# UDOT Weather Operations' Wildfire and Debris Flow Response

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*Western States Rural Transportation Technology Implementers Forum | Yreka, CA | June 14, 2023*

# UDOT Weather Operations Where We're At

Keeping Utah Moving

## Central Maintenance

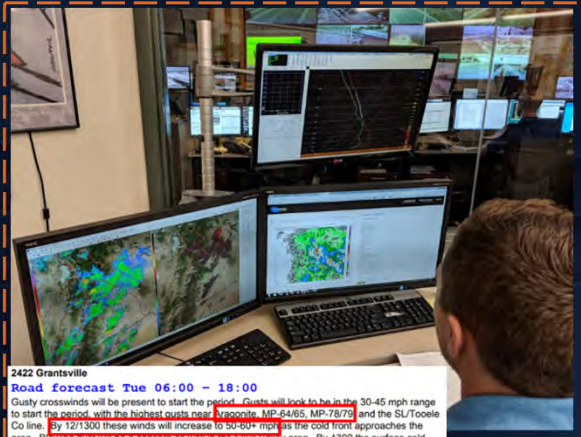
## Traffic Management Division

Keeping Utah Moving

Weather Operations

# UDOT Weather Operations
# How We're Organized

UDOT Keeping Utah Moving
Weather Operations



2422 Grantsville

**Road forecast Tue 06:00 - 18:00**

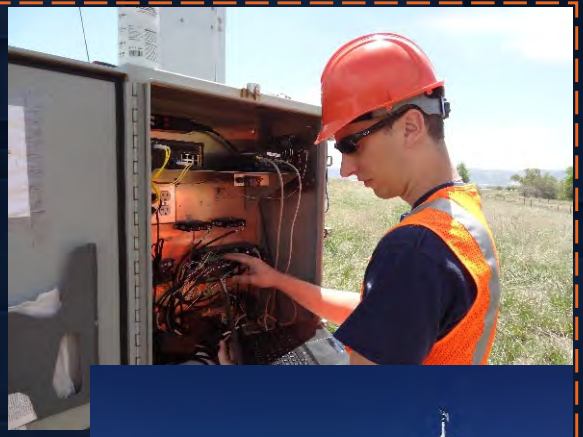
Gusty crosswinds will be present to start the period. Gusts will look to be in the 30-45 mph range to start the period, with the highest gusts near Aragonite, MP-64/65, MP-78/79, and the SL/Tooele Co line. By 12/1300 these winds will increase to 50-60+ mph as the cold front approaches the area. Blowing dust will be a concern as well in the Skull Valley area. By 1300 the surface cold front will pass through the area, with precipitation starting to fall within 30 miles of the frontal passage. Winds will calm down behind the front. Precipitation will initially start out as rain before transitioning to snow around 1500. Because of this, surface pretreatment is not advised. Snow will then look to continue through the period. Expecting 1-2" of road snow through 1800 TUE.

**Road forecast Tue Night 18:00 - 06:00**

Snow looks to continue through 2200 TUE before becoming more showery in nature. Snow showers will then look to end by 00/0100 WED. Expecting an addition 1-2" of road snow through this time. By 0200 WED, there looks to be a threat of a band of Lake Effect developing near the SL/Tooele County line. Any Lake Effect band that does develop will look to bring an addition 2-4" of road snow from 0200-0600 WED. The Lake Effect band does not look to get further W than MP 90 on I-80.

| Time Period | Where | Temp | Dir | Wind | Gust | Sky |
|---|---|---|---|---|---|---|
| Tue | Grassy Shed (4,700') | Hi 35 | SW | 30-40 | | Cloudy |
| Tue Night | Grassy Shed (4,700') | Lo 17 | NW | 20-30 | | Cloudy |
| Tue | Burmester (4,200') | Hi 36 | S | 30-40 | | Cloudy |
| Tue Night | Burmester (4,200') | Lo 18 | N | 20-30 | | Cloudy |

WEATHERNET
A NARWHAL GROUP COMPANY

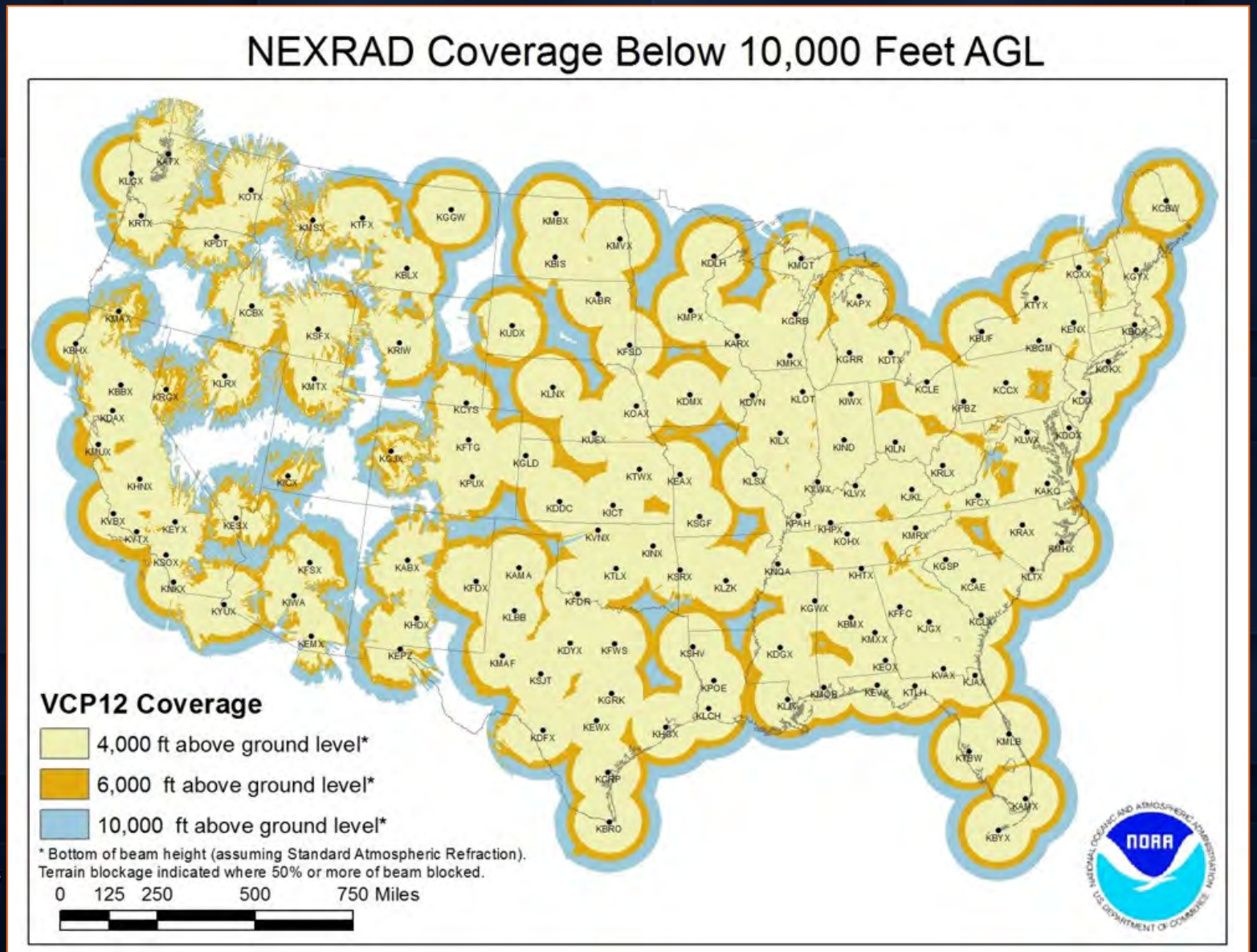


# Seeley Fire, 2012

# Seeley Fire, 2012 Background

- June 26 – July 18, 2012
- Lightning caused
- 20 canyons intersect SR-31
- Burned slopes rise up to 2,500’ vertically above SR-31
- SR-31 AADT < 300

# Radar Coverage



# Seeley Fire, 2012
# Debris Flow Event Snapshot

- July 17 – Huntington Forecast: Thunderstorms will develop once again…
- July 18
  - 1:47 pm – RWIS rainfall alert
  - 1:49 pm – UDOT Weather Group alerts UDOT personnel
    - "Heavy rain and thunderstorms developing over Seeley Burn scar once again... ~0.20" rainfall in 10 minutes, this has been enough to produce flash flooding and mudslides/debris flows the last few days, so expect additional impacts today."
  - 1:58 pm – RWIS rainfall alert
  - 1:59 pm – RWIS rainfall alert
  - 2:04 pm – RWIS rainfall alert
  - 2:04 pm – National Weather Service issues Flash Flood Warning
  - 2:41 pm – National Weather Service reissues Flash Flood Warnings
  - 3:51 pm – Region 4 alerted TOC about mudslide/road closure
  - 3:54 pm – TOC posts on Twitter SR-31 mudslide/closure

# Seeley Fire, 2012
# Sample Feedback

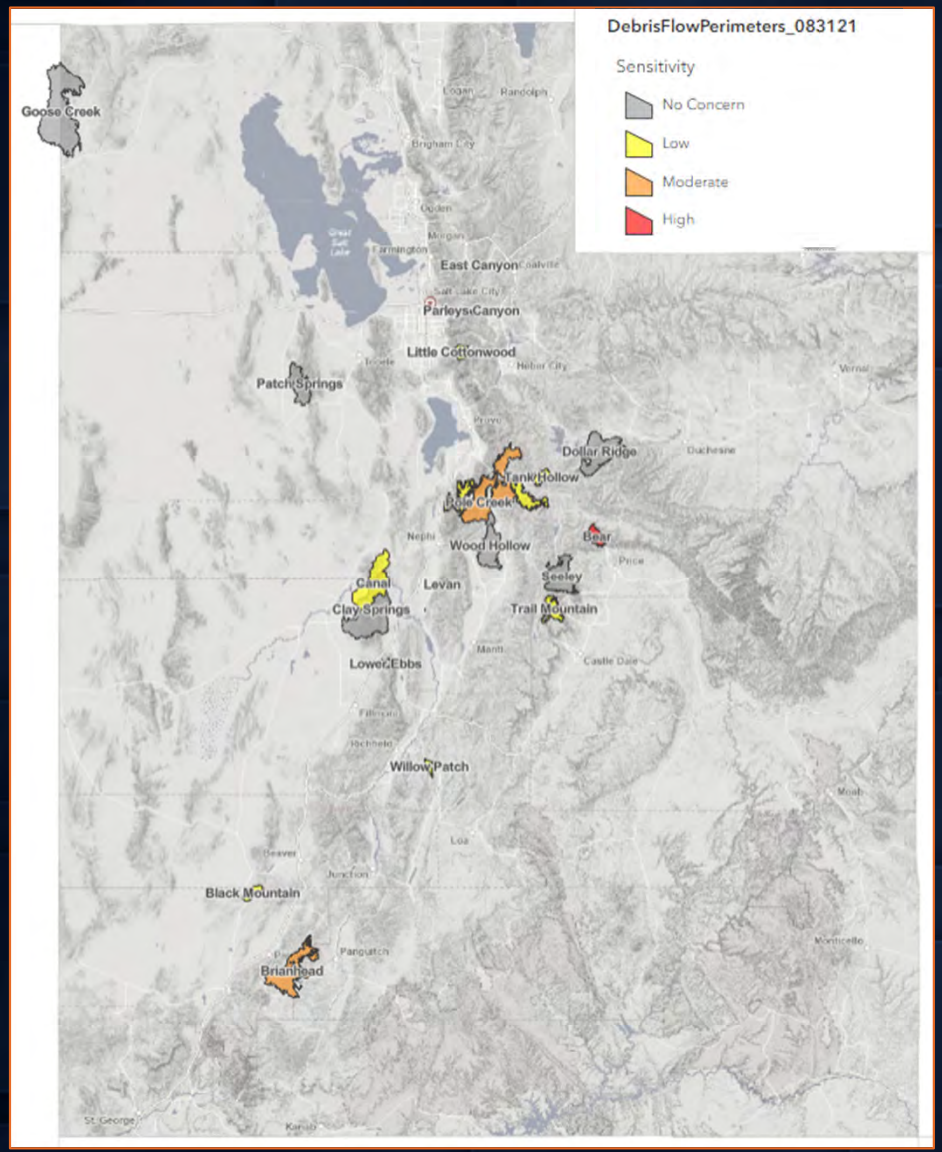
- Huntington Shed Supervisor – Mike Stuart
  - “Really appreciates the Weather Desk’s help, justifies all of the work we are doing.”

- “How long before the next storm?  We will not be working at the mouths of the canyons until it is over”.

- “Debris has come over the road again.  It almost wiped out a contractor.  Road is closed.  It occurred roughly the time one of the forecasters called.”

- “Thanks for the call.  It helps me justify overtime at the end of the week.  There is not much drainage left.  Anything will come over the road.”

# Utah Burn Scars




- **19** burn scars have produced debris flows that impacted UDOT roads **since 2012**
  - Multiple road closures
  - Fatalities due to blowing dust and debris flows on the highway
  - Mitigation efforts have a large positive impact
- **14** burn scars are currently being monitored for potential debris flows

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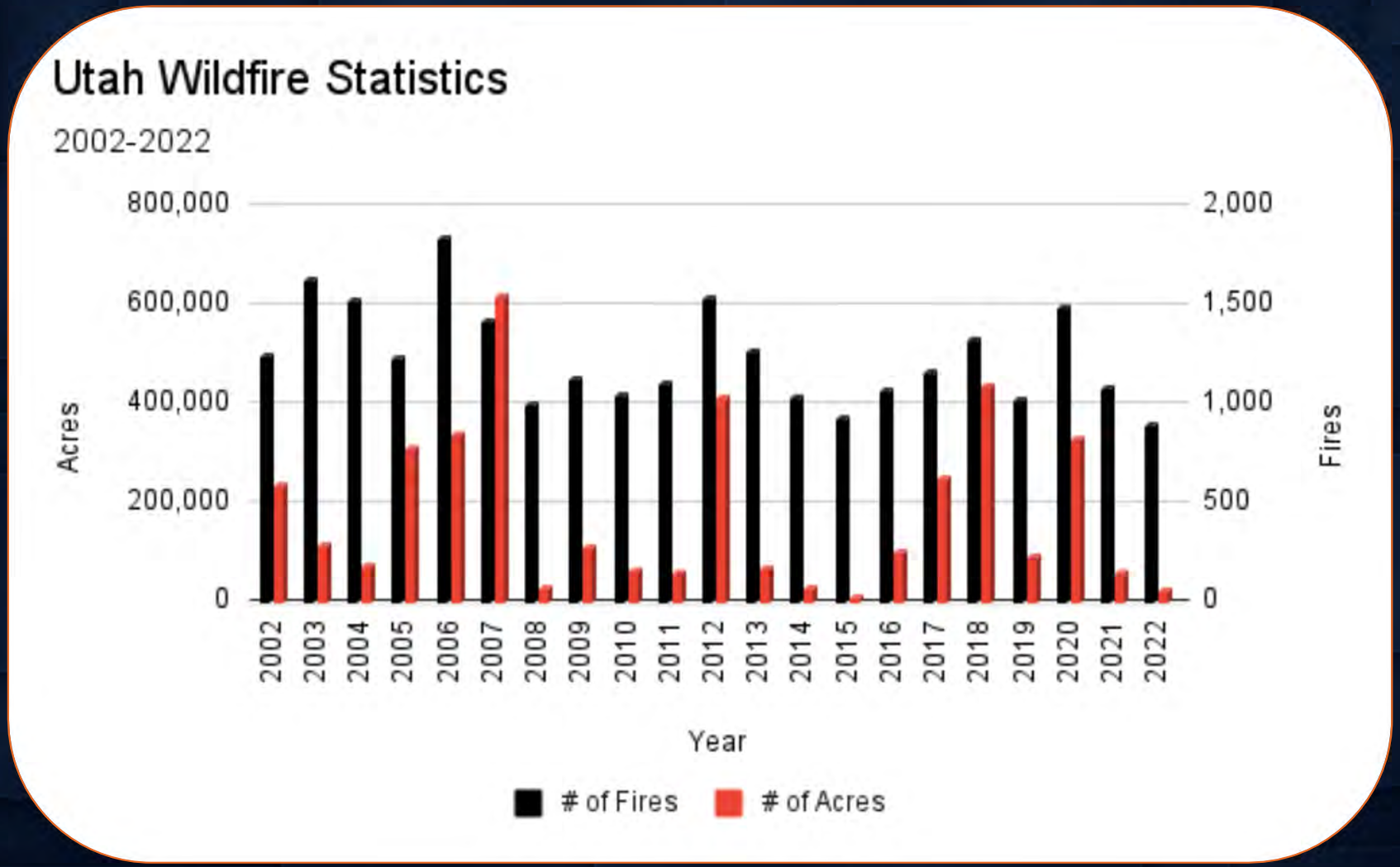
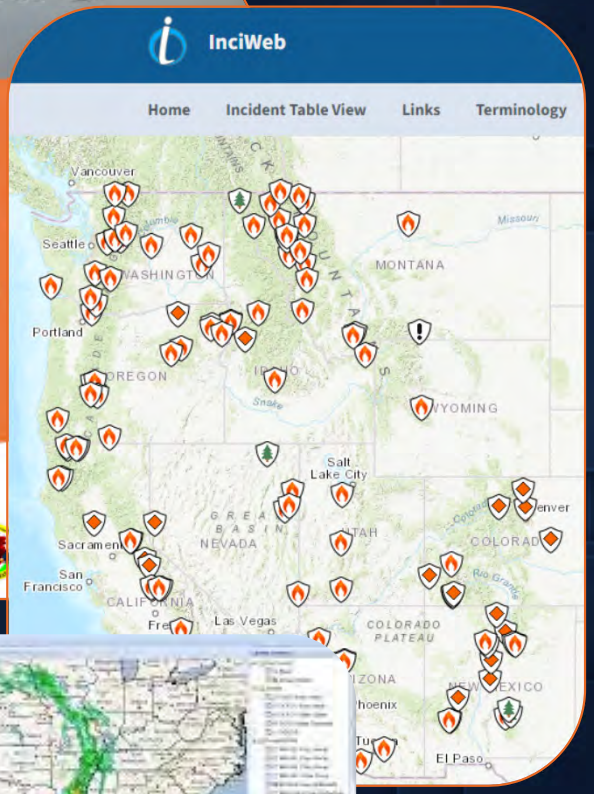
# Utah Burn Scars Log

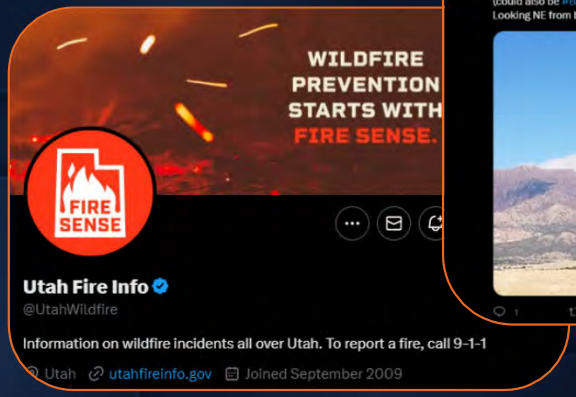
| UDOT Burn Scar Alerting - Working Document | | | | | | |
|---|---|---|---|---|---|---|
| Burn Scar Name | Impacted Route | UDOT Shed | Alert Contacts | Alert Criteria Ranfall Rate | Burn Scar Date | Notes/History/Nearby RWIS |
| *Bear* | US-6; MM 226-227 | Colton | Shed - Tony Cook (435-650-9689); Area Sup - Dan Allred (435-820-4434) | 0.1"/10 minutes | June 2021 | UTTP4; UTPR2. 200' of mud and small rocks/debris flow MM226-227 from both Bear/Crandall Canyons (8/1/2021). |
| *William* | I-15; MM 240-245 | Santaquin | Shed - Gary Steele (801-376-8624); Area Sup - Chad Hansen (801-404-8873) | 0.166"/10 minutes | September 2020 | UTRKY |
| *Parleys* | EB I-80; MM 137-138 | Parleys | Shed - Roger Frantz (801-910-2340); Area Sup - Cooper Crystal (801-910-2532) | 0.166"/10 minutes | August 2021 | UTQRY; UT3 |
| *Pole Creek/Bald Mtn* | US-89 mp 301.5 to 312 Most sensitive area is near 307.2 and 310-312 and US-6 @ mp183.7 to 183.8. | Spanish Fork | Shed - Troy Johnson (801-602-2798); Area Sup - Chad Hansen (801-404-8873) | 0.166"/10 minutes | September 2018 | Burn scar east of US-89 is more sensitive than west of US-89. Debris flow 4/26. |
| *Brian Head* | SR-143/City of Parowan | Parowan | Shed - Dave Burton (435-592-3720); Area Sup - Rick Debban (801-910-2110) | 0.166"/10 minutes | June 2017 | Debris flow 4/27/19, MP 4-15 closed. BHCU1; UTTP5. |
| *East Canyon* | SR-66; MM2-4 | Morgan | Shed - Bryan Woolstenholme (435-640-4470); Area Sup - Rick Pro (801-791-3573) | 0.166"/10 minutes | June 2021 | |
| *Trail Mtn* | SR-31 | Huntington | Shed - Jeremy Larsen (435-749-0725); Area Sup - Dan Allred (435-820-4434) | 0.2"/10 minutes | June 2018 | Minor debris flow 7/12/22. |
| *3 Creeks* | SR-153 | Beaver | Shed - Tom Smith (435-421-1315); Area Sup - Keith Meinhardt (435-979-6355) | 0.2"/10 minutes | September 2020 | S-Turns at MP 17; NOT ON MAP. UTPKL. |
| *Tank Hollow* | US-6 | Spanish Fork | Shed - Troy Johnson (801-602-2798); Area Sup - Chad Hansen (801-404-8873) | 0.2"/10 minutes | September 2017 | |
| *Coal Hollow* | US-6 | Spanish Fork | Shed - Troy Johnson (801-602-2798); Area Sup - Chad Hansen (801-404-8873) | 0.2"/10 minutes | August 2018 | Dairy Fork Creek is likely the greatest threat. Mill Fork Creek is also a threat. Debris flow occurred 8/11/22, but didn't reach US-6. |

# Utah Wildfires



# Before the Fire – Detecting New Fires




CALIFORNIA DEPARTMENT OF FORESTRY & FIRE PROTECTION
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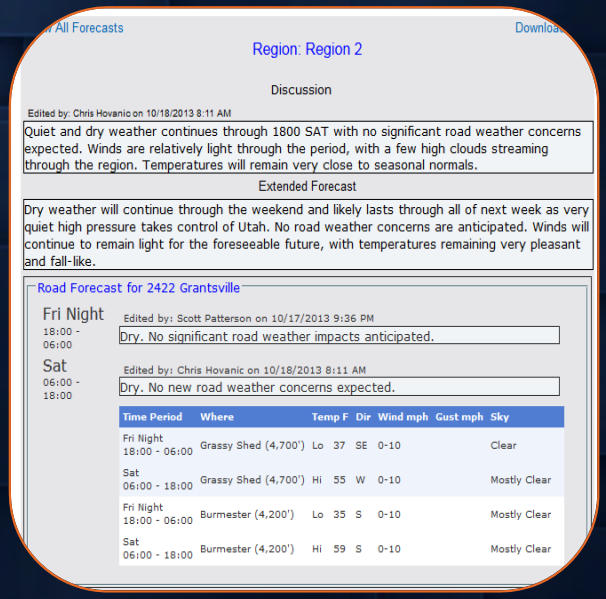
# During The Fire – Weather Operations

- Monitor fire's progress/area


- Forecast any impacts to traffic/infrastructure (low visibility, near-road flames, falling rocks, etc.)



# During The Fire – Incident Response

*Procedure*: Wildfire Response
*Created*: 2021-04-23
*Version*: 1

**Introduction:**
Wildfires are a common occurrence in Utah during the warm and dry summer months. Occasionally, these wildfires impact roadways managed by UDOT to varying degrees. This document provides guidelines for handling different types and sizes of wildfires that affect state-maintained routes. In general, staff should be following standard Incident Evaluation and Escalation procedures, but there are a few additional steps to be completed in fire situations.

This document does **not** cover fire restriction or red flag warning messaging.

**Operational Procedure**:
Fires near the roadway have the potential to impact traffic, and can quickly grow, change direction, or behave in other unpredictable or unexpected ways. Fires near the roadway are incidents that should be carefully monitored by the Control Room for safety or traffic impacts.

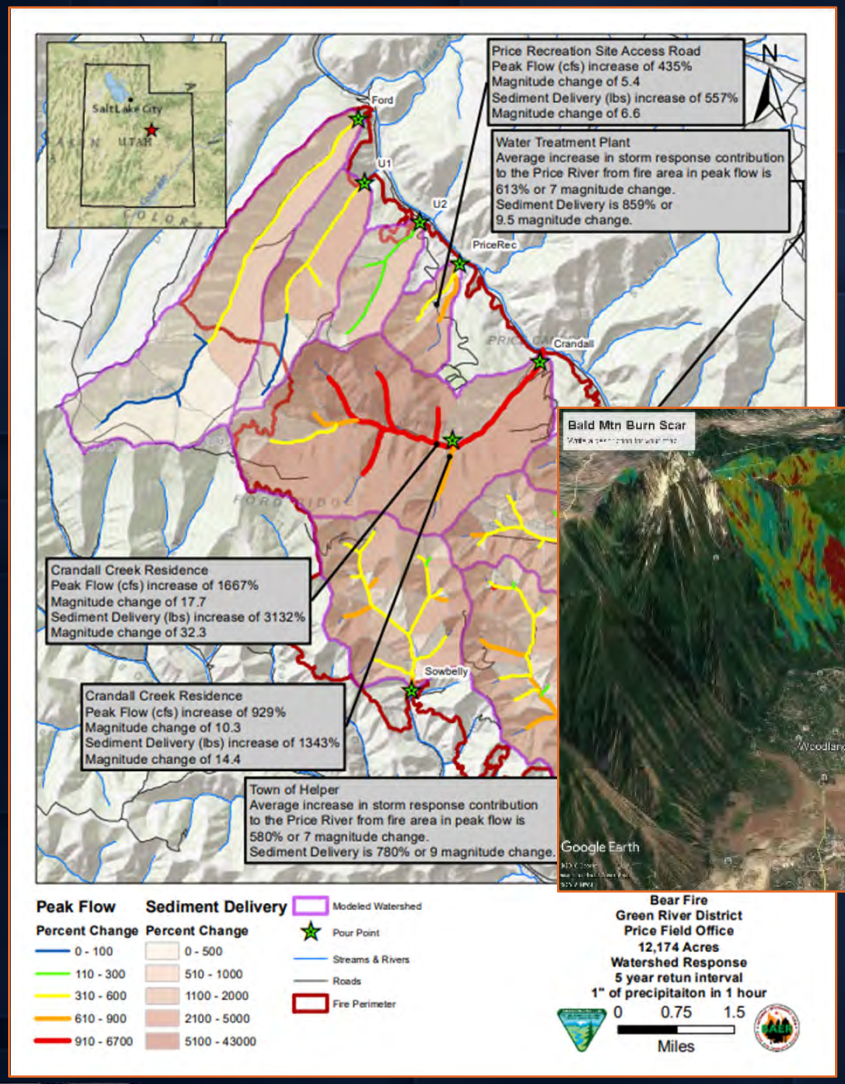
Incident Evaluation is critical when monitoring fires. Be attentive to impacts not only locally near the scene, but to the larger transportation system as well. Full freeway closures, for example, can be very impactful statewide - and not always in expected locations.

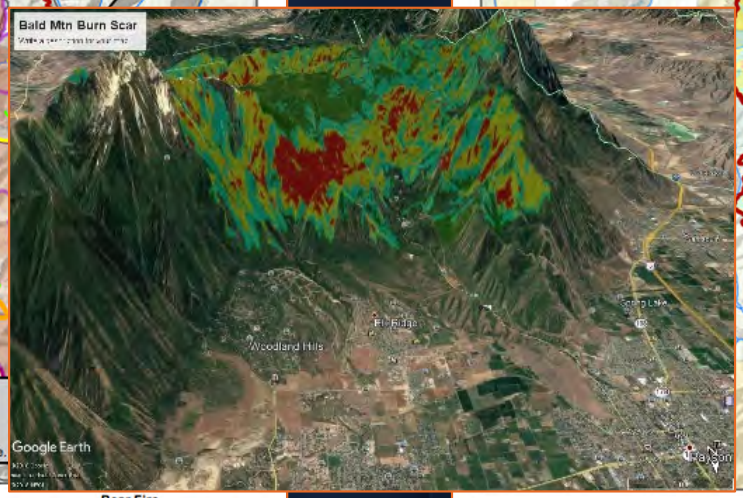
**Incident Response**
Fires near the roadway should be categorized as 'Fire Affecting Roadway' in Event Management.

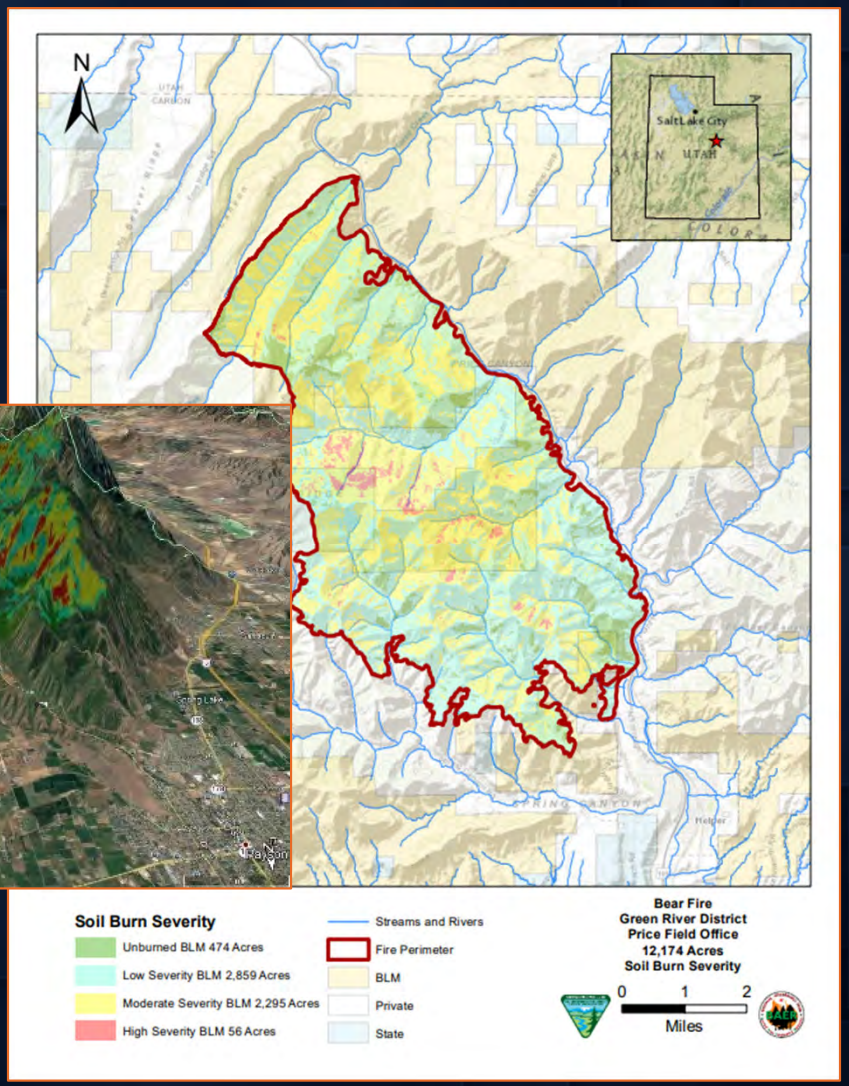
Initial Response


# Outside Agency Coordination

# After The Fire – BAER Assessment

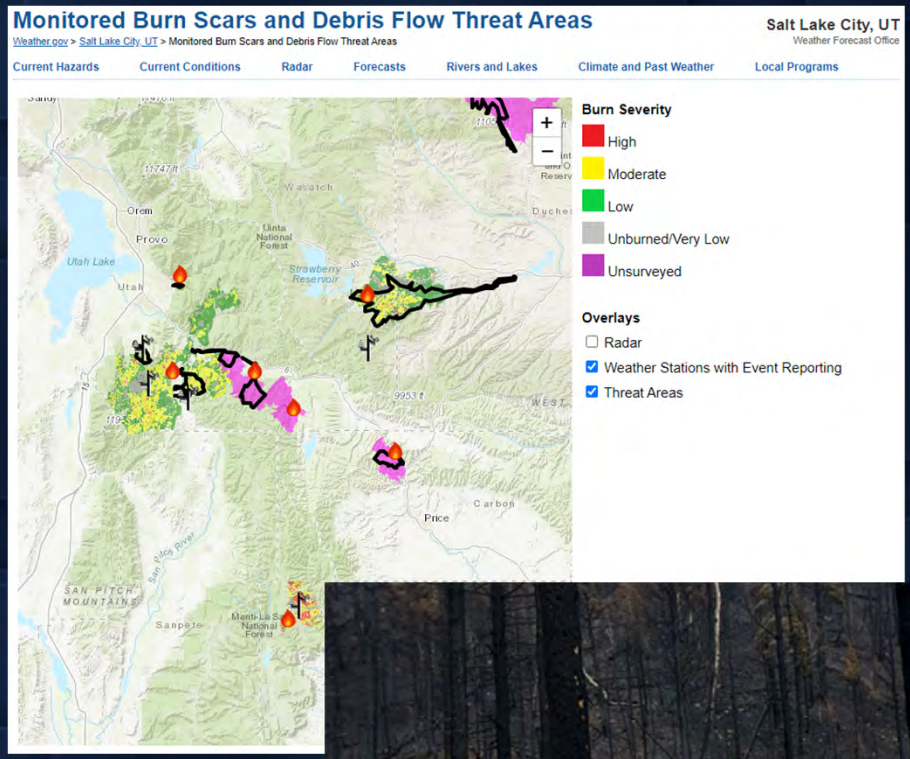


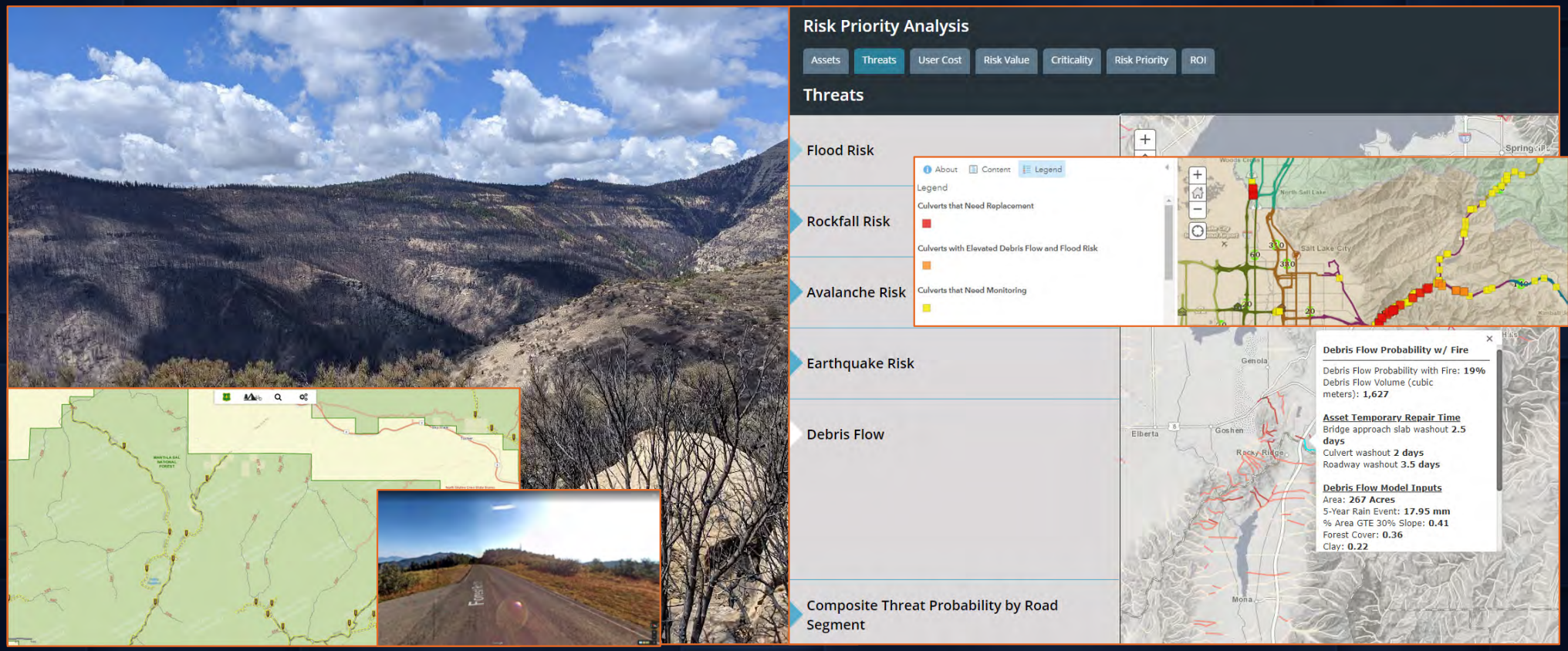



# After The Fire – NWS Assessment

- NWS SLC Hydrologist will join BAER team or conduct own assessment.
- "Utah Post Wildfire Team" convenes
  - State/federal officials
  - Local officials from impacted communities
  - Other affected stakeholders
  - *UDOT Weather Operations to join this team 2023*
- Will deploy tripod(s), issue weather outlooks (various deliverables), watches/warnings, provide decision support, and hold community meetings/conduct area-wide messaging

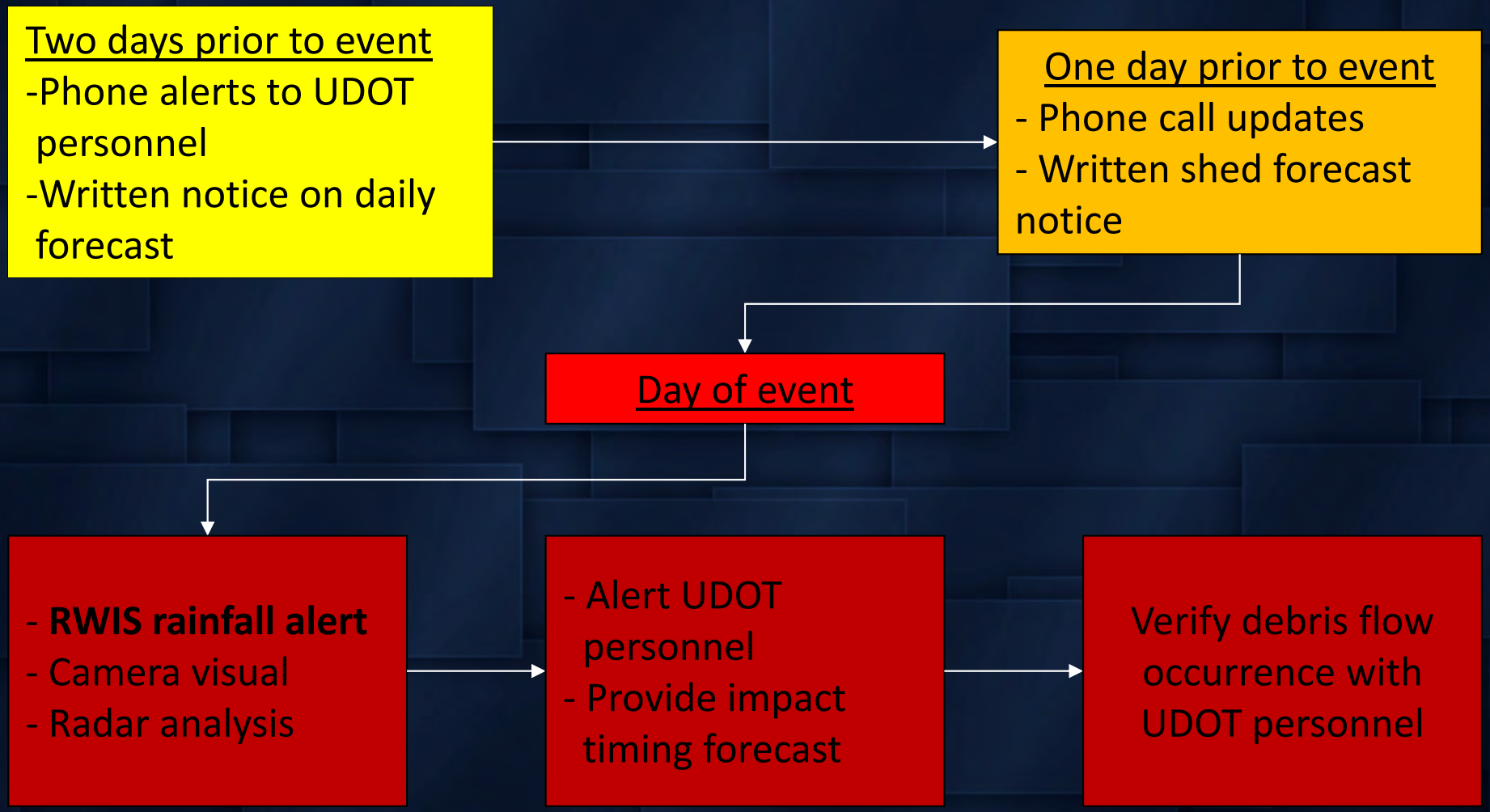



# After The Fire – Weather Ops. Assessment




- Evaluate slope, burn intensity, debris flow probability, culvert quality, and placement of the portable RWIS…

# Forecasting/Alerting Process



# Assessment after first debris flow

- What were the impacts?
- How much rain fell?
- What does the landscape look like now?
  - Mitigation efforts?
    - If yes, was it effective?

- Reevaluate alerting criteria and longer-term use of portable RWIS.

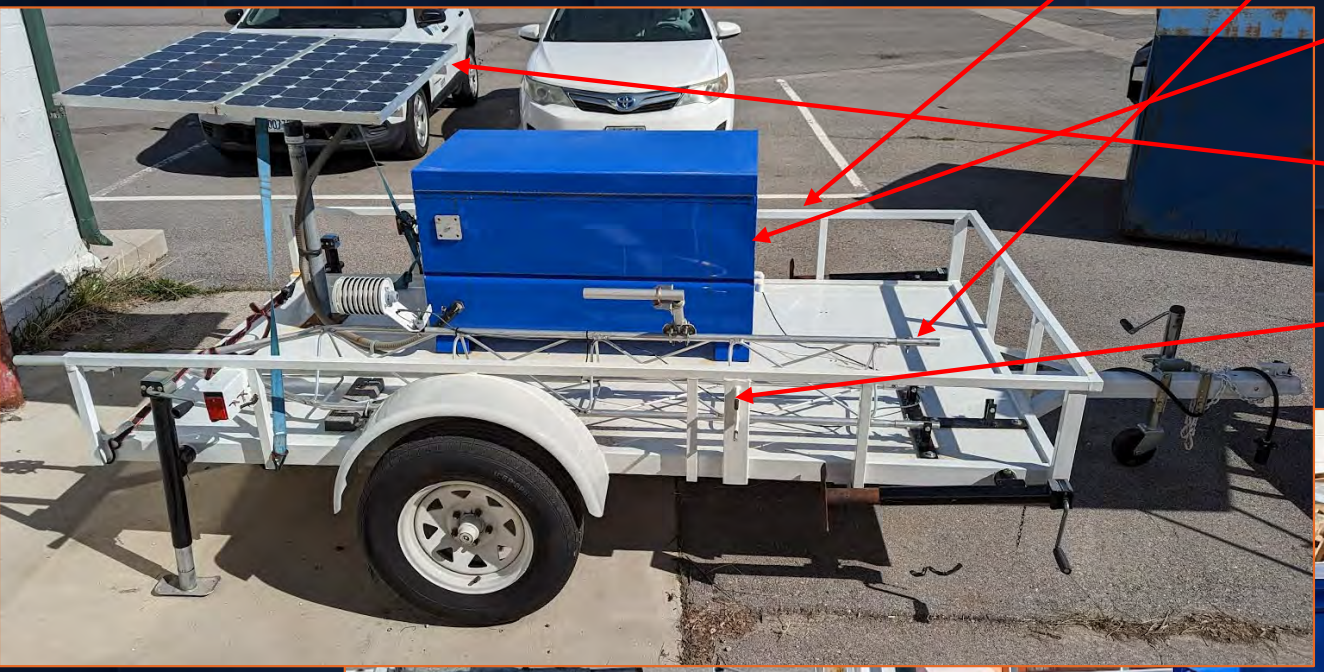
# Drainage Mitigation
# Tank Hollow Fire


# Trailer/Tripod Placement

- Deploy after ~100% containment only
- Primary concerns – water treatment plant, e.g., and not a UDOT road?
- Land available – coordination with landowners
- Radar coverage
- Cell/solar coverage…
- Not visible
- Camera view / dummy camera
- Not the highest point, but also not in a drainage
- RAWS (time of deployment) – predominantly during the fire
- Winter weather – need to pull it back? Trailers usually yes

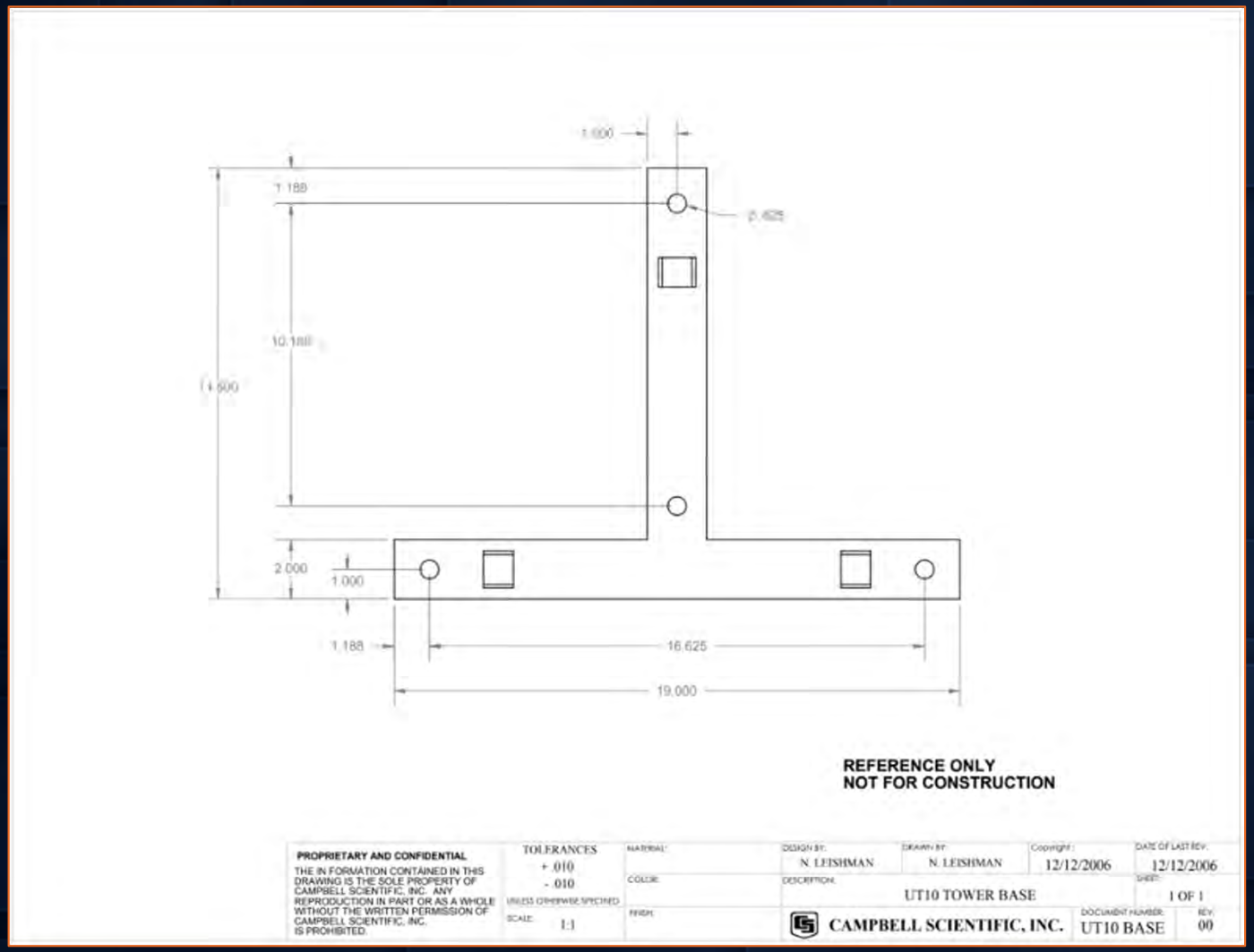
# Trailer Setup

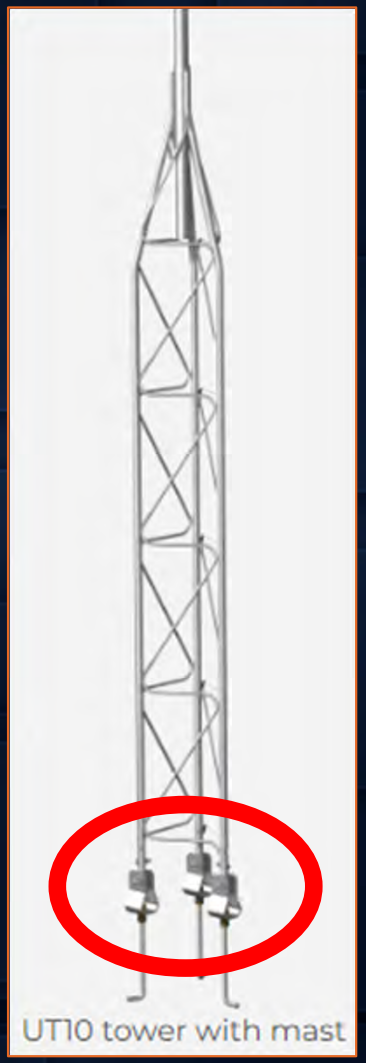
# Trailer Setup
## Ready to transport



- Simple trailer with metal plate (provider unknown)
- Campbell Scientific UT10 tower with base
- Battery/controller enclosure (Kobalt Jobsite Box)
- Pole with solar panels and pole mount
- Spot for spare tire

# Trailer Setup
## UT10 Tower bases

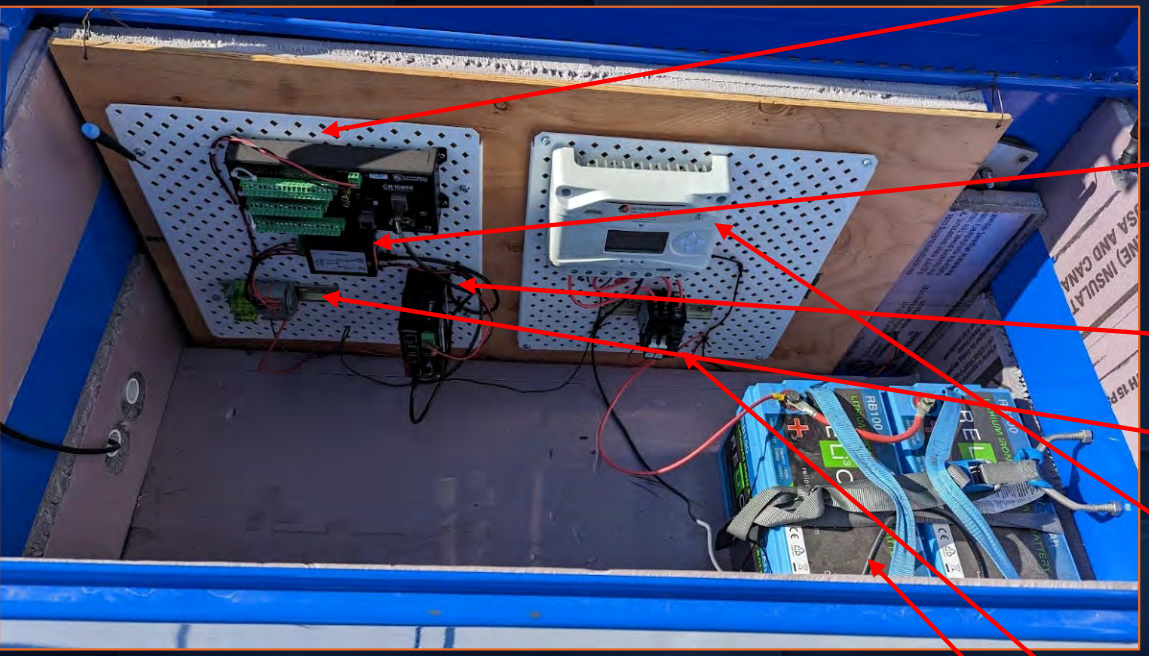




UT10 tower with mast

# Trailer Setup
## Enclosure

# Trailer Setup
## Transporting equipment (gently…)

# Trailer Setup
## Enclosure equipment



- Campbell Scientific CR1000X datalogger
- Network camera midspan/POE injector
- Cell modem
- Power distribution
- Morningstar Prostar MPPT-40M solar controller
- Breakers
- 2 RELiON RB100 LiFePO4 batteries

# Trailer Setup – Tower equip.

- RM Young 05103 anemometer (provided by Campbell Scientific)
- Axis M5525-E network camera with T91L61 wall-and-pole mount
- Campbell Scientific CS125 present weather and visibility sensor
- Two Wilson 301111 yagi antennas (main and diversity)
- Variety of temp/RH sensors… Currently a Campbell Scientific HygroVUE10, radiation shield
- Texas Instruments TE525 rain gauge (provided by Campbell Scientific) on crossarm and right-angle mount

# Trailer Setup – Cable mgmt.

# Tripod Setup
## Tripod equipment


- Campbell Scientific CM355 w/ CM310 (CM106B more standard)
- Campbell Scientific 850 and 17589 lightning rod
- TE525
- Wilson 301111
- “Dummy” camera
- Temp/RH sensor, radiation shield
- Anemometer
- Campbell Scientific ENC16/18 enclosure
- Campbell Scientific 31107 solar panel mounting kit
- (Large) solar panel (Dasol DS-A18-135, discontinued)

# Tripod Setup
## Enclosure equipment


- CR1000X
- Morningstar Sunsaver MPPT-15L
- Cell modem
- Breakers, power distribution
- RELiON RB52

# Axis M5525


- Low-power network PTZ camera to evaluate radar and conditions
- Set up to share with desired stakeholders with controlled logins

# 05103 Anemometer


- Evaluate the potential of blowing dust
- Evaluate any downburst winds – assess strength and lifecycle of a thunderstorm

# CS125 Visibility and Present Weather Detector


- Evaluate blowing dust severity – Can detect rainfall, but will use rain gauge ultimately

# Sometimes a Campbell Scientific CS655 (soil moisture)

- Evaluate wetness of soil to determine if blowing dust could be a concern

# TE525 Rain Gauge

- The star of the show
- Tipping bucket mechanism, datalogger will alert at specified threshold(s)

# Sometimes a Campbell Scientific ClimaVUE50…


- All-in-one device that combines temp/rh, wind, and precipitation, but also has lightning detection and solar radiation
- Better for cheap, long-term installs where wind is not a concern

# (Consistent) Wiring Diagram

**Master CR1000X Program Wiring Diagram: Updated 5/5/2021**

| *RMYoung Anemometer* | *Black Box* | *CR1000X* |
|---|---|---|
| Green | WD Sig (4) | SE 1 |
| Blue | WD Exc (5) | EX 1 (VX 1) |
| Red | WS Sig (6) | P 1 |
| White | WD Ref (3) | SG |
| Black | WS Ref (2) | SG |
| Clear or Yellow | Shield (1) | PG |

| *Vaisala Non-Invasive DSC/DST* | *CR1000X* |
|---|---|
| Black | C5 (Tx) |
| White | C6 (Rx) |
| Grey | PG |
| Brown | 12V |
| Blue | PG |

| *High Sierra Non-Invasive IceSight* | *CR1000X* |
|---|---|
| Red (6-wire: Yellow) | C5 (Tx) |
| White (6-wire: Blue) | C6 (Rx) |
| Red | 12V |
| Black | PG |

| *CC640 Camera* | *CR1000X* | *MD485* |
|---|---|---|
| BL | - | B |
| YL | - | A |
| GN | - | SG |
| BK | PG | - |
| RD | 12V | - |
| WH | C8 | - |

| *LI200X Pyranometer* | *CR1000X* |
|---|---|
| Red | SE 5 |
| Black | SE 6 |
| White | SG |
| Clear | SG |

| *EE181 Temp/RH* | *CR1000X* |
|---|---|
| Yellow | SE 3 |
| Blue | SE 4 |
| Red | 12V |
| Clear | PG |
| Black | PG |

| *Rotronic HC2S3 Temp/RH* | *CR1000X* |
|---|---|
| Brown (Temp) | SE 3 |
| White (RH) | SE 4 |
| Green | 12V |
| Grey | PG |
| Yellow | SG |
| Clear | SG |

| *HMP45C Temp/RH* | *CR1000X* |
|---|---|
| Yellow | SE 3 |
| Blue | SE 4 |
| Red | 12V |
| Black | PG |
| White | SG |
| Clear | SG |

| *Hygrovue 10* | *CR1000X* |
|---|---|
| White | C3 |
| Brown | 12V |
| Black | PG |
| Clear | PG |

| *SR50 Snow Depth Sensor* | *CR1000X* |
|---|---|
| Green | C7 |
| Red | 12V |
| Black | PG |
| White | PG |
| Clear | SG |

| *TE525 Precip Bucket* | *CR1000X* |
|---|---|
| Black | P2 |
| White | SG |
| Clear | SG |

| *107 Ground Temp Subprobe* | *CR1000X* |
|---|---|
| Black | EX 1 (VX 1) |
| Red | SE 2 |
| Purple | SG |
| Clear | SG |

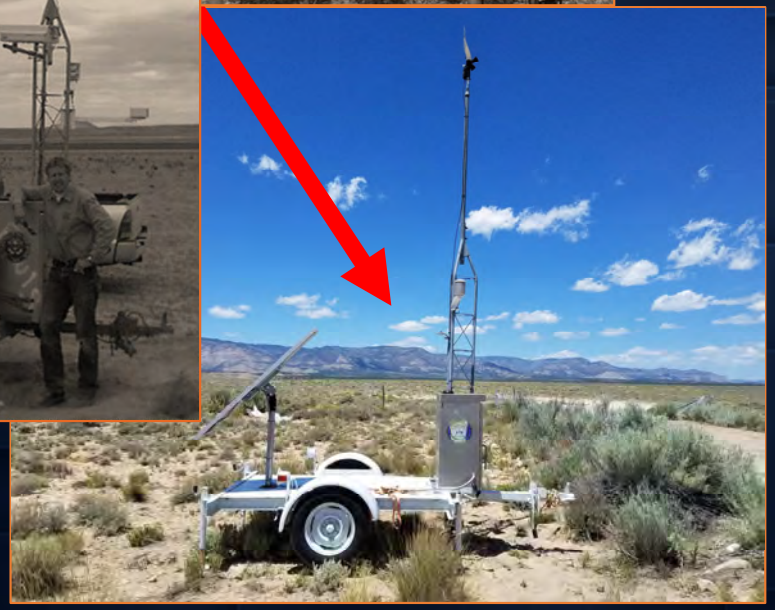
| *CS125 Present Wx Sensor* | *CR1000X* |
|---|---|
| Blue | C1 |
| White | C2 |
| Red | 12V |
| Black | PG |
| Green | PG |
| Clear (can be snipped) | PG |

| *CS215 Temp/RH* | *CR1000X* | *CS125* |
|---|---|---|
| Red | - | Pin 1 |
| Green | - | Pin 2 |
| Black/White/Clear | - | Pin 3 |
| Red | 12V | - |
| Green | C1 | - |
| Black/White/Clear | PG | - |
| Clear | SG | - |

# Maintenance/Calibration

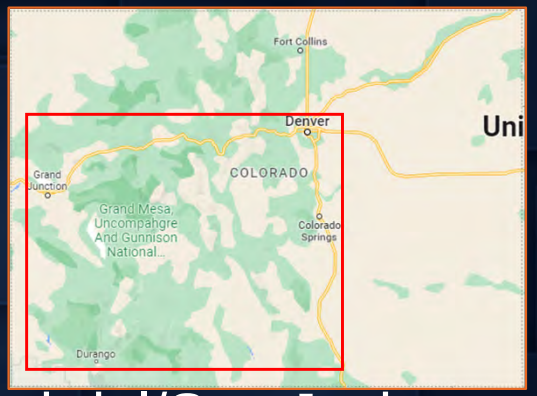
- Treated like any other RWIS when in the field
  - Part of annual preventative maintenance cycles and will conduct any response maintenance
- Since they're usually brought back in fall, sensors can receive calibration and maintenance at the office before being placed back in the field the following year

# Longer-Term Maintenance

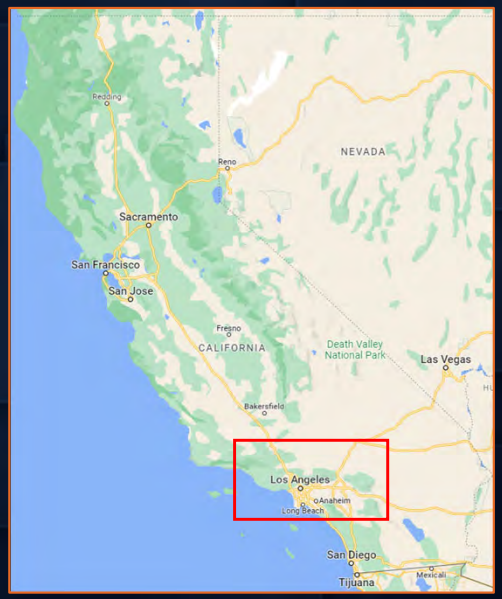


- As needed, bring to vehicle maintenance at UDOT HQ for repaint and tail-light repair.
- Repair/replace solar poles and solar mounts, jack stands, enclosures

# Rainfall Threshold Determination




- **Cannon et al., 2007:**
  - South-central and southwestern Colorado:
    - $I = 6.5*D^{-0.7}$
    - $I = 9.5*D^{-0.7}$
  - Ventura County and San Bernardino/San Gabriel/San Jacinto Mountains, California
    - $I = 12.5*D^{-0.4}$
    - $I = 7.2*D^{-0.4}$
  - Same California Mountains, after one year of vegetative recovery and sediment removal:
    - $I = 14*D^{-0.4}$
      - Threshold of 25 mm/hr (~1 in/hr) higher




- $I$ = rainfall intensity (mm/hr)
- $D$ = duration in hours

# Rainfall Threshold Determination
## Looking for that 10-min threshold…

| Equation | Rate required for 10 minutes (mm/hr) | 10 minute amount required (inches) |
|---|---|---|
| $I = 6.5*D^{-0.7}$ | 22.783 mm/hr | 0.149” |
| $I = 9.5*D^{-0.7}$ | 33.299 mm/hr | 0.218” |
| $I = 12.5*D^{-0.4}$ | 25.596 mm/hr | 0.168” |
| $I = 7.2*D^{-0.4}$ | 14.743 mm/hr | 0.097” |
| | *AVERAGE:* | *0.158”* |

But… The Seeley Fire was observing debris flows < 0.15”/10 minutes…
And we’d like to be on the more cautious side…
Therefore, we chose a value of **0.10” in 10 minutes** for highly sensitive fires

Eventually decided **0.15”** in 10 minutes for moderately sensitive fires
and **0.2”** in 10 minutes for low sensitivity fires

Evaluate fire sensitivity each year (usually trending lower, or dropped altogether)
Note other duration thresholds….

# CR1000X Datalogger Programming – Page 1

```
'Example CR1000X program automatically generated by RWISPrograms.py on 04/20/23
'Generator: Cody Oppermann

'Instruments included:
'HygroVUE, 05103 or Legacy Alpine Anemometer, CS125, TE525
'Output Data Tables: MesoAtmo, MesoRoad, Daily, PresentWx

'Modifications:
'Edited for rainfall alerting for Slack and via email

'General notes:
'Made with variables for sensors that may not exist for output table
'consistency among all UDOT RWIS.
'Variables not NTCIP compliant - dealt with in post-processing.

'Declare Constants:
Const TE525_exist = 1
Const solar_exist = 2

'Declare Public Variables
'Main Variables
Public Batt_volt
Public Air_Temp_f
Public RH_percent
Public TdC
Public TdF
Public TwC
Public TwF
Public Wind_Dir_deg
Public Wind_Speed_mph
Public Two_Min_Wind_Dir_deg
Public Two_Min_Wind_Speed_mph
Public Precip As String *3
Public Precip_Intensity As String *8
Public Solar_v
Public Ground_18in_Temp_f
Public SnowfallRate
Public Rain
Public Snow_Depth_in

Public TRHData(2)
Alias TRHData(1)=AirTC
Alias TRHData(2)=RH
```

# CR1000X Datalogger Programming – Page 2

```
'CS125 Variables - message output format set to Full METAR on the CS125.
Dim CheckVal As Long, TempString As String
Dim NBytesReturned, OutString As String * 40
Public CS125_In As String * 200
Public cs125out(27) As String
Alias cs125out(1)=messID
Alias cs125out(2)=sensorID
Alias cs125out(3)=sysStatus
Alias cs125out(4)=messInterval
Alias cs125out(5)=vis_m_string
Alias cs125out(6)=visUnits
Alias cs125out(7)=avgDuration
Alias cs125out(8)=userAlarm_1
Alias cs125out(9)=userAlarm_2
Alias cs125out(10)=Emitter_failure
Alias cs125out(11)=Emitter_lens_dirty
Alias cs125out(12)=Emitter_temp_error
Alias cs125out(13)=Detector_lens_dirty
Alias cs125out(14)=Detector_temp_error
Alias cs125out(15)=Detector_saturated
Alias cs125out(16)=Hood_temp_error
Alias cs125out(17)=Ext_temp_error
Alias cs125out(18)=Signature_error
Alias cs125out(19)=Flash_read_error
Alias cs125out(20)=Flash_write_error
Alias cs125out(21)=Particle_limit_error
Alias cs125out(22)=Particle_count
Alias cs125out(23)=Intensity_mm_hr
Alias cs125out(24)=SYNOPCode
Alias cs125out(25)=PresentWeather
Alias cs125out(26)=CS125Temp
Alias cs125out(27)=CS125RH

Public visibility_m
Public visibility_mi
```

# CR1000X Datalogger Programming – Page 3

```
'Declare Private Variables - For wet-bulb temp calculation
Dim AirTC_9
Dim SPkPa_6
Dim Twg_7
Dim Twpg_8
Dim Vpg_9
Dim Vp_10
Dim SVp_11
Dim Twch_12
Dim VpgVpd_13
Dim Top_14
Dim Bottom_15
Dim N_17

'Define Units
Units Air_Temp_f=Deg F
Units RH_percent=%
Units Wind_Speed_mph=miles/hour
Units Wind_Dir_deg=Degrees
Units Snow_Depth_in=inches
Units Solar_w=W/m^2
Units Batt_volt=Volts
Units visibility_mi=miles
Units TdF=Deg F
Units TwF=Deg F
Units SnowfallRate=in/hr
Units Rain=inches
Units Ground_18in_Temp_f=Deg F

'Variables for Slack and email rainfall alert
Dim URI As String * 78 = @"Slack Link..." 'Insert Slack WebHook here
Dim Content As String * 100 = @"{""text"": ""There has been 0.1\"" of rain at the Bear (Tripod) Burn Scar in 10 minutes!""}"
Public HTTPResponse As String * 90
Public HTTPHeader As String * 90 = ""
Public HTTPResult As String * 90

Const ToAddr = @"test@example.com" 'Insert email address here
Const Subj = @"Rainfall Alert"
Public email_triggered
Public ServerResp

Public RunningPrecip10min
Public AlertTimer
Const AlertTimerLimit = 3600 'Only alert once every hour in a one-second scan
Public Trigger
```

# CR1000X Datalogger Programming – Page 4

```
'Define Data Tables
'MesoAtmo table
DataTable (MesoAtmo,1,1008)
  DataInterval (0,10,min,10)
  Sample (1,Air_Temp_f,FP2)
  Sample (1,RH_percent,FP2)
  Sample (1,Two_Min_Wind_Dir_deg,FP2)
  Sample (1,Two_Min_Wind_Speed_mph,FP2)
  Maximum (1,Wind_Speed_mph,FP2,False,True)
  Sample (1,Precip,String)
  Sample (1,Precip_Intensity,String)
  Average (1,Snow_Depth_in,FP2,False)
  Average (1,Solar_w,FP2,False)
  Sample (1,Batt_volt,FP2)
  Sample (1,visibility_mi,FP2)
  Sample (1,TdF,FP2)
  Sample (1,TwF,FP2)
  Sample (1,SnowfallRate,FP2)
  Totalize (1,Rain,FP2,False)
EndTable

'MesoRoad table
DataTable (MesoRoad,1,1008)
  DataInterval (0,10,min,10)
  Sample (1,Ground_18in_Temp_f,FP2)
EndTable

'Daily table
DataTable (Daily,1,-1)
  DataInterval (0,1440,min,10)
  Minimum (1,Batt_Volt,FP2,False,True)
  Maximum (1,Air_Temp_f,FP2,False,True)
  Minimum (1,Air_Temp_f,FP2,False,True)
  Maximum (1,RH_percent,FP2,False,True)
  Minimum (1,RH_percent,FP2,False,True)
  Maximum (1,TdF,FP2,False,True)
  Minimum (1,TdF,FP2,False,True)
  Maximum (1,TwF,FP2,False,True)
  Minimum (1,TwF,FP2,False,True)
  Average (1,Wind_Speed_mph,FP2,False)
  Maximum (1,Wind_Speed_mph,FP2,False,True)
  Average (1,Ground_18in_Temp_f,FP2,False)
  Totalize (1,Solar_w,IEEE4,False)
EndTable
```

# CR1000X Datalogger Programming – Page 5

```
'PresentWx table
DataTable (PresentWx,1,1008)
  DataInterval (0,10,min,10)
  Sample (1,visibility_mi,FP2)
  Sample (1,Particle_count,FP2)
  Sample (1,Intensity_mm_hr,FP2)
  Sample (1,SYNOPCode,FP2)
  Sample (1,PresentWeather,String)
  Sample (1,sysStatus,FP2)
  Sample (1,Emitter_failure,FP2)
  Sample (1,Emitter_lens_dirty,FP2)
  Sample (1,Emitter_temp_error,FP2)
  Sample (1,Detector_lens_dirty,FP2)
  Sample (1,Detector_temp_error,FP2)
  Sample (1,Detector_saturated,FP2)
  Sample (1,Hood_temp_error,FP2)
  Sample (1,Ext_temp_error,FP2)
  Sample (1,Signature_error,FP2)
  Sample (1,Flash_read_error,FP2)
  Sample (1,Flash_write_error,FP2)
  Sample (1,Particle_limit_error,FP2)
  Sample (1,CS125Temp,FP2)
  Sample (1,CS125RH,FP2)
EndTable

'TwoMinute table (for wind)
DataTable (TwoMinute,1,-1)
  DataInterval (0,120,sec,10)
  WindVector (1,Wind_Speed_mph,Wind_Dir_deg,FP2,False,0,0,1)
EndTable

'Main Program
BeginProg
Scan (1,Sec,0,0)

  Battery (Batt_volt)

  '(Regular) Wind Speed & Direction Sensor measurements WS_ms and Wind_Dir_Deg:
  PulseCount (Wind_Speed_mph,1,P1,5,1,.2192,0)
  BrHalf (Wind_Dir_deg,1,mV5000,1,Vx1,1,2500,True,20000,_60Hz,355,0)
  If Wind_Dir_deg>=355 Then Wind_Dir_deg=0
  'Pull two minute values from the two minute table
  Two_Min_Wind_Speed_mph=TwoMinute.Wind_Speed_mph_WVc(1)
  Two_Min_Wind_Dir_deg=TwoMinute.Wind_Speed_mph_WVc(2)

  'No subprobe:
  Ground_18in_Temp_f = "NAN"
```

# CR1000X Datalogger Programming – Page 6

```
221   'LI200X Pyranometer measurement
222   If solar_exist = 1
223     VoltDiff (Solar_w,1,mV200,3,True,0,60,1,0)
224     If Solar_w<0 Then Solar_w=0
225     Solar_w=Solar_w*200
226   Else
227     Solar_w="NAN"
228   EndIf
229
230   'TE525 Tipping Bucket Rain Gauge
231   If TE525_exist = 1
232     PulseCount (Rain,1,P2,1,0,.01,0)
233   Else
234     Rain="NAN"
235   EndIf
236
237   'Rainfall alerting code.
238   TotalRun(RunningPrecip10min,1,Rain,600)
239
240   If RunningPrecip10min > 0.1 AND Trigger = 0 Then
241     HTTPResult = HTTPPost(URI,Content,HTTPResponse,HTTPHeader)
242     email_triggered = EmailRelay (ToAddr,Subj,Content,ServerResp)
243     Trigger = 1
244     AlertTimer = AlertTimer+1
245   ElseIf AlertTimer < AlertTimerLimit AND Trigger = 1
246     AlertTimer = AlertTimer + 1
247   Else
248     Trigger = 0
249     AlertTimer = 0
250   EndIf
251
252   'Call Output Tables
253   CallTable MesoAtmo
254   CallTable MesoRoad
255   CallTable Daily
256   CallTable TwoMinute
257   CallTable PresentWx
258
259 NextScan
260
261 SlowSequence
262
263 Scan (10,Sec,0,0)
```

# CR1000X Datalogger Programming – Page 7

```
'HygroVUE
SDI12Recorder(TRHData(),C3,"0","M!",1,0)
Air_Temp_f = AirTC*1.8 + 32
RH_percent = RH
'WetBulbCalc for HygroVUE5/10
AirTC_9=(5/9)*(Air_Temp_f-32)
SPkPa_6=101.325
SatVP(SVp_11,AirTC_9)
Vp_10=RH_percent*SVp_11/100
'Dew Point calculation TdF
DewPoint(TdC,AirTC_9,RH_percent)
If TdC>AirTC_9 OR TdC=NAN Then TdC=AirTC_9
TdF=1.8*TdC+32
'Find Wet-Bulb TwF
Top_14=AirTC_9
Bottom_15=TdC
For N_17 = 1 To 25
  Twpg_8=Twg_7
  Twg_7=((Top_14-Bottom_15)/2)+Bottom_15
  WetDryBulb(Vpg_9,AirTC_9,Twg_7,SPkPa_6)
  VpgVpd_13=Vpg_9-Vp_10
  Twch_12=ABS(Twpg_8-Twg_7)
  If VpgVpd_13>0 Then
    Top_14=Twg_7
  Else
    Bottom_15=Twg_7
  EndIf
  If Twch_12<0.01 OR N_17=25 Then ExitFor
    Next
    TwC=Twg_7
    TwF=1.8*TwC+32

Snow_Depth_in = "NAN"
```

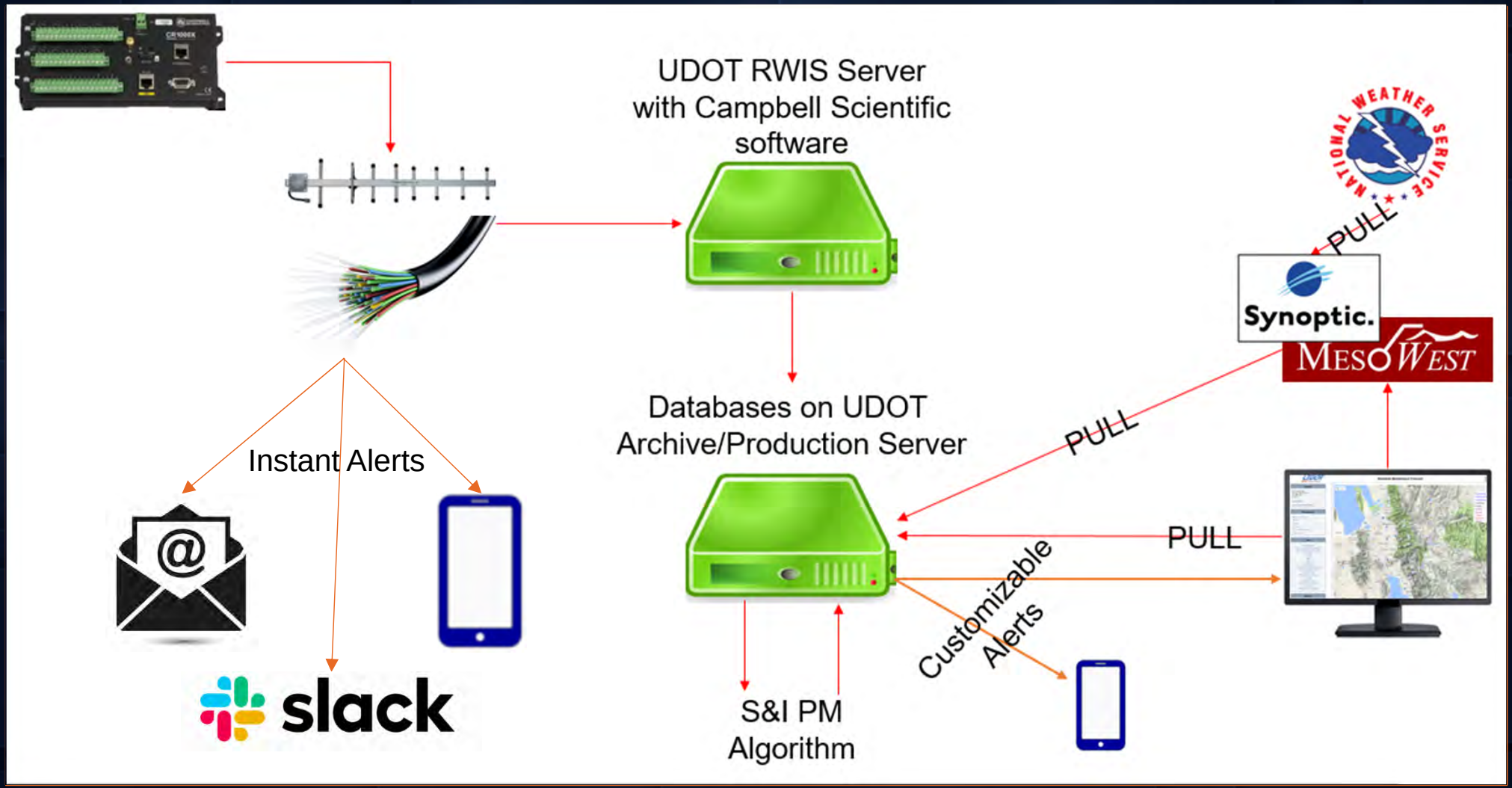
# CR1000X Datalogger Programming – Page 8

```
299   'CS125 Stuff
300   'Setup datalogger port for binary communication
301   SerialOpen(COM1,38400,3,0,1000)
302   TempString = "POLL:0:0"
303   CheckVal = CheckSum (TempString,1,0)
304   OutString = CHR(2) + TempString + ":" + FormatLong (CheckVal,"%04X") + ":" + CHR(3)+ CHR(13) + CHR(10)
305   'Send get data command to cs125, then pause for 1 second
306   SerialOut (COM1,OutString,"",0,100)
307   Delay (1,1,Sec)
308   'Set up COM1 to receive incoming serial data.
309   SerialInRecord (ComC1,CS125_In,&h02,0,&H03,NBytesReturned,01)
310   'Split out visibility parameters from string input
311   SplitStr (cs125out(),CS125_In," ",25,5)
312   visibility_m = vis_m_string
313   visibility_m = visibility_m*2.19 ' UDOT's modification
314   visibility_mi = visibility_m*0.000621371192
315
316   If visibility_mi > 10 Then
317     visibility_mi = 10
318   EndIf
319
320   If visibility_mi < 0.01 Then
321     visibility_mi="NAN"
322   EndIf
323
324   If Intensity_mm_hr >= 0.3 OR SYNOPCode=51 OR SYNOPCode=61 OR SYNOPCode=71 OR SYNOPCode=72 Then
325     Precip="Yes"
326     If Intensity_mm_hr <3 Then
327       Precip_Intensity="Light"
328     ElseIf Intensity_mm_hr >= 10 Then
329       Precip_Intensity="Heavy"
330     Else
331       Precip_Intensity="Moderate"
332     EndIf
333   Else
334     Precip="No"
335     Precip_Intensity=" "
336   EndIf
337
338   If CS125_In="NAN" Then
339     Precip=" "
340     Precip_Intensity=" "
341   EndIf
342
343   If visibility_mi < 0.5 AND Precip="No" Then
344     Precip_Intensity = "Fog"
345   EndIf
```

# CR1000X Datalogger Programming – Page 9

```
347   'Determine snowfall rate
348   If Precip="Yes" AND TvF < 34 AND visibility_mi < 10 Then
349     SnowfallRate = 0.5 / visibility_mi
350     If visibility_mi < 0.25 AND Particle_count <= 200 Then
351       SnowfallRate = 2
352     ElseIf SnowfallRate >= 5
353       SnowfallRate = 5
354     EndIf
355   Else
356     SnowfallRate = 0
357   EndIF
358
359   If visibility_mi="NAN" Then
360     SnowfallRate = 0
361   EndIf
362
363   'Clear out COMC1 serial buffer
364   SerialFlush (ComC1)
365   SerialClose (ComC1)
366
367 NextScan
368 EndProg
```

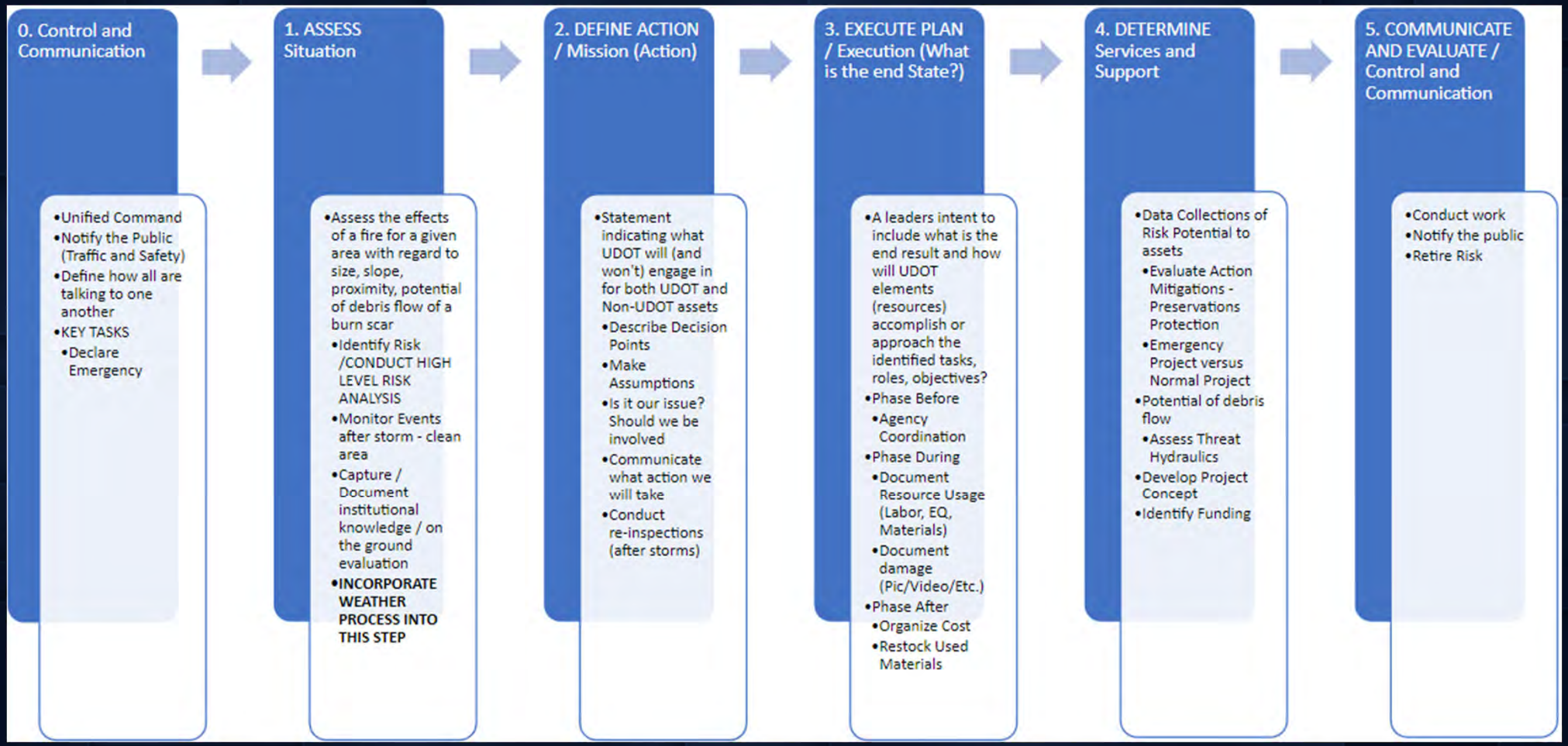
# UDOT's RWIS Network - Dataflow



# Challenges/Lessons Learned

- Deployment challenges
  - Landowner
  - Out of view
  - Capture rainfall without being a lightning rod
  - Solar/cell coverage
- Timeliness/latency of the alerts, public messaging in rural areas
- How long will the burn scar be a threat
  - Some burn scars can cause issues long after it is thought that it has healed
- More of a NWS impact? Or a UDOT impact? Or both?... Who has the more appropriate resources?
- Coordination/flow of information
  - What work is being done outside Weather Operations?
  - Sharing information outside of UDOT
  - Avoid duplication of efforts

# Future Process – UDOT Wide



# Future Process – UDOT Weather Operations

Mostly the same, but with increased coordination
No intention to add more portable RWIS

| Identify Fire | Determine if there could be impacts to UDOT infrastructure | Debris flow potential is identified | Deploy portable weather station | Add burn scar to UDOT GIS Burnscar map | Debris flow has been identified |
|---|---|---|---|---|---|
| | • Assess fire intensity, debris flow potential and available transportable material<br>  • Use BAER assessment maps if available<br>  • Utilize NWS and NFS hydrologists if available<br>• Follow all small and large drainages<br>• Examine culvert capabilities<br>• Determine debris flow potential rainfall rate (rainfall in 10 minutes) | • Add to forecaster procedures<br>• Contact shed and area supervisors<br>• If determined to be a high impact, contact District Engineer and Emergency Management | • Coordinate with NWS to avoid duplication<br>• Determine if camera coverage is important (lack of radar coverage)<br>• Consider access and permission (ie. land owners, NFS)<br>• Consider placing out of line of sight and out of harm's way<br>• Consider solar and communication availability<br>• Decide if a weather trailer or weather tripod is more appropriate | • https://uplan.maps.arcgis.com/apps/mapviewer/index.html?webmap=f6ddae1d337b49e88c044a8bbf73b97c | • Alert shed supervisor, area supervisor, district engineer depending on level of impact<br>• Alert traffic controllers<br>• Alert NWS via chat<br>• Follow up with addition alerts for any incoming threat<br>• Document results on GIS Map |

# IIJA Impacts

- Five-year PROTECT program
  - Resilience planning and improvements

From the “2023 UDOT Strategic Direction”
https://udot.utah.gov/strategic-direction

Resilience Improvement Plan

Implementation of a Resilience Improvement Plan can reduce the non-Federal cost share for a project by up to 10 percent.

Resilience improvement plans include:

- a risk-based assessment of vulnerabilities of transportation assets and systems to current and future weather events and natural disasters
- a systemic approach to surface transportation system resilience
- immediate and long-range planning activities and investments

# Conclusion

- Wildfires will continue, the severity by year will ebb and flow
- Be prepared and continue to have equipment ready to go if a fire is expected to cause impacts
- Focus on UDOT safety and swift response and coordinate with all applicable stakeholders

# Questions?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