Urban Drainage and Flood Control District 2003 ALERT maintenance summary report

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Prepared by	**Approved by**

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Table of contents

Overview

Maintenance activities on the ALERT Gauging Network for 2003 have been completed under Agreement 03-01.15. During the 2003 operating season, OneRain generated 793 maintenance reports for the combined UDFCD/Boulder County network. Of these, a total of 107 (13.2%) service calls were generated: 24 (22.4%) were unscheduled District service calls and 83 (77.6%) were unscheduled OneRain Incorporated service calls; the remainder documented standard maintenance activities.

The overall percentage of service calls increased significantly during the 2003 field season compared to the year 2002. The following sites required the most "unscheduled" visits:

--Roslyn (site 1330) 9 visits

--Blue Mountain Repeater (site 950) 8 visits

--Smoky Hill Repeater (site 740) 7 visits

--Boulder Jail (site 4550) and Lee Hill Repeater (site 4210) 6 visits

--Orodell (site 4400) 5 visits

The 41 total trips to these 6 sites accounted for 38.3% of all 2003 service calls.

With the exception of the Orodell site, over 90% of the service calls associated with the "multiple visit" sites listed above were associated with either problems related to 1) the new Southwest Denver Expansion Project installations (see **Site additions**, below) or 2) the deployment of the new 50386 repeaters (see **Repeater upgrade update**, page 15). Orodell's problems primarily stemmed from a combination of pressure transducer failure and signal conditioning instability (see **PT replacements and discussion**, page 12).

At sites where the District "piggybacks" off of existing USGS DCP's, service calls related to Tiny Basic handshaking issues decreased dramatically during 2003. This is a situation that will hopefully become the norm. It is not known whether the frequency of visits by USGS personnel to download data have decreased, or if the protocol necessary to keep the District ALERT data feed alive is being adhered to with greater care by the USGS.

Site additions

Five additional Southwest Denver Expansion Project (SWDEP) installations occurred early in 2003, prior to and during the annual spring startup effort. The project was originally intended to fill in a major gap in the southwest portion of the system with respect to rain coverage and stage measurements. ("Southwest" turns out to be a bit of a misnomer, as the new Roslyn and Denver Zoo rain-only sites are actually in northeast Denver.)

The following sites were installed from the months of January through April:

1) **Sanderson Gulch,** rain and stage, ID **1340,** see **Figure 1.**
2) **Roslyn**, rain-only, initial ID 1580 switched to ID **1330,** see **Figure 2.**
3) **SPR @ Mausoleum,** rain and stage, initial ID 1560, switched to ID **1320,** see **Figure 3.**
4) **Denver Zoo**, rain-only, initial ID 1570, switched to ID **1360,** see **Figure 4.**
5) **Chatfield**, rain-only, ID **1350**.

After the SWDEP installations were completed, intermittent rain data runaway and rain count spiking, along with RF reliability problems, occurred that required a combination of modifications to correct.

The tipping buckets arrive from the factory with a magnetic armature that passes over a reed switch each time the bucket tips. Activation of the switch by the passing magnet results in a single electrical pulse, with the switch changing either from an “open” to “closed”, or “closed” to “open” condition. In this configuration, the magnet will be “on top” of the switch every other time the bucket tips (in the “closed” position). If the physical grounding of the electronics and antennae are inadequate, the result is a static charge buildup on the gauge. The close proximity of the magnet to the switch increases the potential for “switch fluttering” (i.e., rain count spiking or rain data runaway) if grounding is poor.

Therefore, OneRain performed two separate modifications to address rain count problems. We modified the tipping buckets by installing longer armatures and repositioning the switch such that the magnet would never rest “on top” of the switch, but rather on either side of the switch. The physical reconfiguration results in a dual-pulse output per bucket tip, rather than a single-pulse output, as the switch goes from an “open” to “closed” to “open” state during each bucket tip. The dual-pulse tipping bucket output requires a simple mode update for the sensor setup parameter in the 5096 program.

The second modification directly addressed the potential for static discharge buildup. Static buildup potential was minimized by installing a ground rod next to the standpipe and establishing a common contact point (via #6 gauge solid copper wire to an abraded portion of the body of the standpipe). The intent was to produce a common (earth) ground to the standpipe, antenna, transmitters and sensors.

The third and final modification was programmatic in nature and addressed excessive missing 12-hour reports. These are believed to be a result of the deployment of the new 50386 repeaters, which have slightly different receive characteristics than the older repeaters that were replaced. Two parameters were modified in the 5096 transmitters. The “RF Transmit Warm Time” parameter was increased from the default setting of 200 ms to 250 ms; this is the amount of time given to the repeater receiver to unsquelch (i.e., time allocated to increase receiver gain when the proper modulated input signal from the ALERT gauge is being received). The “RF Preamble Time” parameter has a default

setting of 100 ms that was increased to 200 ms; this is the time during which tone is transmitted for repeater decoder synchronization. These time interval increases were necessary in order to help ensure that the first bits of data in the ALERT message were not lost or corrupted by the new 50386 repeaters.

The Sanderson Gulch site was vandalized shortly after installation and two other times thereafter. The City of Lakewood has painted over “tags” that were applied to the standpipe (see **Figure 1**). Additionally, the door below the moisture “eyebrow” of the standpipe has been permanently sealed with epoxy by OneRain, as vandals broke off both metal tabs on the door that are supposed to accommodate the shackle of the door lock. Fortunately, vandals have not (yet) targeted either the antenna, PT housing, or tipping bucket top section.

A seventh SWDEP location has been identified as a probable rain-stage site along Lakewood Gulch. However, a bridge replacement project at 10th Street has resulted in installation postponement of unknown duration.

Figure 1. Site 1340, Sanderson Gulch

Figure 2. Site 1330, Roslyn

Figure 3. Site 1320, SPR @ Mausoleum

Figure 4. Site 1360, Denver Zoo

Several attempts over the past four years to find a suitable standalone rain-stage site on East Plum Creek in Douglas County have been unsuccessful for a variety of reasons. Now, the District finally can monitor ALERT stage data in Douglas County on East Plum Creek (site 2820) thanks to a cooperative arrangement with the USGS. At the East Plum Creek @ Haskins Gulch gauge house, the USGS monitors stage data with a Sutron DCP and Accubar bubbler. A special replacement Sutron Accubar was installed that allows simultaneous SDI-12 (for the USGS) and analog (for the District) data outputs. The analog output is fed directly into a HSE 3206 binary transmitter and is broadcast in the normal

fashion. The advantage of this configuration is there is no Tiny Basic program needed to extract logged data from the Sutron (and therefore, no handshaking issues). By extension, there are also no unique DCP configurations necessary for USGS technicians to worry about when they download logged data, nor do OneRain personnel have to communicate with the DCP in any fashion. Additionally, using the 3206 allows the District to monitor a rain gauge completely independent of the USGS configuration. Like the other piggybacking schemes, however, the District is dependent upon USGS personnel to maintain the bubbler and DCP for reliable stage data. It should also be stressed that the sediment regime of East Plum Creek (coarse sand, little silt) lends itself to significant scour and deposition of the channel bed, depending on timing, intensity and duration of higher discharge events.

Figure 5. Site 2820, East Plum Creek @ Haskins Gulch

Another new rain and stage site was installed shortly after shutdown at Sulphur Gulch in Parker (see **Figure 6**) on the southeastern edge of the ALERT network.

Figure 6. Site 2840, Sulphur Gulch

At long last, progress has also been made with an expansion to the City of Aurora ALERT network. A new weather suite was installed in November at Aurora Reservoir (site 900), as well as the infrastructure for a new rain only site at Aurora Fire Station 12 (site 840). Additional proposed sites include three rain stage sites (Sand Creek @ Colfax, Murphy Creek near Jewell, Flying J), and another rain only site (Shop Creek). These sites will expand current coverage in Aurora primarily to the east and north.

Damaged equipment and site reinstallations

During the 2003 season, the combined UDFCD/Boulder County network experienced the usual dose of damage resulting from vandalism or "unintended destruction". The Blizzard of 2003 exposed a problem that may have been existent for several years at Winiger Ridge. The resulting ablation of the snow pack completely saturated the ground and exposed a breach in the standpipe below grade. The waterline inside the standpipe was only one inch below the solar bulkhead connector when the problem was discovered, barely sparing the transmitter from probable ruin. The equipment was pulled in April and reinstalled along with a new standpipe in July.

Last spring, the City of Denver Department of Environmental Health (DEH) was informed by the powers that be from the Urban Farm facility that the weather station (site 1460) that had recently (late summer, 2001) been installed on their land needed to be removed. Urban Farm claimed that because the equipment was occupying physical space on their property, someone should be paying a lease for the privilege. Promptly thereafter, the site was taken out of service and removed by DEH personnel in the middle of the summer.

Ongoing discussion continues with regard to the possible reinstallation of the weather station at the new Westerly Creek Elementary/Odyssey school, located less than ½ mile from the abandoned Urban Farm locale. The collective rationale was to try and relocate the new site such that historical data could be combined together to coarsely represent data collection from the same area, and to do so at a site that allows the option for a similar "educational interface" for children that was available at the Urban Farm.

Resurrection of stage data at Kelly Dam was completed in August. Lowry engineers modified the outlet control structure in 2002, resulting in the "disappearance" of the original PT housing, sensor, conduit and cable. While the rehabilitation was relatively straightforward, the resulting pond drains far more slowly than before the new structure was installed last year. In order to be able to anchor the new housing to the new wing wall, OneRain had to accelerate the drainage rate by cleaning the new fine-mesh grate (which serves as a very effective debris filter) in front of the outlet several times. As the District is not responsible for maintenance here, we anticipate that the PT housing will often be submerged during routine maintenance visits in the future due to grate blockage,

meaning that the PT will not be accessible for testing as frequently as it has in the past.

The Overland Fire of October 29th effectively destroyed the rain only site at Golden Age (see **Figure 7**) in Boulder County. The site was reinstalled on November 14th, with a combination of new and old spare hardware and sensors.

Figure 7. Golden Age burn area

PT replacements and discussion

Overall, pressure transducer fallout was rather typical for the 2003 field season. Although a total of 13 PT's were replaced, 6 of these

1) Pine Cliff Road (site 2810)
2) Little Narrows (site 4470)
3) Maple Grove Reservoir (site 1000)
4) Englewood Dam (site 1600)
5) Third Creek @ DIA (site 1480)
6) Kelly Dam (site 410)

were identified as requiring replacement in 2002. Seven others failed during this year's flood season:

1) Havana Park (site 500)
2) Slaughterhouse (site 1620)
3) Simm Street (site 130)
4) Orodell (site 4400)
5) Nolte Pond (site 1020)
6) Lyons Diversion (site 4560)
7) Gunbarrel (site 1110).

Two additional sensors at Bridge (site 4420) and Lower Left Hand (site 4450) have been identified as unreliable and will be replaced before spring 2004 startup.

--The Druck PT at Havana Park died after 4 years of service. It had required recalibrations for two consecutive site visits.

--At Slaughterhouse and Nolte Pond, both the PT's and the signal conditioning boards had to be replaced to achieve reliable stage data. Although this might suggest that electrical surge led to sensor and circuit failure at these sites, no empirical evidence was found to support this hypothesis. The Nolte sensor was nearly 4 years old, the Slaughterhouse sensor had been in service for only 20 months.

--The PT at Simm Street died after 11 years of service. The sensor had required a recalibration once each of the past 3 seasons.

--At Orodell, the PT had to be replaced after 6+ years of service. Additionally, signal conditioning problems contributed to stage data drift. As the signal conditioning circuitry was included on the HSE 3206 logic board, the transmitter was swapped out with another HSE 3206 with onboard signal conditioning.

--The PT at Gunbarrel was replaced after about 5 years of service. Death was sudden, not gradual. No other damage was noted on site.

--At Lyons Diversion, the PT gave up the ghost at the very end of the season. It had been in service for over 6 years.

Unlike the past two field seasons in particular, the majority of the pressure transducers that died this year were sensors that have been in service for several years time. This may be indicative of two trends. First, it may signal an improvement in performance by recently installed Druck PDCR 1830 transducers, which have been disappointingly less than robust (as discussed in the last two EOY reports). If true, this would be very good news indeed, but we would prefer to withhold any judgment on that score until there is more substantial evidence. Second, it may mean that we are witnessing the leading edge of significant dropout in sensors that have been reliable for some time. In

particular, we may begin to see increased dropout rates in the Evergreen and Boulder County pressure transducer populations, which have all been in service since at least 1997.

During 2003, a new variable served to undermine credibility of stage data for several stage sensors, specifically:

1) 6th and Tollgate (site 700)
2) Nolte Pond (site 1020)
3) Slaughterhouse (site 1620)
4) Utah Park (site 430)
5) Confluence Pond (site 720)
6) Orodell (site 4400)
7) Kelly Dam (site 410).

Signal conditioning boards have historically been a rather robust link in the hardware configurations used to collect and produce stage data in the District's system. However, the signal conditioning circuits at the above locations were found to produce instabilities in stage data output. If care is not taken, unstable signal conditioning output can be mistakenly attributed to pressure transducer outputs that appear to drift to an unacceptable degree. Further complicating the problem is the fact that some of the circuit boards that clearly misbehave with specific transmitters and PT's appear to work reliably when used with different transmitters and PT's of the exact same manufacture and model.

OneRain's initial response to this uncertainty is to recommend to the District that any signal conditioning circuit that is verified to produce an unstable output with any specific transmitter and PT pair be put to pasture, irregardless of any subsequent dramatic improvement in "compatibility" with another transmitter/PT pair. Without exhaustive testing and/or information gathering that would enlighten ourselves as to the true nature and cause of the problem *on a component level*, we see a real problem with attempting to use signal boards that fail *anywhere* with *any* other equipment. Our goal is to eradicate any signal conditioning circuit that exhibits anomalous output (read: excessive drift) in any stage configuration. We therefore endorse acquiring enough spare signal conditioning stock that will cover replacement of say (based on 2003 fallout), 10 boards during any given flood season. This quantity can (and will) be adjusted as time goes on, as further information and performance characteristics can (at least in a perfect world) be analyzed. OneRain intends to carry 2 known good spare signal conditioning boards in each field truck so that anytime anomalous stage data is discovered during routine PT testing, the signal conditioning factor can be tested and confirmed with confidence during the site visit.

Repeater upgrade update

Looking at the big picture, 50386 repeater performance has improved dramatically since initial deployment in July, 2002. During 2003, increases in performance have occurred more sporadically and incrementally. Extensive in-house testing performed by OneRain has been episodically followed by iterative returns of the repeaters themselves to the manufacturer, primarily for additional software upgrades, occasionally for hardware upgrades. Right now, the most blatant problem with the repeaters are intermittent binary bit losses/flips that occur *after receipt of reliable site data*, resulting in corrupt sensor IDs or sensor data transmitted in the repeated ALERT messages. This behavior does not appear to be system-wide, but rather associated with several select sites. This indicates that further improvements in receiver and/or modem performance in the 50386 may be necessary.

A more distressing aspect of the current repeater situation is the reluctance by the manufacturer to explicitly acknowledge the scope of the problem(s) that OneRain is articulating, or to conduct its own comprehensive testing on its own product. On a business level, OneRain cannot afford to continue to perform such intensive in-house testing on these products without fair compensation. OneRain has specific ideas relative to this situation that will soon be forwarded to the District in forthcoming correspondance.

Miscellaneous activity of note

--Power system problems at the Eagle Ridge repeater site during 2002 signaled the need for power system upgrades at all non-AC repeater sites in the District's system. New 50-watt solar panels were installed at Choke Cherry, Smoky Hill, and Blue Mountain during 2003. The solar replacement at Blue Mountain fixed a longstanding, very intermittent problem involving insufficient charging of the dual batteries used to power the repeater there.

--The mast box on the Handar standpipe at the Blue Mountain repeater site is cracked. The standpipe will need to be replaced with a new unit.

--There is a possibility that the Smoky Hill repeater can be relocated to a nearby tower located on East Cherry Creek Water District property, meaning the antenna can be mounted several meters above the historical height using the original standpipe configuration. The resulting increase in antenna height alone would enhance reliability of both received and repeated ALERT data.

--The Cherry Creek @ Champa site was effectively disabled during most the 2002 field season due to an inadvertent firmware downgrade that was a result of a DCP swap performed by the USGS. Despite the reintroduction of the original DCP (and hence the correct firmware) to the site last September, the District was still unable to receive cumulative rain totals from the site. In July 2003, the cause

of the problem was finally determined. All along, the assumption had been that there was a problem with the Tiny Basic program specific to the Champa site. However, the problem turned out to be that even though there was a rain sensor defined in the DCP, it was never enabled as a “counter” sensor type after the DCP had been reinstalled last year. The “counter” sensor type is essential for cumulative logging, thus a simple fix to a frustrating problem.

--Mice infestations inside the shed where the Campbell Scientific DCP is stored interfered with routine maintenance activity at DIA. DIA contacted OneRain in February and recommended that maintenance be suspended as there was a concern of the possibility of hantavirus infection; massive amounts of mouse droppings were inside the shed. DIA Environmental Services was unable to clean the site until June. It was then discovered that the DCP was incommunicado and it was pulled for repair, apparently a victim of excessive mouse urine on the sensor terminal blocks. After the DCP was repaired and reinstalled, there remained a problem communicating with the Third Creek PT. Trouble shooting revealed the mice had chewed through the signal cable running from the shed to the exterior junction box. Signal cable was pulled and replaced, fixing the communication problem. Mice poison was deployed inside the shed, and DIA stuffed steel wool in the conduit running from the shed to the stilling well in an attempt to prevent the mice from re-entering (or re-exiting?). Since then, no other mice related problems have reappeared.

--The Boulder County narrowbanding upgrade effort was completed in 2003. Six sites in the “unshared” portion of the network were converted to binary protocol sites:

1) Johnny Park (site 4310)
2) Big Elk Park (site 4300)
3) Red Hill (site 4290)
4) Cannon Mountain (site 4270)
5) Taylor Mountain (site 4260)
6) Indian Ruins (site 4330).

All sites in the UDFCD/Boulder County ALERT network are now transmitting in binary format. Two sites in the shared portion of the UDFCD/Boulder County network do not currently have a 3206 transmitter (and therefore violate narrowbanding requirements): Magnolia, site 4090, and the Justice Center, site 4360.

--The new 3206 transmitter at Indian Ruins died shortly after the Fall maintenance visit. Further investigation revealed that the power amplifier was preventing the radio from providing any power out. Boulder County’s spare 3206 w/PA was installed to keep the site up. The PA is under warranty and is being replaced.

--The District’s narrowbanding upgrade effort also moved forward during 2003, as 10 additional 3206’s were deployed at stage sites during spring startup, replacing S-M 5050’s. Two District stage sites still require upgrades, while

fourteen more S-M 5050's are still deployed at rain only sites, leaving a total of 16 S-M 5050's that still require replacement with 3206's.

--Four more solar panels were replaced with brand new smaller units that better fit the power budget requirements associated with the new Boulder County site configurations using 3206 transmitters and their smaller capacity batteries. The replacements were performed at:

1) Bear Peak (site 4070)
2) Red Hill (site 4290)
3) Indian Ruins (site 4330)
4) Winiger Ridge (site 4530)

One more site (Red Garden, 4030) still requires a solar panel retrofit; the fifth solar panel that was purchased last year for this purpose instead had to be installed as a replacement at site 4310 (Johnny Park), which was vandalized. (Once again, Johnny Park wins the annual Boulder County "beer-drinkin'-gun-totin' target practice" award.)

--The solar panel at Highlands Ranch died and was replaced with a District spare in July.

OneRain Incorporated would like to thank the District's ALERT administrator, Kevin Stewart, for his ongoing assistance, and we hope to again have the opportunity to support the UDFCD ALERT network during the next flood season.

Sincerely,

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