

Memo



Date: July 5, 2007
To: Kevin Stewart and Chad Kudym
From: Markus Ritsch
Subject: June 2007 ALERT Data Analysis

I. ALERT Data Source

Raw ALERT data records extracted from the Urban Drainage and Flood Control District's Nova Star 4.0 base station (ALERT 2) were analyzed for the period June 1 through June 30, 2007.

II. General System Analysis Summary

A total of 259,586 individual data records were analyzed. Meteorological sensors accounted for approximately 56 percent, water level sensors 14 percent and rain sensors 4 percent of the total monthly reports.

Ninety-nine percent of the received data reports were flagged as "good" by the Nova Star validation process. Roughly 3,392 reports were flagged as "bad". Of these "bad" reports, 2,823 originated from the wind sensor (ID 2189 and 2187) at Squaw Mountain.

The system-wide radio traffic loading this month was 8,653 reports per day with an average hourly loading of 361 reports. The peak hourly traffic load in terms of reports received at the base station was 1,005 reports, which occurred on June 12th between 3:00 PM and 4:00 PM. The actual number of reports during this hour was higher, probably on the order of 1,100 to 1,200 reports. A plot of monthly average and peak hourly traffic loading is provided.

A total of 1,425 rain tip reports were received from the Hayman gages this month. The Hayman gages accounted for less than 1% of the monthly total received radio traffic.

The sensors reporting most frequently this month include:

1. Boulder Creek at Broadway (ID 4583) with 10,000 reports,
2. Salisbury Park (ID 2727) with 3,692 reports,
3. Stapleton (ID 1461) with 3,648 reports,
4. Englewood Dam (ID 1603) with 3,348 reports,
5. Quincy Reservoir (ID 747) with 3,004 reports,
6. Green Ditch (ID 4593) with 2,914 reports, and
7. Marston Lake North (ID 1521) with 2,783 reports.

The sensors reporting infrequently this month include:

1. Simms Street (ID 130) with 1 report,
2. SPR at Dartmouth (ID 1626) with 2 reports,
3. Van Bibber @ Hwy 93 (ID 333) with 2 reports,
4. Iliff Pond (ID 654) with 3 reports,
5. Lena @ U.S. Hwy 6 (ID 1043) with 2 reports, and
6. SBC at San Souci (ID 4830, 4835, 4833) with 12 reports.

III. Rain Sensor Timer Reporting Summary

The following analysis assumes that each rain sensor has a 12-hour timer reporting interval. System-wide the ALERT 2 base station received approximately 89 percent of the non-incrementing timer reports. The 5 worst-performing rain sensors for the month are summarized (Table 1).

Table 1. Monthly Summary of Sensors with Poor Timer Performance

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
750	1330	2310	1810	1810	1810						
4470	1460	1710	540	310	1710						
4560	2330	2350	310	540	4470						
4240	4170	2240	850	850	1500						
4510	4470	2250	1710	1710	4290						
				900	540						

Sand Cr at Mouth (1810), Parker/Mississippi (540), Shop Creek (1710), Little Narrows (4470), Powers Park (1500), and Red Hill (4290)

Sensors identified as having poor timer performance in multiple months are shaded with unique colors. A developing trend can thus be identified from the color shading as the year progresses.

Sensor ID 1460 has a 24-hour timer reporting interval and is not included in the timer reporting analysis.

IV. Rain Sensor Event Reporting Summary

A. District-Wide Total Tip/Count Statistics

The incrementing reports from all 1-mm rain sensors (excluding Hayman sensors) that reported for the entire month were analyzed to quantify the District-wide statistical total monthly tip summary (Table 2).

Table 2. District-Wide Total Tip/Count Statistical Summary

Statistical Parameter	Value	Comments
Mean	15.87	Only the 1-mm rain sensors were included in the analysis
Median	13	Only the 1-mm rain sensors were included in the analysis
Standard deviation	12.0	Only the 1-mm rain sensors were included in the analysis
Mean plus three standard deviations	51.94	Several sensors for the month are outside the Mean +/- 3 Std Dev
Minimum total count	4	Gunbarrel (ID 1110)
Maximum total count	106	Powers Park (ID 1500)

A monthly summary of the District-wide mean total tip/count is presented (Table 3).

Table 3. Monthly Summary of District-Wide Mean Total 1-mm Tip/Count

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
2006	4.62	5.92	18.39	20.47	19.44	13.75	74.03	46.89	24.17	41.13	5.04	16.45	24.19
2007	11.56	5.40	29.75	65.03	68.30	15.87							

The average precipitation experienced district-wide in June was decreased from the previous months of April and May. The District-wide precipitation experienced in June of 2007 was close to that experienced in the same month in 2006.

The rain sensor with the minimum tip count total for the month was Gunbarrel (ID 110). This sensor did report for the entire month.

Several sensors experienced a total tip count of more than the system-wide mean plus 3 standard deviations including Powers Park (ID 1500), Expo Park (ID 420) and Temple Pond at DTC (ID 630).

B. Sensors with a Jump of Six or More in the Sequential Count

Two rain sensors experienced a jump in their sequential tip count of more than six. The tip count series for these sensors was manually inspected and discussed in the following paragraphs.

Ralston Reservoir (ID 110)

On June 12th and 13th the count value jumped from 163 to 172 at 12:42:36 PM. The count value of 172 was a timer transmission. The total jump in count of 9 was validated by the base station.

Date/Time	Sensor ID	Count
6/11/2007 12:50:27 PM	110	162
6/12/2007 12:48:28 AM	110	162
6/12/2007 3:12:56 PM	110	163
6/13/2007 12:42:36 PM	110	172
6/14/2007 12:40:36 AM	110	172
6/14/2007 12:38:39 PM	110	172

Elbert (ID 1440)

On June 28th at 9:04:35 AM a new data series is received at the base station on ID 1440. The count series as followed for the month terminates at 336 on June 28th on at timer report received at 12:05:17 AM. At approximately 9:00 AM on the June 28th a new series is evident that begins at count value 69 and counts up to a value of 78 by 11:00:00 AM on June 28th. The count then jumps back to 336 at the timer interval of June 28th at 12:05:16 PM.

A second independent ALERT transmitter was sending incrementing count values on June 28th which confused the base station to erroneously count incrementing tip count values.

The total rainfall accumulation validated at the base station is in error because of the incrementing tip counts added by the second series of data transmissions.

Date/Time	Sensor ID	Count
6/27/2007 12:05:18 AM	1440	336
6/27/2007 12:05:16 PM	1440	336
6/27/2007 6:03:33 PM	1440	108
6/28/2007 12:05:17 AM	1440	336
6/28/2007 9:04:35 AM	1440	69
6/28/2007 9:04:54 AM	1440	71
6/28/2007 10:51:56 AM	1440	72
6/28/2007 10:52:16 AM	1440	72
6/28/2007 10:54:33 AM	1440	72
6/28/2007 10:54:53 AM	1440	73
6/28/2007 10:58:43 AM	1440	73
6/28/2007 10:59:03 AM	1440	75
6/28/2007 10:59:39 AM	1440	75
6/28/2007 11:00:00 AM	1440	78
6/28/2007 12:05:16 PM	1440	336
6/29/2007 12:05:17 AM	1440	336
6/29/2007 12:05:16 PM	1440	336

C. Sensor-by-Sensor Incrementing Count Summary

The system-wide reception rate of incrementing, 1-mm, tip reports for the month was approximately 88 percent. A total of 2,063 incrementing reports were received and a total of 2,333 were expected. The total loss of incrementing reports for the month was approximately 12 percent. Those sensors with the worst rain event transmission performance characteristics are summarized (Table 4).

Table 4. Monthly Summary of Sensors with the Most Missed Tips

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2320	1330	540	1350	860	1710						
2190	4080	310	310	4710	1350						
4710	1640	4470	1100	1810	310						
4090	4050	850	860	1350	1700						
4820	4180	4570	540	400	210						
				4570	110						

* Shop Creek (1710), Chatfield COE (1350), Guy Hill Ranch (310), Cherry Creek at Champa (1700), Leyden Confluence (210), Ralston Reservoir (110)

Sensors identified as having poor event performance in multiple months are shaded with unique colors. A developing trend can thus be identified from the color shading as the year progresses.

Shop Creek (ID 1710)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

Chatfield COE (ID 1350)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

Guy Hill Ranch (ID 310)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

Cherry Creek at Champa (ID 1700)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

Leyden Confluence (ID 210)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

Ralston Reservoir (ID 110)

This sensor reported data for the entire month and experienced numerous missing reports on June 12th which was a day with heavy rainfall.

The majority of missing reports system-wide occurred on June 12th when a high intensity storm moved through the district. This day also produced the hour of peak radio traffic.

V. Heavy Radio Traffic Hour Analysis

Periods exceeding 600 messages per hour are analyzed independently in an attempt to identify rain gage sequences where 3, or more, sequential messages were lost. For the month there were 6 occurrences where a rain sensor missed 3 sequential incrementing reports, 2 occurrences where a rain sensor missed 4 sequential incrementing reports and 2 occurrences of missing 5 sequential reports.

A. June 12, 2007

The heaviest radio traffic for the month occurred on June 12th when a series of severe thunderstorms developed between 2:00 PM and 7:00 PM.

Several occurrences of hourly traffic exceeding 600 messages were identified.

- 6/12/2007 from 2:00 pm to 3:00 pm (615 reports)
- 6/12/2007 from 3:00 pm to 4:00 pm (1,005 reports)
- 6/12/2007 from 4:00 pm to 5:00 pm (884 reports)
- 6/12/2007 from 5:00 pm to 6:00 pm (649 reports)
- 6/12/2007 from 6:00 pm to 7:00 pm (551 reports)

The peak hour of traffic occurred on June 12th from 3:00 PM to 4:00 PM when 1,005 reports were received. The period of heaviest traffic was generally a 5 hour period from 2:00 PM to 7:00 PM. The ALERT data for this period was examined more closely to characterize the distribution of sensor traffic (Table 5). During this time the radio traffic was dominated by rain and water level reports.

Table 5. Peak Traffic Period Sensor Report Distribution

Sensor Group	Reports	Percent
Precipitation	1,216	33%
Water Level PT-HSE	943	25%
None-ALERT-ID	215	6%
Precipitation - Mean	200	5%
Wind Gust	196	5%
Temperature	142	4%
Wind Speed Average & Azimuth	128	3%
Relative Humidity	125	3%
Wind Direction	109	3%
Hayman Precipitation	103	3%
Water Level PT	82	2%
Wind Speed Average	69	2%
Water Level Float	55	1%
Battery Voltage HSE	30	1%
Solar Radiation	17	0%
Battery Voltage Analog	16	0%
Battery Voltage Digital	15	0%
Barometric Pressure	11	0%
Fuel Moisture	8	0%
Fuel Temperature	7	0%
Handar 585 ALARM Status	4	0%
Repeater Pass List	3	0%
Repeater Status Report	3	0%
12Hr Status Report	2	0%
Soil Moisture	2	0%
Longmont Flow Gage	1	0%
Precipitation - Test	1	0%
Total	3,703	100.0%

Incrementing rain records for the period were examined to characterize the loss of sequential incrementing tip transmissions (Table 6).

Table 6. Peak Traffic Analysis - Loss of Incrementing Tip Reports

Heavy Traffic Period June 12, 2007	Occurrences of loss of sequential tip reports during 4-hour period			
	Loss of 2 tips	Loss of 3 tips	Loss of 4 tips	Loss of 5 tips
2:00 pm to 7:00 pm	22	3	1	2

Lost rain reports are evident during the entire 5 hour period on June 12th from 2:00 pm to 7:00 pm. The majority of lost reports include single and double tip reports. The loss of 3 or more sequential tip reports occurred a total of 6 times.

Sixteen percent of the incrementing rain reports were lost during the storm period.

Three rain sensors experienced lost reports that exceeded 3 sequential counts. These rain sensor IDs include: 310, 2280, and 2340. One rain sensor, ID 1620 missed 4 sequential tip count values. Two rain sensors, IDs 310 and 1710 missed 5 sequential tips.

The loss of 3 or more sequential data reports forms a limit of data degradation that causes a serious problem in the evaluation of alarm threshold conditions to support the flood mitigation needs of emergency responders within the District. The loss of sequential reports is a problem at stream sensors because it could cause the delay in triggering critical alarm conditions.

A water level sensor located at Union Avenue is programmed to report 4 times each hour. Periods where 1 sequential report is missing are evident from the data record (Figure 1). More than 2 missing reports are not evident.

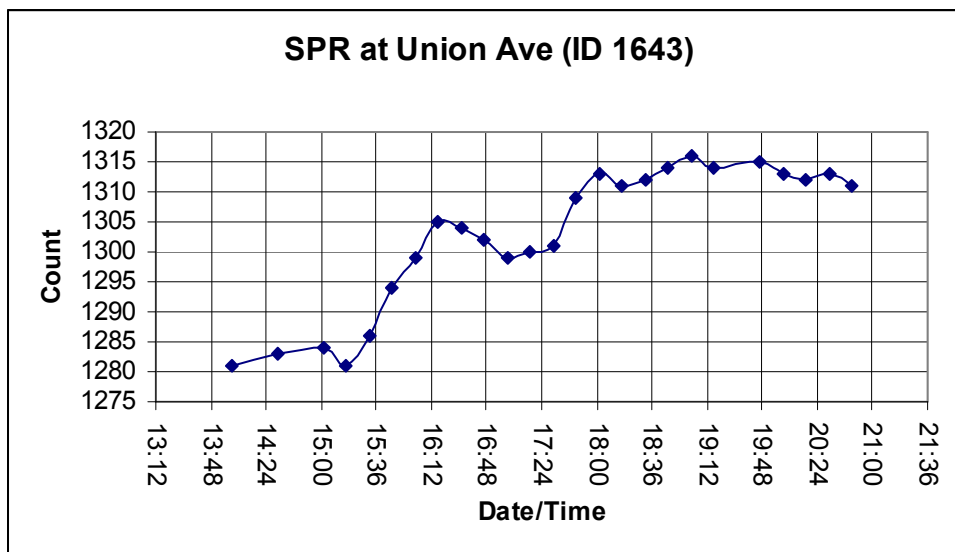


Figure 1. SPR at Union Ave Water Level Plot for June 12 Storm Period

VI. Unknown Device Analysis – Received Data Log

The ALERT IDs present in the audio signal received by the decoder are compared against a list of “active” device IDs that are defined within NovaStar. Those IDs received by the decoder that are not defined within NovaStar are considered to be “unknown” and may be the result of radio noise or problems with the telemetry system. The reception of “unknown” device reports for the month is summarized (Table 7).

Table 7. Summary of Unknown IDs

Description	Quantity
Total number of unknown IDs (IDs without a device definition)	147
Total reports from unknown IDs	593
Unknown IDs with only a single received report (potential noise)	112
Total reports from all IDs – RecData Log entire month	225,337
Unknown reports as a fraction of total active “known” reports	0.26%

The total number of reports from unknown sensor IDs is small relative to the total reports received for the month from the active sensors.

A number of “unknown” sensors had multiple reports which may indicate the existence of a transmitter that is sending information on an ID that is not currently defined within NovaStar. The unknown IDs with multiple reports including the number of reports received by each are quantified (Table 8).

Table 8. Reports Received by Unknown IDs

Unknown Sensor ID	Number of Reports
2754	213
4095	57
2239	57
4013	53
1470	14

Unknown Sensor ID	Number of Reports
4031	9
1316	7
1312	6
4601	5
1314	4
1311	4

The “unknown” device reports were analyzed temporally to understand when they were received during the day (Table 9). The goal of this analysis is to determine a pattern of occurrence that may correspond to a source of noise in the system, such as the use of a wireless microphone nearby.

Table 9. Temporal Distribution of Unknown Reports

Hour (AM)	Reports	Hour (PM)	Reports
0:00-00:59	6	12:00-12:59	19
1:00-1:59	33	1:00-1:59	35
2:00-2:59	6	2:00-2:59	9
3:00-3:59	12	3:00-3:59	15
4:00-4:59	32	4:00-4:59	38
5:00-5:59	9	5:00-5:59	27
6:00-6:59	30	6:00-6:59	29
7:00-7:59	59	7:00-7:59	54
8:00-8:59	15	8:00-8:59	14
9:00-9:59	39	9:00-9:59	36
10:00-10:59	35	10:00-10:59	30
11:00-11:59	7	11:00-11:59	4

Unknown reports were received during each hour and their distribution throughout the day is shown (Figure 2). The unknown device reports seem to peak at 7:00 am to 8:00 am in the morning then again at 7:00 pm to 8:00 pm in the evening.

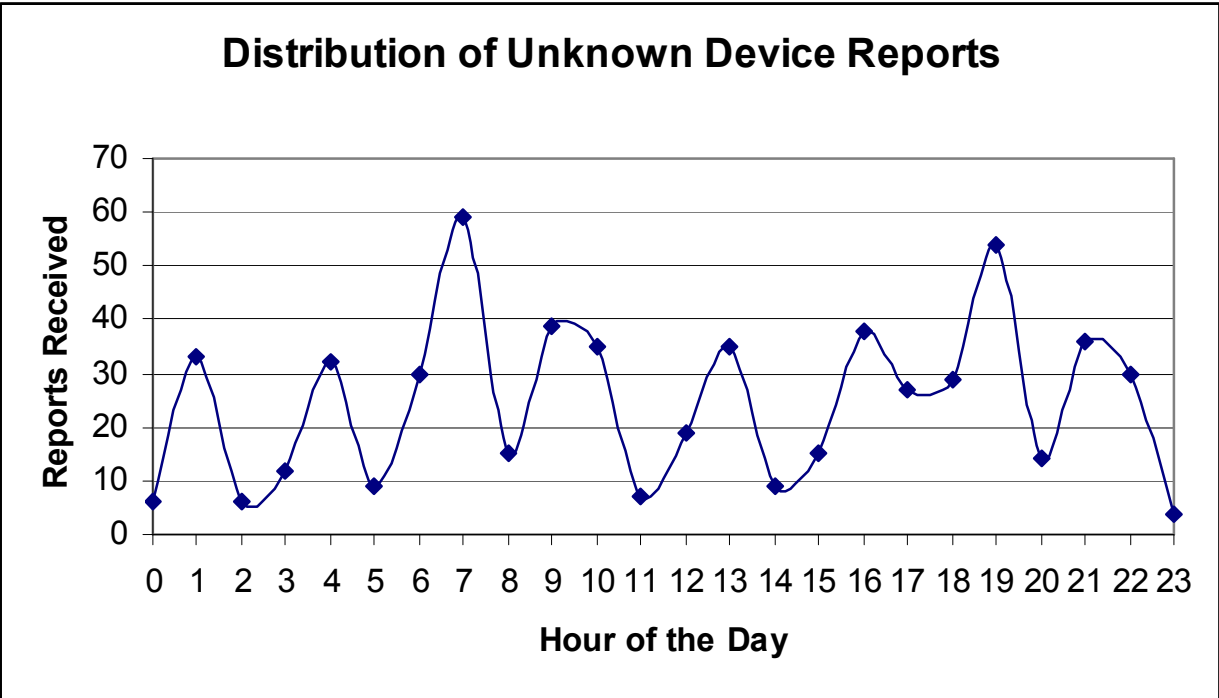


Figure 2. Daily Distribution of Unknown Device Reports

VII. Issues Continued from Previous Month

The following issues were identified last month.

1. **Boulder Jail (ID 4550):** This sensor stopped reporting on May 7, 2007.
2. **Sand Cr at Mouth (ID 1810), Parker/Mississippi (ID 540), Guy Hill Ranch (ID 310), Flying J (ID 850), and Shop Creek (ID 1710):** These sensors all exhibited poor timer performance for the second month in a row.
3. **Sand Creek at Mouth (ID 1810):** This sensor was missing data for a 9 day period extending from May 7th through May 16th.
4. **Aurora Reservoir (ID 900):** This sensor had poor event and timer transmissions characteristics.
5. **Ward C-1 (ID 4710):** On May 2nd the tip count value from this sensor jumps from 663 to 687 in a span of 25 seconds. A total jump of 24 tips was validated by the base station which equates to approximately 0.94 inches of rain in a 25 second period. Was maintenance performed on this sensor during this period?
6. **Storm of May 14, 2007:** Thirty (30) percent of the incrementing rain reports were lost during the 4-hour storm period on May 14 from 7:00 PM to 11:00 PM. The evening of May 14 was a busy period in terms of radio traffic. The peak hour of radio traffic occurred between 7:00 PM and 8:00 PM when approximately 1,341 reports were received at the base station and approximately 1,800 reports/hour or more were actually transmitted (1,341 plus 30% loss of rain transmissions and does not include lost water level reports).
7. Twelve rain sensors experienced lost reports that exceeded 3 sequential counts during the May 14 storm. These rain sensor IDs include: 700, 730, 1710, 400, 410, 440, 620, 760, 1320, 1460, 1800, and 2330. Eight rain sensors, IDs 760, 1800, 420, 650, 800, 840, 900, and 1700 had multiple occurrences of missing 4 sequential tip count values.
8. A number of “unknown” sensors had multiple reports which may indicate the existence of a transmitter that is sending information on an ID that is not currently defined within NovaStar.

Unknown Sensor ID	Number of Reports
2754	251
4095	61
2239	60
4013	56
1339	16
1470	15
1327	12
2200	7
2204	7
754	4
4139	4

VIII. Issues Identified this Month

Further investigation into the following issues is recommended:

1. Those sensors reporting most frequently this month include:
 - Boulder Creek at Broadway (ID 4583) with 10,000 reports,
 - Salisbury Park (ID 2727) with 3,692 reports,
 - Stapleton (ID 1461) with 3,648 reports,
 - Englewood Dam (ID 1603) with 3,348 reports,
 - Quincy Reservoir (ID 747) with 3,004 reports,
 - Green Ditch (ID 4593) with 2,914 reports, and
 - Marston Lake North (ID 1521) with 2,783 reports.
2. The following sensors reported infrequently this month and should be inspected:
 - Simms Street (ID 130) with 1 report,
 - SPR at Dartmouth (ID 1626) with 2 reports,
 - Van Bibber @ Hwy 93 (ID 333) with 2 reports,
 - Iliff Pond (ID 654) with 3 reports, and
 - Lena @ U.S. Hwy 6 (ID 1043) with 2 reports.
3. **Boulder Creek at Broadway (ID 4583):** This sensor reported 10,000 times or almost 14 times per hour for the month. A reporting frequency of 1 report every 4 minutes seems excessive. This location should be inspected and its reporting criteria evaluated.
4. **SBC at San Souci (ID 4830):** This station stopped reporting on June 7, 2007.
5. **Sand Cr at Mouth (ID 1810), Parker/Mississippi (ID 540), Shop Creek (ID 1710) and Little Narrows (ID 4470):** These sensors all had poor timer performance for the past several months.
6. **Shop Creek (1710), Chatfield COE (1350), Guy Hill Ranch (310), Cherry Creek at Champa (1700), Leyden Confluence (210), Ralston Reservoir (110):** These sensors all exhibited poor event performance for the month. The loss of incrementing reports occurred primarily on June 12th during a heavy precipitation period from approximately 2:00 PM to 7:00 PM.
7. **Ralston Reservoir (ID 110):** The incrementing tip count series missed 9 incrementing reports on June 12th and did not catch up to the correct count until the timer report on June 13th.
8. **Elbert (ID 1440):** On June 28th at 9:04:35 AM a new data series is received at the base station on ID 1440. The month-long count series terminates at 336 on June 28th on at timer report received at 12:05:17 AM. At approximately 9:00 AM on the June 28th a new series is evident that begins at count value 69 and counts up to a value of 78 by 11:00:00 AM on June 28th. The count then jumps back to 336 at the timer interval of June 28th at 12:05:16 PM. A second independent ALERT transmitter may have sent incrementing count values on June 28th which confused the base station. The total rainfall accumulation validated at the base station is in error because of the incrementing tip counts added by the second series of data transmissions. Was it possible that a field calibration took place elsewhere in the system and the transmitter being calibrated was accidentally set to ID 1440?
9. **Apple Valley Rain Sensor (ID 4490):** This sensor showed 10 tips of rain for the period June 6 through June 7. The rain total for this station was compared against the total rainfall from NEXRAD Level-III and against the CoCoRaHS observer network. The NEXRAD radar scans show no precipitation at the Apple Valley rain gage for the period. The CoCoRaHS network has two observers near to the Apple Valley rain sensor and both observers recorded no rainfall for the two day period. **Why does the Apple Valley rain**

gage show 10 tips of rain for the period June 6 through June 7 when no one else recorded any rain? Our hypothesis is that movement in the standpipe caused artificial rain tips during the high winds experienced for the two days between June 6 and June 7. The Apple Valley rain gage should be inspected to confirm its structural rigidity to resist movement in the tipping bucket during high wind situations.

10. **Reports from “Unknown” Sensor IDs:** The following table shows the “unknown” sensor IDs and the total number of reports received during the month. These reports indicate the existence of a transmitter that is sending information on an ID that is not currently defined within NovaStar.

Sensor ID Reports Received	
2754	213
4095	57
2239	57
4013	53
1470	14
4031	9
1316	7
1312	6
4601	5
1314	4
1311	4
4739	3
4766	3
2818	3
4053	3

General System Analysis

Database Name P:\A207-UDFCD-Data-Analysis\2007_Jun\Novastar_extract_2007Jun.mdb

First Date in Database	6/1/07 12:00 AM	Total Days	30.0
Last Date in Database	6/30/07 11:59 PM	Total Hours	720.0

Total Records Analyzed 259586

Records by Group

None-ALERT-ID	44447	17%
Wind Gust	34385	13%
Relative Humidity	31605	12%
Water Level PT-HSE	30831	12%
Temperature	28864	11%
Wind Speed Average & Azimuth	19450	7%
Wind Direction	15504	6%
Precipitation	10728	4%
Wind Speed Average	10695	4%
Battery Voltage HSE	6165	2%
Water Level PT	4508	2%
Battery Voltage Digital	3460	1%
Solar Radiation	2649	1%
Barometric Pressure	2196	1%
Water Level Float	1866	1%
Precipitation - Mean	1556	1%
Hayman Precipitation	1425	1%
Fuel Moisture	1376	1%
Fuel Temperature	1335	1%
Battery Voltage Analog	879	0%
Handar 585 ALARM Status	861	0%
Repeater Pass List	593	0%
Repeater Status Report	471	0%
Longmont Flow Gage	321	0%
Precipitation - Test	239	0%
12Hr Status Report	228	0%
Battery	116	0%
Soil Moisture	65	0%
Longmont Water Level PT	55	0%
Solar Power	5	0%
Total	256878	

Records by Major Group

Meteorologic Sensors	145348	56%
Water Level Sensors	37581	14%
Sensor Status Transmissions	12662	5%
Rain Sensors	10728	4%
Soil and Fuel Sensors	2776	1%
Total	209095	

Records by Validation Type

Good	0	256194	99%
Questionable	1	3392	1%
Total		259586	

Sensors With Most Invalid Data

Description	Sensor	Reports
Squaw Mountain	2189	2114
Squaw Mountain	2187	709
Highlands Ranch WTP	2704	31
Salisbury Park	2724	31
Louisville Lake	4744	31

Traffic Loading Summary

Alert Reports	259586	
Average Daily Traffic	8653	
Average Hourly Traffic	361	
Median Hourly Traffic	358	hour beginning
Peak Hourly Traffic	1005	6/12/07 3:00 PM

Total Number of Sensors Defined 855 **Total Number of Sensors Reporting** 557

Reports per Sensor

Description	Sensor	Reports	Fraction of Total
Boulder Cr at Broadway	4583	10000	4%
Salisbury Park	2727	3692	1%
Stapleton	1461	3648	1%
Englewood Dam	1603	3348	1%
Quincy Reservoir	747	3004	1%
Green Ditch	4593	2914	1%
Marston Lake North	1521	2783	1%
Squaw Mountain	2189	2761	1%
Elbert	1439	2738	1%
Salisbury Park	2724	2720	1%

Rain Timer Performance

Analyze Rain Sensors

systemwide average (days)

0.5190

Systemwide Average

91%

Rain Sensors	Description	Timer Reports	Average Timer Interval	Expected	Performance
4830	SBC @ San Souci	11	11:57	60.00	18%
1460	Stapleton	27	1:29	60.00	45%
1810	Sand Creek at mouth	37	18:32	60.00	62%
1710	Shop Creek	42	15:09	60.00	70%
4470	Little Narrows	42	15:44	60.00	70%
1500	Powers Park	46	14:05	60.00	77%
4290	Red Hill	46	14:00	60.00	77%
540	Parker/Mississippi	47	14:57	60.00	78%
1920	Brighton	47	13:21	60.00	78%
4060	Lakeshore	47	14:45	60.00	78%
4570	St. Antons	47	13:09	60.00	78%
4710	Ward C-1	47	15:23	60.00	78%
4820	Doudy Draw	48	14:37	60.00	80%
4010	Crescent	49	14:00	60.00	82%
4560	Lyons Diversion NSV	49	14:14	60.00	82%
1200	Broomfield 3207	50	13:27	60.00	83%
4530	Winiger Ridge	50	14:21	60.00	83%
110	Ralston Reservoir	51	13:27	60.00	85%
1110	Gunbarrel	51	13:57	60.00	85%
1660	SPR at Henderson	51	13:43	60.00	85%
2310	Genesee Village	51	13:31	60.00	85%
2350	Idledale	51	13:15	60.00	85%
4090	Magnolia	51	13:45	60.00	85%
4150	Gold Hill	51	13:19	60.00	85%
4180	Gold Lake	51	13:31	60.00	85%
4510	Pinewood Springs	51	13:00	60.00	85%
310	Guy Hill Ranch	52	13:14	60.00	87%
620	Quincy/Highline	52	13:31	60.00	87%
1100	Louisville Rec Ctr	52	13:40	60.00	87%
1350	Chatfield COE	52	13:42	60.00	87%
2750	Castle Rock	52	13:01	60.00	87%
2820	Haskins Gulch Conf	52	13:13	60.00	87%
4140	Logan Mill	52	13:31	60.00	87%
4170	Pine Brook	52	12:44	60.00	87%
4730	Sugarloaf	52	13:01	60.00	87%
220	Upper Leyden	53	13:26	60.00	88%
1010	Denver West	53	13:24	60.00	88%
1040	Lena @ U.S. Hwy 6	53	13:11	60.00	88%
1300	Hidden Lake	53	13:11	60.00	88%
1800	Sand Creek Park	53	13:25	60.00	88%
4330	Indian Ruins	53	12:59	60.00	88%
4490	Apple Valley	53	12:56	60.00	88%
300	Van Bibber Park	54	12:54	60.00	90%
420	Expo Park	54	12:24	60.00	90%
650	Iliff Pond	54	13:09	60.00	90%
810	Granby Ditch @ 6th	54	13:08	60.00	90%
1310	LDC at 64th	54	12:55	60.00	90%
1400	Upper Sloan Det.	54	12:40	60.00	90%
1620	Slaughterhouse Glch	54	12:56	60.00	90%
2340	El Rancho	54	12:12	60.00	90%
4080	Twin Sisters	54	13:09	60.00	90%
4130	Swiss Peaks	54	12:27	60.00	90%
4840	SBC@S Boulder Ditch	54	12:39	60.00	90%
120	West Woods	55	12:40	60.00	92%
330	Van Bibber @ Hwy 93	55	12:14	60.00	92%
720	Confluence Pond	55	12:40	60.00	92%
820	ETG @ Buckley	55	12:53	60.00	92%
830	Side Creek Park	55	11:57	60.00	92%
840	Fire Station 12	55	12:41	60.00	92%
850	Flying J	55	12:42	60.00	92%
870	Murphy Creek GC	55	12:14	60.00	92%
1030	NREL/S. Table Mtn.	55	12:38	60.00	92%
1340	Sanderson at Xavier	55	12:28	60.00	92%
1640	SPR at Union Ave.	55	12:44	60.00	92%
1700	Cherry Cr @ Champa	55	12:42	60.00	92%
2330	Morrison	55	12:53	60.00	92%
2840	Sulphur Gulch	55	12:27	60.00	92%
4020	Rio Grande	55	12:38	60.00	92%
4040	Martin Gulch	55	12:54	60.00	92%
4110	Betasso	55	12:56	60.00	92%
4240	Sunset	55	12:41	60.00	92%
4810	Shanahan Ridge	55	13:09	60.00	92%
400	Montview Park	56	12:28	60.00	93%
500	Havana Park	56	12:32	60.00	93%

520	Jewell Detention	56	12:40	60.00	93%
600	Harvard Gulch Park	56	12:26	60.00	93%
630	Temple Pond at DTC	56	12:21	60.00	93%
760	Mission Viejo Park	56	12:25	60.00	93%
1060	Heritage Square	56	12:24	60.00	93%
1330	Roslyn	56	12:27	60.00	93%
1420	Diamond Hill	56	12:53	60.00	93%
1600	Englewood Dam	56	12:40	60.00	93%
2230	Bear Cr below Cub	56	12:40	60.00	93%
2240	Cold Sprg Glch conf	56	12:26	60.00	93%
2270	Cub Cr below Blue	56	12:15	60.00	93%
2370	Red Rocks Park	56	12:13	60.00	93%
4030	Red Garden	56	12:41	60.00	93%
4070	Bear Peak	56	12:53	60.00	93%
4220	Fling's	56	12:12	60.00	93%
4750	Louisville Lake	56	12:13	60.00	93%
150	Nott Creek	57	12:14	60.00	95%
210	Leyden Confluence	57	12:24	60.00	95%
320	Sports Complex	57	12:11	60.00	95%
440	Fire Station #7	57	12:24	60.00	95%
730	No Name @ Quincy	57	12:25	60.00	95%
1000	Maple Grove Resv.	57	12:24	60.00	95%
1050	Jeffco Fairgrounds	57	12:11	60.00	95%
1360	Denver Zoo	57	12:27	60.00	95%
1370	West Metro FS13	57	12:13	60.00	95%
1440	Elbert	57	13:00	60.00	95%
1900	Niver Detention	57	12:25	60.00	95%
2210	Hiwan G.C.	57	12:13	60.00	95%
2220	Evergreen Lake	57	12:23	60.00	95%
2260	Brook Forest	57	12:30	60.00	95%
4050	Walker Ranch	57	12:11	60.00	95%
4160	Sunshine	57	11:58	60.00	95%
4230	Golden Age	57	12:25	60.00	95%
4260	Taylor Mountain	57	12:12	60.00	95%
4310	Johnny Park	57	12:11	60.00	95%
4340	Riverside	57	12:12	60.00	95%
4520	Eagle Ridge	57	12:26	60.00	95%
4790	Button Rock	57	12:13	60.00	95%
100	Carr Street	58	12:11	60.00	97%
200	Leyden Reservoir	58	12:11	60.00	97%
410	Kelly Dam	58	12:11	60.00	97%
510	Virginia Court	58	12:15	60.00	97%
530	Fire Station #19	58	12:11	60.00	97%
610	Harvard @ Jackson	58	12:10	60.00	97%
700	Toll Gate @ 6th	58	12:13	60.00	97%
740	Smoky Hill	58	12:13	60.00	97%
750	Quincy Reservoir	58	12:13	60.00	97%
800	Sable Ditch @ 18th	58	11:57	60.00	97%
1020	Lena @ Nolte Pond	58	12:12	60.00	97%
1320	SPR at 3rd Ave	58	12:24	60.00	97%
1520	Marston Lake North	58	12:12	60.00	97%
1530	Bear Creek @ Lowell	58	12:07	60.00	97%
1540	Sanderson at Xavier	58	12:10	60.00	97%
1610	Holly Dam	58	12:10	60.00	97%
1720	Cherry Cr @ Steele	58	12:13	60.00	97%
2280	Kinney Peak	58	12:13	60.00	97%
2710	Highlands Ranch WTP	58	12:12	60.00	97%
2730	Salisbury Park	58	12:13	60.00	97%
2810	Pine Cliff Road	58	12:13	60.00	97%
4100	Filter Plant	58	12:13	60.00	97%
4200	Lazy Acres	58	11:59	60.00	97%
4250	Geer Canyon	58	12:11	60.00	97%
4300	Big Elk Park	58	11:57	60.00	97%
4350	Conifer Hill	58	12:25	60.00	97%
4360	Justice Center	58	12:24	60.00	97%
4770	Cal-Wood Ranch	58	12:13	60.00	97%
640	Goldsmith @ Eastman	59	11:59	60.00	98%
710	Horseshoe Park Drop	59	11:57	60.00	98%
2190	Squaw Mountain	59	12:00	60.00	98%
2360	Indian Hills	59	12:00	60.00	98%
4190	Slaughterhouse	59	11:58	60.00	98%
900	Aurora Reservoir	60	11:48	60.00	100%
1480	Third Creek at DIA	60	11:34	60.00	100%
2250	Rosedale	60	11:46	60.00	100%
4270	Cannon Mountain	60	11:57	60.00	100%
140	Blue Mountain	62	11:30	60.00	103%

Rain Event Performance		Reports Received	2063	Analyze Rain Sensors									
	Systemwide Avg	Total Tips	2333										
	88%	Data Loss	11.57%										
Rain Sensor	Performance	1-tips	2-tips	3-tips	4-tips	5-tips	6-tips	>6-tips	Rcvd	Exp	Missed	Holdoff	
1710	46%	5	3	1	1	0	1	0	11	24	13	0	
1350	50%	2	1	0	1	0	0	0	4	8	4	0	
310	56%	10	1	1	1	0	1	0	14	25	11	0	
1700	63%	6	2	2	0	0	0	0	10	16	6	0	
210	64%	6	0	0	0	1	0	0	7	11	4	0	
110	17%	1	1	0	0	0	0	1	2	12	10	0	
850	67%	6	3	1	0	0	0	0	10	15	5	0	
1100	67%	2	2	0	0	0	0	0	4	6	2	0	
2280	67%	11	0	2	1	0	0	0	14	21	7	3	
4820	67%	4	1	1	0	0	0	0	6	9	3	0	
870	69%	13	5	2	0	0	0	0	20	29	9	0	
1330	70%	5	1	1	0	0	0	0	7	10	3	0	
1620	71%	14	1	1	0	1	0	0	17	24	7	0	
710	71%	7	2	1	0	0	0	0	10	14	4	0	
4470	71%	3	2	0	0	0	0	0	5	7	2	0	
540	73%	6	1	1	0	0	0	0	8	11	3	0	
1040	73%	5	3	0	0	0	0	0	8	11	3	0	
1720	73%	6	1	1	0	0	0	0	8	11	3	0	
800	73%	8	2	1	0	0	0	0	11	15	4	0	
2340	73%	9	1	0	1	0	0	0	11	15	4	0	
1110	75%	2	1	0	0	0	0	0	3	4	1	0	
4010	75%	7	1	1	0	0	0	0	9	12	3	0	
4240	75%	4	2	0	0	0	0	0	6	8	2	0	
4530	76%	12	3	1	0	0	0	0	16	21	5	0	
760	76%	10	2	1	0	0	0	0	13	17	4	0	
1640	77%	16	2	2	0	0	0	0	20	26	6	0	
4200	78%	5	2	0	0	0	0	0	7	9	2	0	
400	79%	10	0	0	1	0	0	0	11	14	3	0	
820	79%	8	3	0	0	0	0	0	11	14	3	0	
1520	79%	9	1	1	0	0	0	0	11	14	3	0	
2730	79%	15	3	1	0	0	0	0	19	24	5	0	
810	80%	9	3	0	0	0	0	0	12	15	3	0	
4090	80%	6	2	0	0	0	0	0	8	10	2	0	
1440	89%	20	4	0	0	0	0	1	24	27	7	1	
440	82%	7	2	0	0	0	0	0	9	11	2	0	
720	82%	7	2	0	0	0	0	0	9	11	2	0	
320	83%	8	2	0	0	0	0	0	10	12	2	0	
530	83%	8	2	0	0	0	0	0	10	12	2	0	
1200	83%	4	1	0	0	0	0	0	5	6	1	0	
1420	83%	8	2	0	0	0	0	0	10	12	2	0	
2370	83%	8	2	0	0	0	0	0	10	12	2	0	
900	84%	25	6	0	0	0	0	0	31	37	6	0	
4710	84%	14	1	1	0	0	0	0	16	19	3	0	
120	85%	9	2	0	0	0	0	0	11	13	2	0	
410	85%	9	2	0	0	0	0	0	11	13	2	0	
1810	85%	10	0	1	0	0	0	0	11	13	2	0	
1540	86%	5	1	0	0	0	0	0	6	7	1	0	
1920	86%	5	1	0	0	0	0	0	6	7	1	0	
2840	86%	11	0	1	0	0	0	0	12	14	2	0	
4250	86%	5	1	0	0	0	0	0	6	7	1	0	
4810	86%	5	1	0	0	0	0	0	6	7	1	0	
2320	87%	11	2	0	0	0	0	0	13	15	2	0	
330	88%	13	2	0	0	0	0	0	15	17	2	0	
860	88%	13	2	0	0	0	0	0	15	17	2	0	
1030	89%	7	1	0	0	0	0	0	8	9	1	0	
2230	89%	14	2	0	0	0	0	0	16	18	2	0	
4270	89%	7	1	0	0	0	0	0	8	9	1	0	
4350	89%	7	1	0	0	0	0	0	8	9	1	0	
4750	89%	7	1	0	0	0	0	0	8	9	1	0	
750	89%	15	2	0	0	0	0	0	17	19	2	0	
1010	90%	8	1	0	0	0	0	0	9	10	1	0	
1050	90%	8	1	0	0	0	0	0	9	10	1	0	
4020	90%	8	1	0	0	0	0	0	9	10	1	0	
4080	90%	8	1	0	0	0	0	0	9	10	1	0	
4330	90%	8	1	0	0	0	0	0	9	10	1	0	
500	90%	33	4	0	0	0	0	0	37	41	4	0	
1000	91%	9	1	0	0	0	0	0	10	11	1	0	
1060	91%	9	1	0	0	0	0	0	10	11	1	0	
2190	91%	18	2	0	0	0	0	0	20	22	2	0	
2350	91%	9	1	0	0	0	0	0	10	11	1	0	
4170	91%	9	1	0	0	0	0	0	10	11	1	0	
200	92%	10	1	0	0	0	0	0	11	12	1	0	

740	92%	20	2	0	0	0	0	0	22	24	2	0
1320	92%	10	1	0	0	0	0	0	11	12	1	0
2360	92%	10	1	0	0	0	0	0	11	12	1	0
4060	92%	10	1	0	0	0	0	0	11	12	1	0
4160	92%	10	1	0	0	0	0	0	11	12	1	0
4730	92%	10	1	0	0	0	0	0	11	12	1	0
2820	92%	21	2	0	0	0	0	0	23	25	2	0
100	92%	11	1	0	0	0	0	0	12	13	1	0
1360	92%	11	1	0	0	0	0	0	12	13	1	0
1400	92%	11	1	0	0	0	0	0	12	13	1	0
2260	92%	23	0	1	0	0	0	0	24	26	2	0
2750	93%	24	0	1	0	0	0	0	25	27	2	0
830	93%	35	3	0	0	0	0	0	38	41	3	0
600	93%	12	1	0	0	0	0	0	13	14	1	0
650	93%	12	1	0	0	0	0	0	13	14	1	0
840	93%	12	1	0	0	0	0	0	13	14	1	0
1800	93%	12	1	0	0	0	0	0	13	14	1	0
2250	93%	12	1	0	0	0	0	0	13	14	1	0
4040	93%	12	1	0	0	0	0	0	13	14	1	0
510	93%	27	0	1	0	0	0	0	28	30	2	0
520	93%	13	1	0	0	0	0	0	14	15	1	0
700	93%	13	1	0	0	0	0	0	14	15	1	1
1600	93%	13	1	0	0	0	0	0	14	15	1	0
2210	93%	13	1	0	0	0	0	0	14	15	1	0
4150	93%	13	1	0	0	0	0	0	14	15	1	0
630	94%	70	5	0	0	0	0	0	75	80	5	0
2810	94%	14	1	0	0	0	0	0	15	16	1	0
4030	94%	14	1	0	0	0	0	0	15	16	1	0
730	94%	15	1	0	0	0	0	0	16	17	1	0
1370	94%	15	1	0	0	0	0	0	16	17	1	0
1460	94%	15	1	0	0	0	0	0	16	17	1	0
1480	94%	15	1	0	0	0	0	0	16	17	1	0
4490	94%	15	1	0	0	0	0	0	16	17	1	0
620	95%	17	1	0	0	0	0	0	18	19	1	0
1340	95%	19	1	0	0	0	0	0	20	21	1	0
4260	95%	20	1	0	0	0	0	0	21	22	1	0
1530	96%	21	1	0	0	0	0	0	22	23	1	0
4570	96%	25	1	0	0	0	0	0	26	27	1	0
420	97%	59	2	0	0	0	0	0	61	63	2	0
1500	97%	100	3	0	0	0	0	0	103	106	3	0
140	100%	15	0	0	0	0	0	0	15	15	0	1
150	100%	17	0	0	0	0	0	0	17	17	0	0
220	100%	12	0	0	0	0	0	0	12	12	0	1
300	100%	10	0	0	0	0	0	0	10	10	0	0
610	100%	16	0	0	0	0	0	0	16	16	0	0
640	100%	18	0	0	0	0	0	0	18	18	0	0
1300	100%	9	0	0	0	0	0	0	9	9	0	0
1310	100%	9	0	0	0	0	0	0	9	9	0	1
1660	100%	10	0	0	0	0	0	0	10	10	0	0
1900	100%	8	0	0	0	0	0	0	8	8	0	0
2240	100%	11	0	0	0	0	0	0	11	11	0	0
2270	100%	30	0	0	0	0	0	0	30	30	0	0
2310	100%	13	0	0	0	0	0	0	13	13	0	0
2330	100%	14	0	0	0	0	0	0	14	14	0	0
2710	100%	10	0	0	0	0	0	0	10	10	0	0
4050	100%	9	0	0	0	0	0	0	9	9	0	0
4070	100%	9	0	0	0	0	0	0	9	9	0	0
4100	100%	10	0	0	0	0	0	0	10	10	0	0
4110	100%	15	0	0	0	0	0	0	15	15	0	0
4130	100%	11	0	0	0	0	0	0	11	11	0	0
4140	100%	5	0	0	0	0	0	0	5	5	0	0
4180	100%	10	0	0	0	0	0	0	10	10	0	0
4190	100%	9	0	0	0	0	0	0	9	9	0	0
4220	100%	11	0	0	0	0	0	0	11	11	0	0
4230	100%	8	0	0	0	0	0	0	8	8	0	0
4290	100%	8	0	0	0	0	0	0	8	8	0	0
4300	100%	18	0	0	0	0	0	0	18	18	0	0
4310	100%	9	0	0	0	0	0	0	9	9	0	0
4340	100%	21	0	0	0	0	0	0	21	21	0	0
4360	100%	14	0	0	0	0	0	0	14	14	0	0
4510	100%	10	0	0	0	0	0	0	10	10	0	0
4520	100%	5	0	0	0	0	0	0	5	5	0	0
4770	100%	14	0	0	0	0	0	0	14	14	0	0
4790	100%	6	0	0	0	0	0	0	6	6	0	0
4840	100%	7	0	0	0	0	0	0	7	7	0	0
Total Tips		1856	168	29	6	2	2	2	2063	2333	274	

