# Seasonal Progress Report #8
# SR431 Treatment Vault Effectiveness Monitoring

**Agreement Number: P423-13-019**

**Submitted by: Tahoe Resource Conservation District**

**Submitted to: Nevada Department of Transportation**

**Water Year: 2018**

**Period: Fall/Winter Season, March 1 , 2018 – May 31, 2018**

**Submission Date: June 30, 2018**

Two stormwater cartridge filter vaults, a Contech Media Filtration System (MFS) and a Jellyfish Filter, were installed by the Nevada Department of Transportation (NDOT) on State Highway 431 (SR431) above Incline Village, Nevada. Monitoring equipment was installed at the inflows and outflows of these two vaults. The Tahoe Resource Conservation District (Tahoe RCD) continued the effectiveness monitoring efforts of the Desert Research Institute (DRI) at the four monitoring stations on May 1, 2015 and will continue to monitor through the end of water year 2018 (September 30, 2018) and beyond if funding allows. Tahoe RCD follows sampling protocols outlined in the Regional Stormwater Monitoring Program Framework and Implementation Guidance document (RSWMP FIG, Tahoe RCD et al 2015).

An amendment to the original agreement between NDOT and Tahoe RCD to extend the end date to June 30, 2018, augment the budget to monitor for water 2017, and complete the annual monitoring report was fully executed in December 2016. A second amendment to extend monitoring and reporting activities to cover water year 2018 will be executed within the next 60 days.

The Tahoe RCD appreciates the opportunity to provide these water quality monitoring services for NDOT and looks forward to continuing the partnership.

**Tasks and subtasks associated with this project and a summary of work completed to date are described below. Table 1 provides a summary of tasks, due dates and percent completion to date.**

Table 1: Summary of tasks, due dates, and percent completion to date.

| Task | Description | Due Date | % Of Work Complete | Date (s) Submitted |
|---|---|---|---|---|
| 1 | Project Administration | | | |
| 1.1 | Quarterly Invoices | 10/31/15, 1/31/16, 4/30/16, 7/31/16, 10/31/16, 1/31/17, 4/30/17, 7/31/17, 10/31/17, 1/31/18, 3/31/18 | ongoing | 10/31/15, 1/31/16, 4/30/16, 7/31/16, 10/31/16, 1/31/17, 4/30/17, 7/31/17, 10/31/17, 4/15/18 |
| 1.2 | Seasonal Progress Reports | 3/31/16, 6/30/16, 10/31/16, 3/31/17, 6/30/17, 10/31/17, 3/31/18, 6/30/18 | ongoing | 3/31/2016, 6/30/16, 10/31/16, 3/31/17, 6/30/17. 10/31/17, 3/31/18, 6/30/18 |
| 2 | Stormwater Monitoring | | | |
| 2.1 | Collect continuous flow and turbidity data at four monitoring stations | 6/30/2018 | ongoing | Available on Acuity |
| 2.2 | Collect stormwater runoff samples during eight events per year | 6/30/2018 | ongoing | NA |
| 2.3 | Collect three diurnal non-event snowmelt events if conditions allow | 5/31/2018 | NA | NA |
| 2.4 | Collect flow bypass data in both vaults | 6/30/2018 | ongoing | 10/31/17 |
| 2.5 | Provide precipitation data to date | 6/30/2018 | ongoing | 3/31/16, 6/30/16, 10/31/16, 3/31/17, 6/30/17, 10/31/17, 6/30/18 |
| 2.6 | Provide hydrograph, turbidity, and sample distribution graphs to date | 6/30/2018 | ongoing | 3/31/16, 6/30/16, 10/31/16, 3/31/17, 6/30/17, 10/31/17, 6/30/18 |
| 3 | Condition Assessments | | | |
| 3.1 | Estimate Road RAM score prior to eight sampled events | 6/30/2018 | ongoing | 3/31/16, 6/30/16, 3/31/17, 6/30/17, 10/31/17, 6/30/18 |
| 3.2 | Measure depth of sediment in both vaults after sampled events | 6/30/2018 | ongoing | 3/31/16, 6/30/16, 3/31/17, 6/30/17, 10/31/17, 6/30/18 |
| 4 | Final Report | | | |
| 4.1 | Provide raw data | 3/15/2018 | 100% | Annual Stormwater |

| | | | | |
|---|---|---|---|---|
| 4.2 | Provide treatment effectiveness analysis | 3/15/2018 | 100% | Monitoring Report 3/15/18 Annual Stormwater Monitoring Report 3/15/18 |
| 4.3 | Correlate Road RAM score to pollutant concentration and load | 3/15/2018 | 100% | Annual Stormwater Monitoring Report 3/15/18 |
| 4.4 | Provide mass loading v. volume calculations for select events | 3/15/2017 | 100% | 3/31/16, 6/30/16 |

## Task 1: Project Administration

### 1. Invoices

Quarterly invoices will be submitted for this project covering the following periods:

#1: May 1, 2015 - September 30, 2015
#2: October 1, 2015 - December 31, 2015
#3: January 1, 2016 - March 31, 2016
#4: April 1, 2016 - June 30, 2016
#5: July 1, 2016 - September 30, 2016
#6: October 1, 2016 - December 31, 2016
#7: January 1, 2017 - March 31, 2017
#8: April 1, 2017 - June 30, 2017
#9: July 1, 2017 - September 30, 2017
#10: October 1, 2017 - March 31, 2018
#11: April 1, 2018 – June 30, 2018

### 2. Progress Reports

Progress reports will not be concurrent with quarterly invoices. Three seasonal progress reports each for water years 2016, 2017, and part of 2018 will be submitted for this project covering the following periods:

#1: Fall/winter: - October 1, 2015 - February 29, 2016
#2: Spring: March 1, 2016 - May 31, 2016
#3: Summer: June 1, 2016 - September 30, 2016
#4: Fall/winter: October 1, 2016 - February 29, 2017
#5: Spring: March 1, 2017 - May 31, 2017
#6: Summer: June 1, 2017 - September 30, 2017
#7: Fall/winter: October 1, 2017 - February 28, 2018
#8: Spring: March 1, 2018 – May 31, 2018

Please accept this report as seasonal progress report #8.

## Task 2: Stormwater Monitoring

### 1. Maintain four stormwater monitoring stations to collect continous flow and turbidity data.

The spring season began on March 1, 2018 and ended May 31, 2018. Spring of water year 2018 was wet. Continuous flow and continuous turbidity were successfully monitored for the spring season. There continues to be of sediment along the roadside and in the pullout above the monitoring station (Figure 1-4).

Figure 1: April 20, 2018 sediment on pullout and road.

Figure 2: April 20, 2018 sediment on road.

Figure 3: April 20, 2018 sediment on pullout and road.

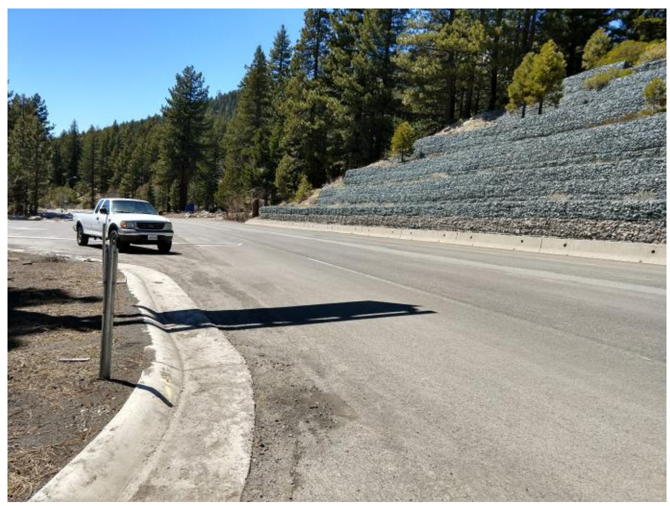

Figure 4: April 20, 2018 sediment on pullout and road.

### 2. Collect stormwater runoff samples at four monitoring sites during eight runoff events per year.

During the spring of water year 2018 three events were successfully sampled; two rain-on-snow events and one rain event (March 20-22, 2018; April 6, 2018; and May 16, 2018, respectively). These events bring the water year total to four events. NDOT vactored out the splitter vault on May 30, 2018.

### 3. If conditions allow for non-event snowmelt sampling, analyze a rising and a falling limb composite during three diurnals (counts as one of the eight events).

The spring snowmelt did not produce sufficient runoff for sampling.

### 4. Install a pressure transducer in each treatment vault to identify when there is bypass flow.

New pressure transducers were installed in June 2016 and linked to the remote access data management system currently used at the SR431 monitoring site. Data indicate that during the spring of WY18 the Contech MFS cartridge filters were bypassed on 16 days (March 13-14, 2018; March 18, 2018; March 20-21, 2018; March 23, 2018; April 6-7, 2018; April 16, 2018; May 13, 2018; May 16-18, 2018; May 22, 2018; May 24-25, 2018 ; see Figure 5). The Jellyfish filters did not bypass during spring of water year 2018 (Figure 6).

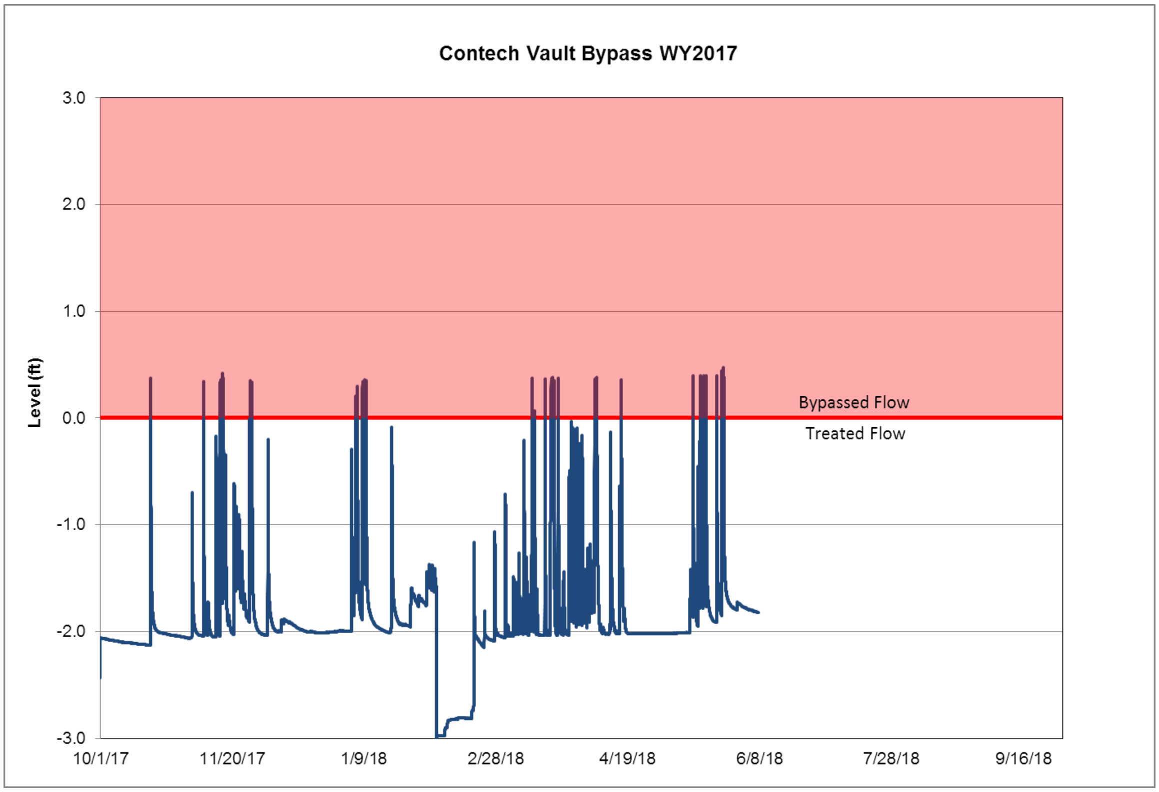


Figure 5: Bypassed flow in Contech MFS vault WY18 to date.

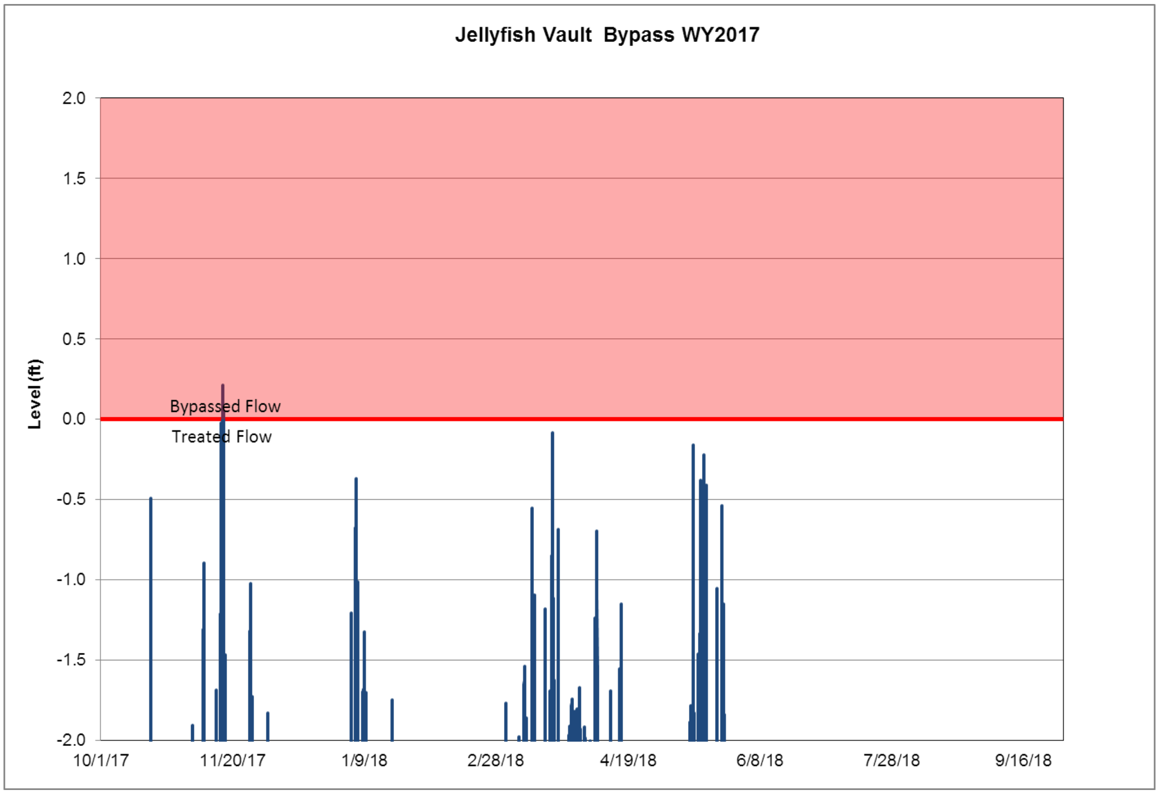

Figure 6: Bypassed flow in Jellyfish vault WY18 to date.

## 5. Provide precipitation data to date.

Table 2 provides summary data for all 18 fall/winter and spring precipitation events that occurred during WY18 at the SR431 monitoring site including event start and end dates, total precipitation, peak precipitation, minimum and maximum temperature, and preciptation type. Events highlighted in pink were sampled for water quality. Because of it's high elevation, preciptation often falls in the form of snow during fall/winter and thus does not always generate sufficient runoff for sampling.

Table 2: Summary of fall/winter, and spring precipitation events at SR431 for WY18. Highlighted rows indicate events that were sampled.

| Station ID | Precip Event (#) | Precipitation event start (PST) | Event end (PST) | Event duration (days) | Interevent duration (days) | Event precipitation (inches) | Event peak precipitation (inch/5min) | Event minimum temp (°C) | Event maximum temp (°C) | Type of Precipitation |
|---|---|---|---|---|---|---|---|---|---|---|
| NDOT | -- | -- | 9/22/2017 14:30 | -- | -- | -- | -- | -- | -- | -- |
| NDOT | NDOT-17-01 | 10/20/2017 00:20 | 10/20/2017 08:10 | 0.3 | 27.4 | 0.33 | 0.027 | -4 | 4 | snow |
| NDOT | NDOT-17-02 | 11/3/2017 22:55 | 11/4/2017 22:40 | 1.0 | 14.6 | 0.12 | 0.008 | -1 | 1 | rain/snow |
| NDOT | NDOT-17-03 | 11/9/2017 01:25 | 11/9/2017 12:45 | 0.5 | 4.1 | 0.3380 | 0.023 | 1 | 2 | rain |
| NDOT | NDOT-17-04 | 11/10/2017 19:55 | 11/10/2017 19:55 | 0.0 | 1.3 | 0.0040 | 0.004 | 0 | 0 | rain |
| NDOT | NDOT-17-05 | 11/13/2017 17:50 | 11/13/2017 22:50 | 0.2 | 2.9 | 0.2280 | 0.008 | -1 | 2 | rain |
| NDOT | NDOT-17-06 | 11/15/2017 08:00 | 11/17/2017 08:35 | 2.0 | 1.4 | 4.6720 | 0.058 | -4 | 4 | rain, snow |
| NDOT | NDOT-17-07 | 11/20/2017 17:50 | 11/20/2017 17:50 | 0.0 | 3.4 | 0.0040 | 0.004 | 5 | 5 | rain |
| NDOT | NDOT-17-08 | 11/22/2017 11:50 | 11/22/2017 11:50 | 0.0 | 1.8 | 0.0040 | 0.004 | 14 | 14 | rain |
| NDOT | NDOT-17-09 | 11/26/2017 14:25 | 11/27/2017 06:35 | 0.7 | 4.1 | 0.8380 | 0.023 | -4 | 3 | rain, snow |
| NDOT | NDOT-17-10 | 12/3/2017 01:35 | 12/3/2017 12:45 | 0.5 | 5.8 | 0.2280 | 0.012 | -6 | -2 | snow |
| NDOT | NDOT-17-11 | 12/20/2017 03:25 | 12/20/2017 08:55 | 0.2 | 16.6 | 0.1200 | 0.008 | -7 | -4 | snow |
| NDOT | NDOT-17-12 | 1/3/2018 19:00 | 1/4/2018 05:25 | 0.4 | 14.4 | 0.0680 | 0.008 | 1 | 4 | rain |
| NDOT | NDOT-17-13 | 1/5/2018 06:50 | 1/6/2018 09:30 | 1.1 | 1.1 | 1.2680 | 0.023 | -1 | 5 | rain, snow |
| NDOT | NDOT-17-14 | 1/8/2018 09:00 | 1/9/2018 21:55 | 1.5 | 2.0 | 0.3920 | 0.008 | 1 | 5 | rain |
| NDOT | NDOT-17-15 | 1/18/2018 20:00 | 1/19/2018 11:00 | 0.6 | 8.9 | 0.4320 | 0.012 | -7 | 0 | rain, snow |
| NDOT | NDOT-17-16 | 1/24/2018 19:40 | 1/25/2018 23:25 | 1.2 | 5.4 | 0.5640 | 0.012 | -11 | -3 | snow |
| NDOT | NDOT-17-17 | 2/12/2018 15:25 | 2/12/2018 16:55 | 0.1 | 17.7 | 0.0080 | 0.004 | -7 | -6 | snow |
| NDOT | NDOT-17-18 | 2/18/2018 15:45 | 2/19/2018 13:50 | 0.9 | 6.0 | 0.1280 | 0.008 | -14 | -6 | snow |
| NDOT | NDOT-17-19 | 2/22/2018 08:00 | 2/22/2018 15:25 | 0.3 | 2.8 | 0.1040 | 0.004 | -10 | -6 | snow |
| NDOT | NDOT-17-20 | 2/24/2018 12:50 | 2/24/2018 12:50 | 0.0 | 1.9 | 0.0040 | 0.004 | -5 | -5 | snow |
| NDOT | NDOT-17-21 | 2/26/2018 07:55 | 2/26/2018 14:35 | 0.3 | 1.8 | 0.1560 | 0.012 | -7 | -5 | snow |
| NDOT | NDOT-17-22 | 3/1/2018 01:50 | 3/3/2018 14:20 | 2.5 | 2.5 | 1.5640 | 0.016 | -13 | -3 | snow |
| NDOT | NDOT-17-23 | 3/10/2018 14:10 | 3/10/2018 20:30 | 0.3 | 7.0 | 0.1880 | 0.008 | -1 | 1 | rain/snow |
| NDOT | NDOT-17-24 | 3/12/2018 23:20 | 3/17/2018 12:10 | 4.5 | 2.1 | 2.4680 | 0.016 | -10 | 8 | rain, snow |
| NDOT | NDOT-17-25 | 3/20/2018 13:05 | 3/25/2018 08:35 | 4.8 | 3.0 | 3.8690 | 0.039 | -12 | 6 | rain/snow |
| NDOT | NDOT-17-26 | 4/6/2018 07:50 | 4/7/2018 07:40 | 1.0 | 12.0 | 0.9890 | 0.031 | 3 | 7 | rain, snow |
| NDOT | NDOT-17-27 | 4/11/2018 20:45 | 4/12/2018 17:50 | 0.9 | 4.5 | 0.172 | 0.01 | -9 | -1 | rain, snow |
| NDOT | NDOT-17-28 | 4/15/2018 17:10 | 4/16/2018 11:20 | 0.8 | 3.0 | 0.239 | 0.02 | -8 | 1 | rain, snow |
| NDOT | NDOT-17-29 | 4/18/2018 06:45 | 4/18/2018 06:45 | 0.0 | 1.8 | 0.004 | 0.00 | -2 | -2 | snow |
| NDOT | NDOT-17-30 | 4/26/2018 18:00 | 4/26/2018 18:00 | 0.0 | 8.5 | 0.004 | 0.00 | 11 | 11 | rain |
| NDOT | NDOT-17-31 | 4/29/2018 16:50 | 4/29/2018 16:50 | 0.0 | 3.0 | 0.004 | 0.00 | 0 | 0 | snow |
| NDOT | NDOT-17-32 | 5/12/2018 13:20 | 5/14/2018 01:15 | 1.5 | 12.9 | 0.4930 | 0.055 | 1 | 9 | rain |
| NDOT | NDOT-17-33 | 5/15/2018 11:35 | 5/18/2018 17:40 | 3.3 | 1.4 | 0.9030 | 0.031 | 1 | 14 | rain |
| NDOT | NDOT-17-34 | 5/21/2018 16:55 | 5/22/2018 18:35 | 1.1 | 3.0 | 0.2360 | 0.023 | 4 | 13 | rain |
| NDOT | NDOT-17-35 | 5/24/2018 13:45 | 5/25/2018 08:45 | 0.8 | 1.8 | 0.8520 | 0.058 | 1 | 15 | rain |
| NDOT | NDOT-17-36 | 5/26/2018 12:10 | 5/26/2018 19:25 | 0.3 | 1.1 | 0.0120 | 0.004 | 4 | 10 | rain |

### 6. Provide hydrograph, continuous turbidity, and sample distribution graphs for each sampled event.

See Figures 7-18 at the end of this report for hydrographs, continous turbidity, and sample distributions for the events sampled in the spring season.

## Task 3: Condition Assessments

### 1. Estimate Road RAM score prior to monitored runoff events.

This task was initiated in November 2015 following a meeting between the Tahoe RCD and NDOT where it was decided that determining a Road RAM score prior to runoff events was valuable. This procedure is expected to help establish a site-specific relationship between road condition and FSP concentration in runoff.

Since November 2015, thirty Road RAM scores have been determined. Road RAM scores assess road condition and are expressed on a scale from 0 to 5. A score of  0 indicates road conditions that present a high risk to downslope water quality, while a score of 5 indicates road conditions with minimal risk to downslope water quality (2NDNATURE et al 2015). Road RAM was not conducted during the months of January and February 2017 and February 2018 because the road surfaces were too wet (Road RAM is not possible on wet roads). Road RAM scores correspond to an estimated FSP concentration range that can be expected in runoff events as outlined in the Road RAM Technical Document (2NDNATURE et al 2015). Efforts were made to take Road RAM scores close to the beginning of sampled runoff events, but this did not always occur.

Observed Road RAM scores thus far nearly cover the full range of possible measurements (0.4 to 4.6); however the majority of scores indicate that the roads were relatively dirty prior to most runoff events (Table 3). Between 12/2/15 and 12/8/15, there was an improvement in Road RAM scores from 1.6 to 2.1, which may either be a result of sediment washing away from the road surface in the 12/5/2015 rain event or from road sweeping activities, but this has not been verified. The lowest score of 0.4 was determined on 4/8/16. Though no events were sampled immediately afterwards, Tahoe RCD staff observed excessively dirty roads during this time and decided that determining a score was prudent. This exceptionally low score may be the reason the splitter vault, inflow flumes, and treatment vaults were inundated with excessive amounts of sediment which necessitated splitter vault and inflow pipe flushing in mid and late April 2016, the clean-out of the Contech MFS vault and cartridge replacement in early August 2016, and the full clean-out of the entire system and the Jellyfish on October 20, 2016. Relatively high scores were determined on 10/11/16 and 10/12/16 and FSP concentrations were correspondingly low in runoff two weeks later on 10/27/16. Relatively low scores were determined during spring of 2017. Turbidimeters at the inflows were occasionally inundated with sediment during this time, sediment in the splitter vault quickly accumulated, and a there was a large amount of sediment (about 2-3 inches deep) visible on the road and SR431 pullout. Vactor trucks removed sediment from the splitter vault, Contech MFS vault, and Jellyfish vault on April 20, 2017. There was an improvement in RAM score between the 5/1/17 RAM and the 5/5/2017 from 0.8 to 1.8, possibly due to sweeping operations. For spring 2017, FSP concentrations were within the expected range for the corresponding RAM score for the 4/6/17 and 5/6/17 events, and below range for the 4/16/17 and 5/12/17 events. It is important to note that the 5/12/17 event was a snowmelt event, with thus there was limited washoff from the road as compared to a rain event. Summer 2017 Road RAM scores were relatively static, with a slight improvement from 1.7 to 2.0 by the end of the season. Road RAM scores improved by November 2018 to a RAM of 2.9, and were variable during December and January 2018 (ranging from 1.6 to 2.5). Road RAM scores during spring of 2018 were relatively low, ranging from 1.3 to 2.2, see accumulated sediment in Figures 1-4. Table 3 summarizes the Road RAM scores, days between RAM determination and runoff event, the expected FSP concentrations associated with that score, actual inflow FSP concentrations (an average of the event mean concentrations (EMCs) measured at the Contech MFS inflow and the Jellyfish inflow), and the percent difference between the expected FSP based on RAM score and the measured FSP concentration.

Table 3: Summary of Road RAM scores and FSP concentrations WY16, WY17, and WY18 to date.

| Road RAM date | Runoff event date | Days between RAM and runoff event | Road RAM Score | Expected FSP concentration * (mg/L) | Average JI+CI inflow FSP EMC (mg/L) | FSP Percent Difference (%) |
|---|---|---|---|---|---|---|
| 12/2/15 | 12/10/15 | 8 | 1.6 | 409 | 722 | 55% |
| 12/8/15 | 12/10/15 | 2 | 2.1 | 267 | 722 | 92% |
| 1/28/15 | 1/29/16 | 1 | 1.7 | 375 | 1,118 | 99% |
| 2/24/16 | 3/4/16 | 8 | 1.5 | 445 | 2,955 | 148% |
| 4/8/16 | 5/5/16 | 27 | 0.4 | 1133 | 387 | -98% |
| 5/4/16 | 5/5/16 | 1 | 2.7 | 160 | 387 | 83% |
| 10/11/16 | 10/27/16 | 16 | 4.6 | 32 | 34 | 6% |
| 10/12/16 | 10/27/16 | 15 | 3.1 | 114 | 34 | -109% |
| 12/7/16 | 12/8/16 | 1 | 1.9 | 317 | 774 | 84% |
| 3/15/17 | 4/6/17 | 23 | 0.7 | 847 | 746 | -13% |
| 4/11/17 | 4/16/17 | 6 | 0.7 | 872 | 612 | -35% |
| 5/1/17 | 5/6/17 | 6 | 0.8 | 802 | 352 | -78% |
| 5/5/17 | 5/6/17 | 2 | 1.8 | 343 | 352 | 3% |
| 5/12/17 | 5/19/17 | 7 | 1.3 | 537 | 13 | -191% |
| 6/5/17 | 8/19/17 | 76 | 1.7 | 363 | 186 | -64% |
| 7/5/17 | 8/19/17 | 46 | 1.7 | 367 | 186 | -65% |
| 7/20/17 | 8/19/17 | 31 | 1.7 | 367 | 186 | -65% |
| 8/7/17 | 8/19/17 | 13 | 2.0 | 281 | 186 | -41% |
| 8/25/17 | 9/21/17 | 27 | 2.0 | 281 | 167 | -51% |
| 8/25/17 | 9/21/17 | 27 | 2.0 | 281 | 167 | -51% |
| 10/5/17 | 11/16/17 | 42 | 2.0 | 281 | 201 | -33% |
| 10/19/17 | 11/16/17 | 28 | 2.5 | 195 | 201 | 3% |
| 11/1/17 | 11/16/17 | 15 | 2.5 | 195 | 201 | 3% |
| 11/11/17 | 11/16/17 | 5 | 2.9 | 130 | 201 | 43% |
| 12/14/17 | 3/20/18 | 96 | 2.5 | 195 | 783 | 120% |
| 12/27/17 | 3/20/18 | 83 | 1.6 | 415 | 783 | 62% |
| 1/13/18 | 3/20/18 | 66 | 2.2 | 248 | 783 | 104% |
| 3/29/18 | 4/6/18 | 8 | 1.7 | 388 | 1,639 | 123% |
| 4/20/18 | 5/16/18 | 26 | 1.3 | 516 | 177 | -98% |
| 5/30/18 | na | na | 2.2 | na | na | na |

*FSP concentrations expected with particular RAM score (from PLRM Road Methodology nhc et al. 2009)

According to the Road RAM Technical Document scores between 0 and 1.0 are considered "poor" and expected FSP concentrations in runoff from roads in this category range from 680-1,592 mg/L. The RAM score of 0.4 determined on 4/8/16 occurred nearly a month before the 5/5/16 event and it is evident by the 5/4/16 RAM score and the resulting FSP EMC for the 5/5/16 event that road condition improved, perhaps due to sweeping or the 2.2 inches of rain that fell between 4/8/16 and 5/5/16. Poor Road RAM scores were determined in March, April, and the beginning of May 2017. Improvement in score was observed after the 5/1/17 RAM for the spring 2017 season. Actual average inflow FSP event mean concentrations (EMC) were less than expected FSP concentrations in all cases for poor scores.

Road RAM scores greater than 1.0 and less than or equal to 2.0 fall into the "degraded" category. The range of FSP concentrations that can be expected in runoff from roads in this condition is 291-679 mg/L. However, the actual average inflow FSP EMCs from runoff events within this score range were higher than the expected FSP concentrations between January 2015 and the beginning of May 2017 (all Road RAM estimations made in the fall/winter and spring seasons), but lower between the middle of May 2017 and August 2017 (summer season) for this category of scores. This may indicate a seasonal influence on the dependability of Road RAM to predict actual concentrations. The 148% difference between expected and actual concentrations may indicate that the road condition worsened significantly between the 2/24/16 score determination and the 3/4/16 runoff event. It is unknown if road abrasives were applied, but there was no precipitation or very cold temperatures that would indicate the need for large amounts of road abrasives during this time. The -191% difference in expected and actual concentrations may indicate that the road condition improved substantially between the 5/12/17 score determination and the 5/19/17 runoff event, perhaps due to road sweeping, though whether this took place or not is unknown. The actual FSP EMC was far lower than the expected for the 5/16/18 event, but the RAM score was taken 26 days prior to the event, and May 2018 was a particularly rainy month, which likely washed the road clean to some extent.

Road RAM scores greater than 2.0 and less than or equal to 3.0 fall into the "fair" category where the range of expected FSP concentrations in runoff is 124-290 mg/L. Actual FSP EMCs that low were not measured during the 12/10/15 event so it is possible that the 12/8/15 score was overestimated slightly. The percent difference between expected and actual concentrations for the 5/5/16 event was 83%, also indicating that the Road RAM score may have been overestimated a bit. Between August 2017 and October 2017 the actual concentrations were all lower than expected concentrations. The percent difference between expected and actual concentrations for the 11/16/17 event were 43%

Road RAM scores greater than 3.0 and less than or equal to 4.0 are considered "acceptable" and expected FSP concentrations range from 53-123 mg/L. The RAM score taken on 10/12/16 predicts an FSP concentration higher than what was measured nearly two weeks later during the 10/27/16 event, indicating that road conditions likely returned to the "desirable" condition that was measured on 10/11/16. (RAM scores between 4.0 and 5.0 are considered "desirable" and expected FSP concentrations range between 23-52 mg/L).

## 2. Measure depth of sediment in vaults after eight monitored runoff events.

This task was initiated November 2015 following the meeting between Tahoe RCD and NDOT mentioned above where it was determined that post event sediment depth was valuable information. The depths shown in Table 4 represent the average depth in each vault in feet. These sediment depths indicate a gradual accumulation in the Contech in the spring and summer of 2016 (with a small decrease between 4/15/16 and 4/22/16 following the system flush on 4/15/16 after the 4/15/16 measurement was taken) and a large increase in sediment accumulation between 4/22/16 and 6/3/16. The roads were relatively clean on 5/4/16 as indicated by a Road RAM score of 2.7, but a snow storm on 5/20/16-5/21/16 likely required road abrasive application that was later washed off in the thunderstorms that followed between 5/23/16 and 5/25/16. This could explain the 0.19 foot (2.28 inch) increase in sediment in the Contech MFS. Over a foot of sediment accumulated in the Jellyfish during spring 2016. The small decrease in sediment between 6/3/16 and 8/3/16 may have been due to indirect flushing during the August 3, 2016 cleanout of the Contech MFS. Sediment depth prior to Contech MFS clean-out on August 3, 2016 was 1.10 feet. Sediment depth prior to Jellyfish clean-out on October 20, 2016 was 1.92 feet. Both the Contech MFS and the Jellyfish vaults were vactored out April 20, 2017 (along with the splitter vault); sediment depth prior to this cleanout was 1.9 feet and 2.85 feet, respectively. Sediment depth in the Jellyfish filter increased to around 0.4 feet during the first part of summer 2017, whereas sediment accumulation in the Contech MFS was minimal. Both the Jellyfish and the Contech MFS vaults were vactored during the 8/15/17 to 8/16/17 clean out performed by Clean Harbors. Some sediment accumulation occurred during the very dry fall/winter of WY18. NDOT vactored the Jellyfish and Contech MFS vault on February 5, 2018. Spring of WY18 was relatively wet; during this time a moderate amount of sediment accumulated in the Jellyfish vault (about a third of a foot), while in the Contech vault a minimal amount accumulated (about an inch). All clean-outs restored sediment depth in the respective vaults to near zero.

Table 4: Average depth of sediment in vaults.

| Date Time | Contech MFS (ft) | Jellyfish (ft) |
|---|---|---|
| 12/30/2015 | 0.33 | 0.92 |
| 3/16/2016 | 0.58 | 1.14 |
| 4/15/2016 | 0.61 | na |
| 4/22/2016 | 0.56 | na |
| 6/3/2016 | 0.75 | 2.17 |
| 8/3/2016 | 1.10 | 2.05 |
| 10/20/2016 | na | 1.92 |
| 12/30/2016 | 0.10 | 0.05 |
| 4/3/2016 | 1.00 | 2.30 |
| 4/20/2017 | 1.90 | 2.85 |
| 5/1/2017 | 0.10 | 0.43 |
| 5/18/2017 | 0.08 | 0.37 |
| 5/22/2017 | 0.10 | 0.46 |
| 6/19/2017 | 0.12 | 0.38 |
| 8/19/2017 | 0.00 | 0.00 |
| 9/21/2017 | 0.01 | 0.10 |
| 10/5/2017 | 0.03 | 0.15 |
| 10/24/2017 | 0.00 | 0.04 |
| 11/14/2017 | 0.10 | 1.19 |
| 11/17/2017 | 0.00 | 0.10 |
| 2/2/2018 | 0.17 | 0.30 |
| 4/7/2018 | 0.00 | 0.05 |
| 5/17/2018 | 0.08 | 0.36 |

## Task 4: Final Report

### 1. Provide raw data.

Final reporting for each water year is provided as part of the Regional Stormwater Monitoring Program (RSWMP) Implementers' Monitoring Program (IMP) Annual Stormwater Monitoring Report (due March 15$^{th}$ of each year), but raw data can be provided at any time upon request.

### 2. Provide treatment effectiveness analysis following formats outlined in the RSWMP FIG.

Final reporting for each water year is provided as part of the Regional Stormwater Monitoring Program (RSWMP) Implementers' Monitoring Program (IMP) Annual Stormwater Monitoring Report (due March 15$^{th}$ of each year) which includes treatment effectiveness evaluations on a seasonal and annual basis. However, treatment effectiveness for FSP is provided on an event by event basis for the spring of WY18 for the Contech MFS in Table 5 and the Jellyfish in Table 6. Removal efficiencies highlighted in pink indicate that FSP was flushed from the system or that outflow turbidity sensors were inundated with accumulated sediment, however this did not occur in the spring of WY18. A removal efficiency of 100% indicates no outflow from the filter vault. High efficiencies for both filters may be due to thorough maintenance in February 2018 coupled with a relative lack of precipitation in the fall/winter of WY18 leading up to the spring season.

Table 5: Contech MFS FSP removal efficiency for each event of spring WY18.

| CONTECH MFS WY18 Spring: March 1, 2018 - May 31, 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Runoff Start Date Time | Runoff End Date Time | Runoff Type | Event Duration | Influent Volume (cf) | Influent FSP (lbs) | Effluent FSP (lbs) | Removal Efficiency |
| 3/3/2018 13:35 | 3/3/2018 15:40 | snow | 2:05 | 70 | 0.23 | 0.00 | -100% |
| 3/8/2018 16:20 | 3/8/2018 16:30 | snowmelt | 0:10 | 1 | 0.0001 | 0.00 | -100% |
| 3/10/2018 14:45 | 3/11/2018 11:00 | rain/snow | 20:15 | 162 | 0.05 | 0.00 | -100% |
| 3/13/2018 11:40 | 3/15/2018 12:00 | rain, snow | 48:20 | 676 | 2.17 | 2.92 | 35% |
| 3/18/2018 12:05 | 3/18/2018 14:45 | snowmelt | 2:40 | 242 | 1.44 | 0.67 | -54% |
| 3/20/2018 13:05 | 3/21/2018 22:40 | rain | 33:35 | 1,958 | 17.12 | 5.51 | -68% |
| 3/23/2018 10:55 | 3/23/2018 15:05 | snow | 4:10 | 423 | 5.85 | 1.21 | -79% |
| 3/27/2018 16:35 | 4/1/2018 17:35 | snowmelt | 121:00 | 741 | 2.14 | 0.00 | -100% |
| 4/6/2018 8:45 | 4/7/2018 7:10 | rain | 22:25 | 638 | 1.47 | 0.12 | -92% |
| 4/12/2018 9:30 | 4/12/2018 11:15 | snowmelt | 1:45 | 89 | 0.27 | 0.00 | -100% |
| 4/15/2018 20:10 | 4/16/2018 13:50 | rain, snow | 17:40 | 262 | 1.01 | 0.02 | -98% |
| 5/12/2018 13:35 | 5/14/2018 1:25 | rain | 35:50 | 364 | 0.72 | 0.19 | -74% |
| 5/15/2018 11:35 | 5/18/2018 17:55 | rain | 78:20 | 1,125 | 1.50 | 0.38 | -75% |
| 5/22/2018 16:00 | 5/22/2018 19:05 | thunderstorm | 3:05 | 259 | 0.46 | 0.04 | -91% |
| 5/24/2018 13:55 | 5/25/2018 8:40 | thunderstorm | 18:45 | 1,320 | 10.60 | 0.70 | -93% |

Table 6: Jellyfish FSP removal efficiency for each event of spring WY18.

| JELLYFISH WY18 Spring: March 1, 2018 - May 31, 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Runoff Start Date Time | Runoff End Date Time | Runoff Type | Event Duration | Influent Volume (cf) | Influent FSP (lbs) | Effluent FSP (lbs) | Removal Efficiency |
| 3/3/2018 13:35 | 3/3/2018 15:40 | snow | 2:05 | 74 | 0.25 | 0.14 | -44% |
| 3/8/2018 16:20 | 3/8/2018 16:30 | snowmelt | 0:10 | 1 | 0.001 | 0.00 | -100% |
| 3/10/2018 14:45 | 3/11/2018 11:15 | rain/snow | 20:30 | 169 | 0.08 | 0.12 | 55% |
| 3/13/2018 11:40 | 3/15/2018 12:05 | rain, snow | 48:25 | 696 | 4.24 | 0.75 | -82% |
| 3/18/2018 12:05 | 3/18/2018 15:15 | snowmelt | 3:10 | 242 | 4.85 | 0.14 | -97% |
| 3/20/2018 13:05 | 3/21/2018 22:50 | rain | 33:45 | 2,234 | 45.03 | 1.03 | -98% |
| 3/23/2018 10:55 | 3/23/2018 15:55 | snow | 5:00 | 469 | 15.32 | 0.23 | -98% |
| 3/27/2018 16:20 | 4/2/2018 15:50 | snowmelt | 143:30 | 922 | 5.27 | 0.14 | -97% |
| 4/4/2018 11:15 | 4/7/2018 11:45 | rain | 72:30 | 884 | 5.5205 | 0.0623 | -99% |
| 4/12/2018 9:30 | 4/12/2018 11:20 | snowmelt | 1:50 | 96 | 0.87 | 0.01 | -99% |
| 4/15/2018 20:10 | 4/16/2018 14:15 | rain, snow | 18:05 | 308 | 2.95 | 0.02 | -99% |
| 5/12/2018 13:35 | 5/14/2018 2:10 | rain | 36:35 | 443 | 2.01 | 0.02 | -99% |
| 5/15/2018 11:35 | 5/18/2018 18:10 | rain | 78:35 | 1,659 | 8.11 | 0.06 | -99% |
| 5/22/2018 16:05 | 5/22/2018 19:00 | thunderstorm | 2:55 | 251 | 0.98 | 0.01 | -99% |
| 5/24/2018 14:00 | 5/25/2018 8:50 | thunderstorm | 18:50 | 1,641 | 13.24 | 6.91 | -48% |

## 3. Correlate Road RAM score to pollutant concentration and load.

This task has been initiated, see task 3.1.

## 4. Provide mass loading v. volume calculations for select events.

Seasonal Progress Report #3 provides this analysis for events that occurred in the fall/winter and spring of water year 2016. Seasonal Progress Report #1 included a similar study based on four events that occurred in the late spring and early summer of water year 2015. Analyses have consistently shown that in general, turbidities (and thus FSP) mirror the flow and therefore no first flush phenomenon exists at SR431 with respect to FSP. This may indicate that the primary road serves as a constant source of sediment. Due to consistent results this analysis has not been repeated since Seasonal Progress Report #3.

## Figures 7-18

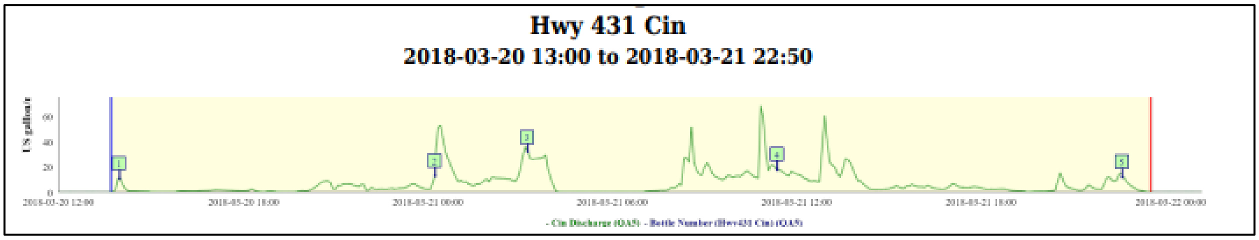


Figure 7: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 3/20/18 rain-on-snow event.

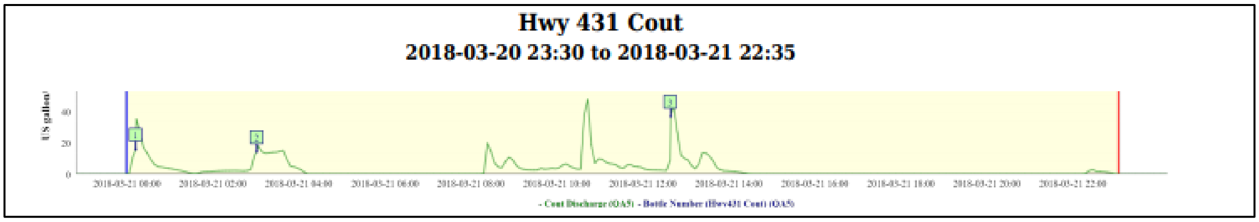


Figure 8: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 3/20/18 rain-on-snow event.

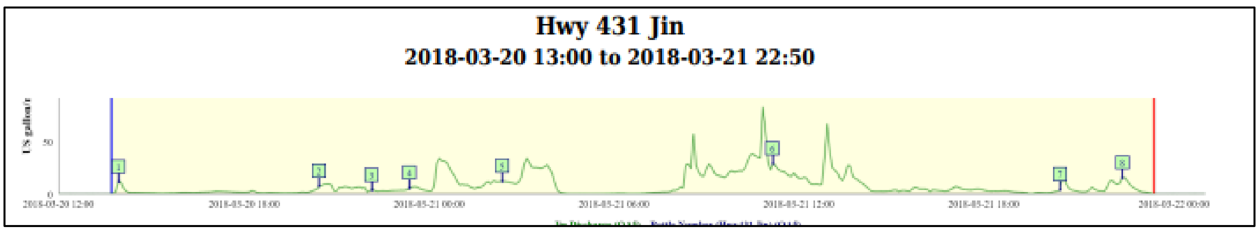


Figure 9: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 3/20/18 rain-on-snow event.

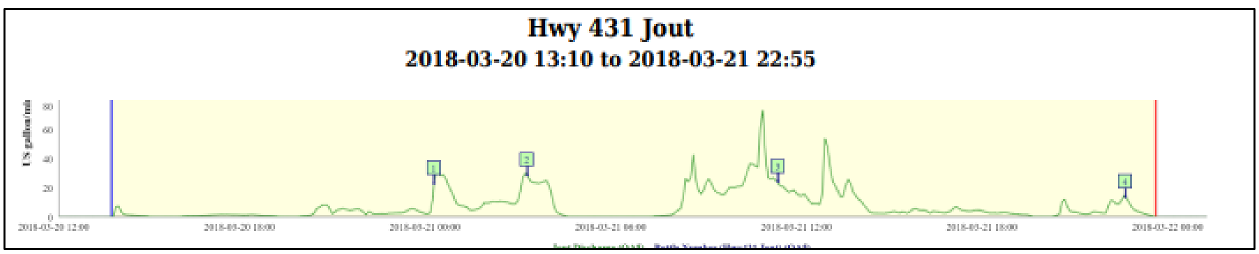


Figure 10: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 3/20/18 rain-on-snow event.

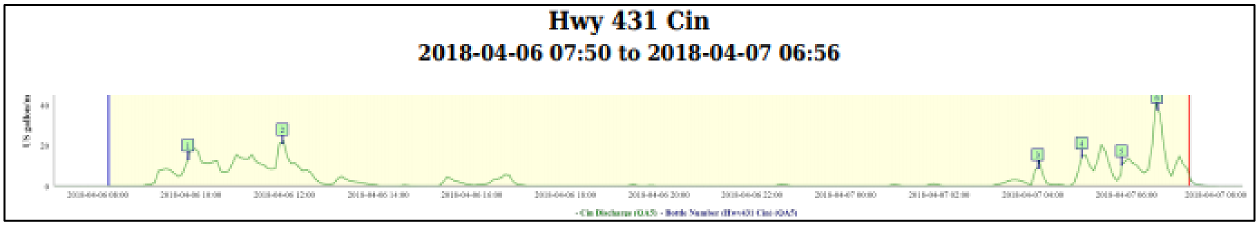

Figure 11: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 4/6/18 rain-on-snow event.

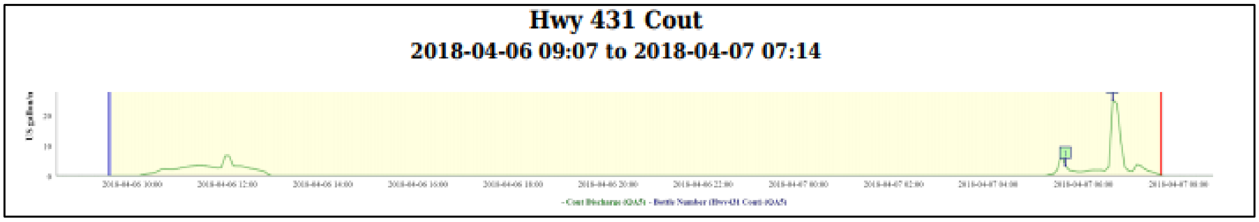

Figure 12: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 4/6/18 rain-on-snow event.

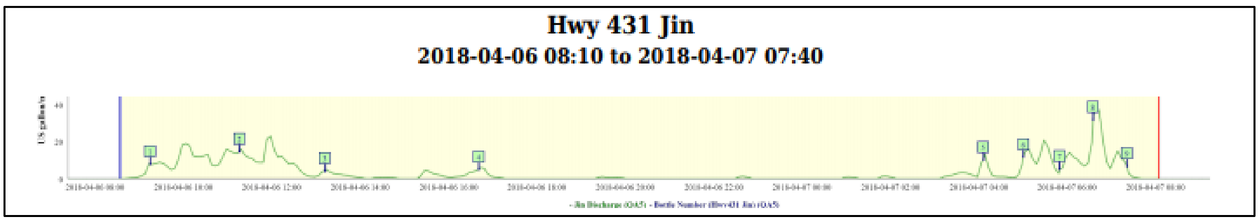

Figure 13: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 4/6/18 rain-on-snow event.

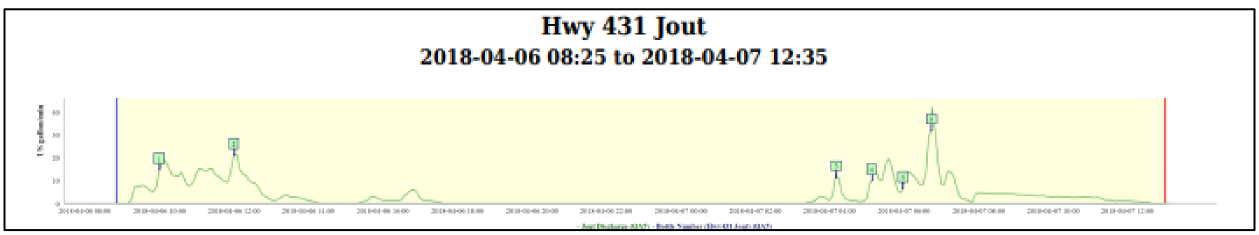

Figure 14: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 4/6/18 rain-on-snow event.

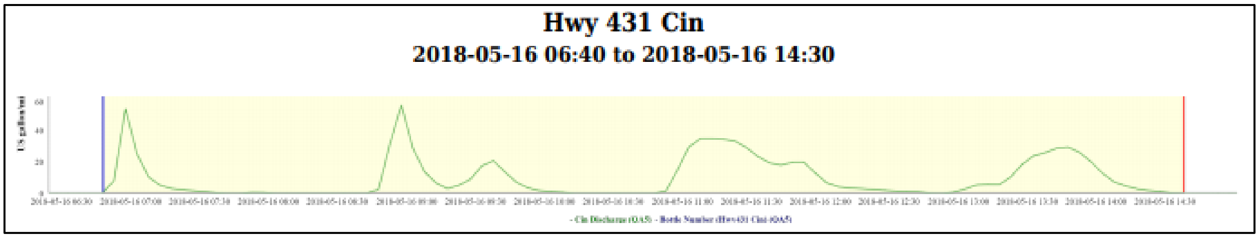

Figure 15: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 5/16/18 rain event.

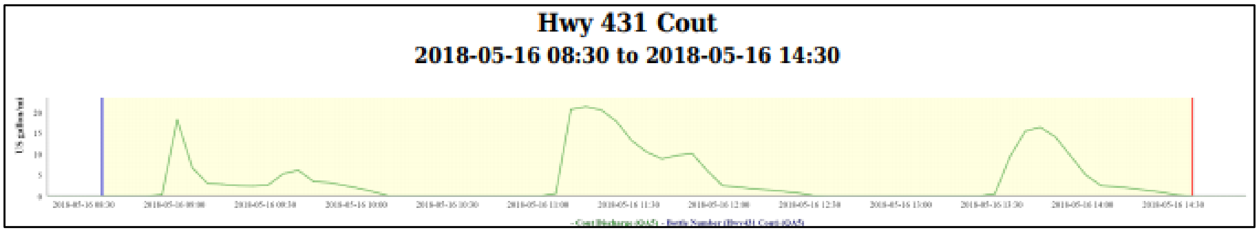

Figure 16: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 5/16/18 rain event.

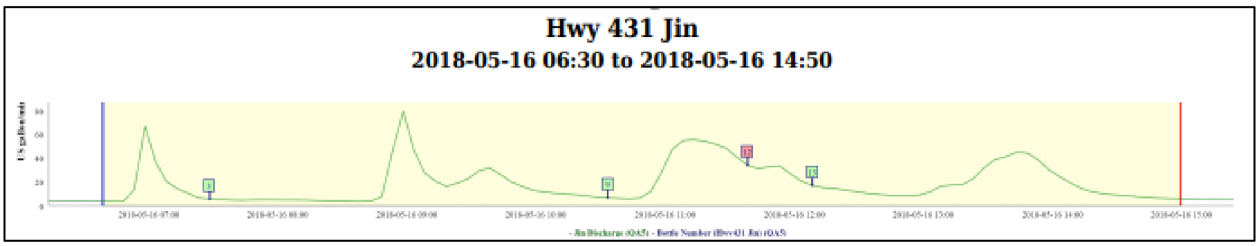

Figure 17: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 5/16/18 rain event.

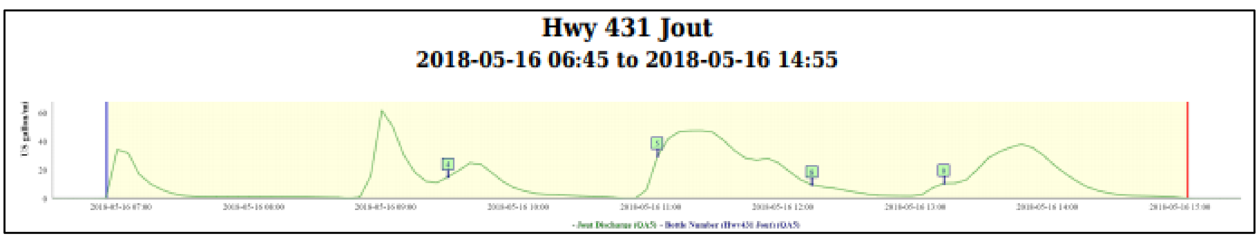

Figure 18: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 5/16/18 rain event.

## References

2NDNATURE LLC, Northwest Hydraulic Consultants, Environmental Incentives, 2015. *Road Rapid Assessment Methodology (Road RAM) User Manual v2, Tahoe Basin. Final Document*. Prepared for the Nevada Division of Environmental Protection and Lahontan Regional Water Quality Control Board. May 2015.

PLRM Model Development Document 2009. NHC, Geosyntec, and 2ndNature.

Tahoe Resource Conservation District, 2NDNATURE, Desert Research Institute, Northwest Hydraulic Consultants. 2015. *RSWMP Framework and Implementation Guidance Document*. Submitted the California State Water Board. March 30, 2015.