MHFD ALERT Gauging System Maintenance 2020 Annual Report

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Report Date: December 16, 2020

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Executive Summary

The purpose of this report is to summarize the ALERT and ALERT2 system maintenance activities completed by OneRain in 2020 on behalf of the Mile-High Flood District (MHFD) under our current contract.

We believe that maintenance for the 2020 season was successful. We are excited about the continued implementation of the ALERT2™ protocol and the positive impact it will have on ensuring reliable data collection. Table 3 near the end of this report summarizes our site recommendations for the 2021 flood season and their respective costs.

Beginning in the 2008 maintenance season, OneRain and the District modified the maintenance schedule slightly from previous years by including an interim trip to all rain gauge sites. Table 1 below summarizes the maintenance activity over the last twenty years. The "Service Rate" column is the ratio (%) of service calls to sites in the combined MHFD/Boulder System.

Table 1: Recent maintenance activity statistics for MHFD & Boulder Co.

Year	Total # of Visits	Service Calls OneRain/District	Number of Sites[1]	Service Rate
2001	701	66 (30/36)	152	43%
2002	723	59 (45/14)	161	37%
2003	794	110 (86/24)	171	64%
2004	790	78 (51/27)	173	45%
2005	810	97 (76/21)	174	56%
2006	696	97 (78/19)	182	53%
2007	653	58 (49/9)	183	32%
2008	715	94 (62/32)	194	48%
2009	715	107 (93/14)	179	60%
2010	744	82 (81/1)	180	45%
2011	680	78 (69/9)	180	43%
2012	692	67 (53/14)	176	38%
2013	635	97(87/10)	177	55%
2014	624	64(64/0)	178	36%
2015	598	73(63/10)	175	42%
2016[2]	529	50	177	28%
2017[2]	634	44	178	25%
2018[2]	577	38	182	21%
2019[2]	667	38	182	21%
2020[2]	610	27(26/1)	180[3]	15%

[1] Includes repeaters and base stations.
[2] In 2016 OneRain began using new Inventory Maintenance software.
[3] Both Fourmile and Bridge were out of service during the 2020 flood season.

System Performance

A total of 610 maintenance records were collected between January 1 – December 8, 2020, including 27 service calls initiated by OneRain.

Service Calls

The 27 total service calls included the following:

- 9 stage issues
- 3 power-related issues
- 3 tipping bucket issues
- 9 transmitter/RF issues
- 3 infrastructure issues

The unscheduled visits can be attributed to the following:

- Transmitter/RF issues – Transmitter-related issues encompass a wide array of onsite issues including dead radios, program corruptions, transmitter failures, and antenna failures.
- Power issues – Due to an aging battery fleet, several batteries did not survive the interval between standard preventative maintenance visits. Batteries are subjected to dynamic discharge testing at our office. If the battery underperforms it is scrapped and replaced.
- Stage issues – Out of the 9 stage service calls, 7 were due to pressure transducer failures/replacements. The other calls were for pressure transducer signal conditioning.
- Tipping bucket issues – Typically most issues for tipping buckets are due to clogging of the funnel by debris.
- Infrastructure issues – These issues were due to damage to sites resulting from construction activities.

Pressure Transducer (PT) Failures and Replacements

There was a similar amount of PT failures compared to last year. Over the past few years, older Druck PTs have been replaced with Keller Acculevel PTs, as the originals have failed. This year 22 PT calibrations were performed. This number is significantly less than last year's, which is mainly attributed to older sensors being replaced. Specific PT replacements for 2020 are listed below.

- Carr St (10012) – Replaced March 25
- Cold Springs Gulch (2240) – Replaced March 31
- ETG @ Buckly (820) – Replaced March 31
- Little Narrows (4470) – Replaced April 7
- Sports Complex (320) – Replaced May 22
- Sanderson Gulch (10035) – Replaced June 26
- Leyden Reservoir (10088) – Replaced July 2

Damaged Equipment/Other Replacements

Lee Hill Repeater

In early March, several ALERT sites stopped reporting and were down for over 2 weeks. A visit to Lee Hill repeater was made after conducting analysis and site visits to the non-reporting gauges. The ALERT repeater was found to be locked up. It was power cycled and its batteries were replaced. Lee Hill repeater has been working as expected ever since. This is a good candidate for a hardware upgrade in the future.

Figure 1: Lee Hill ALERT Repeater

Gold Hill Repeater
OneRain visited this site in late November as part of end-of-season maintenance. The receive antenna mount was loose and angled off vertical. It was reoriented to the correct position and resecured.

Figure 2: Gold Hill Repeater with antenna resecured

Fourmile (4410)

This site was found not reporting in early June 2019. A site visit revealed that all the equipment had been removed by construction workers fixing the stretch of road along Fourmile Canyon. Fortunately, the ALERT transmitter and pressure transducer were recovered intact. If desired, this site will need to be relocated and installed once construction is complete

Bridge (4420)

On October 9th, 2019, OneRain technicians met with a Boulder County CDOT contractor to discuss work being done to widen the channel where this site is located. The PT conduit was destroyed, however, the PT remained intact and was recovered. The antenna cable was also cut, but the enclosure mounted under the bridge is still intact and reusable. Once construction is complete OneRain can determine the steps needed to get this site operational.

Diamond Hill (10028)

Over the past year this site under reported precipitation. The tipping bucket is free floating in the top section and high winds likely caused the tipping bucket to move out of center. On December 7th OneRain made a site visit to resolve this problem by drilling screws through the tipping bucket into the top section to hold it in place. However, it would be ideal to update this top section to the new key-locked version from High Sierra.

Flying J (10043)

At the beginning of September during a site visit to replace a low battery, the enclosure was found to be heavily corroded and waterlogged. It had been getting worse over time, especially in the last year. On December 8th, the enclosure was replaced. Now the sensor and antenna wires enter through the bottom of the enclosure which should help keep water out.

Figure 3: New enclosure at Flying J.

Quincy Reservoir (10047)

The standpipe was damaged by construction activities in early May. The construction company paid for a new standpipe and installed it in the ground. On September 24th OneRain transferred the electronics and sensors from the original standpipe to the new one. All sensors are reporting as expected except for the air temperature and relative humidity sensor which has occasionally been reporting erroneous data.

Figure 4: New standpipe for Quincy Reservoir.

Aurora Reservoir (10051)

Precipitation stopped reporting in late September. A site visit found that the CR850 datalogger internal battery was low and its firmware was out of date. The logger was brought back to OneRain to have these issues fixed. The logger code was also updated to match similar sites that use the same electronics. All sensors are reporting as expected as of October 15th.

Expo Park (10085)

In early September OneRain was made aware of upcoming work on the outlet structure at Expo Park. This work will most likely affect where the PT resides. The PT was removed and will be reinstalled when work is complete.

End of Season Pressure Transducer Failures

There are 3 sites with a failed pressure transducer that will be visited before April 1st, 2021. Englewood Dam, Harvard/Jackson, and Ralston Reservoir's PTs were found to be bad during the takeout of this year. OneRain hopes to use shorter PTs that might be ordered as spares to replace these sensors.

2020 Site Installs, Reconstruction, Relocations, and Upgrades

Blue Mountain Repeater and Weather Station Upgrade

The repeater at Blue Mountain was updated on January 22nd, 2020. OneRain removed legacy equipment from the site including an R2013A ALERT2 repeater, a 50386 ALERT repeater, and the CR1000 controlling the Blue Mountain weather station. The removed R2013A ALERT2 repeater will be used to replace the repeater at Gold Hill sometime in the future. The CR1000 was returned to the MHFD spare inventory.

Figure 5: Legacy Cabinet Configuration

A High Sierra Electronics Model 3336 Series A2X was installed to replace the ALERT and ALERT2 repeaters. This model repeats received messages in two ways. Received ALERT messages are decoded and repeated as concentrated ALERT2 messages. ALERT2 messages are repeated in the same form in which they were received. This new piece of hardware has a smaller form factor and is more serviceable than the previous configuration. Battery voltage and GPS status are reported hourly to ensure batteries remain healthy and GPS time is accurate.

Figure 6: New Cabinet Configuration

The weather station at Blue Mountain is now being controlled by the 3512 board within the 3336. The Handar 435 RHAT and the Vaisala ultrasonic wind sensor were removed from the site and returned to MHFD inventory due to interoperability issues with the 3512 board. A new HMP45A RHAT and RM Young wind sensor were installed at the site. Precipitation is still being measured by the HSE 2400-03 tipping bucket. The fuel moisture sensor was not integrated into the new weather station due to deterioration.

Figure 7: New RM Young wind sensor (left) and HMP 45A RHAT (right).

As a separate matter, upon arrival, the receive antenna was found separated from the tower. The bottom 3 ft. of the antenna broke from the mounts due to fatigue. The broken antenna was temporarily secured to the side of the tower with 2 worm drive hose clamps. On April 10th a replacement antenna was installed.

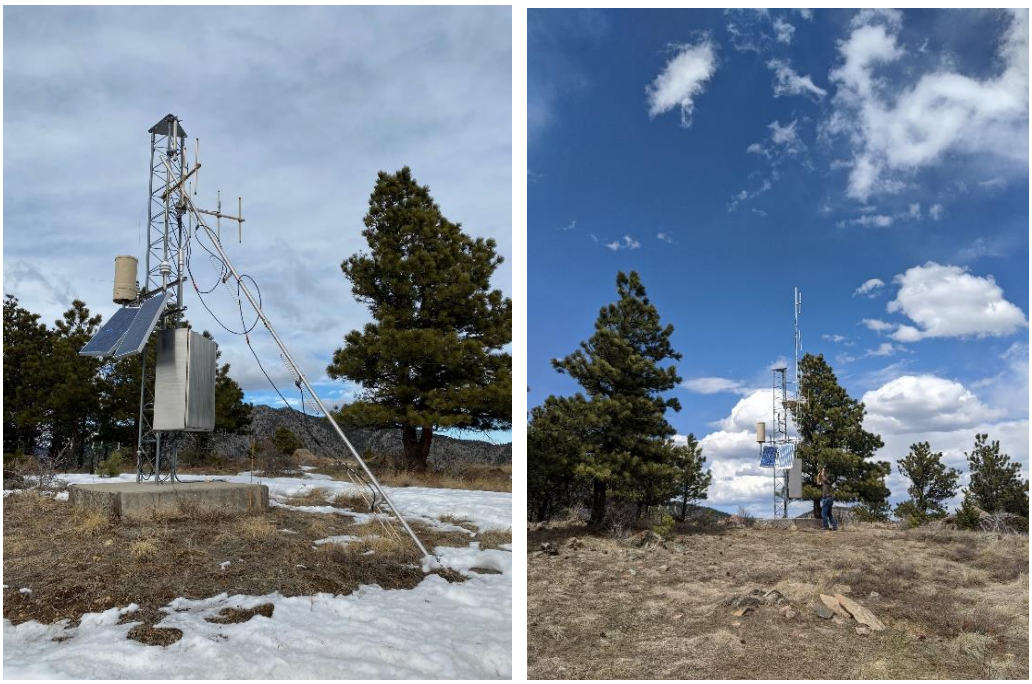

Figure 8: Separated antenna (left). Newly installed antenna (right).

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Rotolo Park (10087)

A new ALERT2 stage and rain gauge was installed for the City of Englewood on June 24th. This site was paid for by the City of Englewood but shares the MHFD backbone of repeaters and base stations. Its ALERT2 source address is 10087.

Figure 9: Rotolo Park ALERT2 rain and stage gauge

Leyden Reservoir (10088)

Leyden Reservoir was upgraded to ALERT2 on July 2nd 2020. OneRain installed an HSE 3306-02 transmitter with a GPS antenna. At the request of the MHFD, this site will be operational year-round. Its ALERT2 source address is 10088.

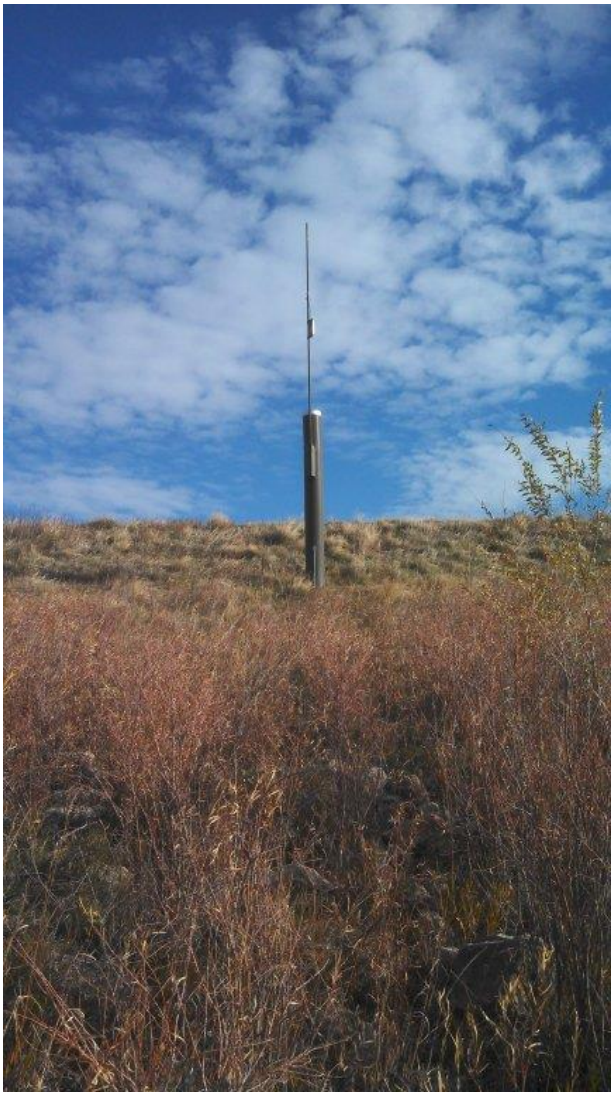

Figure 10: Leyden Reservoir standpipe

Bear Creek @ Lowell (10089)

The original site was collocated with the Colorado Division of Water and USGS until it was destroyed by a car accident in May. This site was reinstalled as an ALERT2 site on September 30th with the standard standpipe configuration provided by High Sierra Electronics. Its new ALERT2 source address is 10089. This site measures both rain and stage.

Figure 11: New ALERT2 site at Bear Creek at Lowell.

Howard Berry WX (10090)

A new ALERT2 weather station was installed for the City of Louisville on November 25th. Like Rotolo Park, this site shares the MHFD backbone and was paid for separately by the City of Louisville. This ALERT2 site reports rain, air temperature, relative humidity, barometric pressure, and wind. Its ALERT2 Source address is 10090

Figure 12: Howard Berry ALERT2 weather station.

Boulder County Activity

There were no major issues in Boulder County this year. A separate report will be delivered to the county with additional recommendations and upgrades.

Geer Canyon (4250)

While remaining relatively unscathed this site's antenna cable was melted from the Calwood Fire in October. While the site was still transmitting, its radio had a high forward-reverse power ratio, indicating damage to the antenna assembly. The ALERT transmitter was removed and will be reinstalled after a replacement antenna assembly is purchased.

Figure 13: Geer Canyon ALERT gauge surrounded by wildfire damage.

Button Rock Weather Station (4790)

The Button Rock weather station's performance has been degrading over the past year. This site uses a Hydrolynx 5096 transmitter that is over 20 years old. The battery voltage has ceased to report in the last year. It is recommended that this site be upgraded to ALERT2 with new sensors.

Miscellaneous Activity

FCC Licensing

Currently, all sites are associated with an FCC license and are not due for renewal until 2025.

Alarming

Rainfall alarms were added to all sites in Contrail. Alarming is triggered by the following events:

- 0.5 Inches in 10 Minutes
- 1.0 inches in 1 hour
- 3.0 inches in 2 hours
- 5.0 Inches in 5 hours

Deliveries are set up for e-mail and/or text message. When a site is in the alarm state, the icon in the user interface will reflect this.

Inventory *plus*

All current and historical maintenance activities can be tracked in real-time at *inventory.onerain.com*. Here you will find current work orders, site issues, and historical activities.

Contrail Branding

OneRain software engineers have updated the Mile High Flood Districts Contrail site with a new URL and logo to reflect the change in naming from UDFCD to MHFD. An additional subdomain was created: *mhfd.onerain.com*

TDMA

OneRain has been in charge of managing source addresses and TDMA information for WET and other agencies since 2013 when ALERT2 gauges had started to be deployed in the MHFD. This info is tracked under three separate websites: alert2.org, tdma.onerain.com, and mhfd.onerain.com.

Alert2.org provides the next available source address to be used, tdma.onerain.com tracks a site's ALERT2 parameters and the mhfd.onerain.com site tracks a site's location relative to its closest repeater to keep a site’s slot or time to transmit as evenly dispersed as possible so that we can efficiently grow the system.

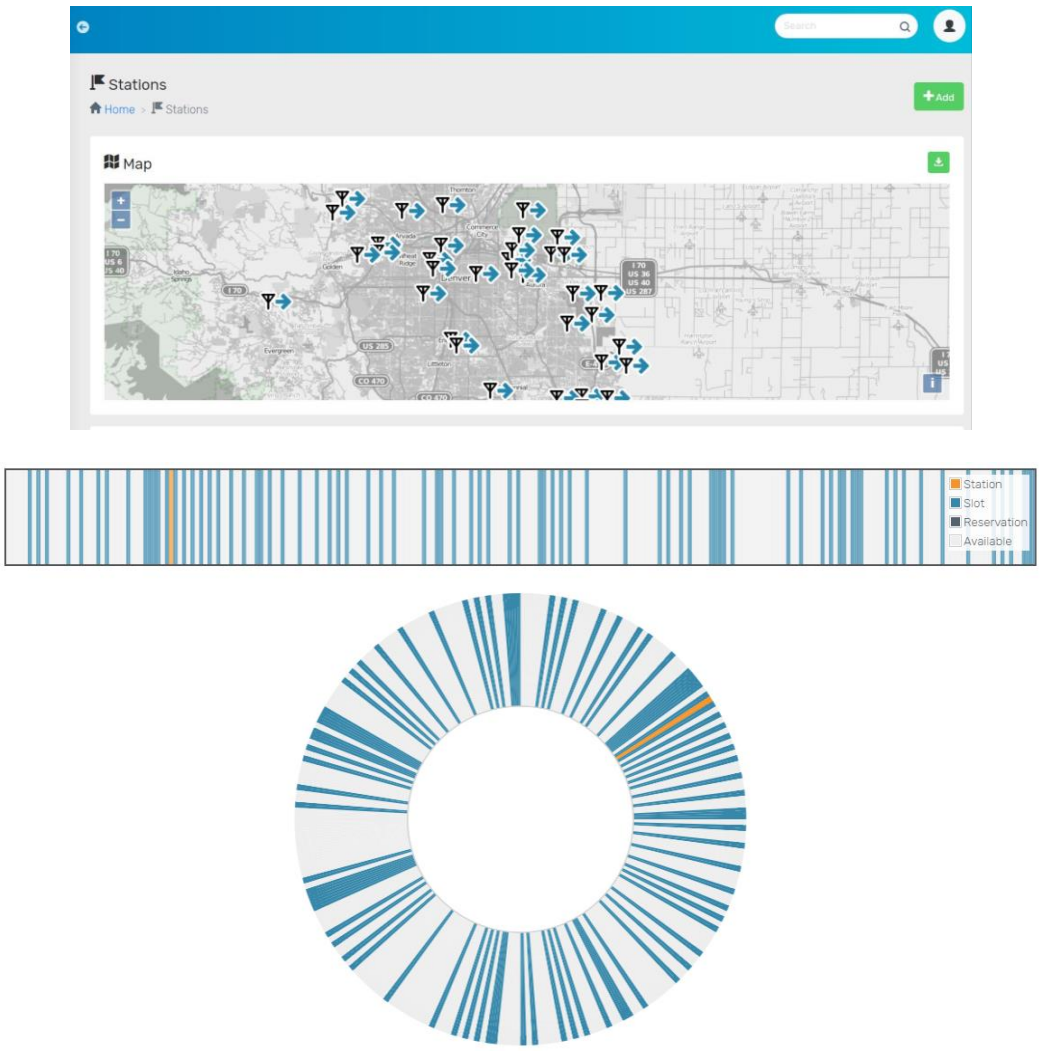

Figure 14: MHFD ALERT2 sites and TDMA timeslots.

Figure 14 was taken from tdma.onerain.com and highlights the ALERT2 sites in Denver (top) and all the slots currently used in the MHFD system (bottom). There are currently 78 ALERT2 sites in total which puts the system at 35% capacity.

Future Areas of Interest

The sections below outline areas that the District and OneRain have been tracking through our monthly meetings, or areas of future concern worthy of note.

ALERT2™ Upgrade

Below is a complete list of sites using the ALERT2 protocol, maintained by OneRain (45 total):

- Carr Street
- Maple Grove Reservoir
- East Toll Gate at Hampden
- Blackstone
- Havana Pond
- James Creek at Jamestown
- Lower Lefthand
- Murphy Creek
- Nolte Pond
- South St. Vrain at Berry
- Quincy Reservoir Wx
- Flying J
- Broomfield
- Aurora Reservoir Wx
- Green Ditch
- Van Bibber @ 93
- Kelly Dam
- Sable @ Colfax
- Hiwan
- Urban Farm
- Cherry Creek @ Steel
- Powers Park
- Leyden Reservoir
- Sand Creek at Colfax
- Westerly Creek Dam
- Coal Creek at McCaslin
- Diamond Hill Wx
- Sanderson Gulch
- Side Creek Park
- Little Dry Creek @ 64th
- Broadway
- Porphyry
- Montview
- Filter Plant
- NREL
- Lakewood Gulch
- Walker Mountain
- Maple Grove res Gates
- Fairview Peak
- Slaughterhouse
- Aurora Regional Pond
- Brighton
- Louisville WTP
- Expo Park
- Bear Creek @ Lowell

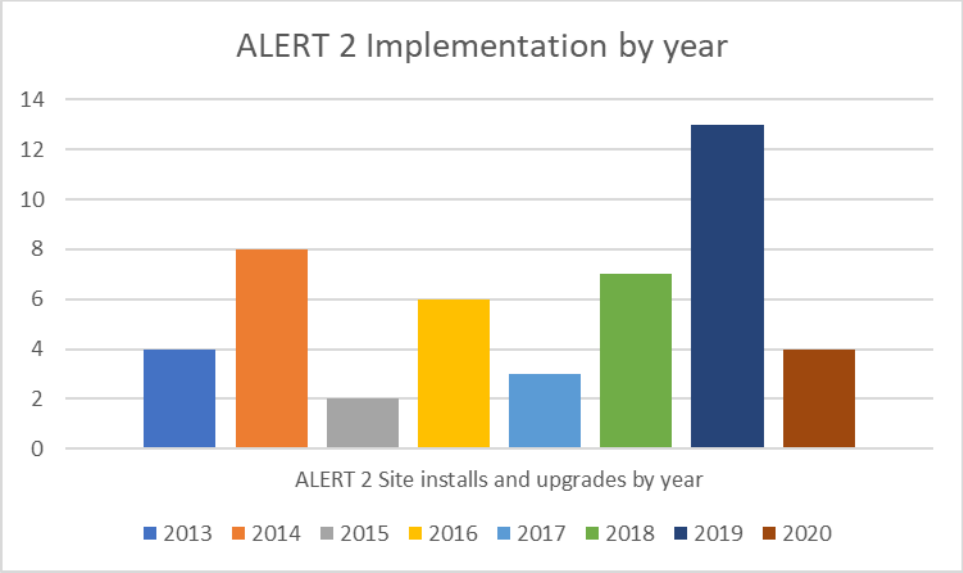

Figure 15: ALERT2 sites added to the MHFD system by year.

Metadata Consistency

OneRain will continue to work with WET and other agencies to integrate database metadata ensuring accuracy and consistency. This includes sharing sensor calibration data, updating rating tables, and E19 levels.

Spare Equipment Recommendations for 2021 Season

There are currently 5 spare pressure transducers in stock all of which are 120ft in length or longer. OneRain recommends adding shorter spare PTs since many sites require less than 100ft of cable.

Table 2: Spare equipment recommendations

Manufacturer	Model	Cost	Purchase	Total	Notes
Keller	Acculevel	$1,339.55	4	$5,358.2	50 ft PT
Keller	Acculevel	$1,471.05	4	$5,884.2	100 ft PT
Keller	Acculevel	$1,602.55	2	$3,205.1	150ft PT
			TOTAL	**$14,410.2**	

Additional Site Recommendations

The following are additional site recommendations not associated with spares. The approximate cost for these recommendations is summarized in Table 3 and explained below. A detailed proposal can be provided upon request.

Table 3 Approximate cost of additional site recommendations

Site / Activity	Approximate Cost (per site)
Quincy Reservoir RH/AT Replacement	$793
Standpipe Door Retrofit	$548
Top Section Replacement	$815
Solar Panel Installation	$363

Quincy Reservoir Temp / RH Sensor

This sensor has been reporting erratically since it was relocated to the new standpipe in September. The MHFD does not have a spare sensor with the proper MS connector. The cost of a replacement 5722-01 Temp / RH sensor is **$793**.

Standpipe Door Retrofit Implementation

In previous seasons OneRain has been retrofitting old standpipes with doors using the High Sierra door kit. There are still many sites that lack a door and are therefore difficult to access the electronics inside. We propose purchasing at least 7 retrofit kits for installation during the Spring of 2021. The installation of doors improves both maintenance safety, hardware wear and tear, and efficiency. The cost of **$548** per retrofit includes hardware and labor. The list below contains sites that would benefit most greatly from the upgrade:

- Parker @ Mississippi
- Temple Pond
- Brighton
- Sand Creek Park
- Pinebrook
- Mission Viejo
- Sports Complex
- Fire Station 13

Replacement Top Sections

In addition to adding doors to standpipes, several sites would benefit from having their top sections replaced due to old age and damage. High Sierras newer style top sections use a key locking mechanism that makes maintenance safer and more efficient. Sites with these new top sections and door retrofits improve safety and reduce potential damage to electronics or pinched wires by not having to remove the transmitter from the top of the standpipe. Sites chosen to have a new top section installed should already have a door or have a door installed. The cost for a new top section is **$815**. The actual cost may be less depending on the type of tipping bucket currently installed at the site. The following sites would greatly benefit from this:

- Parker @ Mississippi
- Temple Pond
- Brighton
- Sand Creek Park
- Pinebrook
- Mission Viejo
- Sports Complex
- Fire Station 13
- SPR @ 3rd

Solar Panel Campaign

There are 7 year-round sites located in the canyons of Boulder that currently do not have solar panels. To ensure data continuity and alleviate unnecessary site visits due to failing batteries it is recommended that a solar panel be installed. This campaign could be spread out over multiple seasons. The cost to purchase and install a solar panel is **$363**. The 7 sites owned by MHFD are as follows:

- St. Antons
- Dowdy Draw
- Sunset
- Sunshine
- Logan Mill
- Crescent Rain
- Shanahan Ridge

MHFD Comm Engine Sites / HydroLynx 5096 Legacy Transmitters

There are 12 Comm Engine and 4 Hydrolynx 5096Transmitter sites left in the MHFD system that are over 20 years old. This equipment is outdated, and no longer supported by the original vendors. The following table lists sites that would most benefit from being updated to ALERT2.

Table 4 Legacy hardware recommended site upgrades

Site	Legacy Equipment	Cost
Calwood Ranch WX	5096	$9,485
Sugarloaf WX	5096	$9,485
Hills Mills WX	5096	$9,217 (currently has a door)
Elbert WX	CE	$9,485
Shop Creek (rain only)	CE	$3323
Upper Leyden (rain only)	CE	$3323

Weather station upgrades include an ALERT2 transmitter, new sensors as well as a door, top section, and solar panel if applicable. We propose upgrading 1 or 2 a year starting with Calwood Ranch and Shop Creek.

Blue Mountain RV50 Installation

A RV50 Cellular modem and antenna would greatly enhance the repeater at Blue Mountain by providing a failover if one of the ALERT / ALERT2 radios failed. This would also allow OneRain to do configurations of the repeater over the air. The total cost for this upgrade would be **$3,965**, which includes one year of data. The recurring annual data fee would be **$360**.

Appendix A: Spares on Hand

Per separate PDF accompanying this document