# ANNUAL MONITORING REPORT
# 2019

Savage Fen Tree Frog

**Prepared for:**

## Lower Minnesota River Watershed District

**By: SCOTT SWCD**

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## Table of Contents

## Introduction

This report focuses on the summary and comparison of water resources data collected by Scott Soil and Water Conservation District (SWCD) from 2019 and previous monitoring seasons. Like previous years, the monitoring work plan for 2019 included three temperature logging locations in Eagle Creek, one continuous water monitoring station in Eagle Creek (operated in conjunction with Metropolitan Council Environmental Services (MCES) Watershed Outlet Monitoring Program (WOMP)), 19 observation wells located in the Savage Fen and surrounding area, and one water monitoring station on the inlet to Dean Lake (DLI). New to the 2019 monitoring activities included adding three additional temperature loggers and performing chloride sampling in the Eagle Creek watershed.

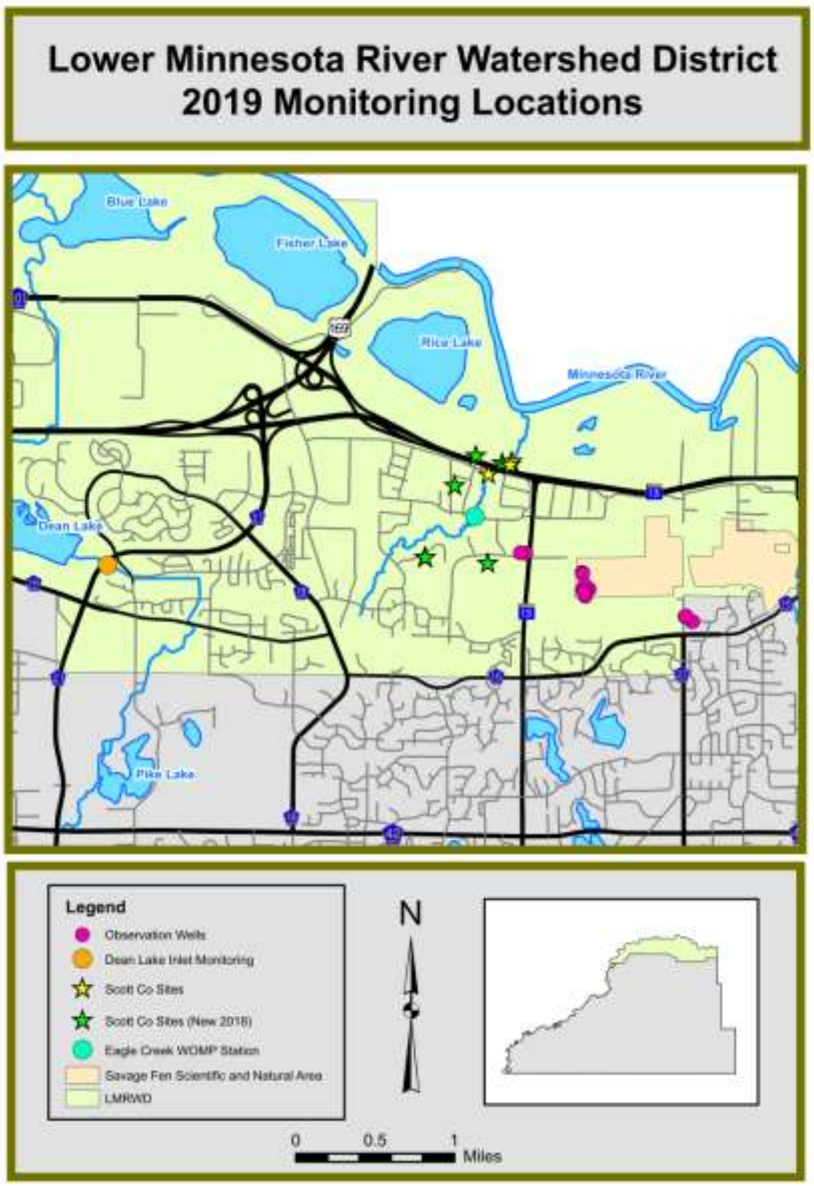


**Figure 1**. Monitoring Location Map.

## I. Thermal Monitoring

This study was initiated by the Lower Minnesota River Watershed District (LMRWD) to evaluate the impact storm water runoff from Highway 101 has on temperatures in Eagle Creek, a DNR designated trout stream. Brown Trout are very sensitive to temperature as it impacts growth rate, habitat, and food resources. The optimal temperature range for adult brown trout is approximately 12.4 – 17.6$^{o}$ Celsius (Bell, 2006).

### Methods

Temperature loggers were placed upstream and downstream of Highway 101 in June of 2006 and have been recording stream temperature since that time. In October 2012, a midstream logger was placed just upstream of a pond tributary to monitor its impact on stream temperatures. Three additional loggers have been placed on the outlets of the ponds adjacent to Eagle Creek in late July of 2018 (Figure 2). The goal of the additional pond loggers is monitor water temperatures leaving the ponds, and help zero in on potential warm thermal sources contributing to the creek. All the loggers record continuous temperature data in 15-minute intervals. Scott SWCD contracted with the LMRWD to collect and report the instream temperature data. Rainfall data used for this report is taken from the Shakopee Mdewakanton Sioux Community (SMSC) rain gauge located in Shakopee.

### Results

Under most conditions, stream temperatures trend with atmospheric temperatures. The downstream logger shows a deviation from the midstream and upstream loggers during both the winter and summer. A combination of atmospheric temperatures and the inflow of cold and warm water from the inlet near the Hwy 101 logger would influence the deviation.


**Figure 2.** Location of temperature loggers and WOMP station. The new 2018 loggers are represented by the orange triangles. No temperature logger exists at the WOMP station.

Similar to other years, the upstream logger continues to be the warmest during the winter and coolest in the summer of the three Eagle Creek loggers. The downstream logger shows an opposite trend as it is the warmest in the summer and coolest in the winter (Figure 3). During warm summer days, water temperatures occasionally exceeded the optimal range for trout but for only a few hours at a time (Figure 4). The maximum daily temperatures exceeded the optimal range 15, 6, and 2 times for the downstream, midstream, and upstream loggers respectively. A noticable seperation in water temperatures is noticed after rain events. It appears that the midstream and downstream loggers tend to peak higher than the upstream logger, likely due to surface runnoff from the stormwater inlets under Hwy 101 and increased side channel flow from the inlet at the Hwy 101 logger location. The midstream logger is inbetween the Hwy 101 overpass and the Hwy 101 inlet, downstream temperature logger is located approximately 30 feet downstream of the Hwy 101 inlet.

The additional three loggers at the Creek Way pond outlet, Shroeder's park outlet and the Hwy 101 pond inlet are not a part of the spring fed Eagle Creek main channel. They are more reactive to atmospheric temperature fluctuations (Figure 5). The Creek Way pond logger tracks very close to average air temperatures, except for a few times in early and late 2019. Shroeder's park and Hwy 101 loggers track very close to one another, with the exception to the Spring of 2019 where the flooding likely kept the Hwy 101 logger cooler than normal. Looking at how these ponds influence the main channnel of Eagle Creek, it is likely that the Hwy 101 pond inlet has some influence to rising temperatures at the downstream logger as the largest seperation in temperatures between the midstream and downstream logger is observed after the Hwy 101 logger temperatures surpase the main channel temperatures (Figure 6). Fluctuations are also observed with the atmospheric temperatures and rain events.

**Discussion**

Multiple flooding events in the Minnesota River appeared to influence the data for all of the loggers during the Spring of 2019. The late May into June flood levels kept field staff out of the water and the levels also seemed to impact the water temperatures at all the loggers in the main channel and at the Hwy 101 logger. Following the flooding, all of the thermal monitoring loggers have shown typical responses to temperature increases and precipitation events. The downstream logger continues to show a greater and more sustained response to the events. This is likely due to the combination of the runoff from the crossing highway and overflow from the adjacent pond. All of the loggers showed spikes in maximum daily temperatures outside the opitimal range for the Brown Trout, but the total number of spikes decreased by 29 between all of the loggers when compared with 2018 data. The pond loggers tracked well with average air temperatures. The logger at Creek Way pond only appeared to be submerged for a short period during the Spring thaw, the rest of the time it tracked with the atmospheric temperatures. The Hwy 101 pond logger tracked diurnally with the downstream and midstream loggers. It remained cooler than the main channel in the winter and warmer in the summers. It likely has some influence on the downstream logger temperatures as a noticable seperation is observed between the midstream and downstream loggers after the Hwy 101 logger temperatures surpase the main channel temperatures. This is similar to the results found in the brief investigation in 2009.

An investigation was conducted on August 19, 2009 during a 2-inch rain event at numerous temperature monitoring locations on Eagle Creek. Termperatures were recorded upstream and downstream of the pond tributary and in the tributary itself. The temperature of Eagle Creek rose almost 2°C directly after the tributary discharged into Eagle Creek. The tributary was almost 5°C higher than Eagle Creek. According to this study, temperature spikes in Eagle Creek appear to be from large volumes of solar heated pondwater and warm surface runoff dishcarhging from the pond. The temperature of the pond may not actually increase during storm events, but rather the volume of water discharging into Eagle Creek is perhaps the stronger influence on temperature rise. This greatly exceeds the small increase in temperature that typically occurs during dry periods that could be attributed to atmospheric warming of the stream. The addition of the thermal loggers at the outlets of the ponds adjacent to the creek will provide a longer record of the actual influence of temperature increases from the ponds. Even though the temperature exceeds the optimal range for trout by only a few degrees and for only a short period, these rapid temperature increases could be stressful to fish. The state water quality standard for Class 2A waters maintain there shall be "no material increase" in temperature.

Other factors that show influence to fluctuating Eagle Creek temperatures are atmospheric temperatures, Spring flooding, and precipitation events. All of the loggers generally track with seasonal air temperatures with the main channel loggers have a more diluted effect, likely due to the flooding influences. Flooding usually occurs as early as March and can last up to June. This can artificially increase or surpress temperature fluctuations during these periods. Finally, precipitation events are seen to have impacts to the logger temperatures, especially in the midstream and downstream loggers. These loggers have the greatest potential for influence from highway runoff and pond overflow discharge.

Continually monitoring of Eagle Creek and the adjacent ponds will allow the tracking of temperature shifts. It also allows for historical background for past and future restoration projects, similar to the MNDNR habitat improvement project in 2013. Construction near the Schroeders park pond resulted in a missing logger data for much of the late 2018 to early 2019 season. The logger has since been replaced and all the loggers within the Eagle Creek watershed continue to capture continuous water temperature data.

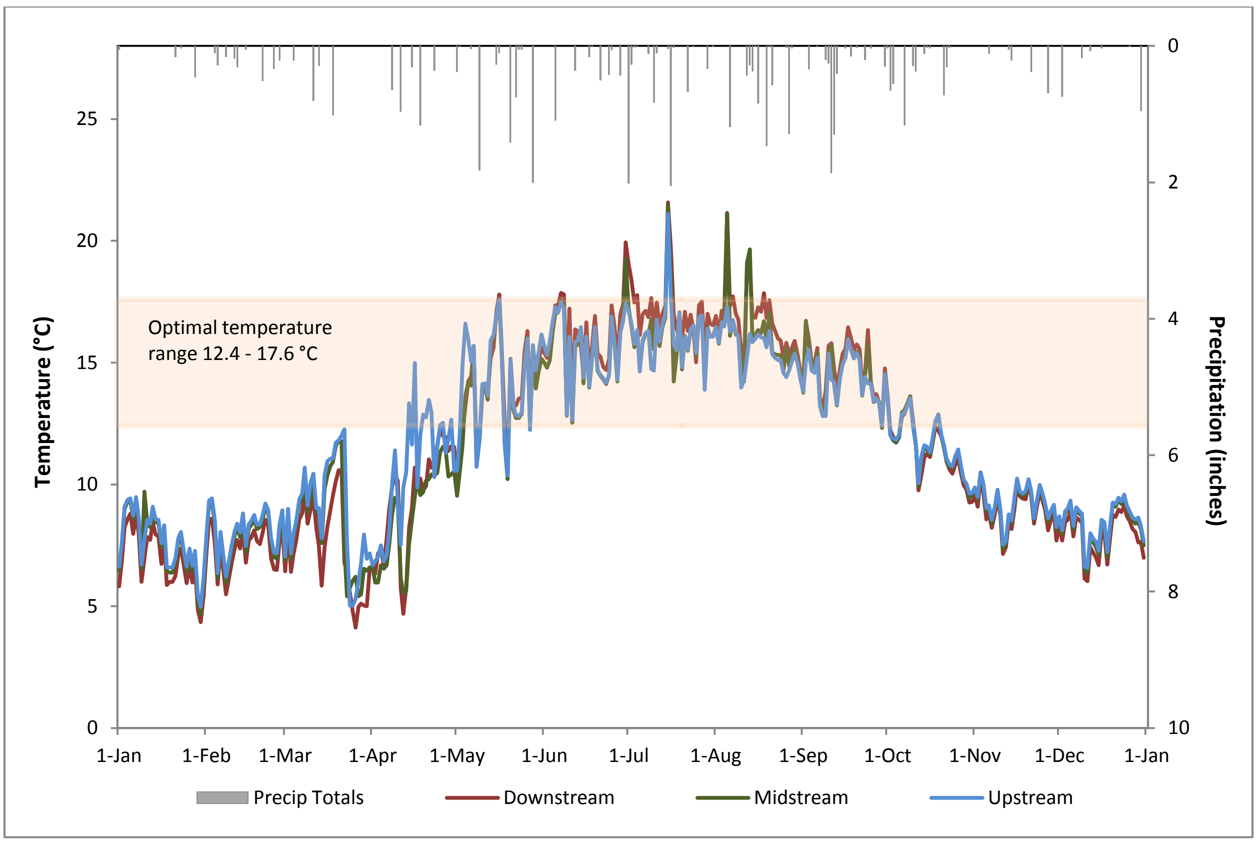


**Figure 3.** 2019 Maximum daily water temperatures in Eagle Creek.

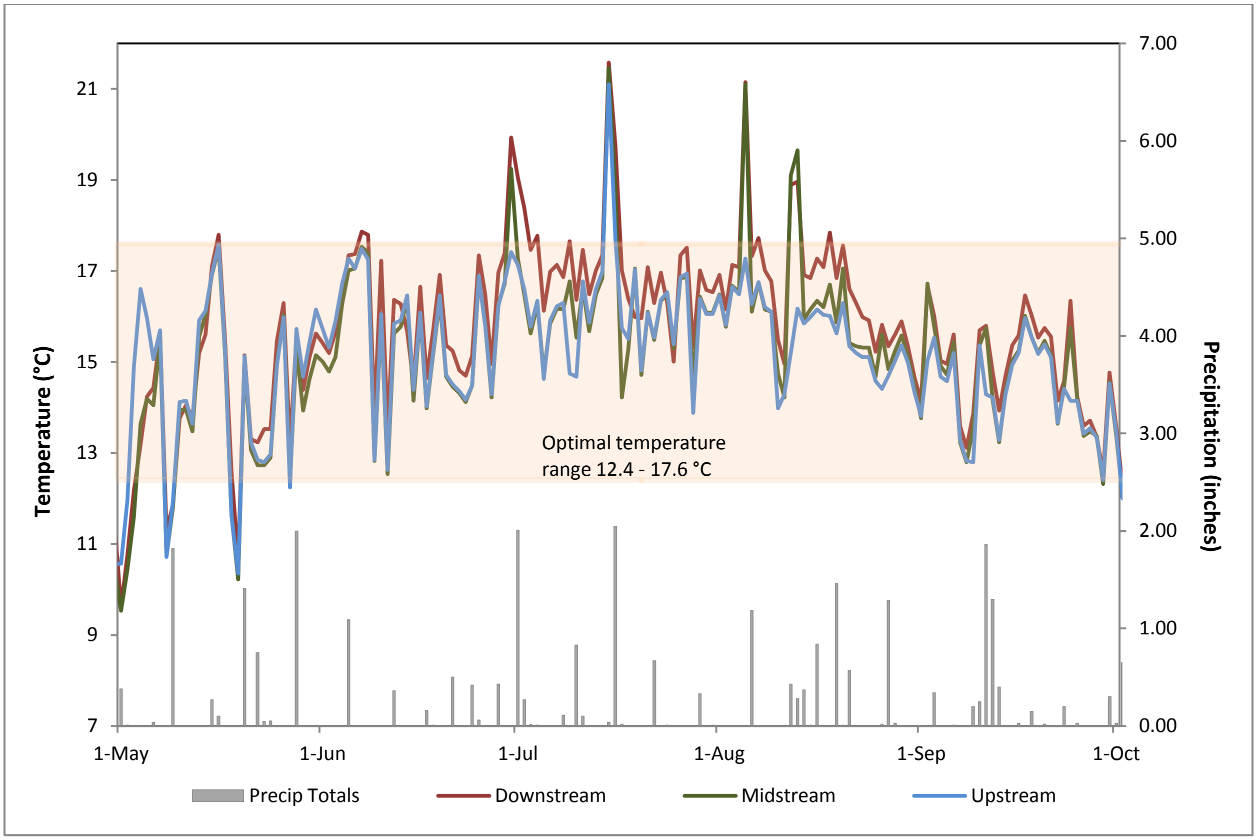


**Figure 4.** Maximum daily temperatures for the 2019 summer.

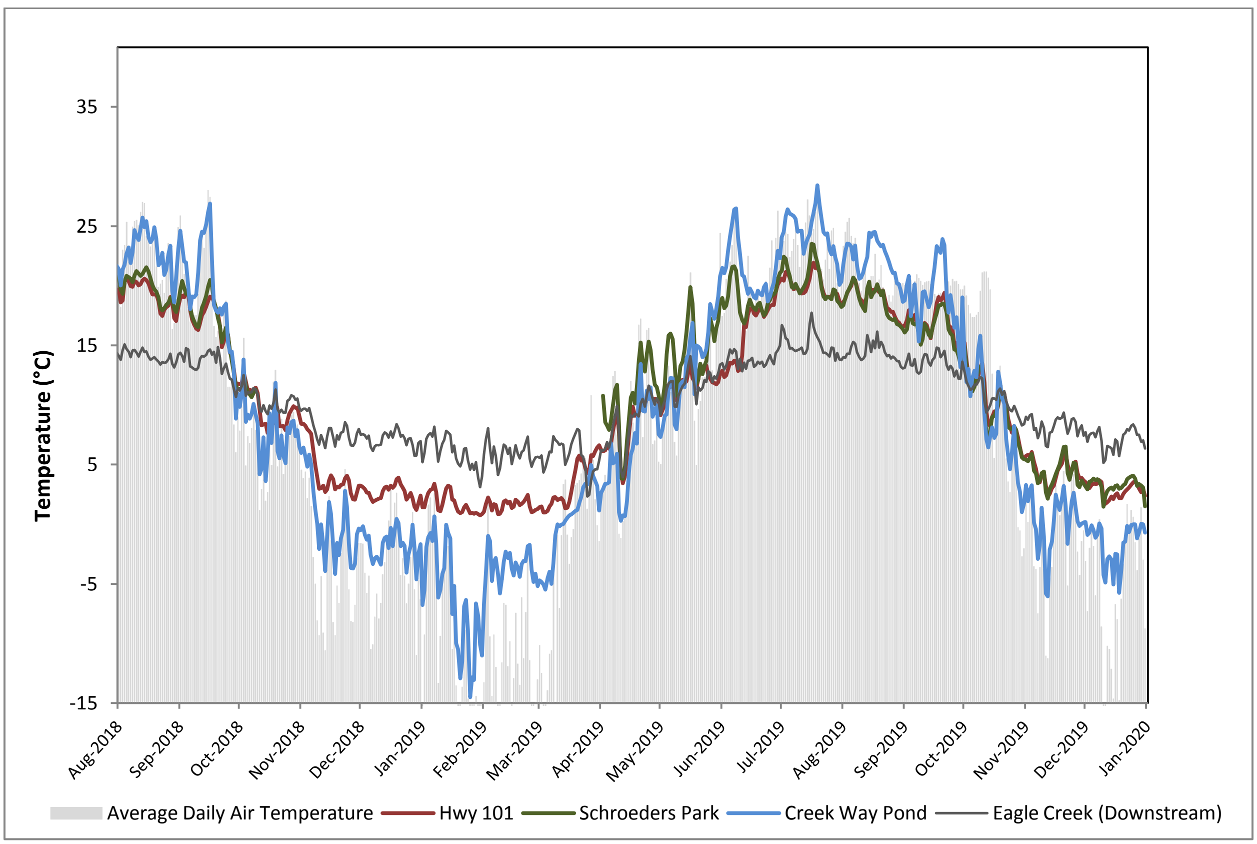


**Figure 5**. Pond outlet loggers 2019 average daily water temperatures. The Eagle Creek (Downstream) logger is shown for reference.

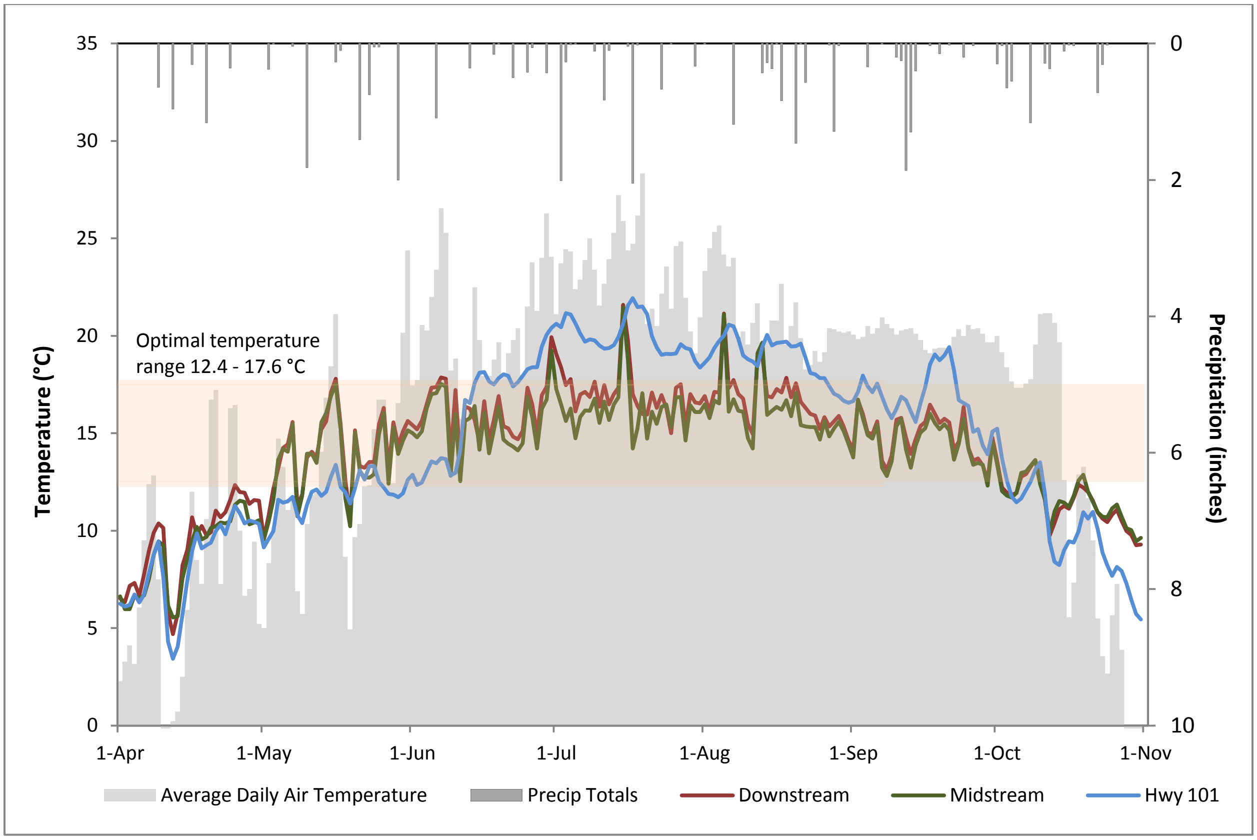


**Figure 6**. Comparison of 2019 water temperatures at the Hwy 101 pond and Eagle Creek upstream and downstream of pond confluence.

## II. Eagle Creek Monitoring

Eagle Creek is a Class 2A self-reproducing trout stream, a unique water resource in the metropolitan area. The Creek originates at the Boiling Springs (an area considered sacred by the Mdewakanton Sioux Community) and outlets into the Minnesota River.  Significant measures have been taken over the past couple of decades to prevent degradation of Eagle Creek, including diverting storm water from the stream, the establishment of a 200-foot natural vegetative buffer along each side of the bank, and most recently in 2013, a habitat improvement project along the west branch of Eagle Creek.  These and other steps have helped to significantly minimize impacts from this rapidly growing suburban area.

### Chloride Monitoring

Located in a highly developed area, Eagle Creek is a unique metropolitan Brown Trout (*Salmo trutta*) stream that may be susceptible to increased levels of chloride.  With over 67% of the watershed "developed" and a road density greater than 18%, the runoff potential from impervious surfaces that can transport deicing products into the creek is significant (MPCA, 2018).  High levels of chlorides have been found to impact trout development and reduce their growth (Hintz & Relyea, 2017).  Smaller streams in highly urbanized areas, like Eagle Creek, are more susceptible to higher chloride concentrations (SEWRPC, 2013).

## Methods

New monitoring to trace potential chloride inputs began in early November of 2018 and is scheduled to conclude at the end of March 2019. Samples are collected in three targeted areas around the watershed to capture baseline and runoff chloride concentrations to see if there are areas that are susceptible to higher levels of chloride pollution during the winters (Figure 7). The selected locations will divide the watershed into sections that can help identify areas with the highest inputs. Chloride and *Escherichia coli* (E. coli) samples were collected bi-weekly along with up to five additional event samples. The event samples are dictated by two consecutive days of above freezing ambient temperatures (32°F). This will capture the greatest potential for chloride runoff into the creek. During each sample run stream parameters (temperatures, pH, conductivity, and dissolved oxygen) were recorded with an YSI EXO 1 sonde at each sample location along with four additional sonde only sample sites. The goal is to relate chloride concentrations to conductivity levels and translate the correlated chloride values to the sonde only measurements. In addition to chloride, E. coli samples are also collected to help isolate the source of historically high levels observed during the winter months.

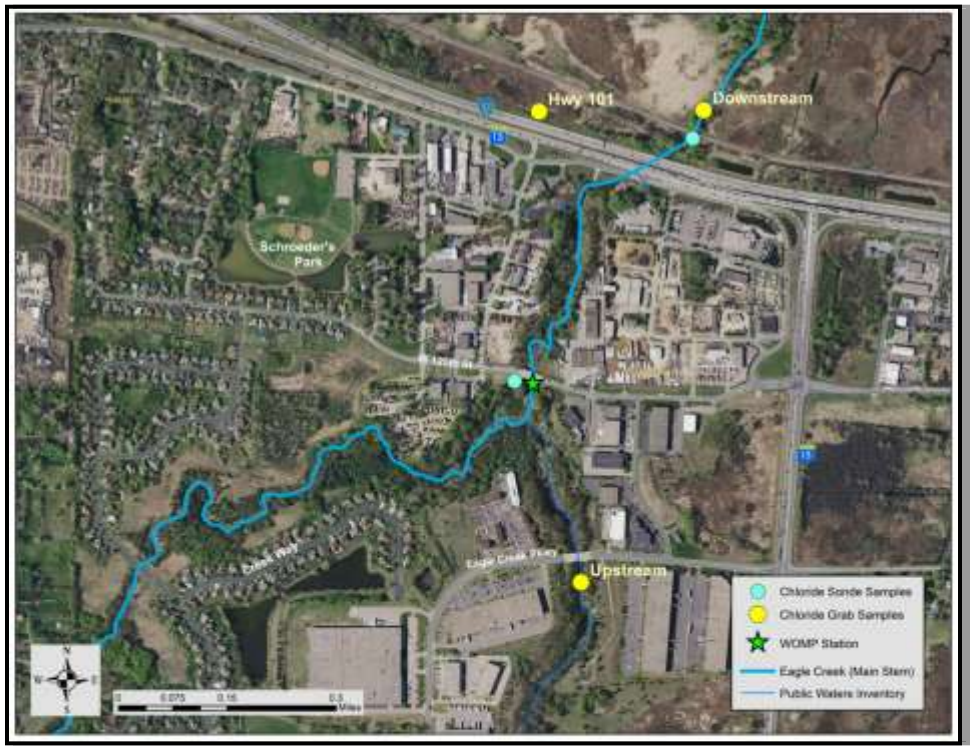


**Figure 7.** Map depicting the locations of the grab samples and sonde readings for the 2018-2019 chloride analysis.

## Results

A total of eleven bi-weekly samples were collected throughout the 2018-2019 winter, only ten were collected at the downstream and Hwy 101 site due to flooding. The chloride levels recorded ranged from 31-360 mg/L (Table 1). Most of the sites stayed below the state concentration standard of 230 mg/L, the Hwy 101 site was the only location with values above the state standard (Figure 8). Most of the sites did not see much fluctuation in chloride levels, the two sites upstream (upstream and WOMP) only varied 6-11 mg/L from the lowest to highest values collected. The upstream site even decreased in concentration for the event samples. Lower in the watershed there appears to be more variation with the Hwy 101 site has a range of 247 mg/L for routine and 195 mg/L for event samples. This likely impacted the lowest site downstream as it had a range of 50-60 mg/L, the highest in the Eagle Creek main channel. Even comparing routine and event samples the upstream site had the lowest range in averages with only a 4 mg/L difference, the Hwy 101 site had ten times that range with a 47 mg/L difference. Again this bumped the variation in the downstream site to a 17 mg/L difference.

**Table 1.** Chloride results of samples collected for the Eagle Creek chloride project. Data represents routine and event samples collected from 11/7/18 to 3/27/19. Red values are in exceedance of state standards for chlorides (230 mg/L).

| Site | Type | Min | 25th % | Median | Avg | 75th % | Max | N |
|---|---|---|---|---|---|---|---|---|
| Upstream | Routine | 45 | 48.7 | 50.1 | 50.6 | 53.9 | 56.3 | 11 |
| | Event | 30.8 | 38.6 | 50.7 | 46.18 | 51.5 | 51.6 | 5 |
| WOMP | Routine | 47.2 | 47.9 | 48.5 | 49.14 | 50.1 | 53 | 11 |
| | Event | 38.7 | - | - | - | - | 38.7 | 1 |
| Hwy 101 | Routine | 112.4 | 126 | 132.15 | 155.57 | 149.8 | 359.1 | 10 |
| | Event | 102.9 | 133.75 | 212.5 | 203.04 | 267.6 | 297.6 | 5 |
| Downstream | Routine | 59.1 | 60.35 | 64 | 67.95 | 67.95 | 108.3 | 10 |
| | Event | 58.9 | 64 | 84.9 | 85.08 | 106.25 | 116.9 | 5 |

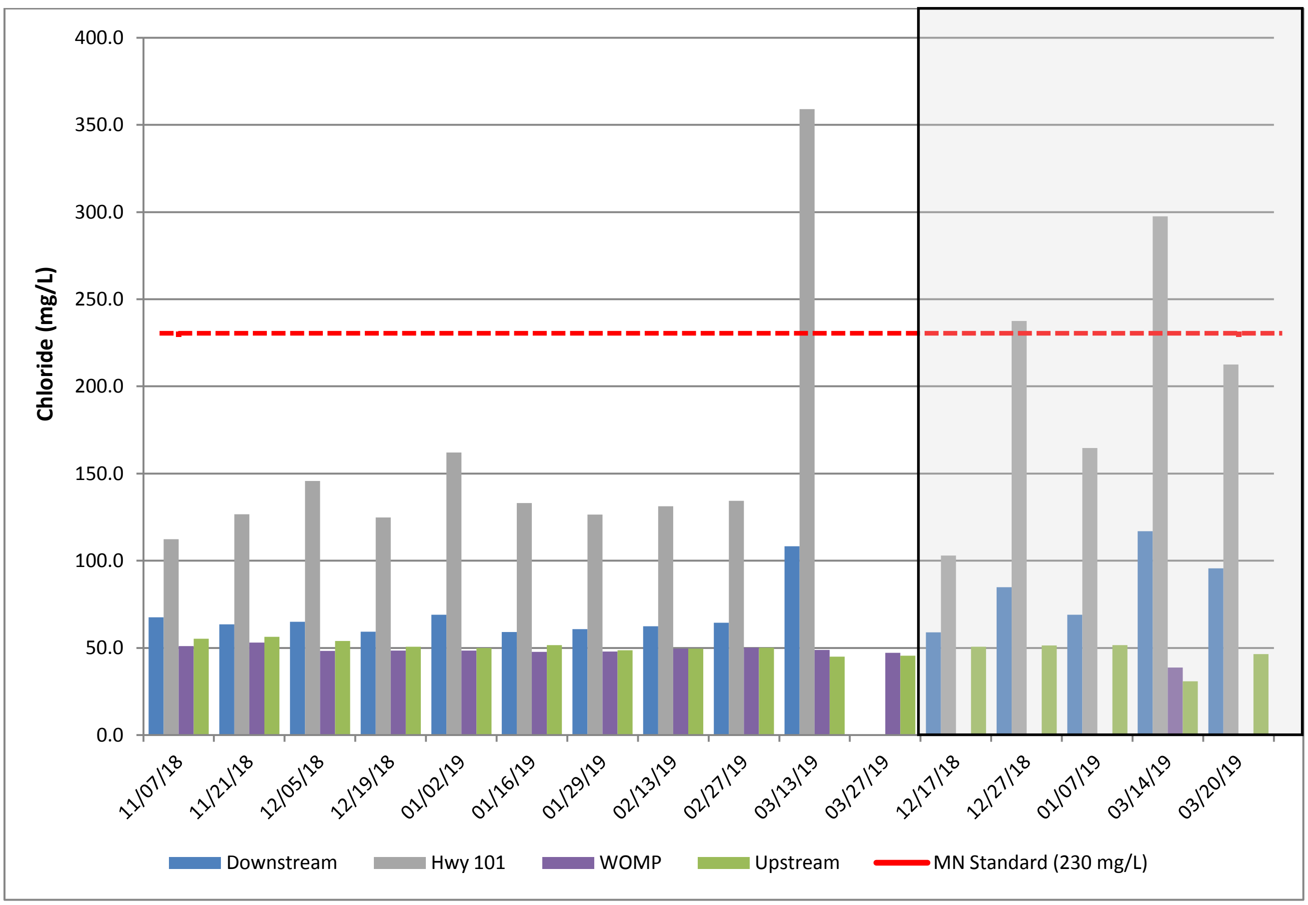


**Figure 8.** Distribution of chloride concentration for each grab sample. The highlighted area represents the event samples.

Along with chloride analysis, this study also collected E.coli data at the sample locations. Historically, the WOMP location sees and uptick in E.coli values during January and February, this has remained true during this study (Figure 9). The upstream site had the highest and lowest values observed (Table 2). On average the WOMP site had the highest values and in most cases decrease further downstream. There are no state standards for the winter, but a general 126 CFU/100ml is a standard values set for the summer that was used here to compare values. All the sites exceeded this value with their max values and most sites even exceeded the value with their averages.

**Table 2.** E.coli results of samples collected for the Eagle Creek chloride project. Data represents routine and event samples collected from 11/7/18 to 3/27/19. Red values are in exceedance of state standards for chlorides (126 CFU/100ml). The state standard only applies to Geometric means for summer measurements; the standard here is used as a guide to compare results.

| Site | Type | Min | 25th % | Median | Avg | 75th % | Max | N |
|---|---|---|---|---|---|---|---|---|
| Upstream | Routine | 3 | 8 | 12 | 142 | 58 | 1203 | 11 |
| | Event | 6 | 8 | 26 | 51 | 107 | 185 | 5 |
| WOMP | Routine | 5 | 11 | 25 | 175 | 411 | 548 | 11 |
| | Event | 206 | - | - | - | - | 206 | 1 |
| Hwy 101 | Routine | 17 | 21 | 31 | 60 | 108 | 201 | 10 |
| | Event | 16 | 20 | 29 | 148 | 335 | 548 | 5 |
| Downstream | Routine | 8 | 14 | 52 | 172 | 307 | 649 | 10 |
| | Event | 7 | 9 | 13 | 41 | 87 | 152 | 5 |

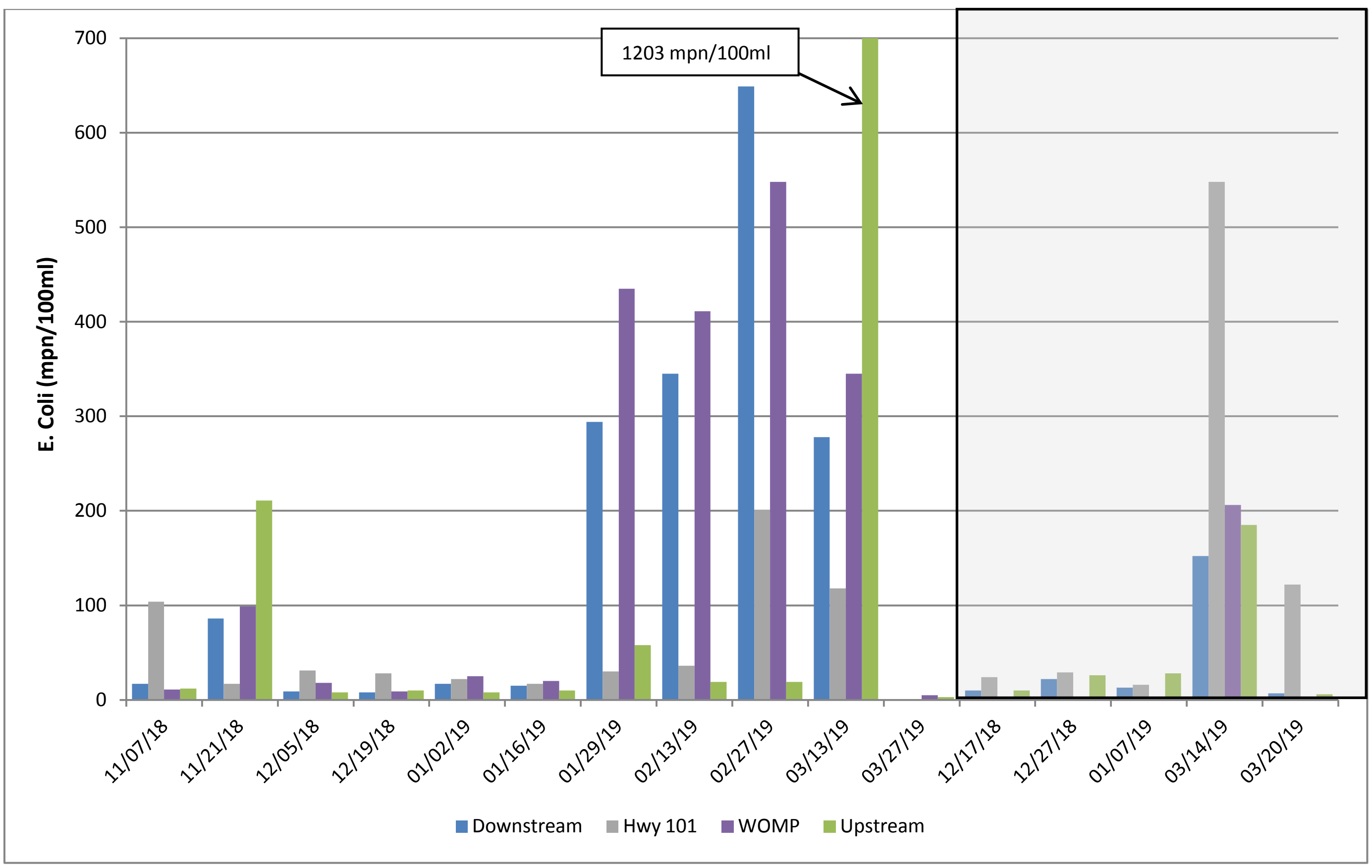


**Figure 9.** Distribution of E.coli concentrations for each grab sample. The highlighted area represents the event samples.

**Discussion**
The main channel of Eagle Creek upstream of Hwy 101 does not appear to be greatly impacted by chlorides, as the monitored levels remained fairly constant throughout the study. Furthermore, the reported levels never came close to the 230 mg/L state standard. Downstream has a little more room for concern as the main stem levels correlated with the levels of the inlet just downstream of Hwy 101. The Hwy 101 monitoring site recorded much higher levels than the main stem of Eagle Creek and even exceeded the state standard on a few occasions. Although the mixing of the main channel and the inlet kept chloride levels well below the standard at the downstream monitoring location, it is concerning to see these high levels anywhere within the Eagle Creek watershed. Further monitoring would provide more data in this area and would track whether the situation stays the same, or deviates from these results.

Monitoring E.coli levels at the Metropolitan Councils watershed outlet monitoring program (WOMP) site has been conducted for multiple years. Every year a spike in concentrations consistently appears in early part of the year (January, February and March). This trend remained consistent in this study as high levels of E.coli were seen at the WOMP station during those months. These high levels could have added to higher levels at the downstream site but was likely diluted further downstream. There was a case when the downstream site had higher levels than the WOMP station. Water fowl were noticed near the Hwy 101 overpass during this measurement which may have increased the readings. Similarly, at the Hwy 101 sampling location there were a few times that signs of muskrats were present which could have influenced the data. Eagle Creek has historically had issues with E.coli levels, as seen in the WOMP data, and it will continue to be monitored through the Metropolitan Councils WOMP program.

## Watershed Outlet Monitoring Program (WOMP)

The Eagle Creek monitoring station began in 1999 as part of the Metropolitan Council's Watershed Outlet Monitoring Program (WOMP). This program was designed and is currently managed by the Metropolitan Council, for the primary purpose of improving the ability to calculate pollutant loads to the Minnesota River. The Lower Minnesota River Watershed District (LMRWD) is the local funding partner for this station, and contracts with the Scott Soil and Water Conservation District (SWCD) to perform field-monitoring activities. The monitoring station is located in the City of Savage near Highway 13 and Highway 101, approximately 0.8 miles upstream of the confluence with the Minnesota River.

The following water quality and flow data is preliminary and is subject to change until the Metropolitan Council submits the final report for this period.

**Table 3**. Precipitation near Eagle Creek WOMP Station.

| Month | 2019 Precipitation* (inches) | 30 Year Record ** Average | Minimum | Maximum |
|---|---|---|---|---|
| January | 0.70 | 0.82 | 0.08 | 4 |
| February | 2.13 | 0.84 | T | 2.18 |
| March | 2.31 | 1.68 | 0.34 | 4.26 |
| April | 3.43 | 3.01 | 0.42 | 7.51 |
| May | 6.88 | 4.46 | 1.08 | 11.08 |
| June | 3.03 | 5.34 | 2.1 | 12.3 |
| July | 6.48 | 4.16 | 0.87 | 8.48 |
| August | 6.50 | 4.97 | 1.11 | 10.86 |
| September | 5.09 | 2.85 | 0.21 | 6.88 |
| October | 4.26 | 2.57 | 0.46 | 5.83 |
| November | 1.44 | 1.56 | T | 4.99 |
| December | 1.97 | 1.18 | T | 3.4 |
| **Total** | **44.21** | **34.26** | **21.93** | **41.99** |

* Precipitation data obtained from Shakopee Mdewakanton Sioux community weather station.
** The 30 year average (normal) is from 1989-2019, NOAA National Weather Service Forecast Office: site Jordan 1SSW Minimum annual average is from 1989 and maximum is from 2019. Records indicated with a "T" represent a trace of precipitation.
https://w2.weather.gov/climate/xmacis.php?wfo=mpx

## Methods

### *Sampling*

Many parameters are recorded continuously at the Eagle Creek WOMP station including stage, velocity, conductivity, precipitation, and stream temperature. Samples are collected and analyzed for multiple parameters (Table 5) during base flow conditions and storm events. Base flow samples are taken monthly during periods of time unaffected by rainfall or snowmelt events. Samples are taken directly from the stream and then transported to the Metropolitan Council Environmental Services Laboratory (lab) for analysis. The station is set with a composite sampler to collect a number of samples during peak flow events, but during 2019 the Metropolitan Council staff was still trying to fine tune the equipment's collection capabilities. The goal is to capture the water quality at or near the peak of the hydrograph. The event samples are treated similar to base flow samples and the grab samples are brought to the lab for analysis. The site was visited and samples were collected thirty-seven times during the 2019 monitoring season, a few of the composite samples did not collect enough water to run a full analysis.

### *Flow*

There are two means of measuring stage and flow at the WOMP station: a WaterLOG bubbler system and Sontek Argonaut Shallow Water (SW) system. The bubbler system has been used since 1999 to measure stage. To determine the amount of flow related to stage, flow measurements are taken manually by MCES staff with a flow meter while the creek is at different stages and a rating curve is developed. With this data, a stage-flow relationship can be applied to the datalogger program, which then calculates continuous flow values as determined by the measured stage.

The Sontek Argonaut-SW was installed by the Metropolitan Council in 2008. This equipment calculates instantaneous flow based on the cross section area, stage, and velocity of the water. This equipment was determined necessary because of occasional backwater conditions caused by beaver dams or flooding of the Minnesota River. The bubbler system is not able to determine that the water is moving slower, so it automatically calculates higher flow as the stage rises. The Argonaut is able to adjust the flow as velocity changes, making the flow values more accurate during backwater conditions.

## Results

The range of sampled water quality parameters are reported in table 5. The minimum, 25th percentile, median, mean, 75th percentile and maximum values are reported along with any state standard or comparable ecoregion range or mean for comparison purposes. Individual TSS and E. coli samples are plotted in figures 11 and 13 respectively. The 5 year trend of monthly TSS values and monthly geometric mean of all E. coli samples taken over the past 10 years are reported in figure 12 and 14 respectively.

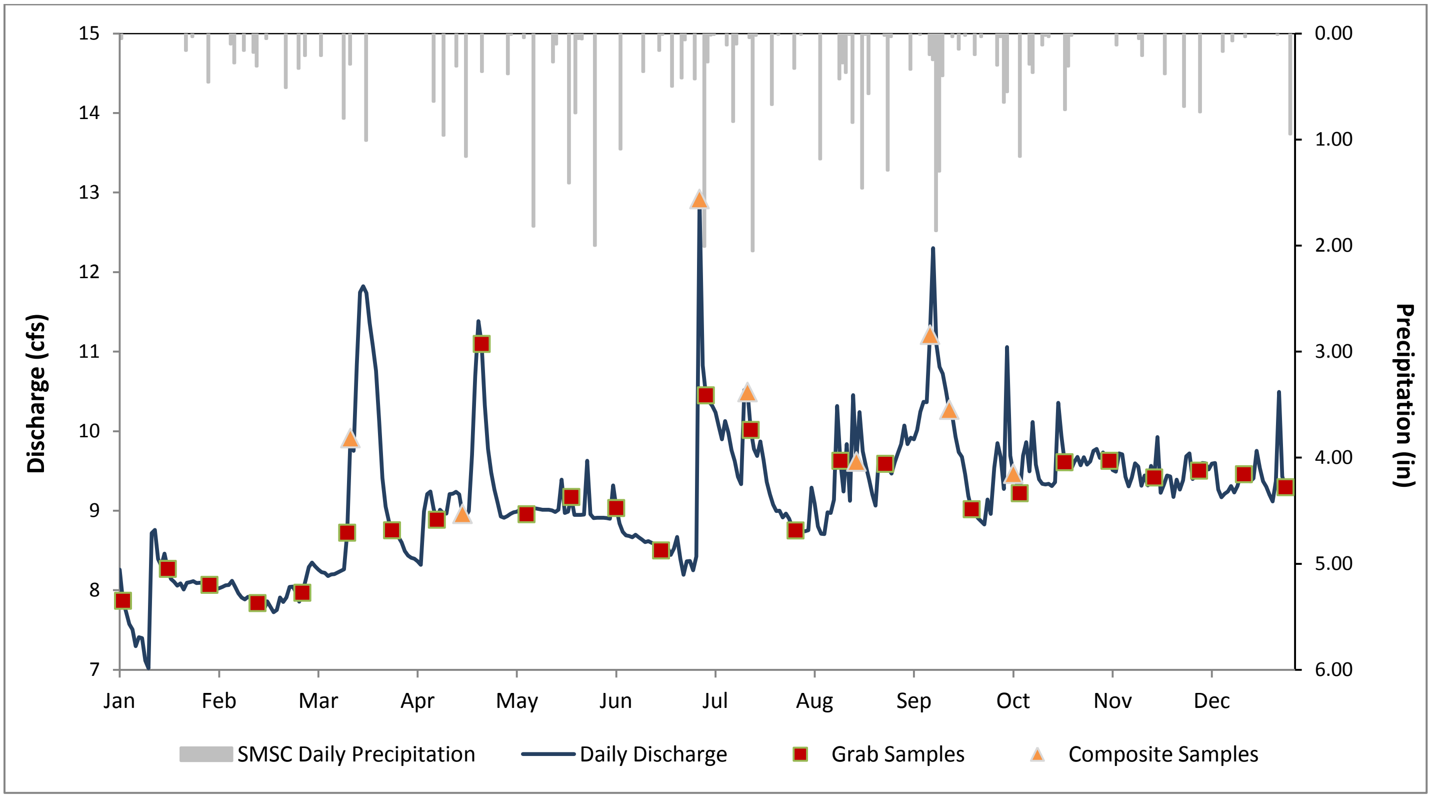


**Figure 10**: 2019 Eagle Creek WOMP discharge, precipitation, and samples collected. Discharge data is provided by METC and is preliminary.

**Table 4.** 2019 *In situ* water quality measurements taken by YSI EXO 1 multi-probe mini sonde during 2019 sampling.

| Parameter | Min | 25th % | Median | Avg | 75th% | Max | N | Notes |
|---|---|---|---|---|---|---|---|---|
| Temp (deg C) | 5.30 | 7.67 | 9.92 | 10.36 | 12.60 | 21.06 | 32 | |
| DO (mg/L) | 7.30 | 8.00 | 8.57 | 8.62 | 9.12 | 10.47 | 32 | Standard = > 7 mg/L |
| pH (Units) | 7.43 | 7.58 | 7.71 | 7.69 | 7.76 | 8.09 | 32 | Standard = 6.5-8.5 |
| Conductivity (umho/cm) | 452.0 | 658.6 | 670.9 | 652.6 | 673.2 | 688.6 | 33 | |

**Table 5.** 2019 Water quality preliminary lab results. Red text indicates exceedance of the state standard or NCHF ecoregion mean.

| Parameter | Min | 25th % | Median | Avg | 75th% | Max | N | Notes |
|---|---|---|---|---|---|---|---|---|
| Alkalinity (mg/L_CaCO3) | 270 | - | 277 | 277 | - | 283 | 2 | No standard, 20-200 mg/L typical |
| Chloride (mg/L) | 22.8 | 46.6 | 49.8 | 47.3 | 51.3 | 55.8 | 37 | Standard = 230 mg/L |
| Hardness (mg/L_CaCO3) | 276.0 | - | 293.0 | 293.0 | - | 310.0 | 2 | |
| Ammonia (mg/L) | 0.02 | 0.03 | 0.06 | 0.07 | 0.08 | 0.13 | 37 | |
| Sulfate (mg/L) | 18.2 | - | 19.3 | 19.3 | - | 20.4 | 2 | |
| Nitrate (mg/L) | 0.19 | 0.20 | 0.20 | 0.24 | 0.24 | 1.00 | 37 | Ecoregion mean = 0.04-0.26 mg/L |
| Nitrite (mg/L) | 0.03 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 37 | Ecoregion mean = 0.04-0.26 mg/L |
| Total Kjeldahl Nitrogen (mg/L) | 0.14 | 0.26 | 0.38 | 0.50 | 0.50 | 2.20 | 37 | |
| Total Phosphorus filtered (mg/L) | 0.020 | 0.020 | 0.020 | 0.081 | 0.022 | 1.730 | 36 | Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L |
| Total Phosphorus unfiltered (mg/L) | 0.020 | 0.025 | 0.041 | 0.072 | 0.084 | 0.386 | 37 | Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L |
| Ortho Phosphate (mg/L) | 0.005 | 0.007 | 0.008 | 0.008 | 0.010 | 0.016 | 33 | |
| Total Organic Carbon (mg/L) | 2.5 | - | 3.1 | 3.1 | - | 3.6 | 2 | |
| Suspended Solids (mg/L) | 2 | 5 | 11 | 25 | 22 | 198 | 35 | Ecoregion mean = 4.8-16 mg/L Standard = 10 mg/L |
| Volatile Suspended Solids (mg/L) | 1 | 2 | 3 | 8 | 7 | 59 | 35 | |
| E. Coli (#/100ml) | 1 | 25 | 104 | 235 | 345 | 1553 | 31 | Standard = 126 CFU/100ml as geometric mean |

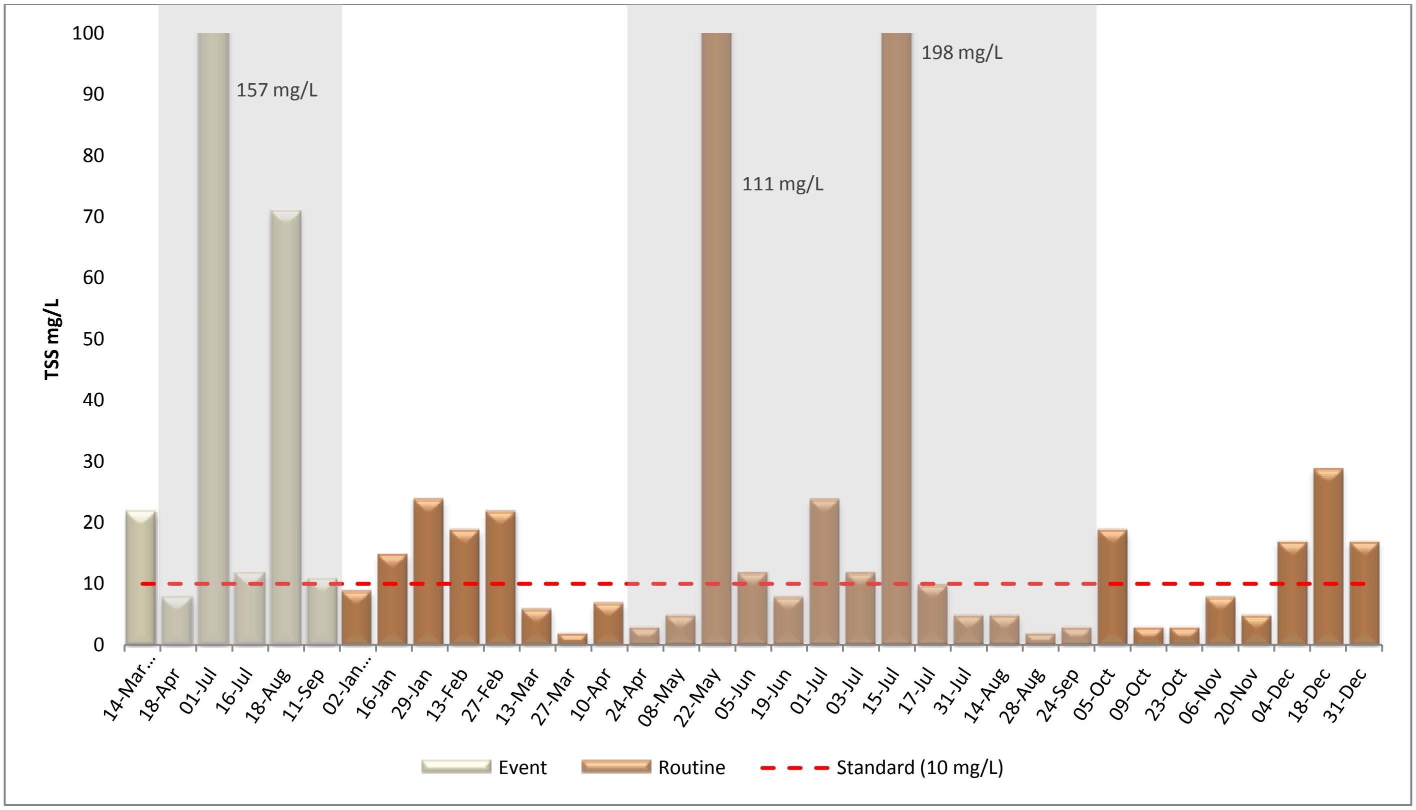


**Figure 11.** Total Suspended Solids (2019). State Standard for Class 2A Waters = 10 mg/L with no more than 10% exceedance between 1 April and 30 September (indicated by the red dashed line and the shaded areas in the graph).

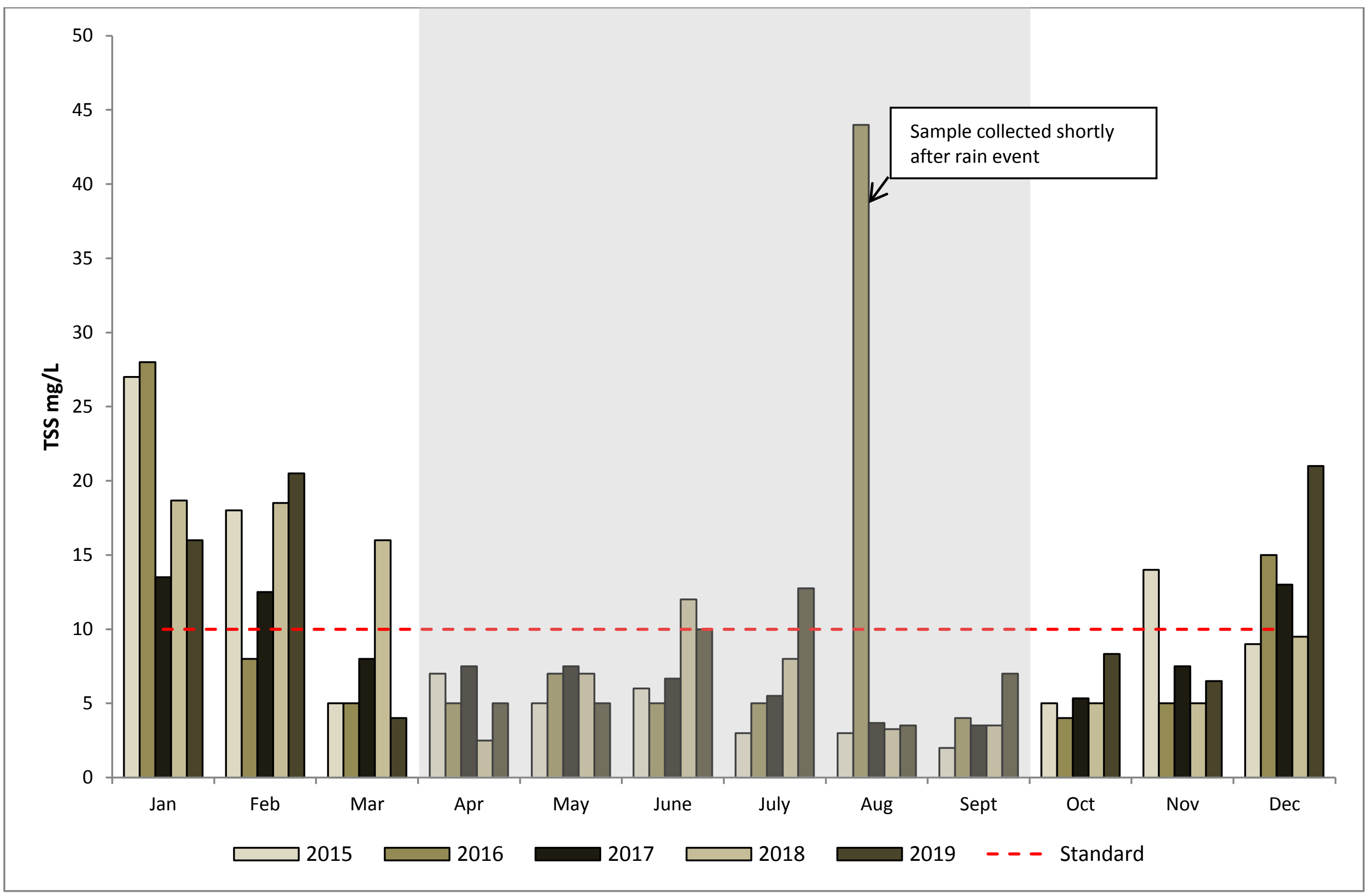


**Figure 12.** Total suspended solid monthly average over the last 5 years for non-event samples. The state standard is 10mg/L indicated by the dashed red line. No more than 10% exceedance shall occur between 1 April and 30 September (shaded area).

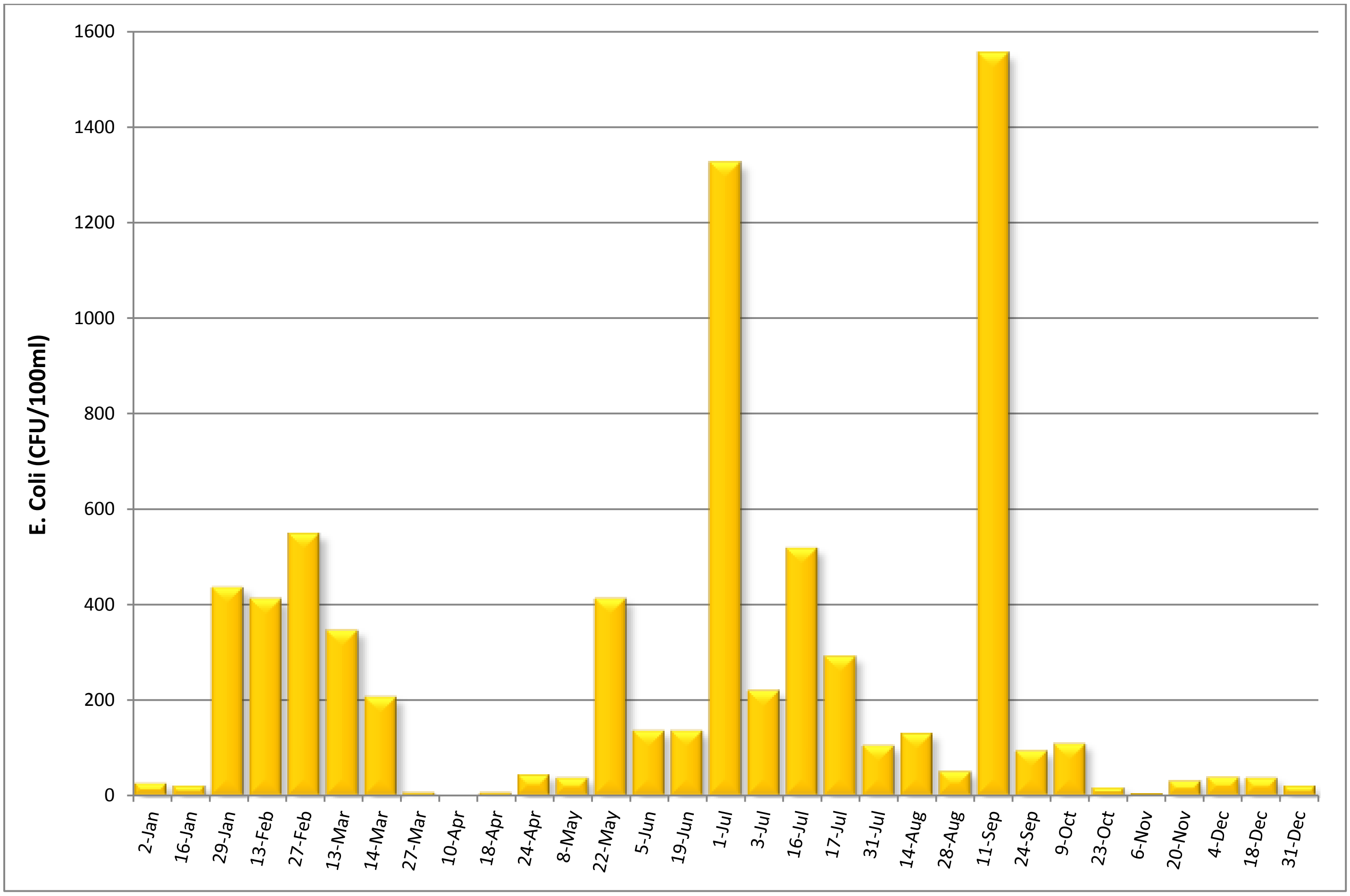


**Figure 13**. *E. coli* samples (2019). *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

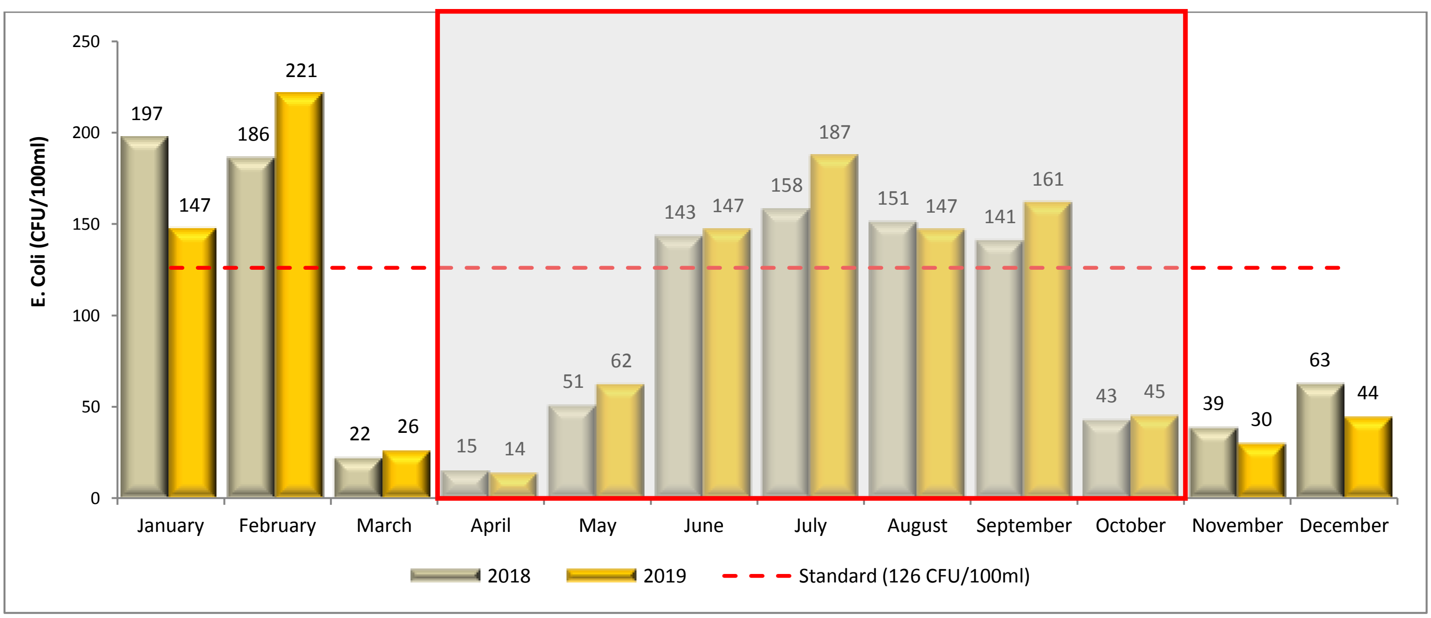


**Figure 14**. Geometric mean of *E. coli* at Eagle Creek. The geometric mean was calculated using all samples over the past 10 years (2009-2019) for any given month. *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

## Discussion

In general, the monitoring data suggests that Eagle Creek consistently meets state water quality standards and ecoregion means[1], with the exceptions being bacteria and suspended solids (Figure 11, Figure 14 and Table 5). The elevated levels of these parameters in winter is characteristic of this stream due to the fact that Eagle Creek is spring fed and does not freeze over in the winter. The open water attracts a large number of waterfowl, which results in historically higher bacteria, sediment, and turbidity levels than observed in summer months (Figures 11 and 13). Elevated levels during the summer are a result of continual waterfowl use and runoff from significant rain events.

The *E. coli* standard is applicable from April 1 – October 31 and is exceeded when greater than 10% of the samples exceed 1260 Colony Forming Units (CFU) per 100 ml *or* the geometric mean of no fewer than five samples in a calendar month exceed 126 CFUs. Two samples exceeded 1260 CFU's from April through October, one in July and another in September (Figure 13). Additionally, the geometric mean of the previous ten years of *E. coli* samples resulted in the exceedance of 126 CFU's for June thru August (Figure 14). January and February also exceeded the 126 CFU threshold leaving six month's below the standard.

The previous state turbidity standard was replaced with a Total Suspended Solids (TSS) standard. The new TSS standard for Class 2A waters state that no more than 10% of samples shall exceed 10 mg/L between April 1 and September 30. This year, Eagle Creek exceeded 10 mg/L in 5 of 13 (38%) lab samples during the applicable season (Figure 11). In addition two of the five event samples and all samples exceeded the 10 mg/L level. For all of the samples collected from April thru September, 7 of 18 (39%) exceeded the state standard. Additionally, nine of the other samples outside of the standards date range had TSS levels above 10 mg/L.

## III. Dean Lake Inlet Monitoring

Dean Lake Inlet was once on the Minnesota Pollution Control Agency (MPCA) 303 (d) list of impaired waters from 2006-2016. It was impaired for Aquatic Recreation due to excess nutrients causing eutrophication. In 2016 the body of water was re-assessed and reclassified as a wetland in the MPCA's Lower Minnesota River Watershed Monitoring and Assessment Report of June 2017. Although the reclassification removes the body of water from the 303 (d) list the nutrient loading still remains. Scott SWCD continues to provide monitoring data on the inlet to Dean Lake to document nutrient loading. The monitoring site is located where CR21 passes over the Prior Lake Outlet Channel to the southeast of Dean Lake. The SWCD monitors water chemistry and continuous stage and flow at this location. This site has been monitored from 2014 to present.

### Methods

In-stream field measurements of dissolved oxygen, temperature, turbidity, pH, and conductivity were taken using an YSI EXO 1 multiparameter Sonde. Field transparency is measured with a 1 meter secchi tube. Bi-weekly scheduled samples and additional event grab samples taken after rain events are taken while the stream channel is open (March-November). In 2019, 17 base grab samples and 4 event grab samples were collected totaling 21 samples. In addition to water quality samples, a total of five periodic flow measurements were taken in 2019. These measurements are used and in conjunction with flow measurements taken over

[1] There are seven ecoregions in Minnesota. Ecoregions are classified by geographic areas with similar plant communities, land use, soil, and geology. Eagle Creek is located in the North Central Hardwood Forest (NCHF) ecoregion. Each ecoregion has unique water quality goals as determined by historical monitoring of representative and minimally impacted reference streams within that ecoregion.

the previous years to develop a discharge rating curve. This rating curve is applied to the continuous 15 minute stage measurements collected by Campbell Scientific SR50 Ultrasonic Distance Sensor and CR1000 data logger to calculate continuous discharge data at the site (Figure 15).

**Results**

The 2019 monitoring data suggest that the inlet to Dean Lake meets MN water quality standards for all measurable categories, but it fell out of ecoregion mean and EPA recommendations for phosphorus, nitrate and suspended solids (Table 6). Historically, the inlet has seen spikes in nitrate and phosphorus. During the 2019 sampling season the total unfiltered phosphorus fell beyond the recommended level 19% of the time and measured below and above the Ecoregion mean 52% and 10% of the time respectively. The nitrates only exceeded the Ecoregion high 14% of the time and never went below the low. Finally, the suspended solids exceeded the state standard 9% of the time and went above the Ecoregion high 33% of the time.

**Table 6.** 2019 water quality data from Dean Lake Inlet. Red, bolded text indicates exceedance of the state standard or North Central Hardwood Forest ecoregion mean.

| Parameter | Min | 25th % | Median | Avg | 75th% | Max | N | Notes |
|---|---|---|---|---|---|---|---|---|
| Chloride (mg/L) | 28.60 | 47.1 | 50.0 | 49.0 | 53.3 | 60.4 | 21 | Standard = 230 mg/L |
| Nitrate (mg/L) | 0.16 | 0.20 | 0.20 | 0.22 | 0.21 | **0.42** | 21 | Ecoregion mean = 0.04-0.26 mg/L |
| Nitrite (mg/L) | 0.03 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 21 | Ecoregion mean = 0.04-0.26 mg/L |
| Total Kjeldahl Nitrogen (mg/L) | 0.08 | 0.75 | 0.80 | 0.81 | 0.90 | 1.20 | 21 | |
| Total Phosphorus filtered (mg/L) | 0.020 | 0.020 | 0.028 | 0.041 | 0.046 | **0.164** | 21 | Ecoregion mean = 0.06-0.15 mg/L<br>EPA recommends < 0.1 mg/L |
| Total Phosphorus unfiltered (mg/L) | 0.015 | 0.048 | 0.055 | 0.074 | 0.094 | **0.170** | 21 | Ecoregion mean = 0.06-0.15 mg/L<br>EPA recommends < 0.1 mg/L |
| Lab Turbidity (NTRU) | 3 | 5 | 6 | 8 | 11 | 19 | 21 | |
| Suspended Solids (mg/L) | 4 | 9 | 13 | 17 | 17 | **73** | 21 | Standard = 30 mg/L<br>Ecoregion mean = 4.8-16 mg/L |
| Volatile Suspended Solids (mg/L) | 1 | 3 | 3 | 4 | 5 | 9 | 21 | |

**Table 7**. 2019 *In situ* water quality measurements taken by a YSI EXO1 multi-probe mini sonde for Dean Lake Inlet.

| Parameter | Min | 25th % | Median | Avg | 75th% | Max | N | Notes |
|---|---|---|---|---|---|---|---|---|
| Temp (deg C) | 4.24 | 11.02 | 16.59 | 16.09 | 11.02 | 25.51 | 20 | |
| DO (mg/L) | 6.04 | 7.27 | 8.59 | 8.77 | 10.00 | 12.48 | 20 | |
| pH (Units) | 7.56 | 7.81 | 7.90 | 7.90 | 8.02 | 8.24 | 20 | |
| Conductivity (umho/cm) | 391.5 | 437.0 | 455.4 | 454.2 | 471.7 | 575.7 | 20 | |

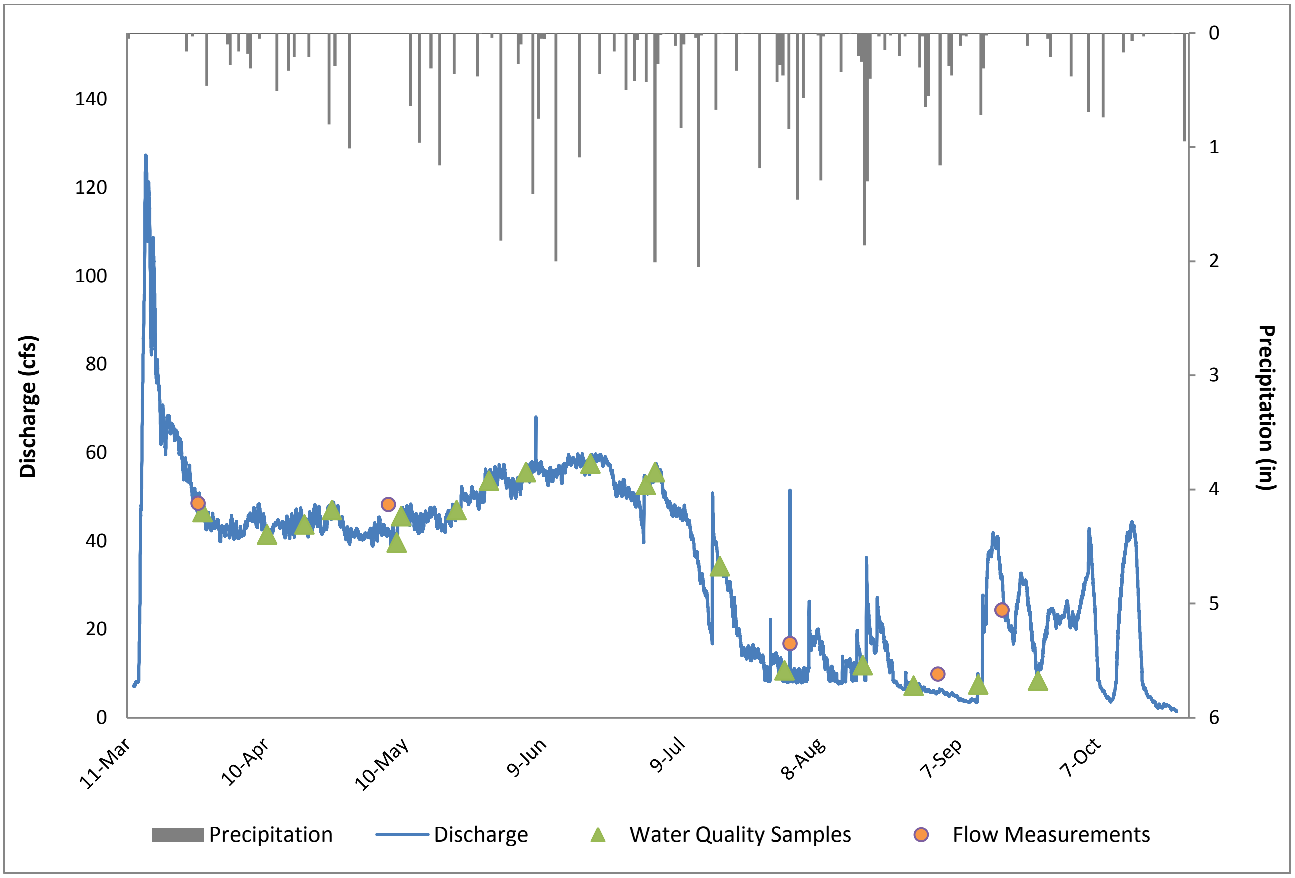


**Figure 15**. Dean Lake Inlet discharge, precipitation, flow measurements, and water quality samples collected (2019).

**Discussion:**

Most of the water quality parameters at the Dean Lake Inlet are within the recommended standards and ecoregion averages. With all of the exceeding parameters, most exceedance is occurring after precipitation events, droughts, or seasonally influence. Monitoring these levels should continue to track any potential increases or decreases in these levels. Although Dean Lake Inlet is no longer on the 303 (d) list because of its reclassification, it is important to track the amount of nutrients at the site to maintain historical data and track nutrient loading downstream.

## IV. Well Monitoring

In 2005 the LMRWD contracted with Scott Soil and Water Conservation District to collect groundwater measurements from 13 wells in the Savage Fen, 4 wells in the Eagle Creek area and 2 Bluff wells. The data from these recordings is used to assess groundwater resources, determine long-term trends and interpret the impacts of pumping and climate. The wells in the Savage Fen were installed by the DNR to monitor development effects and water usage from the City of Savage on the water level in the Fen. All well data is entered into the DNR's groundwater level database and can be accessed at http://www.dnr.state.mn.us/waters/cgm/index.html.

## Savage Fen Area Wells

The Savage Fen is a rare wetland complex at the base of the north-facing bluffs in the Minnesota River Valley, the largest calcareous fen of its kind in Minnesota. A plant community of wet, seepage sites with an internal flow of groundwater rich in calcium, magnesium bicarbonates and sulfates result in a thick peat base that is able to support a unique diversity of plants. More than 200 various plant species have been found in the Savage Fen, some of which are rare.

### Methods

Scott SWCD monitors 13 wells in the Savage Fen monthly between April and December (Figure 16). The water level fluctuates throughout the year and the artesian wells record water levels above ground level. In addition, four wells are monitored in the Eagle Creek portion of Savage Fen on the other side of highway 13 (Figure 21).

The SWCD monitors two additional wells in the Savage Bluff area. In 2010 the Savage Post Office and Fire Department was constructed near the bluff wellheads and as a result, the wellheads were reconstructed and placed below the street, accessible beneath a manhole cover. The SWCD did not read these two wells in 2011 or 2012 as a result of the construction. In 2013, the SWCD resumed monitoring these wells with the City of Savage staff providing access. The Bluff wells were sealed during the 2019 season and are not longer accessible.

In total, the SWCD recorded 141 water level measurements in 2019 from 19 wells for LMRWD.

### Results

The Savage Fen water levels remained relatively constant throughout the monitoring season with individual well fluctuations throughout the year (Figure 16). Overall, the average Savage Fen water levels for 2019 decreased 0.42 feet throughout the year, with some wells dropping more than others (Figure 18, 19 &20). Historically, the Fens have shown signs of fluctuation, and besides a dip in 2012 the water levels have shown a general sign of increase. This year the wells continue to rise with an average 0.14 foot gain in water levels over the last 10 years (Figure 17). The 2019 Eagle Creek well levels generally showed a decrease throughout the year with all the wells averaging a 0.42ft drop throughout the year (Figure 21). Even with the drop in levels this year, the past 10 years show a 0.57ft average rise in water elevations with EC3, EC4, EC5 and EC6 gaining 0.19, 0.71, 0.27 and 1.11ft respectively (Figure 22).

The bluff wells both showed signs of water levels increasing before they became inaccessible (Figure 23). The water level in the deep bluff gained 0.67ft through the abbreviated 2019 monitoring, and the shallow well also gained 0.35ft. The historic monitoring at the bluff well sites is discontinuous due to construction. However, since the construction water levels have generally increased and are the highest levels recorded since the initial observation in 1994 (Figure 24). This year the wells were showing a rebound to the decreasing levels observed in 2018.

All figures in this section are reported in depth to water (DTW) which is a product of the wells measuring point elevation minus the elevation of the recorded observed elevation.

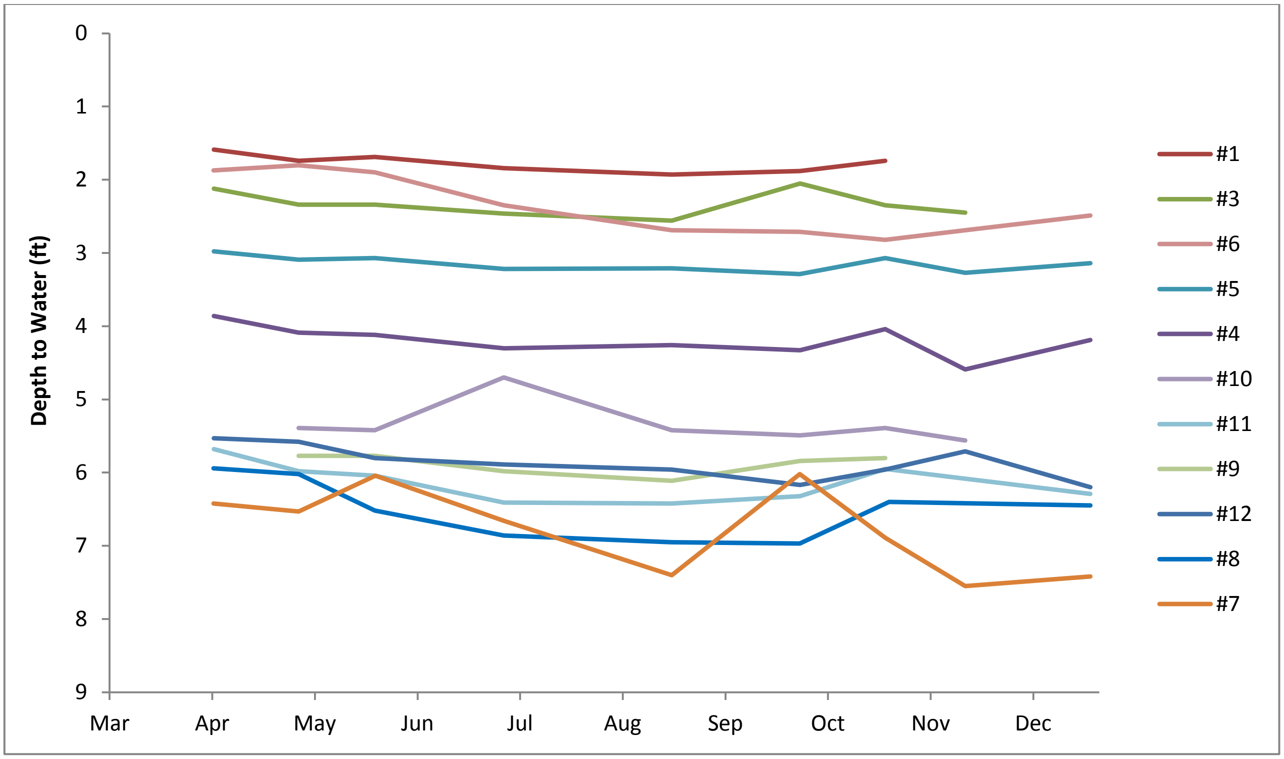


**Figure 16.** Savage Fen Wells (2019).

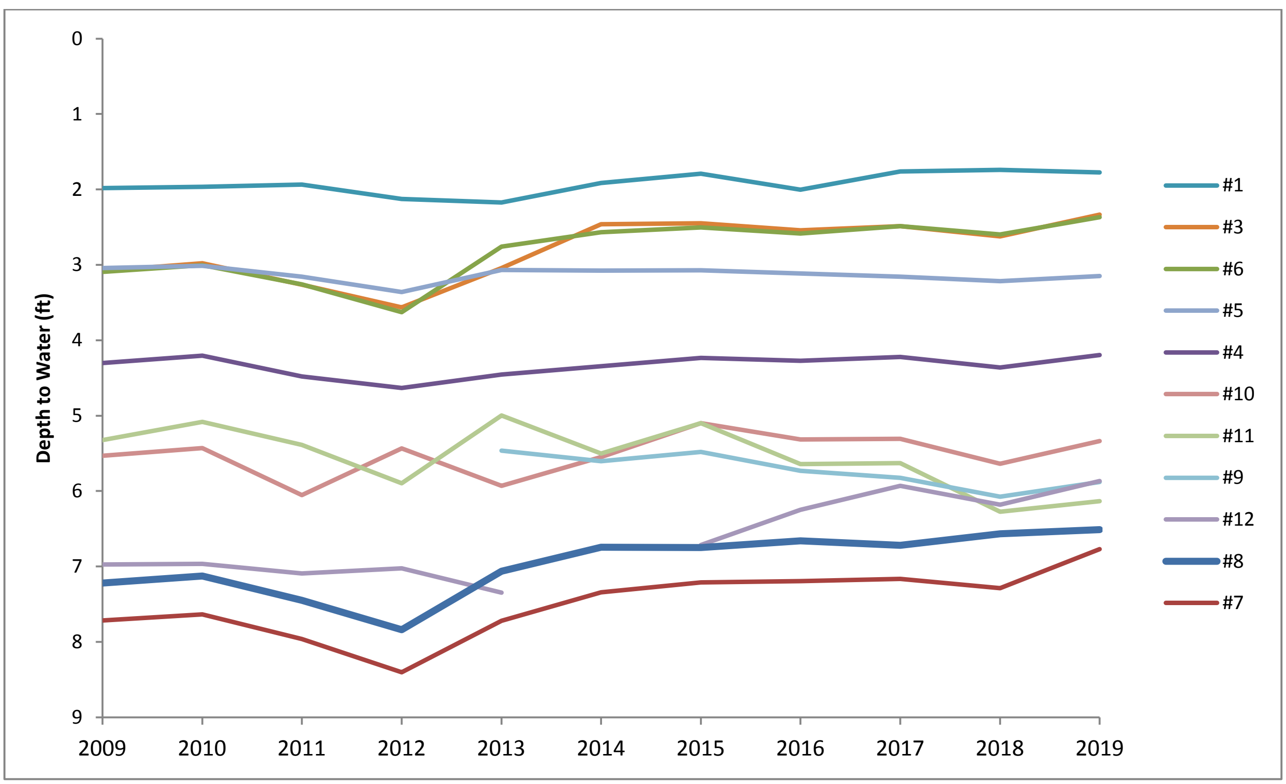


**Figure 17.** Average annual water level in Savage Fen wells (2009-2019). Averages include all observations in a calendar year.

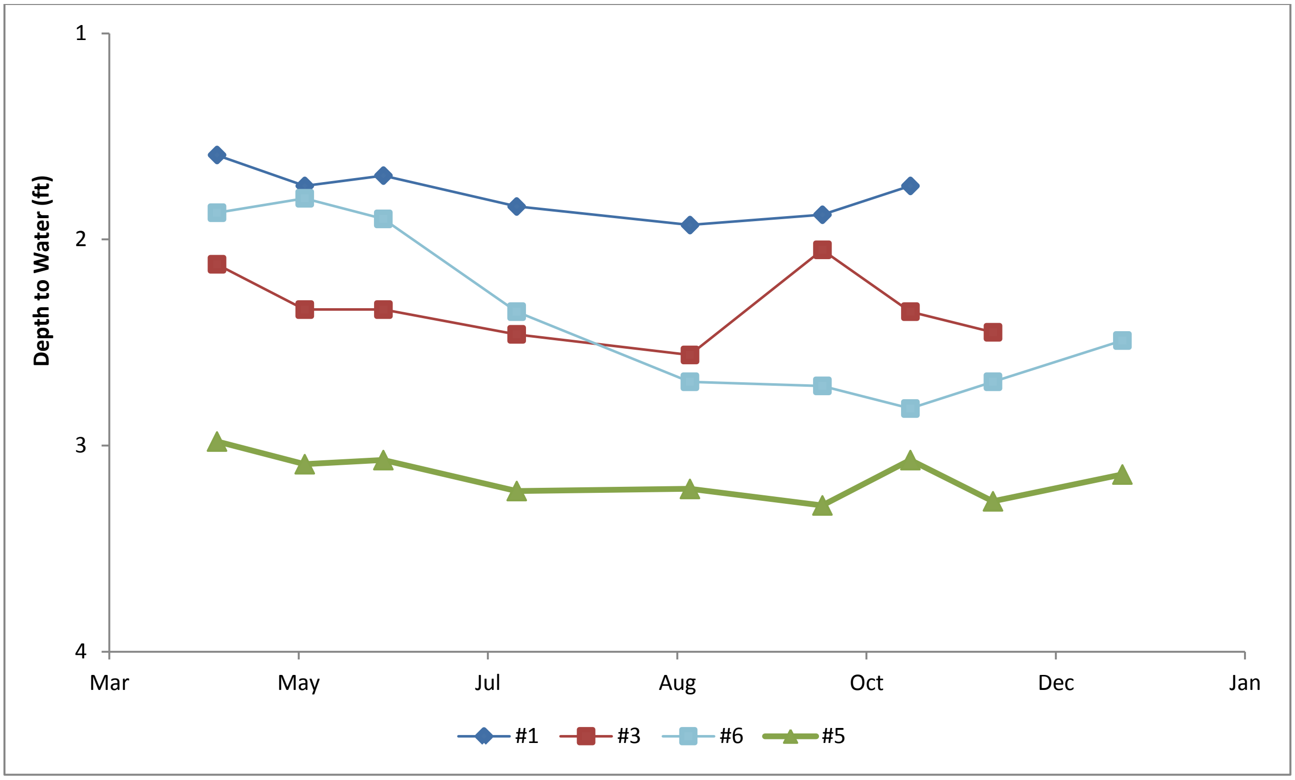


**Figure 18.** The four Savage Fen wells with the lowest depth-to-water (DTW) values (2019).

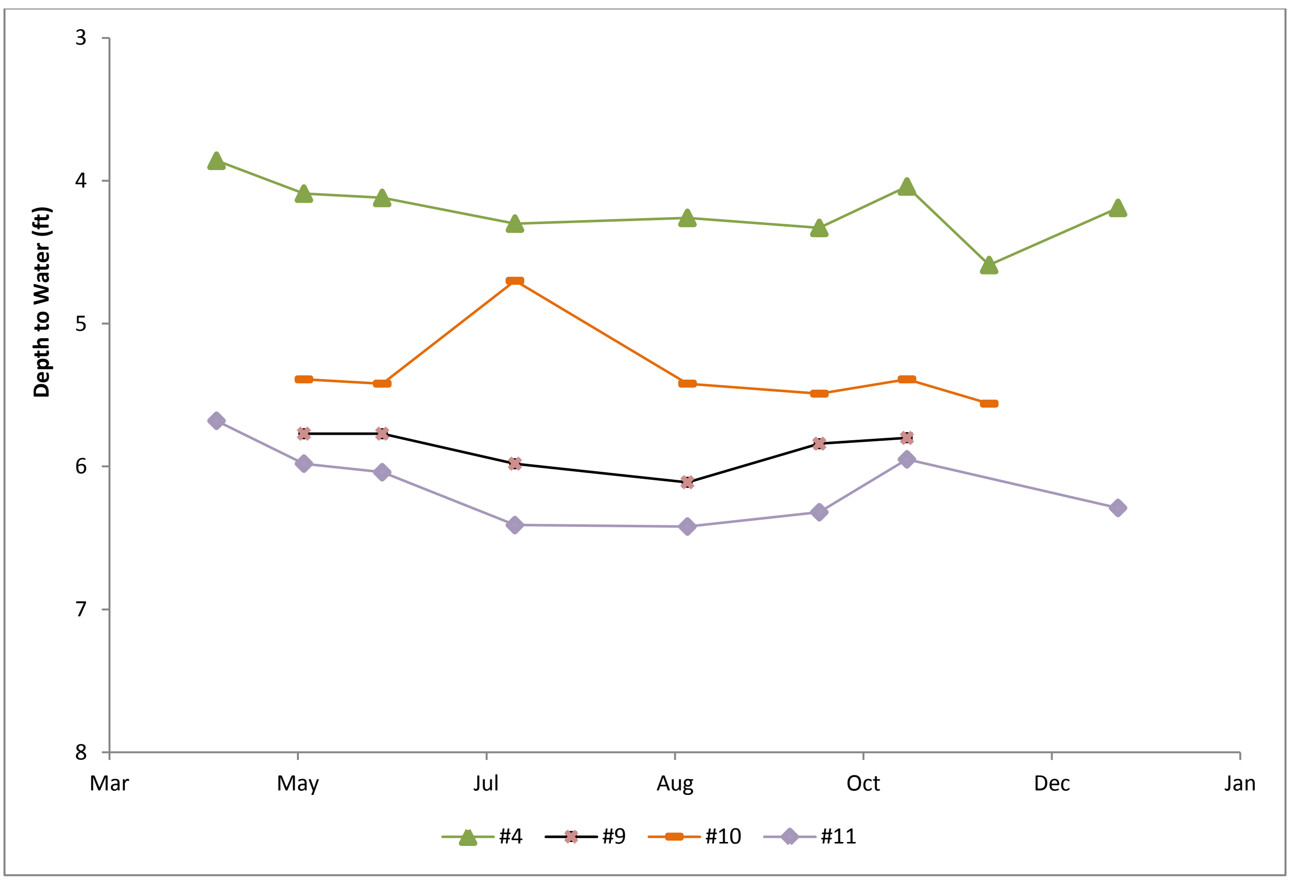


**Figure 19**. The four Savage Fen wells with the mid-level depth-to-water (DTW) values (2019).

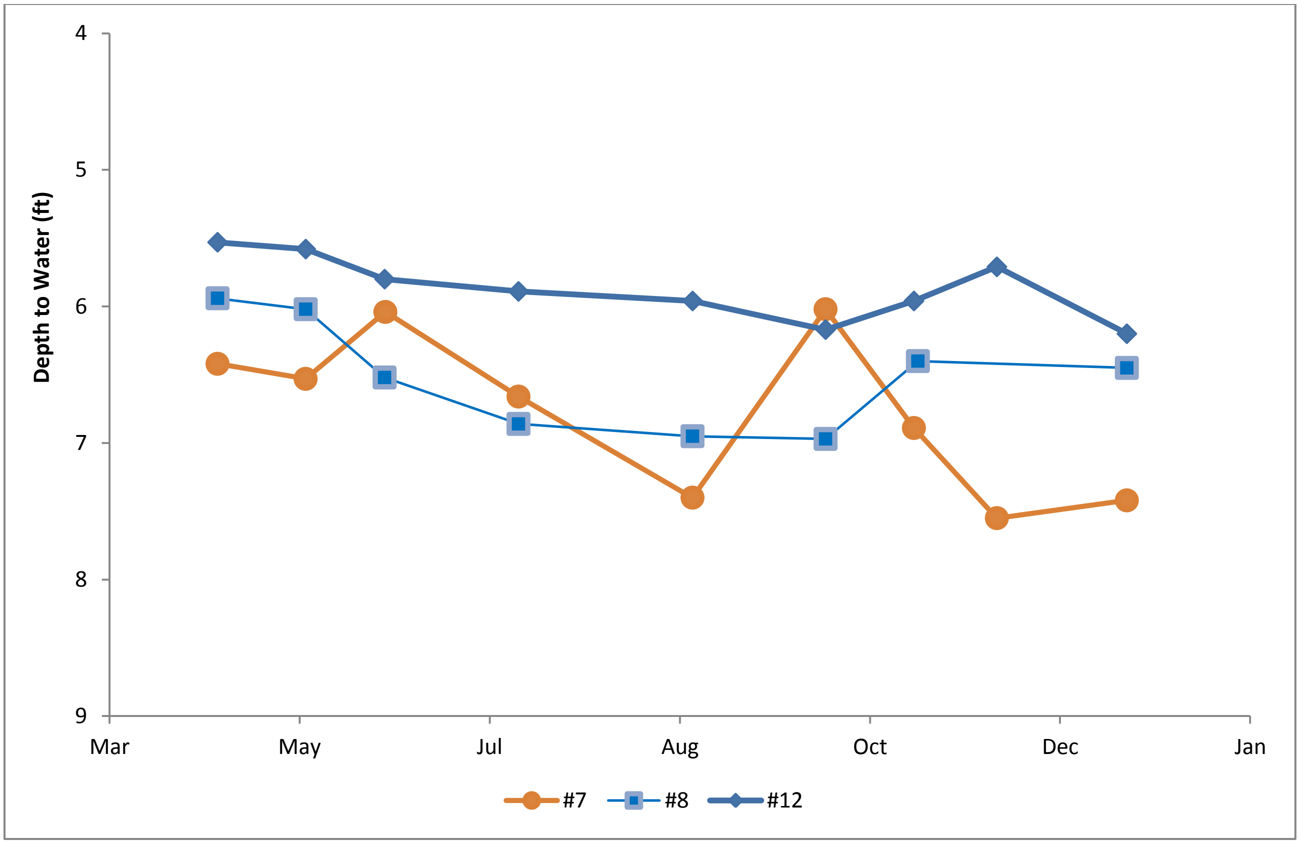


**Figure 20.** The three Savage Fen wells with the highest depth-to-water (DTW) values (2019).

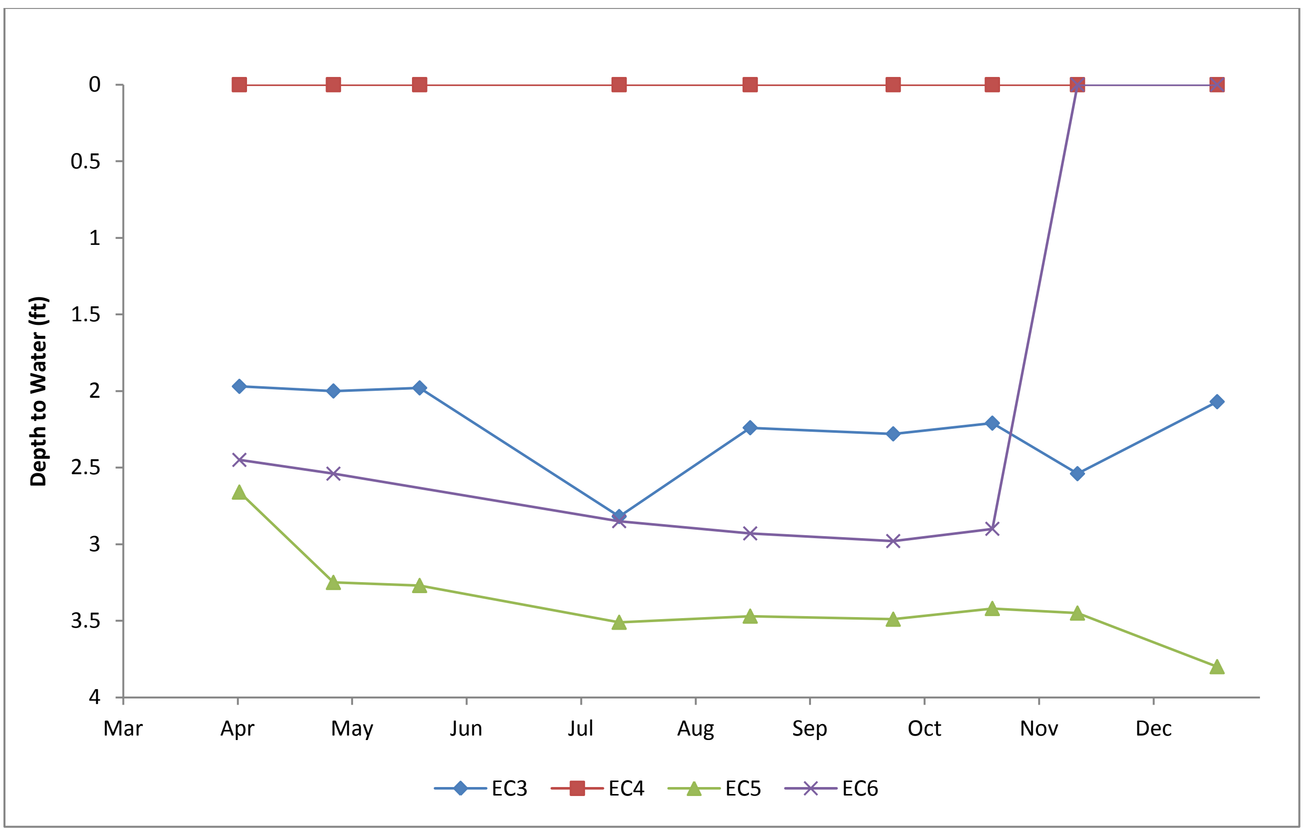


**Figure 21.** Eagle Creek wells (2019). Measurements recorded as "zero" are over-topped wells from April-October, and frozen wells from October-End of year.

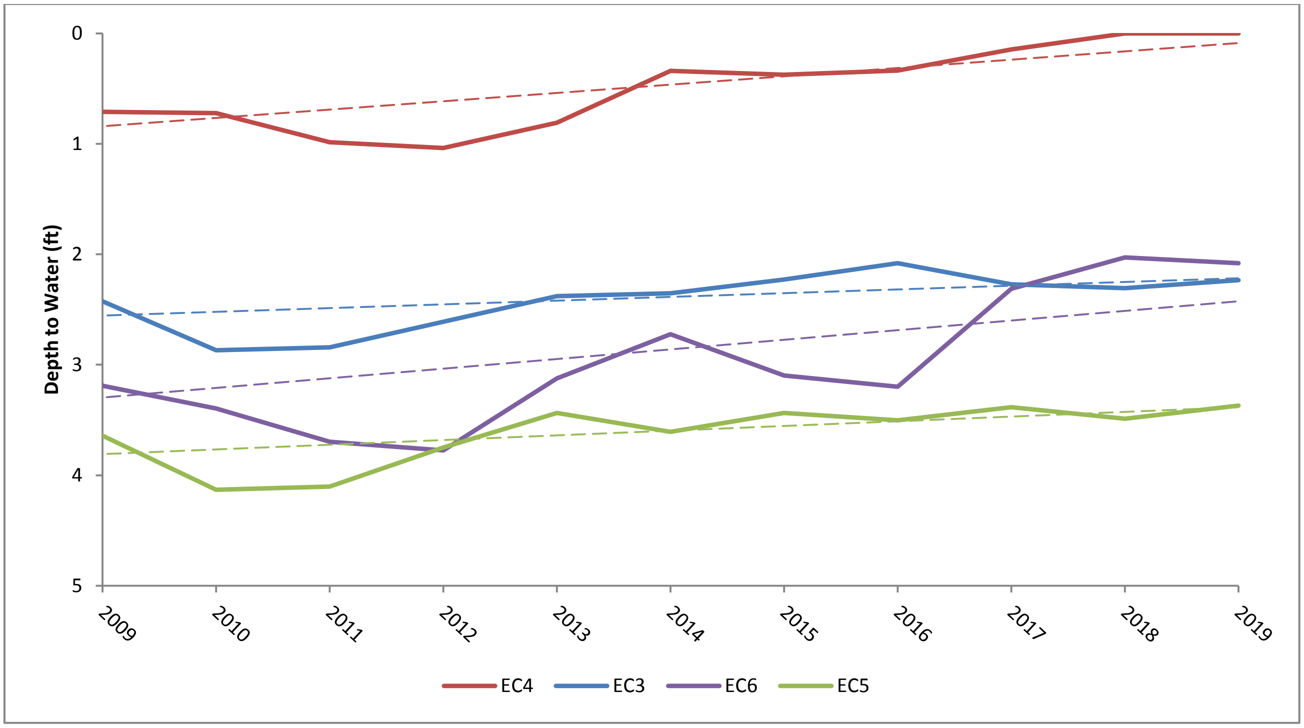


**Figure 22.** Eagle Creek historical 10 year trend. Values are yearly averages and include all values taken within the year.

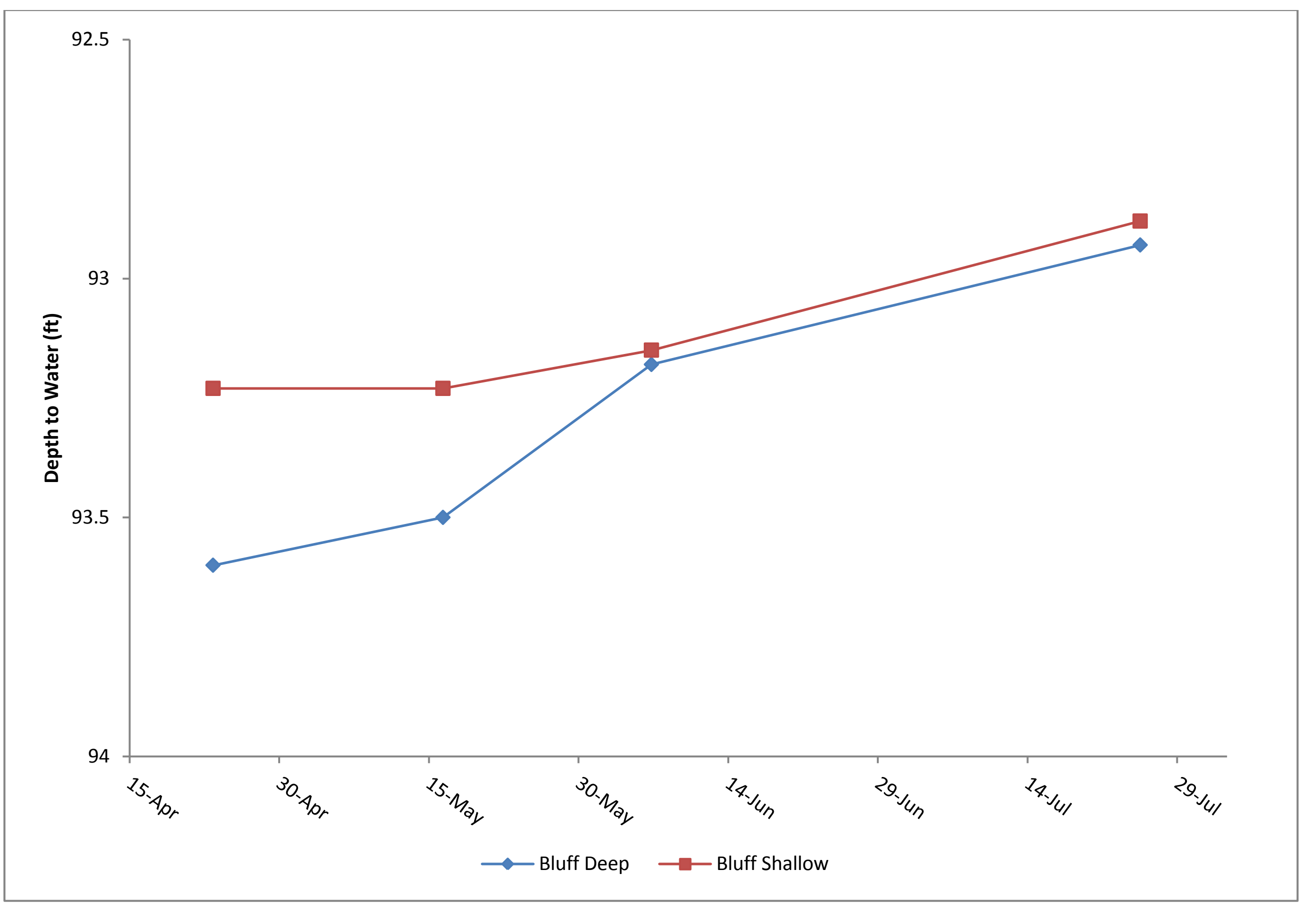


**Figure 23:** Shallow and deep bluff well data (2019). **Both wells were sealed during the 2019 season. Going forward, no further measurements will be available.**

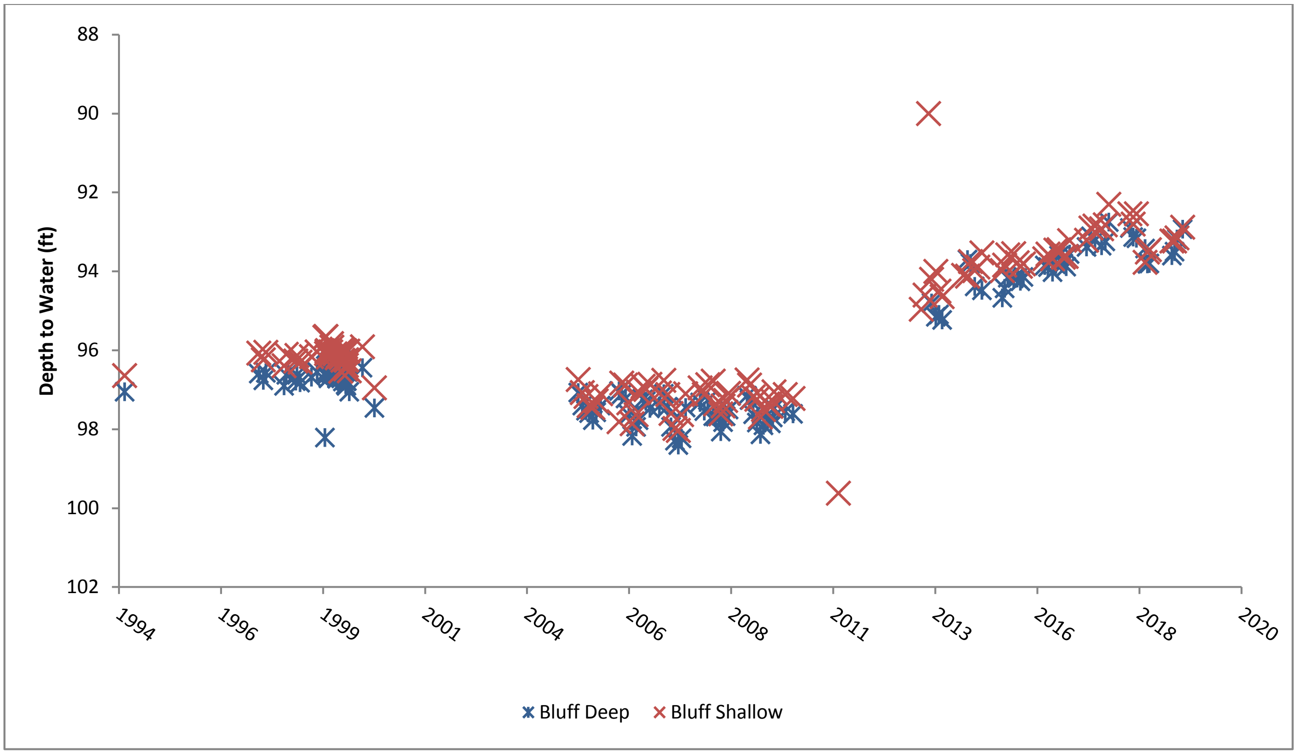


**Figure 24.** Shallow and deep bluff well historic water levels. Scott SWCD began monitoring in 2005. Monitoring was suspended between 2010 and 2013 due to construction in the area. All available data for these two wells are reported.

**Discussion:**

Even with a very wet 2019 season, all the wells (except the bluff wells) showed a seasonal decrease in water levels. Unlike previous year's most wells did not see significant spikes throughout the season, the slight decreases were gradual throughout the year. Historically, the water levels in all the wells are higher than they have been in the past ten years. A combination of a wet 2018 Fall and a wet 2019 season will likely help the slight decreases seen in the wells this season. Although the Bluff wells are no longer accessible, the increase seen throughout the year is a good sign that the wells will continue to increase their water levels as long as the human influences in the area remain minimal. Continual monitoring of all the wells in the LMRWD area will provide information on groundwater levels that can provide information on the impacts of water usage and recharge capabilities.

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