

Memo



Date: February 10, 2009
To: Kevin Stewart and Chad Kudym
From: Markus Ritsch
Subject: January 2009 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 January 1 through January 31, 2009.

II. General System Analysis Summary

A total of 248,453 data records were analyzed from the ALERT 2 base station. Meteorological sensors account for 86 percent, water level sensors 4 percent, and rain sensors 2 percent of the total monthly records.

More than ninety-nine percent (99%) of the received data reports were flagged as "good" by the Nova Star validation process.

The system-wide radio traffic loading was 8,015 reports per day with an average hourly loading of 334 reports. The peak hourly traffic loading was 454 reports, which occurred on January 7, between 11:00 AM and 12:00 PM. A plot of monthly average and peak hourly traffic loading is provided.

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 80 percent of the non-incrementing timer reports. The worst performing rain sensors for the month are summarized (Table 1).

Table 1. Monthly Summary of Sensors with Poor Timer Performance (Sensor ID)

Sensor ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2850												
1650												
1810												
4250												
4790												
4300												

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 Sensor ID 1810 has an 18-hour timer-reporting interval.

IV. Rain Sensor Event Reporting Summary

A. District-Wide Total Tip/Count Statistics

The incrementing reports from all 1-mm rain sensors 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	6.33	Only the 1-mm rain sensors were included in the analysis
Median	6	Only the 1-mm rain sensors were included in the analysis
Standard deviation	3.74	Only the 1-mm rain sensors were included in the analysis
Mean plus three standard deviations	17.54	Only the 1-mm rain sensors were included in the analysis
Minimum total count	1	Walker Ranch (ID 4050)
Maximum total count	15	Johnny Park (ID 4310)

The highest reporting rain sensor this month was Johnny Park (ID4310) with 15 tips. Irrigation sprinklers do not influence this sensor. No other sensors reported more than the mean plus three standard deviations.

B. Monthly Average Tip/Count Summary

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	36.20	46.38	22.13	29.50	6.54	11.29	29.00
2008	4.05	7.38	12.26	20.57	54.82	26.06	16.43	90.20	37.54	19.59	2.82	9.24	25.08
2008	6.33												

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

Not one sensor experienced a jump in sequential count of more than six (Table 4).

Table 4. Sensors with a Jump of More than 6 in Sequential Count

Sensor Description	Sensor ID	Comment
		None this month.

D. Sensor-by-Sensor Incrementing Count Summary

The system-wide reception rate of incrementing, 1-mm tip reports for the month was approximately 93.5 percent. A total of 373 incrementing reports were received and a total of 399 were expected. The total loss of incrementing reports for the month was approximately 6.5 percent. Those sensors with the worst rain event transmission performance characteristics are summarized (Table 5).

Table 5. Monthly Summary of Sensors with the Most Missed Tips

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
140											
4490											
1420											
4040											
4160											
4470											

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.

The incrementing data series for those sensors with an event performance of less than 70 % are manually inspected.

a. Blue Mountain (ID 140)

This sensor reported for the entire month and missed two incrementing transmissions on January 7, between 5:00 AM and noon. A manual inspection of the sequential series revealed nothing suspicious.

b. Apple Valley (ID 4490)

This sensor reported for the entire month and missed two incrementing transmissions on January 1, between 2:50:13 AM and 2:50:15 AM. A manual inspection of the sequential series revealed nothing suspicious.

c. Diamond Hill (ID 1420)

This sensor reported for the entire month and missed 4 incrementing transmissions at different times during the month. A manual inspection of the sequential series revealed nothing suspicious. It does seem a bit suspicious that the Diamond Hill transmitter would lose transmissions being so close to the receive station.

V. Heavy Radio Traffic Analysis

Periods exceeding 700 messages per hour are analyzed independently in an attempt to identify rain tip sequences where 3 or more, sequential messages are lost.

A. The Heaviest Hourly Traffic Periods This Month

The hourly periods of highest radio traffic this month include:

Peak Traffic Periods	Reports/hour	Hour Beginning
Peak Hourly Traffic	454	1/7/2009 11:00 AM
2nd Max	445	1/7/2009 10:00 AM
3rd Max	443	1/6/2009 1:00 PM
4th Max	441	1/13/2009 7:00 AM
5th Max	440	1/19/2009 2:00 PM

B. January 7, 2009

The heaviest traffic period occurred on January 7, between 11:00 AM and 12:00 PM. Incrementing rain records from the 1-mm gages for the heavy radio traffic period were examined to characterize the loss of sequential incrementing tip transmissions (Table 6). During the heavy traffic period, a total of 34 reports were expected and 34 were received yielding a loss of approximately 0.00% of the incrementing transmissions.

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

Heavy Traffic Period (January 7)	Occurrences of lost sequential tip reports during period			
	Loss of 3 sequential tips	Loss of 4 sequential tips	Loss of 5 sequential tips	Loss of 6 or more sequential tips
11:00 AM to 12:00 PM	0	0	0	0

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)	191
Total reports from unknown IDs	369
Unknown IDs with only a single received report (potential noise)	128
Total reports from all IDs – RecData Log entire month	248453
Unknown reports as a fraction of total reports	0.15%

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

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 shown (Table 8).

Table 8. Reports Received by Unknown IDs

Unknown Sensor	Reports
1655	28
1657	12
2726	10
4636	10
4091	9
4093	8
4094	8
696	5
2365	5
4063	5
4087	5
4760	5
4766	5
2736	4
4061	4
4272	4
4279	4
4664	4
4768	4
4775	4
698	3
1651	3
2239	3
4092	3
4639	3
4644	3
4663	3
4740	3
4776	3

4782	3
4786	3
4863	3
759	2
980	2
2215	2
2719	2
4011	2
4012	2
4029	2
4062	2
4064	2
4083	2
4132	2
4149	2
4234	2
4569	2
4599	2
4607	2
4643	2
4646	2
4666	2
4739	2
4748	2
4756	2
4809	2
4812	2
4831	2
4861	2
5048	2

The “unknown” device reports are analyzed temporally to understand when they are 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	17	12:00-12:59	19
1:00-1:59	8	1:00-1:59	21
2:00-2:59	21	2:00-2:59	10
3:00-3:59	11	3:00-3:59	15
4:00-4:59	18	4:00-4:59	6
5:00-5:59	15	5:00-5:59	9
6:00-6:59	21	6:00-6:59	11
7:00-7:59	16	7:00-7:59	15
8:00-8:59	20	8:00-8:59	7
9:00-9:59	15	9:00-9:59	10
10:00-10:59	21	10:00-10:59	13
11:00-11:59	18	11:00-11:59	10

VII. Issues Identified this Month

Rain sensors with a large number of invalid reports (bit flip/contention errors/random decode):

Description	Sensor	Reports
Magnolia	4090	6
Button Rock	4790	6
Cal-Wood Ranch	4770	3
Morrison	2330	2

Sensors reporting frequently (over reporting):

Description	Sensor	Reports	Fraction of Total
Quincy Reservoir	749	6,053	2%
Ward C-1	4707	5,608	2%
Castle Rock	2747	3,435	1%
Salisbury Park	2727	3,141	1%
Sugarloaf	4727	3,088	1%

Sensors reporting infrequently (under reporting):

Description	Sensor	Reports
Niver Detention	1905	5
Temple/pre90	4603	3
Bear Cr below Cub	2226	1
Bear Cr below Cub	2235	1
Bridge	4425	1
Button Rock Outlet	4480	1
Cal-Wood Ranch	4280	1
Cold Sprg Glch conf	2240	1
Fourmile at Salina	4415	1
Horseshoe Park Drop	715	1
Mission Viejo Park	765	1
NREL/S. Table Mtn.	1030	1
SPR at 3rd Ave	1560	1
Squaw Mountain	2193	1
Stapleton	1463	1
Third Creek at DIA	1948	1
Toll Gate @ 6th	704	1

Poor timer reporting:

The following sensors reported for the entire month and showed poor timer performance.

Rain Sensor	Description	Rcv	Exp	Performance
2850	Cherry Cr bl Bayou Glch	13	62	21%
1650	SPR at 19th Street	24	62	39%
1810	Sand Creek at mouth	35	62	56%
4250	Geer Canyon	37	62	60%
4790	Button Rock	37	62	60%

Poor event reporting:

The following sensors reported for the entire month and showed poor event performance.

Rain Sensor	Description	Performance
140	Blue Mountain	33%
4490	Apple Valley	50%
1420	Diamond Hill	67%

Low rain total:

Rain Sensor	Tips
970	1
1920	1
2190	1
4050	1

High rain total:

Rain Sensor	Tips
4310	15
4150	14
4220	14
4530	13
1420	12
4570	12
1000	12

Large Jump in Sequential Count (bit flip errors/contention loss/transmitter problems):

Sensor Description	Sensor ID	Comment
		None this month.

Reports from “Unknown Sensors”:

Table 8 in the text shows the “unknown” sensor IDs and the number of reports received for the month.

General System Analysis

Database Name

P:\A207-UDFCD-Data-Analysis\2009\2009-Jan\Novastar_extract_2009Jan.mdb

First Date in Database

1/1/09 12:00 AM

Total Days

31.0

Last Date in Database

1/31/09 11:59 PM

Total Hours

744.0

Total Records Analyzed

248453

Records by Group

Wind Gust	46544	19%
Temperature	41149	17%
Relative Humidity	39509	16%
Wind Speed Average & Azimuth	25790	10%
Barometric Pressure	18887	8%
Wind Direction	17542	7%
Wind Speed Average	16138	6%
Solar Radiation	8872	4%
Water Level PT-HSE	4835	2%
Precipitation	4330	2%
Fuel Temperature	3596	1%
Fuel Moisture	3572	1%
Water Level Float	3417	1%
Battery Voltage Analog	3230	1%
Battery Voltage HSE	3188	1%
Soil Moisture	2611	1%
Battery Voltage Digital	2297	1%
Repeater Pass List	577	0%
Repeater Status Report	459	0%
Water Level PT	392	0%
Wing Gust	308	0%
Battery	274	0%
Precipitation - Test	225	0%
12Hr Status Report	208	0%
Longmont Flow Gage	76	0%
Longmont Water Level PT	43	0%
Battery Voltage	13	0%
Handar 585 ALARM Status	1	0%
Precipitation-ASCII	1	0%
Total	248084	

Records by Major Group

Meteorologic Sensors	214431	86%
Sensor Status Transmissions	9960	4%
Soil and Fuel Sensors	9779	4%
Water Level Sensors	8763	4%
Rain Sensors	4331	2%
Total	247264	

Records by Validation Type

Good	0	248396	99.98%
Questionable	1	57	0.02%
Total		248453	

Sensors With Most Invalid Data

Description	Sensor	Reports
Squaw Mountain	2191	21
Magnolia	4090	6
Button Rock	4790	6
Cal-Wood Ranch	4770	3
Morrison	2330	2

Traffic Loading Summary

Alert Reports	248453	
Average Daily Traffic	8015	
Average Hourly Traffic	334	
Median Hourly Traffic	342	hour beginning
Peak Hourly Traffic	454	1/7/09 11:00 AM
2nd Max	445	1/7/09 10:00 AM
3rd Max	443	1/6/09 1:00 PM
4th Max	441	1/13/09 7:00 AM
5th Max	440	1/19/09 2:00 PM

Rain Timer Performance

Analyze Rain Sensors

systemwide average (days)

0.5620

80%

Rain Sensors	Description	Rcv	Average Timer Interval	Exp	Performance
2850	Cherry Cr bl Bayou Glich	13	22:54	62.00	21%
1650	SPR at 19th Street	24	6:32	62.00	39%
1810	Sand Creek at mouth	35	19:48	62.00	56%
4250	Geer Canyon	37	15:57	62.00	60%
4790	Button Rock	37	15:38	62.00	60%
4300	Big Elk Park	38	16:04	62.00	61%
4270	Cannon Mountain	39	13:57	62.00	63%
4040	Martin Gulch	40	15:17	62.00	65%
4050	Walker Ranch	40	16:03	62.00	65%
4160	Sunshine	40	16:45	62.00	65%
4200	Lazy Acres	40	15:31	62.00	65%
4230	Golden Age	40	15:17	62.00	65%
4340	Riverside	40	17:06	62.00	65%
4350	Conifer Hill	40	17:25	62.00	65%
4190	Slaughterhouse	41	16:17	62.00	66%
4510	Pinewood Springs	41	15:07	62.00	66%
4520	Eagle Ridge	41	13:53	62.00	66%
4100	Filter Plant	42	16:43	62.00	68%
4290	Red Hill	42	15:02	62.00	68%
4310	Johnny Park	42	14:40	62.00	68%
4470	Little Narrows	42	16:09	62.00	68%
4030	Red Garden	43	15:52	62.00	69%
4110	Betasso	43	14:12	62.00	69%
4260	Taylor Mountain	43	15:05	62.00	69%
4020	Rio Grande	44	14:42	62.00	71%
4360	Justice Center	44	14:16	62.00	71%
4070	Bear Peak	45	14:53	62.00	73%
4560	Lyons Diversion NSV	47	15:35	62.00	76%
4130	Swiss Peaks	49	14:38	62.00	79%
4490	Apple Valley	49	14:00	62.00	79%
4170	Pine Brook	50	13:52	62.00	81%
4570	St. Antons	50	12:34	62.00	81%
1460	Stapleton	26	1:00	32.00	81%
4730	Sugarloaf	51	14:31	62.00	82%
4150	Gold Hill	52	13:44	62.00	84%
4530	Winiger Ridge	52	13:47	62.00	84%
920	Aurora Town Hall Wx	53	12:56	62.00	85%
970	Pump Sta 3	54	13:04	62.00	87%
4010	Crescent	54	13:41	62.00	87%
4060	Lakeshore	54	13:29	62.00	87%
4090	Magnolia	54	13:23	62.00	87%
4220	Fling's	54	12:59	62.00	87%
4750	Louisville Lake	54	13:28	62.00	87%
140	Blue Mountain	55	13:10	62.00	89%
2710	Highlands Ranch WTP	55	12:27	62.00	89%
4240	Sunset	55	12:42	62.00	89%
4710	Ward C-1	55	13:24	62.00	89%
700	Toll Gate @ 6th	56	12:37	62.00	90%
1000	Maple Grove Resv.	56	13:01	62.00	90%
1420	Diamond Hill	56	12:52	62.00	90%
2990	Tomah Rd-Douglas Cnty	56	12:14	62.00	90%
4140	Logan Mill	56	12:26	62.00	90%
750	Quincy Reservoir	57	12:29	62.00	92%
1440	Elbert	57	12:58	62.00	92%

1570	Brighton Ditch Wx	57	12:30	62.00	92%
2190	Squaw Mountain	57	12:13	62.00	92%
2330	Morrison	57	12:17	62.00	92%
2730	Salisbury Park	57	12:38	62.00	92%
4080	Twin Sisters	57	12:57	62.00	92%
4180	Gold Lake	57	11:44	62.00	92%
900	Aurora Reservoir	58	12:26	62.00	94%
1920	Brighton	58	12:26	62.00	94%
1660	SPR at Henderson	59	12:10	62.00	95%
2750	Castle Rock	59	12:12	62.00	95%
1630	SPR at Dartmouth	62	11:47	62.00	100%
2210	Hiwan G.C.	62	10:31	62.00	100%
2220	Evergreen Lake	62	10:13	62.00	100%
4770	Cal-Wood Ranch	62	10:48	62.00	100%
4810	Shanahan Ridge	62	10:44	62.00	100%
4820	Doudy Draw	62	10:11	62.00	100%
4830	SBC @ San Souci	62	10:35	62.00	100%
4840	SBC@S Boulder Ditch	62	10:54	62.00	100%
4550	Boulder Jail	96	7:50	93.00	103%

Rain Event Performance				Analyze Rain Sensors										
		Reports Received	373											
	Systemwide Avg	Total Tips	399											
	93.5%	Data Loss	6.52%											
Rain Sensor	Performance	1-tips	2-tips	3-tips	4-tips	5-tips	6-tips	>6-tips	Rcv	Exp	Miss	Hold	Bucket	
140	33%	0	0	1	0	0	0	0	1	3	2	0	0.0393701	
4490	50%	1	0	1	0	0	0	0	2	4	2	0	0.0393701	
1420	67%	5	2	1	0	0	0	0	8	12	4	0	0.0393701	
4040	75%	5	0	1	0	0	0	0	6	8	2	0	0.0393701	
4160	75%	2	1	0	0	0	0	0	3	4	1	0	0.0393701	
4470	75%	2	1	0	0	0	0	0	3	4	1	0	0.0393701	
1640	78%	5	2	0	0	0	0	0	7	9	2	0	0.0393701	
4360	80%	7	0	1	0	0	0	0	8	10	2	0	0.0393701	
4090	80%	3	1	0	0	0	0	0	4	5	1	0	0.0393701	
700	83%	4	1	0	0	0	0	0	5	6	1	0	0.0393701	
4290	83%	4	1	0	0	0	0	0	5	6	1	0	0.0393701	
4530	85%	9	2	0	0	0	0	0	11	13	2	0	0.0393701	
4350	86%	5	1	0	0	0	0	0	6	7	1	0	0.0393701	
4110	90%	8	1	0	0	0	0	0	9	10	1	0	0.0393701	
4140	90%	8	1	0	0	0	0	0	9	10	1	0	0.0393701	
4820	90%	8	1	0	0	0	0	0	9	10	1	0	0.0393701	
4570	92%	10	1	0	0	0	0	0	11	12	1	0	0.0393701	
4310	100%	15	0	0	0	0	0	0	15	15	0	0	0.0393701	
4150	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701	
4220	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701	
1000	100%	12	0	0	0	0	0	0	12	12	0	0	0.0393701	
4240	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701	
4130	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701	
4510	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701	
2990	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701	
4030	100%	9	0	0	0	0	0	0	9	9	0	1	0.0393701	
4340	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701	
4830	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701	
1810	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701	
2330	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701	
4260	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701	
4770	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701	
4840	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701	
4190	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701	
4100	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4200	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4250	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4270	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4710	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4810	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701	
4730	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701	
4020	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4060	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4080	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4180	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4230	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4550	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
4790	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701	
1460	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701	
4070	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701	
4300	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701	
1660	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
2210	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
2710	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
2730	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
4010	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
4170	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
4750	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701	
970	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701	
1920	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701	
2190	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701	
2320	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701	
4050	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701	
	Total Tips	352	16	5	0	0	0	0	373	399	26	1		

