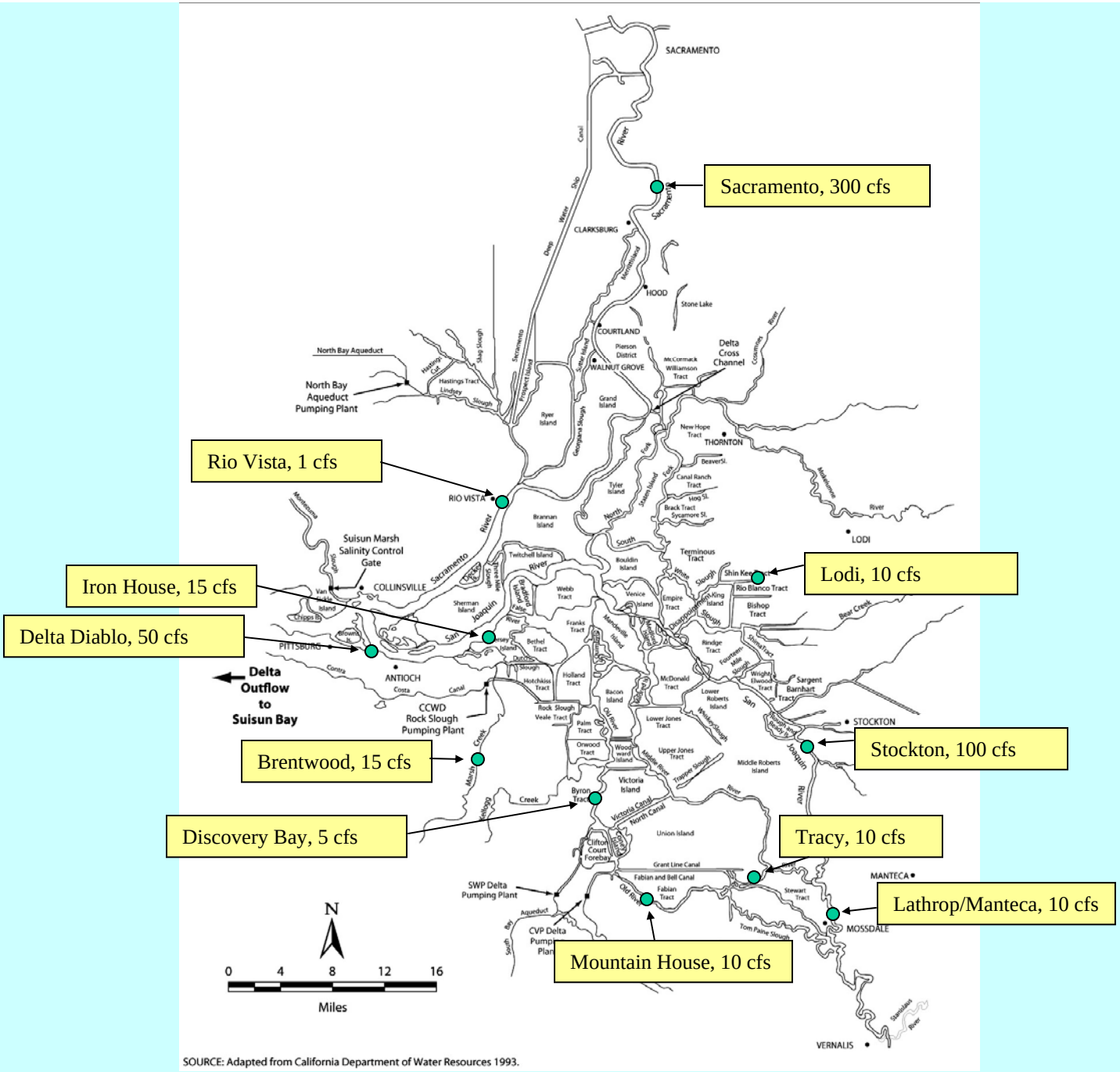
Evaluation of Tidal Dilution of Wastewater Discharges into the Delta Using DSM2 QUAL

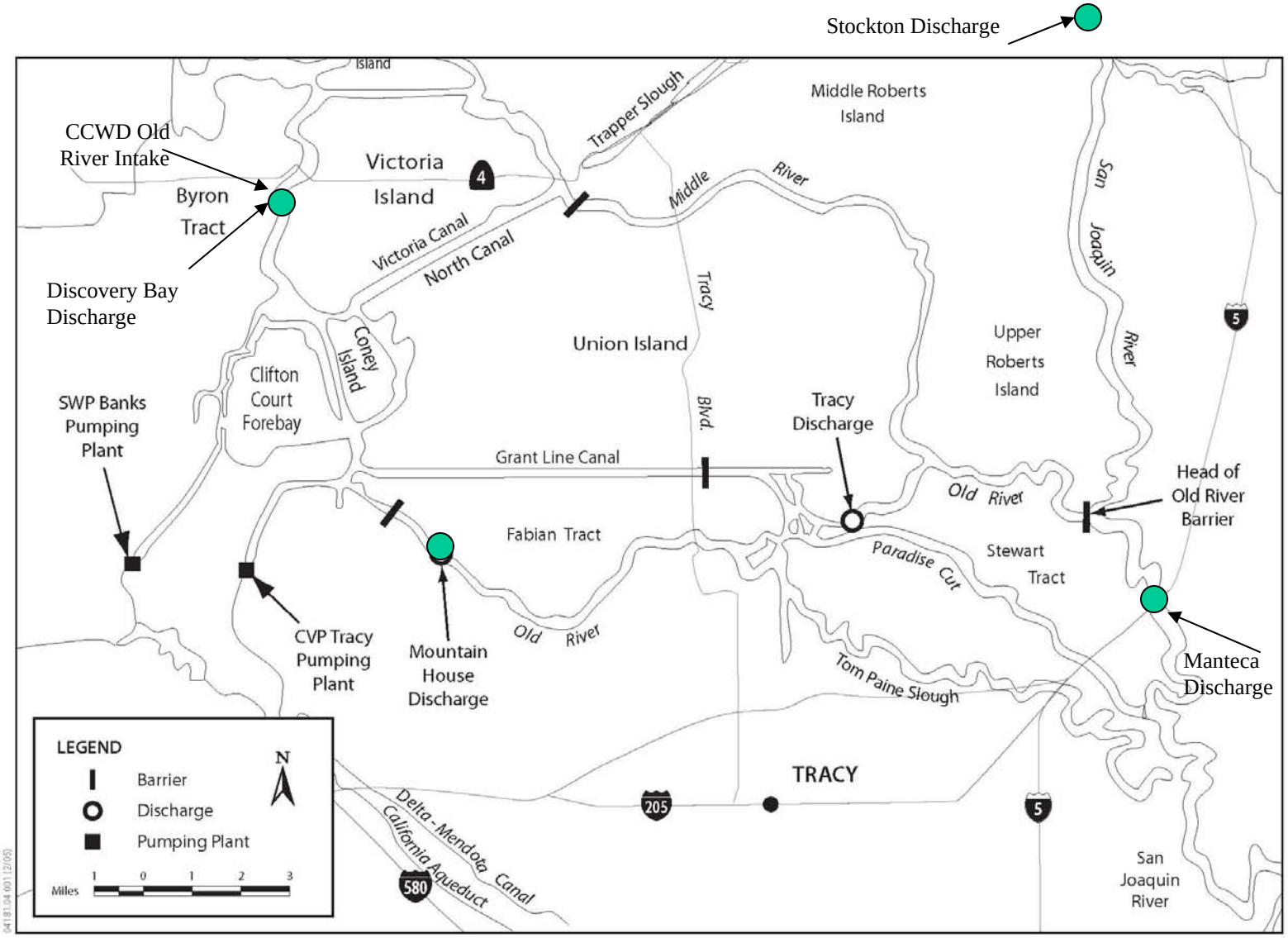
DSM2 User's Group Meeting

April 25, 2006

Work done by Jones & Stokes for
City of Stockton, Mountain House
Community Services District, and
Iron House Sanitation District



SOURCE: Adapted from California Department of Water Resources 1993.



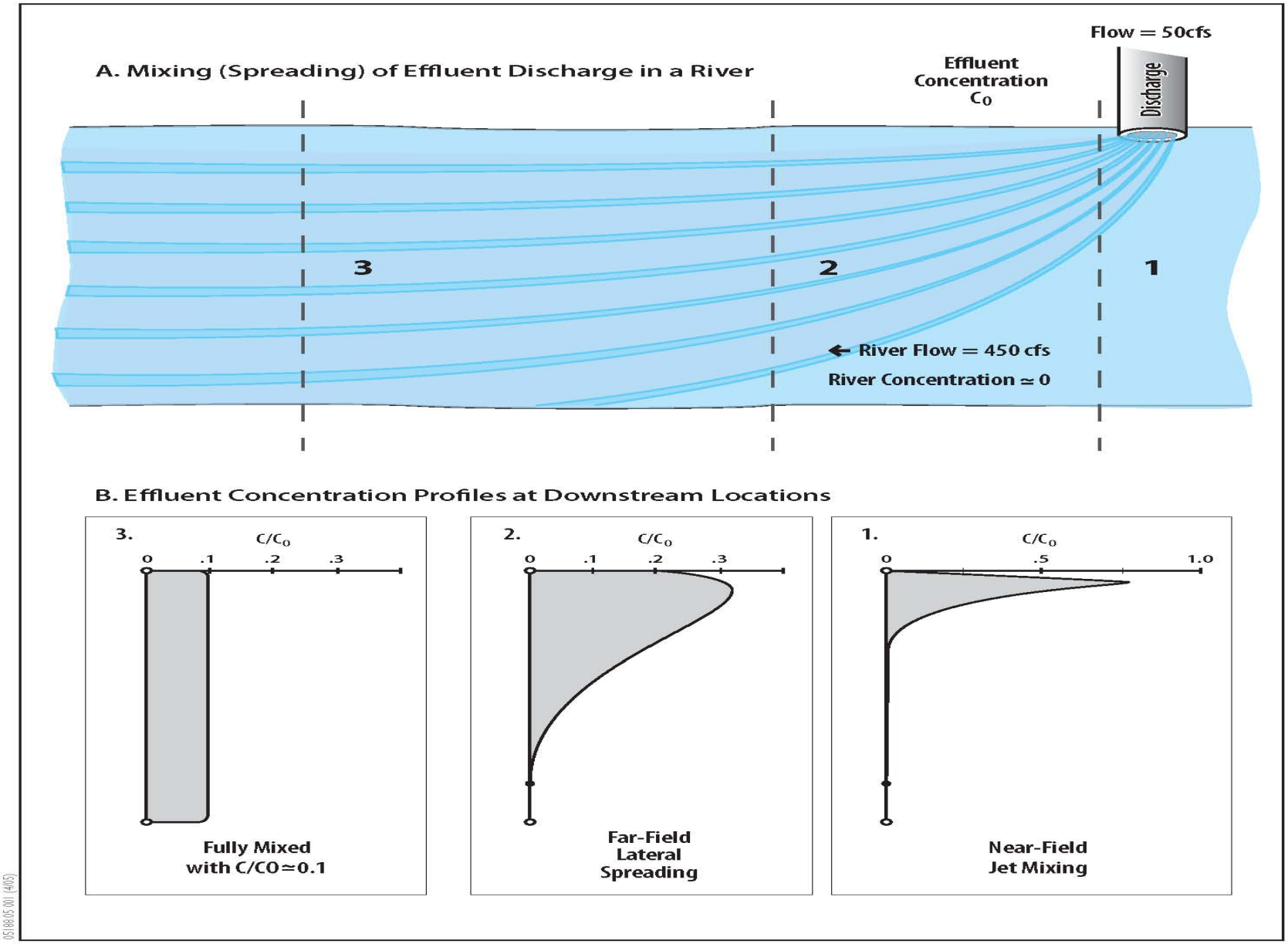
Jones & Stokes

Figure 1
Map of the South Delta Channels

Stockton RWCF discharge (50 cfs) has a long-term near-field dilution of about 10 (10% effluent)

- Mixed River Concentration = Effluent Concentration * Discharge/(river flow + Discharge)
- Mixed Conc = Effluent Conc / Dilution
- Dilution = River/Discharge + 1

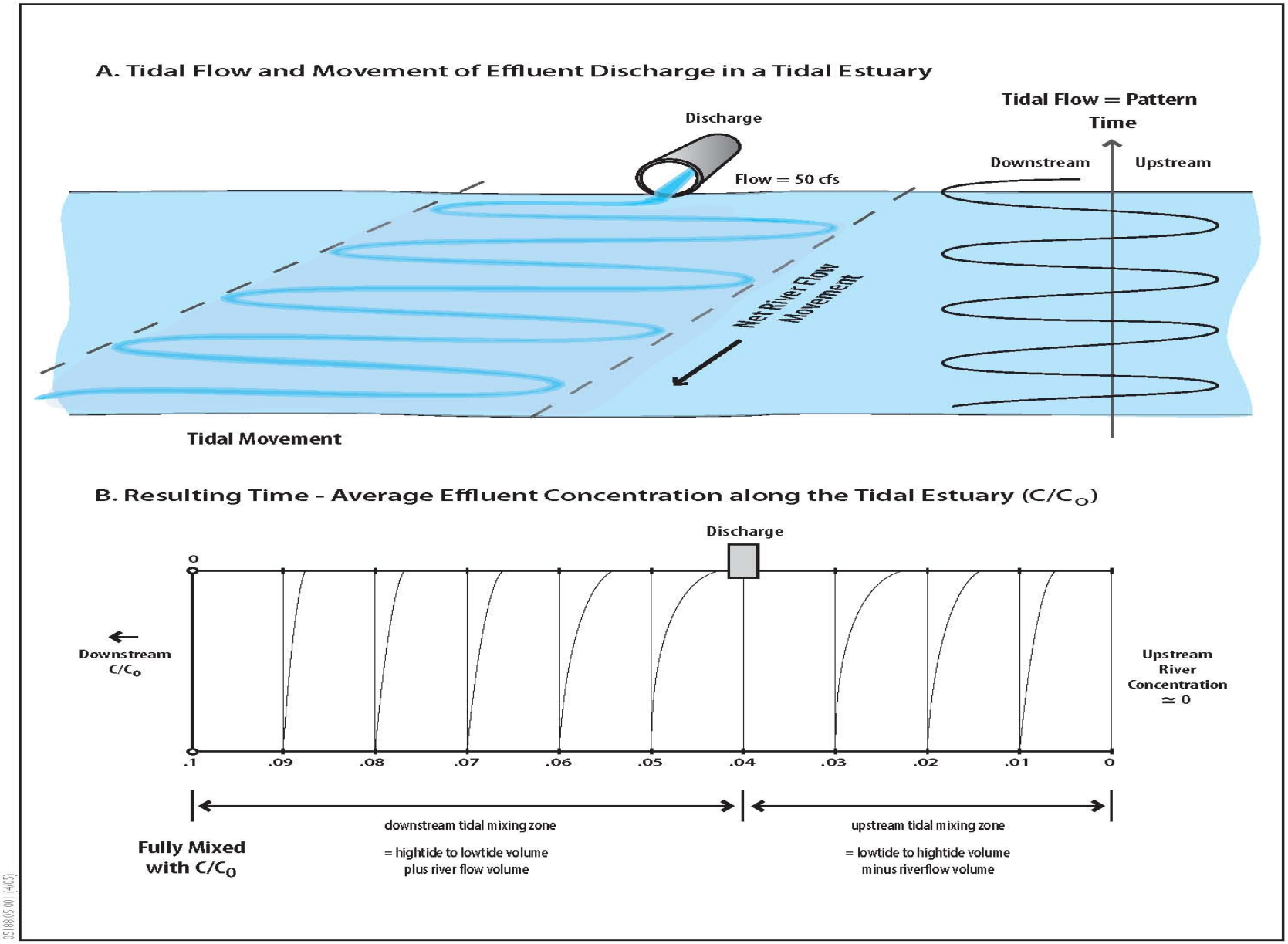
- How much wastewater effluent will reach CCWD, SWP or CVP intakes?



05188.05.001 (4/03)

Jones & Stokes

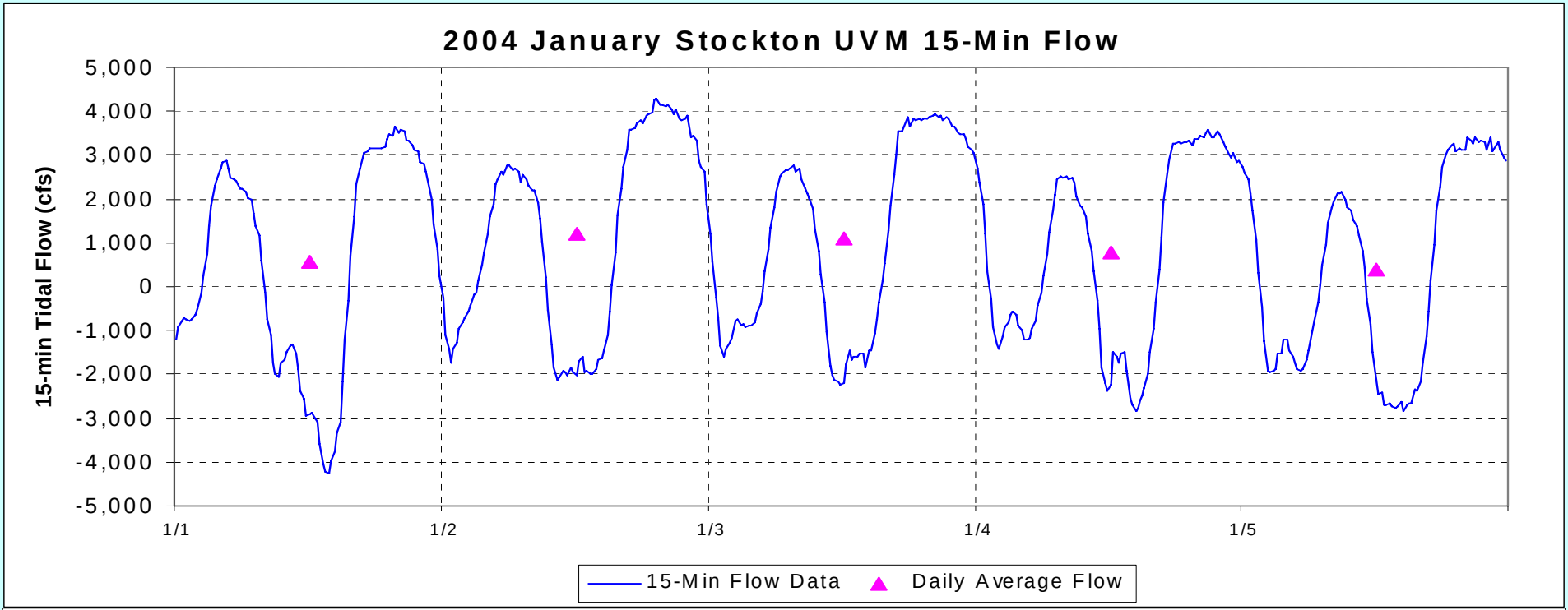
Figure 1
Conceptual Pattern of Mixing in a River

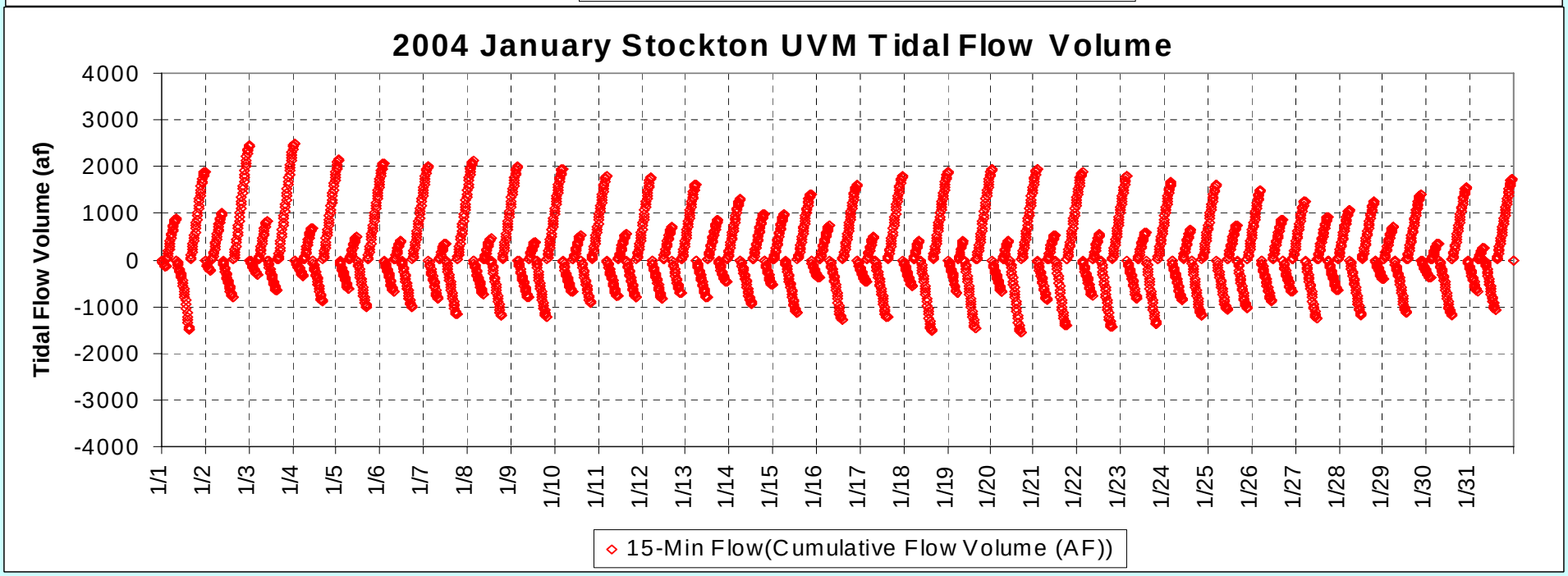


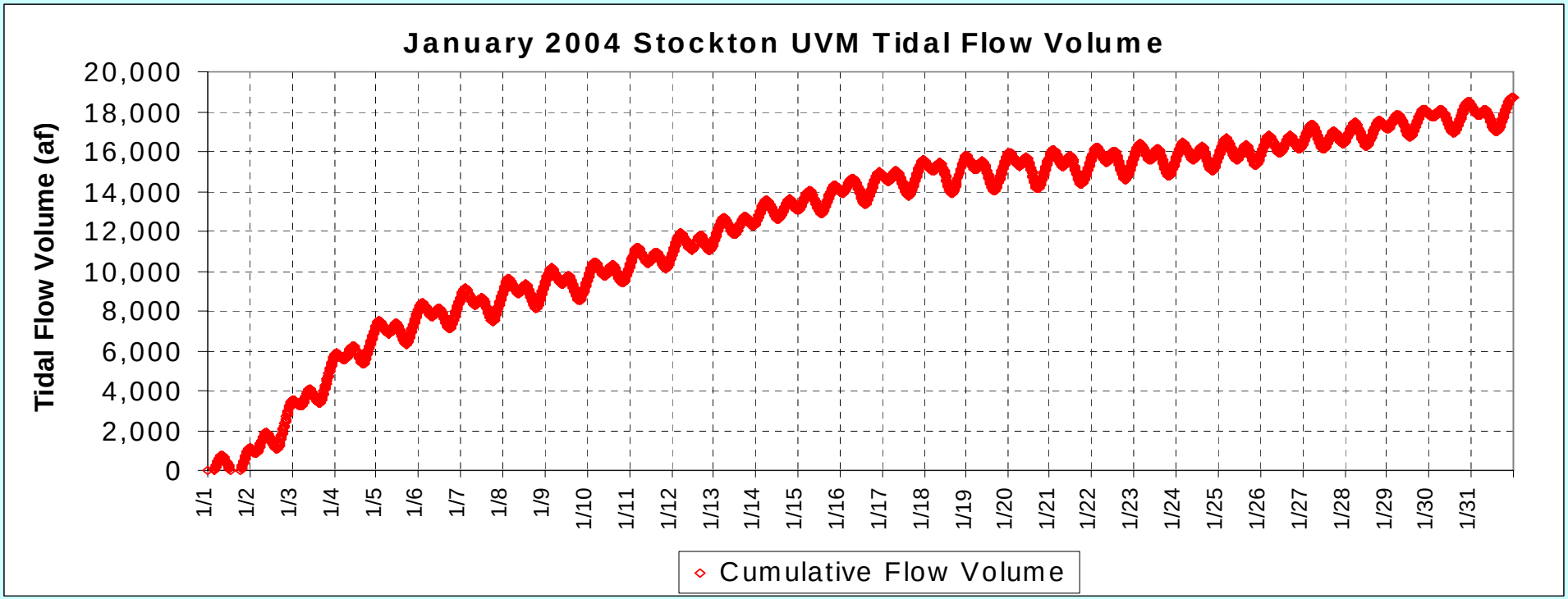
05188.05.001 (4/03)

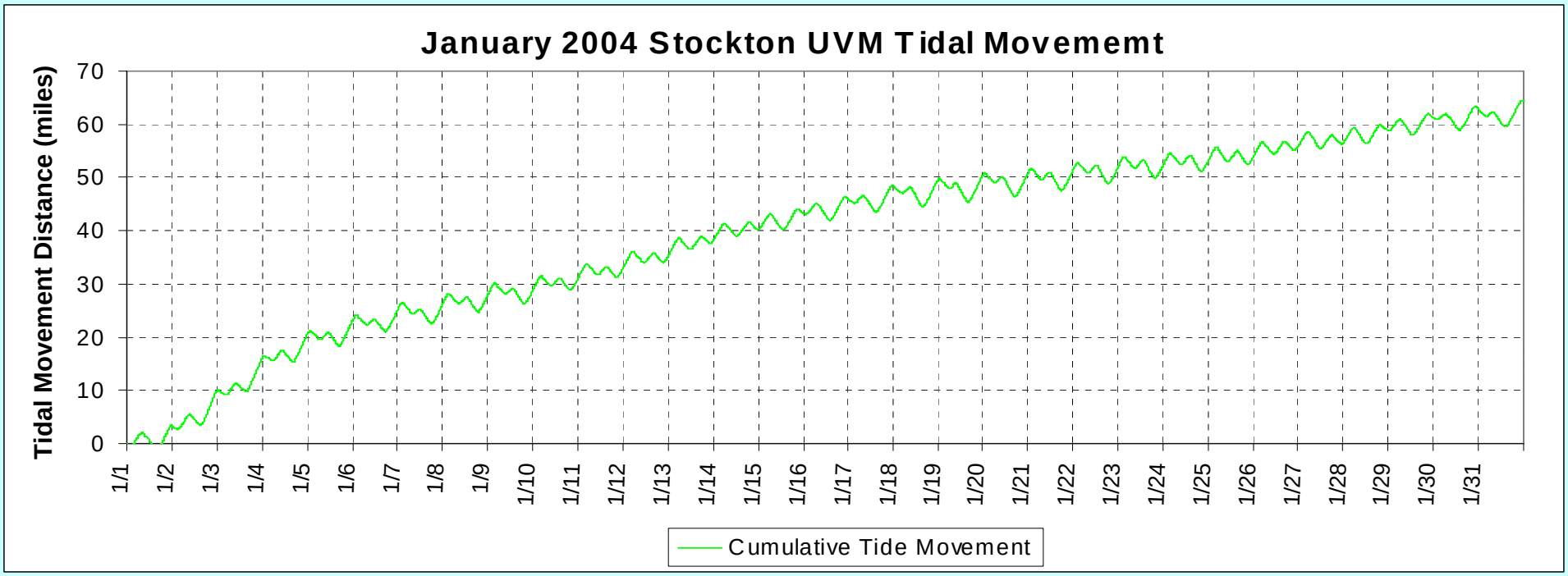
Jones & Stokes

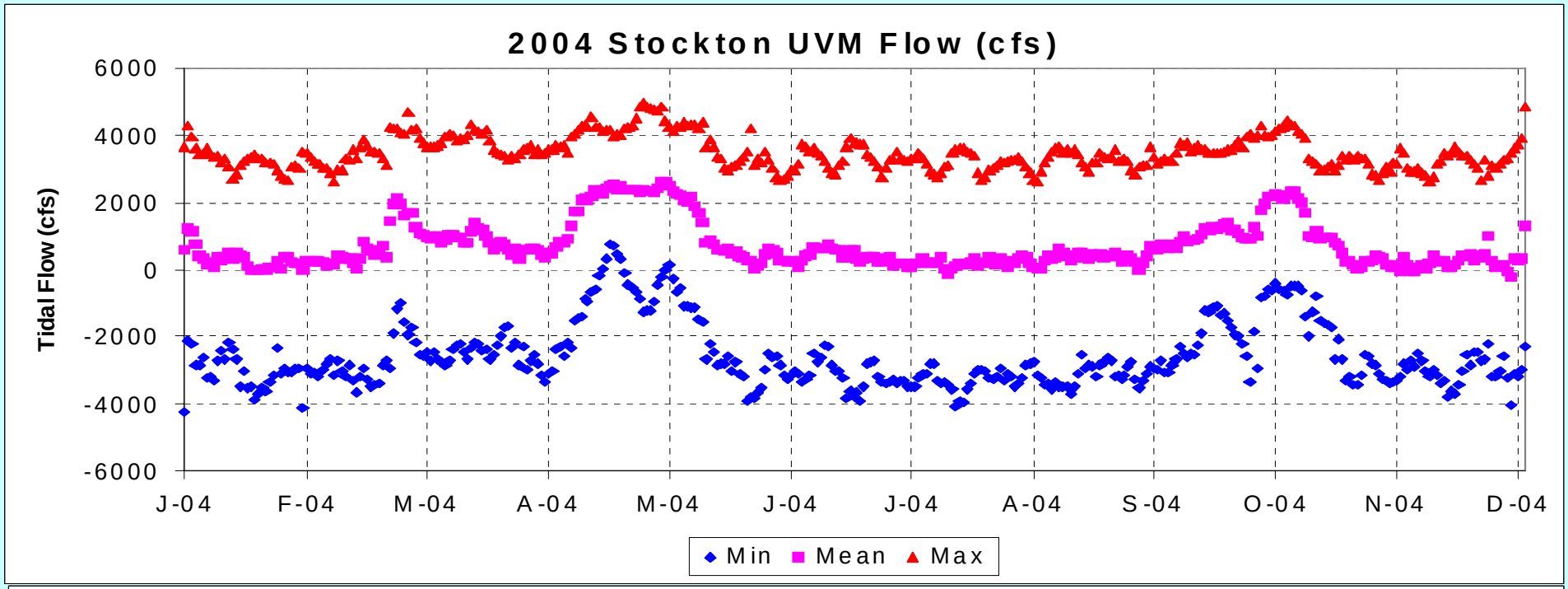
Figure 2
Conceptual Pattern of Mixing in a Tidal Estuary

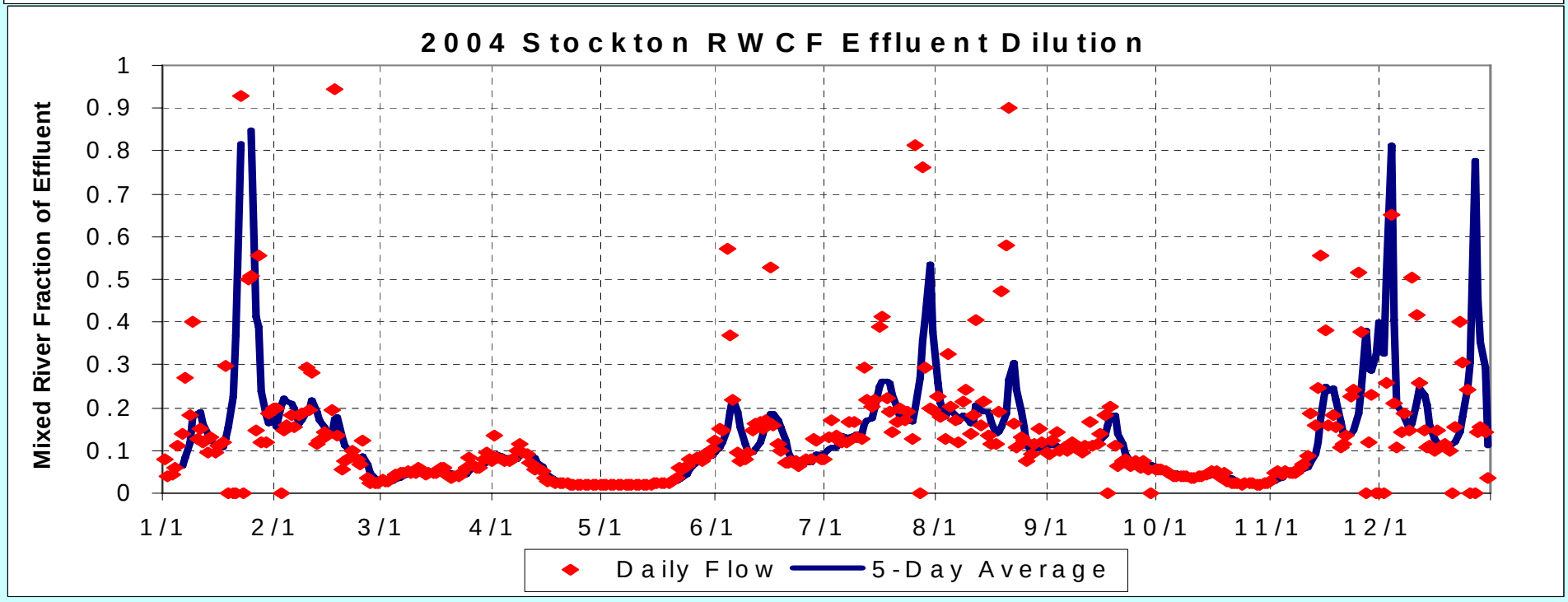

2004 January Stockton UVM 15-Min Flow
15-min Tidal Flow (cfs)
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
-5,000
1/1
1/2
1/3
1/4
1/5
15-Min Flow Data
Daily Average Flow


2004 January Stockton UVM Tidal Flow Volume
Tidal Flow Volume (af)
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
1/1
1/2
1/3
1/4
1/5
1/6
1/7
1/8
1/9
1/10
1/11
1/12
1/13
1/14
1/15
1/16
1/17
1/18
1/19
1/20
1/21
1/22
1/23
1/24
1/25
1/26
1/27
1/28
1/29
1/30
1/31
15-Min Flow(Cumulative Flow Volume (AF))


January 2004 Stockton UVM Tidal Flow Volume
Tidal Flow Volume (af)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1/1 1/2 1/3 1/4 1/5 1/6 1/7 1/8 1/9 1/10 1/11 1/12 1/13 1/14 1/15 1/16 1/17 1/18 1/19 1/20 1/21 1/22 1/23 1/24 1/25 1/26 1/27 1/28 1/29 1/30 1/31
Cumulative Flow Volume


January 2004 Stockton UVM Tidal Movememt
Tidal Movement Distance (miles)
70
60
50
40
30
20
10
0
1/1 1/2 1/3 1/4 1/5 1/6 1/7 1/8 1/9 1/10 1/11 1/12 1/13 1/14 1/15 1/16 1/17 1/18 1/19 1/20 1/21 1/22 1/23 1/24 1/25 1/26 1/27 1/28 1/29 1/30 1/31
Cumulative Tide Movement

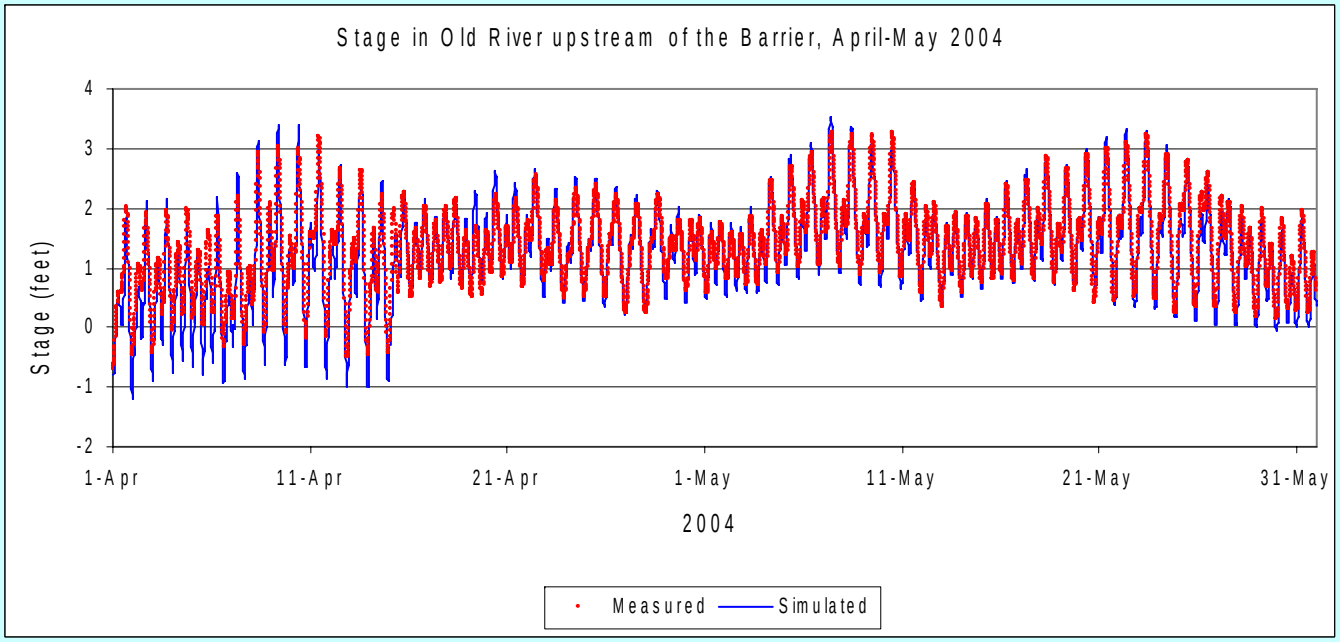

2004 Stockton UVM Flow (cfs)
Tidal Flow (cfs)
6000
4000
2000
0
-2000
-4000
-6000
J-04
F-04
M-04
A-04
M-04
J-04
J-04
A-04
S-04
O-04
N-04
D-04
Min
Mean
Max

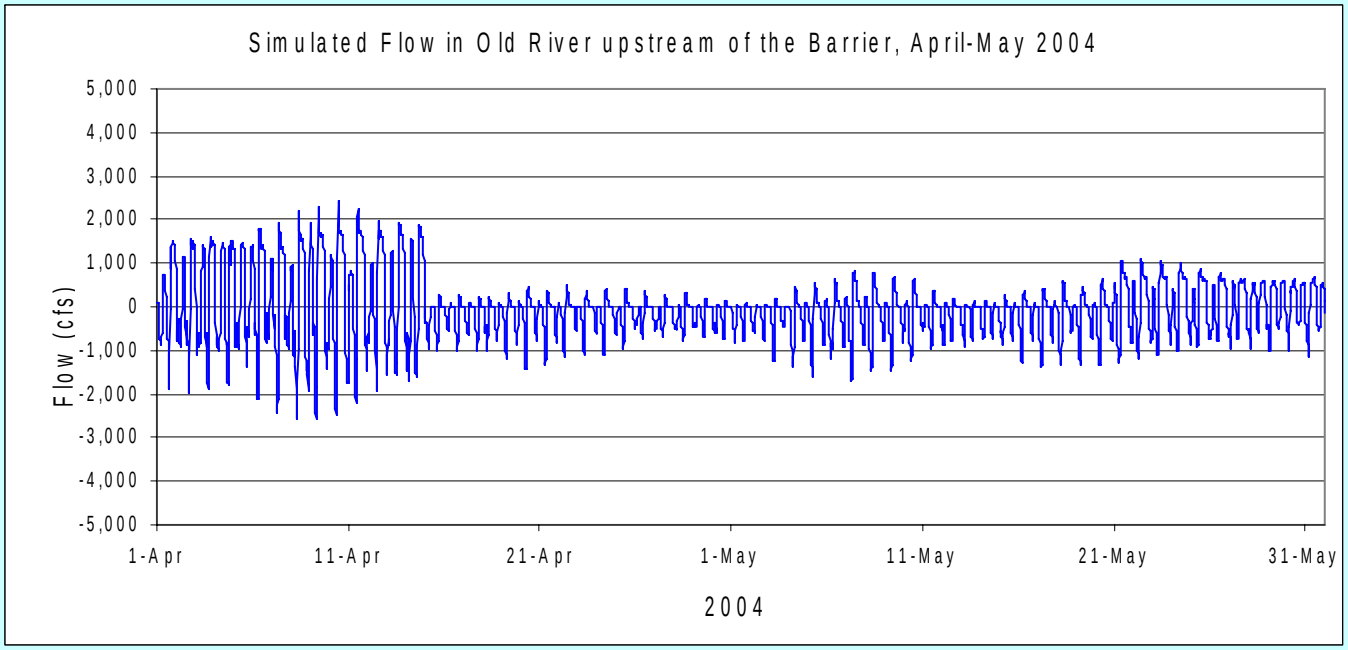

2004 Stockton RWCF Effluent Dilution
Mixed River Fraction of Effluent
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Daily Flow
5-Day Average

Mountain House Tidal Dilution Study

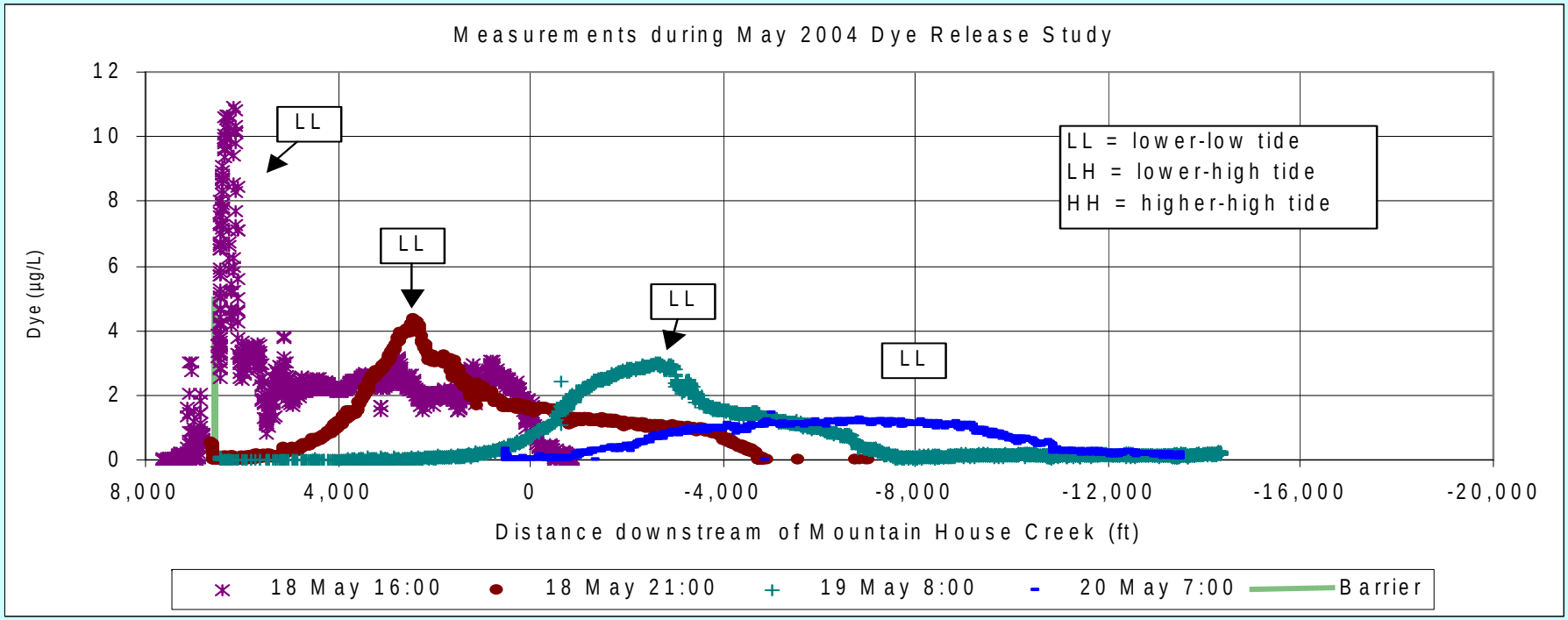
- May and June 2004 dye studies
- Simulated effect of 10 cfs wastewater discharge

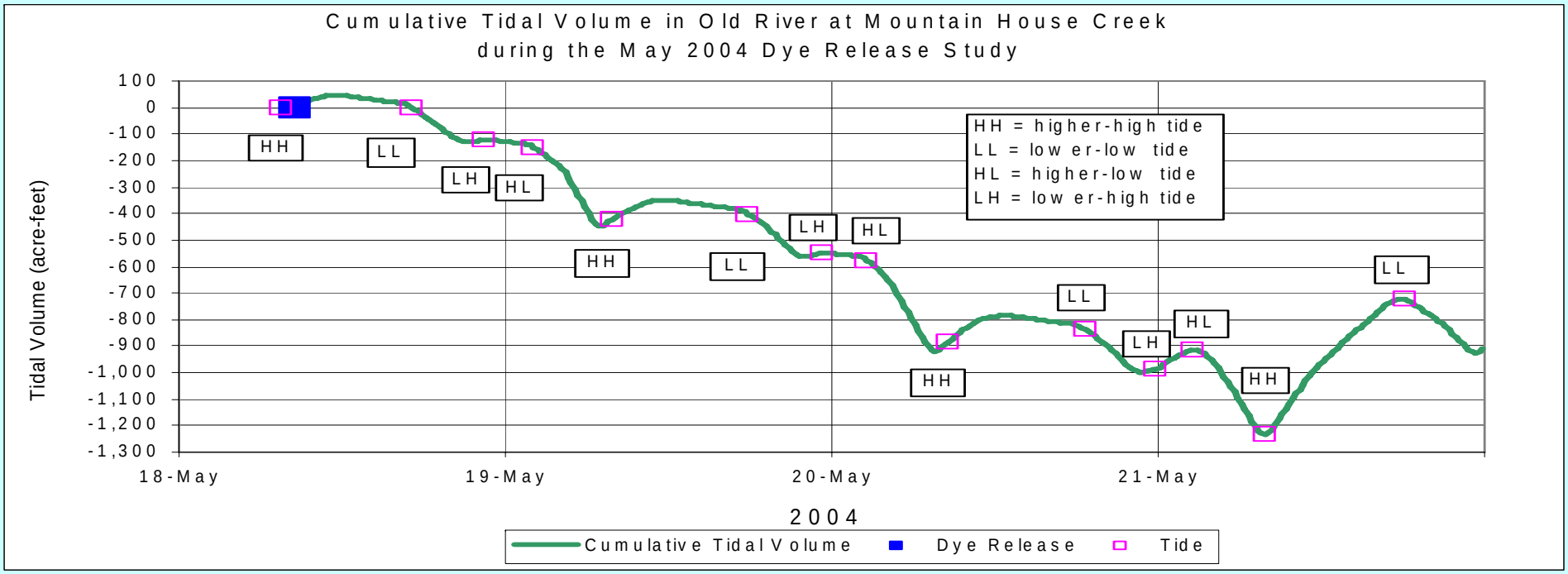
- Dr. Gary Litton from the University of the Pacific Department of Civil and Environmental Engineering performed the Dye Tracer Studies with boat-mounted data acquisition system (GPS, with 1-second sampling of fluorescence, turbidity, temperature, DO, EC, and pH)

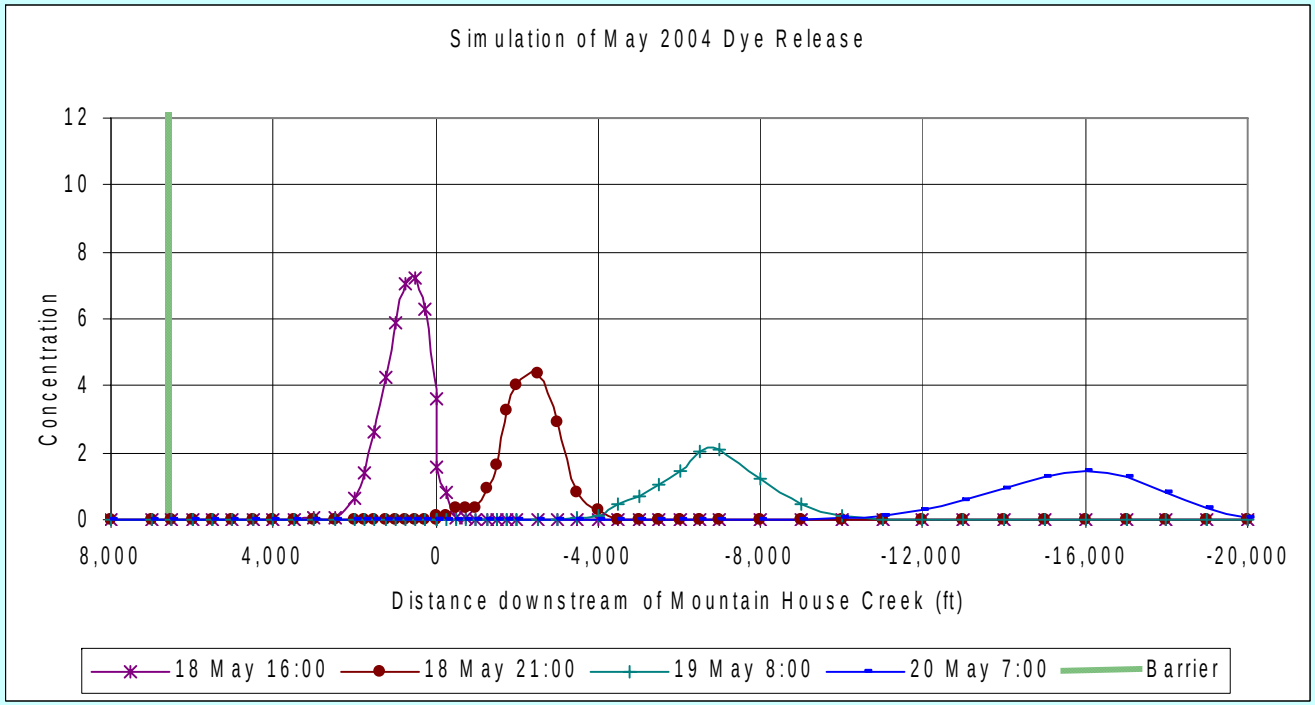




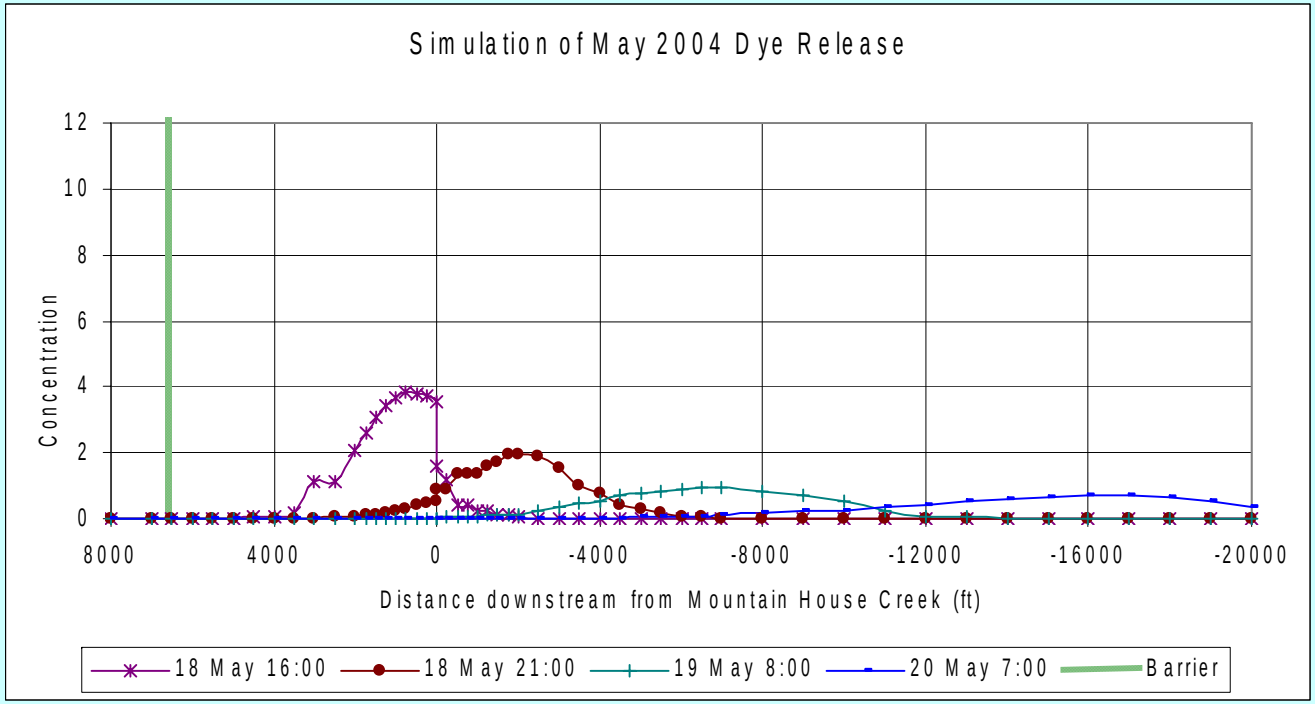
Old River has much less tidal flow with the temporary barrier installed


Measurements during May 2004 Dye Release Study
Dye (µg/L)
12
10
8
6
4
2
0
8,000
4,000
0
-4,000
-8,000
-12,000
-16,000
-20,000
Distance downstream of Mountain House Creek (ft)
LL
LL
LL
LL
LL = lower-low tide
LH = lower-high tide
HH = higher-high tide
18 May 16:00
18 May 21:00
19 May 8:00
20 May 7:00
Barrier

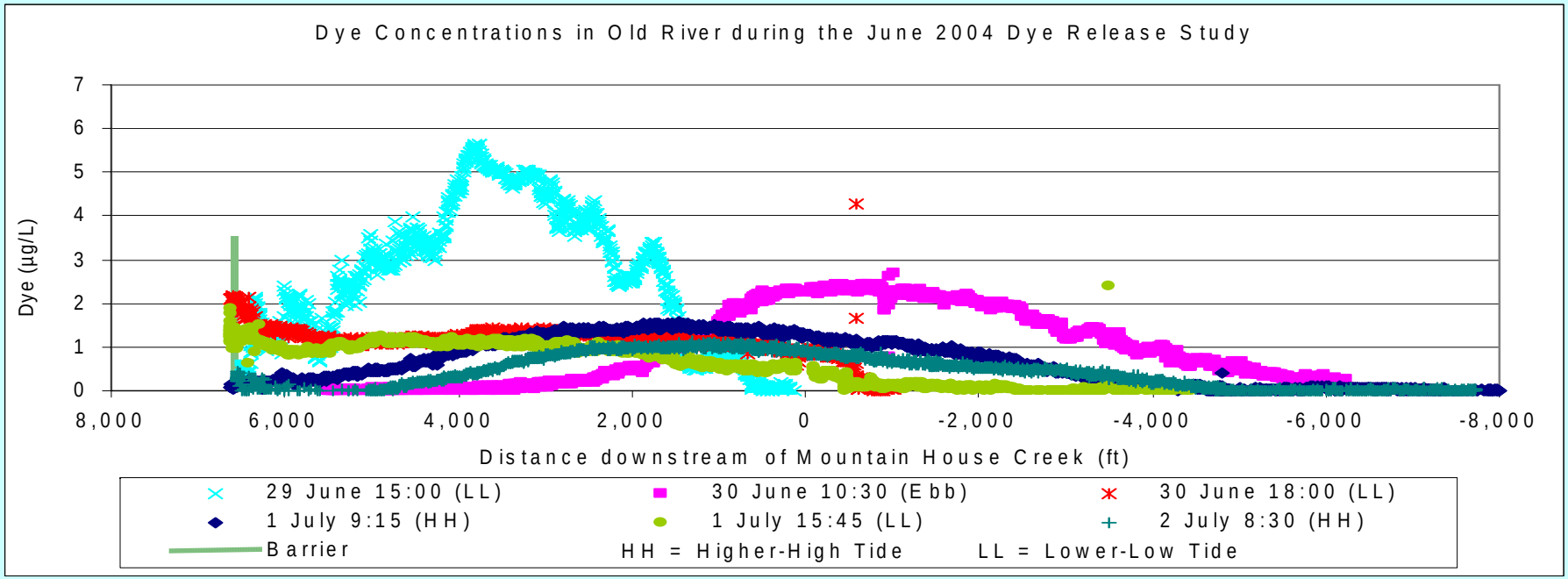

Cumulative Tidal Volume in Old River at Mountain House Creek
during the May 2004 Dye Release Study
Tidal Volume (acre-feet)
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1,000
-1,100
-1,200
-1,300
18-May
19-May
20-May
21-May
2004
HH
LL
LH
HL
HH
LL
LH
HL
HH
LL
LH
HL
HH
LL
HH = higher-high tide
LL = lower-low tide
HL = higher-low tide
LH = lower-high tide
Cumulative Tidal Volume
Dye Release
Tide

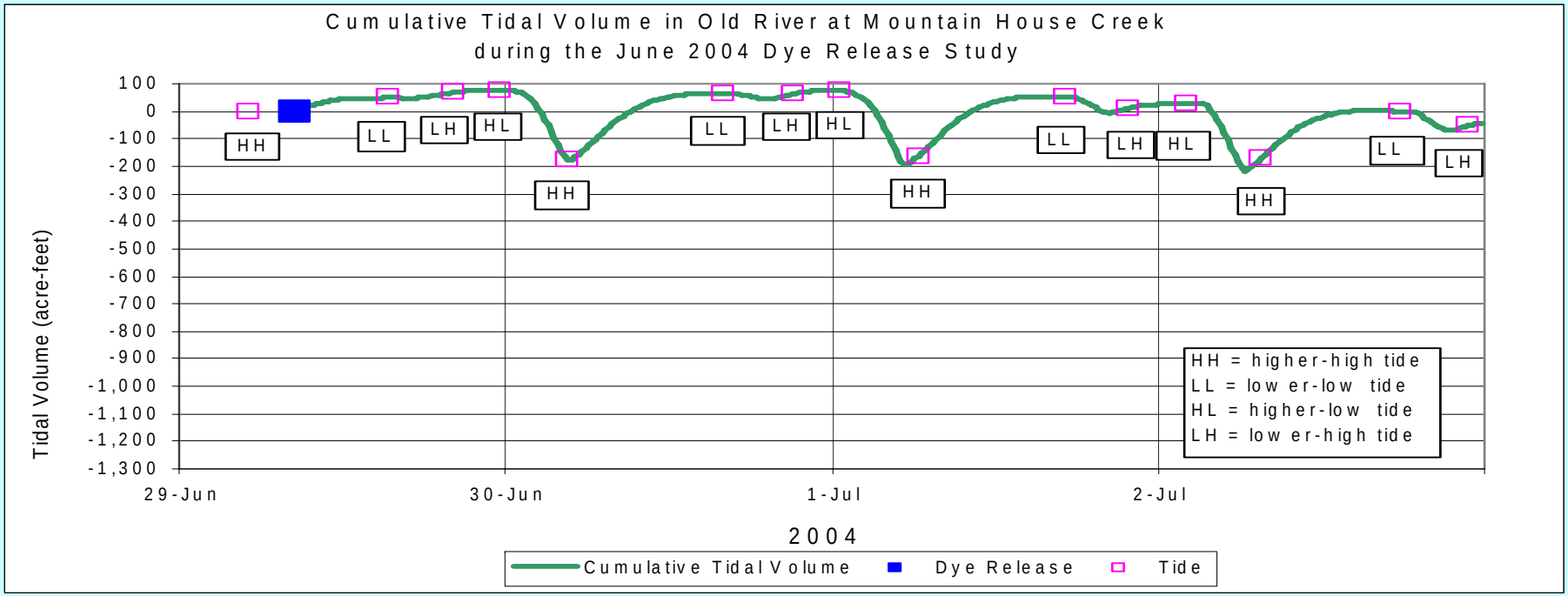


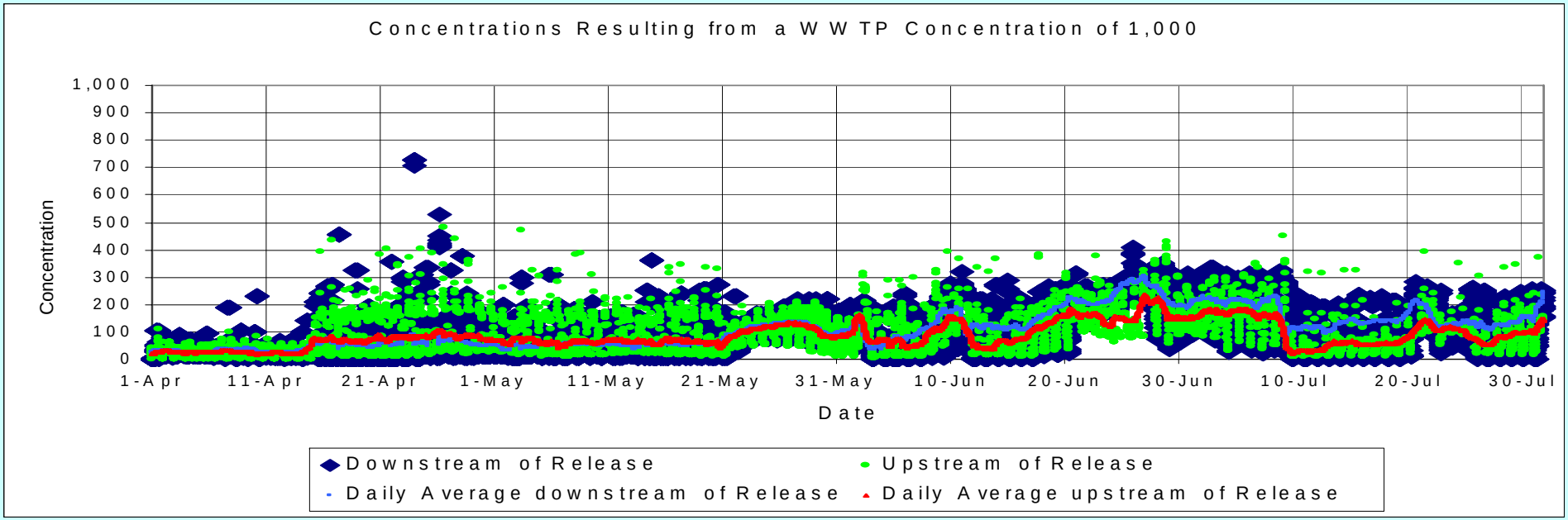
Baseline Dispersion Coefficient = 0.3

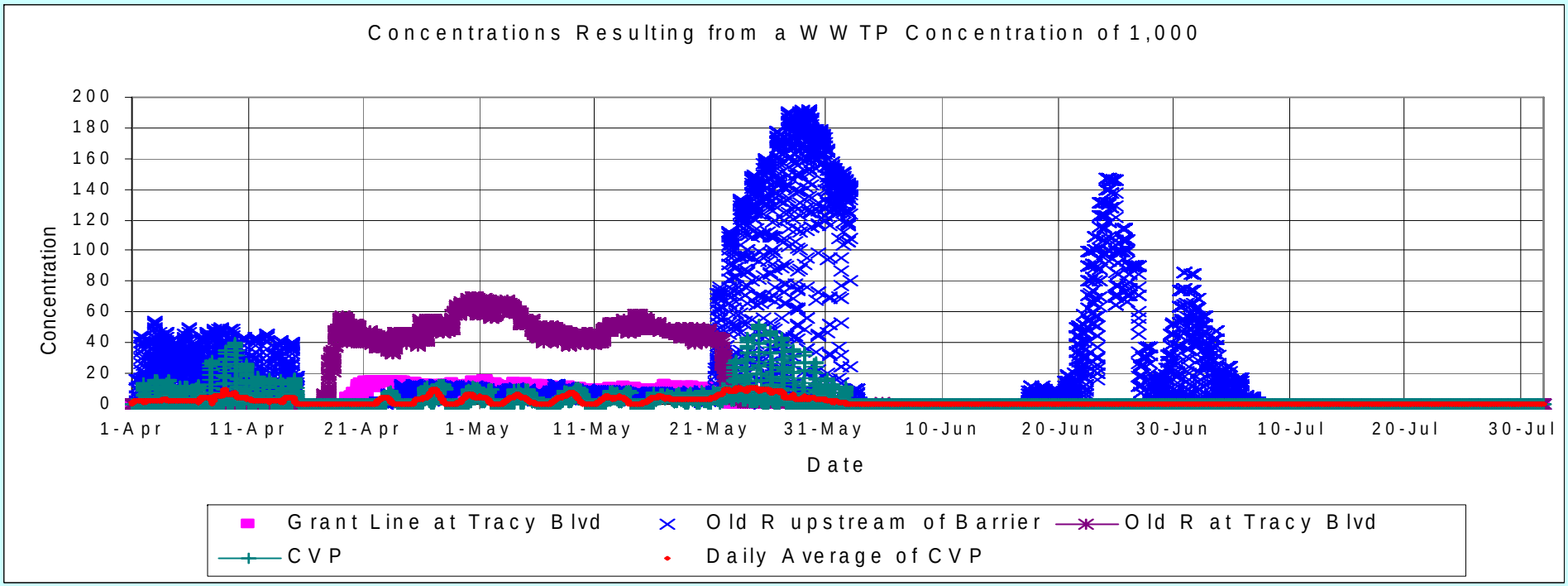


Dispersion Coefficient = 1.5

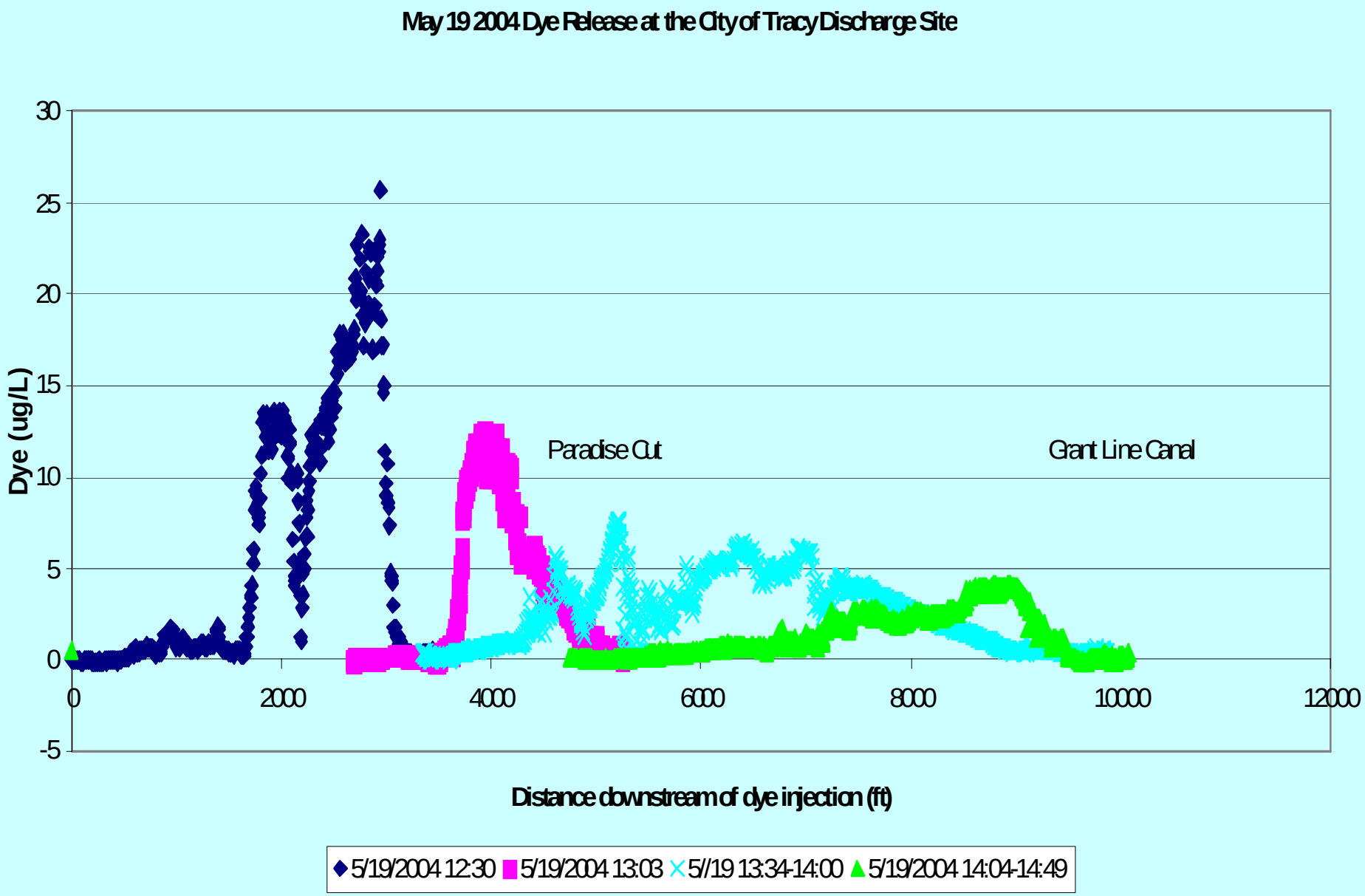

Dye Concentrations in Old River during the June 2004 Dye Release Study
Dye (µg/L)
7
6
5
4
3
2
1
0
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
Distance downstream of Mountain House Creek (ft)
29 June 15:00 (LL)
30 June 10:30 (Ebb)
30 June 18:00 (LL)
1 July 9:15 (HH)
1 July 15:45 (LL)
2 July 8:30 (HH)
Barrier
HH = Higher-High Tide
LL = Lower-Low Tide


Cumulative Tidal Volume in Old River at Mountain House Creek
during the June 2004 Dye Release Study
Tidal Volume (acre-feet)
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1,000
-1,100
-1,200
-1,300
HH
LL
LH
HL
29-Jun
30-Jun
1-Jul
2-Jul
2004
HH = higher-high tide
LL = lower-low tide
HL = higher-low tide
LH = lower-high tide
Cumulative Tidal Volume
Dye Release
Tide


Concentrations Resulting from a WWTP Concentration of 1,000
Concentration
1,000
900
800
700
600
500
400
300
200
100
0
1-Apr
11-Apr
21-Apr
1-May
11-May
21-May
31-May
10-Jun
20-Jun
30-Jun
10-Jul
20-Jul
30-Jul
Date
Downstream of Release
Upstream of Release
Daily Average downstream of Release
Daily Average upstream of Release

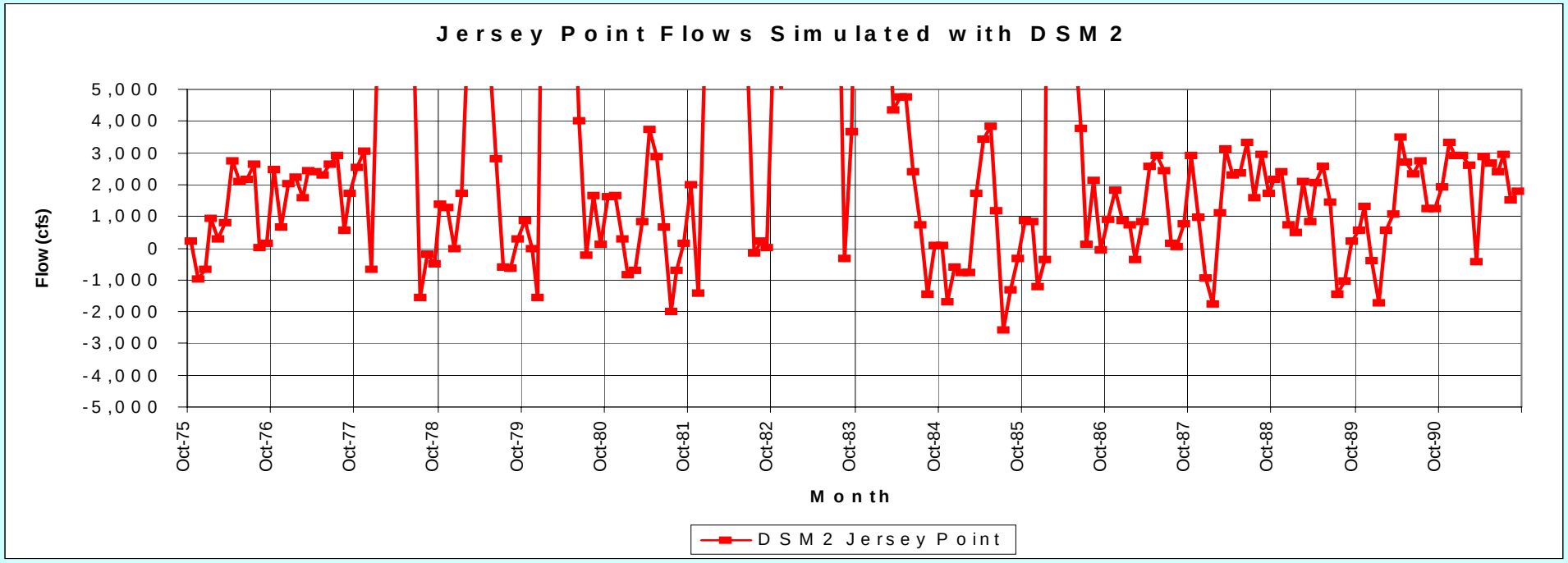

Concentrations Resulting from a WWTP Concentration of 1,000
Concentration
200
180
160
140
120
100
80
60
40
20
0
1-Apr
11-Apr
21-Apr
1-May
11-May
21-May
31-May
10-Jun
20-Jun
30-Jun
10-Jul
20-Jul
30-Jul
Date
Grant Line at Tracy Blvd
Old R upstream of Barrier
Old R at Tracy Blvd
CVP
Daily Average of CVP

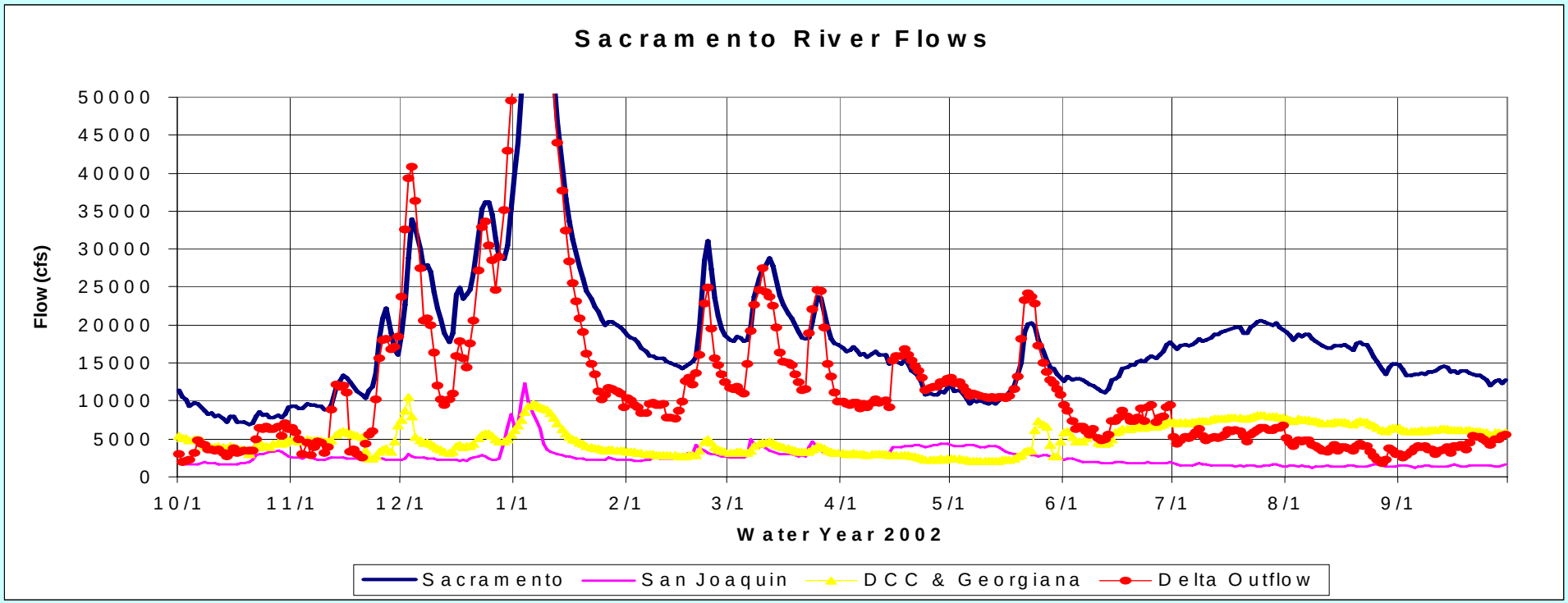
Measured Dye Dilution Downstream of Tracy-May 19, 2004

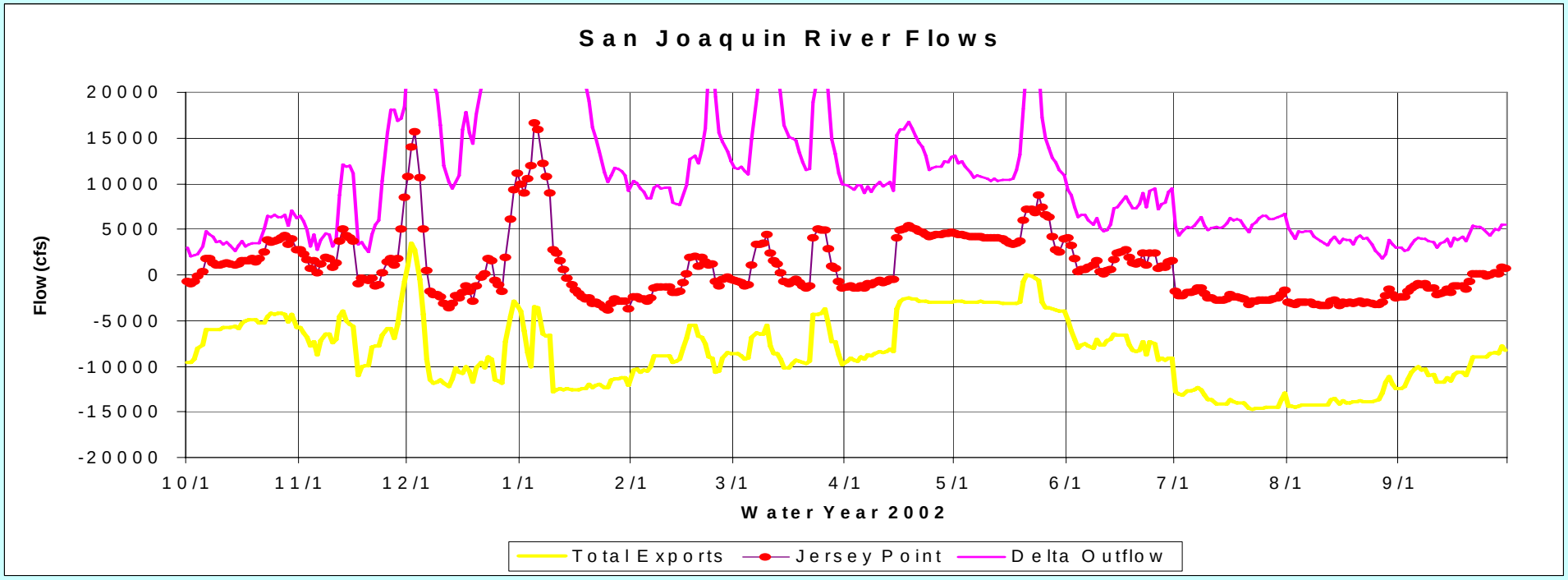


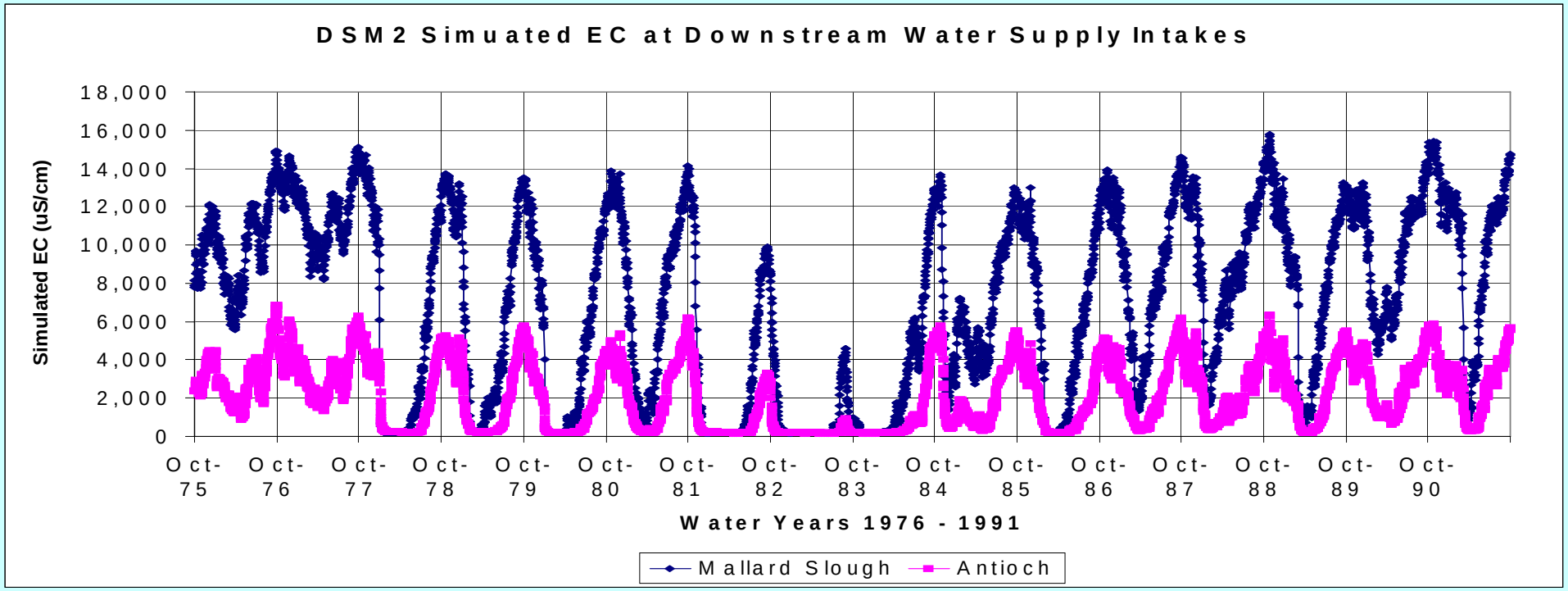
Future Iron House Sanitary District Treated Wastewater Discharge to SJR at Jersey Point

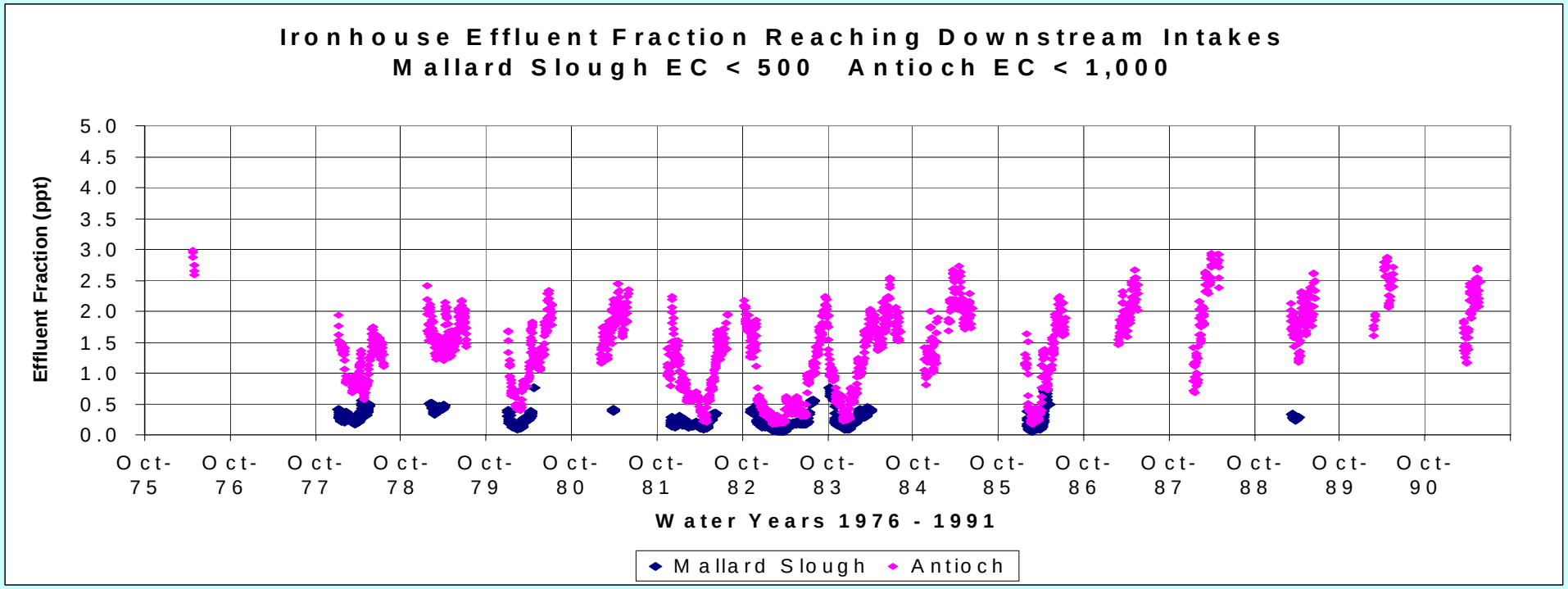
- Maximum 8.5 mgd (13.2 cfs) simulated as 15 cfs with EC of 1,000
- Will the dilution depend on the net flow at Jersey Point or other Delta flows?

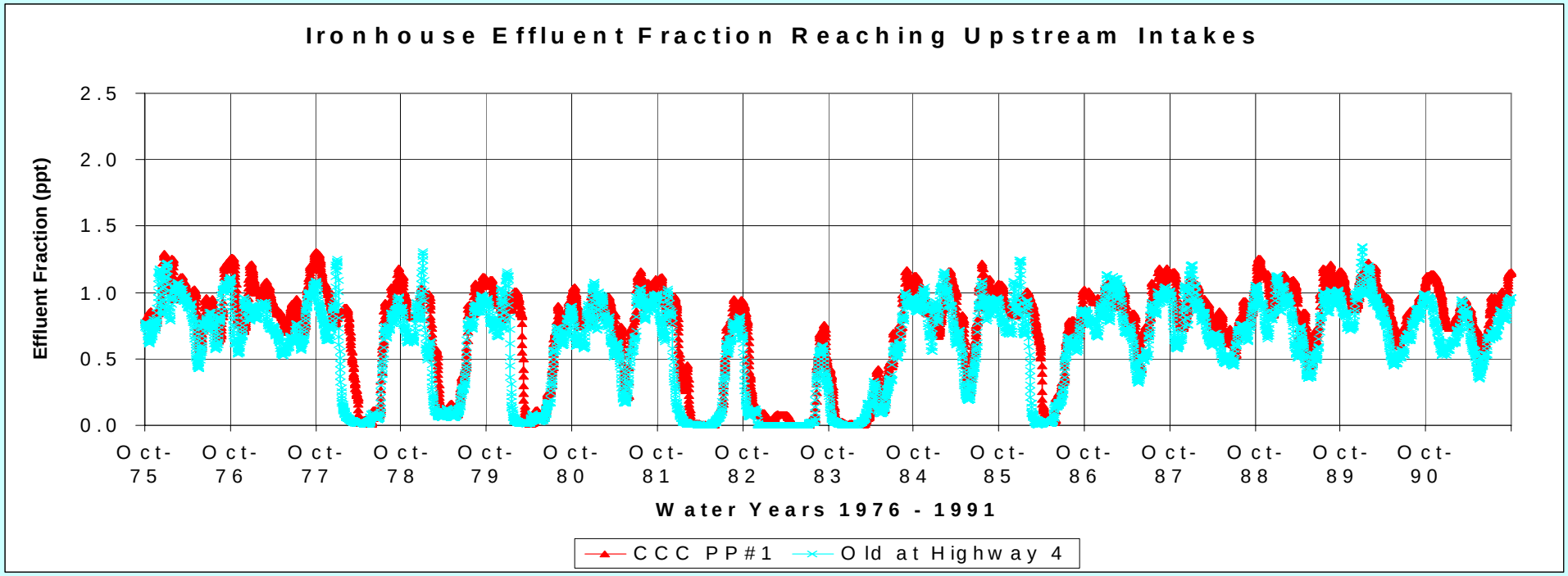


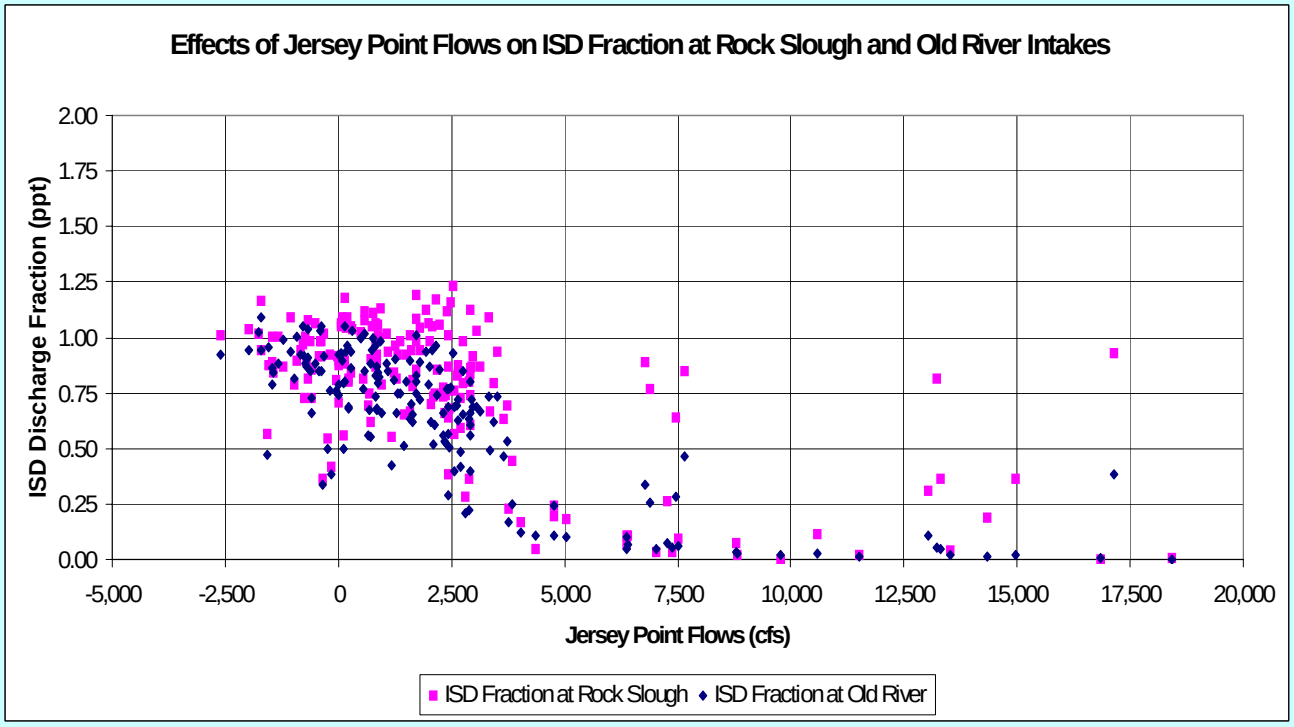

Sacramento River Flows
Flow (cfs)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
10/1
11/1
12/1
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
Water Year 2002
Sacramento
San Joaquin
DCC & Georgiana
Delta Outflow


San Joaquin River Flows
Flow (cfs)
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
10/1
11/1
12/1
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
Water Year 2002
Total Exports
Jersey Point
Delta Outflow

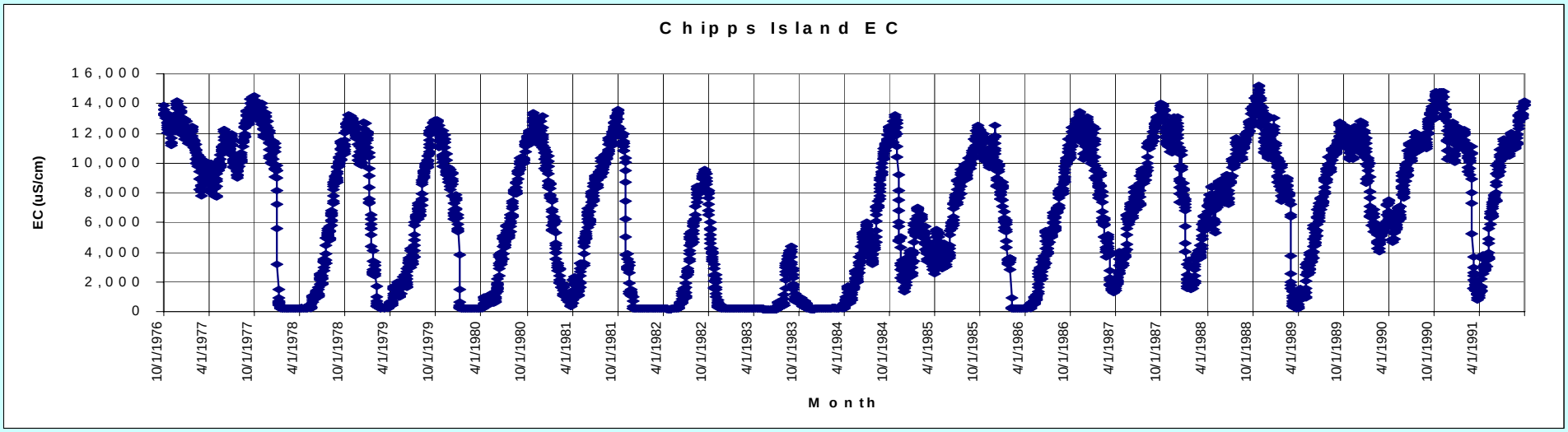

DSM2 Simuated EC at Downstream Water Supply Intakes
Simulated EC (uS/cm)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Oct-75
Oct-76
Oct-77
Oct-78
Oct-79
Oct-80
Oct-81
Oct-82
Oct-83
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Water Years 1976 - 1991
Mallard Slough
Antioch

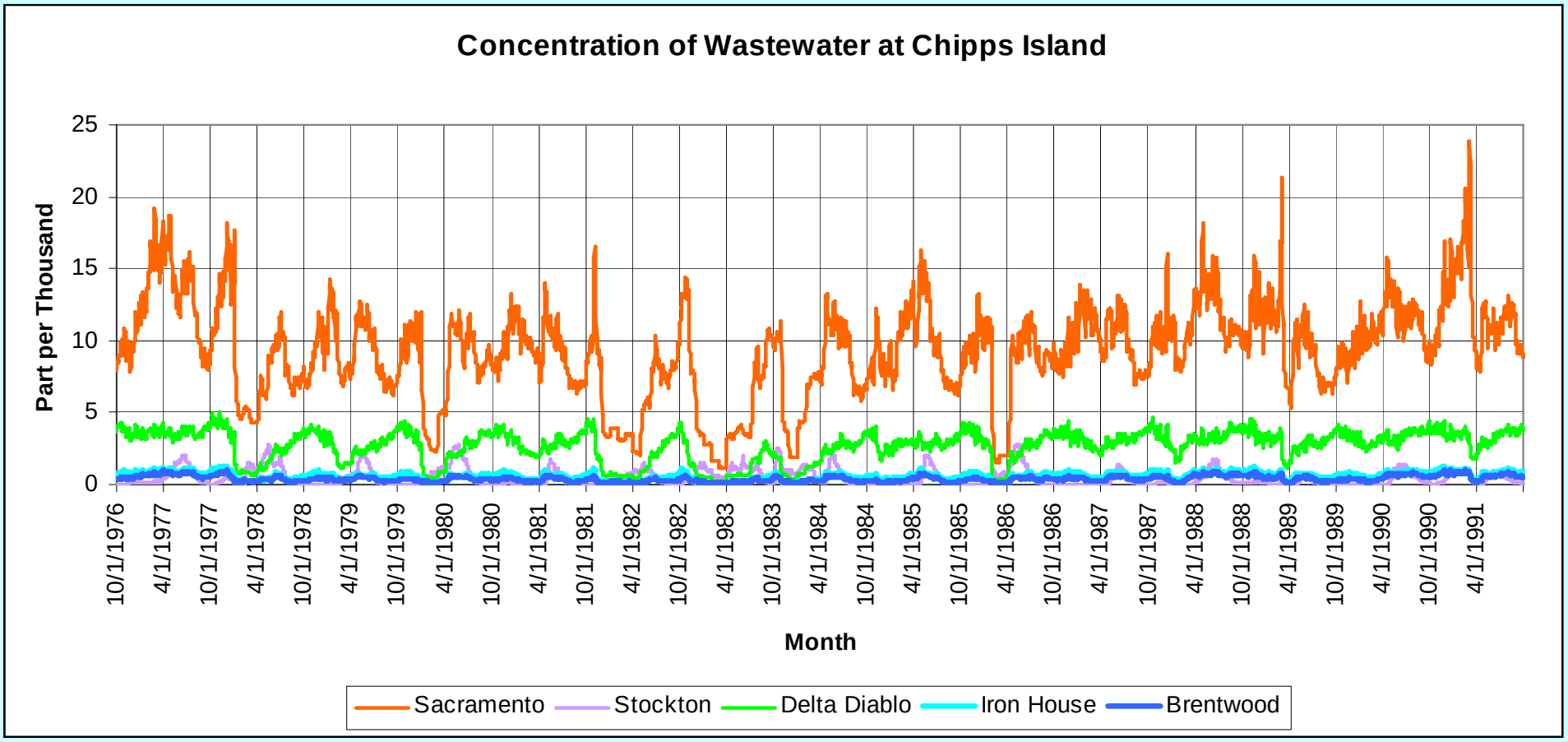

Ironhouse Effluent Fraction Reaching Downstream Intakes
Mallard Slough EC < 500 Antioch EC < 1,000
Effluent Fraction (ppt)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Oct-75
Oct-76
Oct-77
Oct-78
Oct-79
Oct-80
Oct-81
Oct-82
Oct-83
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Water Years 1976 - 1991
Mallard Slough
Antioch

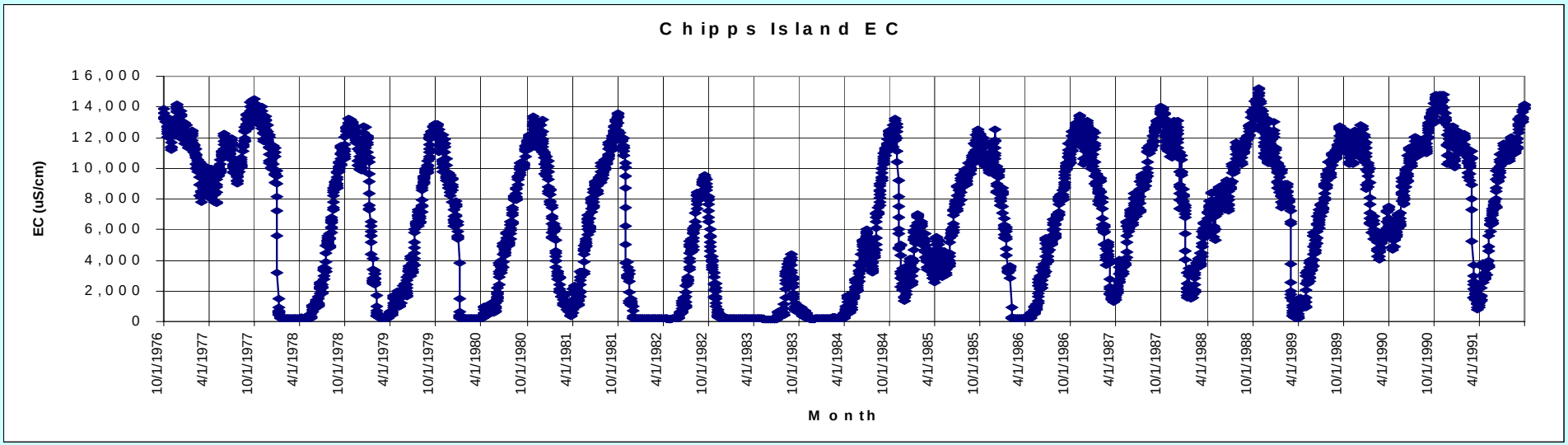


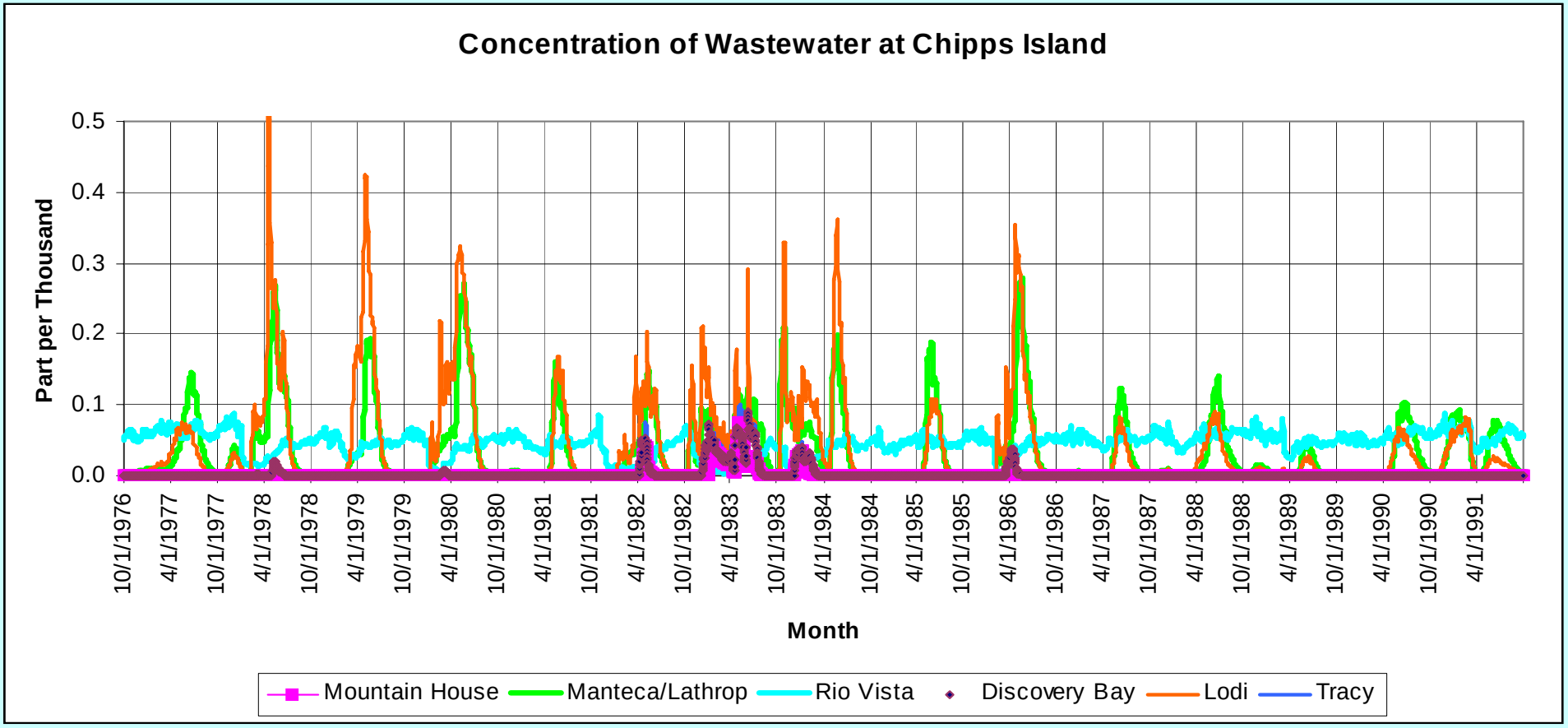


Upstream transport and dilution (of 1000) is dominated by tidal flows unless SJR at Jersey Point net flow is >2,500 cfs


Chipps Island EC
EC (uS/cm)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
10/1/1980
4/1/1981
10/1/1981
4/1/1982
10/1/1982
4/1/1983
10/1/1983
4/1/1984
10/1/1984
4/1/1985
10/1/1985
4/1/1986
10/1/1986
4/1/1987
10/1/1987
4/1/1988
10/1/1988
4/1/1989
10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month


Concentration of Wastewater at Chipps Island
Part per Thousand
25
20
15
10
5
0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
10/1/1980
4/1/1981
10/1/1981
4/1/1982
10/1/1982
4/1/1983
10/1/1983
4/1/1984
10/1/1984
4/1/1985
10/1/1985
4/1/1986
10/1/1986
4/1/1987
10/1/1987
4/1/1988
10/1/1988
4/1/1989
10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month
Sacramento
Stockton
Delta Diablo
Iron House
Brentwood


Chipps Island EC
EC (uS/cm)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
10/1/1980
4/1/1981
10/1/1981
4/1/1982
10/1/1982
4/1/1983
10/1/1983
4/1/1984
10/1/1984
4/1/1985
10/1/1985
4/1/1986
10/1/1986
4/1/1987
10/1/1987
4/1/1988
10/1/1988
4/1/1989
10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month


Concentration of Wastewater at Chipps Island
Part per Thousand
0.5
0.4
0.3
0.2
0.1
0.0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
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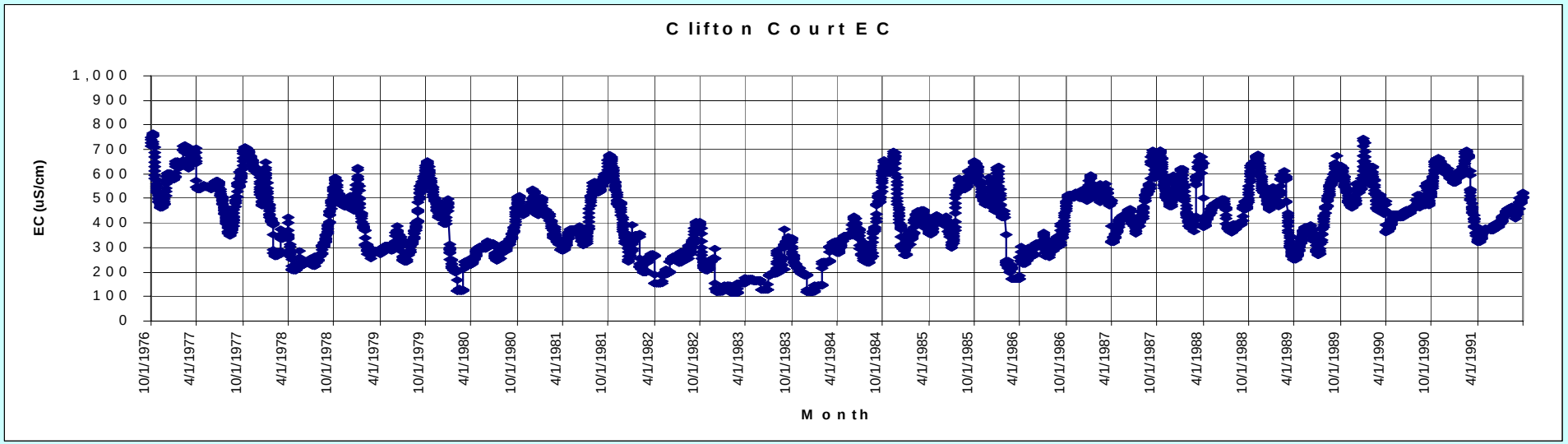
4/1/1988
10/1/1988
4/1/1989
10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month
Mountain House
Manteca/Lathrop
Rio Vista
Discovery Bay
Lodi
Tracy


Clifton Court EC
EC (uS/cm)
1,000
900
800
700
600
500
400
300
200
100
0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
10/1/1980
4/1/1981
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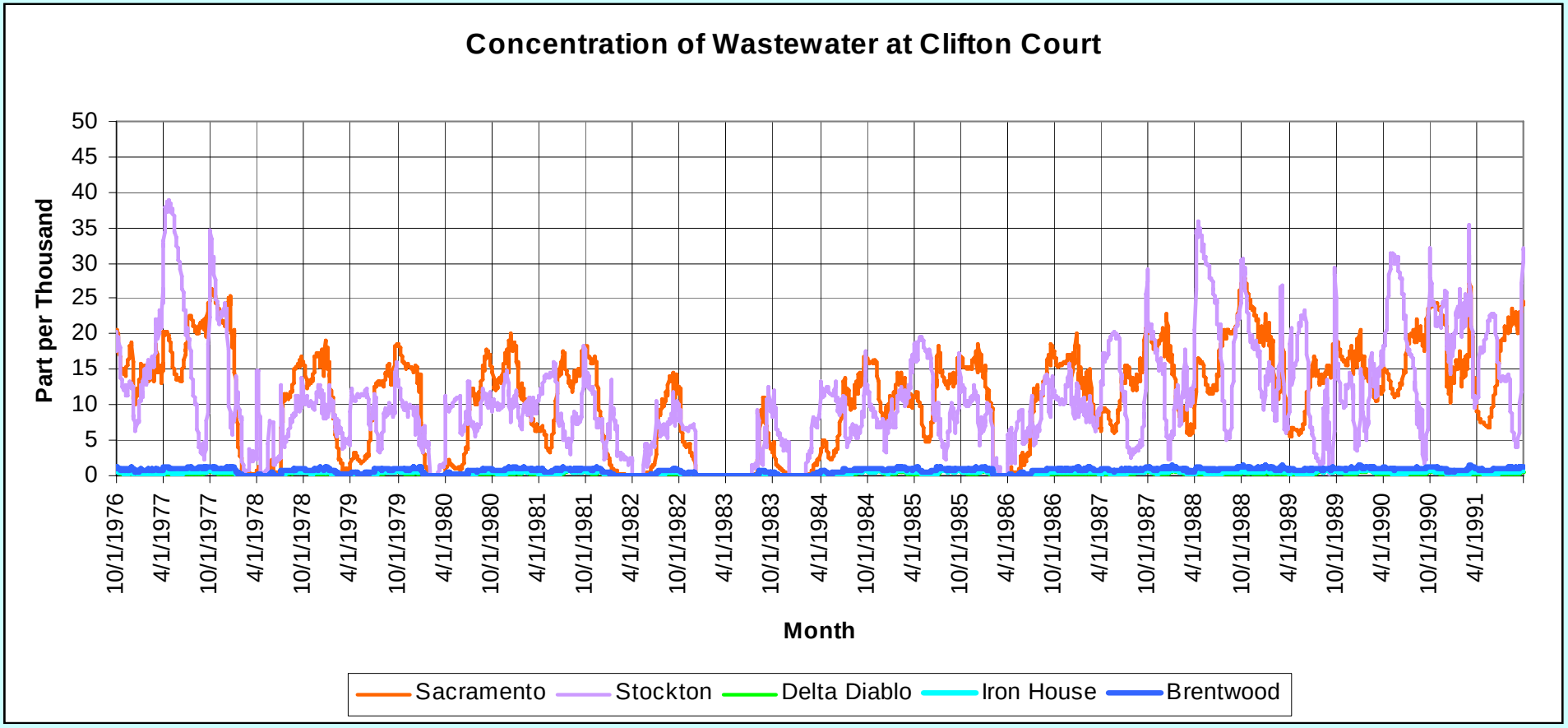
4/1/1987
10/1/1987
4/1/1988
10/1/1988
4/1/1989
10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month


Concentration of Wastewater at Clifton Court
Part per Thousand
50
45
40
35
30
25
20
15
10
5
0
10/1/1976
4/1/1977
10/1/1977
4/1/1978
10/1/1978
4/1/1979
10/1/1979
4/1/1980
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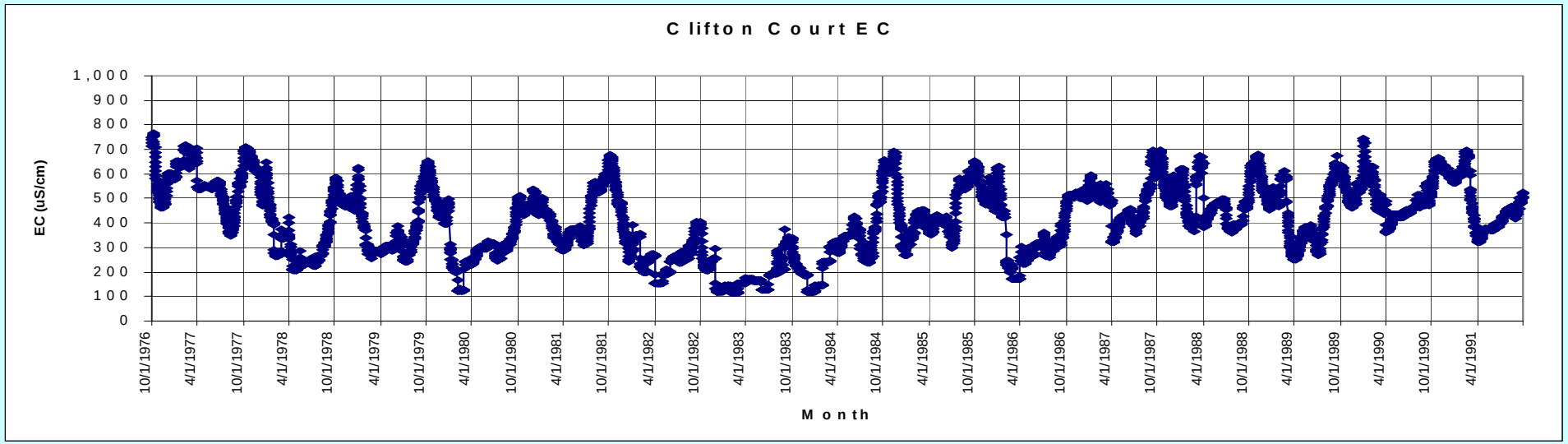
10/1/1990
4/1/1991
Month
Sacramento
Stockton
Delta Diablo
Iron House
Brentwood


Clifton Court EC
EC (uS/cm)
1,000
900
800
700
600
500
400
300
200
100
0
10/1/1976
4/1/1977
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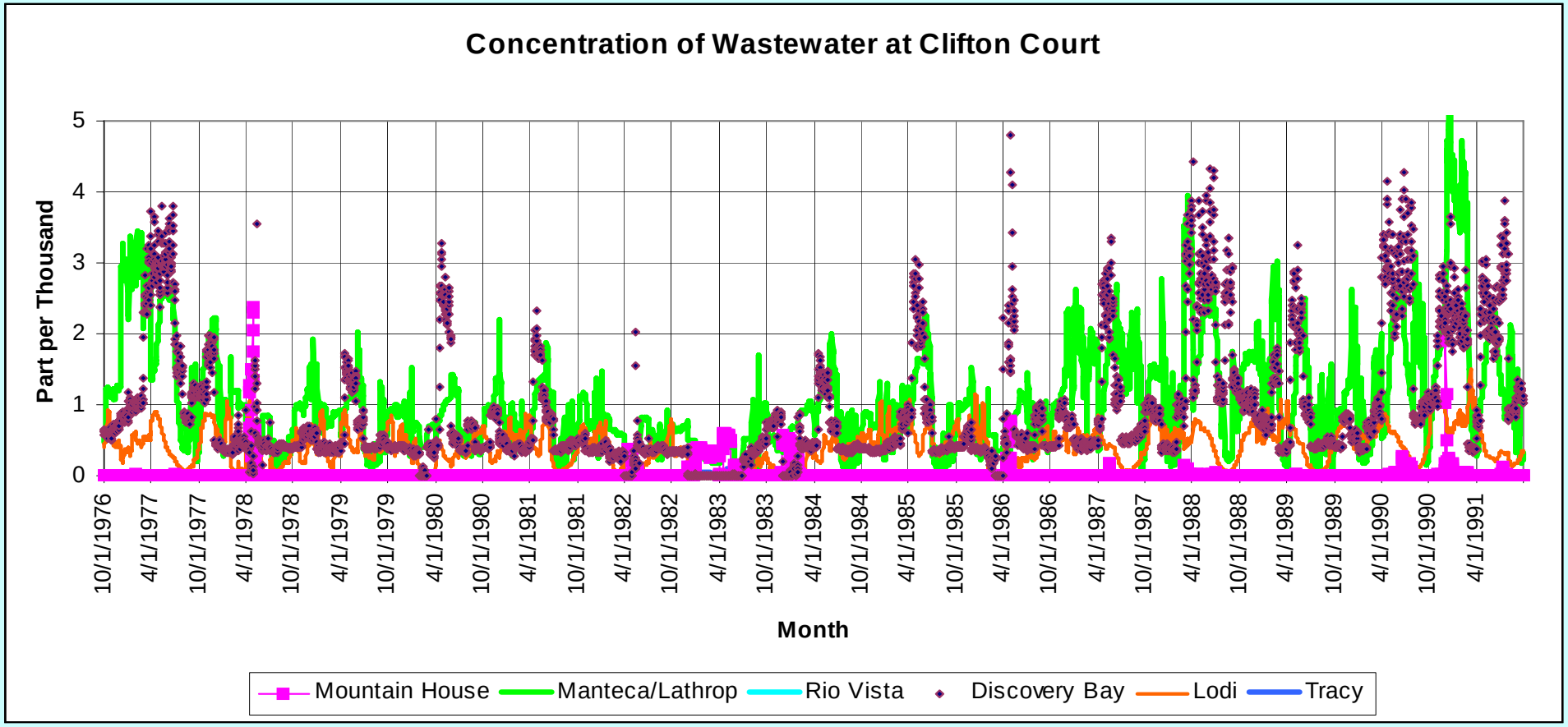
Month


Concentration of Wastewater at Clifton Court
Part per Thousand
5
4
3
2
1
0
10/1/1976
4/1/1977
10/1/1977
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10/1/1978
4/1/1979
10/1/1979
4/1/1980
10/1/1980
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10/1/1989
4/1/1990
10/1/1990
4/1/1991
Month
Mountain House
Manteca/Lathrop
Rio Vista
Discovery Bay
Lodi
Tracy

Wastewater Effluent Concentration of 1000 ppt

		Average Concentration of Wastewater (ppt)			
Discharge Location	Permitted Flow (cfs)	Chipps Island	Rock Slough PP1	Old River Intake	Clifton Court
Sacramento	300	9.3297	15.1037	13.5881	11.1262
Stockton	100	0.4515	2.4814	8.4077	10.8142
Delta Diablo	50	2.7044	0.4005	0.3143	0.2245
Iron House	15	0.6092	0.6690	0.5368	0.3798
Brentwood	15	0.3981	1.4639	1.1263	0.7338
Lodi	10	0.0403	0.1486	0.3369	0.4033
Tracy	10	0.0024	0.0209	0.0635	0.4033
Lathrop/Manteca	10	0.0345	0.1835	0.5267	1.0605
Mountain House	10	0.0014	0.0095	0.0217	0.0222
Discovery Bay	5	0.0026	0.0417	0.9625	0.8766
Rio Vista	1	0.0452	0.0321	0.0252	0.0180
Total	526	13.6193	20.5549	25.9097	26.0624

Summary of Dilution of Delta Wastewater Discharges

- 12 permitted wastewater discharges in the Delta with a total effluent flow of about 525 cfs
- Sacramento (300 cfs) has a relatively constant dilution of about 100, with an average of 15 ppt at PP1 and 11 ppt at Clifton Court
- Stockton (100 cfs) has a more variable dilution, with and average of 10 ppt at Clifton Court and 2.5 ppt at PP1
- Downstream discharges tidally mix into the Delta, with about 1.5 ppt of Brentwood and 0.5 ppt Delta Diablo at PP1, and 0.75 ppt and 0.25 ppt at Clifton Court