


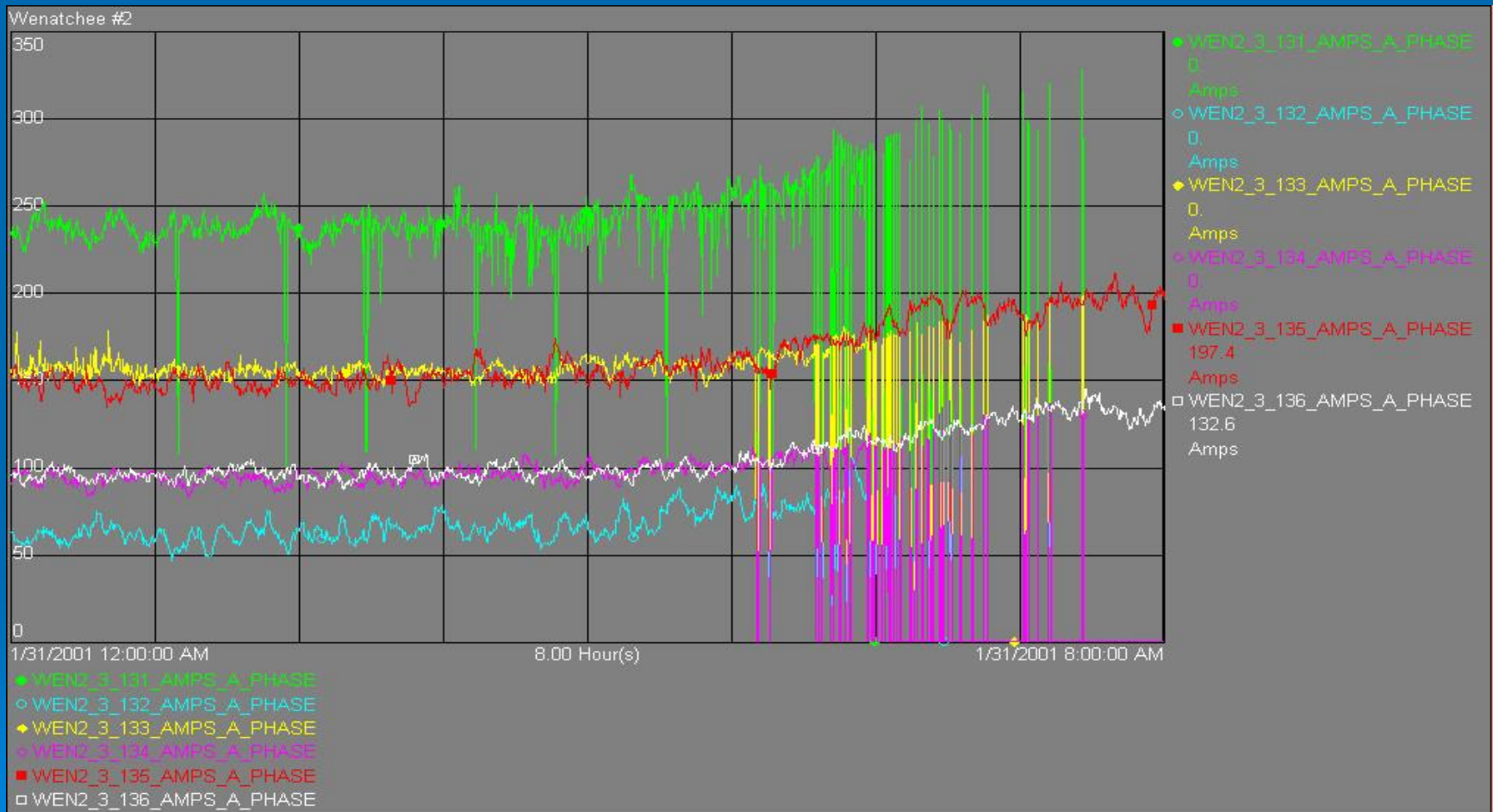
Using PI to Monitor Hydroelectric Control Systems

Presented by Jeff Mettler
Chelan County PUD
Wenatchee, WA 98801

The background of the slide is a solid blue color. In the bottom right corner, there are several concentric white circles of varying sizes, resembling ripples on water. These ripples are arranged in a cluster, with some overlapping, and they extend from the bottom edge towards the center of the slide.

Our First Week with PI

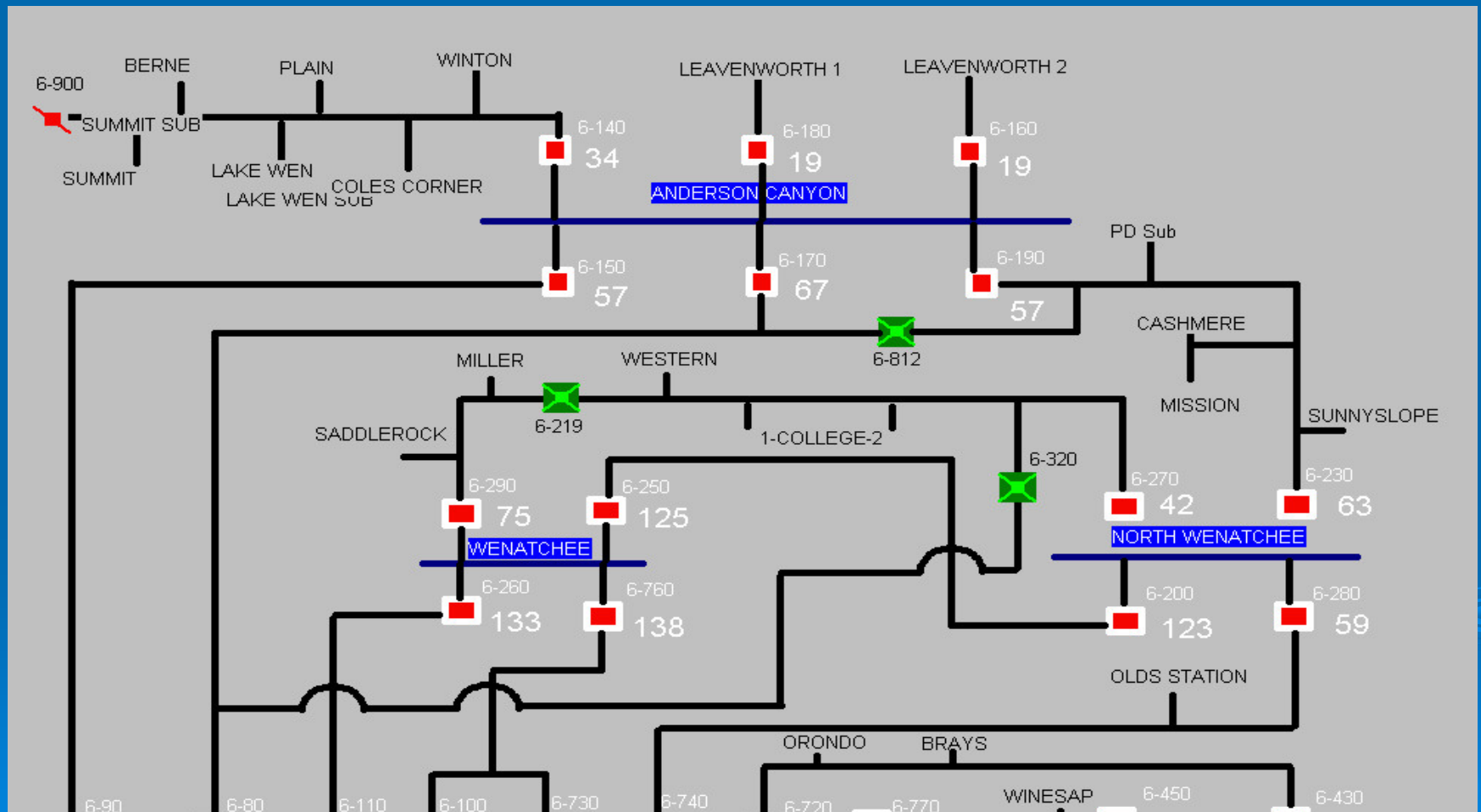
Bad SCADA Transducers Found



System Operations

- System One Line Display
- PNSC Report
- Water System Alarm Summary
- Water System Station Level Monitoring
- Water System Equipment Monitoring

System Operators: One-Line Diagram



System Operators: PNSC Report

[illegible]

System Operators: Water System Alarm Summary

Site Alarms

Any site listed in red has at least one alarm in at that site.
Click on the text to go to the display for that site.

Broadview Reservoir
Chelan Falls
Chelan Ridge
Circle Street Reservoir
Day Road Reservoir
Eaglerock Reservoir
Euclid Ave PS
Garland-Wade PS
Hawley Street PS
Knowles
Lester Road PS
[Levels](#)
Lovell Road PS
Lower Skyline Reservoir

Maiden Lane Reservoirs
Monitor Comm Failure
Ohme Reservoir & PS
Olds Station WW PS
Pump Station 1
Pump Station 2
Pump Station 3
Pump Station 4
Pump Station 5
Pump Station 6
Reservoir 1
Reservoir 2

Use Network Files

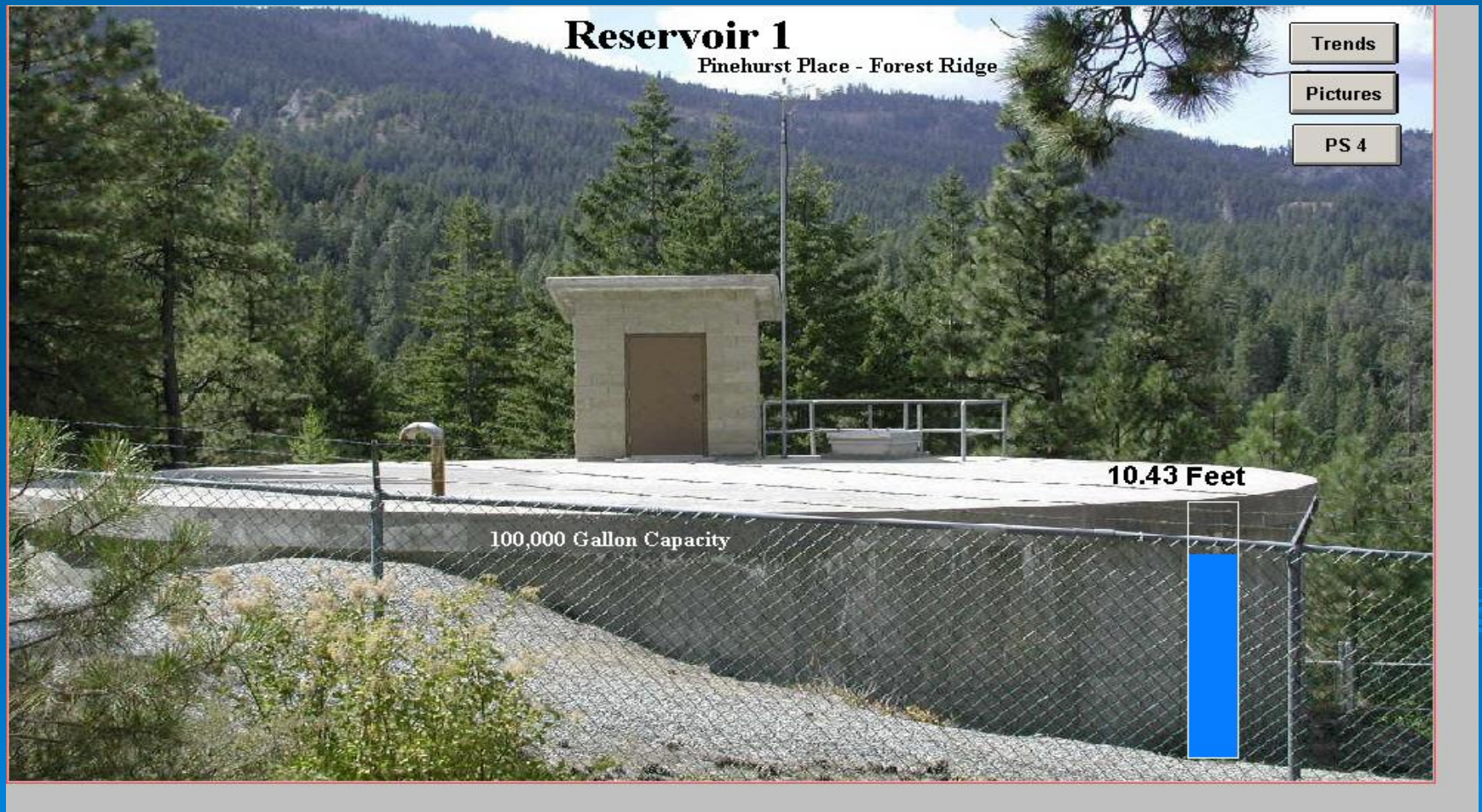
Click to test alarm sound.

Reservoir 3
Roddy Reservoir
School Street Res & PS
[Setpoints](#)
[Site Alarm Trends](#)
Skyline PS
Sleepy Hollow Res & PS
Springwater PS
S Wenatchee Reservoir
Upper School St Reservoir
Upper Skyline Reservoir
Whispering Ridge PS

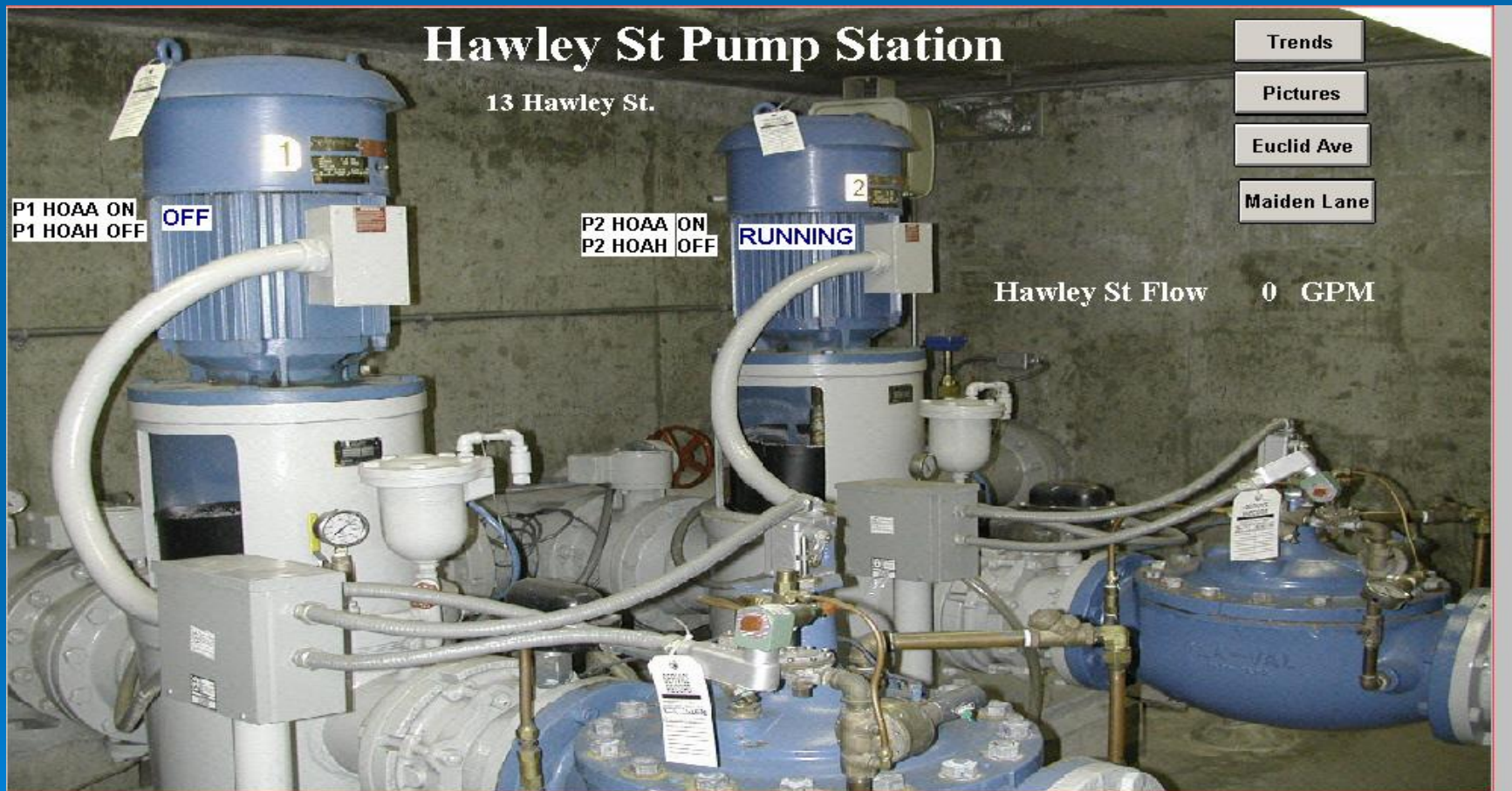
Use Local Files

Update Local Files

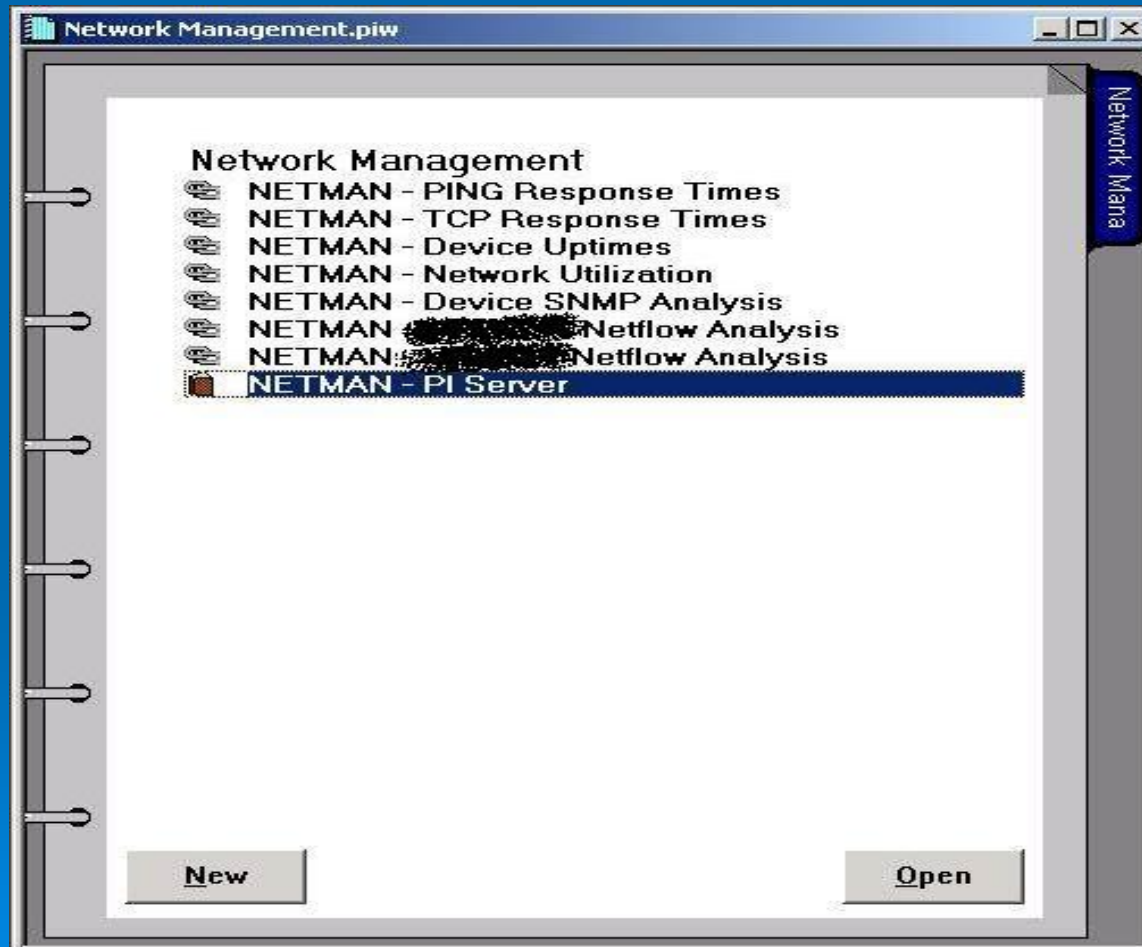
System Operators: Reservoir 1



System Operators: Hawley St. Pump Station



Network Manager: Overview Page



Network Manager: Ping Response

PING Responses

I/O Timeout 5/1/2003 1:43:59 PM

0 NET_PING_ 5/1/2003 1:34:29 PM
0 NET_PING_ 5/1/2003 1:41:59 PM
0 NET_PING_ 5/1/2003 1:43:59 PM
0 NET_PING_ 5/1/2003 1:41:59 PM
0 NET_PING_ 5/1/2003 1:36:29 PM

0 NET_PING_ 5/1/2003 1:39:59 PM
0 NET_PING_ 5/1/2003 1:41:59 PM
0 NET_PING_ 5/1/2003 1:43:59 PM

0 NET_PING_ 5/1/2003 1:37:59 PM

0 NET_PING_ 5/1/2003 1:42:29 PM

I/O Timeout NET_PING_ 5/1/2003 1:40:29 PM

0 NET_PING_ 5/1/2003 1:40:29 PM
10 NET_PING_ 5/1/2003 1:43:59 PM
0 NET_PING_ 5/1/2003 1:38:29 PM
0 NET_PING_ 5/1/2003 1:36:29 PM

0 NET_PING_ 5/1/2003 1:42:29 PM
0 NET_PING_ 5/1/2003 1:38:29 PM
0 NET_PING_ 5/1/2003 1:34:29 PM
0 NET_PING_ 5/1/2003 1:36:29 PM

0 NET_PING_ 5/1/2003 1:42:29 PM
0 NET_PING_ 5/1/2003 1:40:29 PM

10 NET_PING_ 5/1/2003 1:42:29 PM
0 NET_PING_ 5/1/2003 1:38:29 PM

0 NET_PING_ 5/1/2003 1:40:29 PM

0 NET_PING_ 5/1/2003 1:41:59 PM

I/O Timeout NET_PING_ 5/1/2003 1:34:29 PM

I/O Timeout NET_PING_ 5/1/2003 1:43:59 PM

I/O Timeout NET_PING_ 5/1/2003 1:40:29 PM

0 NET_PING_ 5/1/2003 1:35:59 PM

10 NET_PING_ 5/1/2003 1:43:59 PM
0 NET_PING_ 5/1/2003 1:43:59 PM
0 NET_PING_ 5/1/2003 1:35:59 PM

0 NET_PING_ 5/1/2003 1:36:29 PM

Network Manager: TCP Ping Response

Intellution Responses

```
Bad Input NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
Bad Input NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
Bad Input NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:36:29 PM
```

```
0 NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:32:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:32:29 PM
```

```
0 NET_TCPR_ IFIX 5/1/2003 1:38:29 PM
10 NET_TCPR_ IFIX 5/1/2003 1:40:29 PM
```

```
10 NET_TCPR_ IFIX 5/1/2003 1:42:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:34:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:36:29 PM
```

```
0 NET_TCPR_ IFIX 5/1/2003 1:40:29 PM
```

```
0 NET_TCPR_ IFIX 5/1/2003 1:38:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:38:29 PM
0 NET_TCPR_ IFIX 5/1/2003 1:38:29 PM
```

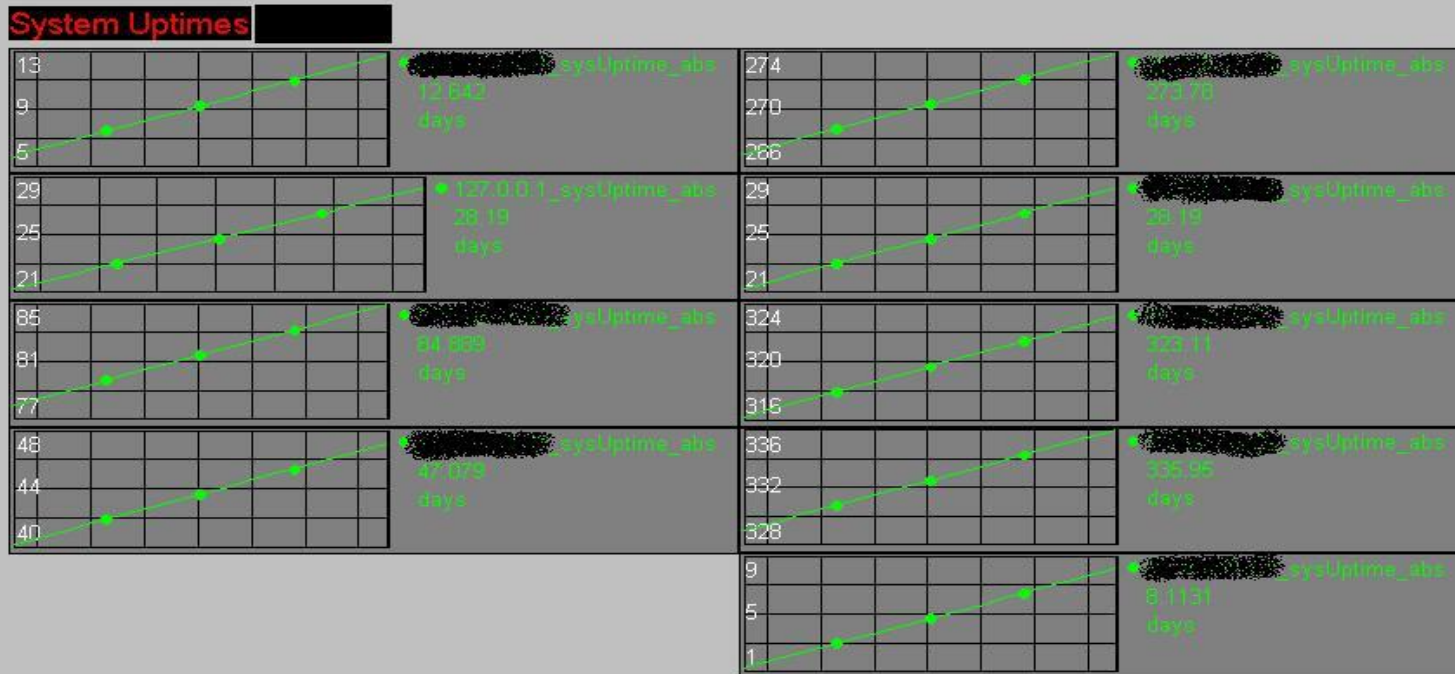
PI Responses

```
0 NET_TCPR_ PI 5/1/2003 1:42:29 PM
0 NET_TCPR_ PI 5/1/2003 1:42:29 PM
0 NET_TCPR_ PI 5/1/2003 1:42:29 PM
0 NET_TCPR_ PI 5/1/2003 1:42:29 PM
```

Allen-Bradley Responses

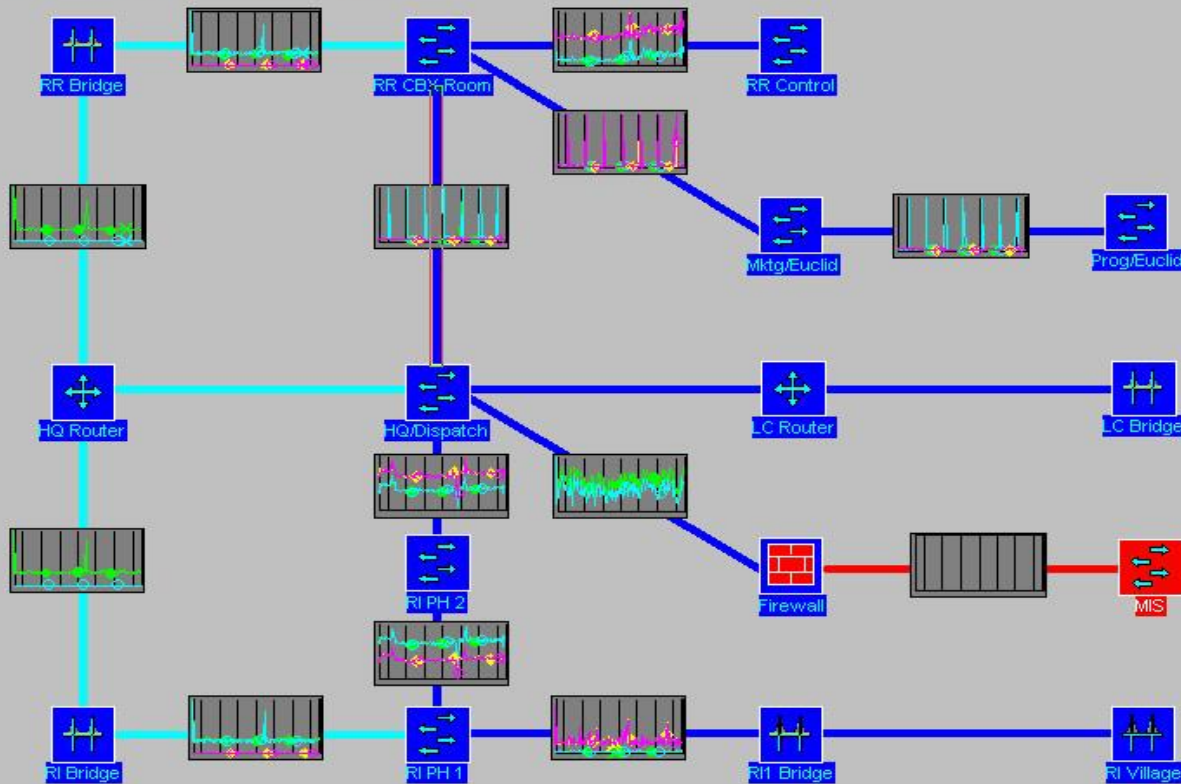
```
10 NET_TCPR_ A-B 5/1/2003 1:42:29 PM
I/O Timeout NET_TCPR_ A-B 5/1/2003 1:42:29 PM
```


Network Manager: Device Uptimes (SNMP)

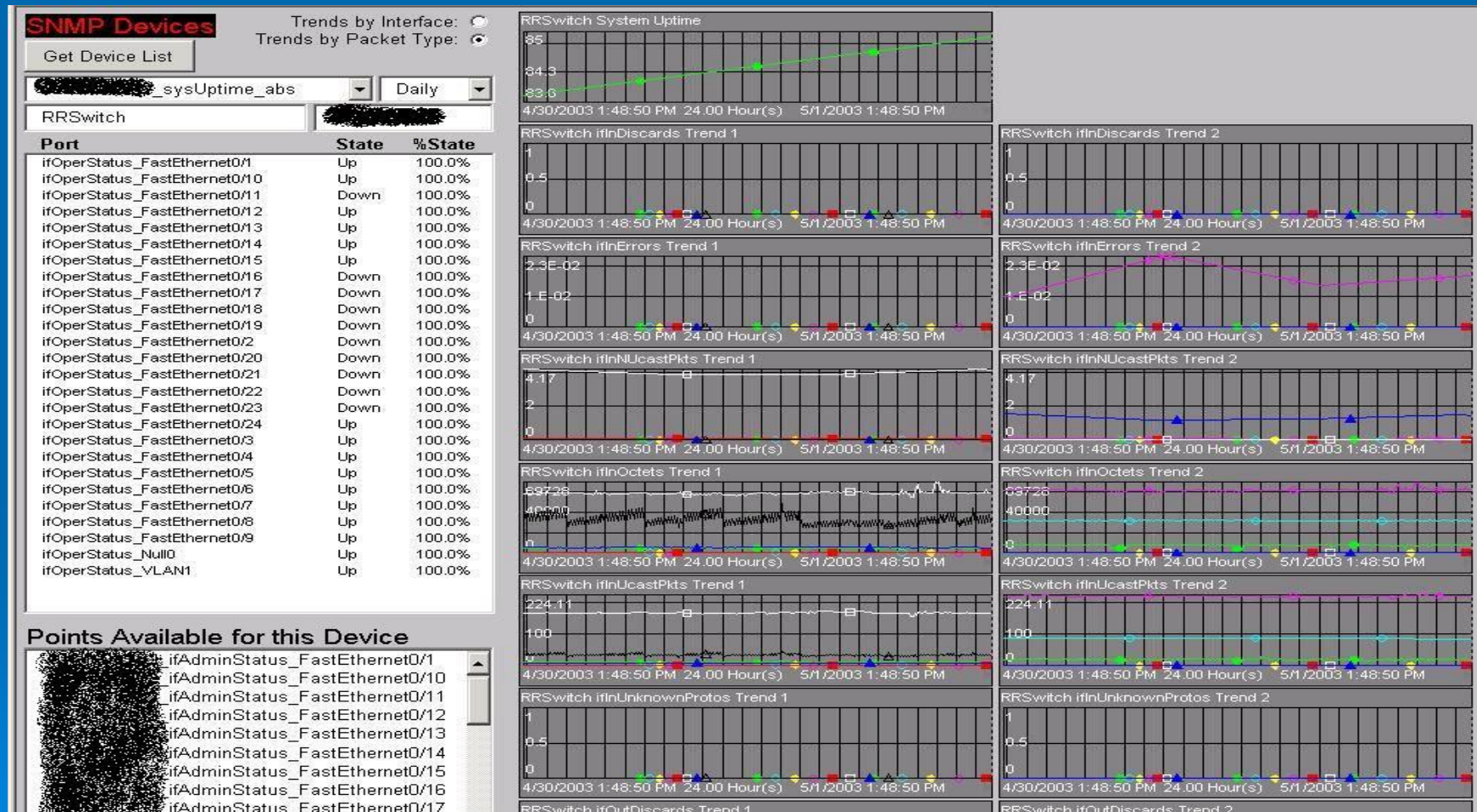


Network Manager: Network Utilization (SNMP)

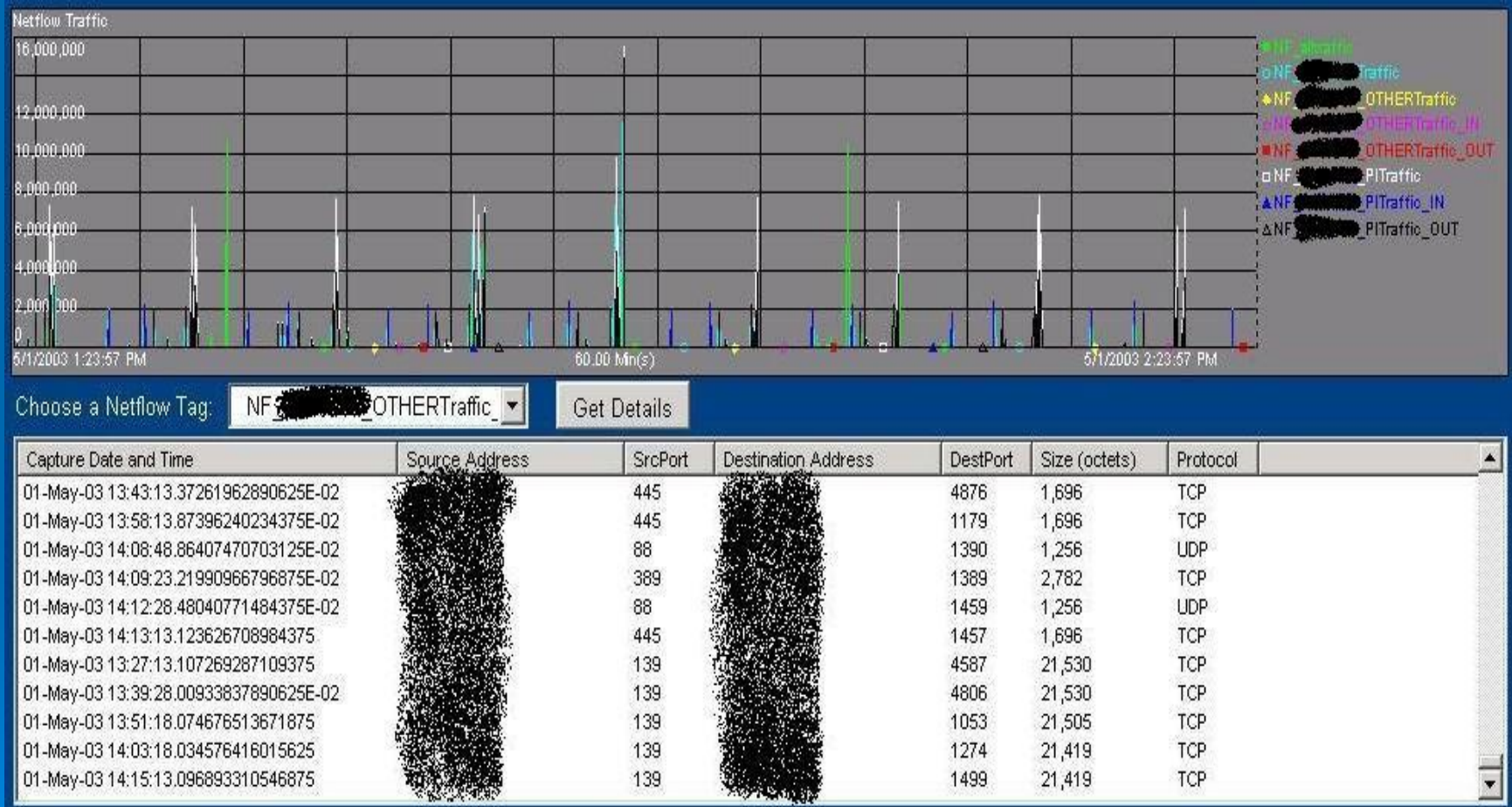
Network Bandwidth Usage



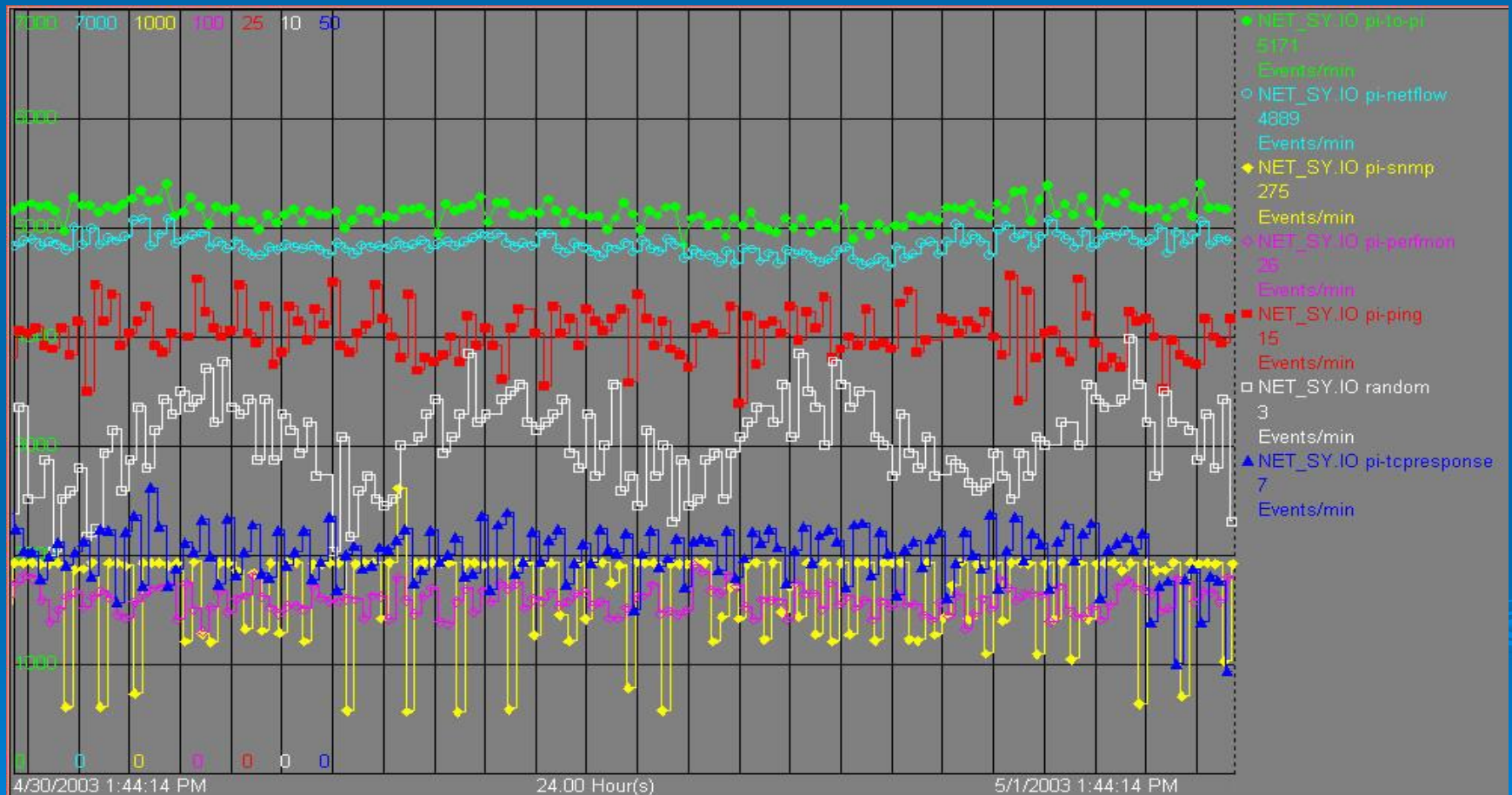
Network Manager: SNMP Device Analysis



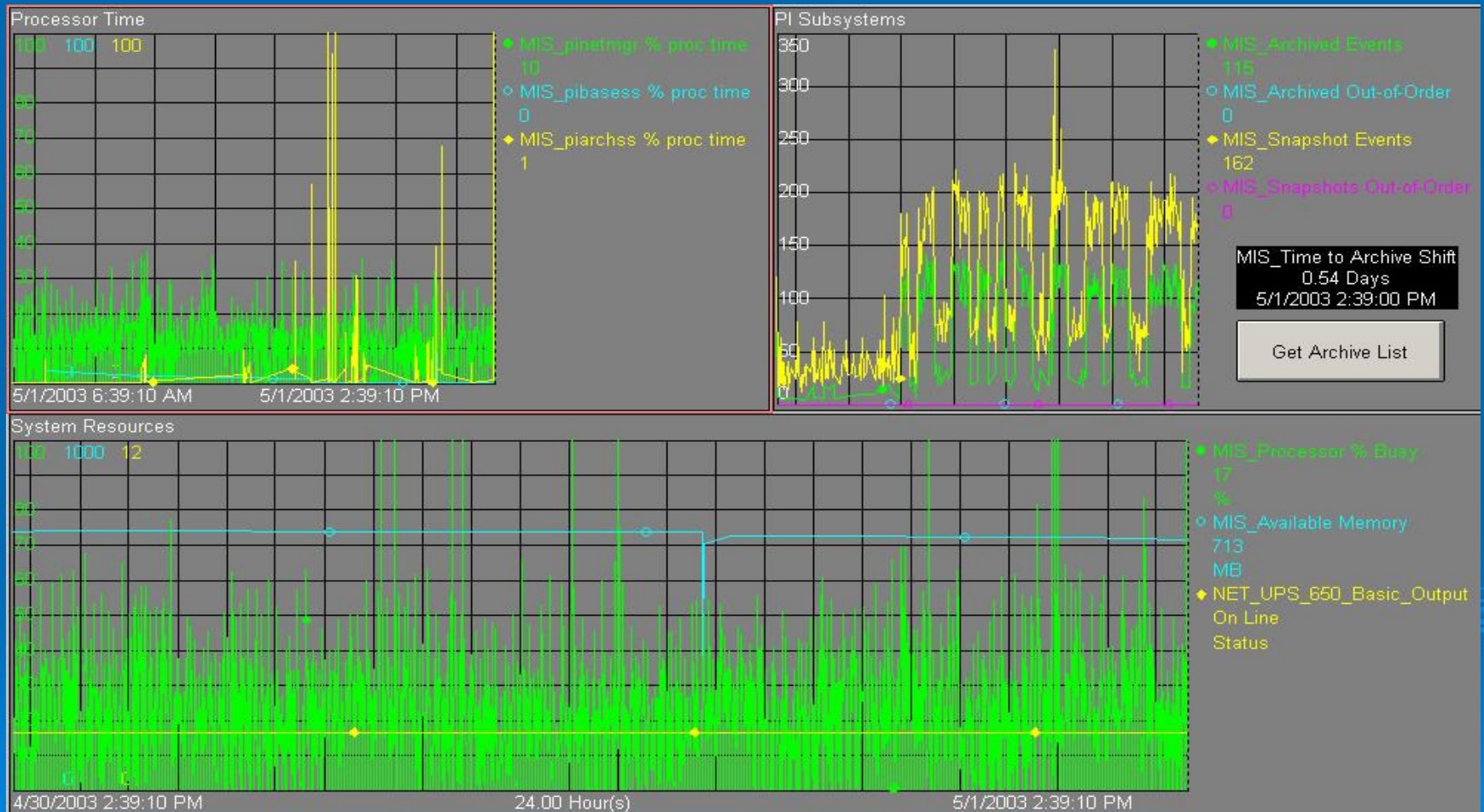
Network Manager: Packet Sniffing (Netflow)



Network Manager: PI Server IO Rates



Network Manager: PI Server Performance

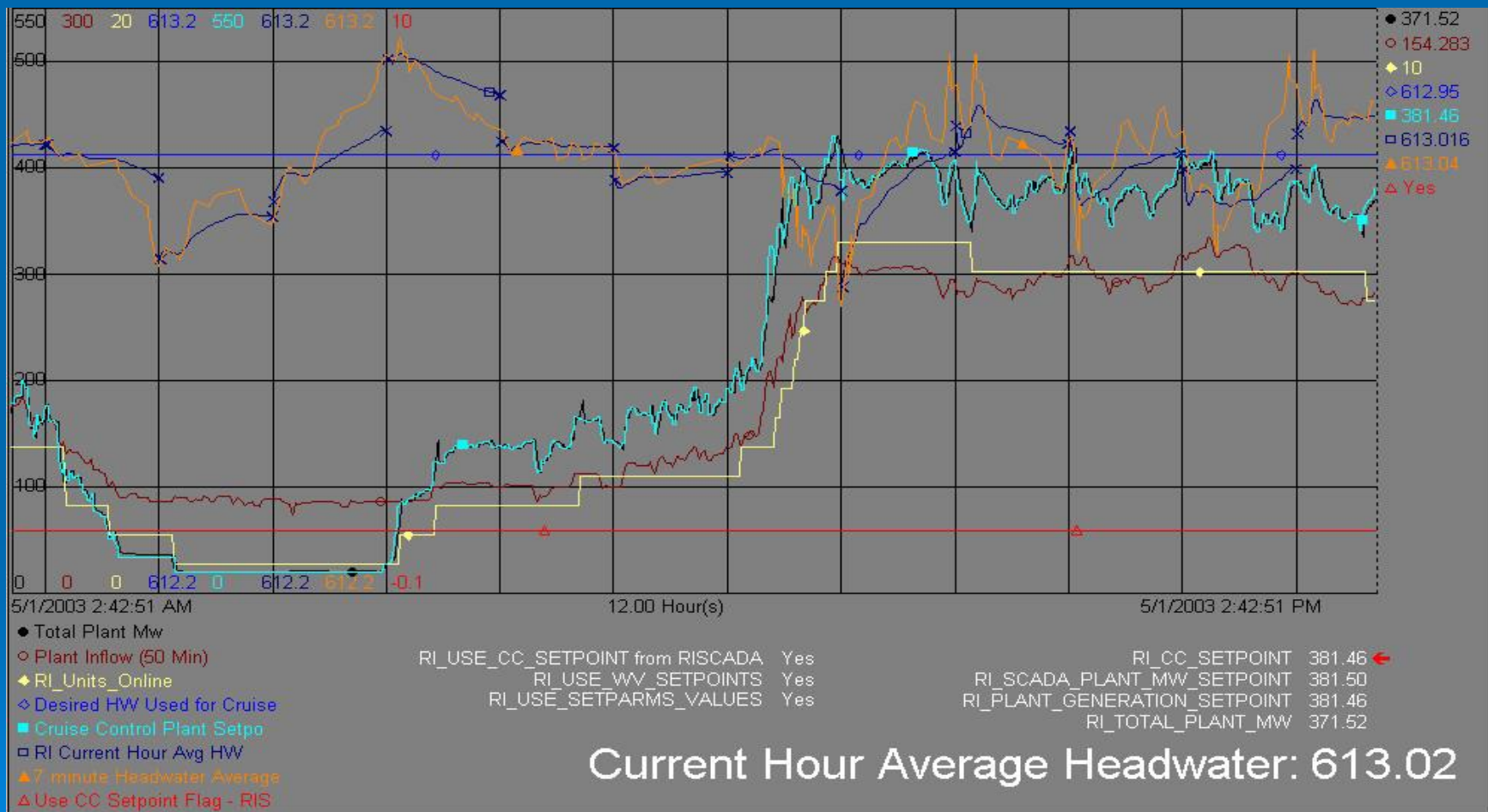


Hydro Operators

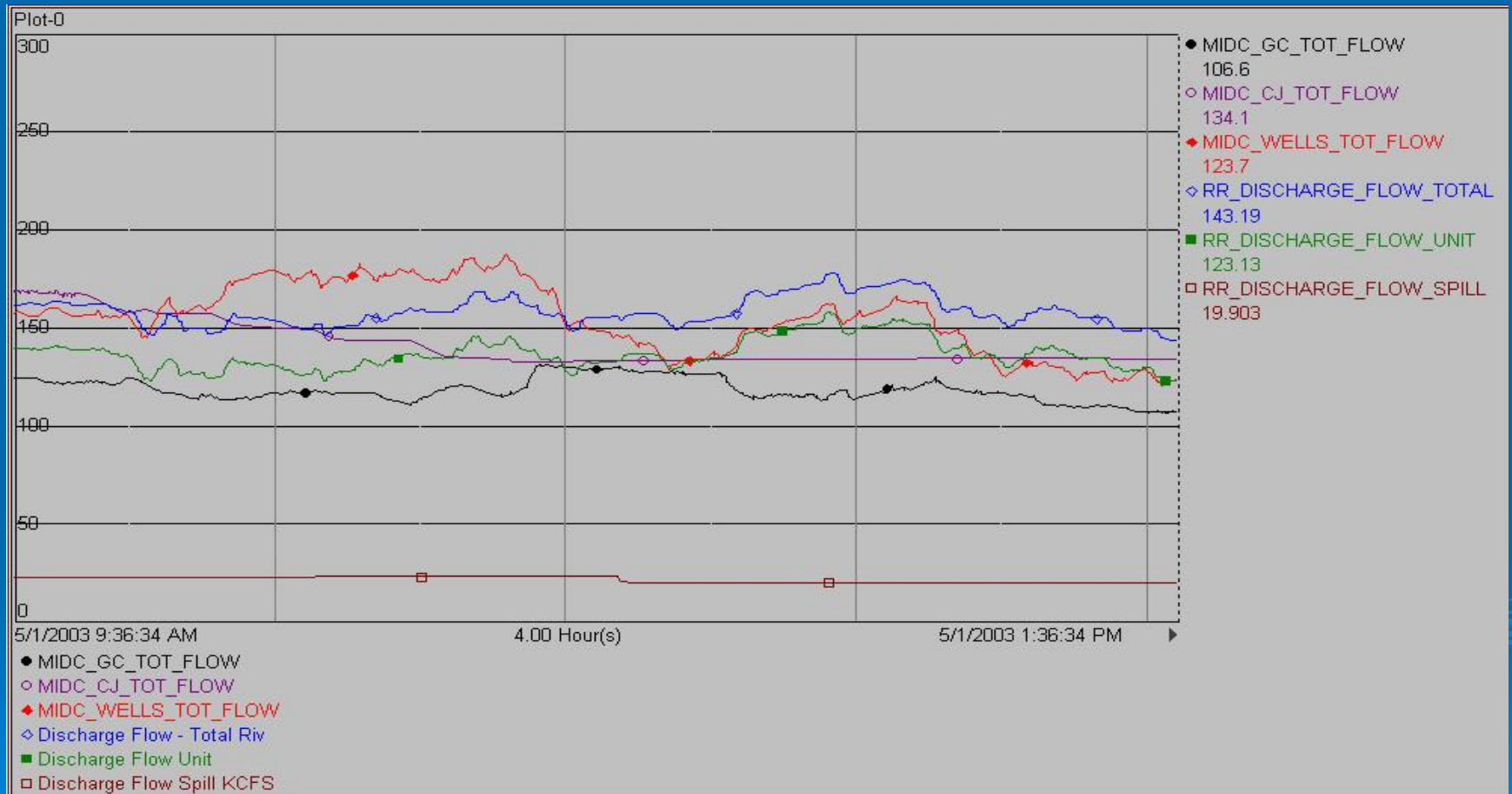
- Cruise Control Monitoring
- Mid Columbia River Flows
- Operator Created Displays
- Transformer Temperature Monitoring
- Bearing Temperature Monitoring
- Unit Vibration Monitoring



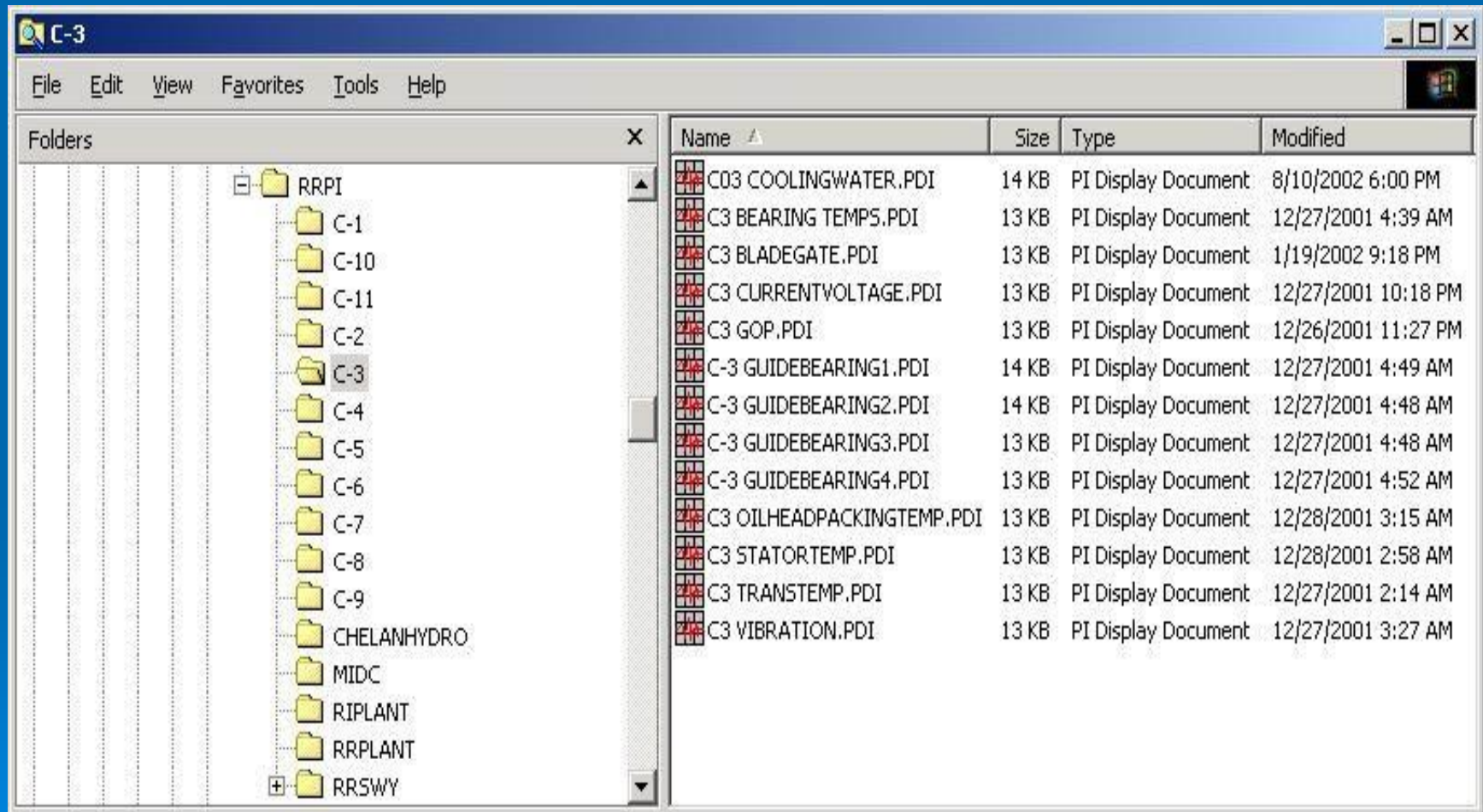
Cruise Control Monitoring



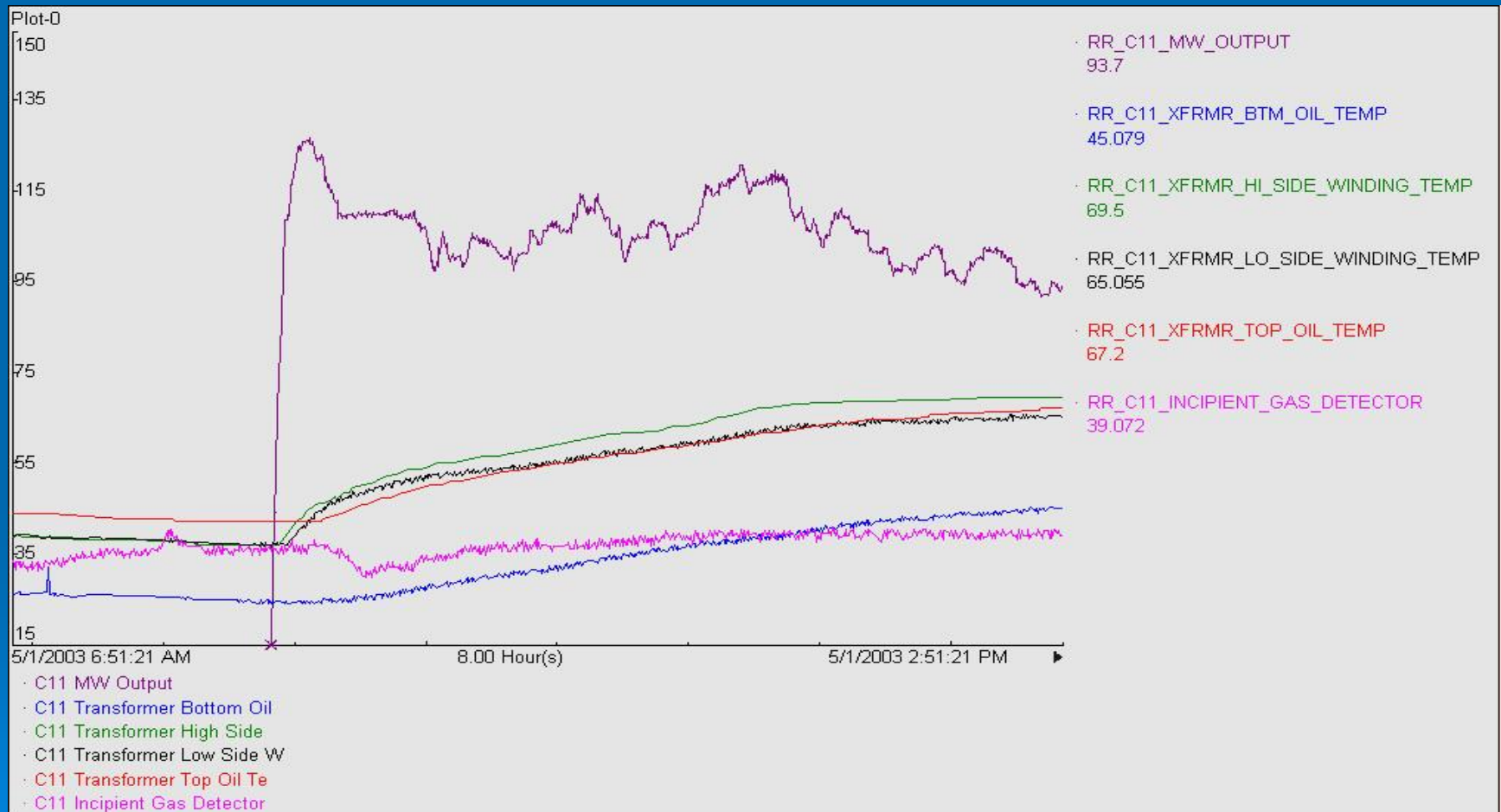
Hydro Operators: River Flows



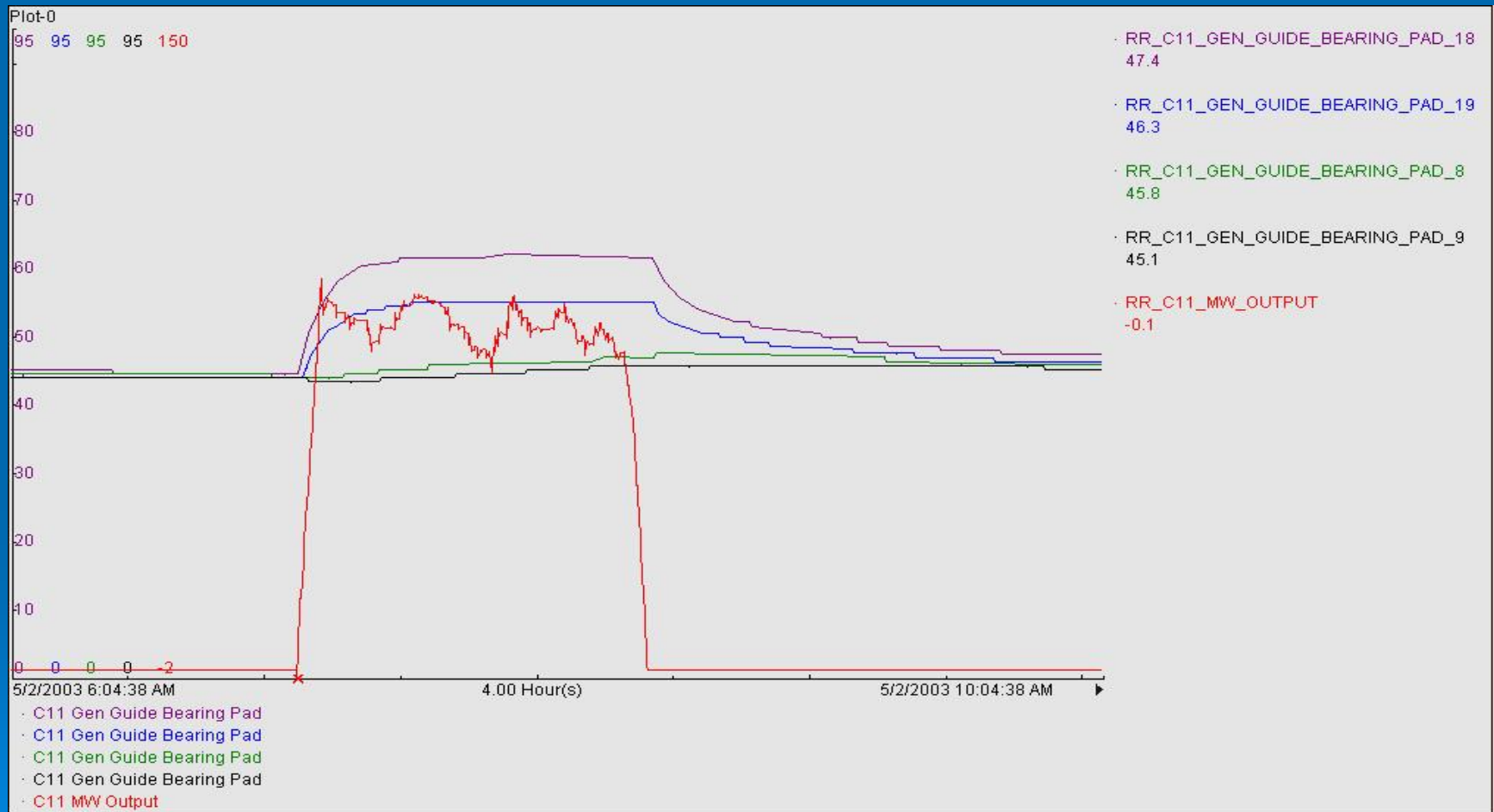
Hydro Operators: They've been busy!



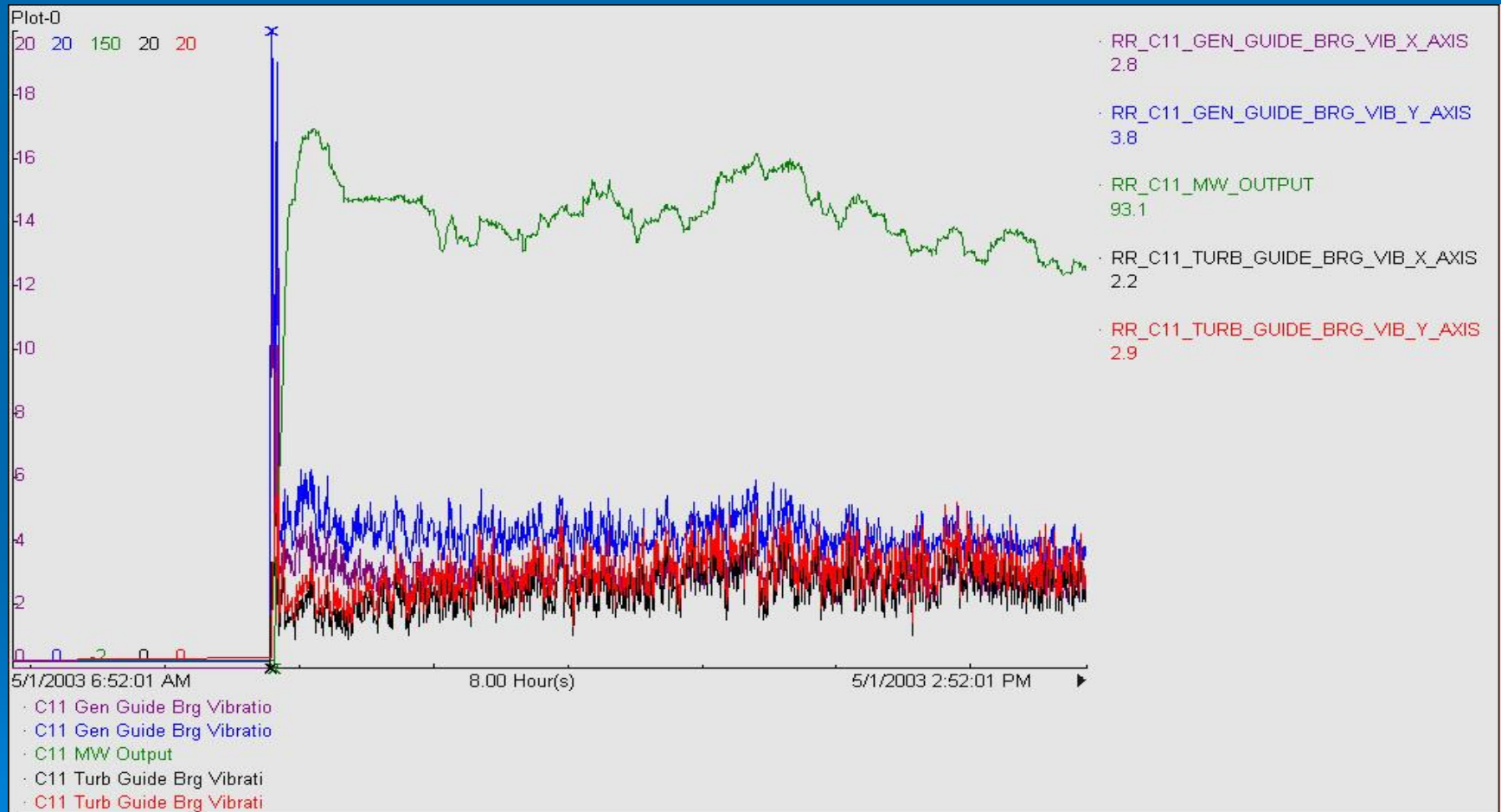
Hydro Operators: Transformer Temperatures



Hydro Operators: Bearing Temperatures



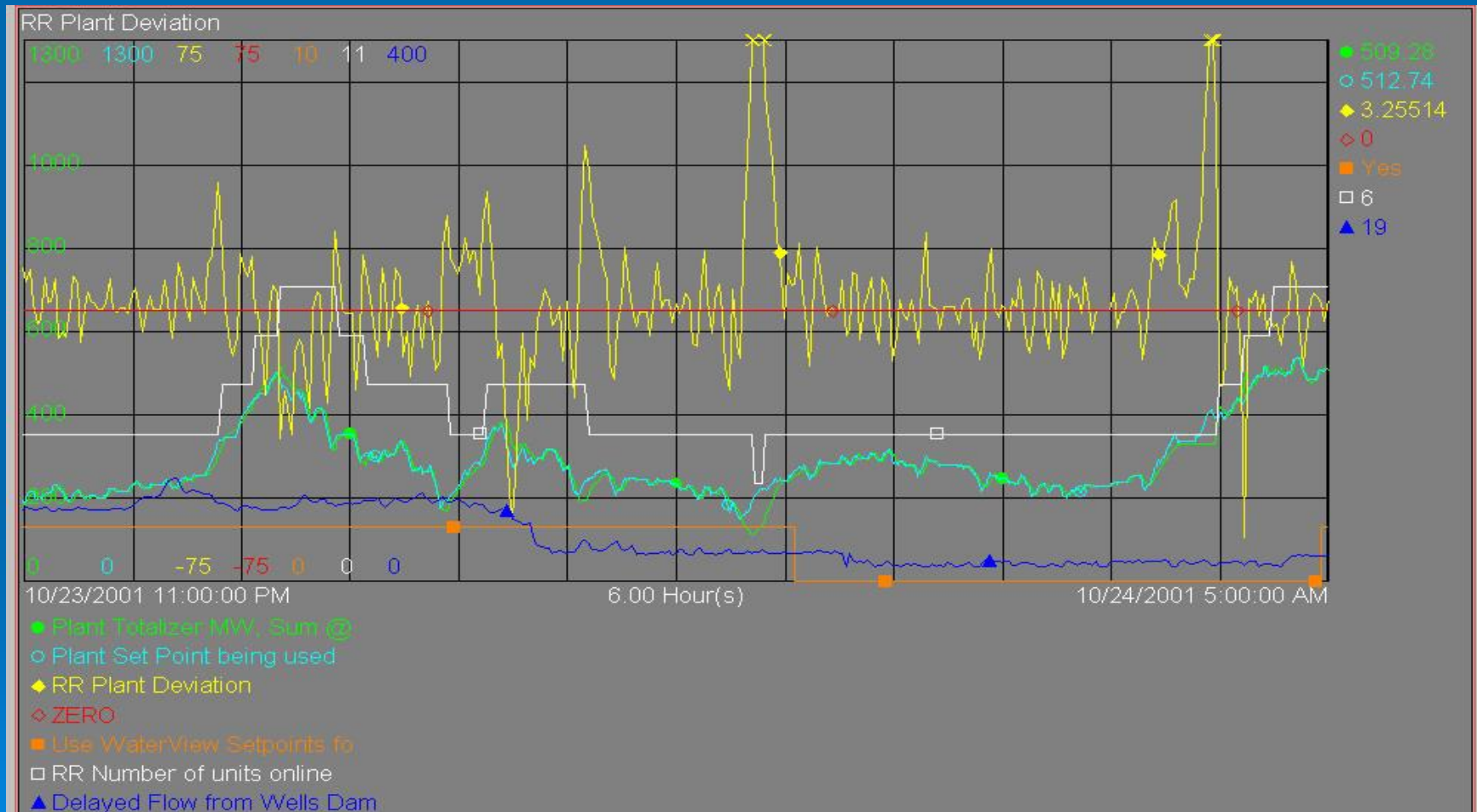
Hydro Operators: Vibration Monitoring



Plant Engineers

- Plant Deviation Analysis
- Temperature Analysis
- Unit Trip and Failed Starts Analysis

Plant Engineers : Plant Deviation



Plant Engineers : Temperature Analysis

Microsoft Excel - PI - RR Temperature Analysis.xls

File Edit View Insert Format Tools Data Window PI Help

Type a question for help

Reply with Changes... End Review...

C6 =PISampDat(C\$5,\$A5,\$A6,\$C\$2,0)

	A	C	N	X	Z	AK	AU	AW	BH	BR	BT	CE	CO	CP
		RR_C02_STAT OR_WDG_TE MP PHASE A	RR_C02_ XFRMR_T OP_OIL_ TEMP		Stator Temp C2	XFRMR Temp C2		Stator Temp C2	XFRMR Temp C2		Stator Temp C2	XFRMR Temp C2		
5	3/28/01 0:00:00													
84	3/28/01 6:35:00	58.2	51.3		4.7	3.0		Increasing	Increasing		.	.		
85	3/28/01 6:40:00	57.9	51.3		4.8	3.0		Increasing	Increasing		.	.		
86	3/28/01 6:45:00	57.5	51.3		5.0	3.4		Increasing	Increasing		.	.		
87	3/28/01 6:50:00	56.9	50.8		4.7	2.9		Increasing	Increasing		.	.		
88	3/28/01 6:55:00	56.1	50.3		4.1	2.4		Increasing	Increasing		.	.		
89	3/28/01 7:00:00	55.7	50.3		3.8	2.4		Increasing	Increasing		.	.		
90	3/28/01 7:05:00	55.9	50.8		4.1	3.4		Increasing	Increasing		.	.		
91	3/28/01 7:10:00	55.6	50.3		4.0	2.9		Decreasing	Increasing		COOLING	.		
92	3/28/01 7:15:00	54.8	49.8		3.1	2.4		Decreasing	Decreasing		.	COOLING		
93	3/28/01 7:20:00	53.9	48.3		2.1	0.4		Decreasing	Decreasing		.	.		
94	3/28/01 7:25:00	52.9	47.3		0.9	-0.6		Decreasing	Decreasing		.	.		
95	3/28/01 7:30:00	52.2	46.3		-0.2	-2.0		Decreasing	Decreasing		.	.		
96	3/28/01 7:35:00	51.8	45.8		-0.9	-2.5		Decreasing	Decreasing		.	.		
97	3/28/01 7:40:00	51.4	44.8		-1.6	-3.5		Decreasing	Decreasing		.	.		
98	3/28/01 7:45:00	51.1	44.3		-1.4	-4.0		Decreasing	Decreasing		.	.		
99	3/28/01 7:50:00	50.9	43.8		-1.4	-4.5		Decreasing	Decreasing		.	.		
100	3/28/01 7:55:00	50.7	43.3		-4.9	-7.0		Decreasing	Decreasing		.	.		
101	3/28/01 8:00:00	50.5	42.8		-7.3	-8.5		Decreasing	Decreasing		.	.		
102	3/28/01 8:05:00	50.2	42.3		-8.0	-9.0		Decreasing	Decreasing		.	.		
103	3/28/01 8:10:00	50.0	41.8		-7.9	-9.5		Decreasing	Decreasing		.	.		
104	3/28/01 8:15:00	49.8	41.3		-7.7	-10.0		Decreasing	Decreasing		.	.		
105	3/28/01 8:20:00	49.6	40.8		-7.3	-10.0		Decreasing	Decreasing		.	.		
106	3/28/01 8:25:00	49.3	40.3		-6.8	-10.0		Decreasing	Decreasing		.	.		
107	3/28/01 8:30:00	49.1	39.9		-6.6	-10.4		Decreasing	Decreasing		.	.		
108	3/28/01 8:35:00	48.8	39.9		-7.1	-10.9		Decreasing	Decreasing		.	.		
109	3/28/01 8:40:00	48.6	39.3		-7.0	-11.0		Increasing	Decreasing		HEATING	.		
110	3/28/01 8:45:00	48.3	38.8		-6.5	-11.0		Increasing	Decreasing		.	.		
111	3/28/01 8:50:00	48.1	38.8		-5.8	-9.5		Increasing	Increasing		.	HEATING		
112	3/28/01 8:55:00	47.8	38.3		-5.1	-9.0		Increasing	Increasing		.	.		
113	3/28/01 9:00:00	47.6	38.3		-4.6	-8.0		Increasing	Increasing		.	.		
114	3/28/01 9:05:00	47.3	37.8		-4.5	-8.0		Increasing	Increasing		.	.		

Ready Calculate NUM

Plant Engineers : Unit Trip/Failed Start Analysis (1)

Microsoft Excel - PI - Unit Trip & Failed Start Analysis with lists new.xls

Type a question for help

J27

	A	B	C	J	P	Q	R	S	T	U
1	Rocky Reach Unit Trips and Failed Starts									
2										
3	Starttime:	9/1/02 12:00 AM								
4	Endtime:	10/1/02 12:00 AM								
5	Unit Trips:									
6	Description			C07						
7	Gen Protective DGP Rel			No Events						
8	Generator Breaker Fail			No Events						
9	Generator Dropping			No Events						
10	Generator Lockout 86G			1						
11	Main Xfmr Lockout 86T			1						
12	Mechanical Lockout Rel			2						
13	Unit Overspeed Trip			No Events						
14	Gen Split Phase Differ			No Events						
15	Trip Generator 86G			No Events						
16	Trip Generator 86M			No Events						
17										
18	Failed Starts:									
19	Start Phase 1 Timeout			2						
20	Start Phase 2 Timeout			No Events						
21	Start Phase 3 Timeout			No Events						
22	Start Phase 4 Timeout			No Events						
23	Start Phase 5 Timeout			No Events						
24										
25										
26										
27										

Transition Count Transition List

Ready Calculate NUM

Plant Engineers :

Unit Trip/Failed Start Analysis (2)

Microsoft Excel - PI - Unit Trip & Failed Start Analysis with lists new.xls

Type a question for help

File Edit View Insert Format Tools Data Window PI Help

Reply with Changes... End Review...

G34

	G	H	I	J	K	L	U	V	AE	AF
1	List of events for each tag (20 max shown)									
3	Starttime for list: 9/1/02 12:00 AM									
4	Endtime for list: 10/1/02 12:00 AM									
5	UNIT: C07									
11	data points: 1		data points: 1		data points: 2		data points: 2			
12	09-Sep-02 09:34:05 TRUE		09-Sep-02 09:34:05 TRUE		30-Sep-02 06:44:34 TRUE		30-Sep-02 06:44:34 TRUE			
13					30-Sep-02 07:50:04 TRUE		30-Sep-02 07:50:04 TRUE			
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										

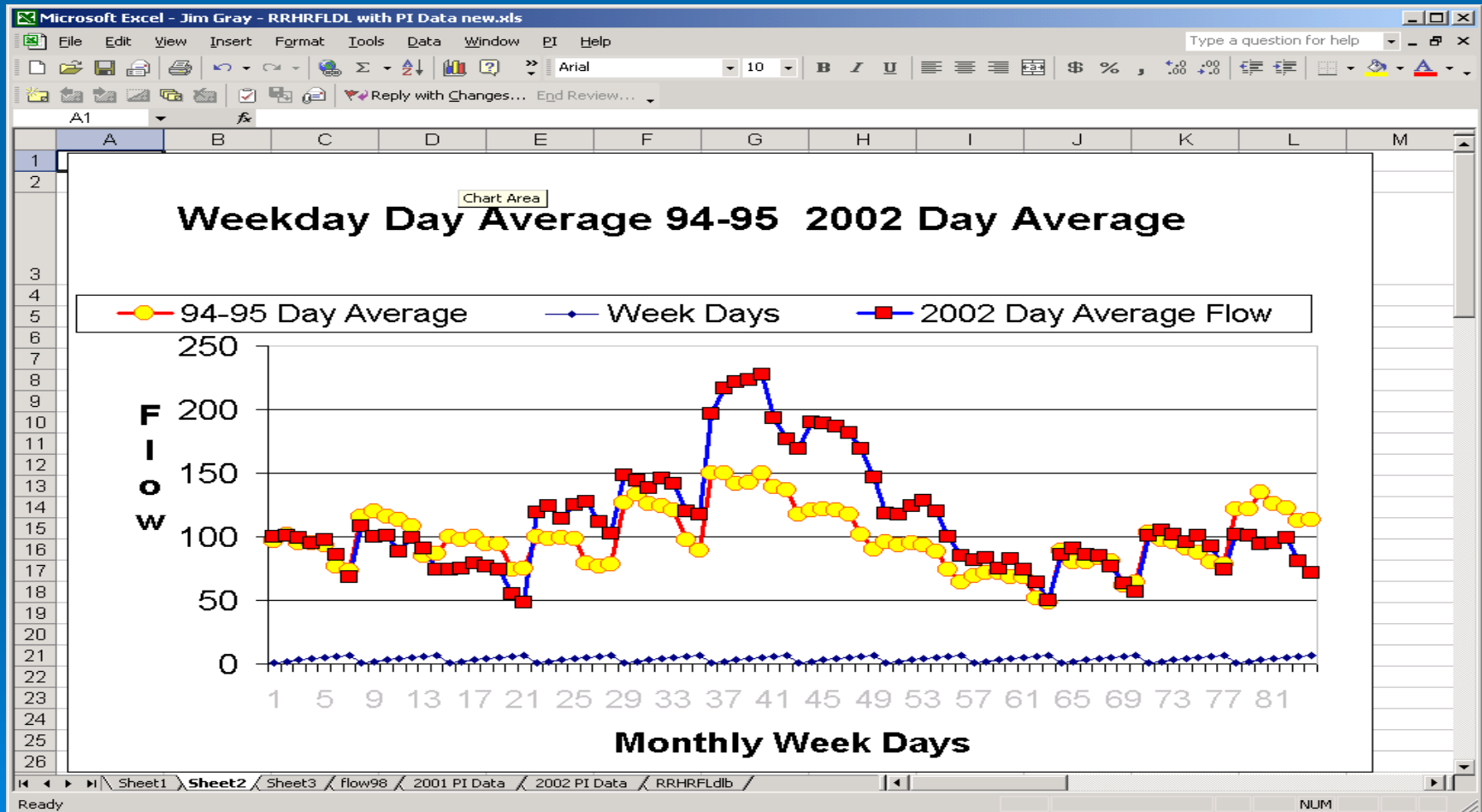
Transition Count Transition List

Ready Calculate NUM

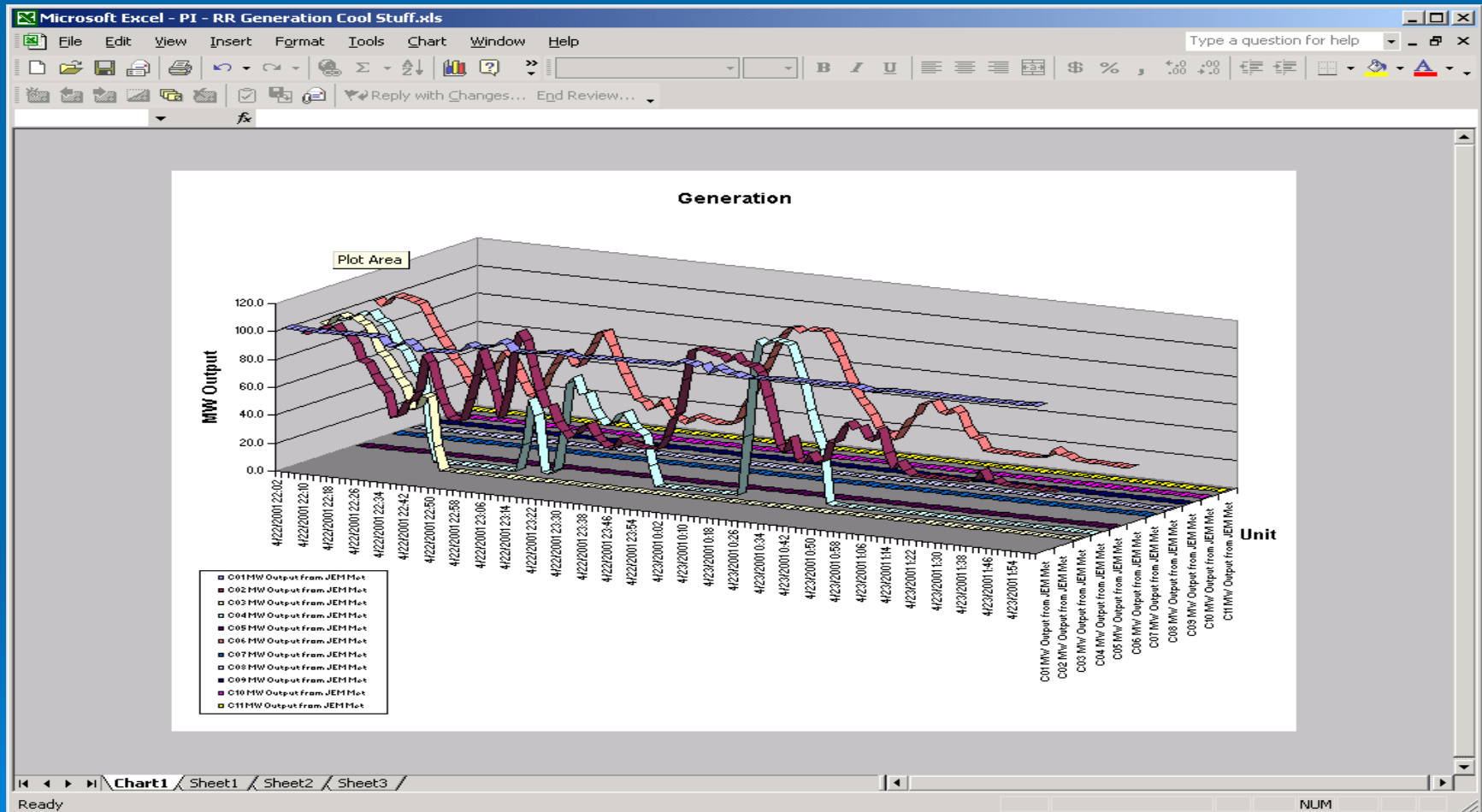
Generation Managers

- River Flow Analysis
- Plant Generation Analysis
- Unit Start/Stop Analysis
- Plant Optimization Analysis

Generation Managers: River Flow Analysis



Generation Managers: Plant Generation Analysis



Generation Managers: Unit Start/Stop Analysis

Microsoft Excel - RR Start Stop Times.xls						
Type a question for help						
E3						
	A	B	C	D	E	F
1	RR STARTS and STOPS Event Listing					
3	Start	1/1/2002				
4	End	1/1/2003				
8	PrevVal('RR_C01_GEN_BREAKER_POSITION') = "CLOSE" AND 'RR_C01_GEN_BREAKER_POSITION' = "OPEN" OR PrevVal('RR_C01_GEN_BREA					
9	RR_C01		RR_C02		RR_C03	
10	data points:	138	data points:	672	data points:	810
11	1/10/02 11:05:21 AM	OPEN	1/1/02 1:39:32 AM	OPEN	1/1/02 1:31:41 AM	OPEN
12	1/10/02 4:19:11 PM	CLOSE	1/1/02 9:26:51 AM	CLOSE	1/1/02 9:59:40 AM	CLOSE
13	1/11/02 2:33:21 PM	OPEN	1/2/02 12:16:10 AM	OPEN	1/2/02 12:13:32 AM	OPEN
14	1/11/02 2:43:11 PM	CLOSE	1/2/02 7:21:02 AM	CLOSE	1/2/02 7:46:11 AM	CLOSE
15	1/16/02 6:05:31 AM	OPEN	1/3/02 2:54:41 AM	OPEN	1/3/02 2:52:21 AM	OPEN
16	1/16/02 9:50:10 AM	CLOSE	1/3/02 4:11:02 AM	CLOSE	1/3/02 5:37:21 AM	CLOSE
17	1/21/02 7:55:11 AM	OPEN	1/3/02 9:11:32 AM	OPEN	1/3/02 9:14:01 AM	OPEN
18	1/23/02 8:10:21 AM	OPEN	1/3/02 10:06:11 AM	CLOSE	1/3/02 10:13:21 AM	CLOSE
19	1/23/02 10:14:32 AM	CLOSE	1/4/02 8:32:51 AM	OPEN	1/4/02 8:36:41 AM	OPEN
20	1/24/02 8:59:20 AM	OPEN	1/4/02 10:24:21 AM	CLOSE	1/4/02 10:44:11 AM	CLOSE
21	1/24/02 10:46:10 AM	CLOSE	1/5/02 3:06:41 AM	OPEN	1/5/02 3:16:11 AM	OPEN
22	1/25/02 7:53:40 AM	OPEN	1/5/02 7:37:21 AM	CLOSE	1/5/02 9:49:41 AM	CLOSE
23	1/25/02 9:19:21 AM	CLOSE	1/5/02 8:09:32 AM	OPEN	1/6/02 12:44:21 AM	OPEN
24	1/27/02 2:16:01 PM	OPEN	1/5/02 9:07:31 AM	CLOSE	1/6/02 8:16:12 AM	CLOSE
25	1/27/02 2:17:01 PM	CLOSE	1/6/02 1:35:40 AM	OPEN	1/6/02 2:25:21 PM	OPEN

Generation Managers: Plant Optimization Analysis (1)

Microsoft Excel - RI WY start stop report.xls

File Edit View Insert Format Tools Data Window PI Help

Type a question for help

B3 =SUM(H3,J3,L3,N3,P3,R3,T3,V3,X3,Z3,AC3,AE3,AG3,AI3,AK3,AM3,AQ3)

	A	B	C	D	E	F	H	I	J	K	L	M	N
1	RI START/STOP REDUCTIONS						<u>Virtual</u> <u>Unit B1</u>	<u>Actual</u> <u>Unit B1</u>	<u>Virtual</u> <u>Unit B2</u>	<u>Actual</u> <u>Unit B2</u>	<u>Virtual</u> <u>Unit B3</u>	<u>Actual</u> <u>Unit B3</u>	<u>Virtual</u> <u>Unit B4</u>
		Virtual # of starts for time period	Virtual # of stops for time period	Actual # of starts for time period	Actual # of stops for time period		RI_B1_W V_VIRTUA L_MW_S ETPOINT	RI_B1_M W_OUTP UT	RI_B2_W V_VIRTUA L_MW_S ETPOINT	RI_B2_M W_OUTP UT	RI_B3_W V_VIRTUA L_MW_S ETPOINT	RI_B3_M W_OUTP UT	RI_B4_W V_VIRTUA L_MW_S ETPOINT
2	1/1/02 0:00:00												
15	8/1/02 0:00:00	549	599	250	243		23	19	59	15	19	16	4
16			reduction:	54.5%	59.4%		25	18	60	13	21	15	4
17	9/1/02 0:00:00	1004	1021	378	376		14	7	46	6	8	4	1
18			reduction:	62.4%	63.2%		14	7	46	6	8	4	1
19	10/1/02 0:00:00	778	782	437	434		47	18	74	12	31	2	
20			reduction:	43.8%	44.5%		44	18	74	12	33	2	
21	11/1/02 0:00:00	1070	1083	454	452		196	40	NOSTARTS	NOSTARTS	261	14	3
22			reduction:	57.6%	58.3%		197	39	NOSTOPS	NOSTOPS	262	13	4
23	12/1/02 0:00:00	1152	1160	455	458		218	47	47	10	259	17	7
24			reduction:	60.5%	60.5%		218	48	47	11	259	17	7
25	1/1/03 0:00:00	943	949	459	451		168	46	107	31	151	21	3
26			reduction:	51.3%	52.5%		169	46	111	29	149	20	3
27	2/1/03 0:00:00	830	835	503	497		98	36	6	5	159	16	
28			reduction:	39.4%	40.5%		99	36	6	5	163	16	
29	3/1/03 0:00:00	662	659	451	457		51	34	NOSTARTS	NOSTARTS	117	15	5
30			reduction:	31.9%	30.7%		51	35	NOSTOPS	NOSTOPS	118	15	5
31	Total	11423	11515	6090	6075								
32													
33			Reduction (#):	5333	5440								
34			Reduction (%):	46.7%	47.2%								
35													
36													
37													

Sheet1 Sheet2

Ready NUM

Generation Managers: Plant Optimization Analysis (2)

The screenshot displays a Microsoft Excel spreadsheet titled "Microsoft Excel - WV Analysis for RI and RR.xls". The interface includes standard menu bars (File, Edit, View, Insert, Format, Tools, Data, Window, PI, Help) and a toolbar with various icons. A search bar at the top right contains the text "Type a question for help".

The main data area shows a worksheet named "Sheet1" with columns labeled A through I. The active cell is B3, containing the date "4/30/2003".

WATERVIEW ENABLED/DISABLED ANALYSIS

	A	B	C	D	E	F	G	H	I
1	<u>WATERVIEW ENABLED/DISABLED ANALYSIS</u>								
2									
3	Choose Date:	4/30/2003	CALENDAR	Prev . Day	Next Day				
4	Choose Plant:	RI							
5			<u>Waterview ON</u>			<u>Waterview OFF</u>			
6			Time	Percent		Time	Percent		
7	Shift 1 Start:	4/30/03 7:00 AM	12:00:00	100.0%		0:00:00	0.0%	(0.0% missing data)	
8	Shift 1 End:	4/30/03 7:00 PM							
9	Shift 2 Start:	4/30/03 7:00 PM	11:52:37	99.0%		0:07:23	1.0%	(0.0% missing data)	
10	Shift 2 End:	5/1/03 7:00 AM							
11									
19		<u>Shift 1 - Events (35 max shown)</u>				<u>Shift 2 - Events (35 max shown)</u>			
20		No Events	No Events			data points:	4		
21		No Events	No Events			10:29:02 PM	Disabled		
22		No Events	No Events			10:29:30 PM	Enabled		
23		No Events	No Events			10:29:37 PM	Disabled		
24		No Events	No Events			10:36:32 PM	Enabled		
25		No Events	No Events						
26		No Events	No Events						
27		No Events	No Events						
28		No Events	No Events						
29		No Events	No Events						

The status bar at the bottom indicates "Ready" and "NUM".

Summary

- Many users throughout the organization use PI for differing reasons
- Trending is heavily used by the operators
- Data Gathering/Analysis is used by the engineers and managers
- The ease of Trending and Data gathering has taken much of the burden off of the Control Systems Analysts