0030

WATER QUALITY MEMORANDUM

Utah Coal Regulatory Program

OK

November 15, 2007

TO: Internal File

THRU: Pamela Grubaugh-Littig, Permit Supervisor pgl

FROM: Dana Dean, P.E., Senior Reclamation Hydrologist

RE: 2007 Second Quarter Water Monitoring, Canyon Fuel Company, LLC, SUFCO Mine, C/041/0002-WQ07-2 Task ID #2607

The SUFCO Mine is an operating longwall mine. Current operations are in the Quitchupah and Muddy Tracts. Water monitoring requirements can be found in Section 7.3.1.2 of the MRP, especially Tables 7-2, 7-3, 7-4, 7-5, and 7-5A. Page 7-48 contains the important statement that (non Box-Canyon, non-UPDES) "monitoring sites are sampled three times per year," meaning the second, third, and fourth quarters.

1. Was data submitted for all of the MRP required sites? YES ☒ NO ☐

Springs

The MRP requires the Permittee to monitor 25 springs during the second quarter. Some require full laboratory analysis according to Table 7-4, while others simply require field measurements.

The Permittee submitted all required samples for the spring sites.

Streams

The MRP requires the Permittee to monitor16 streams during the second quarter.

The Permittee submitted all required samples for the stream sites.

Wells

The MRP requires the Permittee to monitor 9 wells during the second quarter.

The Permittee submitted all required samples for the wells.

UPDES

The UPDES Permit/MRP require bi-weekly monitoring of 3 outfalls: 001, mine water discharge to Pine Canyon; 002, sedimentation pond discharge to Pine Canyon; and 003, the mine water discharge to the North Fork of Quitchupah Creek.

The Permittee submitted all required samples for the UPDES sites. Outfall 001 reported no flow.

2. Were all required parameters reported for each site? YES ☐ NO ☒

Well WRDSB-5 did not have enough water in it to perform a full laboratory analysis. The Permittee submitted field parameters for the well.

3. Were any irregularities found in the data? YES ☒ NO ☐

Mining Related Flow Reductions

Pines 105 (North Water Spring) stopped flowing immediately after undermining in late 2005/early 2006. The water table was lowered into the alluvium, stopping flow to the surface, but total flow out of the subwatershed has remained constant. Canyon Fuel Company has put into action a plan for temporary water replacement, and has been studying the condition of the flow system at Pines 105 over the past year. They are trying to find the best way to restore flow to Pines 105, and plan to implement a collection system that will take water from the alluvium back to the surface at Pines 105 in the spring of 2008. Attempts to place a grout curtain in the alluvium, damming up the water, and causing it to express at the surface were not successful, but there have been no "high flow" periods since they were installed.

SUFCO began monitoring Pines 310 (lower) and 311 as part of their investigation of and effort to mitigate the water table drop at Pines 105. Pines 310 and 311 were undermined in late 2006, and no flow has been recorded at either since September 2006. Just as it did at Pines 105, the water table seems to have dropped into the alluvium in this area, keeping it from expressing at the surface. The water flowing out of the subwatershed has remained constant, so no water is actually being lost. The mitigation efforts related to Pines 105 include the Pines 310 and 311 areas.

At Pines 214 flow remains low, and conductivity high since undermining in 2003. However, the flow seems to track well with both the Palmer Hydrologic Drought Index (PHDI), and Surface Water Supply Index (SWSI). A good wet period (hopefully next spring) will be a better measure of whether the flow has been impacted by mining.

At Pines 303 flow remains low since undermining in 2001. However, the flow here also seems to track well with both the Palmer Hydrologic Drought Index (PHDI), and Surface Water Supply Index (SWSI). A good wet period (hopefully next spring) will be a

better measure of whether the flow has been impacted by mining.

Parameters Outside of Two Standard Deviations from the Mean

Several parameters fell outside of two standard deviations from the mean encountered at the respective sites. They were:

Site	Parameter	Value	Standard Deviations from Mean	Mean
Pines 106	Total Cations	6.2 meq/L	3.11	4.60 meq/L
Pines 106	Dissolved Calcium	78.1 mg/L	4.19	50.63 mg/L
Pines 106	Dissolved Magnesium	73.1 mg/L	4.05	18.91 mg/L
Pines 106	Total Hardness	290 mg/L	3.88	206.42 mg/L
Pines 106	Total Dissolved Solids	372 mg/L	3.43	259.10 mg/L
Pines 106	Specific Conductivity	531 µmhos/cm	2.20	399.9 µmhos/cm
Pines 106	Sulfate	110 mg/L	4.39	42.38 mg/L
Pines 403	Water Temperature	23.9 °C	2.55	7.73 °C
SUFCO 046	Bicarbonate as $CaCO_3$	301 mg/L	4.55	347.71 mg/L
SUFCO 046	Dissolved Sodium	17.7 mg/L	3.74	28.49 mg/L
SUFCO 047A	Bicarbonate as $CaCO_3$	308 mg/L	3.28	345.71 mg/L
Pines 214	Water Temperature	18.7 °C	2.90	7.65 °C
SUFCO 001	Water Temperature	22.9 °C	3.00	9.37 °C
SUFCO 047	Bicarbonate as $CaCO_3$	308 mg/L	2.28	326.38 mg/L
01-8-1	Depth	1599.11 feet	2.87	1509.50 feet
WRDS B-6	Bicarbonate as $CaCO_3$	331 mg/L	4.46	380 mg/L
WRDS B-8	Bicarbonate as $CaCO_3$	252 mg/L	5.78	286.57 mg/L
WRDS B-8	Bicarbonate as HCO_3^-	307 mg/L	2.53	351.15 mg/L
WRDS B-8	Alkalinity	252 mg/L	4.68	292.6 mg/L
UT-0022918-002 – Jun 20	Flow	156 gpm	7.17	9.48 gpm
UT-0022918-003 – Apr 18	Flow	1177 gpm	2.07	3082.66 gpm
UT-0022918-003 – May 1	pH	7.79	2.39	7.02

Despite the fact that the bicarbonate as $CaCO_3$ was unusually low at SUFCO 046, SUFCO 047, SUFCO 047A, WRDS B-6, and WRDS B-8; the only one that had an alkalinity and bicarbonate as HCO_3^- concentration outside of two standard deviations was WRDS B-8. The correlation between total alkalinity and bicarbonate is ~1, and carbonate is mostly absent, therefore the alkalinity is bicarbonate based and the trends in the two values are expectedly similar.

Total Alkalinity

Site	*Samples*	*Range (mg/L)*	*Value (mg/L)*
SUFCO 046	57	238-488	301

SUFCO 047	47	272-324	308
SUFCO 047A	48	236-373	308
WRDS B-6	38	273-440	331
WRDS B-8	36	252-312	252

Bicarbonate as $HCO3^-$

Site	*Samples*	*Range (mg/L)*	*Value (mg/L)*
SUFCO 046	63	290-595	367
SUFCO 047	54	319-456	376
SUFCO 047A	55	283-455	376
WRDS B-6	49	383-604	404
WRDS B-8	47	293-387	307

Bicarbonate as $CaCO_3$

Site	*Samples*	*Range (mg/L)*	*Std. Dev. (mg/L)*	*Value (mg/L)*
SUFCO 046	8	301-365	18.19	301
SUFCO 047	8	308-326	8.05	308
SUFCO 047A	8	308-368	16.47	308
WRDS B-6	8	331-402	19.19	331
WRDS B-8	8	252-300	12.73	252

There are very few samples of bicarbonate as $CaCO_3$, in a very tight range with small standard deviations.

Well 01-8-1 has been dropping since SUFCO first began to monitor it in 2001. The trend is strong, with an R^2 value of 0.7061. This well is located in an area that has not been mined yet, but the well is screened in the Upper Hiawatha coal seam, the actively mined seam. As the mine progresses, water is pumped out of the working areas, to make it possible to mine. This is beneficial to the mining process and is a common and necessary practice. The mine currently discharges approximately 3.2 million gallons per day. This is much less than last year's average of 4.3 million gallons per day. Most other wells monitored at the SUFCO mine dropped less than 10' over a period of ten or more years. This is an expected result of underground coal mining, and water levels will equilibrate when mining is ceased.

Dissolved calcium and dissolved magnesium have a fairly strong upward trends at Pines 106 (R^2= 0.5238, and 0.4104). Dissolved calcium has no real correlation to flow (R^2 = 0.05), and dissolved magnesium has a fairly strong negative correlation to flow (R^2 = 0.4376). These are the highest readings ever at Pines 106 for these two constituents. There are no criteria for these metals, but they do contribute to water hardness. The total hardness at Pines 106 also has a somewhat strong upward trend (R^2 = 0.4645), with a weak negative correlation to flow (R^2 = 0.3446). This is also the highest total hardness ever recorded at Pines 106. The hardness at this site has always fallen into the hard (150-300 mg/l)

classification, and continues to be in that range.

There is no trend in dissolved sodium at SUFCO 046, but this is the lowest value ever recorded. Most dissolved sodium readings at this site have been between 25 and 30 mg/L. The only two "outliers" before this reading were higher readings of 33 (1999) and 41 mg/L (2005). There is no water quality standard for sodium, but it does affect water hardness (making it "softer"), and salinity. The hardness at SUFCO 046 has ranged from 294-715 mg/L, always falling in the "hard" (150-300 mg/L) and "very hard" (>300 mg/L) classifications. The salinity at SUFCO 046, which is affected by several parameters (Cl, Na, Mg, SO_4, Ca, K, HCO_3, etc.) has a fairly strong upward trend ($R^2 = 0.5811$), and no real correlation to flow. The salinity level for SUFCO 046 has fluctuated between "fresh" (<500 mg/L NaCl equivalent) and "brackish" (500-30,000 mg/L NaCl equivalent), and this is actually the first quarter since September of 2004 where the salinity dropped below 500 mg/L.

The higher than usual flow recorded at Outfall 002 was attributed to a storm event. The lower than usual flow from Outfall 003 was due to a reduction in pumping.

The pH at Outfall 003 was a bit higher than usual, but well within UPDES limits.

There is a weak upward trend in the specific conductivity at Pines 106 ($R^2 = 0.2581$), with no real correlation to flow. There is no standard for specific conductivity, but it is closely related to total dissolved solids (TDS).

There is also a weak upward trend in total cations at Pines 106 ($R^2 = 0.3566$), with no real correlation to flow. The cation/anion balance is within the 5% recommended limit. The number of cations also relates to the total dissolved solids in the water sample.

There is a weak upward trend in TDS at Pines 106 ($R^2 = 0.3673$), with a very weak negative correlation to flow ($R^2 = 0.12$). This is one of the lowest flows ever recorded at Pines 106. The TDS at Pines 106 has always been below the secondary drinking water standard of 500 mg/L and periods of high TDS have generally been followed by periods of low TDS.

There is a strong upward trend in sulfate at Pines 106 ($R^2 = .6015$), and no real correlation to flow. Sulfate is not toxic to plants or animals (even at very high concentration), but has a cathartic effect on humans in concentrations over 500 mg/L. For this reason, the EPA has set the secondary standard as 250 mg/L. The sulfate at Pines 106 has always been less than 120 mg/L.

The higher than usual water temperatures are a result of high air temperatures.

Reliability Checks

Many routine reliability checks fell outside of standard values:

Site	Reliability Check	Value Should Be…	Value is…
Pines 106	Conductivity/Cations	>90 & < 110	86
Pines 106	K/(Na + K)	< 20%	29%
Pines 106	Na/(Na + Cl)	> 50%	22%
Pines 403	Conductivity/Cations	>90 & < 110	89
Pines 403	K/(Na + K)	< 20%	31%
Pines 403	Mg/(Ca + Mg)	< 40 %	62%
Pines 403	Na/(Na + Cl)	> 50%	21%
SUFCO 006	Conductivity/Cations	>90 & < 110	88
SUFCO 006	Mg/(Ca + Mg)	< 40 %	50%
SUFCO 007	Conductivity/Cations	>90 & < 110	76
SUFCO 007	Mg/(Ca + Mg)	< 40 %	40%
SUFCO 007	Na/(Na + Cl)	> 50%	48%
SUFCO 041	Mg/(Ca + Mg)	< 40 %	67%
SUFCO 041	Ca/ (Ca + SO4)	> 50 %	30%
SUFCO 041	Na/(Na + Cl)	> 50%	42%
SUFCO 042	K/(Na + K)	< 20%	21%
SUFCO 042	Mg/(Ca + Mg)	< 40 %	59%
SUFCO 042	Ca/ (Ca + SO4)	> 50 %	39%
SUFCO 042	Na/(Na + Cl)	> 50%	47%
SUFCO 046	Conductivity/Cations	>90 & < 110	88
SUFCO 042	K/(Na + K)	< 20%	35%
SUFCO 042	Mg/(Ca + Mg)	< 40 %	51%
SUFCO 042	Na/(Na + Cl)	> 50%	19%
SUFCO 047A	Conductivity/Cations	>90 & < 110	86
SUFCO 047A	Mg/(Ca + Mg)	< 40 %	49%
SUFCO 047A	Ca/ (Ca + SO4)	> 50 %	50%
SUFCO 047A	Na/(Na + Cl)	> 50%	22%
Pines 100	Na/(Na + Cl)	> 50%	19%
SUFCO 047	Conductivity/Cations	>90 & < 110	87
SUFCO 047	K/(Na + K)	< 20%	30%
SUFCO 047	Mg/(Ca + Mg)	< 40 %	44%
SUFCO 047	Na/(Na + Cl)	> 50%	27%
WRDS B-6	TDS/Conductivity	>0.55 & <0.75	0.78
WRDS B-6	Conductivity/Cations	>90 & < 110	81
WRDS B-6	Mg/(Ca + Mg)	< 40 %	58%
WRDS B-6	Ca/ (Ca + SO4)	> 50 %	41%
WRDS B-6	Na/(Na + Cl)	> 50%	9%
WRDS B-9	Conductivity/Cations	>90 & < 110	89

WRDS B-9	Na/(Na + Cl)	> 50%	17%

These inconsistencies do not necessarily mean that a sample is wrong, but it does indicate that something is unusual. An analysis and explanation of the inconsistencies by the Permittee would help to increase the Division's confidence in the samples. The Permittee should work with the lab to make sure that samples pass all quality checks so that the reliability of the samples does not come into question. The Permittee can learn more about these reliability checks and some of the geological and other factors that could influence them by reading Chapter 4 of *Water Quality Data: Analysis and Interpretation* by Arthur W. Hounslow.

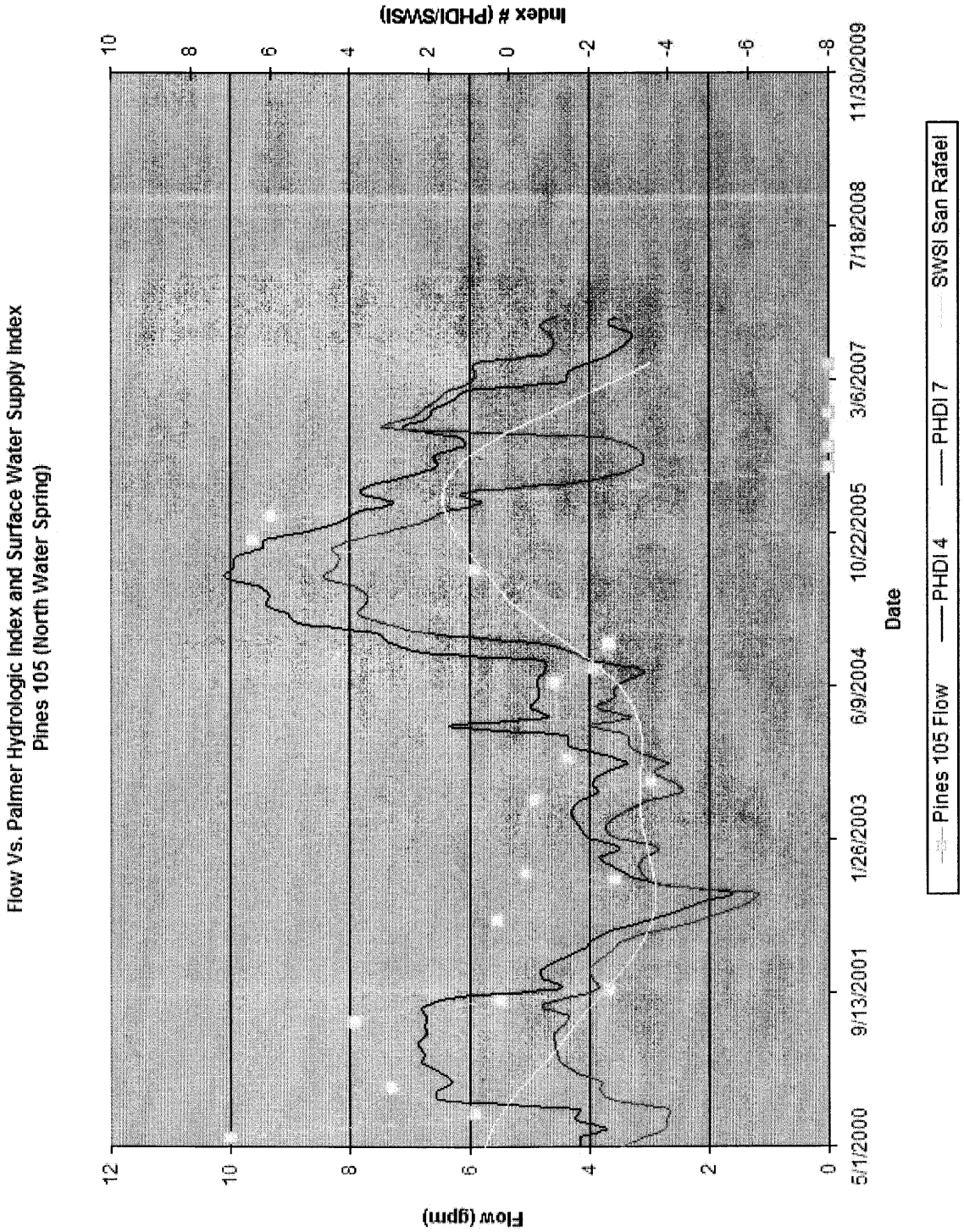
4. On what date does the MRP require a five-year re-sampling of baseline water data.

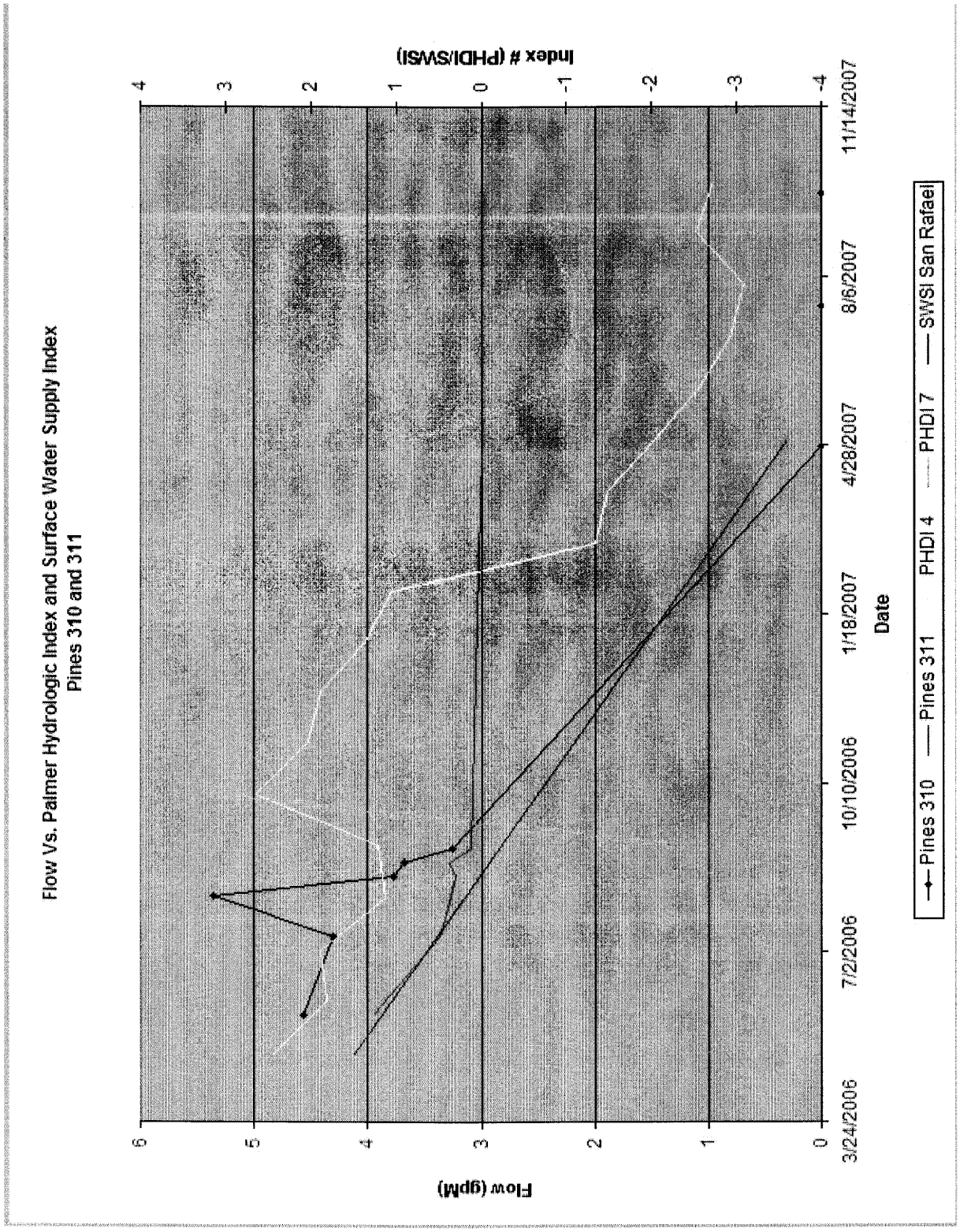
There is no commitment in the MRP to resample for baseline parameters.

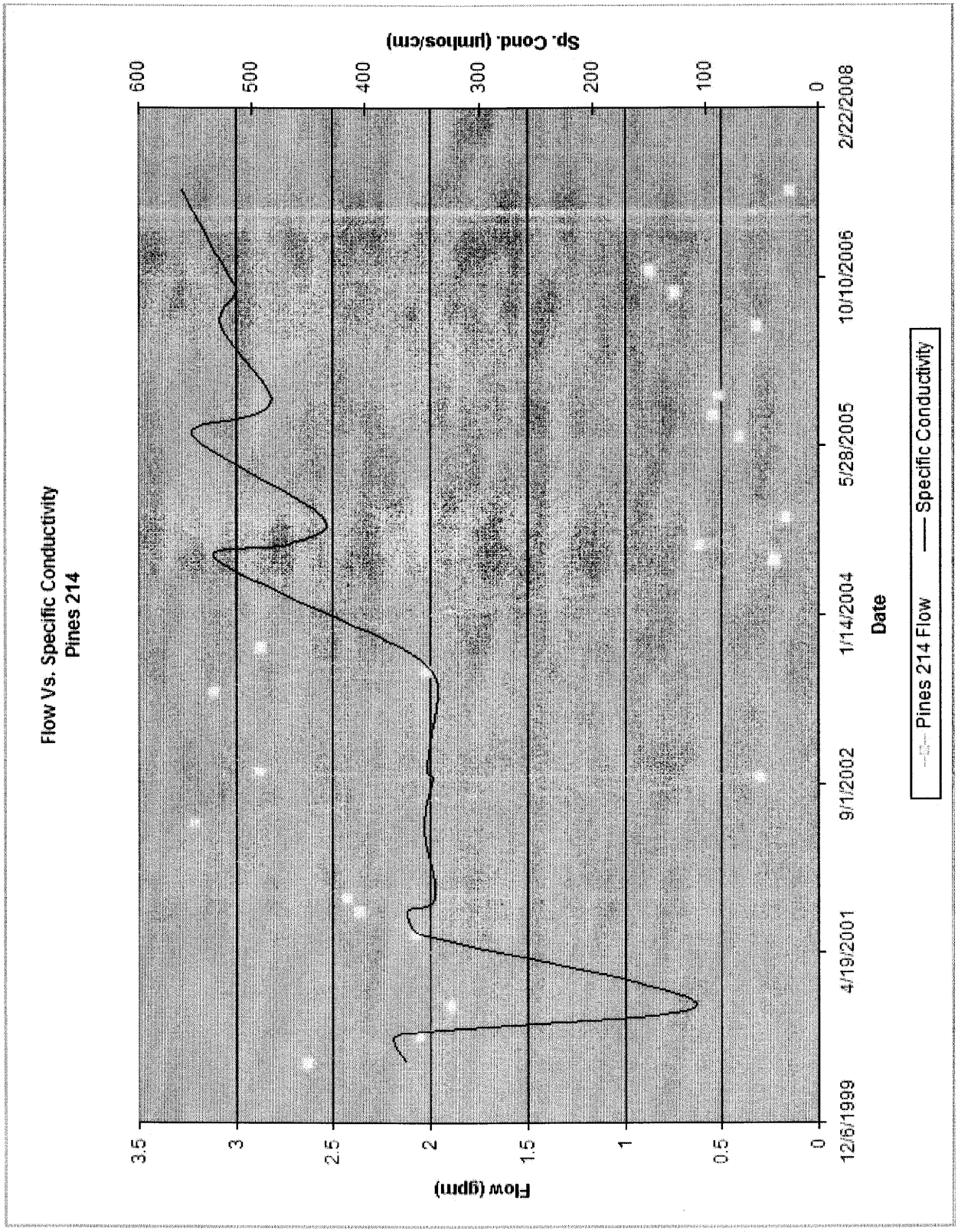
5. Based on your review, what further actions, if any, do you recommend?

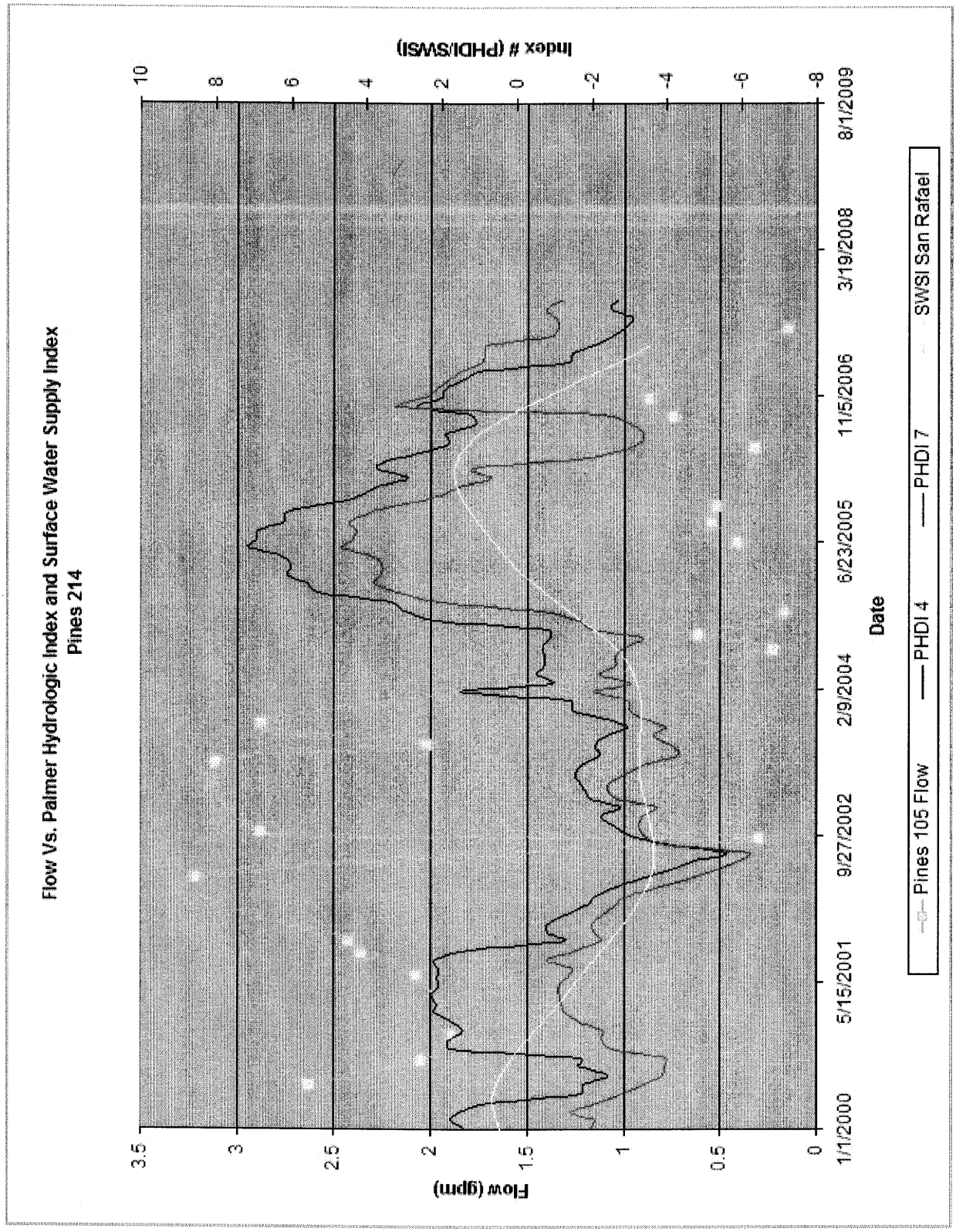
No further actions are necessary at this time. A separate action is underway concerning the Pines Springs.

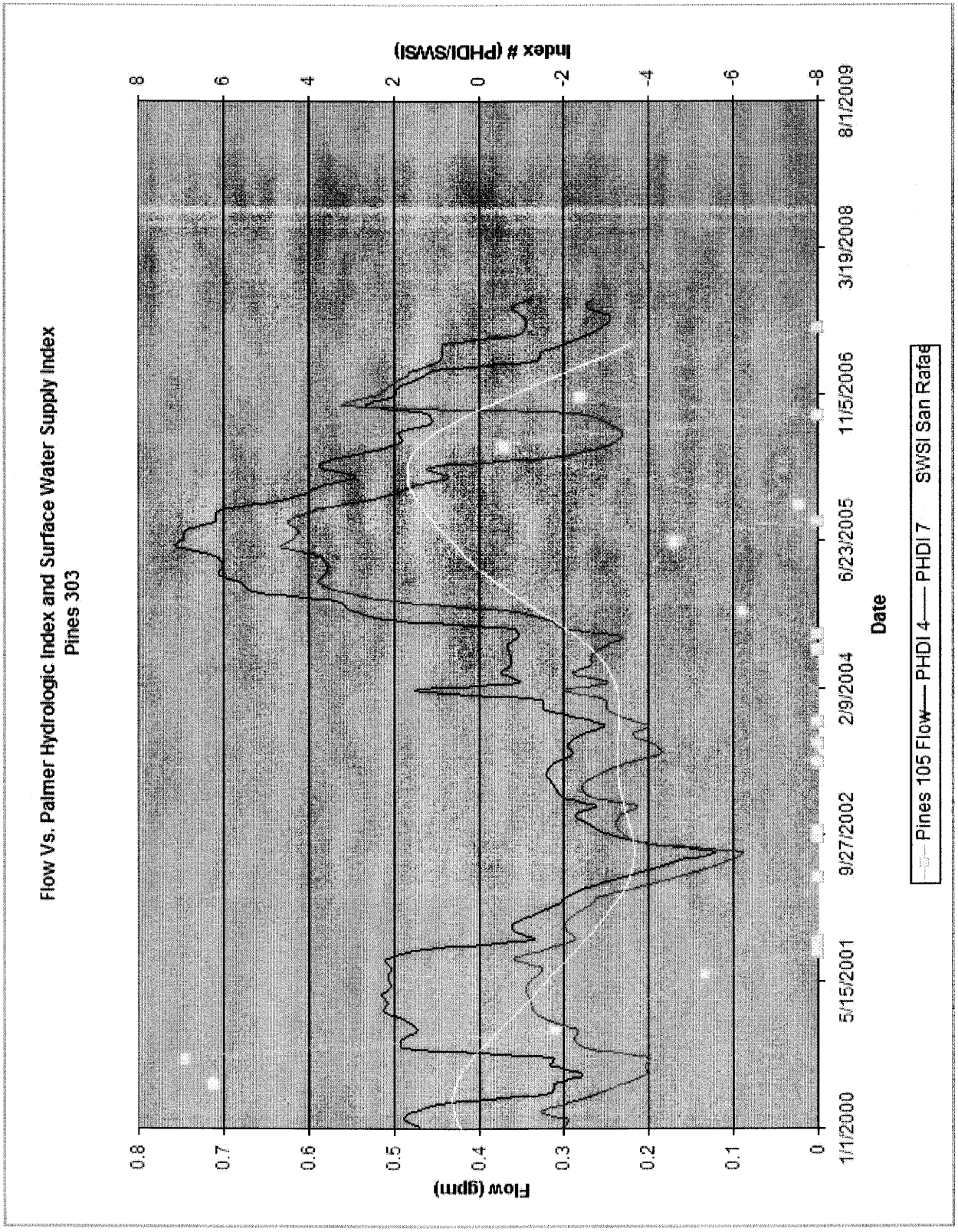
an
O:\041002.CON\WATER QUALITY\DDWQ07-2_2607.DOC

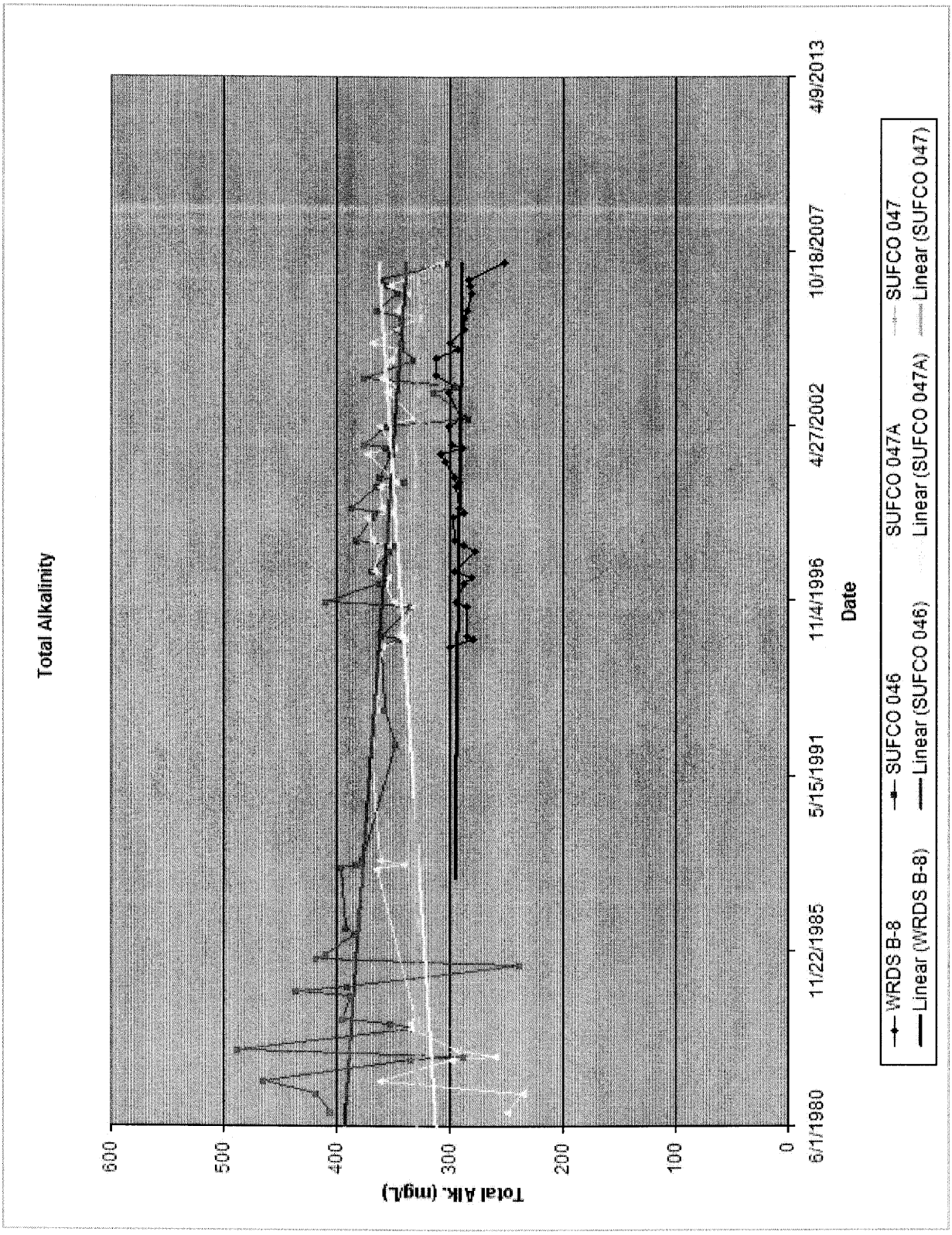

Flow Vs. Palmer Hydrologic Index and Surface Water Supply Index
Pines 105 (North Water Spring)
Flow (gpm)
Index # (PHDI/SWSI)
Date
5/1/2000
9/13/2001
1/26/2003
6/9/2004
10/22/2005
3/6/2007
7/18/2008
11/30/2009
Pines 105 Flow
PHDI 4
PHDI 7
SWSI San Rafael

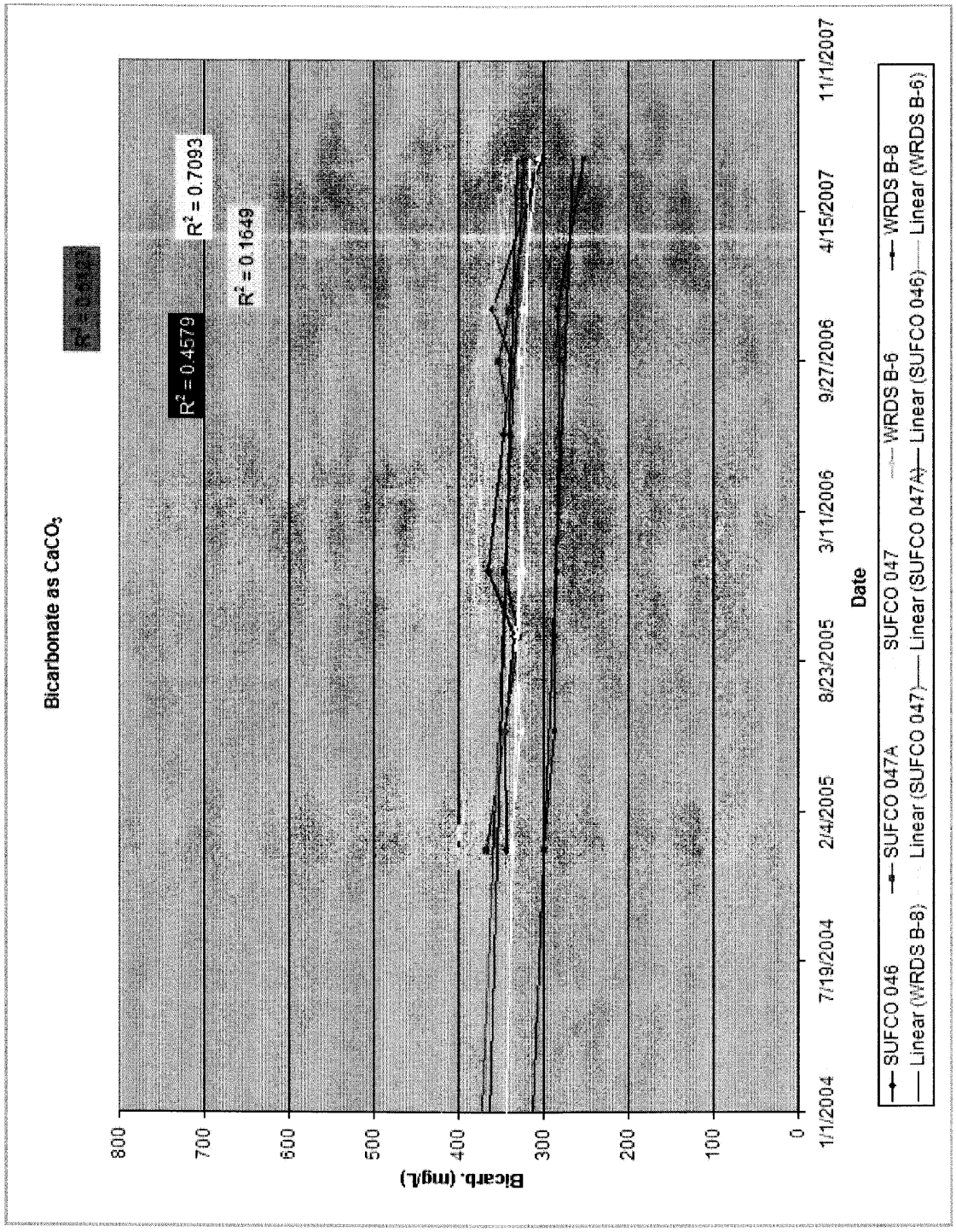

Flow Vs. Palmer Hydrologic Index and Surface Water Supply Index
Pines 310 and 311
Flow (gpM)
Index # (PHDI/SWSI)
6
5
4
3
2
1
0
4
3
2
1
0
-1
-2
-3
-4
3/24/2006
7/2/2006
10/10/2006
1/18/2007
4/28/2007
8/6/2007
11/14/2007
Date
Pines 310
Pines 311
PHDI 4
PHDI 7
SWSI San Rafael

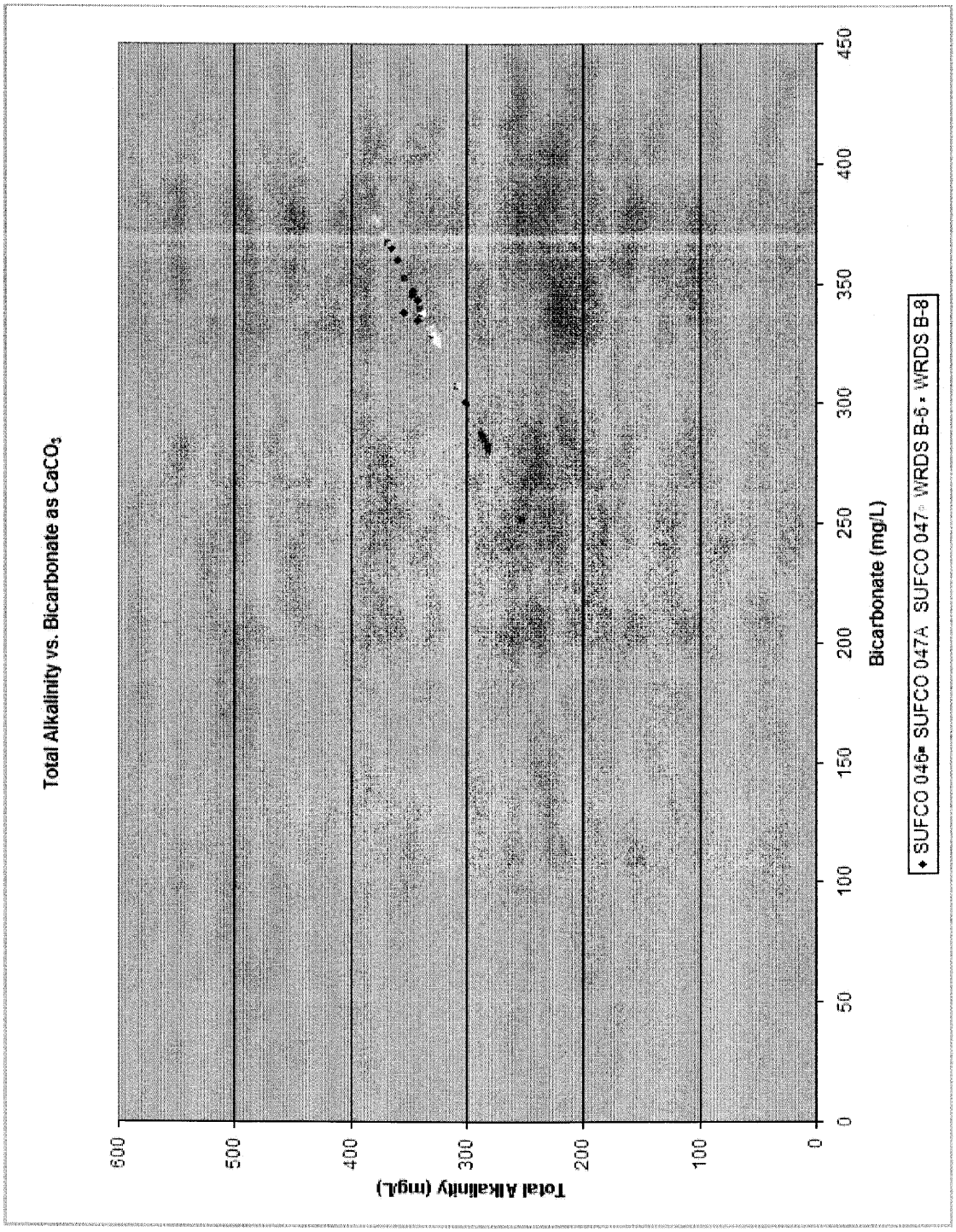

Flow Vs. Specific Conductivity
Pines 214
Flow (gpm)
3.5
3
2.5
2
1.5
1
0.5
0
Sp. Cond. (µmhos/cm)
600
500
400
300
200
100
0
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 214 Flow
Specific Conductivity

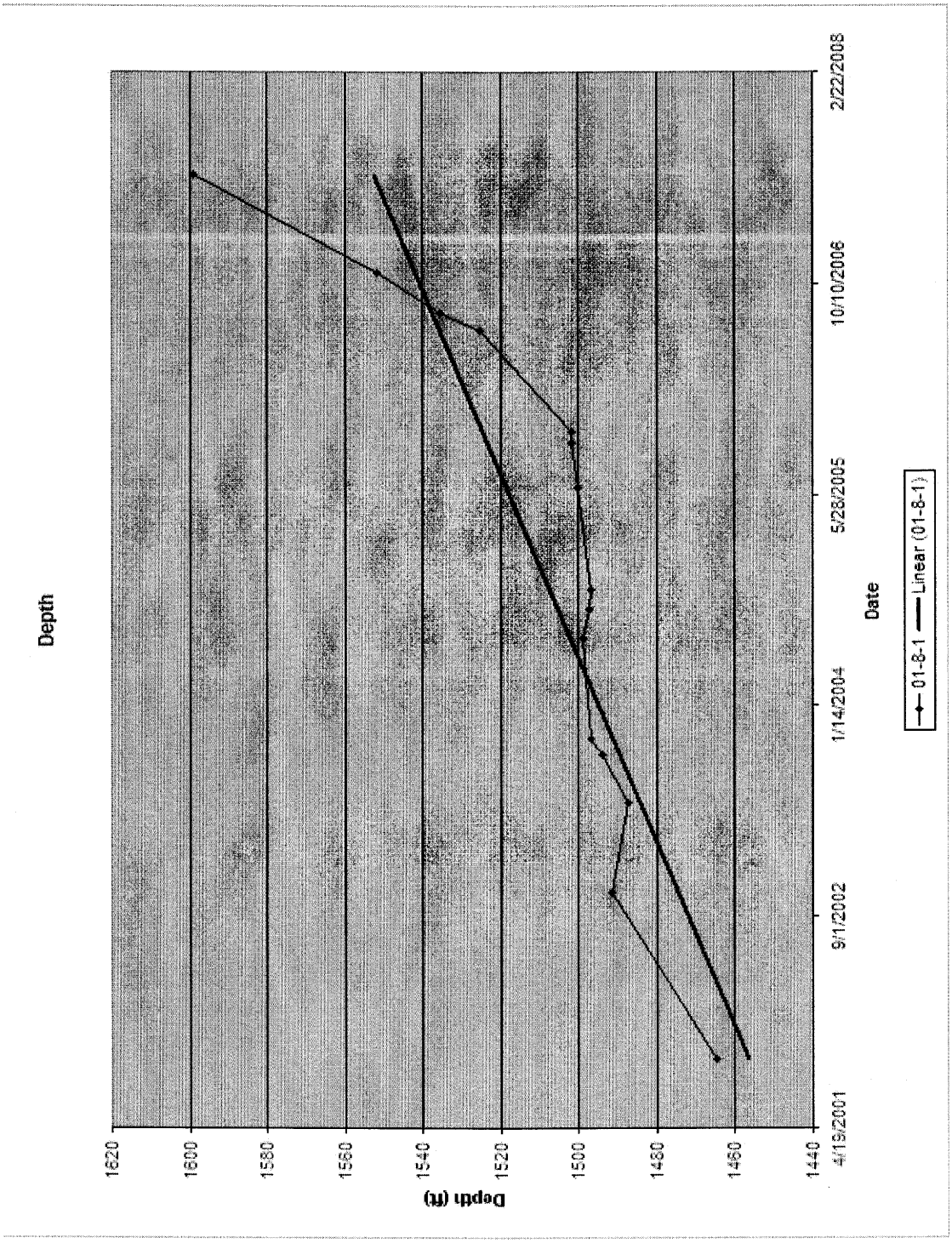

Flow Vs. Palmer Hydrologic Index and Surface Water Supply Index
Pines 214
Flow (gpm)
3.5
3
2.5
2
1.5
1
0.5
0
Index # (PHDI/SWSI)
10
8
6
4
2
0
-2
-4
-6
-8
1/1/2000
5/15/2001
9/27/2002
2/9/2004
6/23/2005
11/5/2006
3/19/2008
8/1/2009
Date
Pines 105 Flow
PHDI 4
PHDI 7
SWSI San Rafael

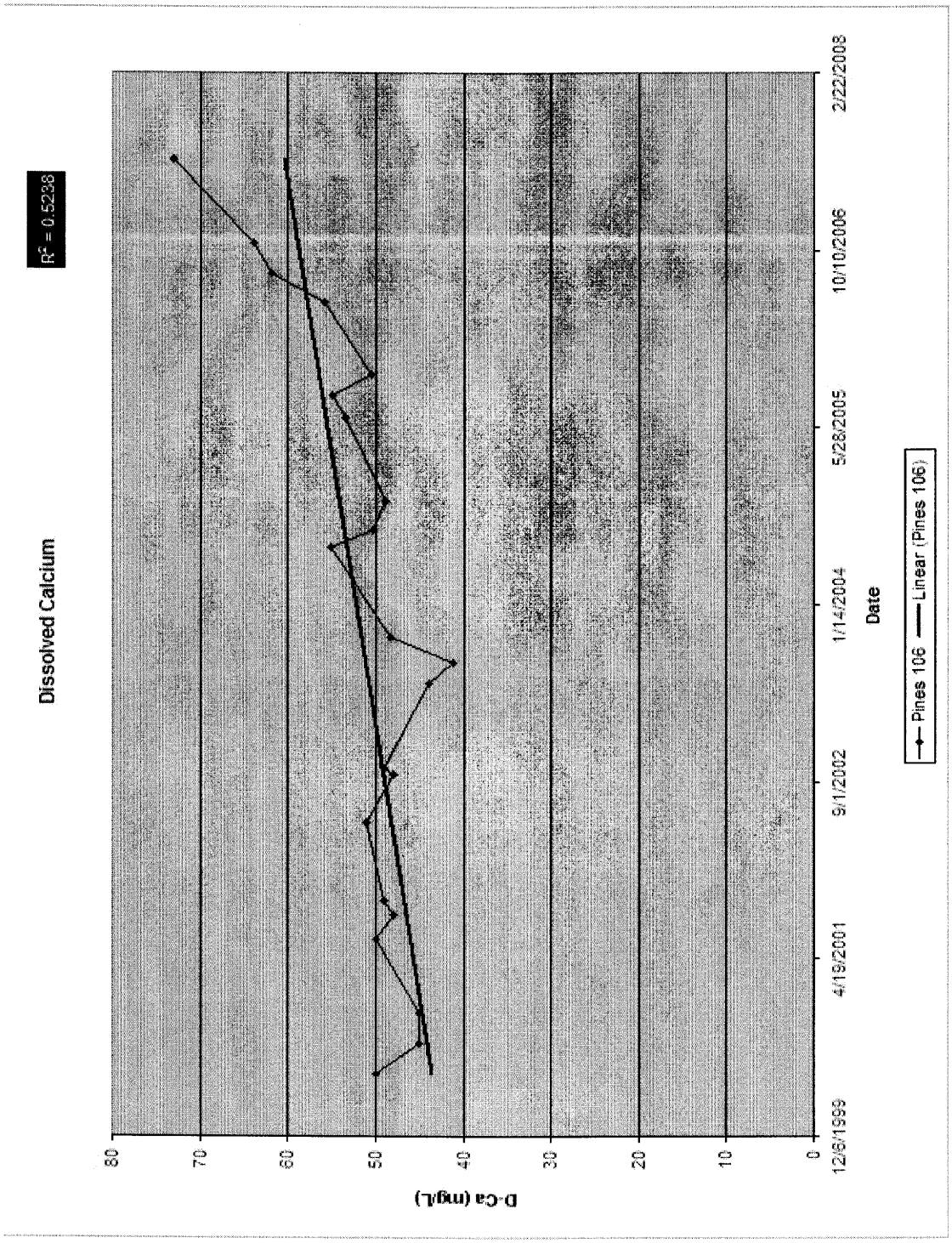

Flow Vs. Palmer Hydrologic Index and Surface Water Supply Index
Pines 303
Flow (gpm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Index # (PHDI/SWSI)
8
6
4
2
0
-2
-4
-6
-8
1/1/2000
5/15/2001
9/27/2002
2/9/2004
6/23/2005
11/5/2006
3/19/2008
8/1/2009
Date
Pines 105 Flow
PHDI 4
PHDI 7
SWSI San Rafael

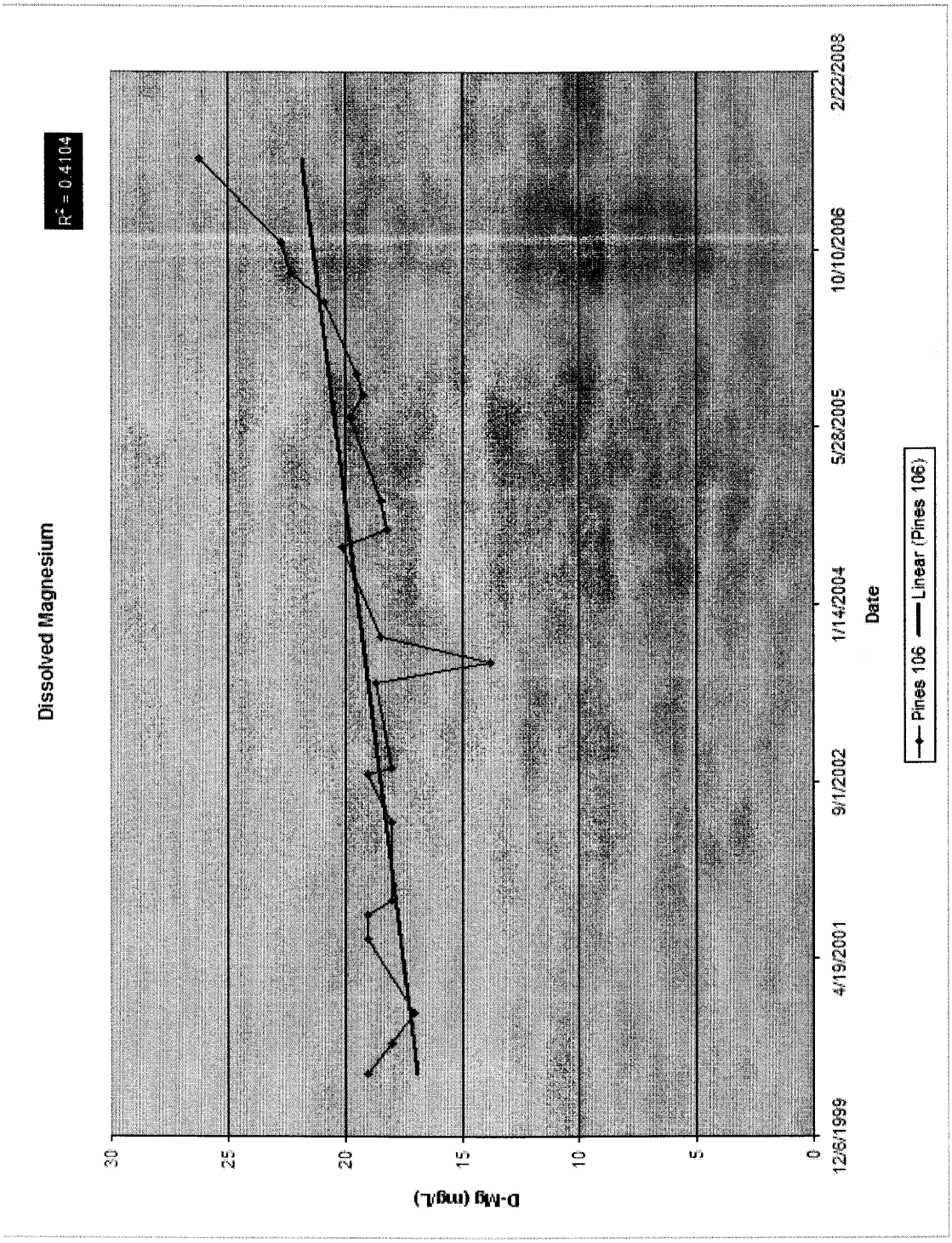

Total Alkalinity
Total Alk. (mg/L)
600
500
400
300
200
100
0
6/1/1980
11/22/1985
5/15/1991
11/4/1996
4/27/2002
10/18/2007
4/9/2013
Date
WRDS B-8
Linear (WRDS B-8)
SUFCO 046
Linear (SUFCO 046)
SUFCO 047A
Linear (SUFCO 047A)
SUFCO 047
Linear (SUFCO 047)

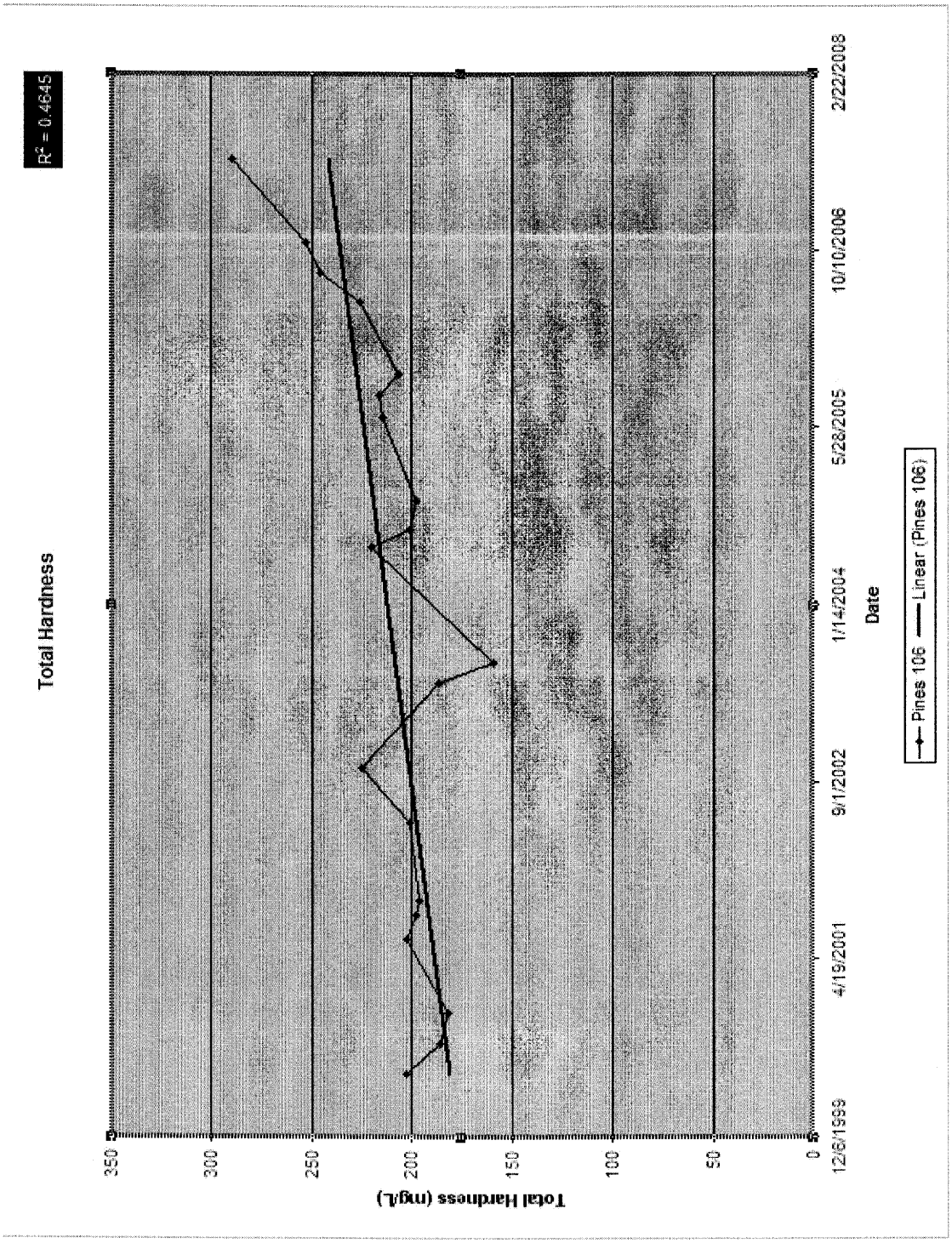

Bicarbonate as $CaCO_3$
$R^2 = 0.4579$
$R^2 = 0.7093$
$R^2 = 0.1649$
Bicarb. (mg/L)
800
700
600
500
400
300
200
100
0
1/1/2004
7/19/2004
2/4/2005
8/23/2005
3/11/2006
9/27/2006
4/15/2007
11/1/2007
Date
SUFCO 046
SUFCO 047A
SUFCO 047
WRDS B-6
WRDS B-8
Linear (WRDS B-8)
Linear (SUFCO 047)
Linear (SUFCO 047A)
Linear (SUFCO 046)
Linear (WRDS B-6)

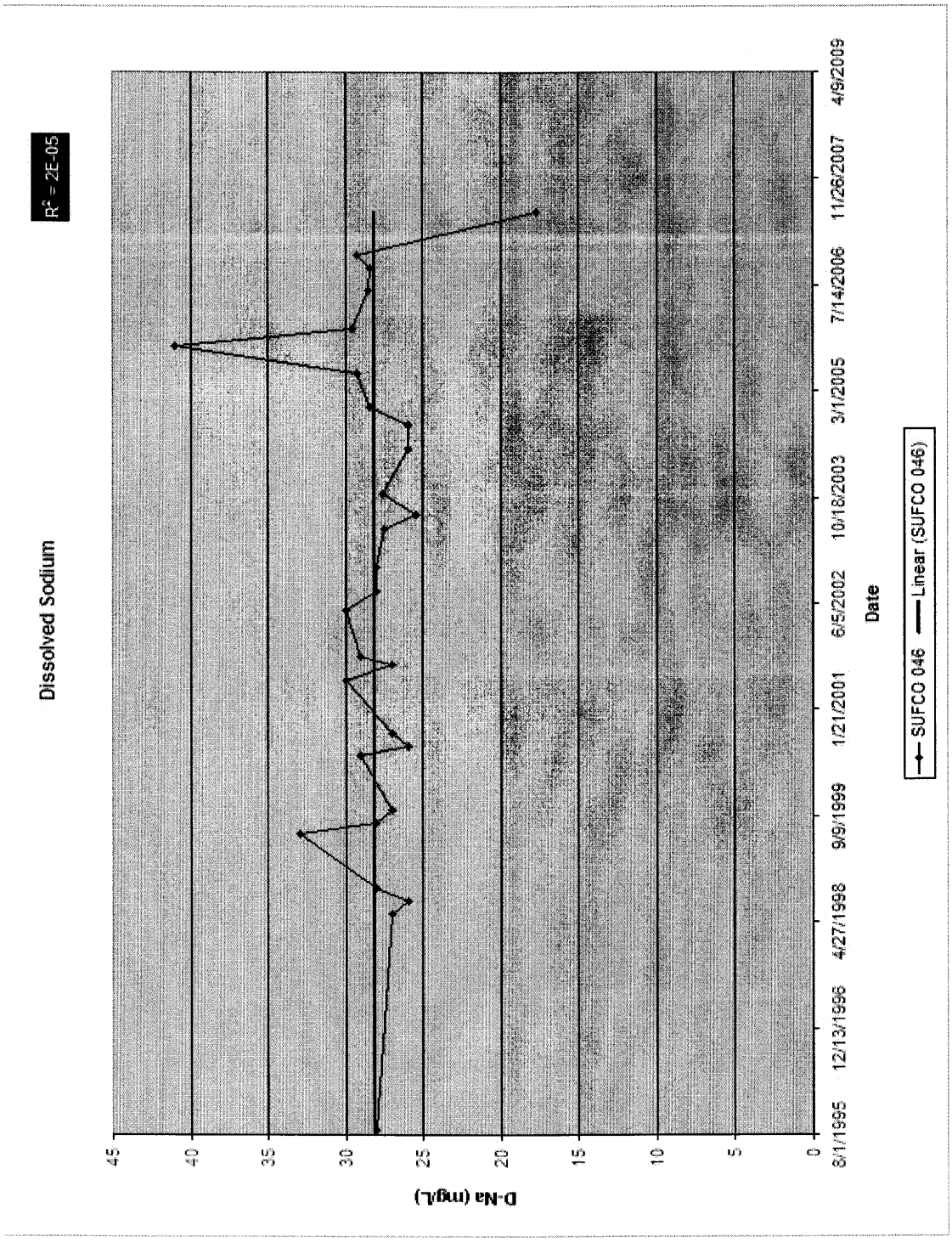

Total Alkalinity vs. Bicarbonate as $CaCO_3$
Total Alkalinity (mg/L)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Bicarbonate (mg/L)
SUFCO 046
SUFCO 047A
SUFCO 047
WRDS B-5
WRDS B-8

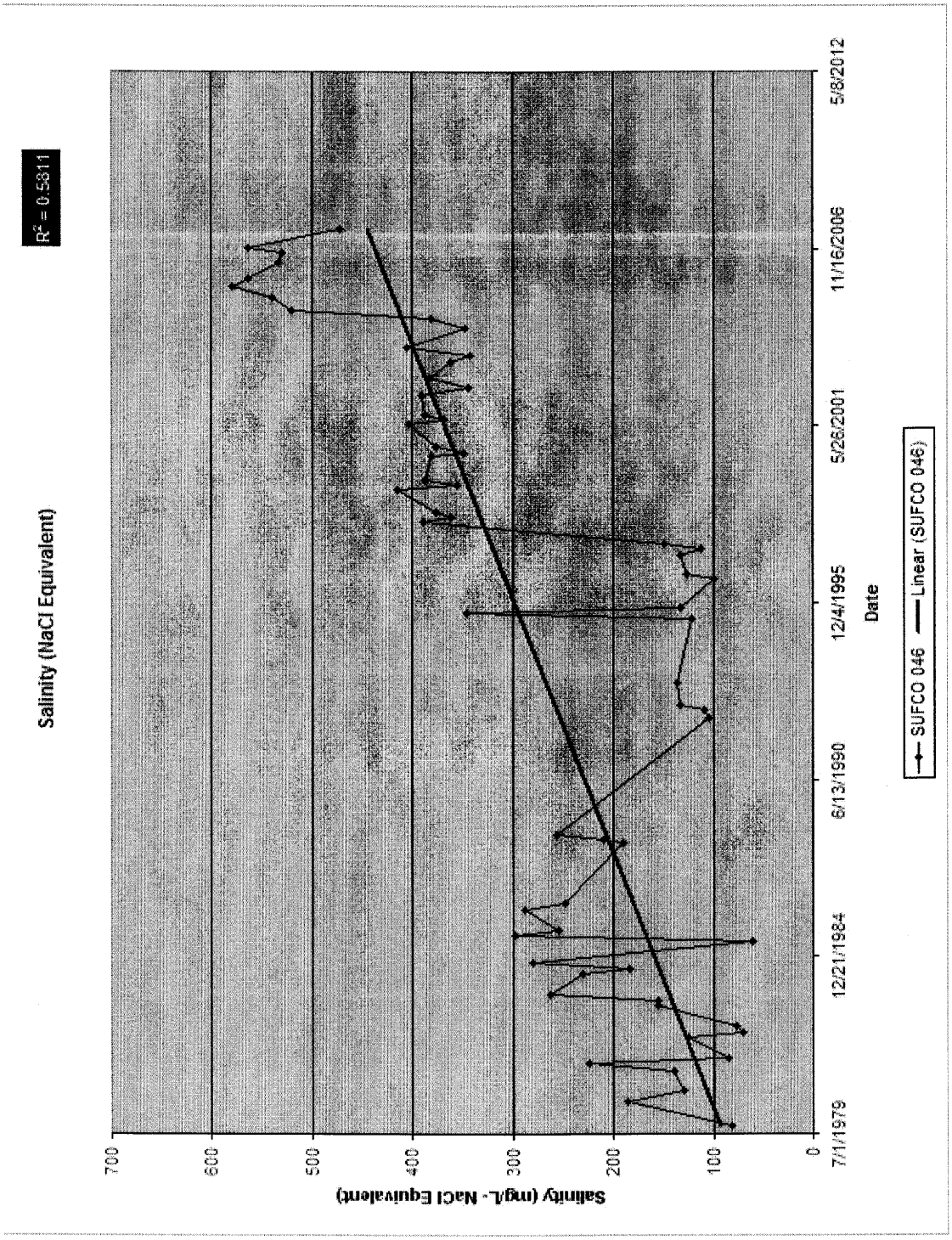

Depth
1620
1600
1580
1560
1540
1520
1500
1480
1460
1440
Depth (ft)
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
01-8-1
Linear (01-8-1)

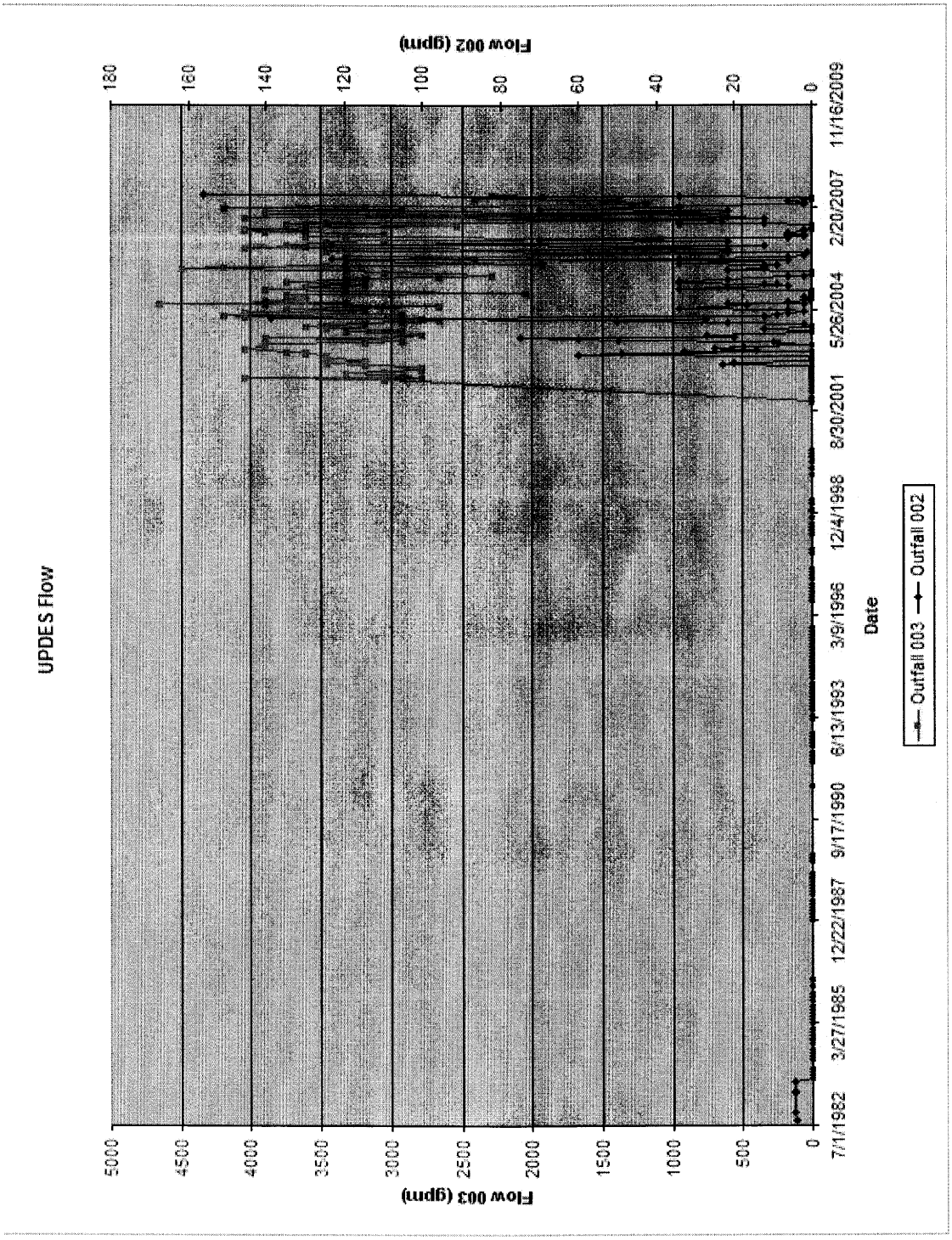

Dissolved Calcium
R^2 = 0.5238
D-Ca (mg/L)
80
70
60
50
40
30
20
10
0
12/8/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)

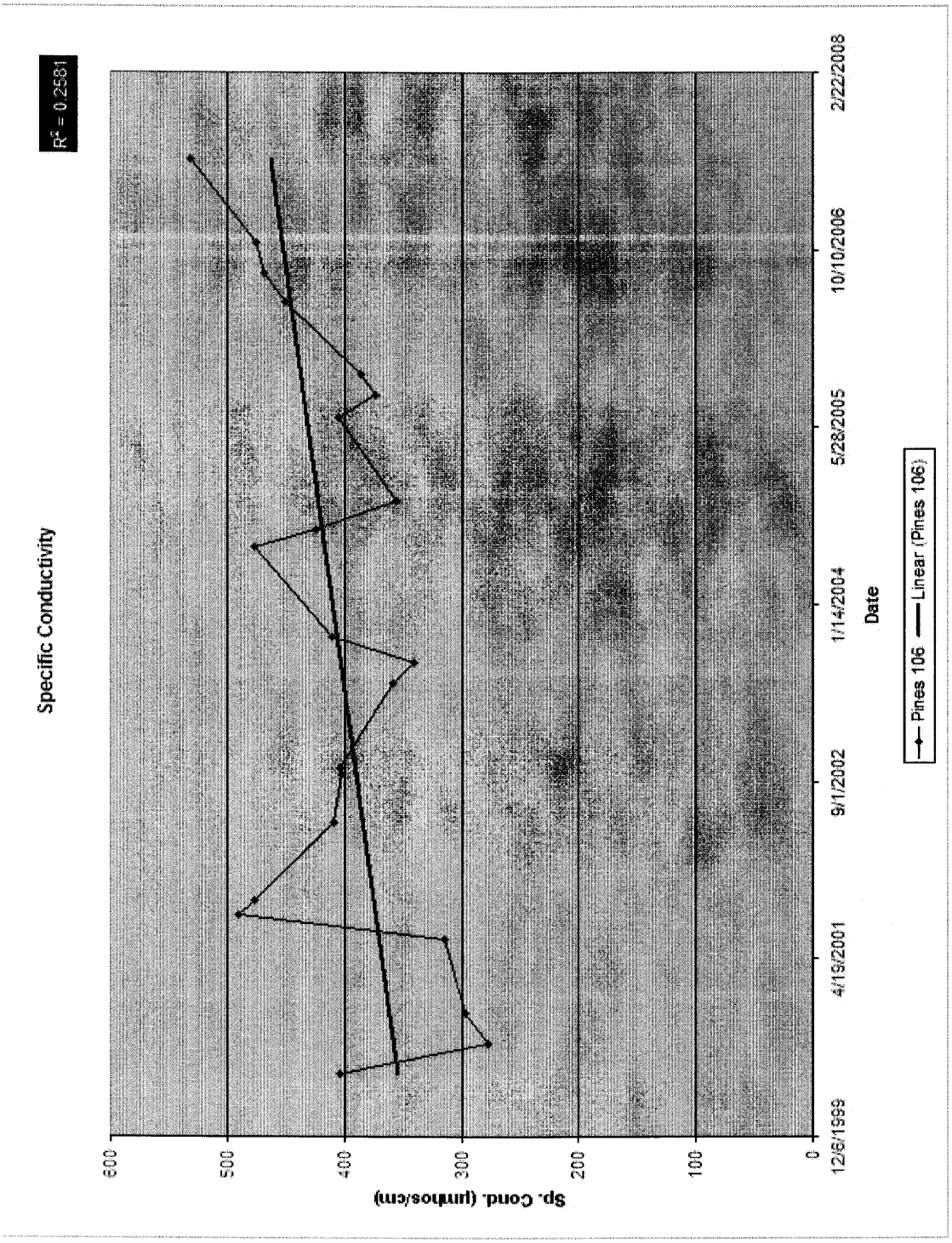

Dissolved Magnesium
R² = 0.4104
D-Mg (mg/L)
30
25
20
15
10
5
0
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)

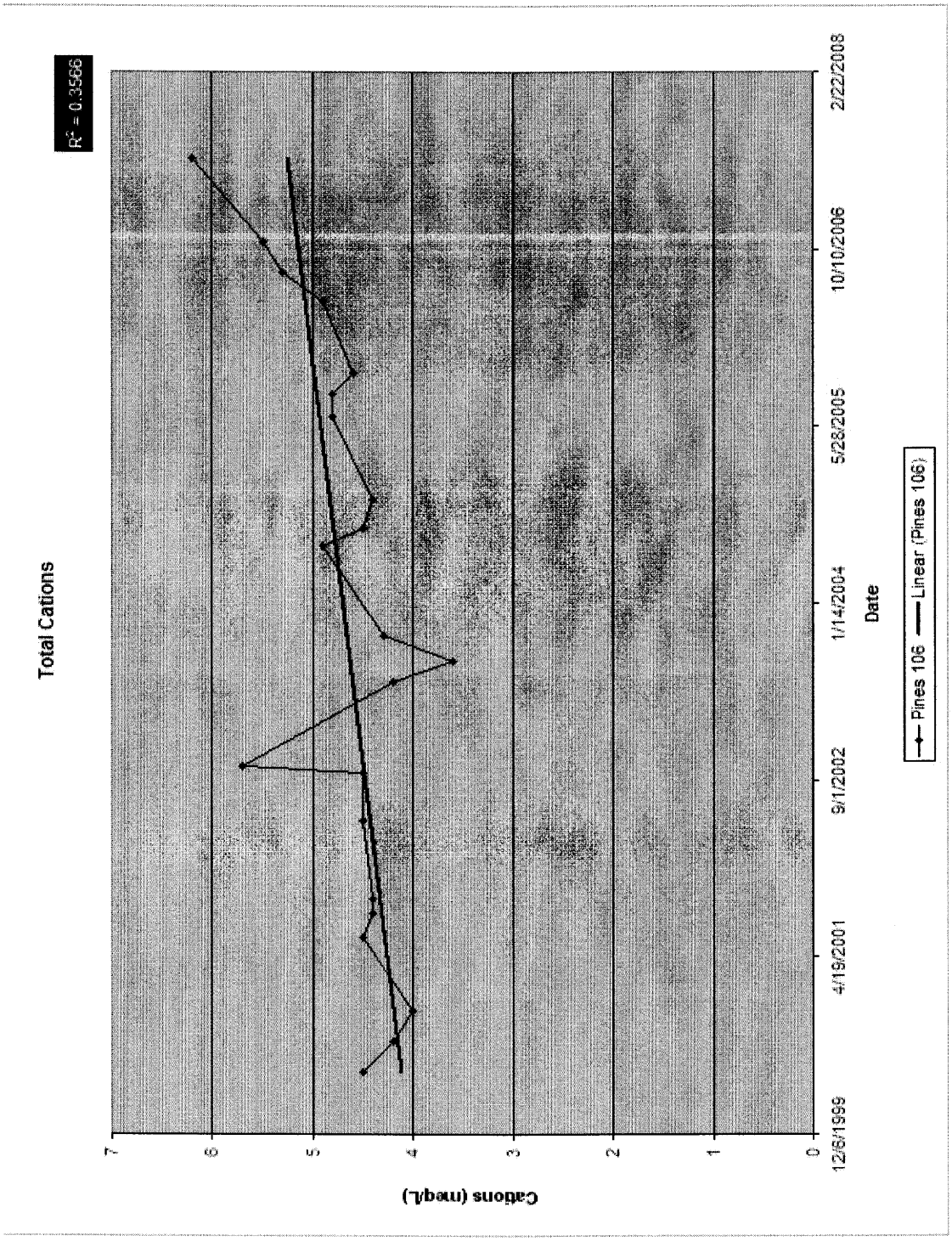

Total Hardness
R^2 = 0.4645
Total Hardness (mg/L)
350
300
250
200
150
100
50
0
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)

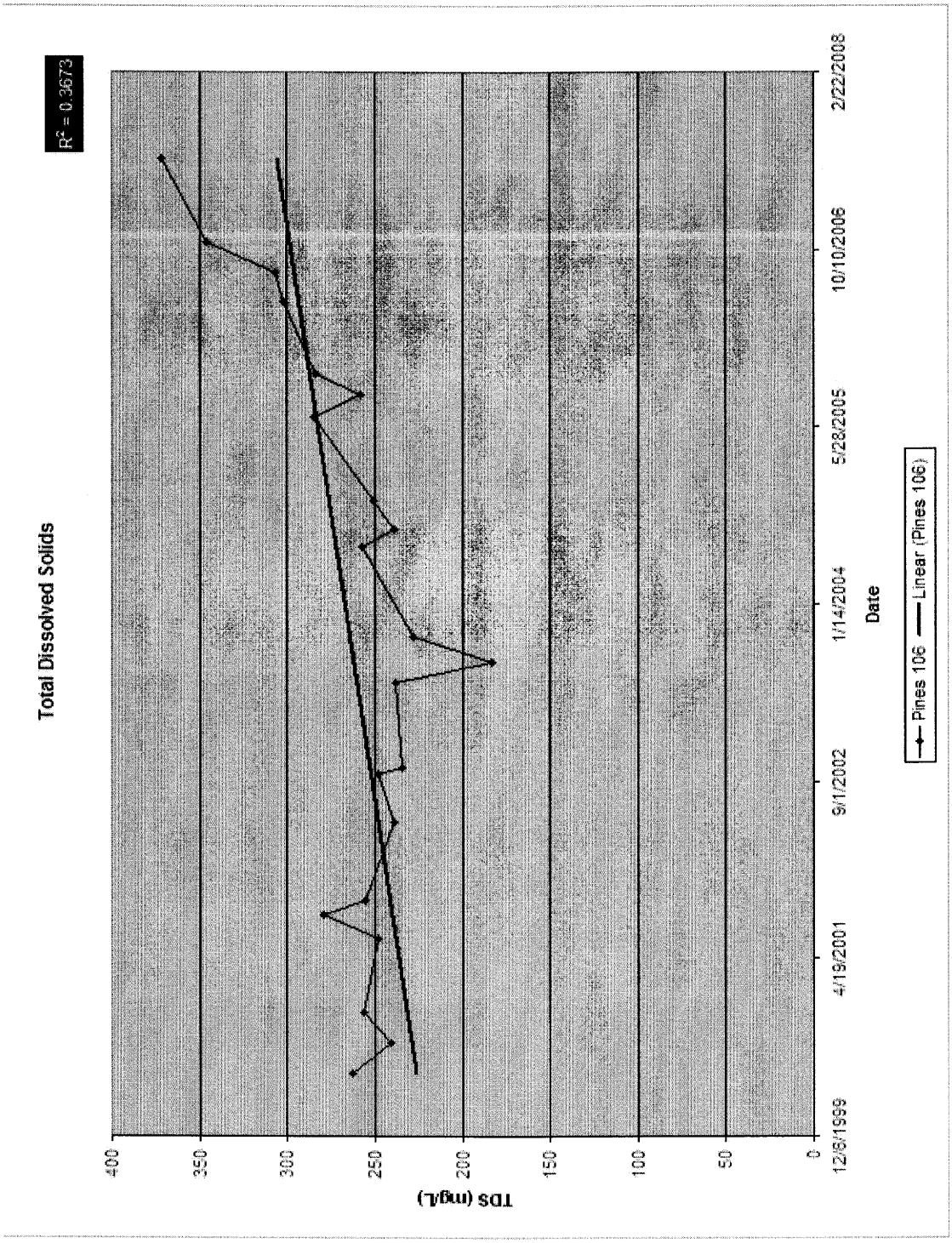

Dissolved Sodium
R^2 = 2E-05
D-Na (mg/L)
45
40
35
30
25
20
15
10
5
0
8/1/1995
12/13/1996
4/27/1998
9/9/1999
1/21/2001
6/5/2002
10/18/2003
3/1/2005
7/14/2006
11/26/2007
4/9/2009
Date
SUFCO 046
Linear (SUFCO 046)

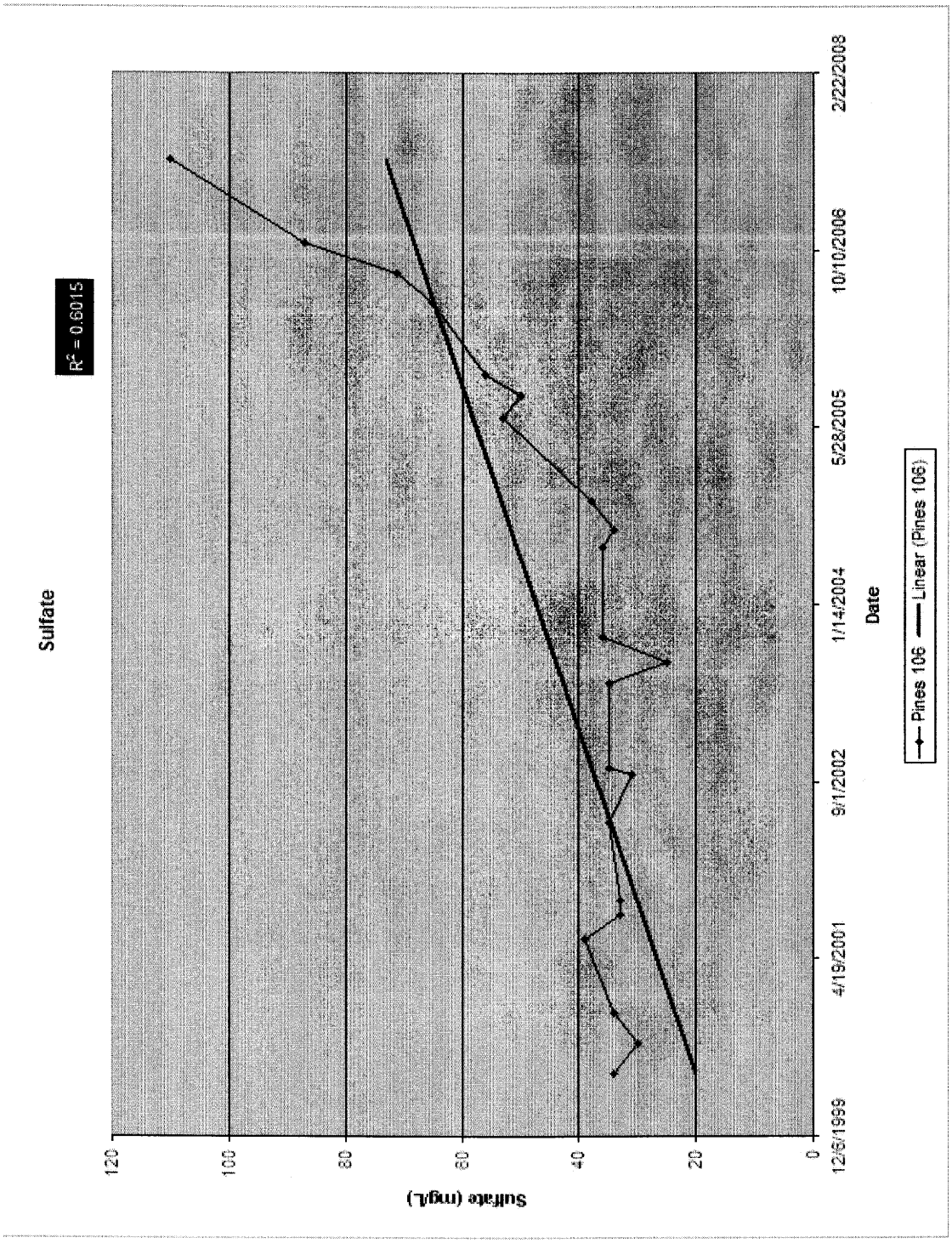

Salinity (NaCl Equivalent)
R^2 = 0.5811
Salinity (mg/L - NaCl Equivalent)
700
600
500
400
300
200
100
0
7/1/1979
12/21/1984
6/13/1990
12/4/1995
5/26/2001
11/16/2006
5/8/2012
Date
SUFCO 046
Linear (SUFCO 046)


UPDES Flow
Flow 003 (gpm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Flow 002 (gpm)
180
160
140
120
100
80
60
40
20
0
7/1/1982
3/27/1985
12/22/1987
9/17/1990
6/13/1993
3/9/1996
12/4/1998
8/30/2001
5/26/2004
2/20/2007
11/16/2009
Date
Outfall 003
Outfall 002


Specific Conductivity
R^2 = 0.2581
Sp. Cond. (µmhos/cm)
600
500
400
300
200
100
0
12/6/1999
4/15/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)


Total Cations
R² = 0.3566
Cations (meq/L)
7
6
5
4
3
2
1
0
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)


Total Dissolved Solids
R^2 = 0.3673
TDS (mg/L)
400
350
300
250
200
150
100
50
0
12/8/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)


Sulfate
R^2 = 0.6015
Sulfate (mg/L)
120
100
80
60
40
20
0
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
Date
Pines 106
Linear (Pines 106)