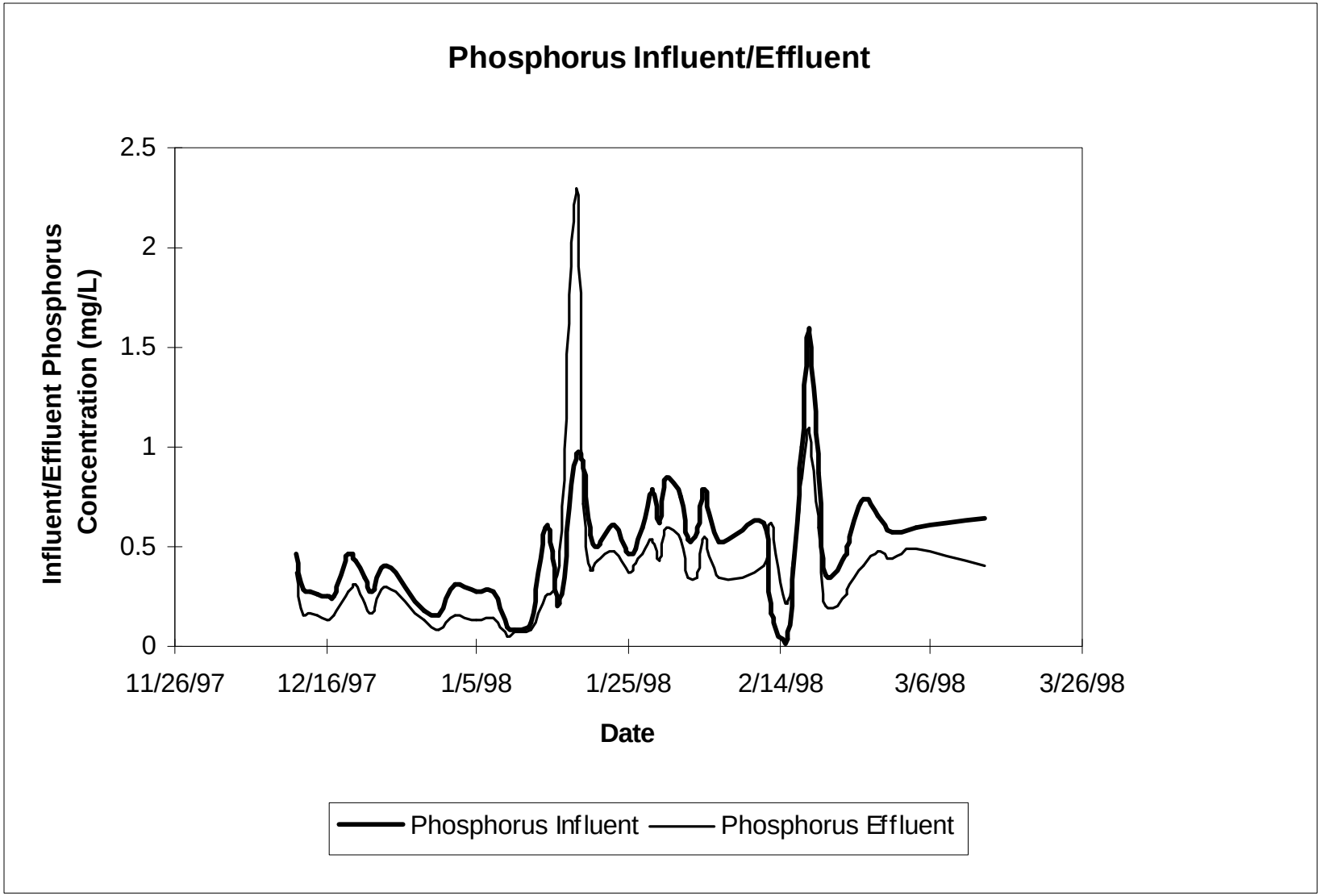

Dissolved Oxygen Profiles for Incomplete/Complete Perchlorate Destruction
Dissolved Oxygen Concentration (mg/L)
6
5
4
3
2
1
0
Inlet
1
2
3
4
5
6
7
8
9
10
11
12
13
Outlet
Reactor Height (ft.)
1/22/98 - High Influent DO - Incomplete Perchlorate Destruction
1/25/98 - Low Influent DO - Complete Perchlorate Destruction


Perchlorate Reactor Profiles
Influent DO Range (0.5 - 1.3 mg/L), 17% Recirculation
Complete/Near Complete Destruction
ppb ClO4
60.0
50.0
40.0
30.0
20.0
10.0
0.0
AS Eff. post-ethanol (BS-C)
Reactor Influent (C)
1/4 h (D)
1/2 h (E)
3/4 h (F)
Reactor Effluent (G)
Position Along Reactor
1/29/98
2/1/98
2/2/98
2/3/98
2/4/98
2/6/98
2/15/98
2/17/98
2/18/98
2/20/98
Average


Nitrate Reactor Profiles
Influent DO Range (0.5 - 1.3 mg/L), 17% Recirculation
Complete Destruction
Nitrate Concentration (mg/L)
20
18
16
14
12
10
8
6
4
2
0
Undiluted GW (BS-C)
Reactor Influent (C)
1/4 h (D)
1/2 h (E)
3/4 h (F)
Reactor Effluent (G)
Position Along Reactor
1/29/98
2/1/98
2/2/98
2/3/98
2/4/98
2/6/98
2/15/98
2/17/98
2/18/98
2/20/98
Average


Effluent ORP vs. Perchlorate/Nitrate Destruction
Influent DO Range (0.5 - 1.2 mg/L)
ORP Measurement (mV)
0.0
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
Perchlorate/Nitrate Percent Destruction
100
90
80
70
60
50
40
30
20
10
0
Ethanol Reduction Testing
1/27/98
1/30/98
2/3/98
2/12/98
2/17/98
2/20/98
2/25/98
3/3/98
3/9/98
3/13/98
Date
Effluent ORP
Nitrate Removal
Perchlorate Removal


Ethanol Reactor Profiles
Influent DO Range (0.5 - 1.3 mg/L), 17% Recirculation
Ethanol Concentration (mg/L)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Undiluted GW (BS)
Reactor Influent (C)
1/4 h (D)
1/2 h (E)
3/4 h (F)
Reactor Effluent (G)
Position Along Reactor
1/29/98
2/4/98
2/6/98
2/17/98
2/18/98
2/20/98
Average


Phosphorus Influent/Effluent
Influent/Effluent Phosphorus Concentration (mg/L)
2.5
2
1.5
1
0.5
0
11/26/97
12/16/97
1/5/98
1/25/98
2/14/98
3/6/98
3/26/98
Date
Phosphorus Influent
Phosphorus Effluent

Conclusions

- Technology can treat low concentrations
- Treated water less than 4 ug/L perchlorate
- Treated water less than 0.1 mg/L nitrate
- Alternative microorganisms work
- Effluent could be potable with disinfection and filtration

Additional Conclusions

- Observed preference for nitrate
- Ethanol input optimized to support growth but not detected in produced water
- Minimum phosphorus required
- Operating controls - redox potential and DO
- Retention time - adjusted by equipment configuration and recycle
- No VOC reduction products detected

Phase 2 Treatability Study

- La Puente Valley County Water District
- Engineering data for scale up
- Rate between 500 and 1,000 gpm
- Disinfection
- Filtration
- Design in Summer 1998
- Startup in early 1999

Contacts

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